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Studies on drying and rehydration characteristics of osmo-treated pineapple slices using different tray drying temperatures

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■ **ABSTRACT :** Drying is an essential process in the preservation of agricultural products. Various drying methods are employed to dry different agricultural products. Each method has its own advantages and limitations. Choosing the right drying system is thus important in the process of drying agricultural products. Care must be taken in choosing the drying system. Study comparing traditional drying and other drying methods for the reduction of the drying time and to a significant improvement of the product quality in terms of color texture and taste. Drying reduces the possibilities of the contamination by insects and micro-organisms so that product is prevented. An experimental study was performed to determine the drying characteristics of pineapple slices subjected to drying in cabinet tray dryer at 50^0C, 60^0C and 70^0C with osmotic treatment indicated that T_0 (Control), T_1(50^0Brix) and T_2 (60^0Brix). The entire drying process took place in the falling rate period. Drying curves were constructed using non-dimensional moisture ratio (MR) and time. Drying is the most widely used and a primary method for preservation. The result indicated that the cabinet tray dryer at 70^oC was found better drying and rehydration characteristics compare to other drying temperatures.

■ **KEY WORDS :** Pineapple slices, Osmotic dehydration, Tray drying, Rehydration, Moisture ratio

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Pineapple is the most important fruit of India and many developing countries due to its export values. Generally, the pineapples are exported as the canned-fruit, concentrated juice and dried pineapple slices. Although there are a number of pineapple products in the market, the food industry still keeps developing new product from pineapple. The benefit of new product development is the elevation of the fresh pineapple demand and consequently help reducing the pineapple loss caused by the microorganisms, chemical and enzymatic reactions during the peak of harvesting season (Nicoleti *et al.*, 2001 and Gabas *et al.*, 2007). Dried pineapple slices is an interesting product because of its long shelf-life at ambient temperature, convenience to use and low transportation expenditure. Pineapple slices can be consumed as an instant juice powder or a flavoring agent. So far, there have been merely few studies about the production of pineapple slices (Jittanit *et al.*, 2010).

The osmotic dehydration process and influence of its process variables such as pretreatment, temperature of sugar solution and additives on the mass transfer in osmotic dehydration of fruits (Chaudhari *et al.*, 2015).

Osmotic dehydration is considered as a pre-treatment for pineapple with the final aim of obtaining high quality dried fruit products. Upto 40 per cent of agricultural produce is wasted in developing countries, mainly due to the lack of storage and processing facilities, as well as to a limited knowledge of processing technologies (Brahim, 2000). Osmotic dehydration is widely used to remove part of the water content of fruit to obtain a product of intermediate moisture or as a pre-treatment before further processing and drying (Lenart, 1996 and Torreggiani, 2004).

Drying process plays an important role in the preservation of agricultural products (Waewsak *et al.*, 2006). It enhances the shelf-life and reduces water activity (Doymaz and Pala, 2003). The post-harvest losses of fruits and vegetables are estimated to be 30-40 per cent of the production (Azharul and Hawlader, 2006). Therefore, in many countries, large quantities of food products are dried to improve shelf-life, reduce packaging costs, lower weights, enhance appearance, retain original flavor and maintain nutritional value (Baysal *et al.*, 2003). Drying is generally evaluated experimentally by measuring the weight of a drying sample as a function of time. Drying curves may be represented in different ways; averaged moisture content versus time, drying rate versus time, or drying rate versus averaged moisture content (Coumans, 2000).

Sun drying is the traditional method of preservation that takes longer time and depends on the weather condition. So, to achieve faster drying and to avoid uncertain whether condition, the mechanical drying method can be used for pineapple preservation. In mechanical dryer, desired temperature could be maintained and higher temperature could be utilized than sun drying (Kumar *et al.*, 2017). This leads to high production rates and improved quality products due to shorter drying time and reduction of insect infestation and microbial spoilage. Therefore, present study was undertaken to the drying kinetics of pineapple using different drying methods and osmotic treatments.

■ METHODOLOGY

Raw material:

The local variety of fresh pineapple was purchased from the Meerut market and was used in the experiments. The cleaned product was then weighed and 300 g samples were made for each methods of drying.

Osmotic treatments:

Fresh, good quality of pineapple were washed to remove soil particles attached to the surface. Then sorted cleaned pineapple was cut into 4.5 mm thickness. The sliced pineapple was subjected to osmotic treatment. In this, the pineapple slices were dipped in osmotic solution having sugar concentration ranging from 50 to 60 °Brix at 45^0C temperature for 180 minute. Then slices were removed from the solution and the surface moisture was removed by blotting paper than after slices were subjected to drying in cabinet tray dryer at 50^0C, 60^0C and 70^0C. After drying slices are packaged in HDPE bags.

Drying procedure:

The experimental set up used for determining the influence of drying temperature on drying behaviour of pineapple slices. The slices were then weighed exactly 300 g for each treatment. These were kept for drying in three replications.

Tray dryer is a batch type twin unit for grain and tray type for food products drying. It was carried by drying the samples at 50^0C, 60^0C and 70^0C air temperatures and a constant air velocity of 1 m/s. Pineapple slices sample weighing 300 g was taken and spread uniformly over the perforated bottom trays in single layer. Drying air temperature was adjusted to the desired level using the thermostat. During drying operation, weight of the sample was taken at every 30min interval for rest of drying period. All the measured observations were recorded for further calculations. Drying was stopped when the drying mass reached the required moisture content. The dried product was cooled to normal temperature in a desiccators containing silica gel and then packed in polyethylene bags, which were then heat-sealed and stored at room temperature. The experiments were repeated twice and the average of the moisture ratio at each value was used to draw the drying curves.

Drying time and curves:

During drying of pineapple slices, samples were weighed at the specified intervals mentioned above for determining moisture content. The drying curves were drawn for all moisture content (% db) were plotted against time of drying. The total time required for complete drying was also recorded in each case. The curves between drying rate and average moisture content (% db) and between drying rate (g/min) and drying time (h) were also plotted.

Rehydration studies:

Rehydration capacity is an important parameter to evaluate the quality of dried products. The difference is attributed to the texture and constituents of the products. Both rehydration ratio and rehydration rate indicated that mechanically and solar dried samples.

Method of analysis:

Moisture content:

Moisture content was calculated using the following expression (Ranganna, 1995).

$$Mc = \frac{Mi - Md}{Mi} x\ 100$$

where, Mi is the mass of sample before drying and Md is the mass of sample after drying.

Drying rate:

$$R = \frac{Mi - Md}{T} x\ 100$$

Where, R is the Drying rate (g/min) and T is the Time taken (h).

Moisture ratio:

$$MR = \frac{M - Me}{Mci - Me} x\ 100$$

Where, MR is the dimensionless moisture ratio, M, Me and Mci are the moisture content at any time, the equilibrium moisture content and the initial moisture content in kg, respectively.

Rehydration ratio:

Rehydration tests for dehydrated samples were carried out by immersing 5 g sample in 50 ml distilled water at 35°C in a 100 ml beaker kept in a hot water bath to maintain a water temperature of 35°C for 5 hr. (Nsonzi and Ramaswamy, 1998). Dehydrated samples were evaluated for rehydration ratio, from the weight before and after the rehydration.

Rehydration ratio:

$$R.R. = \frac{C}{D}$$

where, C is drained weight of rehydrated sample (g) and D is test weight of dehydrated samples (g).

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Drying characteristics of pineapple slices:

The initial average moisture contents of pineapple slices were found to be 566.66 % (db). The drying characteristics of pineapple slices under different drying methods are summarized below. The drying behaviour of pineapple slices in different drying methods and osmotic treatments are presented in Fig. 1 to 3, as a plot of moisture content versus time of exposure and drying curves have been obtained. The result shown that there was a general decline in moisture content of the sample from 566.66 per cent (d.b) to 4.44 % (d.b) in all methods of drying. Time required for cabinet tray drying times at 50°C, 60°C and 70°C were observed as 420, 360 and 300 min, respectively. The data indicated that the loss of moisture was at its highest magnitude in the first hour of drying however, the moisture loss was slowed down in the subsequent drying period. The reduction in moisture content of pineapple during first hour in cabinet tray drying at 60 and 70^0C drying was at higher rate than the 50^0C drying condition. Similar trend was also observed by (Bhosale and Arya, 2004), in cabbage,cluster bean, fenugreek, spinach and okra. Among the drying methods the removal of moisture from pineapple slices was found to be at faster rate in T_0 at 70^0C drying whereas compare to T_1 and T_2 at 50 and 60^0C. This was attributed to the level of temperature and rate of air flow in the dryer which might be responsible for higher difference in loss of moisture. Differences in final weight were observed with the samples dried under different methods of drying. The moisture content was found highest in 50 ^{0}Brix (T_1) and 60 ^{0}Brix (T_2) as compared to controlled (T_0) samples. The variation in moisture content with drying time are shown in Fig. 1 to 3 for different osmotic treatment. The drying time was longest at 50°C and least at 70°C in the tray drying. The final moisture content 11.11 per cent, 6.66 per cent and 4.44 per cent at 50°C, 60°C and 70°C, respectively under cabinet drying. The final moisture content of 50 ^{0}Brix (T_1) treated pineapple slices was 66.66 per cent, 64.44 per cent and 55.55 per cent at

50°C, 60°C and 70°C, respectively under cabinet drying. The final moisture content of 60 ^{0}Brix (T_2) pineapple slices was 84.44 per cent, 82.22 per cent and 66.66 per cent at 50°C, 60°C and 70°C, respectively under cabinet tray drying.

Drying rate:

The variation of drying rate with time under different drying methods and pretreatments are shown in Fig. 3 to 6. On examination of the plots between drying rate and drying time, it is clear that the entire drying process was accomplished in the falling rate period of drying and the constant rate period was absent like many other biological materials. This indicates that there was no free water on the product surface. Further, it can be seen that as the drying time increased the drying rate decreased. The rate was higher at the beginning of the process, which gradually reduced as the drying process progressed and the availability of moisture was reduced. On comparing the method of drying, it can be visualized that the highest drying rate was achieved with (T_{1-}) control at 60 and

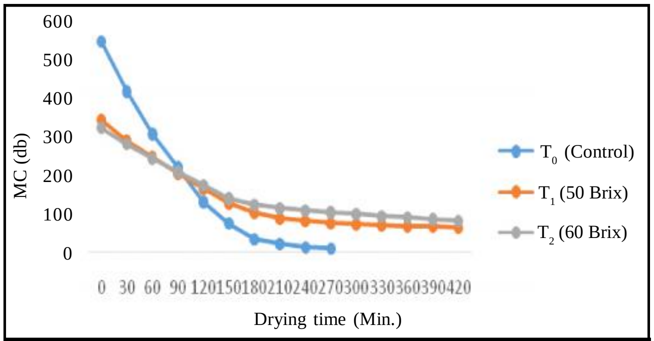

Fig. 1 : Variation of moisture content with drying time in cabinet tray drying at 50°C

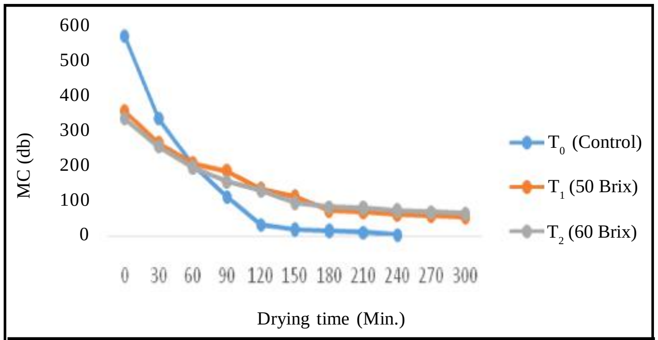

Fig. 2 : Variation of moisture content with drying time in cabinet tray drying at 60°C

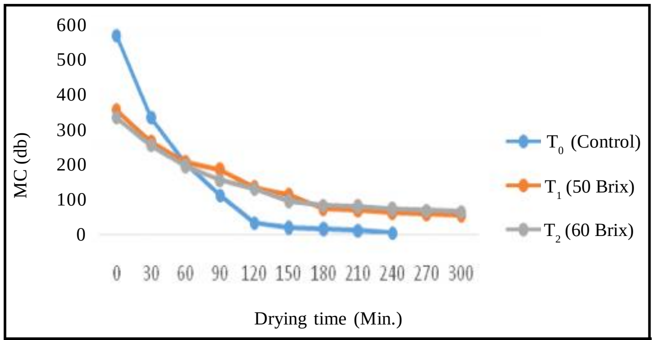

Fig. 3 : Variation of moisture content with drying time in cabinet tray drying at 70°C

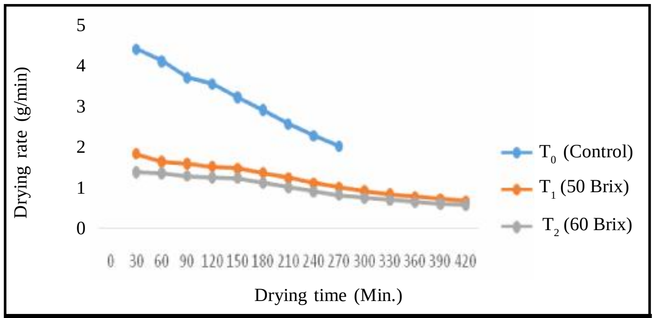

Fig. 4 : Variation of drying rate with drying time in cabinet tray drying at 50°C

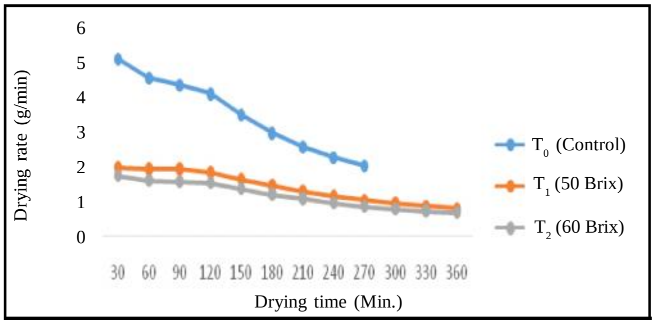

Fig. 5 : Variation of drying rate with drying time in cabinet tray drying at 60°C

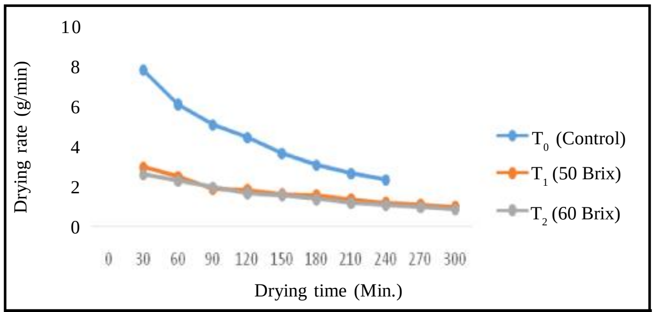

Fig. 6 : Variation of drying rate with drying time in cabinet tray drying at 70°C

70^0C cabinet drying and 50^0Brix (T_1) and 60^0Brix (T_2) at 50°C least in drying rate.

Moisture ratio:

The variations in moisture ratio with timeunder cabinet tray drying are shown in Fig. 7 to 9. The moisture ratio value at zero timeof drying was one in all the cases and in successive drying it decreases non -linearly. So, moisture ratioversus drying time curve could better describe thedrying phenomena than the curves of moisture content verses drying time (Fig. 7 to 9), because the initialvalue of moisture ratio (MR=1) but latter have different final moisture ratio. It is clear from the graphs that moisture ratio initially decreased very rapidly and in later stage moisture ratio decreased at slower rate.

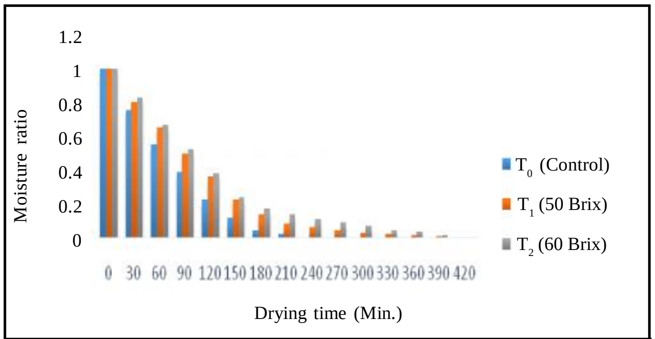

Fig. 7 : **Variation of moisture ratio with drying time in cabinet tray drying at 50^{o}C**

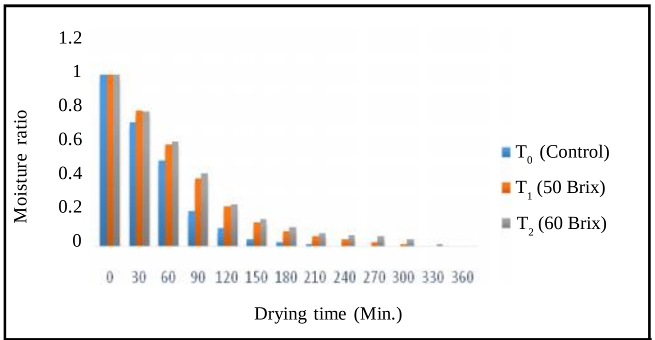

Fig. 8 : **Variation of moisture ratio with drying time in cabinet tray drying at 60^{o}C**

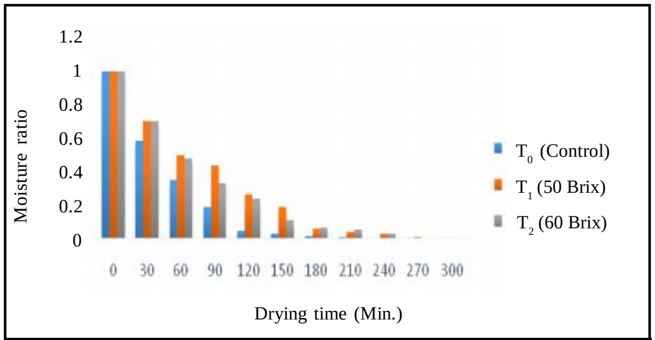

Fig. 9 : **Variation of moisture ratio with drying time in cabinet tray drying at 70^{o}C**

Rehydration ratio:

The data illustrated that time, temperature and osmotic treated methods effect have a reasonable impact on the rehydration ratio of the samples dried at 50°C, 60°C and 70°C, respectively. The curves as graphically

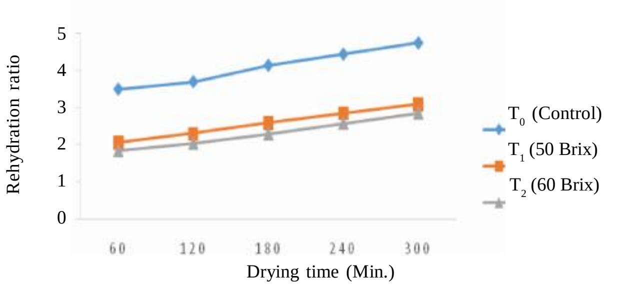

Fig. 10 : **Change in rehydration ratio with time (50^{o}C tray dried)**

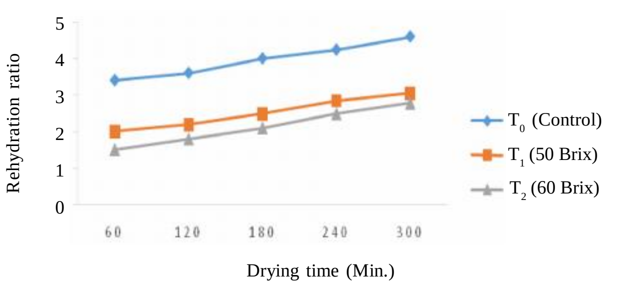

Fig. 11 : **Change in rehydration ratio with time (60^{o}C tray dried)**

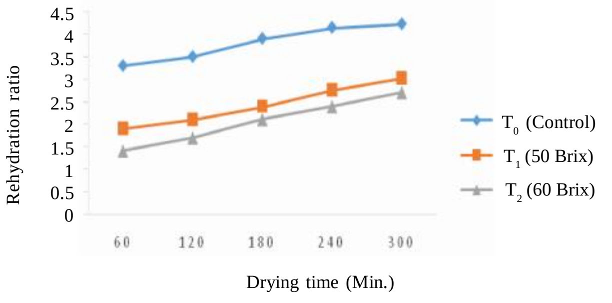

Fig. 12 : **Change in rehydration ratio with time (70^{o}C tray dried)**

presented in Fig. 10 to 12. Among the three drying temperatures and two osmotic treatments, the highest rehydration ratio was reported 4.74 (T$_0$) control at 50^{0}C dried samples and lowest in 60 ^{0}Brix at 70°C dried.

Conclusion:

The three drying methods used greatly affected the drying characteristics of pineapple. According to the results, it can be stated that drying characteristics of pineapple slices in the drying process effect due to air temperature on drying rate and drying time, the drying of pineapple slices occurred in the falling rate period and no constant rate period of drying was observed. The 70 drying technique was more efficient than 50 and 60 drying. Highest drying rate was achieved with by cabinet tray drying at 70^{0}C and least in the 50^{0}C drying. The pineapple slices dried in cabinet tray dryer at 70^{0}C better results in maintaining better appearance, colour and rehydration ratio. This method is better time saving gives better results obtained during drying process.

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