Drying Kinetics of Pomegranate (*Punica Granatum*) Peels

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Abstract

The main product of pomegranate is the juice extracted from the shells. The peels, a by-product after pomegranate juice processing, can be used as animals feed or submitted to extraction of bioactive compounds. The effects of drying parameters before extraction are important in the quality attributes of final products. Thus, the aim of this work was study the drying process of pomegranate peels in order to obtain the best operational condition to preserve the bioactive compounds in the dried raw material. The shells were then dried in a lab cabinet dryer at 40, 50 and 60ºC, air velocity of 1 ms^{-1}, in triplicate assay. Drying curves obtained from the experimental data are fitted from Fick's second law of diffusion for evaluating a suitable thin layer drying model. Statistica (v.7.0) was used to estimate the effective diffusivity (D_{ef}) that reached the maximum value of 1.57×10^{-10} m^2s^{-1} at 60°C.

Key words: antioxidant capacity, adding value to agro-industrial residues

1. Introduction

The pomegranate is a fruit with a long medical history, widely used by many people, especially Asians. Brazil is one of the largest producers of fruits due to its natural biodiversity, but with the globalization of knowledge and investor participation in international events, became aware of the different products obtained from the others fruits like pomegranate due its functional properties, indicating antioxidant potency in higher concentrations than wine and others juices (Seeran et al, 2008). Commercially Brazil imports pomegranates produced by USA, Israel and Iran, and now there are some plantations in the northeast and southeast of the country, but the production has not yet quantified. Embrapa develops research with different varieties of pomegranate to verify its adaptability in Brazilian soil. So, the production of pomegranate is still an incipient activity in the country. There is a little information about value-added utilization of the by-product. Pomegranate residues are normally used as cattle feeds with low value or directly disposed in the field which could cause environmental problem. However, Qu et al. (2009) shown that pomegranate marc is a good raw material for producing natural antioxidants because of its high content of phenolics compounds. The pomegranate peels have high moisture contents which can reduced to extraction higher added value products. Thus, the aim of this work was to study the drying process of pomegranate peels in order to obtain the best operational conditions to preserve the bioactive compounds in the dried raw material.

2. Material and methods

2.1 Material

Pomegranate fruits were obtained from Special Fruit farm located in semiarid Brazilian region. Fruits were carefully processed to separate the seeds and peels and each fraction were vacuum packed and kept at -18 ºC until their use. The peels were cut into strips approximately 10 mm wide and 0.4mm thickness. A sample of 30 units of peels was taken to measure the thickness, size characteristic of an infinite slab, for subsequently applying Fick´s model (Equation 1).

2.2 Drying equipment

The drying experiments were conducted in a cabinet dryer (Fabbe Primar). Overall dimensions of the dryer are, height: 0.60 m, width: 0.60 m and depth: 0.60 m. The dryer consisted of trays (580x580x15 mm), temperature controller (0–300ºC, dry bulb temperature, accuracy ± 1ºC) and a centrifugal fan for airflow (1.0 ms^{-1}).

2.3 Drying procedure

Hot air drying of pomegranate peels was carried out in the cabinet dryer in thin layers. The loading mass of samples was kept at 500g. Drying experiments were performed at 40, 50 and 60ºC temperatures and air velocity at 1m/s. Moisture loss was recorded at 30 min interval with the help of an electronic balance (sensitivity: 0.01 g). The drying was continued till there is no large variation in the moisture loss (25h). The experiments were conducted in triplicate. At the end a sample of dry peels was taken to determine the equilibrium moisture. The ambient air conditions was monitored using a thermo-hygrometer apparatus marc Cole-Parmer to measure relative humidity, dry and wet bulb temperatures during the drying kinetics determination.

2.4 Diffusional Model

Curves of moisture ratio versus drying time for different drying air temperatures are adjusted using Fick´s second law of diffusion to estimate the effective moisture diffusivity (D_{ef}). When internal mass transfer is controlling mechanism and one-dimensional transport in an infinite slab is assumed, the mathematical solution of this model is given by Eq. (1)

$$U^* = \frac{M(t) - M_{eq}}{M_o - M_{eq}} = \frac{8}{\pi^2} \sum_{n=0}^{\infty} \frac{1}{(2n+1)^2} \left[\exp \frac{\left(-(2n+1)\right)^2 \pi^2 D_{ef}}{4L^2} t \right] \text{......................[1]}$$

The moisture ratio was calculated using the relation:

where:
M(t) - moisture content at time t
M_0 - initial moisture content
M_e equilibrium moisture content
L- is the half-thickness of the peels

For sufficiently long drying times, CRANK (1975) gives the solution using only the first term. In this work it was used the two terms of the serial.

2.5 Analysis

Antioxidant Capacity was determined by the Trolox Equivalent Antioxidant Capacity (TEAC), also known as ABTS cationic radical scavenging activity, according to the method proposed by Re et al. (1999) and modified by Rufino et al. (2010). Antioxidant activity analysis was performed in triplicate.

Moisture: according to AOAC (2000), at 60ºC under a vacuum until no weight changes observed.

3 Results and discussion

Drying air temperature had an important effect on drying rate. The decrease in drying time with increase in drying temperature may be due to increase in water vapour pressure within the peels, which increased the migration of moisture.

The parameter fitted (D_{ef}) and statistical data (ANOVA) are showed in Table 1. Two parameters, F-value and coefficient of determination were used to verify the regression adjusts.

TABLE 1 – Moisture diffusivity and ANOVA data

T (℃)	D_{ef} ($m^2 s^{-1}$)	R^2	F-value
40	7.69×10^{-11}	0.99	3502
50	8.89×10^{-11}	0.96	1436
60	1.57×10^{-10}	0.93	434

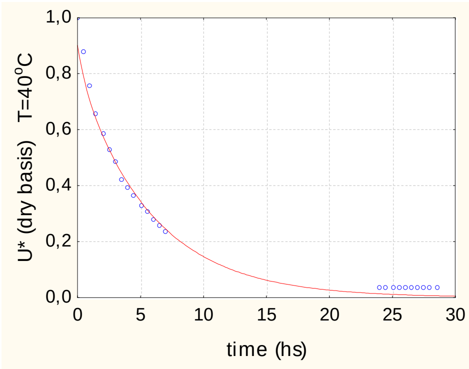
The moisture ratio of pomegranate peels reduced exponentially as the drying time increased Fig. 1. Drying rate decreased continuously indicating the mass transport, between 40 and 60℃, occurred mainly by diffusion. This is in agreement with the results reported for pomegranate arils (Kingsly and Singh, 2007).

Considering the two first terms of Eq (1), effective moisture diffusivity increased with temperature reaching value of 7.69×10^{-11} $m^2 s^{-1}$, 8.89×10^{-11} $m^2 s^{-1}$ and 1.57×10^{-10} $m^2 s^{-1}$, respectively at 40, 50 and 60℃. These values are lower than those reported by Doymaz (2011), which D_{ef} were equal to 4.02 to 5.31×10^{-9} $m^2 s^{-1}$ for pomegranate peels dried at 50 to 70℃. These differences probably occurs due to the drying experiments were performed at higher air velocity 2.0 m s^{-1}, while in present work were used lower air velocity, making slower mass transfer (Vega-Galvez et al. 2012).

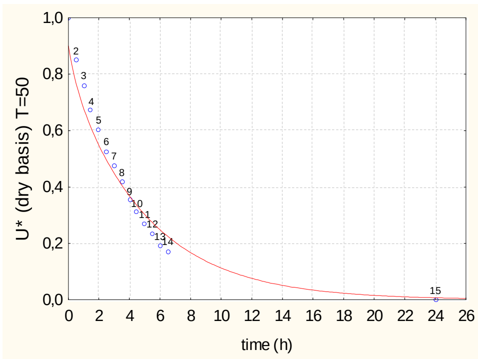
It was observed (Table 2) that the antioxidant capacity increased by two and a half times to three times compared to fresh sample when for the temperatures 40, 50 and 60℃ respectively.

TABLE 2 – Effect of drying temperature on antioxidant capacity of dried pomegranate peels

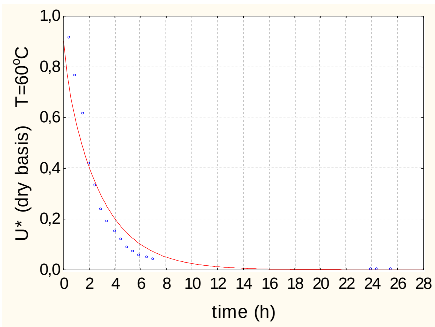
T (℃)	Antioxidant capacity (µmol Trolox eq/g dry material)
40	5233.81 ± 0.15
50	4229.85 ± 545.82
60	4318.04 ± 110.85
fresh	1724.20 ± 35.70



(a) 40℃



(b) 50°C



(c) 60℃

Figure 1. Drying curves fitted by nonlinear regression using Lavenberg-Marquardt algorithm

The values of the fresh peels (Table 2) are similar to those for other fruits, as the mango equal to 1846 (μmol Trolox eq/g) reported by Matsusaka and Kawabata (2010). Soong and Barlow (2004) related that no edible parts of fruits have not generally received much attention as antioxidant sources, although presents TEAC greater than comestible parts. Considering the protective effects of natural products are related to their antioxidants compounds, the studies of these compounds sources becomes increasingly important.

Conclusions

It can be concluded that at lower drying temperature (40℃) the product presented higher antioxidant capacity. In this case the antioxidant capacity was found three times higher than the fresh peels.

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