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Effect of Temperature at Tray Position on Drying of Dark Red Onion-slices at Elevated Air Velocity

Mahesh Bhong, Vinayak Kale

Abstract*: *The convective drying process is used to dry onion-slices. The drying experiments are conducted at a drying temperature of 50°C, 60°C, 70°C, and at an air velocity of 1.99, 3.54, 5.66, and 7.52 m/s. The objective is to study the influence of tray position on drying of dark red onion. The work diverges in analyzing drying constants at air velocity beyond 2 m/s.

The moisture ratio for the middle tray is greater compared to the top and bottom tray. A smaller moisture ratio is observed for 60°C compared to 50 and 70°C. Moisture removal per unit mass flow rate ratio is lowest observed for bottom tray with 60°C. The ratio of moisture content and mass flow rate for 60 and 70 °C, displays a downward trend with drying time. The randomness in the drying rate at 60 °C and 70 °C is comparatively lesser than 50 °C.

Keywords* : *Onion slice, drying, air velocity, tray, dark red.

I. INTRODUCTION

Dehydration is the moisture elimination procedure from the agricultural product. In the food industry, it is used to maintain nutritional values and shelf life of food products. The dehydration techniques are differentiated as per the type of produce.

The dehydration process can be accomplished using thin-layer drying. The meaning of thin-layer drying is to dry product in a one layer of skinny slices [1]. This aids to reassure even temperature distribution in product. In the applied situation, it is expensive in terms of money and time to dehydrate agriculture product in a one layer. In agriculture, produce dryer number of tray positions may exist.

Onion (Allium cepa), an ordinarily used vegetable in cooking arrangements and several medical applications. It titles third in the world production of foremost vegetables [2]. Since a long time, drying of onion by appropriate means is a foremost area.

Rapusas and Driscoll dried onion-slices in a temperature range of 42.5 - 90oC and with dehydration air velocity of 0.6–1.4 m/s [3]. Sarsavadia et al. emphasized the better result with drying air temperature range 50 - 80°C [4]. Jain and Pathare stated that the drying air velocity 1, 1.25, 1.5 gives better drying characteristics [5]. Better drying process of onion-slices observed in the speed range of 0.8 – 2 m/s and temperature array 60 - 80°C [6]. Sharma et al. found Page model was the utmost suitable for dehydration temperature of 30 - 45 °C and drying air velocity 1 - 1.5 m/s [7]; similar results were observed by Mitra et al. [8]. Mesery and Mwithiga also declared page model is the best model for drying air temperature 50 - 70°C [9]. In standard laboratory oven drying, better results detected for the drying air temperature 50 and 70°C [10]. Mota et al. experimented with drying temperature of 30 -60 and reported at 0.35 m/s better results can be perceived [11]. The particulars of experimental parameters are given in Table 1.

Table1: Drying air temperature and velocity details of drying research for onion-slices.

Drying air temperature (°C)	Drying air velocity (m/s)	Reference
50,70,90	0.6,1,1.4	[3]
50,60,70,80	0.25,0.5,0.75,1	[4]
35,40, 45	1, 1.25, 1.5	[5]
60,70,80	0.8, 1.4, 2	[6]
35,40, 45	1, 1.25, 1.5	[7]
50,60,70	-	[8]
50,60,70	0.5, 1, 2	[9]
50, 70	-	[10]
30,50,60	0.35	[11]

The literature indicated that the range of air velocity investigated for dehydration is diverse in the range of 0 to 2 m/s for a single layer. Research for dehydration of dark red onion-slices, with tray position, in the elevated velocity and temperature regime, wants consideration. The objective of the current study is to analyze moisture ratio, moisture removal per unit mass flow rate, and drying rate of dark red onion-slices for the drying velocity greater than 2 m/s at top, middle, and bottom tray position.

II. MATERIALS AND METHODS

A. Raw Material Preparation

Fresh onions of moderate size (about 50 to 60 mm breadth) were procured from the native market.

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Randomly selected onions were cleaned and peeled. Onion-slices of 4 to 5 mm thickness were expurgated at an angle of 90° to the axis with a razor-sharp onion slicer. The dry and clean trays were positioned inside a drying space crossways the airflow. Around 100 grams of onion-slices were positioned in a one layer for each test in each tray.

B. Experimental Setup

The dying tests were executed in a laboratory air-dryer. This air dryer entailed of three segments, namely air-flow rate control segment, heating control segment, and dehydration test compartment, as shown in Fig.1.

Air blower (1200 CFM) delivers high velocity and volume of air. Atmospheric air heated with thermistor controlled electric resistance heater. Regular waterproof plywood (18 mm) used to prepare drying box, which is coated from inside and outside by laminates of 1 mm. The drying chamber was lined inside with aluminum foil to provide reflective insulation. Three wire mesh tray was suspended vertically in the drying chamber. An electronic analytical balance (HMT - EMFC, accuracy: 0.01 gram) used to measure Moistness loss during dehydration, while the produce remains isolated from ambient.

Air temperature (Dry bulb) was recorded during the test using PT-100 temperature thermometer at diverse well-defined positions. The air speed was measured with hot-wire anemometer (Lutron - AM 4204, accuracy: ±5%), and air humidity was measured using humidity meter (Lutron - HT 305, accuracy: ±3%).

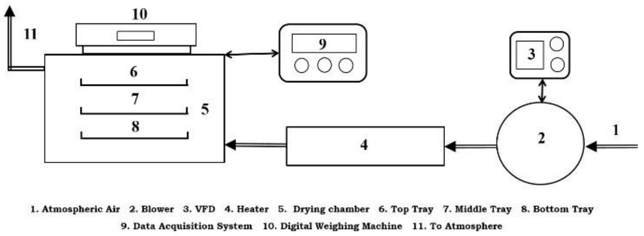

Fig. 1: Schematic illustration of the test setup for convective dehydration of onion-slices.

The dehydration experiments were conducted at a constant temperature of 50, 60, and 70°C. Constant air speed of 1.99, 3.54, 5.66, and 7.52 m/s was retained. The dryer was warmed for 30 min afore the tangible dehydration of onion-slices. The weight of onion-slices was measured over a period of 30 minutes in a total drying span of 360 minutes. Temperature, velocity, and humidity of air were measured at the inlet and outlet of the dehydration chamber. Each experiment set was reiterated three times with fresh onion-slices.

III. RESULTS AND DISCUSSION

The results acquired investigating the effect of drying air temperature on moisture ratio, moisture removal per unit mass flow rate, and drying rate with drying time for top, middle, and bottom tray.

A. Effect of dehydration air temperature on the moisture ratio for the top, middle, and bottom tray

The dehydration air temperature has a substantial consequence on the drying of dark red onion-slices. This hot air generates a diverse effect on the tray position. The moisture ratio variation at temperatures of 50, 60, and 70°C with drying time for top, middle, and bottom tray are shown in Figure 2.

The moisture ratio of the onion-slices during dehydration was premeditated using modified Equation (1) [12], [13], [14] and [15]

$$MR = \frac{M_t}{M_i} \quad (1)$$

Where MR is the moisture ratio, M_i is the initial moisture content, and Mt is the moisture content after time t.

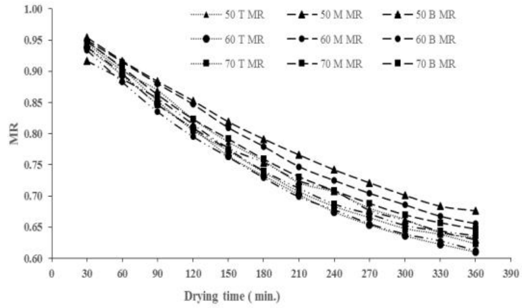

Fig. 2. Deviation in moisture ratio with drying time at the top, middle and bottom tray for 50, 60 and 70°C

A smaller moisture ratio specifies that more moisture removed with respect to specific drying time. The larger moisture ratio is observed for 50°C for the middle tray. Similarly, for 60 and 70°C, the middle tray indicates a large moisture ratio. A smaller moisture ratio is observed with 60°C for the bottom tray between 60 to 210 minutes and for top tray after 240 minutes.

Overall it is observed that the moisture ratio for the middle tray is greater compared to the top and bottom tray. A smaller moisture ratio is observed for 60°C compared to 50 and 70°C. For 60°C may be airflow is augmented to carry the maximum amount of moisture for the top and bottom tray. Lesser air circulation may be taking place from the middle tray for all the velocity and temperature range under study. Similar results were also pronounced by Singh et al. [16]. All the temperatures for the top, middle, and bottom trend line tray display almost the same nature.

B. Effect of drying air temperature on moisture removal per unit mass flow rate for top, middle, and bottom tray

Mass airflow is a vital functional constraint in analyzing the moisture removal process. By comparing a mass of air utilized per unit time, there will be a better understanding of the moisture removal process of dark red onion-slices. The wet basis moisture content per unit mass flow rate variation at the top, middle, and bottom tray with drying time is shown in Figure 3.

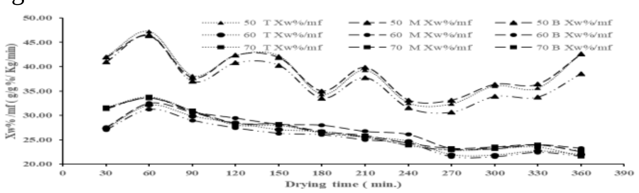

Fig. 3. Variation in moisture removal per unit mass flow rate with drying time at the top, a middle and bottom tray for 50, 60 and 70°C

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For 50° C, this ratio is more scattered compared to 60 and 70 °C. A high ratio indicates that more moisture is removed per mass flow rate. In the initial period of dehydration, the moisture available in upper layers and on the surface leads to an increase in ratio. In overall lowest ratio observed for the bottom tray with 60°C. The highest ratio over the after 180 minutes is observed at the middle tray with 60°C. The ratio of moisture content and mass flow rate for 60 and 70 °C, displays a downward trend with dehydration time. As the dehydration time increases, the moisture available for removal goes on decreasing and eventually ratio observed to be decreasing.

C. Effect of dehydration air temperature on drying rate for top, middle, and bottom tray

The drying rate postulates the rate of moisture removal with respect to the previous state at a specific time. The drying rate of dark red onion-slices for 50, 60, and 70°C with drying time are shown in Figure 4. All the curves for different velocity indicate falling rate behavior.

The drying rate at 50°C clearly indicates that in the initial period, the drying rate is rising, and after 60 min., it starts falling. Dropped drying rate is observed at 90, 180, 240, and 300 minutes. Very profound dropping in drying rate observed for top and bottom tray whereas minor dropping observed for the middle tray. This dropping observed may be due to a delay in the migration of moisture from the lower layer to the upper layer.

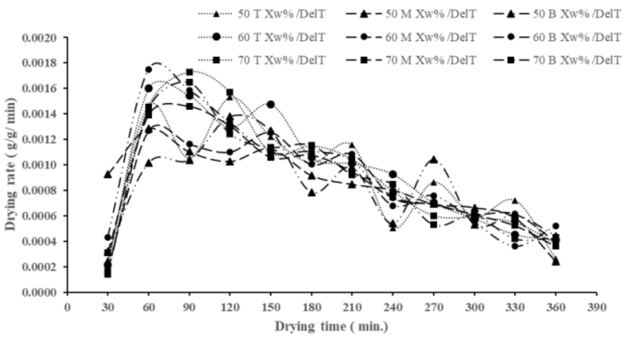

Fig. 4. Deviation in drying rate with dehydration time at the top, a middle and bottom tray for 50, 60 and 70°C

The middle tray gets comparatively less exposure of hot air, leads to slow migration of moisture from the lower layer to the upper layer.

Similar to 50 °C, at 60 °C and 70 °C, it is clearly observed that, in the initial period, the drying rate is rising, and after 60 min., it starts falling. Minor dropping in drying rate at 60 °C is observed at 120, 180, 240, and 300.

Overall, it is observed that the moisture content curve is smoother than the drying rate curve. The randomness in the drying rate at 60 °C and 70 °C is comparatively lesser than 50 °C. the drying rate plot typically has a substantial amount of random noise, and as moisture content reduction takes place with elongated drying time, noise becomes more turbulent towards the end. Similar observation, also described by Kem et al. [17].

IV. CONCLUSION

From experimental statistics investigation of dark red onion-slices dehydration, the subsequent inferences are derived. The moisture ratio for the middle tray is greater compared to the top and bottom tray. A smaller moisture ratio is observed for 60°C compared to 50 and 70°C. For 60°C, maybe airflow is augmented to carry the maximum amount of moisture for the top and bottom tray.

Moisture removal per unit mass flow rate ratio is lowest observed for bottom tray with 60°C. The ratio of moisture content and mass flow rate for 60 and 70 °C, displays a downward trend with dehydration time. As the dehydration time increases, the moisture available for removal goes on decreasing and eventually ratio observed to be decreasing.

The moisture content curve is smoother than the drying rate curve. The randomness in the drying rate at 60 °C and 70 °C is comparatively lesser than 50 °C. the drying rate plot typically has a substantial amount of random noise, and as moisture content reduction takes place with elongated drying time, noise becomes more turbulent towards the end.

The existing investigation can be extended in the exploration of the effect of a wide range of velocity on drying of Indian dark red onion for different tray positions.

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