Modeling and Simulation of Hydration Operation of Date Palm Fruits Using COMSOL Multiphysics

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Abstract

Hydration is the key unit operation in the thermal process of dates. Excessive times of hydration could reduce the shelf stability of dates and induce a waste of energy whereas insufficient hydration durations lead to non acceptable final product quality. This study focuses on modeling and simulation of hydration process of dates in order to optimize this unit operation.

The work is divided into two parts: an experimental investigation and a modeling approach with COMSOL Multiphysics.
In the first part, dry Tunisian Deglet Nour dates were hydrated experimentally at a laboratory scale by using saturated air at atmospheric pressure and temperatures ranging from 50 to 65°C. We obtained hydration curves by measuring the average moisture content of dates flesh at regular intervals during the operation. A monitoring of the temperature within the dates for the range of hydration times used for undertaking experiments showed that the temperature can be considered as homogeneous.

In the second part of the work, a 2D axisymmetric model was developed in COMSOL Multiphysics by taking into account only mass transfer phenomena. This model considers the real shape of dates and the variation of density as a function of moisture content.

By using appropriate mass transfer equation and boundary conditions, date flesh moisture distribution is computed during the hydration process (Kechaou and Maalej, 2000). For post-processing, the mean water concentration is calculated as a function of time with the average coupling operator. Then, by using the optimization module from COMSOL, both moisture diffusivity and convective mass transfer coefficient at the surface were estimated by minimizing the least-square objective function calculated from experimental and numerical mean moisture contents.

Results showed a good agreement between experimental and calculated numerical values of average moisture contents for various operating conditions. Figure 1 shows the simulated distribution of moisture content within one date after 14640s (4h) of hydration using estimated moisture diffusivity and convective mass transfer coefficient.

Such a methodology can now be employed as a predictive tool to simulate the hydration of dates

in order to improve the quality of final product and reducing processing time.

Reference

N. Kechaou and M. Maalej. A simplified model for determination of moisture diffusivity of date from experimental drying curves. Drying Technology, 18, 1109-1125 (2000)

Figures used in the abstract

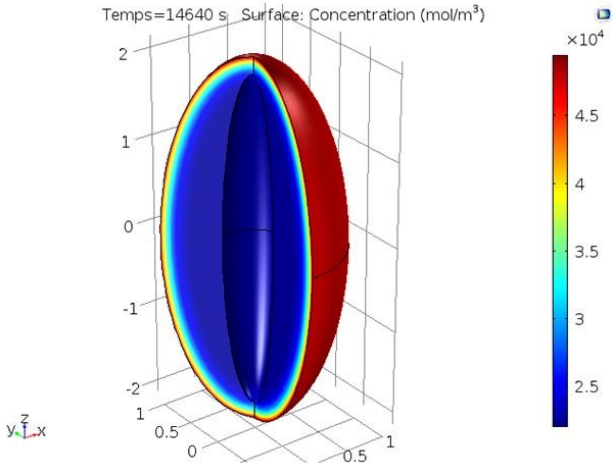

Figure 1: Simulated moisture concentration distribution within a date flesh after 4h of hydration.

Figure 2

Figure 3

Figure 4