COMPARING THE DRYING CHARACTERISTICS OF APPLE AND KIWI FRUITS

by

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In this study, the effects of drying air velocity on the organic apple and kiwi fruits that were sliced in same sizes were experimentally examined in a convective type dryer. In order to examine the effect of drying air velocity to drying process, drying air at 45 ºC and 10% relative humidity was applied to kiwi and apple fruit samples sliced in 4 mm thickness at 0.5, 1.0, and 1.5 m/s drying air velocities. It was observed from the experimental results that drying air velocity has a significant effect on the total drying time. The drying time of apple and kiwi slices under these conditions varied between 150-360 minutes. The lowest drying time (150 minutes) was obtained at 1.5 m/s for the apple sample with 4 mm slice thickness, and the highest drying time (360 minutes) was obtained at 0.5 m/s for the 4 mm thick kiwi sample. Freshly collected products were successfully dried in a convective dryer at different velocities.

Key words: *drying, drying air velocity, apple, kiwi*

Introduction

Drying fruits and vegetables is one of the oldest methods of food preservation known to humans and is the most important process as it has a great impact on the quality of dried products. Natural outdoor Sun drying is widely practiced in hot climates and tropical countries. However, this technique also causes some problems. Elements such as rain, wind, dust, and insects reduce the quality of the drying process. Vegetables and fruits are an indispensable part of the human diet, but 30% of the total production is wasted. This waste can be effectively reduced by applying the appropriate method of processing and preservation. In this context, some vegetables have been traditionally processed by drying to extend their storage life to much longer than a few weeks and to make them available for off-season use [1-5].

Kiwi fruit is a highly nutritious fruit due to its rich vitamin C level and strong antioxidant capacity [6]. Apple is one of the most important fruits in the world and annual apple production is over 2.2 million tons. Apples are either consumed fresh or served as processed products such as juice, jam, and marmalade [7]. Recently, many studies have been carried out on the drying behavior of different fruits in the literature. Sacilik and Elicin [8], tested the thin-layer drying properties of organic apple slices. The effects of drying air temperature and slice thickness on drying properties and quality parameters of dried apple slices were determined.

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Akpinar *et al.* [9], experimentally examined the drying behavior of red pepper slices in a convective dryer and created a model by using mathematical drying models in the literature. Kouhila *et al.* [10], examined the cyclic variation of the drying air temperature in the convective drying system for mussels. Diamante *et al.* [11], examined the effect of temperature on the drying characteristics of kiwi fruit. They presented the variation of moisture content and drying rate values over time under different temperature conditions in graphs. Ozgen [12], experimentally examined the drying characteristics of cranberry fruit at different drying temperatures and different drying air velocities, and presented the effects of these parameters in graphics. Ozgen and Celik [13], examined the drying behavior of kiwi fruit in a convective dryer. They experimentally examined how drying air temperature and drying air velocity affect the drying time of kiwi sliced in different sizes. Similar studies are available in the literature [14-16].

In this study, the drying properties of kiwi and apple samples with 4 mm thickness were experimentally compared at 45 °C air temperature and 0.5, 1.0, and 1.5 m/s air velocity in a convective dryer. The results are shown as the variation of moisture content and drying rate with time. It was observed from the experimental results that drying air velocity has a significant effect on the total drying time.

Theoretical analysis

Moisture content

Moisture content is a measure of the relative humidity (RH) in the product, expressed on a wet and dry basis. Moisture content in accordance with the wet and dry basis was determined using the following equations (1) and (2) [17]:

$$M_{\mathrm{wb}} = \frac{M_{\mathrm{w}}}{M_{\mathrm{T}}} \tag{1}$$

$$M_{\mathrm{db}} = \frac{M_{\mathrm{w}}}{M_k} \tag{2}$$

where M_w is the water weight of the product, M_T is the total weight of the product, and M_k is the dry weight of the product.

Dimensionless moisture ratio

The ratio of the moisture content of the dried material at any time t to the initial moisture content is called the moisture ratio. The moisture ratio is determined by:

$$W_s = \frac{M_{\mathrm{t}} - M_{\mathrm{e}}}{M_0 - M_{\mathrm{e}}} \tag{3}$$

where M_t is the weight of the dried material at time t, M_e – the equilibrium moisture weight, and M_0 is the initial weight of the dried material.

Materials and methods

The experimental set-up designed to determine the drying behavior is shown in fig. 1. The experimental set-up consisted of a 0.537 kW radial fan, an air heating chamber, a drying chamber, and a weighing system, a digital scale with an accuracy of ±0.1 g, and an electric heater with a 2000 W power. The air flow rate was determined with a radial fan, and the ambient air humidity was measured with a humidity meter with a sensitivity of ±0.5 RH. Drying room temperature was controlled with the help of a heater. The sample tray (27 cm long and 21 cm wide), in which apple and kiwi fruits were placed equally, was attached to the electronic balance with the help of the sample holder wire. The electronic scale is located outside the drying chamber. In the experiments conducted, drying room inlet temperature, drying room outlet temperature, ambient temperature, drying air velocity, mass loss of fruits and moisture values were measured. The *T*-type thermocouples with a sensitivity of 0.018 °C were used to carry out these experiments.

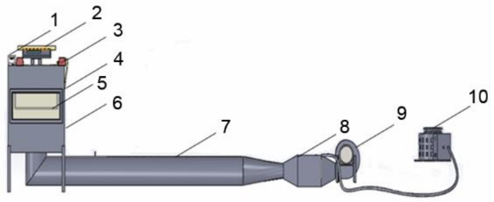

Figure 1. Schematic view of the experimental set-up; *1 – humidity meter, 2 – digital scale, 3 – thermoanemometer, 4 – air outlet channel, 5 – drying tray, 6 – drying cabinet, 7 – air-flow channel, 8 – heating system, 9 – fan, and 10 – variac*

The appearances of kiwi and apple fruits used in this study are given as photographs in figs. 2(a) and 2(b). The drying stages of the kiwi used in the experiment are shown in fig. 2(a) and the drying stages of the apple in fig. 2(b).

Figure 2. Different appearances of the fruits used in the experimental set-up

Before starting the drying process, the experimental set-up was stabilized by adjusting the drying air temperature and drying air velocity. The ambient air humidity where the experiments are carried out varies between 22-40% and the ambient temperature varies between 20-25 °C. The kiwi and apple fruits used in the experiment were freshly harvested. Then, 142 g of fresh fruits were placed on the drying tray and the mass loss was measured with digital scale. The initial moisture content of the fruits, which was 80% relative to the wet base, reached 10% at the end of the drying process.

Table 1. Drying times of the products for certain velocity and temperature values

Product	Drying air velocity [ms^{-1}]	Drying temperature [˚C]	Drying time [minute]
Apple	0,5	45 ˚C	285
Apple	1	45 ˚C	225
Apple	1,5	45 ˚C	150
Kiwi	0,5	45 ˚C	360
Kiwi	1	45 ˚C	300
Kiwi	1,5	45 ˚C	225

Results and discussion

The drying temperature, drying air velocities and drying times of apple and kiwi fruits used in this study are shown in tab. 1. The lowest drying time was observed for apple samples for 1.5 m/s drying air, while the highest drying time was for kiwi slices at 0.5 m/s drying air velocity.

The variation of moisture content of the products with respect to wet base with time for drying air temperature of 45 °C, drying air velocity of 0.5, 1, and 1.5 m/s is shown in fig. 3(a), and the variation of dimensionless moisture ratio with drying time is shown in fig. 3(b). As the drying time increases, the moisture content decreases rapidly and then gradually decreases. The variation of the internal temperature of the product with time is shown in fig. 4(a), and the mass loss of the products during drying is shown in fig. 4(b). During drying, it was observed that the surface temperature rapidly increased and then slowly stabilized. The drying time decreased as the drying air velocity increased. The highest loss was observed at 1.5 m/s velocity while the longest mass loss was observed at 0.5 m/s.

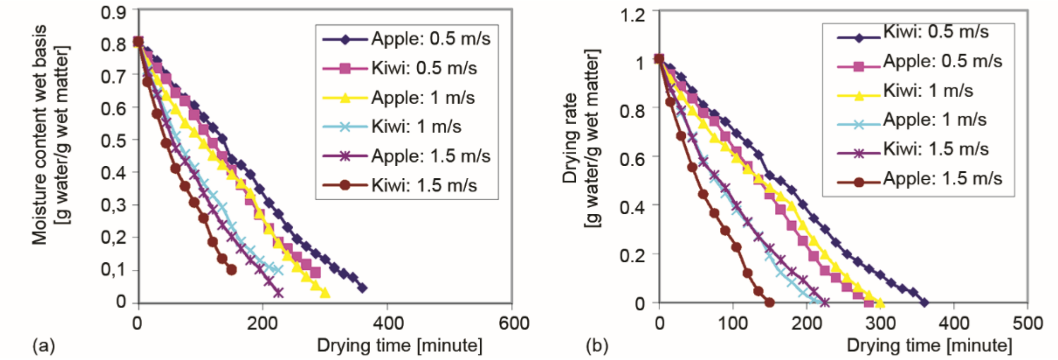

Figure 3. (a) Variation of moisture content with respect to wet basis and (b) variation of dimensionless moisture ratio with time

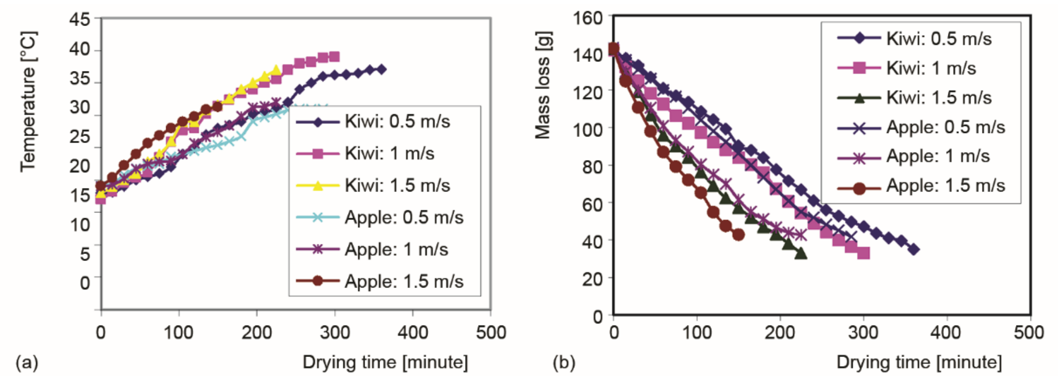

Figure 4. (a) The variation of product temperature with time and (b) variation of mass loss with time

Conclusion

In this study, the drying behavior of kiwi and apple was experimentally examined in a convective type dryer for a drying air temperature of 45 °C and a drying air velocity of 0.5, 1, and 1.5 m/s. The lowest drying time (150 minutes) was observed for apple samples for 1.5 m/s drying air, while the highest drying time (360 minutes) was for kiwi slices at 0.5 m/s drying air velocity. The initial moisture content of the fruits, which was 80% relative to the wet base, reached 10% at the end of the drying process. Moisture content and drying rate were affected by air velocity, and drying time decreased with increasing drying air velocity. Freshly harvested fruits were successfully dried without color change in the convective dryer manufactured for this study.

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