Research Article

# Standardization of Drying Conditions for Production of Osmotically Dehydrated Whole Aonla Fruits

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**Abstract**

The optimized osmotically pretreated samples were subjected to drying till the final moisture content to 11-12 % w.b (Kumar *et al*., 2006). Drying experiments were performed in cabinet type laboratory hot air tray dryer. The dryer was adjusted to the selected temperatures (50, 60, 70, 80 °C). For the production of superior quality osmotically dehydrated Aonla for longer shelf life, the blanched Aonla of *Gujarat Aonla II* variety should be pretreated at 30 min ultrasonication time, 6:1 solution to fruit ratio, 58 °Brix sugar syrup concentration and 50 h osmotic time. The pretreated sample should be dried at 60 °C temperature using hot air tray dryer and packed in HDPE pouches (200 gauge) and stored at ambient temperature (30±2 °C) for 210 days. The production cost of osmotically dehydrated Aonla fruit was found to be Rs.155/kg.

**Keywords:** Osmotic, ultrasonication, blanching, whole aonla, drying, shelf life

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## Introduction

Osmotic dehydration is a process in which partial water is removed by immersion of water containing a cellular solid in a concentrated aqueous solution of high osmotic media (hypertonic media) for a specified time. It has potential advantages of less heat damage, good blanching effect, less enzymatic browning, better retention of flavor, colour, texture and energy saving because no phase change occurs. New methodologies, such as ultrasound-assisted osmotic dehydration, have been implemented as an alternative pretreatment associated to drying procedures. Reduction of drying time as well as processing costs have recently been reported at the experimental scale after research conducted on several horticultural commodities [1, 2]. Ultrasound has been recently studied and applied as a pretreatment to drying techniques and has shown positive effect on the mass transfer rate during drying [3]. Combination of osmotic dehydration and ultrasound process can be applied as a non-thermal pretreatment for saving energy, accelerate drying rate and reducing product quality damage. Ultrasound power produces cavitations of bubbles, causes making microscopic channels, which leads to lower resistance to water diffusion and subsequently enhancing drying rate [4], [5]. Osmotic dehydration of whole Aonla is novel phenomena to keep the fruit intact after drying helps in reduction in laborious job of cutting Aonla into slices as well as more retention of ascorbic acid by reducing oxidation losses.

## Materials and Methods

Optimization of Osmotic Dehydration Process of whole Aonla Fruit was carried out as [6]. The process parameters for osmotic dehydration process were ultrasonication time, solution to fruit ratio, sugar syrup concentration and osmotic time. The optimum conditions for maximum mass reduction and water loss as well as minimum solid gain and ascorbic acid loss were 30 min ultrasonication time, 6:1 solution to fruit ratio, 58°Bx sugar syrup concentration and 50 h osmotic time. The optimized osmotically pretreated samples were subjected to drying till the final moisture content to 11-12 %w.b [7]. Drying experiments were performed in cabinet type laboratory hot air tray dryer (Make: Navrang Scientific Works Pvt. Ltd., New Delhi), fitted with manually controlled digital thermostat, PT-100 thermocouple. The dryer was adjusted to the selected temperatures (50, 60, 70 & 80 °C) for about half an hour before the start of the experiment to achieve the steady state condition. Air velocity was set at 1.0 m/s and maintained by adjustable flap throughout drying time and measured by digital anemometer. Then pretreated samples were uniformly spread on the tray for drying operation. The commercially available osmotically dehydrated whole Aonla were procured from market (control sample) for optimization of drying temperatures for osmotically pretreated Aonla.

The dried samples were evaluated for bio-chemical, textural and sensory attributes. The samples were packed in HDPE bags (200 gauge) [7] and analyzed for its shelf life at ambient storage condition (30±2 °C). Moisture content was estimated using gravimetric method [8]. Protein content of the sample was determined using Micro-Kjeldahl method as per AOAC [9]. Ash content, acidity, total sugars, ascorbic acid and microbial analysis were carried out according to the procedure described by [10]. The sample was analyzed for non-enzymatic browning using the technique developed by [11]. For the sensory evaluation of osmotically dehydrated whole Aonla fruit, the samples were evaluated using a 9 point hedonic rating test. The texture profile analysis test was performed for dried Aonla sample using texture analyzer (Model: TA-HDi, Make: Stable Micro Systems, U.K).

## Results and Discussion

Drying temperatures significantly affected ascorbic acid, hardness and non-enzymatic browning and sensory attributes of osmotically dehydrated Aonla (**Table 1** and **2**).

**Table 1** Effect of drying temperature on ascorbic acid, hardness and non-enzymatic browning of osmotically dehydrated Aonla

| Drying Temperature (°C) | Ascorbic acid (mg/100g) | Hardness (N) | Non enzymatic browning (OD) |
|---|---|---|---|
| 50 | 235.21 | 6.92 | 0.05 |
| 60 | 213.00 | 7.21 | 0.08 |
| 70 | 188.13 | 7.47 | 0.11 |
| 80 | 170.75 | 7.58 | 0.13 |
| Control | 162.93 | 4.58 | 0.04 |
| SEm | 0.816 | 0.033 | 0.001 |
| CD (0.05) | 2.46 | 0.101 | 0.003 |
| CV% | 0.84 | 0.989 | 1.98 |

**Table 2** Effect of drying temperatures on sensory attributes of osmotically dehydrated Aonla

| Sensory attributes | Drying Temperature (ºC) | | | | Control | SEm | CD (0.05) | CV% |
|---|---|---|---|---|---|---|---|---|
| | 50 (T1) | 60 (T2) | 70 (T3) | 80 (T4) | | | | |
| Colour and appearance | 7.14 | 7.50 | 5.71 | 5.07 | 6.57 | 0.353 | 1.020 | 14.606 |
| Texture | 7.43 | 7.43 | 6.07 | 5.36 | 6.93 | 0.236 | 0.682 | 9.407 |
| Taste | 7.07 | 7.64 | 5.93 | 5.00 | 6.64 | 0.298 | 0.860 | 12.208 |
| Overall acceptability | 7.43 | 8.00 | 6.36 | 5.50 | 6.50 | 0.224 | 0.648 | 8.785 |

Data from Table 1 revealed that during drying, the significantly higher ascorbic acid content (235.21mg/100g) was found at 50°C drying temperature as compared to the rest of temperatures. Minimum ascorbic acid content was found (170.75 mg/100g) when the Aonla was dried at 80 °C temperature, while the control sample had lowest ascorbic acid (162.93 mg/100g). A decreasing trend of ascorbic acid content was found with increase in drying temperature. It might be because of the ascorbic acid gets degraded when it is being exposed to higher temperature. Similarly, an increasing trend in hardness was found with increase in temperature. During tray drying, maximum hardness (7.58 N) was found for sample prepared at 80 °C drying temperature and the minimum hardness (6.92 N), when it was dried at 50 °C, while control sample had lowest hardness (4.58 N) values. This may be due to product loses its moisture from surface very fast at higher temperature and problem of case hardening occurs, so dehydrated Aonla becomes harder in texture. When the Aonla were dried at different temperatures, increasing trend of non-enzymatic browning was found with increase in temperature. During tray drying, the maximum non enzymatic browning (0.13) was found for sample prepared at 80 °C drying temperature and the minimum non enzymatic browning (0.05) when it was dried at 50 °C, while control sample had lowest non enzymatic browning (0.04) values. The loss of bright colour with increasing drying temperature was possibly due to the oxidation of carotenoids after long exposure to oxygen and heat.

Data from Table 2 revealed that the highest score for colour and appearance (7.50) was found when the Aonla were dried at 60 ºC though it was at par with 50 °C, and the lowest score (5.07) was found for the sample dried at 80 ºC, while the control sample had 6.57 score for colour and appearance. It can be concluded from the data that colour and appearance of all treatments were significantly different at 5 % level of significance. Similar results were obtained for texture and taste properties also. The highest score for overall acceptability (8.00) was found when the

Aonla were dried at 60ºC and the lowest score (5.50) was found for the sample dried at 80ºC. It was concluded that all treatment samples are significantly different at 5% level of significance in overall acceptability. From the statistical analysis it was observed that treatment T2 (8.00) was highly significant, while T1 (7.43) was at par with T2. Treatment T3 (6.36), T4 (5.50) and control (6.50) were significantly different at 5% level of significance.

From the above study, it is known that osmotically pretreated Aonla dried at 60 °C was organoleptically acceptable in terms of colour and appearance, texture, taste and overall acceptability as compared to the Aonla dried at other temperatures as well as market sample (control), though statistically both 50 and 60 °C drying temperatures were at par. The sample dried at 60 °C require less time (**Table 3**) and thus saving in energy as compare to sample dried at 50 °C. Hence, sample dried at 60°C temperature was selected for further study, which has 213.00 mg/100g ascorbic acid content, 7.21 N hardness and 0.08 OD for non-enzymatic browning and it takes 5 h for drying.

**Table 3** Effect of drying temperatures on drying time of osmotically dehydrated Aonla

| Drying temperature (ºC) | Drying Time (h) |
|---|---|
| 50 | 6 |
| 60 | 5 |
| 70 | 4.5 |
| 80 | 4 |

The bio-chemical analysis, sensory evaluation, texture and microbiological analysis of the control and optimized product processed at 30 min ultrasonication time, 6:1 solution to fruit ratio, 58 ºBrix of sugar syrup, 50 h osmotic time and dried at 60 °C temperature were carried out as per the methods explained in the previous chapter and the results are presented in **Table 4**.

**Table 4** Quality characteristics of control and optimized osmotically dehydrated whole Aonla

| Parameters | Control | Optimized |
|---|---|---|
| **Bio chemical** | | |
| Moisture, % | 14.05 | 12.01 |
| Protein, % | 0.31 | 0.43 |
| Ash, % | 0.76 | 0.71 |
| TSS, °B | 71.32 | 78.55 |
| Acidity, % | 0.59 | 0.53 |
| pH | 4.33 | 4.5 |
| Reducing sugars,% | 33.43 | 34.88 |
| Total sugars, % | 60.54 | 61.85 |
| Non-reducing sugars, % | 27.11 | 26.97 |
| Ascorbic acid, mg/100g | 162.93 | 213.00 |
| **Sensory Scores** | | |
| Colour and appearance | 6.57 | 7.50 |
| Texture | 6.93 | 7.43 |
| Taste | 6.64 | 7.64 |
| Overall Acceptability | 6.50 | 8.00 |
| **Texture Profile Analysis** | | |
| Hardness, N | 4.58 | 7.21 |
| **Microbiological Analysis** | | |
| SPC, cfu/g | 80 | 60 |
| Coliform, cfu/g | Absent | Absent |
| Yeast & Mold, cfu/g | Absent | Absent |

***Storage Study of Osmotically Dehydrated Whole Aonla***

The bulk sample of osmotically dehydrated whole Aonla was prepared using optimized process parameters for storage study. The sample was packed in HDPE pouch (200gauge) and stored at ambient temperature (30±2°C). The storage study was carried out 30 days interval for chemical and sensory analysis as shown in **Tables 5** and **6**.

The moisture content, non-reducing sugar, pH, ascorbic acid content and SPC reduced significantly with increase in storage period. The acidity, reducing sugar, total sugar, total soluble solids and non-enzymatic browning increased significantly with increases in storage period. The scores for sensory attributes are given in Table 6. Initial sensory

scores for colour and appearance, texture, taste and overall acceptability were higher and at 210 days of storage the scores were reduced considerably.

Total production cost of 100kg of dehydrates Aonla per day including raw material cost, processing cost, electricity cost, labour cost was estimated to be Rs.14892.25 (**Table 7**). The production cost of dehydrates whole Aonla was found to be Rs.148.92.

**Table 5** Changes in chemical parameters in chemical parameters in osmotic dehydrated Aonla during storage

| Chemical parameter | Storage days | | | | | | | | Avg | SEm | CD (0.05) | CV% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | | | | |
| Moisture, % | 12.06 | 11.82 | 11.53 | 11.35 | 11.27 | 11.11 | 11.08 | 10.38 | 11.36 | 0.019 | 0.054 | 0.4682 |
| Acidity, % | 0.53 | 0.53 | 0.53 | 0.54 | 0.55 | 0.57 | 0.58 | 0.61 | 0.55 | 0.009 | 0.025 | 4.545 |
| Reducing sugar, % | 34.90 | 34.95 | 35.52 | 35.70 | 35.85 | 36.16 | 36.43 | 36.74 | 35.78 | 0.008 | 0.024 | 6.651 |
| Non reducing sugar, % | 26.94 | 26.71 | 26.64 | 26.60 | 26.54 | 26.45 | 26.36 | 26.27 | 26.60 | 0.007 | 0.021 | 0.0793 |
| Total sugar, % | 61.84 | 61.96 | 62.15 | 62.29 | 62.38 | 62.61 | 62.78 | 63.01 | 62.38 | 0.011 | 0.031 | 4.978 |
| TSS, °Brix | 78.54 | 78.62 | 78.79 | 79.07 | 79.14 | 79.27 | 79.37 | 79.54 | 79.07 | 0.006 | 0.018 | 2.309 |
| pH | 4.51 | 4.47 | 4.43 | 4.43 | 4.42 | 4.42 | 4.41 | 4.40 | 4.44 | 0 | 0.007 | 0.162 |
| Ascorbic acid, mg/100g | 247.42 | 242.98 | 239.54 | 236.97 | 235.11 | 231.92 | 229.06 | 226.38 | 236.17 | 0.233 | 0.664 | 0.2801 |
| Standard plate count, cfu/g | 65.00 | 37.50 | 35.00 | 32.50 | 33.00 | 33.50 | 32.50 | 30.00 | 39.66 | 2.17 | 6.16 | 15.552 |
| Non enzymatic browning, OD | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.11 | 0.11 | 0.07 | 0.01 | 0.014 | 19.73 |

**Table 6** Changes in Sensory parameters in osmotic dehydrated Aonla during storage

| Sensory parameter | Storage days | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 |
| Colour and appearance | 7.50 | 7.43 | 7.28 | 7.03 | 6.83 | 6.30 | 6.14 | 5.73 |
| Texture | 7.43 | 7.18 | 7.10 | 6.75 | 6.38 | 6.65 | 6.10 | 5.60 |
| Taste | 7.64 | 7.55 | 7.08 | 6.83 | 6.53 | 6.35 | 6.20 | 5.71 |
| Overall Acceptability | 8.00 | 7.73 | 7.60 | 7.10 | 6.75 | 6.40 | 6.13 | 5.80 |

**Table 7** Production cost estimation of osmotically dehydrated Whole Aonla Fruit

| Ingredients | Cost (Rs) | Quantity required (kg) | | Total cost (Rs.) |
|---|---|---|---|---|
| Aonla | 20 | 160 | | 3200 |
| Sugar | 32 | 300 kg | | 9600 |
| Total Cost of raw materials (a) | | | | 12,800 |
| Processing cost 10% of raw materials cost (b) | | | | 1280 |
| **Electricity cost of tray dryer** | | | | |
| **Particulars** | **Electrical load (kwh)** | **Electrical cost (Rs/kwh)** | **Electrical load (kw)** | **Total cost (Rs)** |
| Tray dryer heater | 9 | 5 | 135 | 675 |
| Tray dryer blower motor | 1.49 | 5 | 22.35 | 111.75 |
| Total electricity cost (c) | | | | 786.75 |
| **Labour cost** | | | | |
| | **Personnel required** | **Daily wages (Rs.)** | | **Total cost (Rs)** |
| Skilled labour | 1 | 250 | | 250 |
| Unskilled labour | 2 | 150 | | 300 |
| Total labour cost (d) | | | | 550 |
| Total cost for production of 100kg osmotically dehydrated whole Aonla (a+b+c+d) | | | | 15,416.75 |
| Total cost for production of 1kg osmotically dehydrated whole Aonla | | | | 154.17 |

## Conclusion

For the production of superior quality osmotically dehydrated Aonla for longer shelf life, the blanched Aonla of *Gujarat Aonla II* variety should be pretreated at 30 min ultrasonication time, 6:1 solution to fruit ratio, 58 °Brix sugar syrup concentration and 50 h osmotic time. The pretreated sample should be dried at 60 °C temperature using hot air tray dryer and packed in HDPE pouches (200 gauge) and stored at ambient temperature (30±2 °C) for 210 days. The production cost of osmotically dehydrated Aonla fruit was found to be Rs.155/kg.

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Publication History
Received 11th July 2017
Revised 29th July 2017
Accepted 05th Aug 2017
Online 30th Aug 2017