Influence of shape, pre-treatment and drying air temperature on quality of dried aonla

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Abstract: Experiments were conducted to assess the effect of aonla shape, pre-treatment and drying air temperature on the quality attributes of dried product. The aonla fruit was subjected to mechanical treatment to form three shapes i.e. spherical (whole pricked), cylindrical (15×35 mm) and sheet (2 mm thickness) and were exposed to different pre-treatments i.e. untreated UT, water blanching WB, steam blanching SB, blanching and sulphiting B+S, sugar osmosis and salt osmosis prior to convective drying at temperature of 50°C, 60°C and 70°C. The dried aonla (nearly 10% w.b) were analyzed for different quality attributes such as re-constitutional properties, vitamin C, color and overall acceptability. The data indicated that re-constitutional properties, color (L, a, and b values), vitamin C and overall acceptability of dried aonla samples were significantly affected by the sample shape, pre-treatments and drying air temperature. The L, a, and b values of sheet shaped aonla were close to the fresh sample resulting in minimum (6.43) color change. The B+S pre-treatment samples witnessed minimum color change and were at par to the salt osmosed samples. In comparison to UT samples, all the treated samples witnessed higher retention of vitamin C and overall acceptability. The maximum (74.49%) vitamin C was retained by the B+S pretreated cylindrical shaped sample dried at 50°C temperature whereas, the maximum consumer acceptance (98.15%) was recorded for sugar osmosed sheet shaped sample dried at 50°C.

Keywords: aonla, convective drying, pre-treatment, quality parameters

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1 Introducion

Indian Gooseberry or aonla fruit (*Phyllanthus emblica* L.), being one of the richest sources of vitamin C is acidic, cooling, refreshing, diuretic as well as laxative and works better than synthetic ascorbic acid in the cure of deficiency diseases. Due to its medicinal value, aonla fruit has been widely used in Unani and Ayurveda (Alam and Singh, 2008a; Arya and Moond, 2004). India ranks first for production of aonla and production of aonla has been increasing rapidly in the last couple of years occupying an area of 103.55 thousand ha with production of 1221.25 thousand MT in 2014-15 out of which Punjab has contributed 6.06 thousand MT (Wali et al., 2015). Due to its high astringency and low shelf life, this fruit is not popular as table fruit. The other methods of extending shelf life are by processing the aonla fruit to murabba, pickle, juice syrup, squash and dehydrated powder. Thus, it shows great potential for processing into various quality products, which can have great demand in national as well as international market (Kalra, 1988).

Preservation of fruits and vegetables is essential for long time consumption without further deterioration in the quality of the product. As moisture content of freshly harvested aonla varies from 600% to 800% (d.b), it is needed to be dried to 9% to 10% (d.b) moisture content to prevent insect and fungi attack during storage. One of the simplest and inexpensive methods by which food can be preserved is by drying as it is one of the easiest and least

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expensive method to make it readily available throughout the year (Alam et al., 2010). The main objective of drying is to reduce the moisture naturally present at the time of harvest to a safe limit of say 8% to 10%. At this moisture level, the chances of mold infestation are minimized and thus commodity can be kept well (Alam et al., 2004). Due to the decreased water activity, dehydration process immunes the food spoilage by reducing microorganism growth (Agarry et al., 2005). Open sun drying and solar drying has gained popularity among the aonla processers, but this technique has limitations such as climatic adversities, contamination by insect and pests, loss in vitamin C and browning of the dried fruit resulting into reduced consumers overall acceptability of product (Alam and Singh, 2010). In order to mitigate this problem, there was need to look for the alternative drying process which would be simple, inexpensive and offer way to maintain the quality and overall acceptability of the final product. Retention of various heat sensitive nutrients has been indicated by the retention of vitamin C of the dried product (Maeda and Salunkhe, 1981). It has been reported that blanching treatment prior to drying not only prevents the off flavour and colour changes caused by enzymatic reactions but also decreases the initial microorganism load (Karim et al., 2008). In addition, it also affects the distribution of the soluble components within the product leaching it to the surrounding environment and loss of these solute affect the rate of drying (Tunde-Akintunde et al., 2011). Osmotic dehydration was observed to be one of those methods (Shi and Le Maguer, 2002). Osmotic dehydration is a process in which diffusion of water takes place by immersion of water containing a cellular solid in a concentrated aqueous solution (hypertonic media mostly of salt or sugar) with high osmotic pressure for a specified time (Chua et al., 2004; Alam et al., 2019).

Pre-treatment prior to drying operation has potential advantages of less heat damage, good blanching effect, less enzymatic browning, better retention of flavour, colour, texture and energy saving because no phase change occurs (Alam and Singh, 2008b). Many reports have been available regarding pre-treatment of blanching and osmotic pre-treatment on carrot (Al-Amin et al., 2015), potato (Agarry et al., 2005), pineapple (Karim et al., 2008), tomato (Asare et al., 2014) etc. However, combination of these pre-treatments on quality of dried aonla has not been investigated. Keeping the above points under consideration, the study was undertaken to evaluate the effect of pre-treatment, shape and drying air temperature on the quality of dried product.

2 Materials and methods

2.1 Sample preparation

The fresh aonla fruits (variety: Francis; selected due to its high vitamin-C content) were procured from New Orchard, PAU, Ludhiana, and were sorted for uniform size, color and physical damage, washed with fresh water and then wiped with a muslin cloth. Initial moisture content of sample was determined as suggested by Ozkan et al., (2003). The initial moisture content of fruit with seed and without seed was found to be 86.73% and 87.78% (w.b) respectively.

2.2 Pre-treatment of aonla

As the waxy skin of the aonla is highly resistance to mass transfer, mechanical treatments were given to aonla in order to form three different shapes i.e. spherical (whole pricked), cylindrical (15 × 35 mm) and sheet (2 mm thickness).

In order to inactivate peroxidase enzyme which causes surface browning and to maintain the color of the fruit during and after the drying process, pre-treatments were given before mechanical treatment i.e. water blanching BW, steam blanching BS and blanching followed by sulphiting B+S of whole aonla. Blanching of un-osmosed fruits in water was carried out in 2.0% sodium chloride solution. Both blanching by water BW and steam BS were standardized and the optimum blanching time to inactivate enzymes was found to be 7 minutes and 5 minutes respectively. Steam blanching was done in an autoclave (NSW-227, Narang Scientific Works Pvt Ltd, New Delhi). The optimum blanching time was calculated by testing of browning with the Guiacole solution. The blanching followed by sulphiting B+S method was given as suggested by Khurdiya et al. (1972).

The osmotic treatment by salt and sugar was given to all the three shapes of unblanched aonla samples. The optimum conditions of osmotic drying of aonla were shown in Table 1.

Table 1 Optimized processing parameters for salt and sugar osmosed samples

Processing parameters	Salt osmosed sample			Sugar osmosed sample		
	Spherical	Cylindrical	Sheet	Spherical	Cylindrical	Sheet
Concentration (w/v)	18.96	25.00	19.82	68.09	70.00	59.99
Temperature (ºC)	46.23	47.08	46.99	60.00	59.75	44.16
Solution to water ratio	6.82	6.03	6.62	5.17	7.01	4.00
Immersion time (min)	60.00	65.61	60.00	69.87	60.00	60.00

2.3 Drying of pretreated aonla

The pretreated samples of aonla were dried in laboratory tray dryer (No.146, Macheill and Magor Ltd New Delhi) at air temperature of 50ºC, 60ºC and 70ºC at an inside air velocity of 0.8 m s-1. The complete format of convective experiment is given in Table 2.

Table 2 Complete format of experiment for convective dehydration

Mechanical treatment	Chemical treatment	Drying air temperature (°C)
Spherical pricked (SPH)	Untreated, UT	50
Cylindrical (1.5 × 3.5 cm) (CYL)	BW	60
Sheet, 2 mm (SH)	BS	70
	B+S	
	Sugar osmosed	
	Salt osmosed	

Note: SPH – Spherical shape, CYL – Cylindrical shape, SH – Sheet shape, UT – Untreated, BW– Blanching with water, BS- Blanching with steam, B+S - Blanching followed by sulphiting

2.4 Physical and biochemical analysis

2.4.1 Estimation of moisture content

The samples were oven dried at 103°C ± 2°C for 16 hours in uncovered pre-weighted petri dishes (Ozkan et al., 2003). Moisture content of sample was calculated by

$$Moisture\ Content\ (\%\ wet\ basis) = \frac{W_1 - W_d}{W_1}\ x\ 100 \quad (1)$$

Where, W_1 = Initial weight of sample, g; W_d = Bone dry weight of sample, g

2.4.2 Re-constitutional quality parameters

Due to the low porous structure of whole aonla fruit, its re-constitutional time was standardized at 95°C constant temperature varying various reconstitution time of 5, 10, 15, 20, 25, and 30 minutes and found 20 minutes to be the most adequate for all shapes of dried samples maintaining texture of the rehydrated product (Ranganna, 1986). Re-constitutional properties such as rehydrated moisture content (RMC), rehydration ratio (RR) and coefficient of restoration (COR) of the samples were computed as follows:

$$RMC = \frac{[W_r - W_d(1 - \frac{B}{100})]}{W_r} \quad (2)$$

$$RR = \frac{W_r}{W_d} \quad (3)$$

$$COR = \frac{[W_r \times (100 - A)]}{\left[W_d\ x\{1\text{-}(\frac{B}{100})\} \times 100\right]} \quad (4)$$

Where, W_r = drained weight of rehydrated sample, g;

W_d = weight of dried sample used for rehydration, g;

A, B = moisture content (%w.b) in original and dried sample respectively, g

2.4.3 Color measurement

Color is the most important parameter for the acceptability of the product. The color properties of the fresh and rehydrated sample were measured by using Miniscan XE plus Hunter Lab Colourimeter (U.S.A), Model No. 45/0-L. The color of the fresh and rehydrated aonla was measured in terms of 'L', 'a' and 'b' value after making paste of the sample by mortar and pestle. For the determination of color, the sample was completely filled in petri dish provided that no light is allowed to pass during the measuring process. The 'L', 'a' and 'b' values were recorded at D 65/10° and were compared to the standard values of fresh aonla. Three desired functions were calculated from the 'L', 'a' and 'b' readings as follows (Gnanasekharan et al., 1992).

$$Colour\ change = \sqrt{\left[(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2\right]} \quad (5)$$

Where, L_0, a_0 and b_0 represent the respective readings of fresh sample.

2.5 Organoleptic evaluation of dried product

Organoleptic evaluation of the dried aonla samples for all the three shapes (spherical, cylindrical and sheet) was conducted on a 9-point hedonic scale. Semi-trained panels of 10 judges were selected for the evaluation. The samples were evaluated in terms of appearance, color, taste, texture, flavour and overall acceptability.

2.6 Determination of vitamin-C content (Ascorbic acid)

Ascorbic acid is oxidized by the color dye 2,6-dichlorophenolindophenol to dehydro ascorbic acid. At the same time, the dye is reduced to a colourless compound so that the end point of the reaction can be easily determined. 10 g of the sample were blended in waring blender with 70 mL of metaphosphoric acid–acetic acid stabilizing extracting solution and filtered after making the volume to 100 mL. The 10 mL of filtrate was titrated with standard indophenols solution. The end point was obtained when a permanent pink colour was seen in the organic phase. The ascorbic acid was expressed as mg/100g of fruit sample.

Ascorbic acid content of the sample was calculated by using the following formula:

$$V \times S \times D \times 100 = mg\ ascorbic\ acid/100g\ of\ sample \quad (6)$$

Where V = mL of the dye used

S = standardization value expressed in mg ascorbic acid / mL of the dye

D = dilution factor

2.7 Statistical analysis for quality analysis

The data observed from various treatments was analyzed in terms of effect of shape, temperature, and treatments on the quality of dried fruit. The quality parameters studied were re-constitutional properties (RR, COR and RMC), vitamin-C retained, coefficient of restoration, overall acceptability, L, a, b value and color change. The data were statistically analyzed using univariate analysis of variance (UNI-ANOVA) in general linear model in Statistical Package for Social Sciences (SPSS, version 13.0). Analysis was done considering the main effects and two factor interactions. Means were computed and tested at 5% level of significance.

3 Results and discussion

The effect of shape, pre-treatment and drying air temperature on the quality of aonla was assessed. The quality of dried aonla was statistically evaluated in terms of re-constitutional properties (rehydration ratio, coefficient of restoration and rehydrated moisture content), color parameters, vitamin C retention and overall acceptability.

3.1 Re-constitutional properties

The re-constitutional properties studied were rehydration ratio, coefficient of restoration and rehydrated moisture content. Rehydration ratio of dried sample varied from 1.52 to 3.96 irrespective of the shape, temperature and treatments. The minimum (1.52) RR was observed for sugar osmosed spherical sample dried at 60°C while maximum (3.96) for untreated spherical sample dried at 70°C. It is clear from Table 3 that the rehydration ratio was maximum (3.24) for sheet shape aonla and minimum (1.84) for whole pricked aonla. The RR increased with the increase in drying air temperature and was found at par for untreated, BW and BS samples whereas minimum for sugar osmosed samples. The sheet shaped sugar osmosed rehydrated samples resembles close to the fresh samples. Among spherical shaped (whole pricked) dehydrated aonla samples, the maximum (2.15) rehydration ratio was observed for water blanched samples dried at 50°C; water blanched samples dried at 60°C for cylindrical shaped samples and untreated samples (3.96) dried at 70°C temperature. It was concluded from the statistical analysis that shape, treatment and temperature and their interactions significantly affected ($p<0.05$) the RR. Shape followed by treatment showed maximum significant effect on RR as indicated by F-value.

The coefficient of restoration (COR) of dried sample varied from 0.22 to 0.53 irrespective of the shape, temperature and treatments. The minimum (0.22) COR was observed for sugar osmosed spherical sample dried at 60°C whereas, maximum (0.53) was recorded for untreated spherical sample dried at 70°C. COR was increased with the increase in temperature and was found to be maximum for sheet (0.43) shaped aonla fruit. Among various pre-treatments, the sugar-osmosed samples showed lower COR (0.29), this might be due to high molecular weight of sugar causing the blocking of sample pores (Table 3). The Analysis of variance for COR indicated that shape, treatment and their interactions significantly ($p<0.05$) affected the COR whereas, drying temperature showed non-significant ($p<0.05$) effect. Shape followed by treatment showed maximum significant effect on COR as indicated by F-value.

Rehydrated moisture content (% d.b.) varied from 69.13 to 333.73 irrespective of the shape, temperature and treatments. The minimum (69.13) RMC was noticed for sugar osmosed spherical sample dried at 60°C while maximum (333.73) RMC for salt osmosed spherical sample dried at 50°C. Table 3 clearly shows that, rehydrated moisture content (RMC) witnessed the same results as obtained for RR and COR indicating maximum (258.45% d.b) RMC for sheet shaped aonla and minimum (127.35% d.b) RMC for sugar osmosed samples. The analysis of variance for RMC indicated that shape, drying temperature, treatments and their interactions significantly ($p<0.05$) affected the RMC. Shape followed by treatment showed maximum significant effect on RMC as indicated by *F*-value.

Table 3 Statistically analyzed factor mean values for re-constitutional properties

Re-constitutional properties	Shape (A)				Temperature (°C) (B)				Treatment (C)						
	SPH	CYL	SH	*F* - A	50	60	70	*F*-B	UT	BW	BS	B+S	Salt osmosed	Sugar osmosed	*F* -C
RR	1.84	1.91	3.24	1541.72	2.28	2.33	2.37	4.87	2.44	2.42	2.42	2.32	2.32	2.05	26.50
COR	0.27	0.28	0.43	694.57	0.32	0.33	0.33	2.81	0.34	0.34	0.34	0.32	0.33	0.29	17.77
RMC (% d.b)	104.62	112.20	258.45	1454.62	153.62	158.93	162.72	4.04	170.70	168.96	169.33	157.05	157.16	127.35	26.11

Note: RR= Rehydration ratio, COR=Coefficient of restoration, RMC=Rehydrated moisture content

Table 4 Statistically analyzed factor mean values for color, vitamin-C and overall acceptability

Properties	Shape (A)				Temperature (°C) (B)				Treatment (C)						
	SPH	CYL	SH	*F* - A	50	60	70	*F* - B	UT	BW	BS	B+S	Salt osmosed	Sugar osmosed	*F* - C
L-value	39.50	44.48	51.52	570.89	47.29	44.93	43.27	63.67	36.14	45.86	47.19	48.54	48.07	45.16	165.84
a-value	5.68	4.62	0.73	574.58	2.56	4.16	4.32	79.61	5.59	3.05	3.43	3.33	3.13	3.53	8.94
b-value	14.04	16.28	13.76	204.70	14.53	15.01	14.55	7.83	13.06	14..99	15.18	15.96	14.96	14.44	50.11
Color change	16.59	12.56	6.43	480.10	9.78	11.99	13.79	74.00	11.25	11.66	10.09	9.26	9.54	11.35	128.53
Vitamin C (%)	62.10	66.82	49.82	141.91	62.15	59.92	56.66	14.04	45.22	65.83	68.77	74.49	55.42	47.737	130.78
Overall acceptability (%)	68.62	67.28	71.71	17.36	71.71	70.80	65.12	42.85	63.89	64.71	65.43	65.02	75.21	80.97	85.87

3.2 Color parameters

The color of the rehydrated aonla samples were evaluated on the basis of ‘L’, ‘a’, ‘b’, and color change. Table 4 clearly shows that the color values of sheet shaped aonla witnessing ‘L’ (51.52), ‘a’ (0.73) and ‘b’ (13.76) values resulting in minimum (6.43) colour change which were close to fresh aonla having ‘L’, ‘a’ and ‘b’ values of 53.15, -2.93 and 13.29 indicating greenish yellow colour of fresh aonla fruit. It was observed that with lower temperature of 50°C the ‘L’, ‘a’, ‘b’ values were close to the fresh sample recording minimum (9.78) color change. Among the various pre-treated samples, the B+S samples followed by salt osmosed samples recorded minimum color change of 9.26 and 9.54 respectively.

It can be concluded from analysis of variance for color parameters that the shape, drying temperature, treatment and their interactions significantly ($p<0.05$) affected the ‘L’, ‘a’, ‘b’ and color change values. Shape followed by treatment showed maximum significant effect on ‘L’, ‘b’ and color change whereas, shape followed by temperatures significantly affected the ‘a’ values as indicated by F values. The statistically analyzed factor mean values as shown in Table 4 depicts that among the different shapes, temperature and treatment combinations used, the minimum colour change was observed for spherical shaped (6.43) sample, B+S treated (9.26) and dried at 50°C (9.78) temperature.

3.3 Vitamin-C retention

It was observed that there was considerable vitamin-C loss irrespective of shape, treatment and drying air temperature. Highest vitamin C content retention of 83.78% was found for steam blanched spherical shape sample dried at 60°C whereas least vitamin C content retention was 17.95% for sugar osmosed spherical shape sample dried at 50°C. Table 4 shows that %vitamin C retention reduces with the increase in drying air temperature and was found to be maximum for the samples dried at 50°C. In comparison to untreated samples, all the treated samples showed higher retention of vitamin-C. Moreover, highest %VCR was noticed for blanched samples followed by sulphiting B+S. Salt osmosed samples retained higher vitamin-C in comparison to sugar osmosed samples. Sheet shaped samples witnessed minimum %VCR in comparison to whole (spherical) and cylindrical samples. It was concluded from the statistical analysis of variance for % vitamin-C retained that shape, drying temperature, treatments and their interactions significantly ($p<0.05$) affected the %VCR. Shape followed by treatment showed maximum significant effect on %VCR as indicated by F-value.

3.4 Overall acceptability

The overall acceptability (%OA) of the dried product i.e. mean of the group of properties such as appearance, colour, taste, texture and flavour was evaluated to assess the consumer acceptance. Overall acceptability of the samples varied from 54.63% to 98.15% irrespective of shape, treatment and drying air temperature. The spherical shaped, B+S treated samples dried at 50°C witnessed minimum overall acceptability while the sugar osmose spherical sample dried at 50°C recorded maximum overall acceptability. The statistically analyzed factor mean values as shown in Table 4 clearly indicates that the samples dried at lower temperature, which showed higher %OA in comparison to higher temperature of 70°C. Among the various shapes the most liking was observed for sheet shaped samples. The pre-osmosed samples showed comparatively higher scores than un-osmosed samples. The sugar osmosed samples received maximum consumer acceptance due to its bright golden color, sweet taste and pleasant flavour. The sugar osmosed sheet shaped aonla sample dried at 50°C was adjudged to be the best among all the samples (Figure 1). The analysis of variance shown for %OA revealed that shape, drying temperature, treatments and their interactions significantly affected the %OA at 5% level of significance. Shape of the aonla followed by treatment showed maximum significant effect on %OA as indicated by F-value.

Figure 1 Dried aonla slices with maximum consumer acceptance

4 Conclusions

The quality attributes of dried aonla were significantly influenced by shape, pre-treatment, osmotic treatment and drying air temperature. Blanching followed by sulphiting pre-treatment resulted into highest vitamin-C content retention. Maximum consumer acceptance was witnessed by sugar osmosed sheet sample dried at 50°C temperature. The osmotic dehydration improved the quality of dehydrated and rehydrated product. It improved the color as well as increased the overall acceptability of the dehydrated product by manifolds.

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