

Effect of Tray Loading Density on the Drying Characteristics of Okra

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Abstract: Okra was dried in thin layer at two different tray loadings of 0.5kg and 1.0kg to determine the effect of tray loading density on its drying characteristics. The time required to dry okra (0.5kg tray loading) from an initial moisture content of 88.0% wet basis to 19.8, 9.3 and 4.4% wet basis at temperatures of 50, 60 and 70°C respectively was found to be 9hrs. The time required to dry okra (1.0kg tray loading) from an initial moisture content of 88.2% wet basis to 14.5, 9.3 and 4.9% wet basis at temperatures of 50, 60 and 70°C respectively was found to be 12hrs. The drying rate decreased as drying progressed and the drying rate was increased by increasing drying air temperatures at the constant airflow of 14.6m/s used. For a particular temperature setting, it decreased per unit time as the final moisture content was approached. It was observed that the tray loading density has effect on the drying characteristics. Increase in tray loading increased drying time and decreased drying rate.

Key words: Drying, okra, moisture content, tray loading

INTRODUCTION

Drying is the removal of moisture from a product, usually to some predetermined moisture content while dehydration is the rapid removal of moisture, usually to a very low level (ASABE, 2008). Usually, it is a process of simultaneous heat and moisture transfer, the heat being required to remove (by evaporation) the moisture from the product being dried. The moisture is removed from the drying product surface by external drying medium, usually air. It is perhaps one of the most effective means to extend the shelf life of foods. The main purpose of drying in preserving foods is to remove moisture, so that the water activity of the dried product is low enough (e.g. $a_w < 0.6$) to stop spoilage and the growth of pathogenic microorganisms and to reduce other deterioration processes. Okra has high moisture content which makes it liable to rapid deterioration resulting in heavy losses during handling, transportation and storage after harvesting; therefore, drying of the product becomes very essential. For small, medium or large scale processing, tray loading density is very important based on several factors most especially the timeliness of drying operation to reduce deterioration,

the number of working hours available and whether drying is achieved in batch or continuous system.

The objective of the study reported in this paper was to determine the effect of tray loading density on the drying characteristics of okra.

MATERIALS and METHOD

Fresh okra whose length ranged from 30-80mm and diameter 15-25mm were used for the experiment. The stalk of each fruit was cut into slices of thickness approximately 8-10mm. These were then arranged in the trays such that the flat portions lay horizontally in the trays (Figure 1). Two tray loadings of 0.5kg and 1.0kg were used to determine the effect of tray loadings on the drying kinetics of okra. For each of the experiment, three replicates were made and average values chosen. The initial moisture content of the product was determined using the oven-drying method. The products were then dried in thin layer in an electric dryer.

The dry matter content and moisture content during drying were computed as follows:

$$MC_{db} = \frac{M - D.M.}{D.M.} \quad (1)$$

$$D.M. = \frac{M}{1 + MC_{db}} \quad (2)$$

Where,

D.M. = Mass of dry matter in the same product (kg)

M = Mass of the wet product (kg)

MC_{db} = Moisture Content, % dry basis.



Figure 1. The electric dryer with okra

- 1: Chimney 2: Tray 3: Drying Chamber
4: Heat Exchanger 5: Thermostat

RESULTS and DISCUSSION

Dehydration of okra

The effect of moisture content on the drying rate of okra (0.5kg tray loading) during the drying process at temperatures of 50, 60 and 70°C respectively is shown in Figure 2. The curves show distinct breaks in the drying rate which possibly suggested changes in the mechanism of water movement through the okra. No constant rate drying phase was obtained for this product as evident from the curves for each of the

temperature setting used. This conforms to results earlier reported by Doymaz (2007), Sobukola (2009) and Deepak and Suresh (2010). It was observed that the drying rate decreased as drying progressed. Also, the effect of moisture content on the drying rate of okra (1.0 kg tray loading) during the drying process at temperatures of 50, 60 and 70°C respectively is shown in Figure 3. The curves also followed a similar trend as the dehydration of the product at 0.5kg tray loading. This implies that the rate of loading has no significant effect on the drying phenomenon of the product. It was also observed that the drying rate decreased as drying progressed and the drying rate was increased by increasing drying air temperatures at the constant airflow of 14.6m/s used. For a particular temperature setting, it decreased per unit time as the final moisture content was approached.

The time required to dry okra (0.5kg tray loading) from an initial moisture content of 88.0% wet basis to 19.8, 9.3 and 4.4% wet basis at temperature settings of 50, 60 and 70°C respectively was found to be 9hrs, while the time required to okra (1.0kg tray loading) from an initial moisture content of 88.2% wet basis to 14.5, 9.3 and 4.9% wet basis at temperature settings of 50, 60 and 70°C respectively was found to be 12hrs.

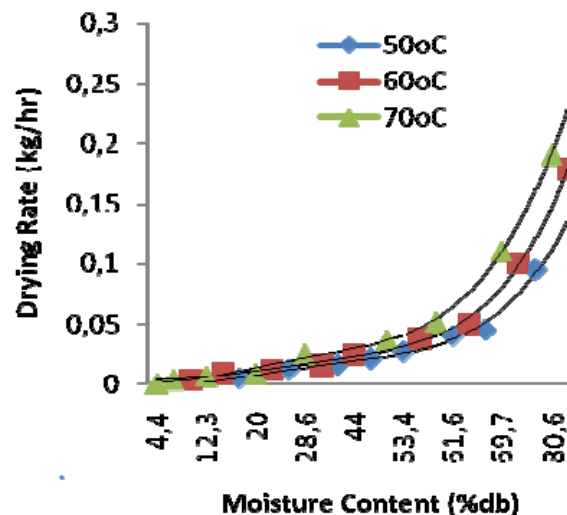


Figure 2. Effect of moisture content on drying rate of okra (0.5kg tray loading) at 50, 60 and 70°C temperature settings

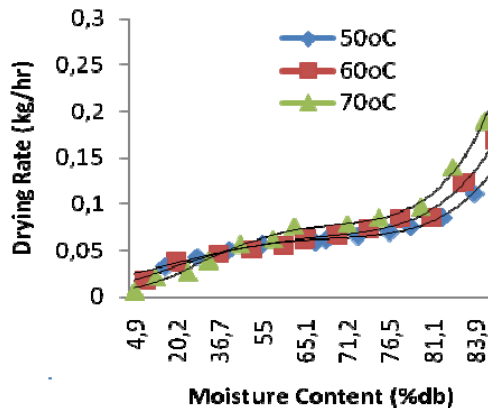


Figure 3. Effect of moisture content on drying rate of okra (1.0kg tray loading) at 50, 60 and 70°C temperature settings

Variation of moisture content with time

The drying curves for both tray loadings (0.5kg and 1.0kg) at temperatures of 50, 60 and 70°C are shown in Figures 4-6. As expected, it was observed that the moisture content of okra decreased with increase in drying time for a particular tray loading. This was due to the fact that as drying progressed, moisture was being removed from the products leading to decrease in moisture content. Drying occurred in the falling-rate period for both tray loadings. As drying progressed, the rate at which moisture moved through the product was superseded by the rate of evaporation from the surface. A concentration gradient was established in which the drying process was lowered as it proceeded; so that the rate of moisture removal fell even more rapidly than before. At this instance, the moisture content of the material had fallen to the equilibrium moisture content for the prevailing air conditions and drying stopped. This same trend was applicable to both tray loadings.

Variation of drying rate against time

The effect of time on the drying rate of the products at the two different tray loadings of 0.5 and 1.0kg at temperatures of 50, 60 and 70°C respectively is shown in Figures 7-9. It was observed that the amount of water removed at the initial stage of drying was higher for all temperatures and decreased with time. This was as a result of low internal resistance of moisture at the beginning of drying, in which when energy was impacted, moisture easily

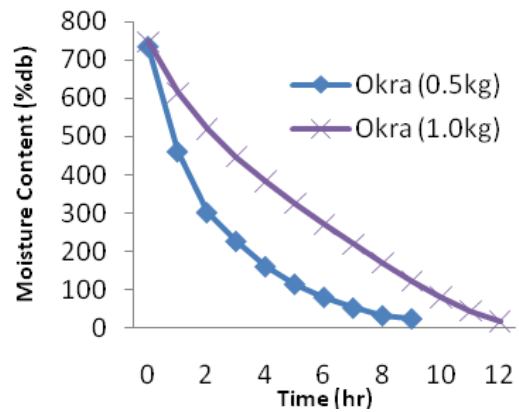


Figure 4. Drying curves for okra at 50°C.

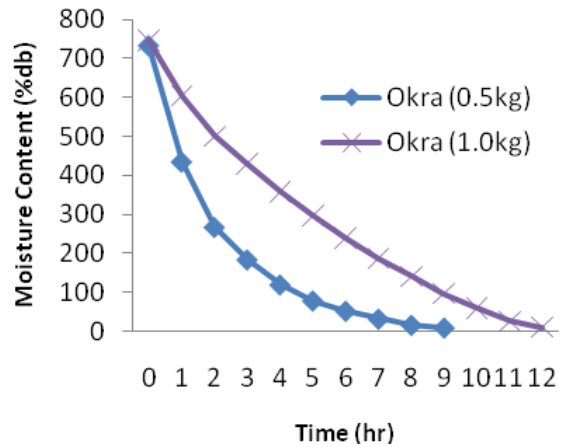


Figure 5. Drying curves for okra at 60 °C

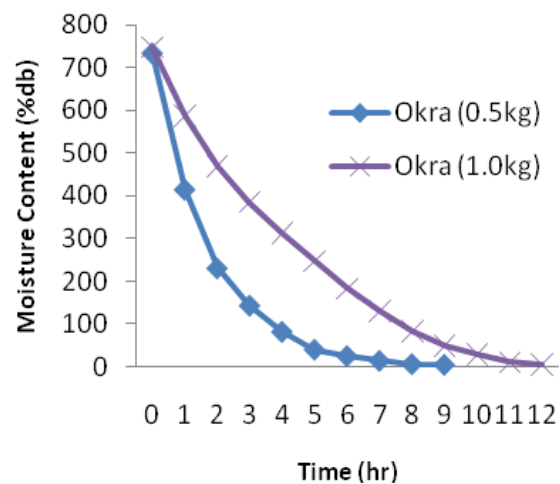


Figure 6. Drying curves for okra at 70 °C

moved to the surface where it was evaporated. As the drying progressed, more energy was required to break the molecular bond of the moisture and since constant energy (heat) was supplied, it took longer time to break the bond, therefore drying rate decreased. This agreed with the findings of Ndukwu (2009) who observed that the drying rate was highest at the first hour of continuous drying of cocoa bean. Drying rate also decreased because of decrease in wet surface area and as drying progressed, the fraction of wet surface decreased to zero. It was also observed that increase in tray loading decreased drying rate. This conforms to the findings of Holdsworth (1971), Fashanu (1989) and Osuji et al. (1985). From the foregoing, it would be observed that the tray loading density has an effect on the drying characteristics of okra. This conforms to the findings of Kumar et al. (2006) who observed the same for mango, guava and aonla. Increase in tray loading increased drying time and decreased drying rate. Tray loading and drying time are therefore important process variables which must be carefully monitored so as to get good quality osmo-dehydrated products.

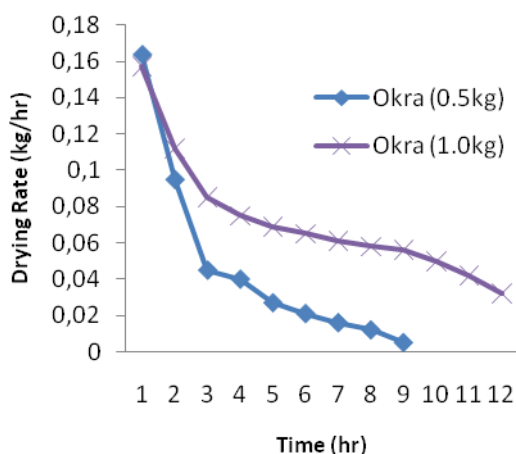


Figure 7. Effect of drying time on the drying rate of okra at 50 °C

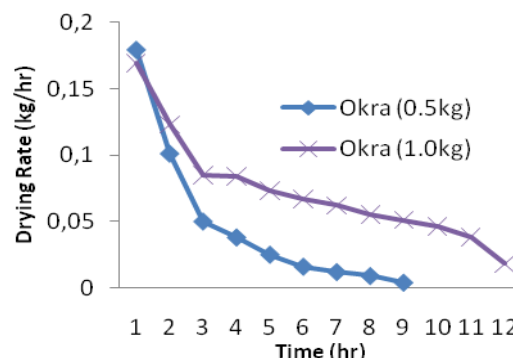


Figure 8. Effect of drying time on the drying rate of okra at 60 °C

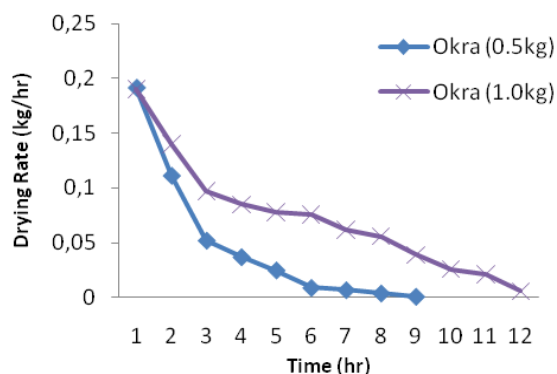


Figure 9. Effect of drying time on the drying rate of okra at 70 °C

CONCLUSIONS

Experimental results showed that at the two different tray loadings of 0.5 and 1.0kg, there was no constant rate drying phase. This implied that the tray loading density has no effect on the drying phenomenon of okra. Also, the moisture content decreased with drying time at both tray loadings. The drying rate decreased as drying progressed and the drying rate was increased by increasing drying air temperatures at the constant airflow of 14.6m/s used. For a particular temperature setting, it decreased per unit time as the final moisture content was approached. It was also observed that increase in tray loading increased drying time and decreased drying rate.

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