

Physico-chemical and Sensory Attributes of Osmotically Dehydrated Jakfruit (*Artocarpus heterophyllus* Lam.)

K. Prasannath and T. Mahendran

ABSTRACT

A research was conducted to develop osmo-air dried jakfruit which could be used as ready-to-eat snack foods. The fruit slices of $2.5 \times 2.5 \text{ cm}^2$ were obtained from partially ripe soft fleshed jakfruit var. *Vela*. The slices were immersed in 0.03% of potassium metabisulphite solution for 5 minutes, to prevent browning reactions during processing and storage. The treated slices were dehydrated at six different concentrations of osmotic solutions such as 60%, 70% and 80% sugar with 1% and 2% salt solution for 24 hours followed by drying in a heat pump de-humidifier dryer at 50°C and 60°C for 20 and 18 hours, respectively. Weight reduction of jakfruit slices was measured at 2 hours interval during the osmosis and these treated fruit slices were analyzed for physico-chemical parameters at the end of osmosis and after drying. The fruit slices were also assessed for sensory characteristics using nine-point hedonic scale test. The results of weight reduction revealed that the jakfruit osmosed in 70% sugar with 2% salt solution showed 41.8% weight loss. At the end of the osmosis, the titrable acidity reduced by 20.8% whereas the total sugar content increased by 1.71% in jakfruit osmosed in 70% sugar with 2% salt solution. After drying, all the physico-chemical properties retained better at 50°C than at 60°C. The sensory evaluation revealed that the highest overall acceptability was observed in the jakfruit osmosed in 70% sugar with 2% salt solution and oven dried at 50°C. Based on the quality analyses, osmotic solution of 70% sugar with 2% salt and drying temperature of 50°C were selected as the best combination for osmo-air drying of jakfruit.

Key words : Jakfruit, nutritional quality, osmo-air drying, sensory attributes

INTRODUCTION

Human forced to face the greatest problem of fruit spoilage because of its perishability before the modern technologies are introduced. Now, there

are many preservation methods innovated as a remedy for this problem (Kader, 1997). Osmotic dehydration process has gained more interest during the last two decades and is being applied to many fruits. It can be used successfully for 50% weight reduction in the material and require further drying or processing for longer shelf life. Based on the process advantages in terms of energy savings and quality improvement, it is predicted that osmo-air drying process has good potential in Sri Lanka for utilization of several fruits such as banana, jakfruit, guava, mango, pineapple and other fruits (Jain, 2003).

Jak tree (*Artocarpus heterophyllus* Lam.), a member of mulberry family, *Moraceae*, is a very important plant to the people of tropical Asia. The major jak growing countries are Sri Lanka, Bangladesh, Brazil, India, Indonesia, Nepal and Thailand. The jak trees grow in most parts of Sri Lanka and fruits are produced profusely during the season (Medagoda, 2003). Being a seasonal bearer, limited market demand when the production is high and lack of preservation technology mainly contribute to postharvest losses of jakfruit. Postharvest loss of *Vela* (soft fleshed) is greater than *Waraka* (firm fleshed) so that osmo-air drying can be well enough to reduce the losses of *Vela* jakfruit. Therefore, a study was carried out to improve consumer acceptability and marketability and to minimize losses of *Vela* jakfruit using osmo-air drying techniques.

MATERIALS AND METHODS

Mature, soft fleshed jakfruits (*Vela*) were obtained from the local growers in the Batticaloa district. The fruits were brought to the laboratory and kept in a humidity controlled cabinet at $20 \pm 0.5^\circ\text{C}$ and the RH of 90-95% for ripening. Partially ripe jakfruits after 3 days of

Department of Agricultural Chemistry,
Faculty of Agriculture,
Eastern University of Sri Lanka,
Vantharumoolai, Chenkalady,

harvest were used in this study. The bulbs were removed from the fruit, washed and cut into $2.5 \times 2.5 \text{ cm}^2$ slices. Some of the slices were treated as controls and analyzed for the physico-chemical parameters. The osmotically treated fruits were used for product development. Osmotic solutions of 60%, 70% and 80% sugar with 1% and 2% salt were prepared according to the weight by volume basis as below.

- S₁ - 60% sugar with 1% salt solution
- S₄ - 60% sugar with 2% salt solution
- S₂ - 70% sugar with 1% salt solution
- S₅ - 70% sugar with 2% salt solution
- S₃ - 80% sugar with 1% salt solution
- S₆ - 80% sugar with 2% salt solution

The jakfruit slices were dipped in the 0.03% potassium metabisulphite for 5 minutes, to prevent browning reactions during further processing and storage. Thirty jakfruit slices were immersed in each different concentration of osmotic solution for 24 hours (h). During the osmosis, weight reduction was measured at 2 h interval using an electronic balance (Mettler-PJ3000). The final moisture content of all the samples after osmosis was determined using the standard vacuum oven drying method at a temperature of 70°C for 24 h. Thirty treated jakfruit slices from each osmotic solution were placed in perforated stainless steel trays and dried in a heat pump de-humidifier dryer using an air velocity of 2.0 m/s with the co-current drying method. These slices were dried at two different temperatures of 50°C and 60°C for 20 and 18 h, respectively. Therefore, a total of 12 treatments were tested initially in order to select the suitable concentration of osmotic solution and drying temperature to produce good quality osmo-air dried jakfruits. Based on the quality, the best eight treatments were selected for further analysis of physico-chemical characteristics and sensory attributes.

The treatments are shown as follows:

- T₁ - Jakfruit osmosed in 70% sugar with 1% salt solution and dried at 50°C

- T₂ - Jakfruit osmosed in 70% sugar with 2% salt solution and dried at 50°C
- T₃ - Jakfruit osmosed in 80% sugar with 1% salt solution and dried at 50°C
- T₄ - Jakfruit osmosed in 80% sugar with 2% salt solution and dried at 50°C
- T₅ - Jakfruit osmosed in 70% sugar with 1% salt solution and dried at 60°C
- T₆ - Jakfruit osmosed in 70% sugar with 2% salt solution and dried at 60°C
- T₇ - Jakfruit osmosed in 80% sugar with 1% salt solution and dried at 60°C
- T₈ - Jakfruit osmosed in 80% sugar with 2% salt solution and dried at 60°C

Physico-chemical analysis was carried out at the end of osmosis and after oven drying using standard AOAC methods (2000). The titrable acidity of the fruit was determined as anhydrous citric acid by titrating the fruit extract with 0.1N NaOH using phenolphthalein as the indicator. The ascorbic acid content was determined by titrating the fruit extract with 2, 6-dichlorophenol indophenol dye. Total sugars were determined by Lane and Eynon volumetric method (AOAC, 2000). Crude fibre was estimated by treating the samples with 1.25% NaOH and 1.25% H₂SO₄ and ignited at 450°C in a muffle furnace. Three replicates were carried out for each parameter.

In sensory evaluation, the samples were subjected to nine-point hedonic scale test and the acceptability of samples was judged by 20 trained panelists to determine consumer preference. The sensory characteristics such as taste, colour, jakfruit flavour, texture, absence of browning and overall acceptability of the osmo-air dried jakfruit were judged by the panelists. Descriptive statistics was done on sensory attributes and the means were compared using the Tukey's test ($p < 0.05$).

RESULTS AND DISCUSSION

Weight Reduction

Loss of water from the fruit slices due to the osmosis, leads to the weight reduction. Rahman and Lamb (1990) pointed out that water loss and solid gain increased linearly with the increase of

solution concentration. The weight reduction at 80% sugar solution was very quick compared to the other concentrations initially due to the creation of high osmotic pressure in the 80% sugar solution (Figure 1). Treatment of 80% sugar with 2% salt solution showed more weight reduction initially compared with 80% sugar with 1% salt solution because of high solute gain action of highly concentrated solution. Jakfruit osmosed in 70% sugar with 2% salt solution showed significant weight reduction of 41.8% at the end of osmosis and took 16 h to reach the constant weight. Jain (2003) stated that upto 50% of the initial weight of fruits and vegetables could be reduced by the osmotic dehydration techniques.

Physico-chemical Analysis

The titrable acidity of fruits reduced from 0.24% to 0.19% during the osmosis at 70% sugar with 2% salt solution (Figure 2). The acidity reduction was due to the loss of organic acids along with water during osmosis (Moy *et al.*, 1978). High reduction in acidity is a desirable quality of fruit products for consumer acceptability. Therefore, osmotic dehydration lowers the significant amount of acidity in jakfruit. Titrable acidity of the samples was further declined during the drying process. Sebastiano (2001) reported that a decrease in total acidity in blood orange after heat-air treatment was due to the evaporative losses of acids. In this study, acidity reduction was significantly higher in samples dried at 60°C than that of 50°C due to the evaporative losses of organic acids during drying at higher temperature.

The retention of vitamin C during osmosis varied with the concentration of the osmotic solution. When the concentration of the osmotic solution increased, the loss of ascorbic acid also significantly increased due to the removal of cell sap. Gerschenson (2000) reported that the increase in concentration of sucrose medium raised the ascorbic acid oxidation in osmotic dehydrated papaya. In this study, ascorbic acid content of fruits

reduced from 8.55 mg% to 7.40 mg% during the osmosis at 70% sugar with 2% salt solution. Among the tested treatments, fruit slices immersed in 70% sugar solution showed significantly higher retention of ascorbic acid than in 80% sugar solution due to their lower osmotic concentration. Ascorbic acid loss was further increased during drying of the fruit slices. According to Labuze (1981), temperature and oxygen availability are the critical factors with respect to loss of vitamin C. The ascorbic acid content of jakfruit osmosed in 70% sugar with 2% salt solution was reduced from 7.40 mg% to 5.98 mg% during drying at 50°C (Table 1). It was observed that the loss of ascorbic acid was significantly higher in samples dried at 60°C than that of 50°C due to the oxidative losses of ascorbic acid at higher temperature.

Total sugar content of fruits increased from 15.78% to 16.05% during the osmosis at 70% sugar with 2% salt solution (Figure 3). The increment of total sugar content was due to the solute gain action during osmosis. This is support by Giraldo *et al.*, (2003) in which they reported that the increase in concentration of sucrose solution gave rise to sugar uptake during osmotic dehydration of mango. Total sugar content of the all samples were decreased during drying. This reduction was due to browning reactions and caramalization of sugars during drying at high temperatures. During heating, sugars undergo dehydration and produce complex polymers having different colour, flavour and aroma (Fennema, 2004). The samples dried at 60°C had significantly lower amount of total sugars compared to the samples dried at 50°C as a result of increased caramalization of sugars at higher temperature.

All the samples contained higher amount of crude fibre after the osmosis. This was due to the removal of water from the fruit tissues during the osmotic dehydration process (Ponting, 1973). Therefore, the fibre content per unit mass of tissue increased due to the removal of

water. Crude fibre content of fruits were increased from 0.94% to 1.01% during the osmosis at 70% sugar with 2% salt solution. Crude fibre in the all samples had the decreasing trend during the drying process due to the increased hydrolysis and degradation of fibres at high temperatures. The crude fibre content of jakfruit osmosed in 70% sugar with 2% salt solution reduced from 1.01% to 0.98% during drying at 50°C. The samples air dried at 50°C contained significantly higher amount of crude fibre compared to the samples air dried at 60°C (Table 2). This was due to the higher extent of thermal degradation of fibres at high temperature than that of low temperature.

Sensory Analysis

There were significant differences between the treatments for taste, colour, jakfruit flavour, texture, absence of browning and overall acceptability at 5% probability level (Table 3).

The jakfruit osmosed in 70% sugar with 2% salt solution and dried at 50°C had the highest preference rating for taste. Jeyaraman and Dasagupta (1992) reported that more sugar intake in highly concentrated solution increases the sweetness and consumer acceptability of the osmo-air dried fruit products. Fruit samples treated in 80% sugar with 2% salt and dried at 60°C (T_8) had the least preference for taste and jakfruit flavour. Sensory characteristics such as jakfruit flavour, colour, texture and absence of browning were also best in the jakfruit osmosed in 70% sugar with 2% salt solution and dried at 50°C because this treatment possessed attractive yellow colour with characteristics jakfruit flavour. The highest overall acceptability was observed in the jakfruit osmosed in 70% sugar with 2% salt solution and dried at 50°C because all the sensory qualities were most preferred by 91% of the tested panelists.

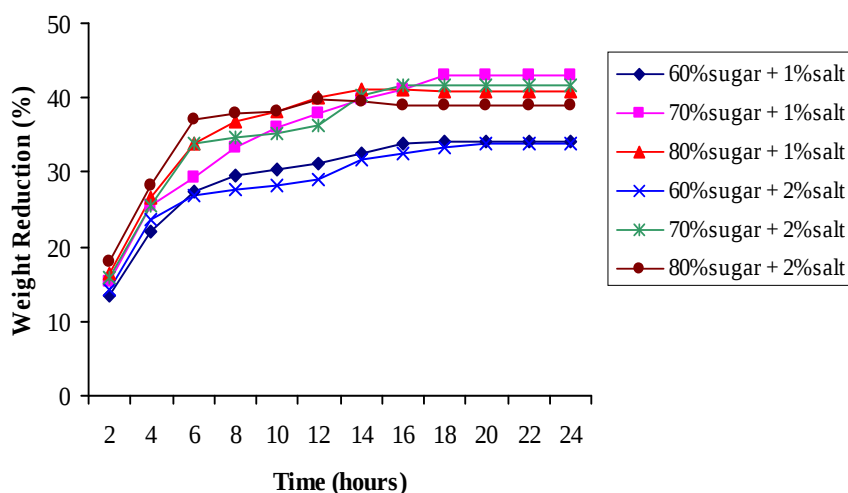
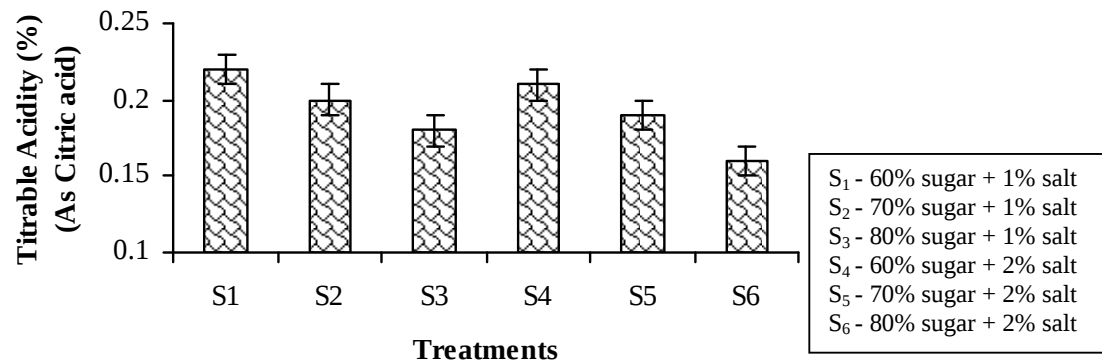
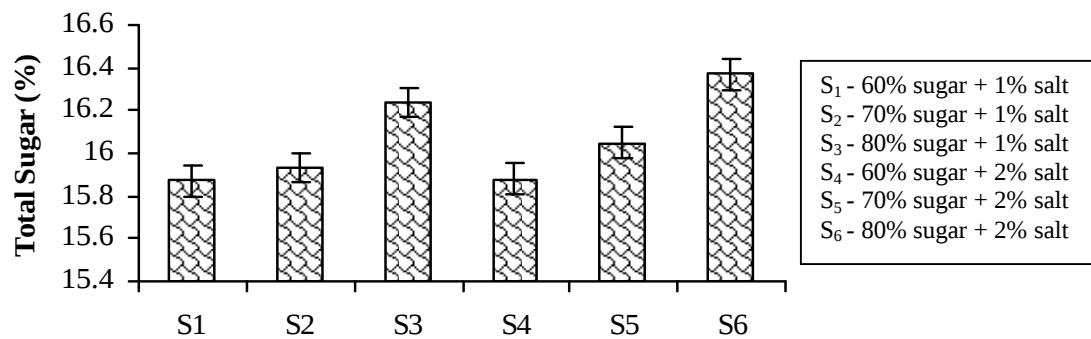


Figure 1- Changes in percentage weight reduction of jakfruit slices during osmosis



Values are means of triplicates.
Vertical bars indicate the standard errors.

Figure 2 - Titration acidity of jakfruit slices after osmosis



Values are means of triplicates.
Vertical bars indicate the standard errors.

Figure 3: Total sugar content of jakfruit slices after osmosis

Table 1: Ascorbic acid content of Jakfruit Slices after drying

Concentration (W/V)		Ascorbic acid Content (mg%)	
Sugar (%)	Salt (%)	50°C air drying	60°C air drying
70	1	6.03±0.01 ^a	4.78±0.12 ^a
80	1	5.93±0.10 ^b	4.68±0.09 ^b
70	2	5.98±0.02 ^a	4.73±0.17 ^a
80	2	5.90±0.12 ^b	4.65±0.11 ^b

Values are means of triplicates ± standard error.

Means in a column having the same letters are not significantly different at 5% level.

Table 2: Crude Fibre content of Jakfruit Slices after drying

Concentration (W/V)		Crude Fibre Content (%)	
Sugar (%)	Salt (%)	50°C air drying	60°C air drying
70	1	1.00±0.12 ^a	0.97±0.02 ^a
80	1	0.96±0.10 ^b	0.93±0.12 ^b
70	2	0.98±0.01 ^a	0.95±0.10 ^a
80	2	0.95±0.02 ^b	0.92±0.01 ^b

Values are means of triplicates ± standard error.

Means in a column having the same letters are not significantly different at 5% level

Table 3: Sensory Evaluation Scores for Osmo-air dried Jakfruit Slices

Treatments	Taste	Colour	Jakfruit Flavour	Texture	Absence of browning	Overall acceptability
T ₁	7.20 ^b	6.25 ^{bcd}	6.90 ^{ab}	6.90 ^a	5.40 ^{cd}	7.05 ^{bc}
T ₂	8.35 ^a	7.70 ^a	7.20 ^a	7.00 ^a	7.75 ^a	8.40 ^a
T ₃	6.75 ^b	6.40 ^{bcd}	6.55 ^{abc}	6.25 ^{ab}	6.40 ^b	7.25 ^b
T ₄	6.95 ^b	6.90 ^{bc}	6.15 ^{bc}	5.70 ^b	6.50 ^b	6.60 ^c
T ₅	5.65 ^{cd}	6.10 ^{cd}	5.30 ^{de}	6.95 ^a	5.85 ^{bc}	5.30 ^{de}
T ₆	5.65 ^{cd}	5.75 ^d	5.00 ^e	4.70 ^d	4.85 ^d	5.20 ^e
T ₇	6.00 ^c	7.00 ^{ab}	5.80 ^{cd}	5.50 ^{bc}	6.30 ^b	5.75 ^d
T ₈	5.15 ^d	6.45 ^{bcd}	4.80 ^e	4.80 ^{cd}	6.25 ^b	4.90 ^e

Nine point hedonic scale test, 1 – Dislike extremely 9 – Like extremely

Values are the means of two replications for sensory evaluation completed by 20 panelists.

Means in a column having the same letters are not significantly different at 5% level by Tukey's test.

CONCLUSIONS

Osmotic dehydration technique could reduce the postharvest losses of the soft fleshed variety of jakfruit. The fruits osmosed in 70% sugar with 2% salt solution showed higher weight reduction of 41.8% at the end of osmosis. After drying, jakfruit slices osmosed in 70% sugar with 2% salt solution and dried at 50°C possessed lower moisture content of 15.4%. At the end of the osmosis, there was a decrease in ascorbic acid and titrable acidity and an increase in total sugar and crude fibre of the jakfruit slices. After drying, all the physico-chemical characteristics were significantly lower at the drying temperature of 60°C than that of 50°C. The sensory analysis depicted that there were significant ($p < 0.05$) differences for the organoleptic characteristics between the treatments. The highest overall acceptability was observed in the jakfruit osmosed in 70% sugar with 2% salt solution and dried at 50°C. According to the results of weight reduction, physico-chemical and sensory analyses, it was concluded that osmotic solution of 70% sugar with 2% salt and drying temperature of 50°C were recommended as the best combination for osmo-air drying of jakfruit.

REFERENCES

- Association of Official Analytical Chemists. (2000). Official Methods of Analysis. (17th Edn). Washington, USA. pp. 8-14.
- Fennema, O. R. (2004). Carbohydrates. In: *Food Chemistry*. (5th Edn). CRC Press, USA. pp. 157-224.
- Gerschenson, L. N. (2000). Chemical and Physical Interactions between Components and their Influence on Food Stability. In: *Minimally Processed Fruits and Vegetables*. (Eds. C. Campos & A. M. Rajas). Aspen Publishers, USA. pp. 101-125.
- Giraldo, G., Talens, P. and Fito, P. (2003). Influence of sucrose solution concentration on kinetics and yield during osmotic dehydration of mango. *Journal of Food Engineering*. 58: 33-43.
- Jain, S. K. (2003). Osmotic dehydration: A new, promising and emerging industry. *Journal of beverage and food world*. 30(5): 30-34.
- Jeyaraman, K. S. and Dasagupta, D. K. (1992). Dehydration of fruits and vegetables - Recent developments in principles and techniques. *Drying Technology*. 10: 1-50.
- Kader, A. A. (1997). Processing and Preservation of Fruits. II. Drying and dehydration. Chapman & Hall Publishing Company, USA. pp. 175-207.
- Labuze, T. P. (1981). Prediction of moisture protection requirement for foods. In: *Cereal Food World*. Sankan Publishing Ltd., Thailand. pp. 345.
- Medagoda, I. (2003). Distribution, Diversity, Conservation and Evaluation of Jakfruit. *Agricultural Research News*, CARP. 3(4): 24-29.
- Moy, J. H., Lau, N. B. and Dollar, A. M. (1978). Effect of sucrose and acids on osmotic-dehydration of tropical fruits. *Journal of Food Processing and Preservation*. 2: 131-138.
- Ponting, J. D. (1973). Osmotic dehydration of fruits- Recent modifications and application. In: *Process Biochemistry*. Chapman and Hall, UK. pp.8-18.
- Rahman, M. D. S. and Lamb, J. (1990). Air-drying behaviour of osmotically dehydrated Pineapple. *Journal of Food Process Engineering*. 14: 163-171.
- Sebastiano, S. S. (2001). Heat Air-treatment of Blood orange fruit. *Journal of Food Chemistry*. 42(6): 28-64.