OSMOTIC DEHYDRATION OF SLICES OF KESAR MANGO (*Mangifera indica* L.)

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ABSTRACT

Mango was osmo-convective dried by immersing in 30, 40 and 50 per cent sugar syrup at 40, 50 and 60°C temperatures for 150 min. duration of osmosis. The effects of process parameters (such as duration of osmosis, syrup concentration and syrup temperature) on mass exchange (such as water loss, solid gain and mass reduction) during osmotic dehydration of mango slices were studied. It was found that the water loss, solid gain and mass reduction increased with increase of syrup concentration and syrup temperature. After 150 min of osmotic dehydration, the minimum and maximum mass reduction, water loss and sugar gain after osmotic dehydration were observed in the range of 16.56 to 28.54 per cent, 20.59 to 35.45 per cent and 4.33 to 6.90 per cent, respectively corresponding to low levels (30°Brix, 40°C after 150 min.) and high levels (50°Brix, 60°C after 150 min.) of syrup concentration and temperature, respectively.

Keywords: Concentration Mango, duration, osmotic dehydration, temperature

INTRODUCTION

The mango (*Mangifera indica L*) is one of the most important tropical and subtropical fruit of the world and is popular both in the fresh and the processed form. India dominated the world trade of processed mango products; even though hardly 1 per cent of the total mango production in India is processed. The post harvest losses of this highly nutritious fruits are quite serious in our country. Generally losses of Kesar mango fruit of produce annually are due to lack of proper handling, transportation facility, processing facility and storage management. Therefore, in order to overcome these losses, one effective method would be by converting it into various commercial mango products. It would help in reducing the volume, reduce the cost of transportation and enhance the shelflife.

Osmotic dehydration (OD) is used to produce ready to eat foods of intermediate moisture content with superior sensory properties (Sakhale and Pawar, 2011). It was introduced in the early 1960's to preserve foods of high water activity *via* partial dehydration. It is a promising technique and an active area of research. In osmotic dehydration, the cell membrane, by virtue of its permeability, develops the chemical potential between dehydrating food cells and the surrounding osmotic solution (OS), facilitating solute gain (SG) and water loss (WL) by diffusion and osmotic mechanisms, respectively (Ponting *et al.*, 1966; Krokida *et al.*, 2000). It has received wide acceptance, because it has numerous advantages over traditional drying processes. It is cost-effective due to low energy requirements and preserves the cellular integrity of dehydrated foods, leading to improved retention of colour, flavour, and nutritional characteristics. Therefore, a study was proposed to investigate the wide range of process parameters (such as duration of osmosis, syrup concentration and syrup temperature) on moisture movement characteristics during osmotic dehydration of mango slices.

MATERIAL AND METHODS

Fresh matured mango cv. Kesar, having about moisture content (wb) (78-82 %), was procured from local market, Udaipur Rajasthan. The graded (free from bruises and blemishes) mango were kept at ambient temperature for ripening. Full ripened mangos were used for further study. The commercial sugar was taken as an osmotic agent. The mango fruits were thoroughly washed under tap water to remove adhering impurities, then mango immediately placed on tissue paper to soak the surface moisture. Peel of mango was removed and slices (10 ± 0.5 mm thick) were made manually with the help of stainless steel knife. Sugar syrup samples of required concentration (30, 40, and 50 ^{o}Brix) were prepared.

The moisture content of the fresh as well as osmotically dehydrated mango slices was determined by using AOAC (1984) method. A small capacity laboratory temperature controlled water bath of size 30 cm x 20cm x 20 cm (approximate capacity, 5 liters) was used as osmotic dehydration unit. The unit consists of osmotic dehydration chamber, temperature indicator and electric pump. The heating chamber made of stainless steel sheet, has an immersion heater (500 watt) connected to the bottom of the osmotic chamber. The temperature of the osmotic solution in the chamber is controlled with the help of a thermostat. A water level indicator is also provided. Temperature sensor is also provided to determine the temperature of the syrup solution.

Experiment was conducted with nine combinations of three concentration (30, 40 and 50 ^{o}Brix) and three temperatures (40, 50 and 60°C). The prepared samples (mango slices) were weighed approximately 40g for every experiment and immersed in the sugar syrup (30, 40 and 50 ºBrix) contained in a 200 ml glass beaker. The beakers were placed inside the constant temperature water bath. The syrup in the beakers was manually stirred at regular intervals to maintain uniform temperature. One beaker was removed from the water bath at designated time interval 30, 60, 90, 120 and 150 minutes and the samples were immediately rinsed in flowing water and placed on tissue paper to remove the surface moisture. The samples were weighed and their moisture contents were determined. The data were utilized for determining water loss and sugar gain.

Water loss

The water loss (WL) is defined as the net weight loss of the fruit on initial weight basis and was estimated as

$$WL = \frac{W_i X_i - W_\theta X_\theta}{W_i} \tag{1}$$

Sugar gain

The sugar gain is the net uptake of sugar by the mango slices on initial weight basis. It was computed using following expression:

$$SG = \frac{W_\theta(1 - X_\theta) - W_i(1 - X_i)}{W_i} \times 100 \tag{2}$$

Mass reduction

Mass reduction (MR) is defined as the net weight loss of the fruit on initial weight basis.

$$MR = \frac{W_i - W_\theta}{W_i} \tag{3}$$

Also mass reduction (MR) can be defined as the difference between water loss and solid gain.

$$MR = WL – SG \tag{4}$$

Where,
WL= Water loss (g water per 100 g initial mass of sample),
SG= Solid gain (g solid per 100 g initial mass of sample),
MR=Mass reduction (g mass per 100 g initial mass of sample)
W_θ =Mass of ripen mango slices after time θ, g,
W_i =Initial mass of ripen mango slices, g,
X_θ =Water content as a fraction of mass of ripens mango slices at time θ, and
X_i = Water content as a fraction of initial mass of ripen mango slices, fraction.

RESULTS AND DISCUSSION

Water loss

The kinetics of osmotic dehydration is shown in Figure 1, 2 and 3 giving the variation in water loss at various concentrations and temperatures of syrup solution. The water loss from test samples under selected process parameters are shown in different curves, indicating relatively smooth progression of drying despite the fact that almost all data points came from independent test runs. The water loss was different for different conditions of syrup temperatures and concentrations.

The minimum and maximum water loss after 150 min. osmotic dehydration was 20.89 and 35.45 per cent, respectively, corresponding to low levels (30^{o}Brix, 40^{o}C after 150 min) and high levels (50^{o}Brix, 60^{o}C after 150 min) of syrup concentration and temperature. The water loss was increased from 0 to 20.89, 25.11 and 27.75 per cent, when duration of osmotic dehydration increased from 0 to 150 min. for 30^{o}Brix concentration at 40, 50 and 60^{o}C syrup temperatures, respectively. Similarly for 40 and 50^{o}Brix concentrations, it varied from 0 to 25.26, 29.43 and 32.32 per cent and 0 to 28.19, 32.45 and 35.45 per cent for 40, 50 and 60^{o}C syrup temperatures, respectively (Figure 1, 2 and 3).

It can be observed that when syrup temperature was increased from 40 to 50^{o}C for 30^{o}Brix syrup concentration, water loss increased from 20.89 to 25.11 per cent after 150 min. of osmotic dehydration causing approximately 4.22 per cent point increase and on further increase in syrup temperature to 60^{o}C, the water loss was observed to be 27.75 per cent (3.64 per cent point increment). For 40^{o}Brix syrup concentration, the water loss increased from 25.26 to 29.43 per cent (4.17 per cent point increment), when syrup temperature increased from 40 to 50^{o}C, and on further increase in syrup temperature from 50 to 60^{o}C, the water loss was increased to 32.32 per cent (2.89 per cent increment in water loss) for the same duration of 150 min. The similar results were also obtained for 50^{o}Brix syrup concentration, the water loss was increased from 28.19 to 32.45 per cent (4.26 per cent point increment), when syrup temperature increased from 40 to 50^{o}C, and on further increase in syrup temperature from 50 to 60^{o}C, the water loss was increased to 35.45 per cent (3 per cent point increment) (Figure 1, 2 and 3).

Inference can be drawn from Figure 1, 2 and 3 that a low temperature-low concentration condition (40^{o}C-30^{o}Brix) gives a low water loss (20.89 % after 150 min. of osmosis) and a high temperature-high concentration conditions (60^{o}C-50^{o}Brix) gives a higher water loss (35.45 % after 150 min. of osmosis). The low temperature–high concentration condition 40^{o}C-50^{o}Brix gives a slightly higher water loss of 28.19 per cent after 150 min. of osmosis than high temperature-low concentration condition 60^{o}C-30^{o}Brix (27.75 % after 150 min. of osmosis) indicating a pronounced effect of concentration of sugar syrup on water loss (Figure 1, 2 and 3). This indicates that water loss can be increased by increasing either the syrup concentration or temperature of solution. However, an increase in concentration by 10^{o}Brix of syrup has more influence on water loss than an increase in temperature by 10^{o}C (Figure 1, 2 and 3).

The water loss at any concentration was affected by the temperature of the syrup as it was increased with increase in syrup temperature. This may be due to changes in semi-permeability of the cell membrane of the fruit, allowing more water to diffuse out in a shorter period. Also increase in water loss with increase in syrup concentration may be due to increased osmotic pressure in the syrup at higher concentrations, which increased the driving force available for water transport. This is in agreement with earlier results of Pokharkar and Prasad (1998) and Nieuwenhuijzen *et al*., (2001). In all the experiments, the water loss was very fast at the beginning of process (up to half hour) and decreased gradually with the increase of duration of osmosis, but did not approach the equilibrium. The similar results were quoted in case of the osmotic dehydration of banana (Pokharkar *et al*., 1997), papaya (Jain *et al*., 2011) and aloe-vera (Pisalkar *et al*., 2011).

Sugar gain

The variations in sugar gain at various concentrations and temperatures of syrup are shown in Figure 4, 5 and 6. Similar to water loss, the sugar gain also indicates relatively smooth progression of various curves despite the fact that almost all data points came from independent test runs. The sugar gain was different for different conditions of syrup temperatures and concentrations. It can be seen that sugar gain increased with duration of osmosis and did not approach the equilibrium even after 150 min. of osmotic dehydration.

The sugar gain was increased from 0 to 4.33, 4.95 and 5.30 per cent, when duration of osmotic dehydration increased from 0 to 150 min. for 30^{o}Brix concentration at 40, 50 and 60^{o}C syrup temperatures, respectively. Similarly for 40 and 50^{o}Brix concentrations, it varied from 0 to 4.94, 5.59 and 6.11 per cent and 0 to 5.40, 6.27 and 6.90 per cent for 40, 50 and 60^{o}C syrup temperatures, respectively (Figure 4, 5 and 6). It can be observed from the data that when syrup temperature is increased from 40 to 50^{o}C for 30^{o}Brix concentration, sugar gain increased from 4.33 to 4.95 per cent causing 0.62 per cent point increase after 150 min. of osmosis, however for further increase in syrup temperature to 60^{o}C, the sugar gain was 5.30 per cent (0.35 per cent point increase) in the same period of osmosis. Similarly, for 40^{o}Brix syrup concentration, the sugar gain increased from 4.94 to 5.59 per cent (0.65 per cent point increment), when syrup temperature was increased from 40 to 50^{o}C, while it increased to 6.11 per cent (only 0.52 per cent point increase) with further increase in syrup temperature from 50 to 60^{o}C. However for 50^{o}Brix syrup concentration, the sugar gain increased from 5.40 to 6.27 per cent (0.87 per cent point increment) when syrup temperature was increased from 40 to 50^{o}C, while it increased to 6.90 per cent (only 0.63 per cent point increase) with further increase in syrup temperature from 50 to 60^{o}C (Fig. 4, 5 and 6).

The results also showed that a low temperature-low concentration condition (40^{o}C-30^{o}Brix) gives a low sugar gain (4.33 % after 150 min. of osmosis) and a high temperature-high concentration conditions (60^{o}C-50^{o}Brix) gives a higher sugar gain (6.90 % after 150 min. of osmosis). The low temperature–high concentration condition 40^{o}C-50^{o}Brix gives a slightly higher sugar gain of 5.40 per cent after 150 min. of osmosis than high temperature-low concentration condition 60^{o}C-30^{o}Brix (5.30 % after 150 min. of osmosis) indicating a pronounced effect of concentration of sugar syrup on sugar gain. This indicates that sugar gain can be increased either by increasing the syrup concentration or temperature of solution. However, an increase in concentration of syrup has more influence on sugar gain than an increase in temperature (Figure 4, 5 and 6).

It can be seen that sugar gain increased with duration of osmosis and did not approach the equilibrium even after

150 min. of osmotic dehydration. The increase in sugar gain with the concentration of the syrup may be because of the increased concentration difference between fruits and syrup. The increased sugar gain with increase in syrup temperature may be due to the collapse of the cell membrane at higher temperatures. Similar results have also been reported for blueberries (Nsonzi and Ramaswamy, 1998a), papaya (Jain *et al*., 2011) and aloe-vera (Pisalkar *et al.*, 2011).

CONCLUSION

Syrup concentration, solution temperature and duration of osmosis had definite effect on the kinetic of osmotic dehydration of mango slices. During osmotic dehydration, the water loss and sugar gain both increased with an increase of either syrup concentration or solution temperature. Water loss from the mango slices were very rapid for the first half hour of osmosis and reduced subsequently with duration of osmosis. However, an increase in concentration of syrup solution has more influence on water loss than an increase in solution temperature. But, in case of sugar gain, an increase in solution temperature has more influence than an increase in concentration in the range.

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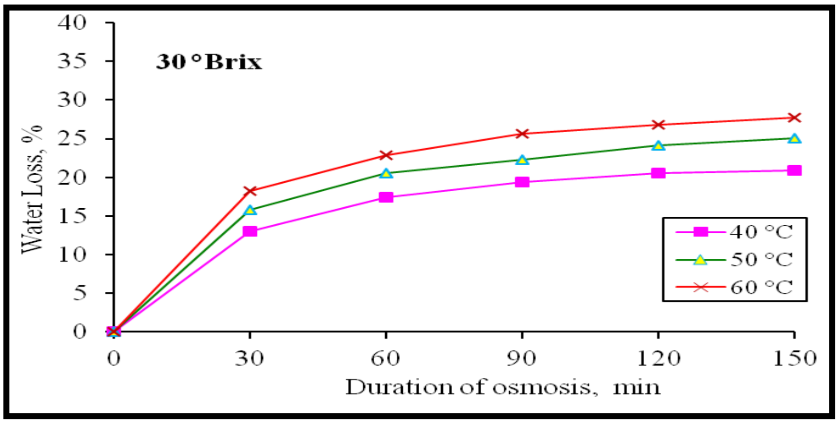

Fig. 1: Variation in water loss with duration of osmosis with 30°Brix syrup concentrations at 40, 50 and 60°C syrup temperatures

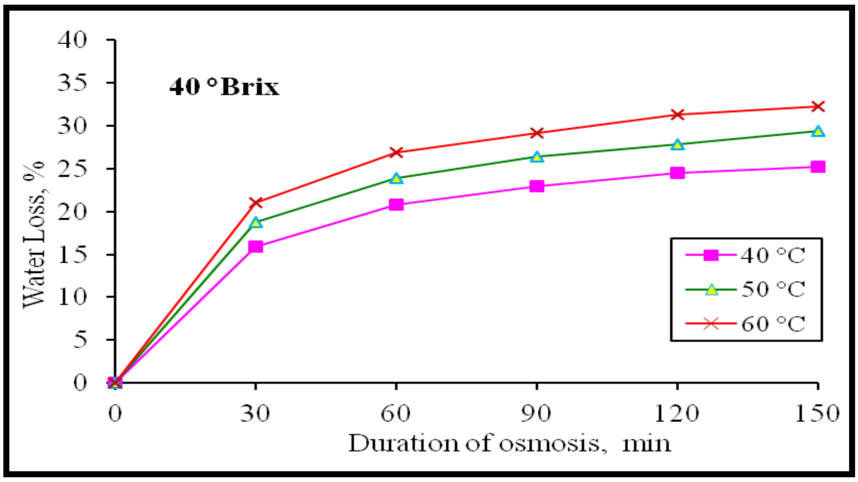

Fig. 2: Variation in water loss with duration of osmosis with 40°Brix syrup concentrations at 40, 50 and 60°C syrup temperatures

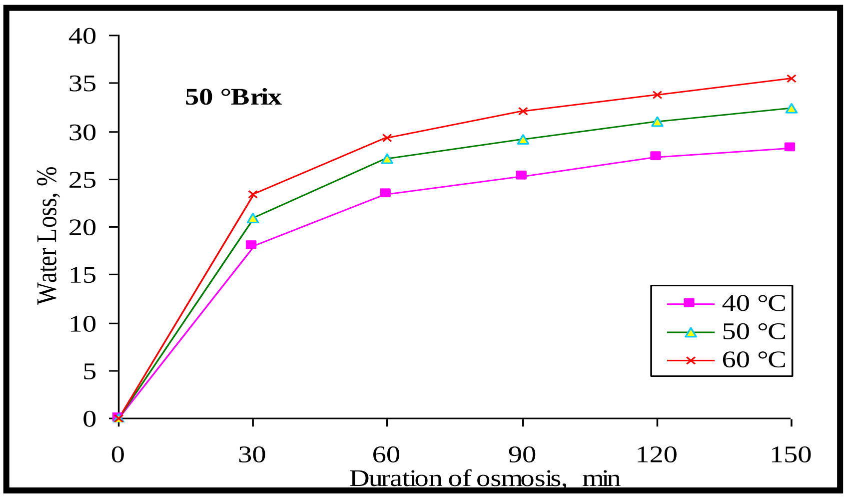

Fig. 3: Variation in water loss with duration of osmosis with 50°Brix Syrup concentrations at 40, 50 and 60°C syrup temperatures

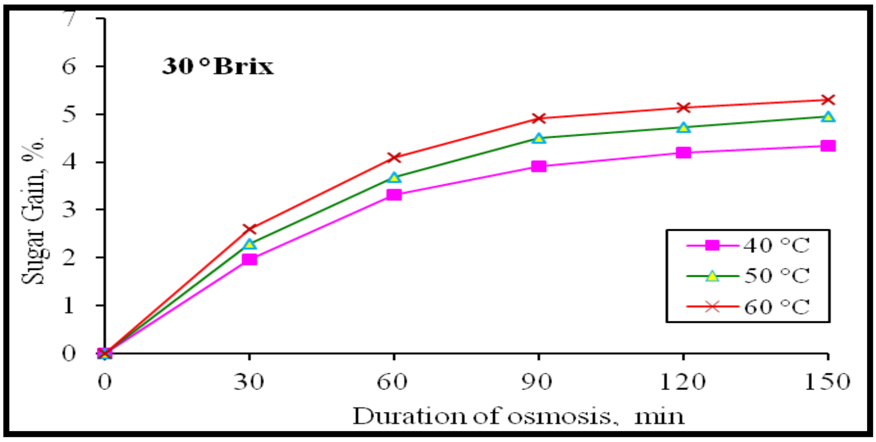

Fig. 4: Variation in sugar gain with duration of osmosis with 30°Brix syrup concentrations at 40, 50 and 60°C syrup temperatures

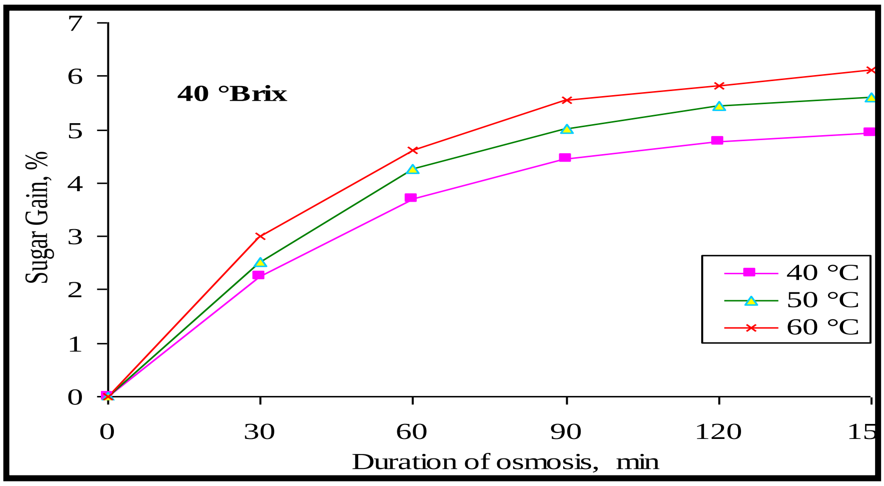

Fig. 5: Variation in sugar gain with duration of osmosis with 40°Brix syrup concentrations at 40, 50 and 60°C syrup temperatures

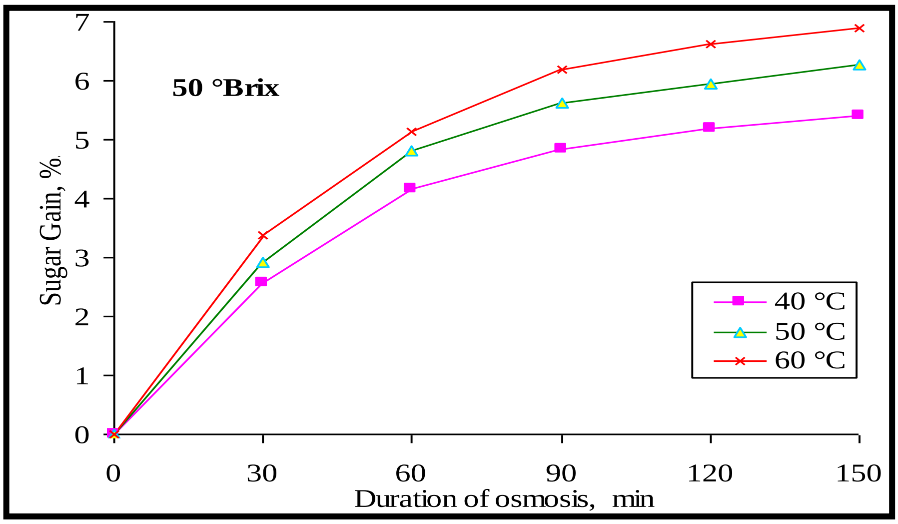

Fig. 6: Variation in sugar gain with duration of osmosis with 50°Brix syrup concentrations at 40, 50 and 60°C syrup temperatures

[MS received : May 09, 2017] *[MS accepted : May 23, 2017]*