

Original Research Article

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## Standardization and Quality Evaluation of Osmotically Dried Whole Strawberries

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### ABSTRACT

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Strawberry (*Fragaria x ananassa* Duch.) is an edible red fruit which is attractive, luscious, tasty and nutritious with a distinct pleasant aroma and delicate flavour. Strawberries have a short postharvest life due to sensitivity to physiological disorders and infection through several pathogens during transport, storage and processing. In order to enhance the shelf life of strawberries, whole ripe strawberries were treated with osmotic agents viz. sugar and honey (50, 60 and 70%) for the preparation of strawberry candy followed by packing in polypropylene bags and storage in ambient conditions for shelf life studies. On the basis of the evaluation of range of quality parameters, it was observed that osmotic drying of whole strawberries is possible with different concentration of sugar and honey and retained fresh like characteristics up to 3 months of storage under ambient condition in polypropylene bags. Osmotic drying enhanced the acidity of freshly dried whole strawberries from 0.36 to 0.42 per cent as citric acid and sugar content from 13.21 to 66.38 °Brix. Better retention of ascorbic acid (62.40 mg/100g) and anthocyanin contents (229.66 mg/100g) was observed after dipping and drying with sugar solution as compared to control samples having 32.41 and 89.38 mg/100g ascorbic acid and anthocyanin content. The overall acceptability scores (sensory scores) were higher after osmotic drying of strawberries when compared to control sample (strawberries dried without any osmotic agent). Osmotically drying of strawberries is an effective treatment for extending shelf life of strawberries for three months with better retention of nutritional and sensory characteristics.

### Introduction

Strawberry (*Fragaria ananassa*) is one of the important fruit belonging to family *Rosaceae* and is nutritionally rich source of vitamin C, organic acids, anthocyanin, phosphorus, iron, flavonoids, malic acid and other minerals

(Sabina, 2011). The fruit is widely appreciated for its typical aroma, bright red fruit color and juicy texture. Nutritionally, strawberry contains low calorie carbohydrate and a potential source of vitamin C than oranges. The main composition per 100 g of fresh strawberries are 91.75 g water, 7.02 g

carbohydrate, 2.3g fiber, 14.0 mg calcium, 166.0 mg potassium and 64.4mg vitamin C with 27 IU of vitamin A (Dilip, 2016). Strawberries are rich source of diverse range of phytochemicals especially anthocynin, ellagic acid, catechin, quercetin and kemferol alongwith vitamins, fibre and folic acid, that can contribute towards maintenance of good health (Battino *et al.*, 2009; Astawan, 2009). Once harvested strawberries are extremely perishable and have precision postharvest handling requirement. The reason behind their short postharvest is susceptibility towards mechanical injury, physiological deterioration and decay. With the beginning of loss of membrane integrity, the loss of the fruit quality starts leading to senescence (Vu *et al.*, 2001).

The berries are consumed in large quantities, either as fresh or in processed foods like preserves, juices, bakery products, ice creams and shakes. It is also used for the production of purees, juice concentrate, jams and red wine alone or in combination with other fruits (Mehriz *et al.*, 2013). The fruits are attractive, luscious, tasty and nutritious with a distinct and pleasant aroma and delicate flavour. But the disadvantage is that the attractive red colour of strawberry juice is highly degraded due to heat processing (Rodrigo and Hendrickx, 2007). Seasonality is one of the key factors which determine the need for fruit processing primarily for juices, beverages and concentrates, but also for solids and frozen or dried products (Sunjka *et al.*, 2004). Short shelf life of strawberries resulted in various technological processes, mainly freezing and processing into jams or beverages for enhancing its utilization. Drying is one of the most important methods that enhance the possibility of extending the shelf life of strawberries and also manufacturing a wide range of new products. In addition, pre-treatment processes such as osmotic dehydration with various solutions are used to

ensure the desired nutritional and sensory properties of dried products (Kowalska *et al.*, 2017). The most commonly used osmotic substances are sugar and honey. The functionality of fruits can be improved by using an osmotic process to enrich them with functional ingredients. Because of the higher osmotic pressure of the infusion medium, dehydration as well as osmotic exchange of dissolved sugars and ingredients takes place, resulting in the infusion of solids into fruit. Partially dehydrated fruits prepared in this way can be added to food products such as desserts, yogurt, ice-cream and baked goods (Azizah, 2013). In addition, with further drying the infused fruits can be used in dry cereals and snacks. The aim of this study was to analyze sugar and honey as an osmotic substance to enhance bioactive properties of dried strawberries that is rich in nutrients for consumption and utilization for the preparation of various new products.

## **Materials and Methods**

Fully ripe, even sized bright red coloured strawberries were purchased from the local market. The bruised and diseased fruits were sorted out and only healthy and uniform sized fruits were selected for the study. The stalks were removed with the help of knife. The selected whole fruits were washed by treating with chlorine solution (200 ppm) for 10 minutes and were then air dried for further use. The air dried whole strawberry fruits were divided into seven lots (400g each). Out of these, six lots were immersed in three different concentrations of sugar solution (50, 60 and 70°Brix) and honey (50, 60 and 70°Brix) with Sodium benzoate as chemical preservative. After three days, the strawberries were removed from the solution and excess of sugar and honey syrup was removed followed by freeze drying. One lot (control) was directly freeze dried. Freeze dried whole strawberries were packed in polypropylene bags and kept

at ambient room temperature for analysis and shelf life studies. The observations for various physico-chemical parameters were recorded at an interval of 30 days. The recorded data were subjected to statistical analysis by adopting factorial CRD.

### **Chemical characteristics**

The total soluble solids (TSS) of the fruit juice were determined using a hand refractometer and expressed as per cent TSS after making the temperature correction at 20°C. AOAC (2004) method was used to determine the moisture content of osmotically dried strawberries. The titratable acidity was estimated as per standard procedures by treating against sodium hydroxide solution (Ranganna, 2008). Ascorbic acid content was determined by the procedure of Sadasivam and Manicham (2008) using 2, 6-dichlorophenol indophenol dye. Anthocyanin estimation was made as per the procedure cited in hand book of analysis and quality control. Five ml of nutraceuticals prepared from juice sample was taken in 100 ml conical flask and 50ml of 0.1N HCl was added. It was shaken well for 10 minutes in mechanical shaker and kept in dark place for one hour. The absorbance was measured at 510 nm against blank. A standard curve was plotted on graph showing absorbance against the standard (Ranganna, 2008). The overall organoleptic rating of the fruits was done by a panel of ten judges on the basis of colour, flavour (taste + aroma), texture and overall quality rating was calculated making use of a nine point Hedonic scale (Amerine *et al.*, 1965). The data were analyzed statistically in completely randomized design.

### **Results and Discussion**

Table 1 presents the moisture per cent and titratable acidity per cent of osmotically dried strawberries. The moisture per cent increased

with the increasing level of sugar and honey and the values were 12.100, 13.840 and 14.230 per cent in control, in osmotically dried strawberries containing 70 per cent sugar and strawberries dried with 70 percent honey. However, during storage the mean moisture content increased from 14.347 to 16.241 per cent in polypropylene bags, which might be due to absorption of small quantities of moisture by the stored products. Gawale (2014) also reported an increasing trend in moisture content of pineapple-papaya blended leather during 3 months of storage period. Similar trend of increase in moisture during storage has been recorded by Khadtar (2011) in jackfruit bar and Sadawarte (2014) in jamun leather. Titratable acidity on the other hand increased with increase in the level of sugar and honey. The lowest acidity of 0.36 per cent was found in strawberries dried without any osmotic agent but addition of sugar and honey at 60 per cent level resulted in osmotic dried strawberries with 0.39 and 0.40 per cent acidity. The results are in agreement with the conclusions of Ali *et al.*, (1999) who observed an increase in titratable acidity during preservation of persimmon slice. Similar results were investigated by Kumar *et al.*, (2008) in osmotically vacuumed dried mango slice and Khan *et al.*, (2014) in osmotically dried strawberries. The increase in acidity might be due to development of acidic substances by the degradation of pectic bodies or breakdown or oxidation of reducing sugar into acid due to high temperature.

The data in Table 2 reveals that the ascorbic acid content of the leather showed increasing trend with the increasing level of osmotic agents. The combined mean of ascorbic acid increased from 23.24 mg/100g in T<sub>1</sub> (control) to 53.95 mg/100g in T<sub>3</sub> (60°Brix sugar) and 46.11 mg/100g in T<sub>6</sub> (60°Brix honey). Significantly higher vitamin C content was determined by Kowalska *et al.*, (2018) in dried strawberries previously subjected to osmotic

dehydration than in those with no pre-treatment. According to Santos and Silva (2008), Heng *et al.*, (1990) and Vial *et al.*, (1991), the protective effect on vitamin C can be attributed to the use of sugar as osmotic substance. As indicated by Santos and Silva (2008), the mechanism of vitamin C degradation primarily depends on water content. The statistical analysis revealed significant differences in the mean values for ascorbic acid during storage and the values decreased during storage due to oxidation of ascorbic acid to dehydroascorbic acid. The oxidative reactions also results in decreased ascorbic acid content of the product during storage (Dalip, 2016). Similar results were observed by Gawale (2014) in pineapple-papaya blended leather, Khan *et al.*, (2014) in guava bar, Shakoor *et al.*, (2015) in guava bar, Chandane (2015) in aonla-mango blended leather during 3 months of storage at ambient conditions

TSS in finished dried strawberries was affected with the addition of sugar and honey and the maximum mean TSS of 66.38°Brix was observed in T<sub>4</sub> (70°Brix sugar) when prepared fresh. Significant changes were observed in TSS during storage and the mean values decreased from 57.41 to 55.96 during 90 days of storage. The trend of decrease in TSS during storage has also been reported by Parekh *et al.*, (2015) in mango bar fortified with desiccated coconut powder. Gawale (2014) and Venilla (2004) also reported similar decrease in TSS values of guava-papaya fruit bar and pine-apple papaya blended leather, respectively.

The anthocyanin is an important parameter for assessing the acceptability of the product. A perusal of data in Table 3 depicts that at 0 day the anthocyanin content were observed highest 229.66 (mg/100g) in treatment T<sub>3</sub> (60°Brix sugar). During storage, the mean anthocyanin content decreased from 178.97 to 130.83

mg/100g. The lowest mean anthocyanin content of 73.99 mg/100g was observed in T<sub>1</sub> (control) followed by T<sub>7</sub> (70°Brix honey) having anthocyanin content of 131.95mg/100g. The treatment storage interaction was observed to be significant.

Loss of anthocyanin in osmo dried strawberries might be due to their high susceptibility to auto-oxidative degradation and due to heat degradation during storage (Sherzad *et al.*, 2017). More retention of this characteristic in the product might be due to slower rate of auto oxidation of anthocyanin in the refrigerated storage condition, than ambient condition (Thakur *et al.*, 2013 and Gemenez *et al.*, 2001). Perusal of data further indicates that sensory score for overall acceptability was highest (8.50) in T<sub>3</sub> (60°Brix sugar) followed by 8.20 in T<sub>4</sub> (70°Brix sugar). However, the lowest mean overall acceptability of 7.15 was obtained in T<sub>1</sub> (Control). Treatment T<sub>3</sub> (60°Brix sugar) was rated best organoleptically, which might be due to better sugar acid blend of the product. These results are in commerce with Sabrina *et al.*, (2009) who observed decline in the overall acceptability of osmo dehydrated mango slices with inverted sugar syrups and with sucrose syrup Sabina *et al.*, (2011). Gamboa-Santos *et al.*, (2014) performed sensory evaluation of dried and rehydrated strawberries reported higher flavor and texture values for the freeze dried fruit compared to the convection-microwave-vacuum dried samples.

It can be concluded from the study that the osmo dried strawberries prepared after dipping in 60°Brix sugar followed by freeze drying had the best organoleptic quality. The mean values of TSS, anthocyanin and ascorbic acid increased significantly with the increase in sugar content. Therefore, best quality osmo dried strawberries can be prepared by using sugar syrup of concentration 60°Brix having shelf life of 3 months

**Table.1** Effect of osmotic agents on Moisture content and Titratable acidity of osmotically dried whole strawberries

|   | Moisture (%)   |               |               |               |               | Titratable acidity (%)   |              |              |              |              |
|---|----------------|---------------|---------------|---------------|---------------|--|--------------|--------------|--------------|--------------|
|   | Storage (days) |               |               |               |               | Storage (days)   |              |              |              |              |
|   | 0              | 30            | 60            | 90            | Mean          | 0  | 30           | 60           | 90           | Mean         |
| <b>T<sub>1</sub> (Control)</b>  | 12.100         | 12.560        | 13.040        | 13.860        | <b>12.890</b> | 0.460  | 0.410        | 0.370        | 0.360        | <b>0.400</b> |
| <b>T<sub>2</sub> (50 °Brix sugar)</b>   | 14.350         | 15.020        | 15.750        | 16.210        | <b>15.333</b> | 0.480  | 0.440        | 0.410        | 0.380        | <b>0.428</b> |
| <b>T<sub>3</sub> (60 °Brix sugar)</b>   | 14.000         | 14.800        | 15.530        | 16.030        | <b>15.090</b> | 0.520  | 0.450        | 0.410        | 0.390        | <b>0.443</b> |
| <b>T<sub>4</sub> (70 °Brix sugar)</b>   | 13.840         | 14.650        | 15.020        | 15.660        | <b>14.793</b> | 0.550  | 0.490        | 0.450        | 0.420        | <b>0.478</b> |
| <b>T<sub>5</sub> (50 °Brix honey)</b>   | 14.590         | 15.190        | 15.820        | 16.560        | <b>15.540</b> | 0.490  | 0.420        | 0.390        | 0.370        | <b>0.418</b> |
| <b>T<sub>6</sub> (60 °Brix honey)</b>   | 14.320         | 15.140        | 15.760        | 16.240        | <b>15.365</b> | 0.500  | 0.430        | 0.410        | 0.400        | <b>0.435</b> |
| <b>T<sub>7</sub> (70 °Brix honey)</b>   | 14.230         | 14.840        | 15.210        | 16.130        | <b>15.103</b> | 0.540  | 0.470        | 0.440        | 0.410        | <b>0.465</b> |
| <b>Mean</b>   | <b>14.347</b>  | <b>15.029</b> | <b>15.590</b> | <b>16.241</b> |               | <b>0.390</b>   | <b>0.444</b> | <b>0.411</b> | <b>0.506</b> |              |
| <b>CD</b> (P = 0.05)<br><b>Treatments (A) = 0.094</b><br><b>Storage (B) = 0.056</b><br><b>A×B = 0.148</b> |                |               |               |               |               | <b>CD</b> (P = 0.05)<br><b>Treatments (A) = 0.025</b><br><b>Storage (B) = 0.019</b><br><b>A×B = NS</b> |              |              |              |              |

**Table.2** Effect of osmotic agents on TSS and Ascorbic acid content of osmotically dried whole strawberries

|  | TSS (°Brix)    |              |              |              |              | Ascorbic acid (mg/100g)   |               |               |               |               |
|--|----------------|--------------|--------------|--------------|--------------|---|---------------|---------------|---------------|---------------|
|  | Storage (days) |              |              |              |              | Storage (days)  |               |               |               |               |
|  | 0              | 30           | 60           | 90           | Mean         | 0   | 30            | 60            | 90            | Mean          |
| <b>T<sub>1</sub> (Control)</b>   | 13.84          | 13.67        | 13.44        | 13.21        | <b>13.54</b> | 32.410  | 24.290        | 20.320        | 15.930        | <b>23.238</b> |
| <b>T<sub>2</sub> (50 °Brix sugar)</b>  | 64.73          | 64.49        | 64.21        | 63.27        | <b>64.18</b> | 55.800  | 50.360        | 44.340        | 37.750        | <b>47.063</b> |
| <b>T<sub>3</sub> (60 °Brix sugar)</b>  | 66.92          | 66.46        | 66.18        | 65.22        | <b>66.20</b> | 62.400  | 56.760        | 51.310        | 45.320        | <b>53.948</b> |
| <b>T<sub>4</sub> (70 °Brix sugar)</b>  | 67.75          | 67.27        | 66.90        | 66.38        | <b>67.08</b> | 61.310  | 53.700        | 46.450        | 38.990        | <b>50.113</b> |
| <b>T<sub>5</sub> (50 °Brix honey)</b>  | 62.23          | 61.80        | 61.07        | 60.66        | <b>61.44</b> | 51.000  | 44.510        | 38.370        | 31.160        | <b>41.260</b> |
| <b>T<sub>6</sub> (60 °Brix honey)</b>  | 62.98          | 62.33        | 61.79        | 61.16        | <b>62.07</b> | 55.120  | 48.500        | 43.580        | 37.250        | <b>46.113</b> |
| <b>T<sub>7</sub> (70 °Brix honey)</b>  | 63.43          | 62.87        | 62.30        | 61.82        | <b>62.61</b> | 54.070  | 46.130        | 40.040        | 32.730        | <b>43.243</b> |
| <b>Mean</b>  | <b>57.41</b>   | <b>56.98</b> | <b>56.56</b> | <b>55.96</b> |              | <b>53.159</b>   | <b>46.321</b> | <b>40.630</b> | <b>34.161</b> |               |
| <b>CD (P = 0.05)</b><br><b>Treatments (A) = 0.04</b><br><b>Storage (B) = 0.03</b><br><b>A×B = 0.08</b> |                |              |              |              |              | <b>CD (P = 0.05)</b><br><b>Treatments (A) = 0.410</b><br><b>Storage (B) = 0.310</b><br><b>A×B = 0.820</b> |               |               |               |               |

**Table.3** Effect of osmotic agents on anthocyanin and overall acceptability scores of osmotically dried whole strawberries

|   | Anthocyanin (mg/100g) |                |                |                |                | Overall acceptability scores  |             |             |             |             |
|---|-----------------------|----------------|----------------|----------------|----------------|---|-------------|-------------|-------------|-------------|
|   | Storage (days)        |                |                |                |                | Storage (days)  |             |             |             |             |
|   | 0                     | 30             | 60             | 90             | Mean           | 0   | 30          | 60          | 90          | Mean        |
| <b>T<sub>1</sub> (Control)</b>  | 89.380                | 84.320         | 71.880         | 50.360         | <b>73.985</b>  | 7.70  | 7.20        | 7.00        | 6.70        | <b>7.15</b> |
| <b>T<sub>2</sub> (50 °Brix sugar)</b>   | 213.380               | 187.430        | 162.170        | 156.290        | <b>179.818</b> | 8.03  | 7.91        | 7.80        | 7.57        | <b>7.83</b> |
| <b>T<sub>3</sub> (60 °Brix sugar)</b>   | 229.660               | 201.200        | 180.430        | 173.400        | <b>196.173</b> | 8.50  | 8.20        | 8.03        | 7.90        | <b>8.16</b> |
| <b>T<sub>4</sub> (70 °Brix sugar)</b>   | 220.390               | 194.610        | 171.240        | 168.110        | <b>188.588</b> | 8.20  | 8.07        | 7.80        | 7.72        | <b>7.95</b> |
| <b>T<sub>5</sub> (50 °Brix honey)</b>   | 166.040               | 149.240        | 135.560        | 122.650        | <b>143.373</b> | 7.98  | 7.76        | 7.69        | 7.53        | <b>7.74</b> |
| <b>T<sub>6</sub> (60 °Brix honey)</b>   | 183.220               | 167.660        | 146.520        | 130.090        | <b>156.873</b> | 7.80  | 7.72        | 7.61        | 7.45        | <b>7.65</b> |
| <b>T<sub>7</sub> (70 °Brix honey)</b>   | 150.740               | 135.000        | 127.130        | 114.920        | <b>131.948</b> | 7.69  | 7.56        | 7.29        | 7.11        | <b>7.41</b> |
| <b>Mean</b>   | <b>178.973</b>        | <b>159.923</b> | <b>142.133</b> | <b>130.831</b> |                | <b>7.99</b>   | <b>7.77</b> | <b>7.60</b> | <b>7.43</b> |             |
| <b>CD (P = 0.05)</b><br><b>Treatments (A) = 1.140</b><br><b>Storage (B) = 1.040</b><br><b>A×B = 1.280</b> |                       |                |                |                |                | <b>CD (P = 0.05)</b><br><b>Treatments (A) = 0.41</b><br><b>Storage (B) = 0.03</b><br><b>A×B = 0.088</b> |             |             |             |             |

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