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Drying Kinetics of Apple Tissue Treated by Pulsed Electric Field

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The aim of this work was to study the influence of pulsed electric field (PEF) on the drying kinetics of apple tissue. Therefore, mathematical models that are commonly used in the literature were applied to describe the process. PEF treatment of the samples was carried out at an intensity of $E = 5$–10 kV/cm and 10–50 pulse numbers. Subsequently, the apples were convectively dried at 70°C and air velocity of 2 m/s. Based on electrical conductivity measurement, the cell disintegration index Z_p was computed. Midilli et al.'s(*Drying Technology*, Vol. 20, pp. 1503–1513, 2001) model was evaluated as the most adequate to describe the moisture transfer in PEF-treated and intact samples. PEF pretreatment induced a reduction in drying time of up to 12% when 10 kV/cm and 50 pulses were applied. For instance, after 60 min of drying, the dimensionless moisture ratio for PEF-treated (10 kV/cm, 50 pulses) samples was 0.18 compared to 0.26 for the untreated apples. The effective moisture diffusivity, calculated on the basis of the Fick's second law, was 1.04×10^{-9} m/s for intact samples and from 1.09×10^{-9} to 1.25×10^{-9} m^2/s for PEF-treated samples at 10 pulses at 5 kV/cm and 50 pulses at 10 kV/cm, respectively.

Keywords Food drying; Mathematical modeling; Pretreatment; Pulsed electric field

INTRODUCTION

Drying is one of the oldest food preservation methods. It is also one of the most commonly applied unit operations in food processing. The essence of this process depends on moisture removal, which prevents spoilage. A reduction in microorganism growth can be achieved when the water content in food does not exceed more than 15%. However, chemically, enzymatic ally, or nonenzymatically induced reactions are inhibited when the moisture content is lower than 5%. In addition to prolonged shelf life, other benefits include a reduction in shipping and packaging costs.[1] Additionally, drying can be used to minimize post harvest losses.[2] Nevertheless, this common unit operation disadvantages, such as high energy consumption, structural changes,[3] decomposition of thermolabile substances—for example, vitamins or volatiles—and others.[4] These concerns and increasing nutrition cognition of consumers have prompted engineers and scientists to improve this unit operation. Generally, drying enhancement is carried out by pretreatment techniques applied prior to the drying. Therefore, all manipulations performed before the main operation determine both the course of next stages of the process and the quality of the product.[5] A number of drying pretreatment methods have been reported in the literature. The most popular are osmotic dehydration and blanching.[6–10]

Recently, new nonthermal techniques have been proposed as methods of drying enhancement; for instance, ultrasound, high-pressure treatment, and pulsed electric field (PEF) treatment.[11–14] This latter technology is considered one of the most promising and is applied not only to enhance drying but to other processes based on mass transfer or even as a preservation technique.[15] The nature of PEF treatment is grounded on the cell membrane disintegration phenomenon, called *electro oration* (or *electropermeabilization*). It appears as the formation or growth of native micropores in plasma lemma so that the intracellular juice can flow out. This makes mass transfer easier,[16] which can be proved by the value of the diffusion coefficient. For instance, after PEF treatment (at moderate electric field intensity of 0.5 kV/cm), the diffusion coefficient of soluble substances in apple slices increased from 2.5×10^{-10} m^2/s (for untreated) to 3.9×10^{-10} m^2/s.[17]

Pulsed electric field treatment of the plant tissue, due to the mechanism of the process, causes both desirable and undesirable changes in the properties of the material. For instance, PEF treatment of apple can lead to more intensive browning of the tissue,[18] which is due to the release of substrates for enzyme activity. PEF treatment can also affect the Maillard reaction. It has been proven that the application of an electric field at high intensity (>30 kV/cm) can result

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