Available online at www.sciencedirect.com
ScienceDirect
Journal of Food Engineering 78 (2007) 1291–1297
JOURNAL OF FOOD ENGINEERING
www.elsevier.com/locate/jfoodeng

Air-drying characteristics of tomatoes

İbrahim Doymaz *

Department of Chemical Engineering, Yildiz Technical University, 34210 Esenler, Istanbul, Turkey

Received 15 June 2005; accepted 20 December 2005
Available online 28 February 2006

Abstract

The drying characteristics of tomatoes were investigated at 55, 60, 65 and 70 °C with air flow rate of 1.5 m/s. Prior to drying, tomatoes were subjected to dipping in alkaline ethyl oleate solution (2% ethyl oleate + 4% potassium carbonate). Also, drying of raw tomatoes was taken as a control. During the experiments, tomatoes were dried to the final moisture content of 11% from 94.5% (w.b.) It has been found that pre-treatment and air temperature affect the course and rate of drying. The increase in the air temperature in the range 55–70 °C markedly increased the drying rate of tomatoes. The experimental data were fitted to two drying models: Henderson and Pabis, and Page models. The models were compared using the coefficient of determination and reduced chi-square. The Page model best described the drying curve of tomatoes. A diffusion model was used to describe the moisture transfer and the effective diffusivity at each temperature was determined. The effective diffusivity of pre-treated and untreated varied between $5.65–7.53 \times 10^{-10}$ and $3.91–6.65 \times 10^{-10}$ m^2/s, respectively. The temperature dependence of the diffusivity coefficient was also described by the Arrhenius type relationship. The activation energy of tomatoes was in the range of 17.40–32.94 kJ/mol.
© 2006 Elsevier Ltd. All rights reserved.

Keywords: Air-drying; Rehydration capacity of tomatoes; Thin-layer drying models; Effective diffusivity; Activation energy

1. Introduction

Tomato is the world's most commonly commercially produced vegetable. The world tomato production reached 124,111,781 metric tons and Turkey produced about 9,440,000 metric ton of tomatoes in the 2004 (FAO, 2005). United States, Turkey, Italy, and Spain are the leading tomato growing countries (Jumah, Banat, Al-Asheh, & Hammad, 2004). Tomato is used to great extent in the fresh state, and in some processes as juice, puree, sauces and canned varieties (Akanbi, Adeyemi, & Ojo, 2006). Moreover, dried tomato products are used as a component for pizza and various vegetable and spicy dishes.

Drying is the most common form of food preservation and extends the food self-life. The major objective in drying agricultural products is the reduction of the moisture content to a level, which allows safe storage over an extended period. Also, it brings about substantial reduction in weight and volume, minimising packaging, storage and transportation costs (Okos, Narsimhan, Singh, & Witnauer, 1992). In the Mediterranean countries the traditional technique of fruit and vegetable drying is by using the sun. This technique has the advantages of simplicity and the small capital investments, but it requires long drying times that may have adverse consequences to the product quality: the final product may be contaminated from dust and insects or suffer from enzyme and microbial activity (Andritsos, Dalampakis, & Kolios, 2003). In order to improve the quality, the traditional sun drying technique should be replaced with industrial drying methods such as hot-air and solar drying (Ertekin & Yaldiz, 2004; Diamante & Munro, 1993).

Generally, some fruits and vegetables such as grapes, plums, apricots, peppers and tomatoes are covered naturally with a thin layer of wax. This outer layer offers benefits such as protection to the fruit or vegetable from

* Tel.: +90 212 449 17 32; fax: +90 212 449 18 95.
E-mail address: doymaz@yildiz.edu.tr

0260-8774/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jfoodeng.2005.12.047

Nomenclature

a	drying constant	M_0	initial moisture content, kg water/kg dry matter
D_{eff}	effective diffusivity, m^2/s	N	number of observations
D_0	pre-exponential factor of Arrhenius equation, m^2/s	n	drying constant, positive integer
E_a	activation energy for the moisture diffusion, kJ/mol	R	ideal gas constant, kJ/mol K
k	drying constant, 1/min	R^2	coefficient of determination
k_0	slope	T	temperature, °C
L	the half-thickness of the halve in samples	t	drying time, min
M_t	moisture content, kg water/kg dry matter	z	number of constants in models
M_e	equilibrium moisture content, kg water/kg dry matter	χ^2	reduced chi-square

environmental and external factors. The wax layer also affects the flow of moisture from inside the fruit to its surface, a crucial process in drying (St. George et al., 2004). Prior to drying process, chemical dipping such as methyl and ethyl ester emulsions or alkaline pre-treatment in aqueous solutions of sodium hydroxide, sodium chloride, potassium carbonate and calcium chloride has been used to overcome the wax barrier on fruits or vegetables. Dipping waxy fruits for several seconds in solution of ethyl oleate or other suitable compound (usually fatty acid derivatives used as wetting agents and emulsifiers) greatly reduces drying time. The effects of dipping solutions on various fruits and vegetables during drying are reported in literature (Bolin, Petrucci, & Fuller, 1975; Doymaz, 2004; Doymaz & Pala, 2002; Raouzeos & Saravacos, 1986; Riva & Peri, 1986). Tomatoes before drying process are pre-treated various solutions such as calcium chloride (Lewicki, Le, & Pomarańska-Lazuka, 2002; Lewicki & Michaluk, 2004), sodium chloride (Sacilik, Keskin, & Elicin, 2006), and sodium chloride-sucrose (Kross, Mata, Duarte, & Junior, 2004) and then can be dried in different shapes such as halves, slices and quarters (Telis & Sobral, 2002; Zanoni, Peri, Nani, & Lavelli, 1999). However, no reports have been found detailing the effects of alkaline ethyl oleate solution on drying of tomatoes in the literature. The purpose of the present work was to investigate the effect of alkaline ethyl oleate solution on tomatoes drying and rehydration capacity of tomatoes, to calculate effective moisture diffusivity and the fit the experimental data to Page and Henderson and Pabis models.

2. Materials and methods

Fresh tomatoes (*Lycopersicon esculentum* Mill) were purchased from a local market in Istanbul, Turkey. Freshly samples were sorted visually for colour and size (average diameter and weight of 5 ± 0.2 cm, 135 ± 5 g). The initial moisture content of tomato samples was determined by using the oven method at 105 °C for 4 h. Average moisture content was found to be 94.5% (w.b.).

2.1. Drying process

Drying experiments were performed in a laboratory scale hot-air dryer, described previously by Doymaz (2004) and installed in the Chemical Engineering Department of Yildiz Technical University, Istanbul, Turkey. Desired experiments conditions inside the dryer were obtained for at least 1 h prior to each run.

Tomatoes were washed in fresh running water, dipped in alkaline ethyl oleate solution (AEEO: 2% ethyl oleate + 4% potassium carbonate) for 1 min, cut into halves with a knife, and then spread on a perforated tray. Drying runs of tomato were conducted at four temperatures (55, 60, 65, and 70 °C) with fixed airflow (1.5 m/s). The drying experiment involving untreated (NAT) samples was also performed at same conditions. Moisture loss was recorded at 30 min intervals during drying by means of a digital balance (Mettler, model BB3000) with an accuracy of ±0.1 g. The drying was carried out to final moisture content of 11% from initial moisture content of about 94.5% (w.b.). After drying, all products were packed in polyethylene bags wrapped in aluminium foil to prevent light damage and stored at ambient temperature. Drying runs were done in triplicate.

2.2. Rehydration capacity

Five grams of the dried products were added to 200 ml distilled water, in a 400 ml flask beaker at 25 °C for 24 h. Then, the samples were weighed by a Mettler balance (model BB3000), which has 0–3000 g measurement range with an accuracy of ±0.1 g. Rehydration capacity was calculated as the maximum amount of water absorbed (kg) per kg of dry material as determined at the end of the rehydration time for each experiment. Determinations were made in triplicate.

Download English Version:

https://daneshyari.com/en/article/226399

Download Persian Version:

https://daneshyari.com/article/226399

Daneshyari.com