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Evaluation of drying behavior of sweet potato slices in convective air dryer

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Abstract
In this paper, drying behavior of sweet potato slices at three different temperatures (50, 60 and 70°C) and slice thicknesses (1.5, 3 and 4.5 cm) was studied. Results shows that drying time increased appreciably as the slice thickness increased from 1.5 to 4.5 cm. The drying time decreased with increase in convective air temperature from 50°C to 70°C. For a slice thickness of 1.5 cm the drying rate increased rapidly in the beginning, attained a maximum value followed by a gradual decrease. The average drying rate varies from 3.25 to 0.12 (kg of water/ kg of dry solid) s^{-1}. The drying rate increased with increase in temperature.

Keywords: Dying, sweet potato and drying rate

Introduction
Sweet potato (*Ipomoea batatas* L) is one of the major root crops, mainly because of its attractive texture and high-energy content (Diamante and Munro, 1993) [3]. Moreover, it is rich in carbohydrates, protein, carotenoids, vitamin C, and dietary fibers (Falade and Solademi, 2010) [4]. In developing countries like India, sweet potato plays a major role in human nutrition. It is widely used in many ready to eat food formulations such as noodles, fries, desserts, chips, etc. as base ingredient (Onwude *et al.* 2018) [11]. However, fresh sweet potato can not be stored for longer time, even at refrigerated temperatures, due to its high moisture content. As a result, it must be preserved to improve its shelf life (Falade and Solademi, 2010) [4].

Drying is an important food preservation method which reduces water activity by decreasing moisture content, avoiding microbial contamination and potential deterioration during storage (Nguyen *et al.* 2018) [10]. In addition to this, drying reduces weight and volume, storage and transportation costs. The traditional method which is used in drying of fruits and vegetables through sunlight is not common nowadays, it takes more time leading to low quality product with microbial growth and low process capability (Madamba *et al.* 1996) [7]. The most common method in drying of foodstuffs is hot air dying which causes rapidity, produces high capacity (Naderinezhad *et al.* 2016) [9].

Drying involves the removal of moisture due to simultaneous heat and mass transfer process. Sweet potato, just like other agricultural crops with high moisture content is often preserved by drying (Diamante and Munro, 1993) [3]. The study of the drying behavior of fruits or vegetables is essential to design drying processes, and therefore, to obtain high-quality dehydrated products (Mayor and Sereno, 2004) [8]. However, reports on drying behaviour sweet potato slices were limited. Therefore, the main aim of this work was to study was to study the drying behavior during the hot-air drying process of sweet potato, and the analysis of the influence of temperature and time on drying rate during different time intervals.

Materials and Methods
Sample preparation
Sweet Potatoes used for sample preparation were purchased from local market. They were kept in dark and cold place (4°C) before the experiments were conducted. Sorted and cleaned sweet potatoes peeled with stainless steel (S.S) knife, then sliced into 1.5, 3 and 4.5 cm thickness using manual slicer. The uniform thickness of samples (±0.1 mm) was maintained with the help of the scale attached to the slicer.

The moisture content and equilibrium moisture content were determined in hot air oven, at 105°C for 24 h (Aghbashlo *et al.* 2009) [2] and maximum deviations of about 5% were observed between the triplicates.

Drying Equipment and Procedure

A lab-scale tunnel tray dryer was used for drying experiment. The temperature considered for the experiment was 50, 60 and 70°C. The air temperature was controlled by means of a proportional controller. The sample (100 g) was put in thin layer without any contact between slices and placed on the sample tray in the hot air unit. Depending on the drying conditions, the moisture loss was recorded every 10 min until constant mass was observed. After the set time, the sample was taken out of the drying chamber and weighed with an electronic balance (accuracy of 0.001 g) within 10 s.

Effect on parameters on drying time

Effect of drying temperature and thickness of sample on drying time was represented graphically by calculating moisture content based on weight measured (triplicate) at each interval. Drying rate was calculated using equation (1).

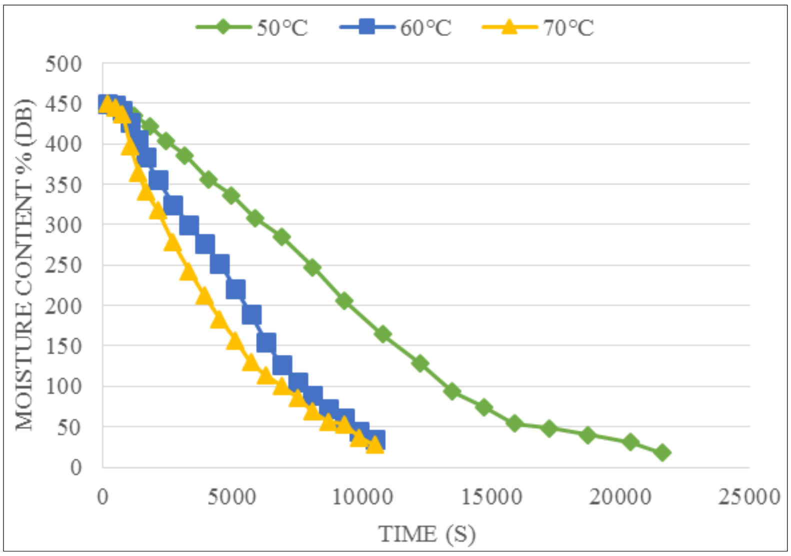
$$DR = \frac{M_t - M_{t+\Delta t}}{\Delta t} \quad (1)$$

Where M_t moisture content at any time of drying and $M_{t+\Delta t}$ is moisture content at t + Δt (kg water/kg dm), t is the time (min) and Δt time difference (min).

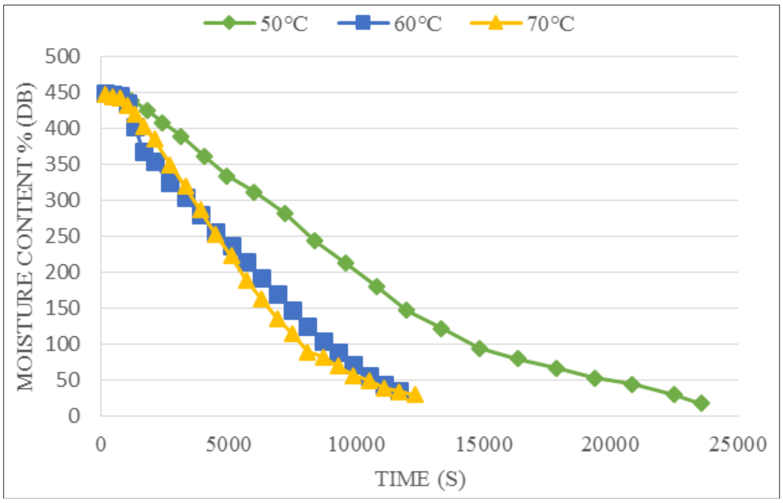
Results and Discussion

Effect of Process Variable on Drying Time

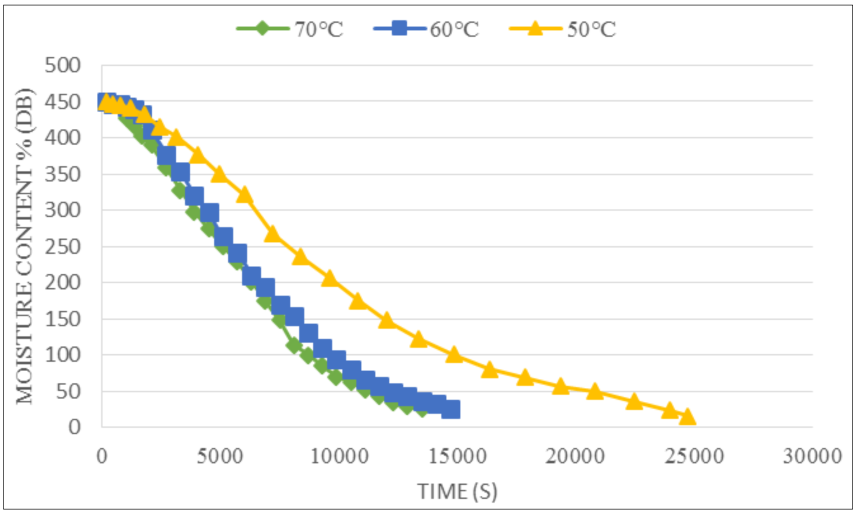
Sweet potatoes were subjected under different convective air-drying conditions and dried from 81.8% ± 0.2 to 15 % ±1 (w.b) moisture content. Variation in moisture content with elapsed drying time at each of the slice thickness are shown in Fig. 1. Based on experimental results obtained, it was observed that drying time increased appreciably as the slice thickness increased from 1.5 to 4.5 cm. The drying time decreased with increase in convective air temperature from 50°C to 70°C, due to increase in the water vapour pressure within the sample which facilitated the migration of moisture from inside of the product to its surface. Similar findings were observed by some authors (Abdelhaq and Labuza, 1987) [1] in apricot, (Lin *et al.* 1998) [6] in carrot, (Madamba *et al.* 1996) [7] in garlic and (Ozkan *et al.* 2007) [12] in spinach. The time required for drying sweet potato up to 15±1% (w.b) takes 175 min for 1.5 cm slice thickness at 70°C and 412.5 min for 4.5 cm slice thickness at 50°C temperature. As expected higher the drying air temperature, higher would be the mass transfer, which results in higher drying rate, and consequently lower drying time.



(a)



(b)



(c)

Effect of Process Variable on Drying Rate

Drying rate were calculated from the observed data by estimating change in moisture content observed in each consecutive interval. Initially surface of the sweet potato slice was very wet and a continuous film of water existed on the drying surface. This water is entirely unbound water and acted as if solids were not present. The rate of drying in this case was not dependent on the solid and is the same as that of evaporation from a free liquid surface. Increased roughness of the surface, however, led to a higher rate than from a flat surface (Krokida *et al.* 2003) [5]. Though moisture was evaporating from the surface, internal moisture was coming towards the surface at the same rate at that of moisture vaporization. Presence of short constant rate period was also confirmed by previous researchers (Diamante and Munro 1993; Krokida *et al.* 2003) [3, 5]. For a slice thickness of 1.5 cm the drying rate increased rapidly in the beginning, attained a maximum value followed by a gradual decrease. The average drying rate varies from 3.25 to 0.12 (kg of water/ kg of dry solid) s^{-1}. The drying rate increased with increase in temperature.

Conclusion

Vegetables, fruits, meat and other foods are materials that without proper processing cannot be preserved for long periods. In this sense, one of the conventional drying technique that is convective air drying technique is applied. In this study, convective air drying characteristics of sweet potato slices were investigated and it was reported that drying of sweet potato takes place in falling rate period. The drying rate was significantly influenced by air temperature. The drying time decreased with the increase in convective air temperature.

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