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Osmotic dehydration of hog-plum and product development

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Abstract

The study is concerned with the kinetics of osmotic dehydration and development of jam from hogplum. Dehydration process was performed using sucrose and sodium chloride as osmotic agents. The study showed that the rate and extent of water loss, moisture content, solid gain and normalized solid content (NSC) were strongly influenced by concentration of osmotic solution and immersion time. Among the different solution concentration of sucrose and/or salt, 55/10% sucrose/salt solution gave the highest NSC (4.11) for 6 hours contact time, while 60% sucrose solution also gave an NSC value of 3.36 for similar contact time. Two equations were developed using Fick's diffusion equation from which the value of mass transfer co-efficients were calculated and found to be 0.1263 $min^{-1/2}$ and 0.1616 $min^{-1/2}$ for 60% sucrose and 55/10% sucrose/salt solution respectively. Organoleptic taste testing using 1-9 hedonic scale showed that all the developed jams (from different hogplum samples) were acceptable by the panelists. Jam from 55/10% sucrose/salt osmosed solution was ranked as 'Like very much' and that from mechanically dried hogplum slices was ranked as ' like moderately' while jam from fresh hogplum was adjudged 'Like slightly'.

Keywords: Hog-plum, Osmotic dehydration, Hogplum, Water loss, Solid gain

Introduction

Hogplum (*Spondius mangifera*) is a seasonal fruit in Bangladesh. It is an acid fruit and a rich source of vitamins (Ahmed, 1966). Hogplum is usually eaten raw and can be used for preparation of pickles, jam and other processed foods. Canning, drying, freezing and other processing methods are also applied for preservation of this fruit. Hot air dehydration has been largely employed to preserve fruits and vegetables. In this case, simultaneous mass and heat transfer takes place. In order to obtain high quality dehydrated food, osmotic dehydration has been introduced as a pretreatment by immersion in liquids with lower water activity than that of the food.

Osmotic dehydration (OD), due to its energy and quality related advantages, is gaining popularity as a complimentary processing of fruits and vegetables to obtain several kinds of products such as minimally processed, in intermediate moisture products (Smith *et al.,* 1997), as a pre treatment in air drying (Lenart, 1996) or freezing (Giangiacomo *et al.*, 1994). OD involves soaking foods in a osmotic solution i.e. concentrated sugar, salt, alcohols or soluble starch solutions, which partially dehydrates the food. During the process, two major mass transfer processes take place: the solute is transferred from the solution into the food and water flows out of the food into the solution (Le maguer, 1988, Islam, 1990 and Raoult-Wack, 1994), which is stronger than the previous one. These phenomena provoke changes in macroscopic product properties, such as mechanical properties, to a different degree depending on the process conditions and product characteristics (Torregiani *et al.*, 1995). These changes are directly related with the texture of product. OD has been successfully used in conjunction with air drying, freezing, freeze drying, vacuum drying, fluidized bed drying and microwave drying on the laboratory, pilot and commercial scales.

Most fruits are generally dried convectively with heated air but hot air dried fruits are often difficult to dehydrate because of case-hardening and shrinkage during the drying process. The consumer demand has increased for processed products that keep more of their original characteristics. The use of osmotic pretreatment and subsequent air-drying not only greatly enhances the drying rate, but may also improve the final product quality. However, Rahman and Lamb (1991) reported that osmotic dehydration would usually not lead to sufficiently low moisture content for the product to be considered shelf-stable. Therefore, osmotically treated product should be further processed (dried, frozen, freeze dried and etc.). According to Lenart and Lewicki (1988) this method can be used as a pretreatment before air drying in order to reduce from 30% to 70% of the water content of the food.

Considering the above facts, the present study investigates the drying behavior of hogplum using osmotic dehydration and to develop Jam from osmotically dehydrated hogplum.

Materials and Methods

Hogplums were washed and sliced into 7-mm thickness and initial moisture content was determined by AOAC method. Weighed and identified pieces were immersed into different concentrated solutions with sucrose and sugar-salt combination at room temperature (31°C) for different period of time. At the end of each definite time interval the slices were removed and quickly rinsed in water. Subsequently surface water was removed by gently blotting with tissue paper. The ratio of sugar to hogplum slices was 5:1 w/w.

After weighing the slices at definite time interval, moisture content of each individual sample was determined by oven drying method. From the weight loss due to osmotic dehydration of each sample, percentage of water loss (%WL), solid gain (%SG), total solids (%TS) and Normalized solid content (NSC) were determined according to Hawkes and Flink (1978). After finishing all the experiment jams were prepared from fresh, mechanically and osmosed dried samples as per method described by Cruess (1958).

Results and Discussion

For the determination of the effect of solution concentration on osmotic dehydration of 7-mm thick hogplum, an experiment was conducted with 40%, 50% and 60% sucrose solution. The result of the experiment is shown in Fig. 1. It is clear from the Fig.1 that 60% sucrose solution was the most effective among the solutions tested, when compared at the same immersion time interval. The result also showed that the higher the immersion time, the lower was the moisture content. As solution concentration increases osmotic pressure gradient also increases. As a consequence more water is lost and solute gained with resultant increase in solid concentration in the product.

Another experiment was conducted using different sucrose-salt combinations such as 45/5, 45/10, 45/15, 50/5, 50/10, 55/5 and 55/10% sucrose/salt solution. The result of the experiment is shown in Fig 2. It is seen from Fig.2 that 55/10% sucrose/salt solution was the most effective among the solutions tested when compared at the same immersion time interval. The result also showed that the higher the immersion time, the lower was the moisture content which is also in agreement with the principles of diffusion and osmosis process (Hawkes and Flink ,1978 and Islam, 1990).

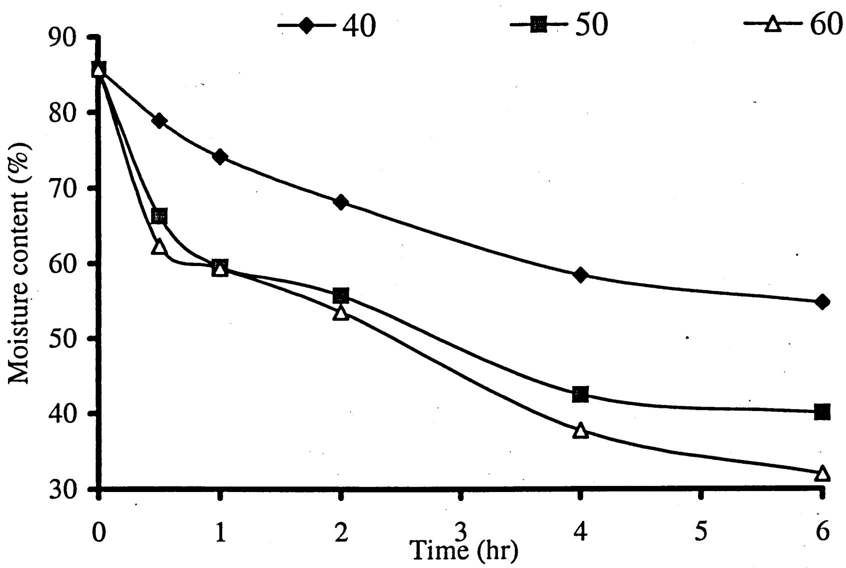

Fig.1 Change in moisture content of hogplum slices with time in different sucrose/salt solution

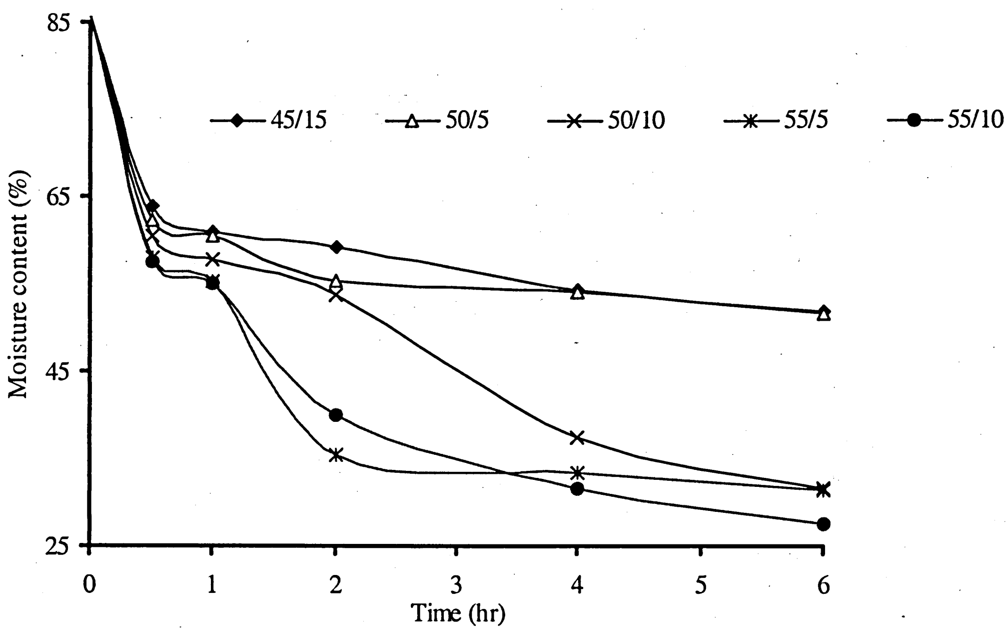

Fig.2 Change in moisture content of hogplum slices with time in different sucrose/salt solution

To investigate the effect of solution concentration on NSC, experiments were conducted with 40, 50 and 60% sucrose solution for periods upto 6 hrs. NSC Vs concentrations (for constant immersion time) were plotted and shown in Fig. 3. It is seen that increase in sucrose concentration gave increased NSC and a linear relationship was obtained as:

NSC = 5.95C – 0.1883 (for 6 hrs, C= sucrose concentration) ---------- (1)

The above equation indicated that higher concentration of sucrose in osmosis solution gave increased NSC at a given time. It is obviously understandable since the higher the concentration, the higher is solute and water activity gradient with resultant increased two-way mass transfer i.e. higher NSC (Hawkes and Flink, 1978 and Islam, 1980,1990).

Fig. 4 shows the influence of sucrose or combined sucrose salt solution concentration on normalized solid content (NSC) of hogplum slices. It is seen that, in general at or above 60% total concentration of solution (with or without salt) addition salt as a solute is more effective than only sugar. The highest NSC was given by 55/10% sucrose/salt solution (NSC=4.11) among the combined solutions as well as 60% sucrose solution (NSC = 3.36). From this Fig. (4) it is also possible to choose a binary solution of sucrose and salt to achieve a desired NSC level. However, one should be cautious about the nature of the solid gain in respect of organoleptic compatibility, water activity and thus also stability of the developed product.

The higher NSC (4.11) given by combined 55/10% sucrose-salt solution for hogplum is in agreement with literature (Islam, 1980; Ziauddin, 2001) while working with papaya, Ziauddinn (2001) showed that the highest NSC was given by 55/10% sucrose-salt solution. Islam (1980) however, using 45/15% sucrose-salt solution reported an NSC value of 6.5 for potato for 6 hr. The differences in NSC values achievable with different fruits and vegetables may be attributed to product structure, texture and constituents as well as solute(s) characteristics (Islam, 1980. Afzal babu *et al.* 1997).

The relationship between NSC and time has been derived from throretical consideration (Fick's diffusion equation) and is justified since osmotic dehydration is a two –way diffusion process and diffusional concentration is time dependent (Islam, 1990; Hawkes and Flink, 1978). The relationship for 60% sucrose and 55/10% sucrose/salt osmosed hogplum is respectively:

NSC = 0.1263 $\sqrt{t}$ + 0.8113 ------------------- (4.4)

NSC = 0.1616 $\sqrt{t}$ + 1.0589 -------------------- (4.5)

From Fig. 5 it is seen that at constant solution concentration increase in immersion time gave increased normalized solid content

From regression equation 4.4 and 4.5, it was seen that the mass transfer value (K-value) were 0.1263 and 0.1616 for 60% sucrose osmosed and 55/10% sucrose/salt osmosed respectively. It is noticeable that K-value is higher for 55/10% sucrose/salt than 60% sucrose osmosed product. This confirms that 55/10% sucrose/salt solution is more effective than 60% sucrose osmosed product due to higher molar concentration of 55/10% sucrose/salt solution compared to 60% sucrose solution.

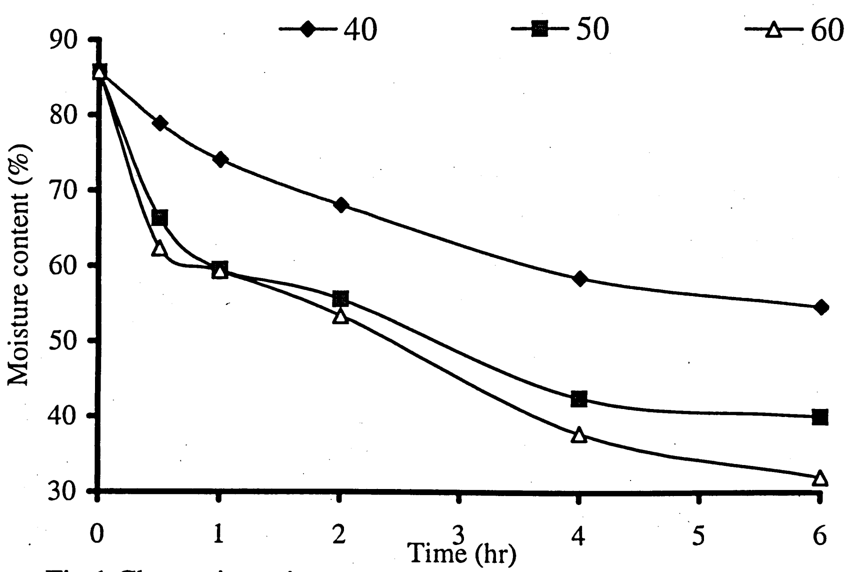

Fig.1 Change in moisture content of hogplum slices with time in different sucrose/salt solution

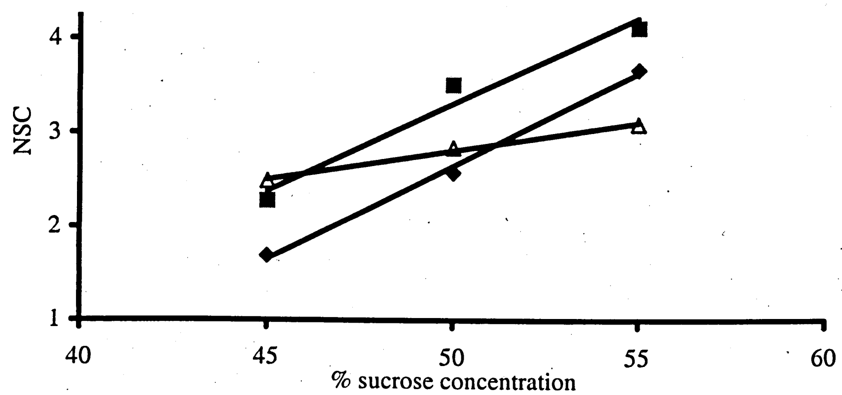

Fig.4 Influence of sucrose and/or salt concentration on NSC for osmosis of hogplum

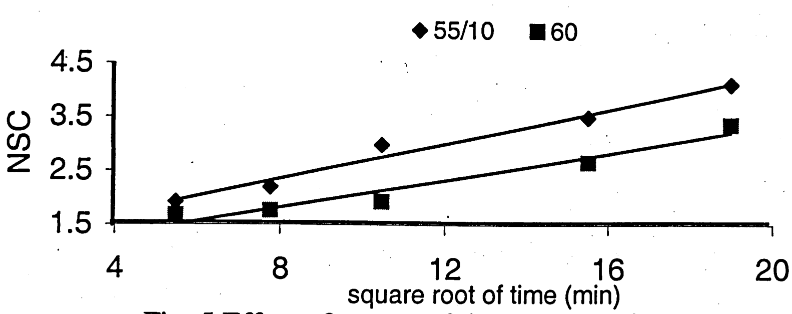

Fig. 5 Effect of square of time on NSC for 55/10 & 60% solution

Mass transfer in osmotic dehydration is a combination of simultaneous water loss and solute uptake (Hough *et al.*, 1993; Rahman and Perera, 1996; Spiazzi and Mascheroni, 1997). For that reason, the experimental data of water loss and solid gain were analysed and displayed in joint way in Fig. 6. It is seen from the figure that as percent sucrose concentration increased, the percent water loss is (WL) also increased. Simultaneously, percent solid gain (SG) increased with increasing percent sucrose concentration. The observed increase in %WL, however, was much higher than the increase in %SG at similar solution concentration. As a result, increased concentrations leads to increased weight reductions. But there is a maximum concentration above which WL can not be improved through increased solution concentration. Contreras and Smyri (1981) reported that at high sugar concentration, additional increase in sugar concentration (above 65%) did not promote faster WL. %WL and %SG also increased with increasing immersion time at similar concentration. This behaviour is in agreement with Islam and Flink (1982); Hawkes and Flink (1978). Similar behaviour was obtained of solution concentration with water loss and solid gain for combined sucrose and or salt solution.

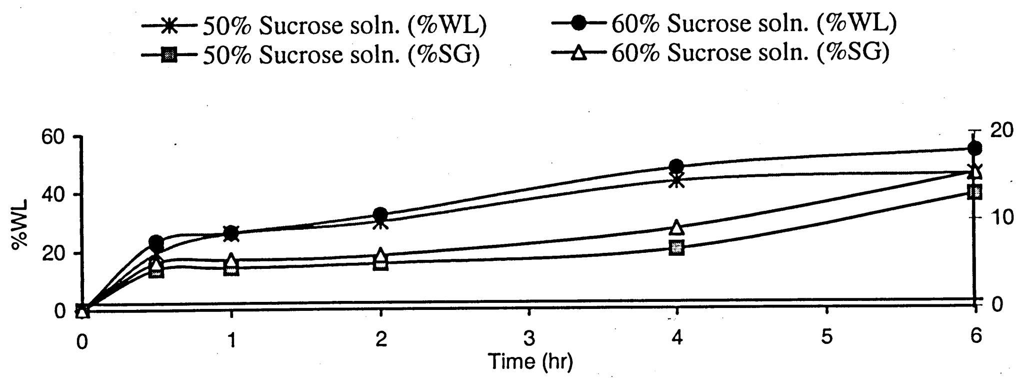

Fig. 6 Effect of different sucrose solution concentration on % of WL and SG at different time of 7 mm thick hogplum slices at 31^{0}C

In this study % WL and %SG and thus also NSC increased with increase in concentration of solute. This is expected since the solute and water activity gradient increased with increasing solution concentration. Several other researchers (Islam and Flink, 1982; Hawkes and Flink, 1978; Hope and Vitale, 1972) also showed that increase in concentration of sucrose and/or salt gave increased amount of water loss and solid gain.

Jam samples prepared by using fresh hogplum, mechanically dried hugplum and 55/10%% sucrose/salt osmosed hugplum and samples were subjected to organoleptic taste testing using 1-9 hedonic scale. A two-way analysis of variance (ANOVA) was carried out for color, flavor, texture and overall acceptability preference of developed product and the results are shown in Table. 1

Table1 Mean score of developed product on 1-9 hedonic scale

Sample	Colour	Flavour	Texture	Overall acceptability
1	5.5^b	6.7^b	5.0^b	6.3^c
2	5.8^b	6.7^b	5.5^b	7.4^b
3	7.1^a	8.5^a	6.6^a	8.4^a

Sample 1 = Jam from fresh hogplum slices
Sample 2 = Jam from mechanically dried hogplum slices
Sample 3 = Jam from 55/10% osmosed hogplum slices

As shown in Table 2 (DMRT) it was apparent that there was significant difference in overall acceptability of the sample. It can be seen from Table 1 that sample 3, jams made from 55/10% sugar/salt osmosed hogplum, is the most acceptable products securing the height score (8.4 out of 9) and ranked as "like very much". Solute uptake and leaching of natural acids, color, and flavor compounds out of osmo-dehydrated plant tissue affect its organoleptic properties, since they modify (to a certain extent) its natural composition. On the other hand, osmotic pretreatment contributes to retention of flavor in convectively dried fruits, making them more acceptable compared to totally air dried products. The other two jam samples made from fresh (1) and mechanically dried (2) jams secured scores from 6.3 to 7.4 for all attributes indicating their acceptance at or above "like slightly" rank. and "like moderately" rank.

Conclusion

From this study it is clear that the overall product quality can be improved by the application of osmotic treatments to conventional and new processes. Since the osmotic concentration process results in some solute uptake, the resulting changes in the composition of the food material will influence the product's quality and subsequent processing steps.

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