INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–3–412–415
http://www.fspublishers.org

Experimental and Numerical Investigations of Moisture Diffusion in Pistachio Nuts during Drying with High Temperature and Low Relative Humidity

SHAHIN RAFIEE[1], ALI JAFARI, MEHDI KASHANINEJAD† AND MAHMOUD OMID
Faculty of Biosystem Engineering, University of Tehran, P.O. Box 4111, Postal Code 31587-11167, Karaj, Iran
†*Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran*
[1]Corresponding author's e-mail: shahinrafiee@ut.ac.ir

ABSTRACT

In this study, a numerical solution based on finite element (FE) is adopted to simulate the mass distribution inside a pistachio nut (cv. Ohadi). It was found that the FE solution of the diffusive moisture transfer equation could improve nut-drying simulation of axisymmetric bodies. An axisymmetric linear triangular element with two degree of freedom per node was used to discretize the pistachio nut in the model. A thin layer pistachio nut was dried at two drying air temperatures of 55 and 70°C under constant air velocity and relative humidity and moisture content was measured every minute. The simulation data were tested using values obtained from thin layer drying experiments. Comparison showed that the simulation program gave good prediction for moisture content variations during the drying process. Results showed that there was no constant-rate drying period and the whole drying process occurs during the falling rate period. The moisture distribution inside the individual pistachio nuts was predicted using the model at five selected periods of 5, 10, 20, 50 and 100 min with drying air temperatures of 55 and 70°C. The results showed that distribution of the moisture content inside kernels was non-uniform. The moisture content at the center and surface of kernels reduced slowly and very rapidly respectively.

Key Words: Drying; Finite element method; Moisture diffusion; Pistachio nut

INTRODUCTION

Artificial drying is one of the most important stages of pistachio nut processing. Many theoretical and experimental studies have been conducted to describe the drying process of agricultural products (Ertekin & Yaldiz, 2004; Sacilik *et al.*, 2006). Luikov developed a mathematical model for describing the drying of porous media (Husain *et al*., 1972). Some researchers, while applied Luikov's model to grain drying (Nemenyi *et al.,* 2000) concluded that consideration of the coupling effects of temperature and moisture in the analysis of grain drying is not required for engineering practice (Husain *et al.,* 1973). Jia *et al.* (2000) combined Luikov's model and considered the effects of thermal behavior of grain, internal temperature and moisture gradients, which increased the drying simulation accuracy. Fortes *et al.* (1981) proposed a model for grain drying, which assumed that the liquid form of moisture diffused to the outer boundary of the kernel and evaporated on the surface of the grain. This assumption was supported by wheat drying experiments in other studies (Sokhansanj & Bruce, 1987). However, some assumptions, such as constant diffusion coefficient and material properties for simplifying calculations could affect the simulation accuracy.

The drying behavior, as described by moisture, temperature and stress distributions inside a kernel during drying and the quality traits of individual grain kernels affect the overall quality of the grain dried in a dryer (Yang *et al.*, 2003). Therefore, it is important to examine the internal behavior of a single nut in order to improve the drying process and product quality. Because of the small size of kernels, internal changes in temperature and moisture cannot easily be measured. Computer simulation is a powerful tool for achieving this goal. The increasing development of special professional software had a great impact on the design of dryers and quality evaluation of agricultural products. Much work has been done to simulate the temperature, moisture content and stress distributions inside single grain kernels (Cnossen & Siebenmorgen, 2000; Jia *et al.*, 2000; Perdon *et al.*, 2000; Yang *et al.*, 2000, 2003; Wu *et al*., 2004), but there is no information about simulation of moisture diffusion in pistachio nut.

Ohadi variety is one of the major pistachio nut varieties that is grown in Iran. Therefore, this cultivar was selected in this study. In this study, the simulation of Ohadi variety drying was modified by the experimental data of the thin layer drying and mass transfer within pistachio nut during drying. The moisture content distribution inside the kernel at five selected times (5, 10, 20, 50 & 100 min) under drying air temperatures of 55 and 70°C was simulated.

MATERIALS AND METHODS

For pistachio nut drying simulation, the Fick's diffusive equation describing the mass transfer process was applied (Jia *et al*., 2000):