

## Effect of drying methods on quality of Indian gooseberry (*Emblica officinalis* Gaertn.) powder during storage

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Indian gooseberry or aonla is a very rich source of ascorbic acid. Its ascorbic acid lost during the process of drying. Therefore effect of 4 different drying methods investigated on ascorbic acid and other quality factors under storage. Drying methods viz., sun drying, oven drying, microwave drying and fluidized bed drying, significantly affect the quality and ascorbic acid content of dried aonla powder. Among 4 drying methods, fluidized bed drying found best. At the start of experiment dried powder with fluidized bed drying had highest ascorbic acid content (272.74 mg / 100 g), total sugars (39.41 g / 100g), reducing sugar (33.69 g / 100g), and lowest content of tannin (8.8 g / 100g), browning index (0.02 OD at 440 nm) and acidity (9.94 g / 100g). The quality parameters deteriorated under storage irrespective of the drying method and ascorbic acid steadily lost during 90 days of storage. However, powder making with fluidized bed drying was acceptable even after 90 days of storage and contains 205.5 mg / 100g ascorbic acid. It is recommended that aonla can be dried with fluidized bed drying at a temperature of 65°C with air velocity of 90 m/min.

**Keywords:** Aonla, Indian gooseberry, Ascorbic acid, Drying methods, Nutritional composition, Storage.

### Introduction

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn.) is one of the most important traditional and underutilized fruits of Indian origin, having immense potential for cultivation on marginal or waste lands. It belongs to the family Euphorbiaceae and sub-family Phyllanthoidae. The fruit is highly nutritive and richest source of vitamin C among fruits after Barbados cherry<sup>1</sup>. The edible fruit tissues of aonla contain about 3 times more protein and 160 times more vitamin C as compared to apple<sup>2</sup>. The fruit contains leucoanthocyanin or polyphenols which retard the oxidation of vitamin C and presence of astringency. Hanif *et al.*<sup>3</sup> noted marked antioxidant effect of gallic acid present in aonla fruits. Tannins containing gallic acid, elagic acid, and glucose retard the oxidation of vitamin C and renders its value as antiscorbutic in the fresh as well as in dried conditions. Aonla is also a source of carbohydrates, carotene, thiamine, riboflavin, and minerals like iron, calcium and phosphorus<sup>4</sup>.

The fresh aonla fruits are not popular as a table fruit due to their high astringency and its storability after harvesting is also limited<sup>5</sup>. The other methods of extending shelf life are by cold storage, sun drying, and hot air drying or by processing to preserve, pickle, juice, syrup, squash and dehydrated powder<sup>6</sup>. Among these processes dehydration offers many advantages. Several drying methods are commercially available and the selection of the optimal method is determined by quality requirements, raw material characteristics, and economic factors.

Because of its heat sensitivity, the aonla is very difficult to dry while maintaining its nutritional quality. Very little information on drying processing of aonla is available in the literature. Among various drying methods available, open sun drying and solar drying have been exploited to some extent and has the limitation of high solar radiations<sup>7</sup>. Murthy & Joshi<sup>8</sup> and Pragati *et al.*<sup>9</sup> studied on fluidized bed drying of aonla. The detailed scientific study is essential to develop a complete package of appropriate technology for the production of dehydrated aonla flakes of high quality. This will enable the growers to get good remuneration as well as the consumers to get nutrition product round the year.

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Fluidization involves the passing of fluid upwards through a bed of particles and expanding it. The minimum fluidization velocity will be reached when the pressure drop over the column is equal to the weight of the bed divided by its cross sectional area. Physical processes, which use fluidized beds, include drying, mixing, granulation, coating, heating, and cooling. All these processes take the advantage of excellent mixing capabilities of the fluid bed. Good solids mixing gives rise to good heat transfer, temperature uniformity, and ease of process control. Fluidized beds are currently used for drying materials such as fruits, vegetables, and other food items<sup>10,11</sup>.

The present primary study is aimed toward this direction with aonla, cultivar 'Chakaiya', being used for the experimentation. The methods used were direct solar drying, oven drying, microwave drying and fluidized bed drying. The data on the quality parameters for different drying methods are recorded.

## Materials and Methods

### Location of the Experiment

The experiment was carried out in the Post Harvest Technology Laboratory of Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan. The fluidized bed drying treatment was applied in the College of Technology and Agricultural Engineering, MPUAT, Udaipur.

### Fruits

The mature aonla fruits cv. 'Chakaiya' of uniform and similar size were obtained from a private orchard of Nathdwara District in a single lot. These were washed under tap water to remove adhering dust and reduce the surface microflora.

### Treatment Application

The selected material was sliced to 5 mm thickness. About 200 g of the sliced sample was taken for drying. The fruit slices were dried using different methods *viz.*, direct solar drying, oven drying, microwave drying and fluidized bed drying until the moisture level was below 15%. The sliced sample was evenly spread on to an aluminum tray and kept under sunlight for drying. Another sample was then spread on to the perforated tray of the oven, which was set to the required temperature of 65°C. Yet another sample was taken in the microwave oven and dried at a temperature of 65°C. The fourth sample

was taken in the perforated mesh container of the fluidized bed dryer. The initial weight of the container with slices of aonla was noted. An electronic top pan weighing balance, having capacity of 5 kg with an accuracy of 0.01 g was used for the purpose of weighing. The air velocity was adjusted using the anemometer and the air flow adjusting valve. The thermostat was set so that the desired temperature was achieved. The aonla slices were dried at a temperature of 65°C with air velocity of 90 m/ min. Then the loaded container was placed inside the plenum chamber of the fluidized bed dryer. The drying was continued until the moisture content of the slices reached about 15%. The dried fruit pieces in each of the drying method were ground in a mortar and pestle and then in a Cyclotech grinder. The dehydrated aonla powder were sealed in air tight polyethylene sealing machine and stored for 90 days.

### Observations

The aonla powder was used for the estimation of various nutrients *i.e.*, total sugars<sup>12</sup>, reducing sugars<sup>13</sup>, ascorbic acid<sup>14</sup>, titrable acidity<sup>14</sup>, total tannins<sup>14</sup>, and browning<sup>15</sup>.

### Statistical Analysis

The experiments were designed complete randomly in factorial. The data obtained were subjected to statistical analysis for analysis of variance using standard methods. Values were considered at 95% confidence level ( $p \leq 0.05$ ) and all experiments were performed in triplicate<sup>16</sup>.

## Results and Discussion

### Total Sugars

The data revealed that the total sugars content (Table 1) was affected by all the drying treatments. It was found that the total sugars content of fluidized bed dried aonla was significantly higher (39.41 g/100 g) than other treatments. The total sugar content in direct solar dried aonla was 22.18 g / 100 g, which was significantly lower than the oven dried aonla (25.59 g /100 g). The total sugar content of microwave dried aonla was found to be significantly higher (27.46 g/100 g) than both oven dried and sun dried aonla but lower than the fluidized bed dried aonla (39.4 g /100 g) before storage.

Even after 90 days of storage, the trend in total sugar content as a result of different drying methods remained the same. Total sugar content was decreased with increase in storage period in all the drying methods. The

Table 1 - Total sugars, reducing sugars, ascorbic acid, tannins and titrable acidity of dried aonla fruit during storage (dry weight basis)

Storage period (days)	Drying methods			
	Direct solar drying	Oven drying	Microwave drying	Fluidized bed drying
	Total sugars (g/100 g)			
0	22.18 ± 0.141	25.59 ± 0.048	27.46 ± 0.038	39.41 ± 0.512
30	21.94 ± 0.136	24.89 ± 0.031	26.75 ± 0.0489	37.08 ± 0.0560
60	21.53 ± 0.408	24.67 ± 0.086	26.52 ± 0.127	36.65 ± 0.311
90	21.40 ± 0.362	24.25 ± 0.095	26.18 ± 0.148	36.27 ± 0.308
	Reducing sugar (g/100 g)			
0	15.44 ± 0.076	19.56 ± 0.041	21.19 ± 0.235	33.69 ± 0.286
30	14.33 ± 0.0562	18.58 ± 0.042	18.03 ± 0.065	29.88 ± 0.072
60	12.81 ± 0.071	14.80 ± 0.148	13.48 ± 0.128	28.09 ± 0.146
90	9.39 ± 0.032	11.23 ± 0.053	8.84 ± 0.046	26.89 ± 0.051
	Total tannin content (mg/100 g)			
0	15.45 ± 0.162	15.05 ± 0.158	14.73 ± 0.115	8.80 ± 0.055
30	10.82 ± 0.587	10.16 ± 0.331	10.11 ± 0.776	4.67 ± 0.544
60	7.86 ± 0.041	6.98 ± 0.415	6.63 ± 0.172	3.08 ± 0.435
90	7.59 ± 0.199	5.32 ± 0.255	5.47 ± 0.112	2.15 ± 0.231
	Titrable acidity (g/100 g)			
0	6.02 ± 0.091	6.11 ± 0.040	6.26 ± 0.006	5.94 ± 0.005
30	6.29 ± 0.088	6.38 ± 0.135	6.51 ± 0.028	5.98 ± 0.007
60	6.48 ± 0.022	6.57 ± 0.008	6.74 ± 0.148	6.06 ± 0.005
90	6.54 ± 0.006	6.62 ± 0.031	6.82 ± 0.004	6.13 ± 0.011

Values are mean ± SE of three independent determinants. CD for storage periods x methods for total sugars, reducing sugars, total tannins and acidity are 0.07345, 0.7635, 1.2461 and 0.2731, respectively

total sugar content of aonla was maximum just after drying whereas it was minimum at the end of storage in all the methods. The rate of decrease was decreased with the advancement of storage period. A steady decline in total sugar content in direct solar dried Banarasi aonla at 90 days of storage<sup>17</sup> have also been reported. A similar trend in Desi and Banarasi cultivars of aonla has been found<sup>18</sup>. The decrease in total sugars might be due to the non-specific hydrolysis of macromolecules, interconversion of sugars and aggregation of monomers during storage<sup>19</sup>.

### Reducing Sugars

The reducing sugars content (Table 1) was found to be highest in fluidized bed dried aonla (33.69%), followed by microwave dried aonla (21.19%) and oven dried aonla (19.56%). The minimum reducing sugars was found in direct solar dried aonla (15.44%) at the start of experiment. A comparison of mean values of reducing sugars showed that the reducing content was significantly higher in fluidized bed dried aonla. On mean value basis, the oven dried aonla was superior to microwave dried aonla, whereas, solar dried aonla showed lowest values

of reducing sugars. However, higher reducing sugar content in osmo-air dried aonla followed by indirect solar dried aonla has been reported<sup>9</sup>.

During storage, with the advancement of storage period reducing sugar content decreased significantly in all the drying methods. At the end of storage period the lowest per cent reduction was recorded in fluidized bed drying (20.18%) followed by solar drying (39.18%), oven drying (42.59%) and microwave drying (58.28%) over the start of experiment. This might be due to the dehydration reactions causing sugars to become unsaturated and highly reactive, the hexose reducing sugars are partially converted to 2-furaldehyde and 5-hydroxymethyle-2-furaldehyde<sup>20</sup>, which remain undetected in a reducing sugar test. A decrease in reducing sugars during storage in dried aonla has been reported<sup>18</sup>.

### Titrable acidity

The lowest titrable acidity (Table 1) was found in fluidized bed dried aonla (5.94%), whereas it was highest in microwave drying (6.26%) and intermediate in solar (6.02%) and oven dried (6.11%) aonla. The titrable

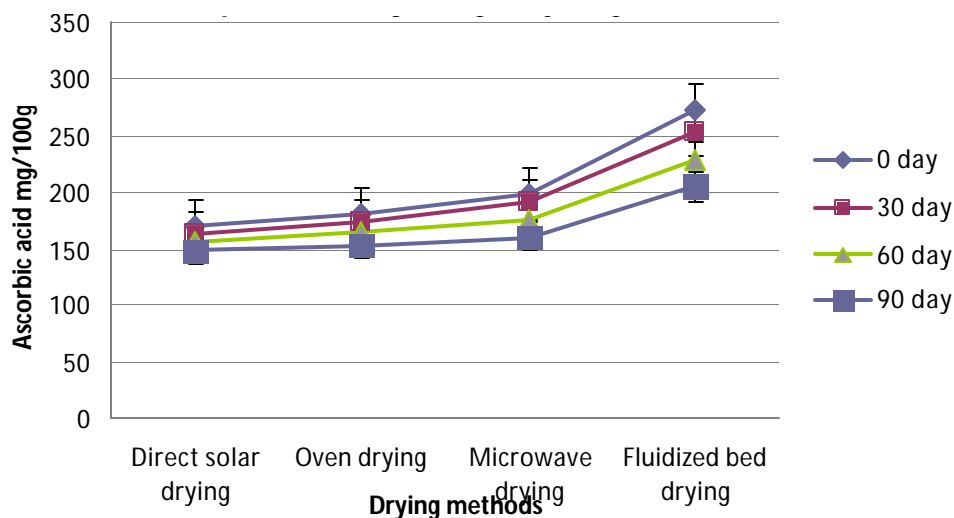


Fig. 1—Ascorbic acid (mg/100g) content in dried aonla fruit power during storage (dry weight basis)

acidity showed steady increase in storage duration in all the four methods of drying. However, it was lowest in fluidized bed dried aonla (6.13%). The increase in acidity might have been due to formation of acids due to interconversion of sugars and other chemical reactions<sup>21</sup> which accelerated at high ambient temperature. Also, de-esterification of pectin molecules occurs during storage resulting in the loss of jelly grade which leads to a gradual decrease in methoxyl content and increase in titrable acidity<sup>22</sup>. However, a decrease in acidity level in dehydrated aonla during storage has also been reported<sup>18</sup>.

#### Ascorbic Acid

Just after applying drying methods, the highest ascorbic acid was found in fluidized bed dried aonla (272.74 mg/100 g), followed by microwave dried (198.40 mg/100 g), oven dried (181.15 mg/100 g) and solar dried aonla (170.11 mg/100 g). All the four drying methods used in the study affect ascorbic acid content significantly on all the four storage periods (Fig. 1). The ascorbic acid content of aonla fruit dried by fluidized bed drying has also been reported to be significantly higher than hot air tray drying and sun drying<sup>17</sup>.

Ascorbic acid content of dehydrated aonla decreased further when stored for 90 days. On 90 days of storage, highest per cent reduction was observed in fluidized bed drying (24.64%), followed by microwave drying (18.94%), oven drying (15.50%) and least in sun drying (12.95%) over the start of experiment (Fig. 1). The reduction in ascorbic acid content might be due to oxidation during storage at high ambient temperature. A similar trend in

the reduction of ascorbic acid in direct solar dried 'Banarasi' aonla<sup>17</sup>, osmo-air, oven, direct solar and indirect solar dried 'Chakaiya' aonla<sup>9</sup>, and in solar tunnel dried and sun dried 'Banarasi730' aonla<sup>23</sup> have been reported.

#### Tannins

Highest tannin content (Table 1) was recorded in solar dried aonla (15.45%) followed by oven dried (15.05%), microwave dried (14.73%) and lowest in fluidized bed dried aonla (8.80%). The decrease in tannin content in fluidized bed dried aonla might have due to more controlled conditions of temperature and air velocity and also with the fluidized nature of drying particles.

The total tannin content of dried aonla just after drying was highest and decreased significantly during storage. This decrease in total tannins in dried aonla might have been due to the action of the enzyme polyphenoleoxidase which might have converted tannins into other products<sup>24</sup>.

#### Browning

Colour of dried aonla is an important quality parameter. Browning index of dried aonla was determined as optical density values. The data regarding change in browning (Fig. 2) during dehydration and storage showed that the extent of browning was affected significantly under different treatments. Fluidized bed dried aonla had minimal browning (OD 0.020) whereas maximum optical density value was recorded in solar dried aonla (0.075). The browning in oven dried aonla was significantly lower than that in microwave dried aonla. Optical density of

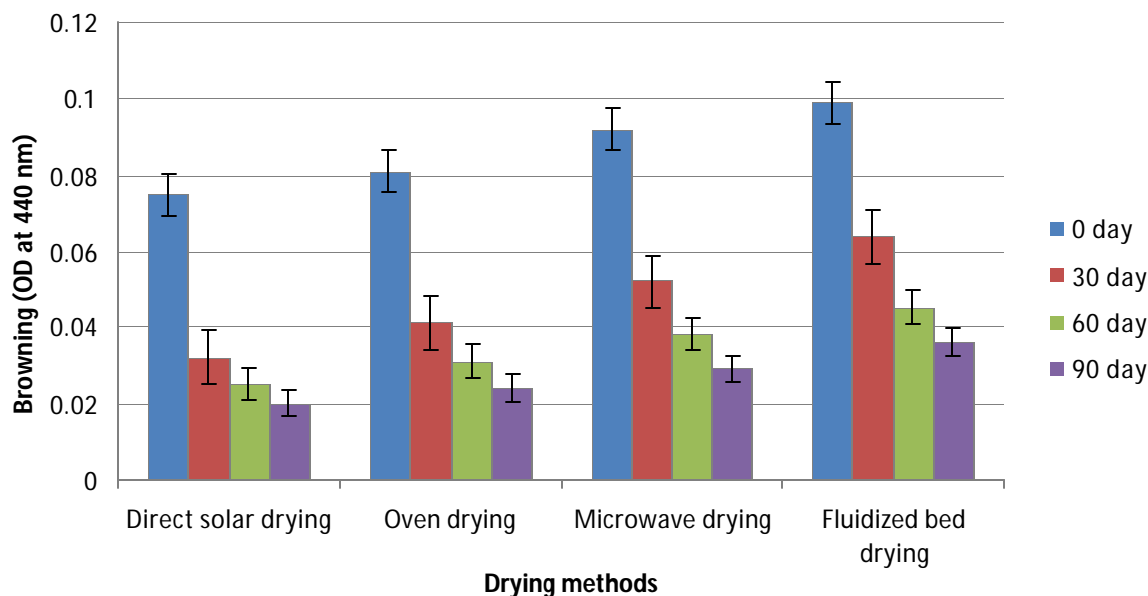


Fig. 2- Browning (OD at 440 nm) in dried aonla fruit during storage (dry weight basis)

direct solar dried ber has been found to be higher than optical density of indirectly solar dried ber<sup>25</sup>. The loss of white colour in sun dried fruits was possibly due to the photo-oxidation of carotenoids after long exposure to light and oxygen.

Optical density values of dried aonla were progressively increased with the increase in storage period from 0 days to 90 days. The increase in browning might be due to a wide range of residual peroxidases, polyphenoloxidases and lipoxigenases even after blanching, as in green peas<sup>26</sup>.

### Conclusion

Fluidized bed drying at a temperature of 65°C and wind velocity of 90 m/min found the best drying method of aonla slices. The browning index was minimum in this method and hence was found superior. The nutrient retention in fluidized bed drying with special reference to ascorbic acid was found highest. The tannin content was also lowest in this method of drying. Hence, fluidized bed drying can be recommended for drying of aonla slices.

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