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Studies on Drying of Osmotically Dehydrated Apple Slices

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A B S T R A C T

The present study was carried out to investigate the effect of solution concentration, immersion time, process temperature and slices thickness on osmotic dehydration of apple slices. The osmotic dehydration characteristics such as water loss (WL), weight reduction (WR) and solid gain (SG) were studied for sugar solution of (50 and 70 ºBrix) at a temperature of (30 °C and 50 °C) for 8 hours of immersion time. After osmotic dehydration, the apple slices were dried in tray dryer for 8 hours at 50 °C and 60 °C temperature. During osmotic dehydration, the maximum value of WL, WR, and SG was found to be 62.9%, 52.0 %, and 11.2 % for 70 ºB sugar solution whereas the minimum value was 52.9 %, 41.21 % and 10.50 % for 50 ºB solution respectively at 50°C after 8 h of osmosis. The drying rate was faster at 60 °C drying temperature for all the sizes osmotically treated apple slices as compared to 50°C drying temperature. This study concludes that several factor such as solution concentration, temperature and immersion time affected affects the osmotic dehydration characteristics. By using the combination of osmotic dehydration followed by drying the losses during storage and handling can be minimized and self-life of the apple fruits could be increased.

Introduction

The apple (*Malus domestica*) is a nutrient rich fruit, widely grown in the temperate regions with varied texture, colour, shape and size. India and China is the largest producer of apple. Apple is consumed in raw as well as processed fruits. Apple can be processed into many products such as fruit leather, candy, fruit bar, and dehydrated slices. Many traditional techniques are used for preparation of dehydrated products which are not much satisfactory from quality point of view. In India every year about 20–40% percent of the fruit and vegetable are waste due to improper transportation, inadequate processing and handling and lack of adequate storage system. Due to moisture losses and spoilage, harvested apple fruits should be marketed, processed or preserved as early as possible. Hence it is very important to convert the apple into other form such as dried product, or to develop a method for preservation and processing, to increase the self-life and quality. The preservation of food product is done to enhance the self-life of without affecting the appearance, colour and maintaining the physical and chemical properties. In fruit and vegetable preservation is usually carried out to slowdown the growth of the bacteria, fugues and other microorganism which cause spoilage. The many techniques are used for preservation of fruits and vegetable which includes drying, dehydration, combination of both and chemical treatment methods.

Osmotic dehydration is one of the potential preservation techniques which produce high quality products. It is the phenomenon of partial removal of water from cellular material such as fruits and vegetables. In food processing industries the osmotic dehydration is used for removal of moisture from fruit and vegetable because it maintained the flavor, color, texture and enhance self-life of final product (Gouravsahu *et al.*, 2017, Sutar, and Gupta 2007; Pokharkar, 2001; Karthanos *et al.*, 1995). The several process parameter influences the removal of water and addition of solid, which includes solution concentration, temperature, immersion time, type of osmotic agent, sample to solution ratio and agitation rate (Pokharkar, 2001). Osmotic dehydration method is used as a pre-treatment to several processes such as freeze drying, vacuum drying, air drying and freezing, (Dixon *et al.*, 1976). During osmotic dehydration process, water flows from material to the osmotic solution, whereas osmotic solute is transferred from solution to the material. Osmotic dehydration is preferred because it retains color, aroma, nutritional constituents and flavor compound.

Drying is the process of removal of the moisture or water to desired and predefined level without affecting the loss of taste, flavor, colour and nutrients (Singh and Kumar, 1984). Drying of apple extent the self-life, increase market value, easy to store as well as decreases losses during storage. The microorganisms responsible for food spoilage are prevent by moisture removal. The removal of moisture from fruits and vegetable can be accomplished by drying or dehydration methods. Drying and dehydration are carried out to reduce the moisture content of the product certain level so that growth of food spoilage microorganism can be prevent and at the same time high nutritive value is maintained. Apples are rich in water content, approximately 85% (w/w) and it is possible to dehydrate and dried apples to enhance self-life by maintaining good texture, high sugar content and acidity and nutritional value. The direct drying of apples by conventional tray drying, cabinet or vacuum drying method cause change in texture, colour, flavour and nutrition loss in product. Pre-drying treatments, such as partial dehydration of fruit are suggested to improve the quality of dried product. Hence combination of osmosis and drying could be used to enhance the self-life and quality of dried apple fruit without affecting the colour, texture, flavour and nutritive value. This study was carried out to investigate the effect of osmotic solute, solution concentration on dehydration of apple slices at different temperature and immersion time further followed by drying. The drying characteristics of osmotically treated apple were also studied.

Materials and Methods

Preparation of sample

The fresh Maharaji apple fruit were procured from the market of Bapatla, Andhra Pradesh, India. The initial moisture content was approximately 85%. The apples were washed in running tap water and drained under shed. The washing was carried out to remove adhering dust, dirt, impurities and surface microorganism as well as to remove fungus, insects and other pest from fruit surface. The apple slices were prepared by chopping the fruit with the help of knife or slicer in a different thickness of 5-15mm. The initial moisture content of raw fresh apples were determined by oven drying method. The osmotic solutions of different concentration of sugar (50, 60 and 70 ºBrix) were prepared by dissolving required and calculated quantity of sugar with distilled water. The apple slices of different thickness (5-15mm) were weight approximately 100 g for each treatment and then immersed into the osmotic solution of different concentration. The ratio of osmotic solute to apple slices was 2:1 on weight by weight basis were maintained.

Experimental procedure for osmotic dehydration and drying

Osmotic dehydration is a suitable step to reduce the water content of food material such as fruit and vegetable. The prepared apple slices of different thickness (5-20 mm) of approximately 100 g weight were immersed in sugar osmotic solution of different concentration (50 and 70 ºBrix) and were placed at different temperature of (30ºC and 50ºC). The osmotic dehydration was done in apples by using water bath arrangement at different temperature and different concentration of sugar syrup. Each sample was taken out from the container at hourly interval up to 8 hour and were immediately rinsed with water and placed in tissue paper to remove excess solution and moisture from surface. Finally the sample were weight and moisture content, water loss and solute gain for all the samples were measured at every hours. After osmotic dehydration the treated samples were weighed. The weighed apple samples were spread in the form of thin layer on aluminum trays. These aluminum trays were put in tray dryer at a temperature of 60^{o}C for 8 h. The process flow chart of drying of osmotically dehydrated apple slices is shown in Figure 1.

Determination of moisture content of apple fruit slices

Moisture content of raw and osmotically dehydrated apple slices was measured by using oven dry at 65^{0} C for 24 h (Ranganna, 2000). Moisture content of samples is measured based on drop in weigh from initial weigh of sample. It is expressed in wet basis and dry basis by equation 1 and 2 respectively.

Moisture content (% WB) $= \frac{(\text{initial weight} - \text{final weight})}{\text{initial weight}} \times 100$...eq. (1)

Moisture content on (% DB) $= \frac{MC\ (\%wb)}{100 - MC\ (\%wb)} \times 100$...eq. (2)

Determination osmotic dehydration characteristics of apple slices

The osmotic dehydration is characterized by solid gain, water loss and the weight reduction from solute to solution during osmosis. The net exchange in solute and water between product and osmotic solution indicate the total mass transfer during osmosis.

Water loss (WL)

The amount of water removed by fruit slices during osmosis is known as the total water loss

It is estimated on the basis of net weight loss from apple slices during osmosis (Hawkes and Flink, 1978).

$$WL = \frac{Wi \times Xi - Wt \times Xt}{Wi} \times 100$$

Solid gain (SG)

The diffusion of solute and solution is takes place which cause the adding of solid and removal of water by apple slices. The loss of water from apple slices leads to increase in solid content during transfer phase. Solid gain is the net amount of solid uptake by apple slices during osmotic dehydration and it is expressed on initial weight basis.

$$SG = \frac{Wt(1-Xt) - Wi(1-Xi)}{Wi} \times 100$$

Weight reduction (WR)

Weight reduction is the total exchange of solid and liquid from the sample during osmotic dehydration and will affect the final weight of the sample.

It is determine by the following formula

$$WR = \frac{Wi - Wt}{Wi} \times 100$$

or

WR = WL – SG

Where,

WL = Water loss in percentage

SG = Solid gain in percentage

W_t = Mass of apple slices after time t, g

X_t= Water content as a fraction of mass of apple slices at time t

W_i = Initial mass of apple slices, g

X_i= Water content as a fraction of initial mass of apple slices.

Drying of osmotically dehydrated apple slices

The fruit slices were dipped in the desired syrup solution for 8 hours.

After that they were removed from the solution and gently washed to remove the adhering sugar syrup to the slice.

Osmotically dehydrated apple slices were dried in dryer at different temperature (50and 60ºC) and the moisture content and reduction in weight were recorded at hourly interval.

Results and Discussion

Effect of osmotic solutes concentrations on osmotic dehydration of apple slices

The solution concentrations are the important factors which affect SG, WR and WR by apple slices. WL, WR and SG by the apple slices with different sugar solution concentration of (50 and 70 ^{0}Brix) with time are shown in the Figure 2. It is observed from the Figure 2 that WL, WR and SG by apple slices were increases with increase in sugar concentration with respective immersion time. The maximum value of WL, WR and SG was found to be 62.9%, 52.0 %, and 11.2 % for 70 ºB solute concentration whereas the minimum value of was reported to 52.9 %, 41.21 % and 10.50 % for 50ºB solute concentration respectively after 8 hour of immersion time. With increase in immersion time during osmosis at same sugar concentration the WL, WR and SG were also increases this indicate that immersion time have significant effect on osmotic process. For first 1 hour, there was not much difference in WL, WR and SG but after 1 hour, the WR was found to increase more rapidly in slices dipped in 70°B solution as compared to those dipped in 50ºB.

Effects of immersion temperature on osmotic dehydration of apple slices

The effect of temperature change on osmotic dehydration is shown in Figure 3. From the data obtained by study, it was found that moisture content decreases as temperature of solution increases with given osmotic time for similar concentration. This conclude that the change in temperature affect the mass transfer rate. As the temperature increases the SG as well as WL also increases for given osmotic time and solution. The maximum WL and WR was found to 38.07% and 29.1 % at 50 °C whereas lowest value was 28.5 % and 15.5 % respectively at 30 °C after 8 hour of osmotic dehydration of apple slices.

Fig.1 Process flowchart of drying of osmotically dehydrated apple slices

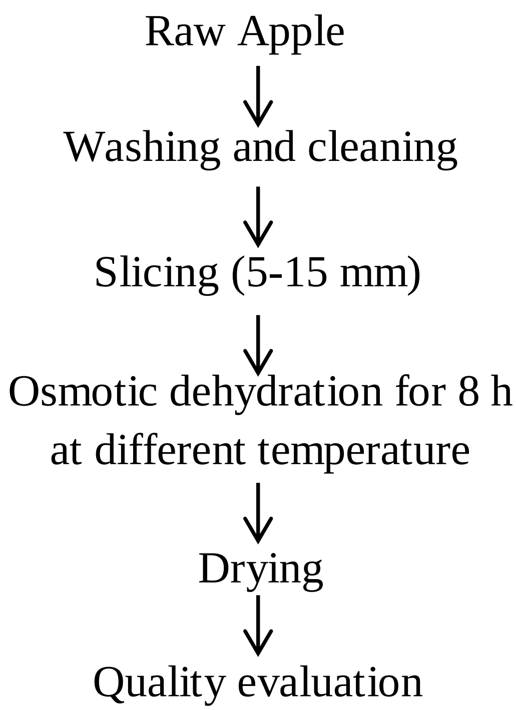


Fig.2 Effect of solute concentration on osmotic dehydration of apple

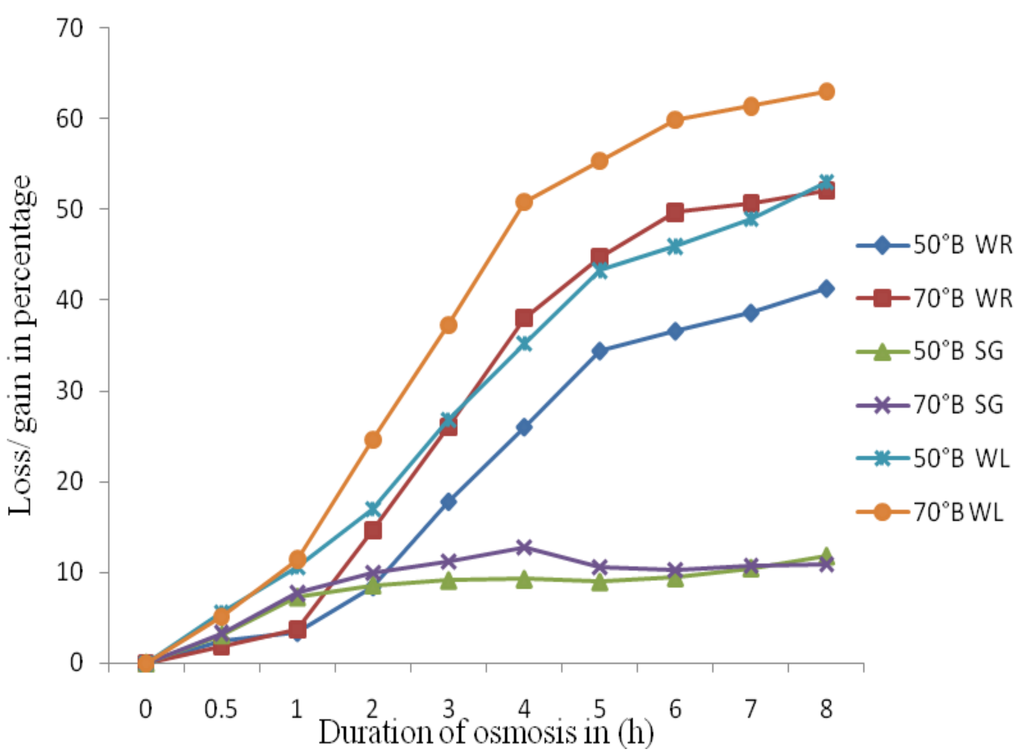


Fig.3 Effect of process temperature on osmotic dehydration of apple

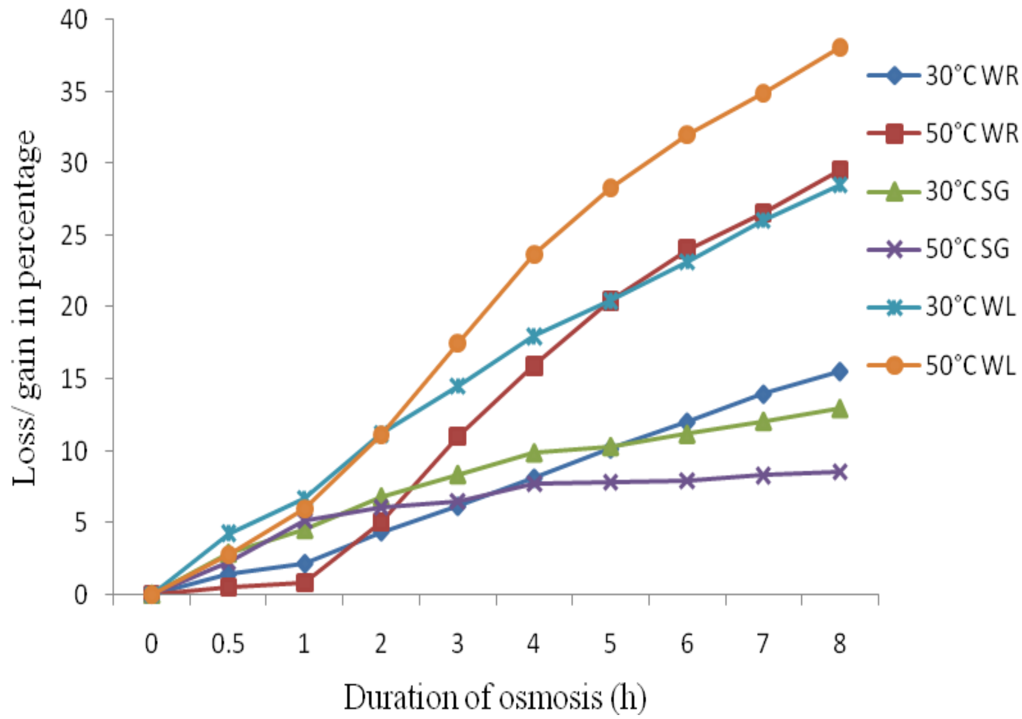


Fig.4 Effect of slice thickness on weight reduction during osmotic dehydration of apple

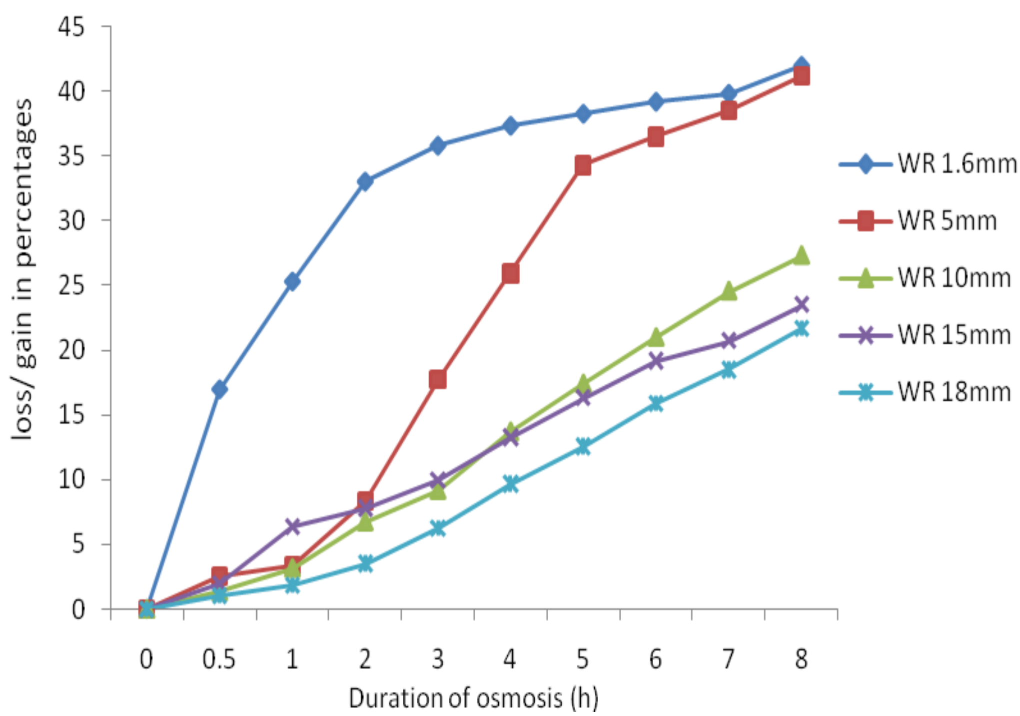


Fig.5 Effect of slice thickness on solid gain during osmotic dehydration of apple

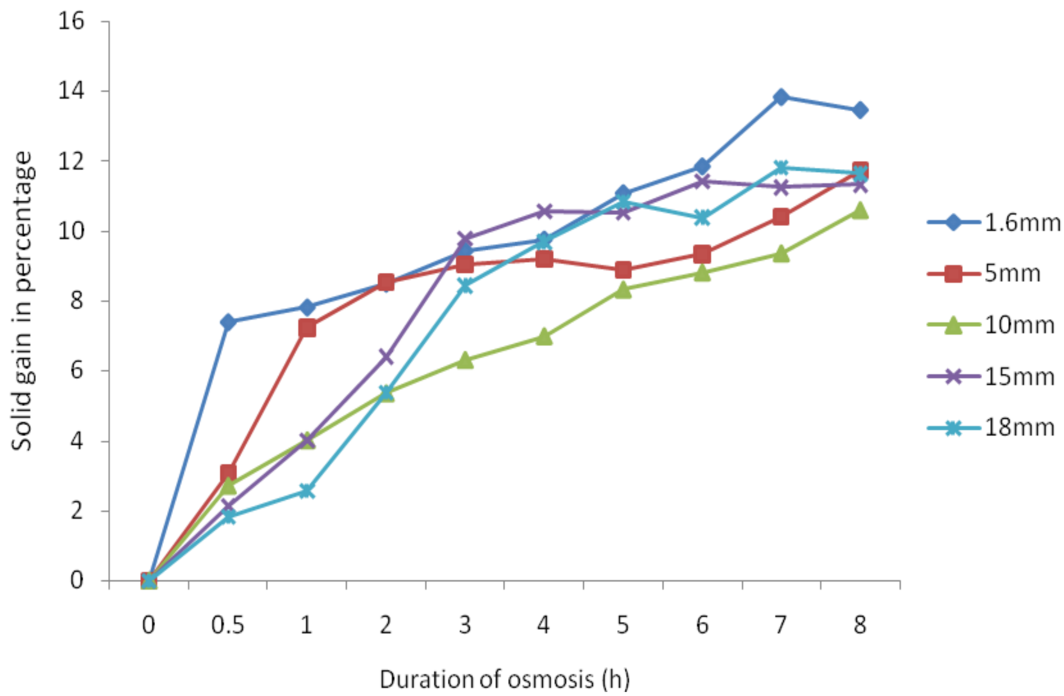


Fig.6 Effect of slice thickness on water loss during osmotic dehydration of apple

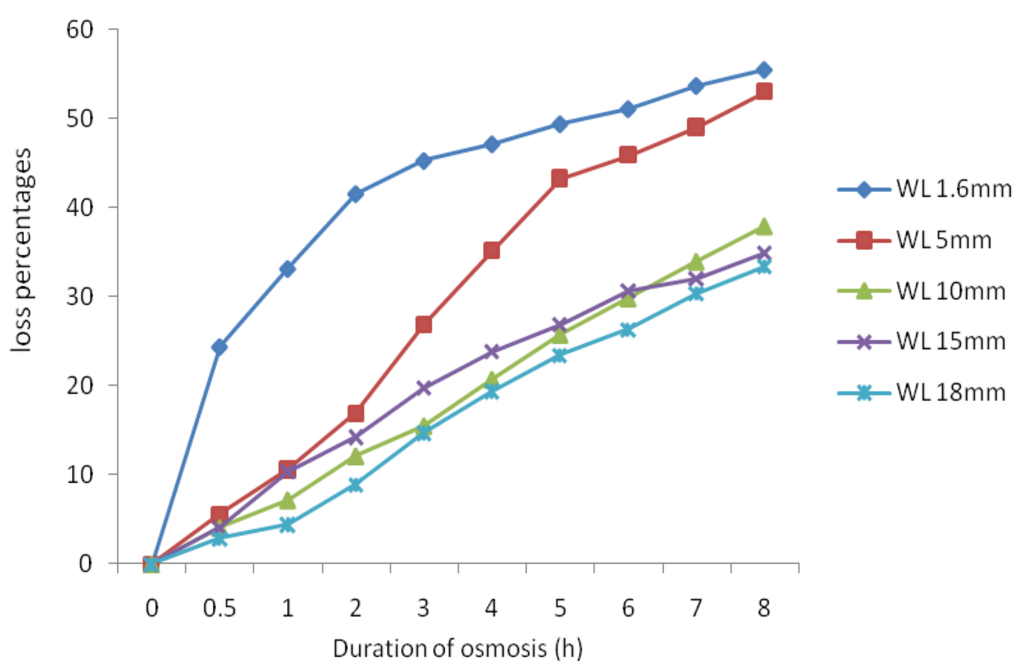
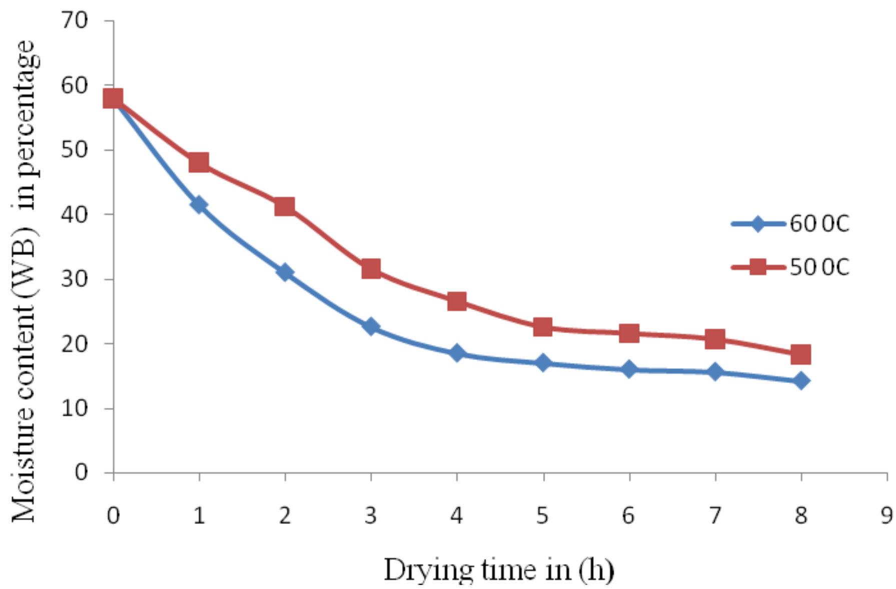


Fig.7 Effect of temperature on moisture content of apple



The value of SG decreases as WR and WL increases. Highest value was SG was 12.97% at 30 °C and lowest value was 8.56 % at 50 °C. From the observation it was concluded that, the osmotic dehydration is the two way mass transfer processes and it is affected by processed temperature and time of immersion (Farkas and Lazar, 1969; Hope and Vital, 1972; Beristain *et al.*, 1990 and Alam *et al.*, (2013)). Temperature can be one of the advantageous factors to complete osmotic dehydration rapidly but same time higher temperature affects colour and flavor of product.

Effect of slices thickness on osmotic dehydration characteristics of apple slices

The effect of slice thickness on WR, WL and SG is shown in Figure 4, 5 and 6 respectively. The WR was much faster in case of 1.6mm slice and this trend was followed by 5 mm thickness apple fruit slices. It was also observed that slice with more thickness, greatly reduced the SG, WR and WL. All three parameters were least when 18 mm slices were used for osmotic dehydration. It was also observed that the dehydration rate decreased with the increase in slice thickness.

Drying of osmotic dehydrated apple slices

The osmotically dehydrated apple slices for 8 h in sugar solution of 70° B at temperature of 50 °C were dried in tray dryer at 60^0C and 50 °C temperature for 8 h. The moisture content was measured at different drying time intervals and data were analyzed. The effect of drying temperature on moisture content is shown in Figure 7. It was observed that drying rate was faster in case of 60℃ as compare to 50℃ and after 5 h of drying the moisture content is almost constant for both 60℃ and 50℃ temperature. The weight reduction was more rapid in first 4 h after that drying rate gradually decreased and almost reached constant.

The drying of osmotic dehydrated apple slices was done at different temperature of 50 °C and 60°C using cabinet dryer for 8 h. Initially the apple slices were dehydrated osmotically for 8 h at 30 °C and 50 °C by different concentrations of sugar solution. The osmotically treated apple slices were dried in tray dryer upto the moisture level of 14%. During osmotic dehydration the maximum value of WL, WR and SG was found to be 62.9%, 52.0 %, and 11.2 % for 70 ºB with 1.6 mm thick apple slice whereas the minimum value was 52.9 %, 41.21 % and 10.50 % for 50ºB with 18mmrespectively after 8 h of osmosis. The maximum WL and WR was found to 38.07% and 29.1 % at 50 °C whereas lowest value was 28.5 % and 15.5 % at 30 °C respectively after 8 hour of osmotic dehydration of apple slices. The value of SG decreases as WR and WL increases. Highest value was SG was reported to 12.97% at 30 °C and lowest value was 8.56 % at 50 °C. From the study it was concluded that solution concentration, sample immersion time and solution temperature and thickness of slices were the most prominent factors which affects the solid gain, water loss and moisture loss during osmotic dehydration of apple slices. By processing of apple fruit post-harvest losses during handling and storage can be reduced, its self-life, product quality and market value can be maximized.

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