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Effect of Osmotic Dehydration on Physicochemical Properties of Pineapple using Honey, Sucrose and Honey-Sucrose Solutions

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***Abstract:** Demands for processed food products are rising worldwide and, consumers nowadays have adopted a healthy lifestyle and are always looking for the products which are advantageous for their health and have the characteristics and taste of a fresh commodity at the same time. Many techniques or combination of techniques have been tried to expand the shelf life of the perishable food commodities. One of the simplest methods which do not require sophisticated equipment is osmotic dehydration. Osmotic dehydration is an excellent phenomenon in which removal of water happens from an area of higher concentration to an area where concentration is lower through a membrane known as a semi-permeable membrane. Since osmotic dehydration lowers the water activity of food item; it has found broad application in the field of food material preservation. In this study pineapple cubes were dehydrated with osmotic dehydration followed by tray drying at 60°C were assessed for physicochemical properties such as moisture, ash, rehydration ratio, ascorbic acid, water activity, color parameters and sensory properties. Sucrose solution, honey solution and honey-sucrose solution were used as osmotic agents. Duncan's test was used to analyze the obtained data. Results showed that the pineapple sample cubes treated with honey sucrose solution at 50°C temperature were found to have better rehydration characteristics and lowest moisture content value as compared to the other samples. Sensory evaluation of all the samples revealed that highest scores were obtained by the sample containing both sucrose and honey (50°C). Highest ascorbic acid content after the osmotic dehydration was found in sample with sucrose and honey. Hence, sample with combination of sucrose and honey solution at 50°C proved to be the best in terms of nutritional quality, shelf stability and all other tested parameters. Therefore, many products with enhanced shelf life can be prepared using this rapid and economical technique.*

***Keywords:** food preservation, honey-sucrose solution, osmotic dehydration, physicochemical parameters*

I. INTRODUCTION

Pineapple (*Ananas comosus L.*), is from the botanical family known as bromeliaceous. It originally belongs to the American tropics. It contains plentiful of important nutrients which includes dietary fiber, ascorbic acid, antioxidants and vitamins and it also includes organoleptic properties (sourness/sweetness ratio, flavor, color, water) [16]. Pineapple can be consumed as raw and/or in processed/treated form [8].

Pineapple is a perishable commodity and has a short shelf life of 2-4 weeks 7-10ºC. Pineapple has a postharvest loss of about 10-15% of the total production [24]. Demands for processed food products are rising worldwide and, consumers nowadays have adopted a healthy lifestyle and are always looking for the products which are advantageous for their health and have the characteristics and taste of a fresh commodity at the same time [4]. This calls for a need for long time preservation of food products. One of the most well-known and economical methods to expand the shelf life of perishable food items is drying technology [9]. As per the recent study made by researches and potential application of osmotic dehydration, this technology has become popular and has gained more attention in comparison with other drying and dehydration methods in the food processing industry [18]. Osmotic dehydration is an excellent phenomenon in which removal of water happens from an area of higher concentration to an area where concentration is lower through a membrane. These membranes are called semi-permeable membranes in nature and thus allows the water molecules to pass through them much easier than solute molecules [15]. Osmotic dehydration is a technique that gives rise to two crucial synchronous mass transfer fluxes which are counter-current, specifically, water flow to the surrounding solution from the product and solute infusion into the product [3]. Since osmotic dehydration lowers the water activity of food item; it has found broad application in the field of food material preservation [12]. Osmotic dehydration plays a significant role in the preservation of fruits and vegetables, which adds value to the final product [20]. Osmotic dehydration has various advantages like this technique has been found suitable for retention of vitamins, minerals, color, flavor and taste properties of foods [12]. Osmotic dehydration is a low temperature water eviction process and which subsequently results in least loss of color and flavor. Secondly; Sugar or sugar syrups are used as an osmotic agent that helps in retention of flavor and other nutritional components. It decreases the load of the water removal on the dryer as it removes the water content in the product to some extent; hence, overall utilization of energy is lesser. This technique yields better-quality frozen products with elevated density because of taking up of solids. The shelf-life of the food item is significantly upgraded and, this process is easy to perform [22].

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Several osmotic agents can be utilized in the process of osmotic dehydration either individually or merging with other osmotic agents. For elevating the moving power, the osmotic agents should decrease the available water of the solution.

An ideal osmotic agent should constitute the following properties: it should be non-poisonous and non-irritating. It must have a great flavor and taste. The osmotic agent must be highly soluble to form any type of concentrated solution. The osmotic agent used must be cost-effective [12].

There are various factors which influence osmotic dehydration: Variables like ageing, diversity, pre-treatments, temperature, type and quantity of osmotic agent, whisking, conformation of the material, ratio of fruit slices to osmotic solution, physicochemical properties, added substance, composition and pressure influencing the osmotic dehydration process [22].

A study was conducted on osmotic dehydration of pineapple slices where sugar was used as an osmotic agent at three different temperatures as well as three different immersion time. This study showed that with an increase in time dipping, loss of water in pineapple also increases. A decrease in mass variation was directly proportional to the immersion time, solution concentration and temperature [5].

Studies have been reported on combined effect of honey, and sugar solution as osmotic agents on quality banana [10] but no study has been reported on combined effect of honey and sucrose as osmotic agent for quality evaluation of pineapple, therefore this study was planned to study the effect of sucrose, honey and sucrose- honey solutions on physicochemical quality parameters of pineapple.

II. MATERIAL AND METHODS

A. Osmotic Dehydration Treatment

The osmotic agents used were honey, sucrose and honey-sucrose solution. Honey has total soluble solids of 80ºbrix which was examined with the help of refractometer. Mixing in distilled water primed the sucrose solution and changed TSS until it exceeded 60ºbrix. The mixed solution of honey-sucrose was prepared (1:1), and TSS was 72ºbrix. Pineapple fruit cubes, previously weighed, were immersed in the osmotic solutions room temperature 30°C and at 50°C for 210 minutes. The weight ratio of fruit samples to the osmotic solution was maintained as 7:1 in the process. Samples were drained after extraction from the solutions and the excess liquid at the surface was collected for posterior weight with absorbent paper. Following nomenclature was given to different samples:

C (RT): Control sample at room temperature, i.e. pineapple cubes immersed in water at room temperature.

C (50ºC): Control sample at 50ºC, i.e. pineapple cubes dipped in water at 50ºC.

HS (RT): Honey solution at room temperature

HS (50ºC): Honey solution at 50ºC

SS (RT): Sucrose solution at room temperature

SS (50ºC): Sucrose solution at 50ºC

HSS (RT): Honey-sucrose solution at room temperature

HSS (50ºC): Honey-sucrose solution at 50ºC

B. Drying Experiments

Three temperatures were selected for standardization of drying temperature; i.e. 50°C, 60°C and 70°C. On the basis of ascorbic acid retention and sensory analysis, the temperature was standardized at 60°C. The pineapple cubes which underwent osmotic dehydration treatment were then properly arranged in a tray and kept in tray-dryer at 60°C to further get dried products. Airtight polythene bag was then used to store the samples underwent drying so that they can be used for further study.

Flow Chart:

Ripe Pineapple
↓
Washing & peeling
↓
Cubing (1.5×1.5×1.5) cm
↓
Osmotic dehydration
(Using three osmotic solutions at the specific time-temperature combination)
↓
Removing from solution and wiping the surface area
↓
Weighing
↓
Drying (Tray drier at 60ºC)
↓
Cooling and sealing (in polyethene)
↓
Storage (30ºC)

C. Estimation of moisture

The moisture content of the osmotically treated cubes of the pineapple was determined by the process of the hot air oven at 105ºC (AOAC, 1969).

$$\% \text{ Moisture} = \frac{W1-W2}{W1-WO} \times 100$$

WO = Weight of petri dish (g),

W1 = Weight of petri dish + sample (g),

W2 = Weight of petri dish + dried sample (g).

D. Estimation of total ash

The ash content was estimated according to the standardized AOAC at 500-550ºC.

$$\% \text{ Ash content} = \frac{\text{Weight after ashing}}{\text{weight before ashing}} \times 100$$

E. Determination of rehydration ratio

For determination of rehydration ratio, the dried samples were added to distilled water (1:10) and kept in a water bath for 20 minutes at 50ºC.

Then distilled water was drained off, and the surface of the cubes was blotted with tissue paper. Then the rehydration ratio was calculated using the following formula.

$$\text{Rehydration ratio} = \frac{\text{weight of reconstituted sample}}{\text{weight of dehydrated sample}}$$

F. Ascorbic acid

The ascorbic acid content of osmotically dehydrated pineapple samples was calculated using a standard titration method using 2,6-dicholorophenolindophenol dye [17] by as given below formula:

$$\text{Ascorbic acid content}\left(\frac{mg}{100g}\right) = \frac{\text{Tiitre value} \times \text{Dye factor} \times \text{volume made up}}{\text{Weight of the sample taken} \times \text{Aliquot weight of sample}} \times 100$$

G. Water activity

Water activity (Aw) was determined using an electronic water activity meter (Model HC2-AW, Rotronic measurement solution, Bassersdorf Switzerland).

H. Color analysis

Color was determined using 3nh portable color spectrophotometer (model NS810). The values of color were expressed as L*, a* and b*. The coefficient of lightness, L*, is between black = 0 and white = 100. Positive a* indicates red-purple and negative a* bluish-green, while positive b* indicates yellow and negative b* blue, respectively. The instrument was calibrated using black and white tiles and pre-evaluation testing of accuracy against standard tiles was performed. The browning index of the samples was calculated [19].

$$\text{Browning Index (BI)} = \frac{100\,(x-0.31)}{0.17}$$

Where,

$$x = \frac{a^*+1.75L^*}{5.645L^*+a^*-0.3012b^*}$$

I. Organoleptic evaluation of dried pineapple cubes

Organoleptic evaluation of dehydrated pineapple cubes was carried out. To compare the control samples with the formulated ones, 9-point hedonic rating scale was used. On each occasion, coded samples were given to the panelists for evaluation. Samples were tested for color, taste, texture, flavor and overall acceptability.

J. Statistical analysis

All the experiments were carried out in triplicate, and the data was used as an average value with standard deviations. Experimental and control values were compared by Duncan's multiple range test ($p<0.05$) using IBM SPSS (24 version).

III. RESULT AND DISCUSSION

A. Moisture content

The moisture content of dehydrated pineapple cubes significantly decreased with the increase in temperature. The initial moisture content of raw pineapple was found to be 86.67%. The moisture content was found to be highest in sample C (RT), which is 10.1%, followed by C (50ºC) (Table I). Moisture content found at HS (50ºC), SS (50ºC) and HSS (RT) were not statistically different (6.18, 5.96 and 5.74). It is evident from Table I that temperature greatly influenced the moisture content of dehydrated pineapple slices. Due to increased temperature, the moisture content of the samples was decreased as evaporation increases with increase in temperature [11]. The control samples took longer time to dehydrate as compared to the osmotically dehydrated treated samples as osmotic dehydration reduces the drying time which further directly relates with less effect on nutritional parameters of treated samples as compared to the control samples.

B. Ash content

The inorganic residue, which remains after the destruction of organic matter is known as ash content. The highest ash content was found in sample HSS (RT), which is 3.36. The values for sample C (RT), C (50ºC), SS (RT) and HSS (50ºC) were found to have no statistical difference (Table I). Singh et al. [20] reported similar findings.

C. Rehydration ratio

Rehydration ratio is used to quantify the capacity of water uptake during rehydration. It shows the ability of the material to regain its original property [13]. The extent of the freshness of the product can be judged by the extent of rehydration it gives. The values of rehydration ratio at different temperatures and different solutions were calculated, which are shown in Table I. It was observed that the rehydration ratio of samples treated with solutions resulted in highest rehydration as compared to the control samples. The statistical analysis explains that there are no significant differences ($p>0.05$) between values of sample HS (RT), HS (50ºC) and SS (RT). High rehydration ratio relates to more concentration of fruit components. Presence of more tissues might have helped in the absorption of more water resulting in higher rehydration ratio [16]. It is evident from Table I that the temperature was found significantly affecting the rehydration ratio of dehydrated pineapple slices with different solutions. With an increase in temperature, rehydration ratio also increases. This suggests that rapid rehydration can be achieved when the temperature of the water is high [14]. Highest rehydration ratio was observed in HSS (50ºC). A high rehydration ratio means that the dried material is of good quality because the pores allow water to enter the cells again [14].

D. Ascorbic acid

The highest amount of ascorbic acid was observed in the sample HSS (RT), followed by HSS (50ºC) (Table I). The statistical analysis explains that there are no significant differences ($p>0.05$) between values of sample HS (50ºC), i.e. 29.55 and SS (50ºC), i.e. 29.44. Temperature and type of sugar solution during osmotic dehydration have influenced on ascorbic acid content of pineapple cubes. The reduction in ascorbic acid content at higher temperatures shows that ascorbic acid is highly susceptible to drying temperature [23]. Similar results were reported by Ramallo and Mascheroni [16], where an increment of drying temperature increased the rate of ascorbic acid degradation. The increasing rate of ascorbic acid due to osmotic dehydration in pineapple cubes in different solutions shows that osmotic dehydration increases the nutritional value and thus yields a better-quality product. Best sample in terms of ascorbic acid content was found to be HSS (RT) and HSS (50ºC).

Table I: Physical parameters of tray dried pineapple cubes at different conditions

	Moisture (%)	Ash (%)	Rehydration ratio	Ascorbic acid (mg/100g)	Water activity (Aw)
C (RT)	10.1±0.22[a]	2.8±0.16[b]	1.45±0.13[f]	26.55±1.39[f]	0.53±0.005[a]
C (50°C)	8.88±0.48[b]	2.37±0.08[bc]	2.18±0.05[e]	22.57±0.86[g]	0.51±0.005[b]
HS (RT)	7.85±0.26[c]	2.1±0.07[c]	2.46±0.07[d]	34.67±1.08[d]	0.44±0.00[c]
HS (50°C)	6.18±0.53[d]	2.2±0.16[c]	2.74±0.11[c]	29.55±0.96[e]	0.32±0.01[f]
SS (RT)	7.76±0.02[c]	2.57±0.48[bc]	2.57±0.1[cd]	36.36±0.43[c]	0.44±0.01[c]
SS (50°C)	5.96±0.7[d]	2.18±0.16[e]	2.92±0.16[b]	29.44±0.46[e]	0.38±0.005[d]
HSS (RT)	5.74±0.39[d]	3.36±0.34[a]	3.09±0.06[ab]	40.41±0.51[a]	0.35±0.01[e]
HSS (50°C)	4.49±0.35[e]	2.43±0.3[bc]	3.22±0.05[a]	37.18±0.33[b]	0.29±0.005[f]

E. Water activity

The data recorded for Aw of osmotically dried pineapple cubes is presented in Table I. The difference in Aw of the samples was statistically significant. Table I clearly shows that the dried pineapple cubes have lower water activity confirming the water loss during the process and directly correlates with an increasing shelf life of the final product. Similar results were reported by Haqbeen [5]. It is evident from the table that the lowest water activity was shown by the sample HSS at 50ºC, which is 0.29. Declination in the water activity of the food product after osmotic dehydration results in no microbial growth as it makes the environment unfavorable for them [1]. As the temperature increases, water activity decreases which shows that water activity is temperature-dependent. Table I indicates that there was no statistical difference found between values of HS (RT) and SS (RT).

F. Color

Table II reveals that there are some differences in the L* values of dehydrated pineapple cubes, the minimum L* value observed was 65.1, whereas 68.41 was the highest observed L* value. While, in case of a* value, the maximum value observed was 7.06 and the lowest value recorded for a* was 0.87. Similarly, 41.53 was the highest b* value recorded, and 28.18 was the minimum b* value observed. During pineapple drying, variations in the L* values were not statistically significant; hence, it can be stated that this it was not affected by process temperature. Tsami and Katsioti [21] reported the similar observations during apple, banana, carrot and potato drying for L* values (notable scattering of values measured; without any inclination to change during the process). While, on the other side, the control sample contained significantly lower a* values. However, higher values of a* for the dried samples ($P<0.05$) were observed; as a result, more browning occurred. The most significant variation was the increase in a* value, which indicates the lowering of green pigmentation without an increase in the yellow color. Similar results were found by Chutintrasri and Noomhorm [2] for the variation of a* value. After the drying process, the increase in a* value and decrease in L* value was observed in all types of treatment ($P<0.05$). This is maybe due to an increased carotenoids content that caused by water loss. Similarly, Heredia et al. [6], due to increased water loss, reported an increase in β-carotene and lycopene content in cherry tomato. As drying proceeds, pineapple cubes tend to get darker as a result of non-enzymatic browning reactions. Hence, pineapple cubes become redder [7]. During drying, the relative visual yellow color (b value) was slightly increased [16]. Highest value of browning index was found in the HSS (50ºC), i.e. 12.46. There was no statistical difference found between samples HS (RT) and SS (RT). As the temperature increases, the browning index is increasing, which corresponds to an increase in a* values.

Table II: Color values of dried pineapple cubes at different temperatures

	L* value	a* value	b* value	Browning Index
C (RT)	67.77±0.94[ab]	0.87±0.34[f]	41.53±0.28[a]	7.11±0.42[f]
C (50°C)	65.1±0.39[cd]	1.46±0.26[e]	39.25±0.28[b]	7.7±0.39[e]
HS (RT)	67.35±0.52[b]	4.79±0.51[d]	32.56±0.82[c]	9.95±0.39[d]
HS (50°C)	65.82±0.38[c]	6.82±0.32[a]	29.12±0.7[e]	11.82±0.31[b]
SS (RT)	68.05±0.42[ab]	5.44±0.45[c]	30.64±1.2[d]	10.23±0.34[d]
SS (50°C)	65.26±0.38[cd]	7.06±0.09[a]	28.18±0.57[e]	12.02±0.2[ab]
HSS (RT)	68.41±0.59[a]	6.06±0.06[b]	32.27±0.86[c]	11.06±0.23[c]
HSS (50°C)	64.64±0.46[d]	7.13±0.2[a]	29.71±0.48[de]	12.46±0.21[a]

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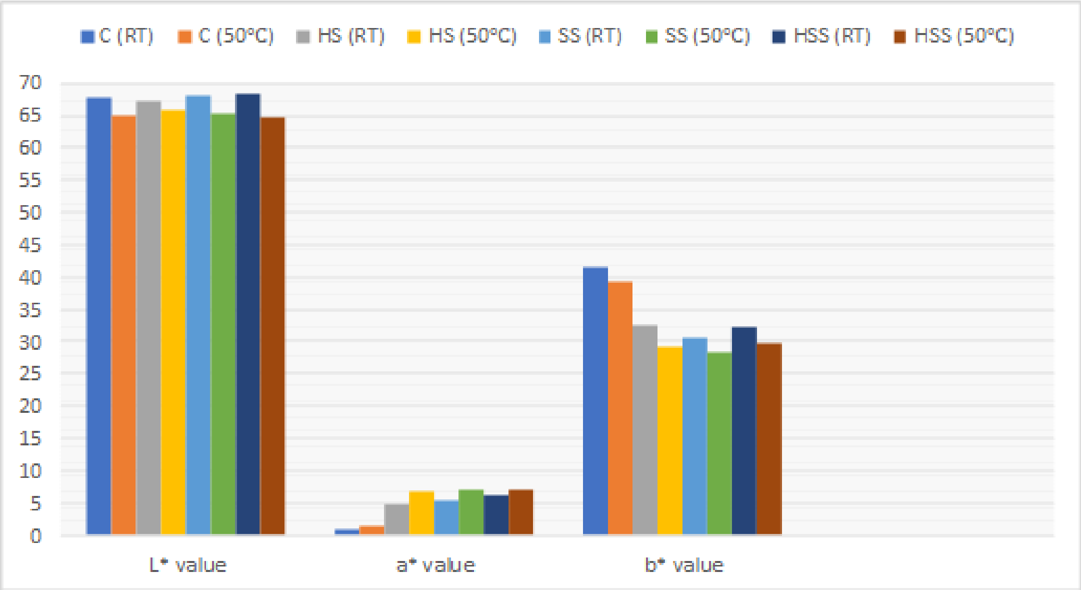

Fig. 1. L*, a* and b* values for different samples of dried pineapple

G. Organoleptic evaluation

Using eight test samples treated with different solutions and at different temperatures, sensory evaluation for the osmotically dehydrated pineapple cubes was carried out and with the help of a panel of fifteen members, these samples were evaluated. These samples were tested with the help of a semi-trained panelists. The data on the organoleptic evaluation in respect of texture, taste, color and overall acceptability of osmotically dehydrated pineapple cubes is presented in Table III. The color score of pineapple cubes was significantly affected by the temperature. Samples prepared at higher temperature scored better than the samples prepared at room temperature in terms of color. The most liked samples were HS (RT) and HSS (50ºC) due to the attractive brown color of honey in samples. The most liked sample in terms of taste was HSS (50ºC). This can be due to the reason that the rest of the samples became soggy, which lead to undesirable texture. Sample with both honey and sucrose solution was liked the most in terms of taste. This may be due to the use of both honey and sucrose in the sample which further increased the overall sweetness and taste of the sample. The minimum overall acceptability recorded was for the C (RT). Dried pineapple cubes scored better in terms of overall acceptability than the not dried one. The higher mean score of overall acceptability was observed in samples with the combination of honey and sucrose. This may be attributed due to the use of combination, which could maintain the shape and reduce shrinkage at the surface of Osmo-dried pineapple. The result of the sensory evaluation was in agreement with the result of different parameters tested.

Table III: Organoleptic evaluation data of dried pineapple cubes at different temperature

	Colour	Texture	Taste	Overall acceptability
C (RT)	4.66 ± 0.57^{bc}	3.33 ± 0.57^{d}	4.66 ± 0.57^{bc}	2.66 ± 0.57^{d}
C (50°C)	4.00 ± 0.00^{c}	5.33 ± 0.57^{c}	3.66 ± 0.57^{c}	3.00 ± 1.00^{d}
HS (RT)	7.66 ± 0.57^{a}	6.00 ± 1.00^{bc}	4.00 ± 1.00^{c}	5.00 ± 1.00^{c}
HS (50°C)	7.00 ± 1.00^{a}	7.00 ± 1.00^{ab}	6.00 ± 1.00^{ab}	6.00 ± 1.00^{bc}
SS (RT)	5.33 ± 0.57^{b}	5.00 ± 0.00^{c}	6.33 ± 1.52^{ab}	7.00 ± 1.00^{ab}
SS (50°C)	7.00 ± 1.00^{a}	5.66 ± 1.15^{bc}	6.33 ± 0.57^{ab}	7.66 ± 0.57^{a}
HSS (RT)	6.66 ± 0.57^{a}	6.33 ± 0.57^{abc}	7.00 ± 1.00^{a}	8.33 ± 0.57^{a}
HSS (50°C)	7.66 ± 0.57^{a}	7.66 ± 0.57^{a}	7.66 ± 0.57^{a}	8.33 ± 0.57^{a}

IV. CONCLUSION

This study was focused on Osmotic Dehydration of Pineapple cubes with the help of three different osmotic agents, i.e. Sucrose, Honey and Sucrose-Honey solution at room temperature and at 50ºC with immersion timing 3 hours and 30 min respectively aided with subsequent dehydration at 60ºC in tray dryer. Drying time for control sample was 8 hours whereas for osmotically dehydrated treated samples it reduced to 5 hours. This study was conducted to evaluate the type and temperature of osmotic solution. Both sucrose and honey proved to be a potential osmotic agent for the successful osmotic dehydration of pineapple. Various parameters were tested to evaluate the best sample. The pineapple sample cubes which were treated with Honey Sucrose solution at 50ºC temperature showed the better rehydration characteristics and lowest moisture content value.

The temperature of osmotic solution was found to have a great effect on value of rehydration ratio and moisture. The pineapple sample cubes which were treated with Honey Sucrose solution (50ºC) are found to best in terms of sensory characteristics. The treatments which were applied to the different osmotic solutions were found to have considerable effect on the different parameters tested for sensory evaluation. Sample with a combination of both the solutions could maintain the shape of the finished product. Also, least value of water activity was found in the sample HSS (50ºC), i.e. 0.29 whereas, sample C (RT) showed the highest value of water activity (0.53). This directly shows that the sample HSS (50ºC) will have greater shelf life and thus would be better as compared to the other samples. Osmotic dehydration is a technique which acts as a preservation technique without decreasing the nutritional content of food products. The sample which was treated with both the solutions at 50ºC was found to be highest in ascorbic acid content. Sample with both sucrose and honey solution at 50ºC proved to be the best in terms of nutritional quality and shelf stability. Further, more advanced technique can also be used in the place of tray drying e.g. vacuum drying can be done at a lower temperature and at a faster rate. Hence, nutritional value of the product can be enhanced with low drying time. Also, combination of different osmotic agents can also be used for further study.

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