Original Research Article

Effect of different Drying methods on Physico-Biochemical aspects of Aonla fruit pulp powder

ABSTRACT

Aonla (*Emblica officinalis* Geartn.) possess significant nutraceutical properties and to utilize Aonla for various value additions, its fruit powder is one of the best option for several preparations. As there are different drying methods for preparation of fruit pulp powder, it is needed to find out the most suitable method for drying which can efficiently retain nutritional and organoleptic properties of Aonla Fruit pulp powder. Thus, we conducted an experiment to study the effect of drying methods *viz.,* Sun Drying, Oven Drying, Air Drying and Freeze Drying on Physico-Biochemical properties of Aonla fruit pulp powder. The findings shows that moisture percent and bulk density was maximum in Sun drying method followed by Air drying while minimum was with Oven drying followed by Freeze Drying. Ash (5.71 %), Fiber (8.41 %), Protein percent (10.73 %), Total Sugar (21.71 %), Reducing Sugar (16.81 %) & Non-Reducing Sugar (4.89 %), Titratable Acidity (4.21 %), Ascorbic acid (546.14 mg/100g), Total Phenols (371.63 mg/100g GAE) and DPPH Radical Scavenging Activity (88.23 %) was found maximum with Freeze Drying followed by Air drying. Taste, Flavour, Aroma and Overall Acceptability was reported best with freeze drying method followed by air drying.

Keywords: DPPH, Emblica officinalis, Nutritional value, Phenols, Pulp powder, Vitamin C.

1. INTRODUCTION

Aonla (*Emblica officinalis* Geartn.) or Indian Gooseberry, is mostly cultivated in India, Pakistan, Sri-Lanka, China, Malaysia and Indonesia. An average aonla tree, usually deciduous in nature, is of medium height (8–18 m). The bark is thick (~ 12 mm) with light grayish or greenish-brown in color, The leaves of this tree are pinnate in type, simple, alternate, bifarious, sub-sessile, light green in color and arranged in a close pattern along the branchlets petioles are striated. February–May mark the flowering period. *E. officinalis* fruits (measuring 15–20 mm × 18–25 mm) are drupe in nature and almost sphere-shaped with a minor conic indentation on both poles. The edible smooth fleshy mesocarp is a pale yellow to yellowish-green in appearance and the endocarp that forms the hard stone encasing the seeds turns yellowish-brown during maturity. The berries generally start to ripen during autumn *i.e.,* from October-November and available up to February-March and each weighs ~ 60–70 g [1].

Aonla fruit possesses higher nutritional and medicinal properties which is utilized in India for consumption as well as Ayurvedic preparations. Aonla is astringent and sour in taste but it is highly nutritive, rich in tannins, polyphenols as well as richest and cheapest source of Vitamin C (ascorbic acid) with high antioxidant properties. Aonla fruit is usually consumed as raw and in processed forms like jam, sauce, candy, pickle, preserve, juice and powder [2].

Being rich in Ascorbic acid, due to its sour and astringent taste makes fresh Aonla less acceptable to the consumers. But processed forms are more acceptable. Drying of fruit pulp and vegetables is the ancient techniques, and Aonla fruit can be effectively made to powder for the consumption as well as for further value addition purposes even during its off season. Trifala is the famous Ayurvedic preparation prepared from Aonla powder with other ingredients.

Among the drying methods available, sun drying and oven drying are most common among folks, but with the advancement of technologies there are other different methods like Vacuum drying, Spray drying, Air drying, Freeze drying developed which are fast and efficient in quality & nutritive value retention. For fruit pulp powder production, fast and feasible method of drying is the need of time but beside this the drying method should also be efficient in retaining quality and nutritional value of pulp powder as well. It is needed to study which drying method can fulfill these drying requirements. In view of this and importance of Aonla pulp powder in value addition, an experiment has been performed to study the effect of different drying methods on physical, biochemical and sensory aspects of Aonla fruit pulp powder.

2. MATERIAL AND METHODS

2.1. Location of Experiment

Experiment was conducted in the University Laboratory, Rajmata Vijayaraje Scindia Agricultural University, Gwalior, MP, India (**Latitude:** 26° 13' 47.39" N and **Longitude:** 78° 10' 24.13" E). Duration of the experiment was from February, 2022 to March, 2022.

2.2. Collection of Fruit Samples

Fully mature fruits were collected from the Aonla Orchard during February, they were thoroughly washed under tap water to remove dust & impurities and segments were cut and separated from the capsules with the help of knife.

2.3. Drying methods and preparation of fruit pulp powder

Four drying methods were adopted for the experiment. In Gwalior during February, it was mild cold sunny days when the fruits were dried under sun, for Sun drying fruit pulp was dried under the sun for six days. In Oven Drying the pulp was kept in the hot air oven at 55 °C and for Air drying, pulp pieces were kept under air circulated incubator at constant temperature of 25 °C until the moisture is reduced to minimum 10 %. For freeze drying, fruit pulp segments were kept at -40 °C for 5 hours and then freeze dried at -50 °C and 52 Pa pressure for 22 hours. The dried pieces were grinded to fine powder and filtered using muslin cloth. The powder was kept under plastic sealed bags and stored at 4 °C until the analysis [3], [4].

2.4. Physico-Biochemical analysis

2.4.1. Total Soluble Solids (TSS), pH, Moisture and Bulk Density

Total Soluble Solids (TSS) (°Brix) of the juice of fresh pulp was measured using hand refractometer and pH of pulp juice was measured with digital pH meter. The moisture content was determined by drying at 70 °C up to constant weight and expressed in terms of the percent wet basis (100 X kg water/kg wet material). Bulk density of samples were determined by measuring the volume in a 100 ml measuring cylinder and weight, the ratio of weight and volume of the samples used to calculate the bulk density (g/cm^3) [5].

2.4.2. Titratable Acidity, Ascorbic Acid

Titratable acidity (%) of aonla powder samples ware measured by AOAC [6] method by boiling the sample for 1 h in water and making up the volume up to 100 ml and then titrating it against 0.1 N sodium hydroxide solution using phenolphthalein indicator.

Ascorbic acid (Vitamin C) content of the sample was analyzed by using 2, 6- dichlorophenol indophenol dye method as described by Ranganna [7] and represented in mg per 100g.

2.4.3. Total Sugar, Reducing Sugar, Non-Reducing Sugar and Protein

Total sugar, and reducing sugar content were measured using methods of Lane and Eynon as described by Ranganna [7]. Non-reducing sugar was estimated by subtracting reducing sugar from total sugar. Protein was estimated as per the method described by Lowry *et al.* [8]. Data is represented in percent basis.

2.4.4. Total Phenols and DPPH Radical Scavenging Activity

Amount of 10g powdered samples were homogenized with 40 ml methanol at a magnetic stirrer, supernatant was separated after centrifugation. Volume of extract was reduced with the help of rotary vacuum evaporator, then filtered through Whatman filter paper and stored in glass bottles at 4°C until analyzed. This extract was used to determine phenols and antioxidant activity (DPPH radical scavenging activity).

Total phenols in fresh aonla and powder samples were determined by the Folin-Ciocalteu method [9] where gallic acid was used as standard and expressed as mg gallic acid equivalent per gram of sample (mg GAE/g).

Free DPPH radical scavenging activity of extracts, an aliquot (100 µl) of fruit extract was mixed with 3.9 ml of 0.1 mM DPPH methanolic solution. The mixture was thoroughly vortexed and incubated at ambient temperature in the dark for 35 minutes. The absorbance at 517 nm was measured along with control (only DPPH solution) and blank (only methanol) with ascorbic acid as standard. Results were expressed as percentage of inhibition of the DPPH radicals [10].

2.5. Sensory Analysis

Sensory analysis of samples was done at 9.0-point hedonic scale. Ten semi trained panelists aged between 21 and 45 years, were selected to take part in the sensory panel. The panel measured the taste, flavor, aroma and overall acceptability. The mean score was calculated from the scores given by each individual panelists [11].

2.6. Statistical Analysis

All the data were noted in triplicates for each parameter and their mean was obtained. The significance of data was analyzed using one-way ANOVA. F-test was adopted to test the level of significance at 5 %. Standard error of difference (SE_d) and critical difference (CD) was calculated.

3. RESULTS

3.1. Physico-biochemical parameters of fresh aonla fruit pulp

Analysis of fresh Aonla fruit pulp reported high moisture (85.90 %) and bulk density (0.75 g/cm^3). TSS (total soluble solids), pH and titratable acidity was found optimum 8.93 °Brix, 2.79 and 2.04 % respectively. Good amount of ash (2.80 %), fiber (3.88 %), protein (5.03 %), total sugar (7.2 %), reducing sugar (5.58 %), non-reducing sugar (1.61 %) and ascorbic acid (611.37 mg/100g) was found in fresh Aonla pulp (Table 1).

3.2. Physico-biochemical parameters of aonla fruit pulp powder

3.2.1. Moisture & Bulk Density

The drying methods showed significant results, highest moisture content (6.48 %) was found in sun drying followed by air drying method (Table 2). Bulk density was reported highest in sun drying (0.76 g/cm^3) followed by air drying (0.69 g/cm^3) and both methods differed significantly. Oven drying possessed minimum moisture percent and bulk density.

3.2.2. Ash, Fiber and Protein

Ash, fiber and protein content were significantly differed among different drying methods; however, oven drying & air-drying methods were found at par with each other. Significantly highest content of ash (5.71 %), fiber (8.41 %) and protein (10.73 %) were found in pulp powder when freeze dried followed by air dried. The minimum content was found with oven drying method (Table 2).

Table 1: Physico-Biochemical characters of fresh aonla fruit pulp

S. No.	Parameters	Mean ± SD*
1.	Moisture %	85.90 ± 0.36
2.	Weight of pulp per fruit (g)	35.63 ± 0.38
3.	Volume of pulp per fruit (cm^3)	47.23 ± 0.83
4.	Bulk Density (g/cm^3)	0.75 ± 0.005
5.	pH	2.79 ± 0.15
6.	TSS (total soluble solids) °Brix	8.93 ± 0.25
7.	Titratable acidity %	2.04 ± 0.21
8.	Ash %	2.80 ± 0.06
9.	Fiber %	3.88 ± 0.27
10.	Protein %	5.03 ± 0.28
11.	Total Sugar %	7.2 ± 0.36
12.	Reducing Sugar %	5.58 ± 0.31
13.	Non-Reducing Sugar %	1.61 ± 0.05
14.	Ascorbic acid (mg/100g)	611.37 ± 1.95

*Data presented in Mean ± Standard Deviation

Table 2: Effect of drying methods on physical aspects and proximate of aonla fruit pulp powder

S. No.	Drying Methods	Parameters						
		Moisture %	**Weight of powder per fruit (g)**	**Volume of powder per fruit (cm^3)**	**Bulk Density (g/cm^3)**	**Ash %**	**Fiber %**	**Protein %**
1.	**Sun Drying**	6.48	7.41	9.66	0.76	5.00	7.12	9.23
2.	**Oven Drying**	3.32	6.12	11.69	0.52	4.39	6.36	8.30
3.	**Air Drying**	5.94	6.79	9.81	0.69	5.25	7.68	9.95
4.	**Freeze Drying**	4.18	6.33	10.72	0.59	5.71	8.41	10.73
	SE_d ±	0.10	0.05	0.35	0.02	0.10	0.22	0.24
	C.D. (*P*=.05)	0.24	0.12	0.82	0.04	0.23	0.52	0.55

3.2.3. Titratable acidity, total sugar, reducing and non-reducing sugar

Significant results were obtained. The maximum titratable acidity (4.21 %), total sugar (21.71 %), reducing sugar (16.81 %) and non-reducing sugar (4.89 %) were found with freeze drying method followed by air drying (Table 3). Minimum titratable acidity (3.22 %) was reported with oven drying method while minimum total sugar (18.72 %), reducing sugar (14.53 %) and non-reducing sugar

(4.17 %) content was reported under sun drying method. Oven drying and air-drying methods were at par with each other.

3.2.4. Ascorbic acid, total phenols and DPPH radical scavenging activity

Data analysis showed highly significant results, the highest recovery of ascorbic acid was reported with freeze drying (546.14 mg/100g) followed by air drying (420.48 mg/100g) and oven drying (341.94 mg/100g) respectively, while minimum was reported with sun drying (264.27 mg/100g). The maximum total phenol content was reported with freeze drying (371.63 %) followed by air drying (337.26 %), while minimum was reported under oven drying method. Highest inhibition of DPPH radicals was observed under freeze drying method (88.23 %) succeeding air drying method (71.49 %) (Table 4).

Table 3: Effect of drying methods on titratable acidity, total sugars, reducing and non-reducing sugars of aonla fruit pulp powder

S. No.	Drying Methods	Parameters			
		Titratable Acidity %	Total Sugar %	Reducing Sugar %	Non-Reducing Sugar %
1.	Sun Drying	3.65	18.72	14.53	4.17
2.	Oven Drying	3.22	20.02	15.62	4.40
3.	Air Drying	3.89	20.62	15.90	4.71
4.	Freeze Drying	4.21	21.71	16.81	4.89
	SE_d ±	0.17	0.64	0.53	0.14
	C.D. (*P*=.05)	0.39	1.49	1.22	0.34

Table 4: Effect of drying methods on ascorbic acid, total phenols and DPPH Radical Scavenging Activity of aonla fruit pulp powder

S. No.	Drying Methods	Parameters		
		Ascorbic acid (mg/100g)	Total Phenols (mg/100g GAE)	DPPH Radical Scavenging Activity %
1.	Sun Drying	264.27	301.10	59.38
2.	Oven Drying	341.94	269.40	56.20
3.	Air Drying	420.48	337.26	71.49
4.	Freeze Drying	546.14	371.63	88.23
	SE_d ±	8.75	1.06	0.44
	C.D. (*P*=.05)	20.18	2.45	1.02

3.3. Sensory analysis of aonla fruit pulp powder

Organoleptic characters significantly affected by different drying methods and they are significantly differed from each other except oven drying and air drying which were at par with each other. Score for taste (8.20), flavour (7.56), aroma (7.50) and overall acceptability (7.41) were maximum under freeze drying succeeding air drying (Table 5). Minimum organoleptic scores were found with oven drying method.

Table 5: Effect of drying methods on sensory aspects of aonla fruit pulp powder

S. No.	Drying Methods	Parameters			
		Taste	Flavour	Aroma	Overall Acceptability
1.	Sun Drying	6.83	6.40	6.80	6.86
2.	Oven Drying	6.40	5.80	6.56	6.40
3.	Air Drying	7.80	6.90	6.90	7.00
4.	Freeze Drying	8.20	7.56	7.50	7.41
	SE_d ±	0.14	0.10	0.09	0.17
	C.D. (*P*=.05)	0.33	0.24	0.22	0.39

4. DISCUSSION

The moisture content of the sun drying method was maximum among all other methods, because drying under sun and open environment is uncontrolled which cause more chances of environmental influence. More moisture tends to put more bulk density. While oven drying is done under higher temperature under controlled condition possessing minimum moisture and bulk density. Freeze drying and air-drying methods characterized with low temperature treatment under controlled conditions which removes the environmental fluctuation along with the minimum degradation of components like ash, fiber, protein and acidity etc. as compared to sun drying which is influenced with environmental fluctuation whereas in oven drying temperature goes high, causing more degradation of components. Results are in accordance with the reports of Alkandari et al. [4], Karam et al. [12]; Radojčin et al. [13]; Shuen et al. [14]; Verma et al. [3], they reported freeze drying method as best as compared to other methods like oven drying, sun drying etc.

The browning of sugars under influence of sun under sun drying and heat under oven drying causes reduction of sugar content. Whereas in freeze drying with low temperature reduces the chances of browning significantly leads to retain high sugar content [4], [15]–[17].

Sun drying tend to lower retention of ascorbic acid and phenols due to the more oxidation and breakdown while oven drying method includes high heat which causes less retention of these compounds as well. Ascorbic acid is a sensitive component which reduces significantly during heat treatment and under the influence of sun heat and environmental fluctuations. Freeze drying and air drying almost removes these problems of oxidation, high temperature and environmental impacts while providing low temperature causing better retention of ascorbic acid and phenol [12]–[14], [16]–[18].

Study reports [19]–[21] that antioxidant activity directly correlates with ascorbic acid content, phenols and other bioactive compounds. The higher ascorbic acid and phenolic content was found under freeze drying and air drying could be the reason for more antioxidant activity (DPPH Radical Scavenging Activity). Freeze drying and air drying retained the better taste, aroma, flavour and overall acceptability because of very less chance of deterioration of originality of fruit pulp as compared to sun and oven drying [13], [16].

5. CONCLUSION

Drying methods for preparing Aonla fruit pulp powder showed significant results for physico-biochemical aspects. We concluded that freeze drying method was found best for retaining all physico-biochemical quality of Aonla fruit pulp powder, whereas second best method was Air-drying. For commercial production of aonla fruit pulp powder, freeze drying and air-drying methods can be adopted effectively for obtaining better quality.

REFERENCES

[1] Gantait S, Mahanta M, Bera S, and Verma SK. Advances in biotechnology of *Emblica officinalis* Gaertn. syn. *Phyllanthus emblica* L.: a nutraceuticals-rich fruit tree with multifaceted ethnomedicinal uses. *3 Biotech*. 2021; 11(2): 62. doi: 10.1007/s13205-020-02615-5.

[2] Nayak P, Tandon DK, Bhatt DK, Kanshi MS and Ji R. Study on changes of nutritional and organoleptic quality of flavored candy prepared from aonla (Emblica officinalis G.) during storage. Int. J. Nutr. Metab. 2012; 4(7): 100–106. doi: 10.5897/IJNAM11.070.

[3] Verma M, Singh J, Kaur D, Mishra V and Rai GK. Effect of various dehydration methods and storage on physicochemical properties of guava powder. J. Food Sci. Technol. 2015; 52(1): 528–534. doi: 10.1007/s13197-013-1020-0.

[4] Alkandari D, Sarfraz H and Sidhu JS. Development of a functional food (pan bread) using amla fruit powder. J. Food Sci. Technol. 2019; 56(4): 2287–2295. doi: 10.1007/s13197-019-03718-5.

[5] Goula AM, Adamopoulos KG and Kazakis NA. Influence of Spray Drying Conditions on Tomato Powder Properties. Dry. Technol. 2004; 22(5): 1129–1151. doi: 10.1081/DRT-120038584.

[6] AOAC. Official methods of analysis, 18th ed. Washington DC, 2005.

[7] Ranganna S. Handbook of Analysis and Quality Control of Fruit and Vegetable Products, 2nd ed. New York, NY: Tata McGrow-Hill Education, 1986.

[8] Lowry OH, Rosebrough NJ, Farr AL and Randall RJ. Protein measurement with the Folin phenol reagent. J. Biol. Chem. 1951; 193(1): 265–275. doi: 10.1016/S0021-9258(19)52451-6.

[9] Singleton VL, Orthofer R and Lamuela-Raventós RM. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. Scientia Horticulturae. 1999; 213(1974): 152–178.

[10] Alothman M, Bhat R and Karim AA. Antioxidant capacity and phenolic content of selected tropical fruits from Malaysia, extracted with different solvents. Food Chem. 2009; 115(3): 785–788. doi: 10.1016/j.foodchem.2008.12.005.

[11] Larmond E. Laboratory Methods for Sensory Evaluation of Food. Research Branch, Canada Dept. of Agriculture, 1977.

[12] Karam MC, Petit J, Zimmer D, Baudelaire Djantou E and J. Scher J. Effects of drying and grinding in production of fruit and vegetable powders: A review. J. Food Eng. 2016; 188: 32–49. doi: 10.1016/j.jfoodeng.2016.05.001.

[13] Radojčin M, Pavkov I, Bursać Kovačević D, Putnik P, Wiktor A, Stamenković, Z *et al.* Effect of Selected Drying Methods and Emerging Drying Intensification Technologies on the Quality of Dried Fruit: A Review. Processes. 2021; 9(1): 132. doi: 10.3390/pr9010132.

[14] Shuen GW, Yi LY, Ying TS, Von GCY, Yusof YAB and Phing PL. Effects of drying methods on the physicochemical properties and antioxidant capacity of Kuini powder. Brazilian J. Food Technol. 2021; 24; 1–14. doi: 10.1590/1981-6723.08620.

[15] Arslan D and Özcan MM. Dehydration of red bell-pepper (*Capsicum annuum* L.): Change in drying behavior, colour and antioxidant content. Food Bioprod. Process. 2011; 89(4): 504–513. doi: 10.1016/j.fbp.2010.09.009.

[16] Guiné RPF. The Drying of Foods and Its Effect on the Physical-Chemical, Sensorial and Nutritional Properties. ETP Int. J. Food Eng. 2018; 4(2): 93–100. doi: 10.18178/ijfe.4.2.93-100.

[17] Pragati, Dahiya S and Dhawan SS. Effect of drying methods on nutritional composition of dehydrated aonla fruit (*Emblica officinalis* Garten) during storage. Plant Foods Hum. Nutr. 2003; 58(3): 1–9. doi: 10.1023/b:qual.0000040332.98384.c4.

[18] Mishra P, Srivastava V, Verma D, Chauhan OP and Rai GK. Physico-chemical properties of Chakiya variety of Amla (*Emblica officinalis*) and effect of different dehydration methods on quality of powder. African J. Food Sci. 2009; 3(10): 303–306, 2009. http://www.academicjournals.org/ajfs..

[19] Kaur C and Kapoor HC. Anti-oxidant activity and total phenolic content of some Asian vegetables. Int. J. Food Sci. Technol. 2002; 37(2): 153–161. doi: 10.1046/j.1365-2621.2002.00552.x.

[20] Scartezzini P, Antognoni F, Raggi MA, Poli F and Sabbioni C. Vitamin C content and

antioxidant activity of the fruit and of the Ayurvedic preparation of Emblica officinalis Gaertn. J. Ethnopharmacol. 2006; 104(1-2): 113–118. doi: 10.1016/j.jep.2005.08.065.
[21] Sultana Bushra. Effect of drying techniques on the total phenolic contents and antioxidant activity of selected fruits. J. Med. Plants Res. 2012; 6(1): 161–167. doi: 10.5897/JMPR11.916.