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Osmotic Dehydration of Apricot using Salt-sucrose Solutions

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***Abstract*—**Fruit drying is a well known process mostly used for preservation of fruits. Osmotic dehydration of apricot slices were carried out in three different salt-sucrose concentrations and four different temperatures. Also three different weight ratios of solution to sample were conducted to one set of experiments. The dehydration curves were constructed using Peleg's model. Increasing the solution volume increased the mass transfer rate and hence the solid gain increased rapidly. Increasing the volume of osmotic media caused an increase in overall mass transfer but a 'solution to sample' ratio of 5:1 gave the best product quality. The best temperature and concentration that had a high water loss to solid gain ratio and an acceptable taste were 40˚C and 5%, respectively.

***Keywords*—**Apricot, Effective diffusivities, Osmotic dehydration

I. Introduction

ACCORDING to FAO, the annual production of apricot in Iran exceeds to 220,000 tons (making Iran as the world second producer). Nearly half of this amount was dried. This shows the importance of attempts for improving the quality of dried apricots. Traditional drying methods incorporate serious decreases of nutritive and sensorial values, by damaging the flavor, color, and nutrients of the product [9, 10].

Osmotic drying is an interesting technique used as a pretreatment prior to air drying as it is supposed to obtain dry apricot ingredients, having a natural color, without sulphur dioxide, which could be suitable for different applications [6] . This process has received considerable attention recently, to reduce the energy consumption and improve food quality [5].

Osmotic dehydration consists of the immersion of the fruit in a hypertonic aqueous solution leading to loss of water through the cell b wall membrane of the fruit and subsequent flow along the inter-cellular space before diffusing into the solution [17]. Solute transference to the fruit during osmosis causes an increase of soluble solids content of the fruit which decreases the phenolase activity and hence reducing the susceptibility of the fruit to the enzymatic browning during air dehydration [12, 16].

We previously [8] reported on the kinetics of osmotic dehydration of apricot using sucrose solution. The osmotic solutions used there were sucrose solutions with high concentrations and hence were highly viscose. As a result using sucrose caused technical problems for mixing and further more it could increase the production costs. Solid gain and water loss of the samples upon application of different salt –sucrose concentrations at different temperatures were studied to evaluate the diffusion coefficient of the salt-sucrose and water using Peleg and Crank's equations.

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II. Materials and methods

Referring to works done before (Park *et al*, 2002; Azoubel, and Murr, 2004; Palou *et al.*, 1993; Corzo and Bracho, 2006) Peleg's model was chosen to understand the mass transfer kinetics of osmotic dehydration:

$$\overline{MC(t)} = MC(0) \pm \frac{t}{k_1 + k_2 t} \qquad (1)$$

where is the water or solid content at instant t, g, is the initial water or solids amount, g, k1and k2 are the Peleg's parameters, and t is the time, h.

To describe a plate of thickness 2L having the uniform initial water or solids amount MC(0), submitted to osmotic dehydration at constant conditions, Fick's unidirectional diffusion equation could be used [4].As described in our previous work (Khoyi and Hesari, 2007) it becomes in three dimensions:

$$W_{AorS} = \left(\frac{8}{\pi^2} \sum_{i=0}^{\infty} \frac{1}{(2i+1)^2} \times \exp\left(-(2i+1)^2 \pi^2 D_{ef,AorS} \frac{t}{4L^2} \right) \right)^3 \qquad (2)$$

where Def,AorS is the effective diffusivity of water loss or solid gain, m2s-1; i is the number of series terms; L is the characteristic length, sample half-thickness, m; t is the time , s.

Allowing the calculation of effective diffusivity for solid gain and water loss based on the dimensionless amount of water loss $W_{A,orS} = \frac{\overline{MC(t)} - MC_{eq}}{MC(0) - MC_{eq}}$ (WA) (3)

and solid gain (WS):

Where WA,orS is the dimensionless amount of water loss or solid gain respectively; MCeq is the equilibrium amount of water loss or solid gain, g.

Fresh apricots, Nasiry cultivar, were obtained from local market. The average refractive index and pH of apricots were 24 and 4.5, receptively. Apricots were cut into 10 mm slices and osmo-dehydrated. They were weighed and placed into 250 ml beakers (5g for each beaker), containing 5, 10 and 15% (w/v) salt solutions and osmo-dehydrated at temperatures of 30, 40, 50, and 60ºC. Dehydration times of 30, 60, 120, 180, 240, 300 and 360 min were used for each salt concentration and time. The duration of osmotic dehydration was based on previously published works [1, 11, 15, 19].

III. Results and Discussion

Determining the best ratio of 'solution to sample'

The volume of the osmotic solution has a direct influence on the water loss and salt gain. Increasing the volume of the osmotic solution causes an increase in both water loss and salt gain (where the latter is undesirable). The results for different 'solution to sample' weight ratios are shown in Fig.1 which were obtained at 30ºC and 5% salt-sucrose concentration. The highest water loss was obtained at 15:1 ratio which is accompanied by the highest salt gain. The highest water loss to salt gain ratio has obtained when using a solution to sample ratio of 5:1. While water loss for this ratio was 12% lower, the WL/SG for 5:1 ratio was 46% more than 15:1 ratio. Therefore we used the 5:1 ratio that could have a better quality.

Evaluating of Peleg's equation parameters and effective diffusivity

Equation parameters and effective diffusivities were calculated for different temperatures and concentrations at solution to sample weight ratio of 5:1. It was assumed that equilibrium concentration in equation [4] equals to concentration at time of infinity which using Peleg's equation becomes $1/k_2$. Then using equation [3] effective diffusivities were calculated.

Peleg's equation parameters, effective diffusivities and WL/SG did not exhibit a trend with increase of temperature at the constant concentration, or with increase of concentration at the same temperature. The average relative error calculated varied from 1.5% to 12.3% for water loss and 1.4% to 3.1% for solid gain. As it is obvious, effective diffusivities were in the order of magnitude between 10^{-10} and 10^{-9} with an overall average of 1.37×10^{-9} m^2/s for water loss and 1.15×10^{-9} m^2/s for solid gain which was found similar for carrot, potato, and pumpkin dehydration in salt solution in previous works [7, 11, 18].

Effect of temperature and concentration variations on mass transfer rate

It is expected that increasing the concentration and temperature of the osmotic media would increase the mass transfer rate but the results shown in Figs. 2, 3 and 4 did not exactly fulfill this expectation. As can be seen in Fig. 2, where the effect of concentration on water loss is shown, at temperatures of 30˚C and 40˚C increasing salt-socrose concentration from 5 to 15% increased the water loss. This effect was less clear for concentrations of 10 to 15% at temperatures of 50˚C and 60˚C. This might be explained by the detrimental effect of salt-sucrose on relatively soft texture of the apricot which causes an overall mass loss at 15% concentration. Because of the aforementioned problems comparison between the results for 15% and other concentrations was not reliable. An increase in concentration from 5% to 10% causes a remarkable increase in water loss but more increase of concentration did not make such an increase in water loss. So without considering the taste of the product the best concentration is 10% but a selection between 5% and 10% depends on the taste that is to be desirable. Using 10% concentration results in a salty and sweet taste but when the salty taste is not desired then 5% concentration should be used. Furthermore the taste of products from 15% solution was very salty.

As is shown in Fig. 3 increasing the temperature did not always cause an increase on the water loss. Approximately the highest water loss was observed at 40˚C. Increasing the temperature decreases the mass transfer resistance and at the same time increases the solubility of natural occurring sugars but at a different rate. As the salt concentration in the solution is a low concentration when temperature increases, the solution attends to absorb more solids form the apricots instead of absorbing water. Because of different increasing rates of mass transfer and solubility, increasing temperature from 30˚C to 40˚C caused an increase in water loss but when we reached 50˚C the overall result was a decrease in water loss and at 60˚C we saw an increase in water loss relative to 50˚C. Regarding these results it is preferable to work at 40˚C to obtain better quality except of when using 10% concentration where higher temperatures result in a similar amount of water loss.

To make a selection for temperature and concentration for the osmotic solution, between 5% and 40˚C, 10% and 40˚C or 10% and 50˚C, it is sufficient to compare the water loss to solid gain ratio for these sets of temperature and concentration. The highest value for that ratio occurred at 5% and 40˚. But if the dehydration rate is more important than the quality of the product, then 10% and 50˚C could be a good choice.

IV. Conclusions

Using salt solution as the osmotic media has some advantages over sucrose solution but has some disadvantages too. It has low viscosity and its ions diffuse better than sucrose (because they are smaller than sucrose molecules) but make a salty taste in the product. To obtain better quality low concentrations such as 5% should be used. Higher temperatures cause more migration of natural solids into osmotic media and higher concentrations cause more solid gain. Because of low concentration and low viscosity in the osmotic media the natural solids of the fruit can easily come in to the osmotic solution and be replaced with salt, so it is important to choose a temperature that improves water loss but limits the solids gain. In this work the optimum temperature and concentration set, was 40˚C and 5%.

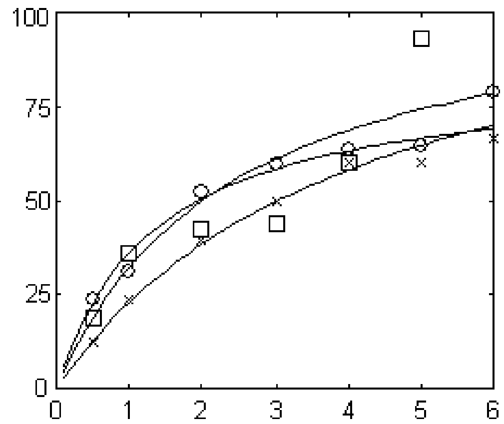

Fig. 1 Water loss and solid gain vs. time for different solution to sample weight ratios.

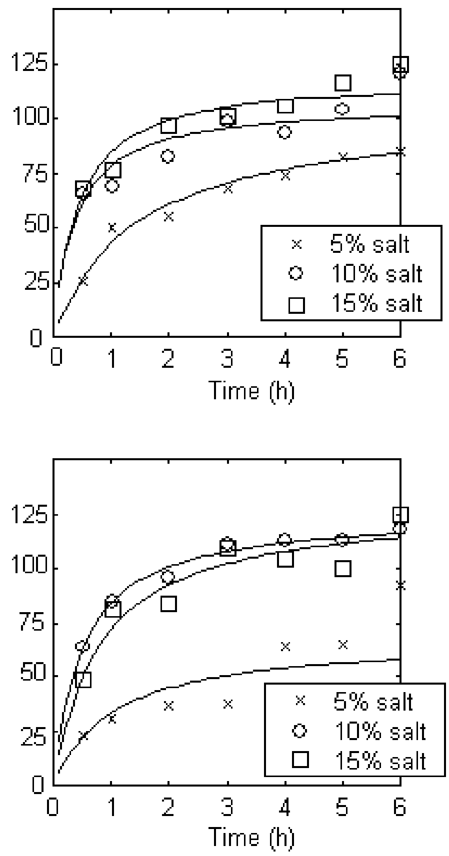

Fig. 2 Effect of concentration on water loss at several temperatures

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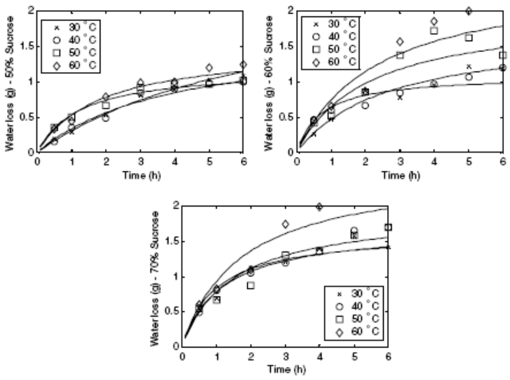

Fig. 3 Effect of temperature on water loss at several concentrations