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A new physical pretreatment of plum for drying

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ABSTRACT

In this paper a new physical pretreatment of plums, consists of piercing them by a thin needle, is proposed to increase the rate of drying. The effect of physical pretreatment on drying time was compared with chemical pretreatment that consists of dipping of plums in hot NaOH solution (1%). Drying experiments were carried out in a convective laboratory dryer at 85 °C and 0.81 m/s air velocity. It was observed that pierced plums were dried faster than chemically pretreated plums. After 480 min moisture ratio of pierced sample was 0.07 while for the chemical method it was 0.25. The moisture ratio at any time was compared with seven different mathematical models and the best model was determined according to the best agreement. Accordingly, two-term exponential model for moisture ratio is found to be superior to the other proposed models. The effective diffusivity was found to be 5.471×10^{-9} m^2/s for chemically pretreated and 1.016×10^{-8} m^2/s for physically pretreated plums.

Keywords: Plum; Physical pretreatment; Drying; Mathematical modeling

1. Introduction

Plum is a source of essential nutrients, vitamins and minerals. Drying of plums makes them available at any time and avoids them from perishing. In addition, dried plums are easy to be transported, packed and shipped. Consumption of plums is becoming widespread, and it is necessary to enhance production rate and develop a new industrial drying process. Plums have a waxy layer in their outer surface that is the main barrier to moisture loss. The main challenge in drying of plums is to reduce drying time by pretreatment of plums to decrease the effect of waxy layer. In this manner, extensive attempts were done and some pretreatments were proposed. Goyal et al. (2007) dried untreated, blanched and dipped plums in potassium meta bisulphate solution (KMS) in a tunnel dryer. Tarhan (2007) applied eight pretreatment combinations for drying of plums and reported that the best pretreatment is dipping in NaOH solution (1%). Menges and Ertekin (2006) dried plums which were dipped into 2% NaOH solution in order to examine the effect of pretreatment. Sacilik et al. (2006) blanched plums in hot water of 80 °C for 2 min and rinsed with tap water at room temperature immediately to increase the water permeability of the skin. Doymaz (2004) pretreated plums in alkali solution containing ethyl oleate. To emphasize on the role of skin on the drying of plum, Sabarez and Price (1999) compared effective diffusivity of moisture when plums were dried with or without skin. In all of mentioned works, chemical or thermal pretreatment was used, and it is found that chemical pretreated plums dried faster than blanched or untreated ones.

There are a few attempts to apply physical pretreatments. A physical pretreatment, consists of superficial abrasion of the plums peel, is proposed by some researchers and compared with chemical method in which the plums were dipped into solution of ethyl oleate (Cinquanta et al., 2002; Matteo et al., 2003, 2002). This physical method was found to be more effective than chemical one.

In this paper, a new physical pretreatment of plums that consists of piercing of plums by a thin needle, is proposed in order to enhance moisture loss and its influence on reducing drying time was examined. In addition drying curve is presented by a suitable mathematical model. Finally, effective moisture diffusivity of physically and chemically pretreated samples was reported.

2. Materials and methods

Samples of Uryani plums at commercial maturity were purchased from local market in Isfahan, Iran. Generally, plums of approximately uniform size (average diameter and weight of

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Nomenclature

a, b, c	coefficients in models
dM/dt	drying rate (kg water/kg dry matter min)
D_{eff}	effective diffusivity (m^2/s)
k, k_0, k_1	constant in models (min^{-1})
M	moisture content at any time (kg water/kg dry matter)
M_e	equilibrium moisture content (kg water/kg dry matter)
M_0	initial moisture content (kg water/kg dry matter)
MR	dimensionless moisture ratio
MR_{cal}	calculated dimensionless moisture ratio
MR_{exp}	experimental dimensionless moisture ratio
MR_{avg}	average dimensionless moisture ratio
MRE	mean relative error
n	positive integer
R	radius of plum (m)
R^2	coefficient of determination
SSR	reduced sum square error
t	drying time (min)
y	coefficient in model

3.4 cm and 31.5 g) were employed. The initial moisture content of plums was 77% (w.b.). Drying experiment was carried out in a pilot scale dryer. The schematic diagram of the experimental apparatus is given in Fig. 1.

Drying experiments were carried out at 85 °C and 0.81 m/s air temperature and velocity. Experiments were replicated twice to ensure reproducible results. Before drying, samples of plums were pretreated using one of the following methods:

a. Piercing by needle in a way that uniform number of holes per surface area be attained (1 hole per 2 cm^2). Then plums should also be blanched with boiling water for 20 s (PS).
b. Immersion in an aqueous solution of 1% (w/v) NaOH at 100 °C for 20 s (DS).

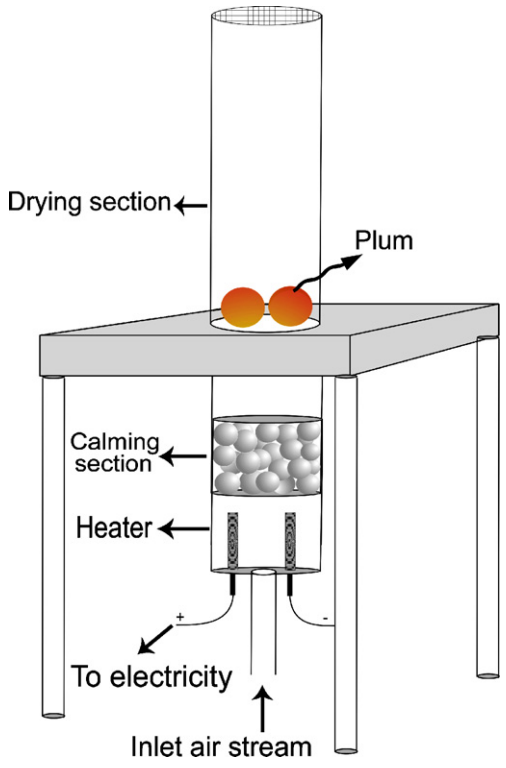

Fig. 1 – Schematic diagram of drying apparatus.

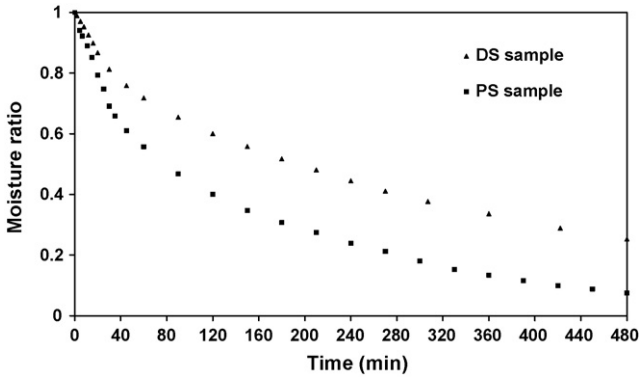

Fig. 2 – Moisture ratio versus drying time for physically pretreated sample (PS) and chemically pretreated sample (DS).

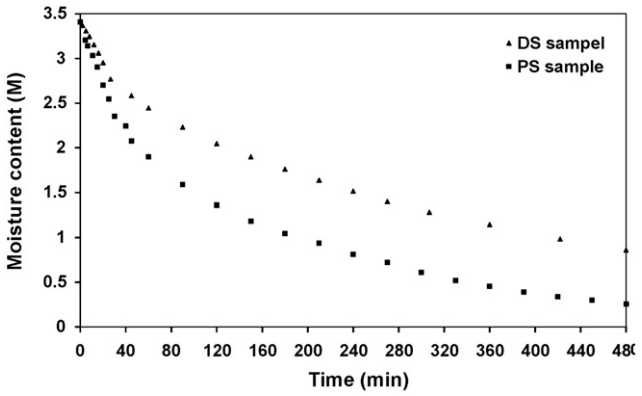

Fig. 3 – Moisture content versus drying time for physically pretreated sample (PS) and chemically pretreated sample (DS).

The moisture ratio of samples during drying is expressed by Eq. (1):

$$MR = \frac{M - M_e}{M_0 - M_e} \quad (1)$$

where MR is the moisture ratio, M, M_e, M_0 are the moisture content at any time, the equilibrium moisture content and the

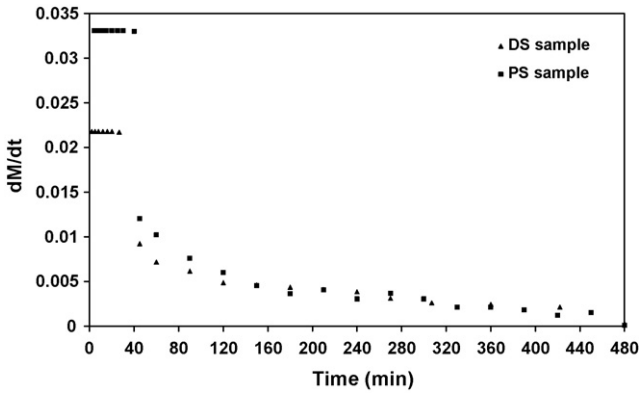

Fig. 4 – Drying rate versus drying time for physically pretreated sample (PS) and chemically pretreated sample (DS).