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# Physico-chemical properties and nutritional composition of aonla *(Emblica officinalis)* varieties

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**Abstract**

Proximate, chemical and nutritional profiles of fresh aonla fruits of five varieties viz. Banarasi, Chakaiya, Kanchan, NA-7 and Desi were studied. Fruits of variety Banarasi were the largest in size and had maximum weight, while fruits of Desi variety had the least values with maximum firmness. Moisture contents of variety NA-7 was the highest. The fruits of Desi variety were reported to have the maximum ash, fat and fibre contents. Varietal differences significantly ($p < 0.05$) influenced the acidity, ascorbic acid, total polyphenol, total sugar and pectin contents. It was observed that iron and zinc contents were significantly higher in Chakaiya variety while sodium and potassium contents were higher in Kanchan variety.



## Introduction

*Emblica officinalis* (aonla) is native of tropical India and Southeast Asia, commonly named as 'Indian gooseberry' (Barthakar and Arnold, 1991). Aonla fruits are fleshy, yellowish green in colour having six vague perpendicular furrows enclosing seeds. Nutritional, commercial and medicinal significance of aonla fruit makes it popular all over the world (Goyal *et al.*, 2007). Aonla is an excellent source of ascorbic acid (300-900 mg/100 g), amino acid and minerals along with phytochemicals such as polyphenols, tannins, emblicol, linoleic acid, corilagin, phyllemblin and rutin (Ghorai and Sethi, 1996; Jain and Khurdiya, 2004; Murthy and Joshi, 2007; Baliga and Dsouza, 2011).

Aonla fruit is helpful in the treatment of haemorrhage, dysentery, diarrhoea, gastric disorders, constipation, headache, jaundice and enlargement of liver (Parrotta, 2001; Goyal *et al.*, 2007). Various research studies show that aonla has prominent antibiotic, antiulcerogenic, diuretic, laxative, adaptogenic, antitumor, antiscorbutic, hepatoprotective, cardio tonic, antiviral, and hypoglycaemic properties (Rege *et al.*,1999; Jose and Kutton, 2000; Dahiya and Dhawan, 2001; Pragati *et al.*, 2003; Mishra *et al.*, 2009). Hypolipidaemic effect of fruit juice of aonla was reported in a study by Mathur *et al.* (1996). Study by Perianayagam *et al.* (2004) reported anti-pyretic and analgesic activity in ethanolic and aqueous extract of *Emblica officinalis.*

Banarasi, Chakaiya, Krishna, Francis (Hathijhool), Kanchan (NA-4), NA-6, NA-7, Anand-1, 2, 3 are some of the commercially cultivated varieties of aonla in India (Goyal, 2008; Singh, 2009). Owing to its excellent nutritional profile and physico-chemical properties, aonla is processed into different types of product. Aonla fruit having sour and astringent taste, generally utilised raw, cooked or in the form of pickle. Murrabas, juice, jam, cheese, candy, powder, beverage, chutney are the different types of aonla products available in the market and preferred by the consumer being the rich source of vitamin C and antioxidants. Aonla is one of the main constituent of many ayurvedic preparations like Triphla and Chyawanprash (Pant *et al.*, 2004; Goyal *et al.*, 2007; Mishra *et al.*, 2009).

There is dearth of literature availability on physico-chemical properties of various Indian cultivar of aonla. The present investigation was therefore planned to evaluate the physico-chemical properties and nutritional composition of five different varieties of aonla.

## Materials and Methods

### *Procurement of aonla fruit varieties*

Five different varieties of aonla: NA-7, Banarasi, Kanchan, Chakaiya and Desi were procured from the farm of Central State Farm, Hisar at fully ripen stage. Fruits were washed under running water to

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remove the adhering dust and other impurities from the surface.

*Physical properties of aonla fruits*

Physical parameters of randomly selected fruits were studied. Weight of different varieties was recorded using the electronic balance, height and width by digital vernier calliper, and shape and colour was judged visually.

*Firmness of aonla fruits*

Firmness was measured by using texture analyser (Stable Micro System, U.K.). Texture analyser was calibrated using 5 kg load cell and probe distance was 25 mm. The setting were: mode-texture profile analysis (TPA); pre-test speed, test speed, and post test speed - 3.0, 2.0 and 10.0 mm/sec respectively; distance- 10 mm; trigger type- auto 10 g and probe P/.5 R was used. The fruits of uniform size were taken and placed over platform facing probe from stem side. Firmness was reported in grams.

*Titratable acidity*

Titratable acidity was estimated by the method of AOAC (2005). Diluted aonla extract was titrated against 0.1 N sodium hydroxide using phenolphathlein indicator. Experiment was performed thrice. Titratable acidity was reported as citric acid (%).

*Proximate analysis*

Moisture and ash content were determined using standard AOAC method. Total soluble solids of the aonla fruits were determined at ambient temperature using portable hand-held refractometer and pH value was measured using digital pH meter. Fat content was determined by solvent extractor (VELP Scientifica SER 148, Italy). Aonla fruit (5 g) was taken in pre-weighed thimbles and petroleum ether was used for the extraction. Extraction was completed in 2 h. Each measurement was performed in triplicates and mean was reported. Fat content was expressed in terms of percentage on dry weight basis. Residue of fat extract was used for the determination of crude fibre using fibra plus (FES6 Pelican equipments India). Acid and base digestion was performed using 0.255 N sulphuric acid and 0.313 N sodium hydroxide solvents, respectively. After washing with boiling water, extract was kept in muffle furnace for 30 min to destroy carbonaceous matter and loss in weight was calculated as crude fibre. Protein content was estimated by microkjeldahl method. Fresh aonla was digested with digestion mix and conc. sulphuric acid. After dilution, 10 ml of sodium hydroxide was added and distillation was done. Distillate was collected in 50 ml conical flask containing 5 ml boric acid with 2 drops of mixed indicator till colour of solution was changed. Then titration of distillate was carried out against standard hydrochloric acid and titer value was noted. Protein content was calculated by multiplying 6.25 to total nitrogen content. Carbohydrate content (%) was calculated by difference method [100 - ((%) moisture – (%) fat – (%) protein – (%) fiber)].

Ascorbic acid content was determined by AOAC (2005) method. Fresh aonla juice was diluted with equal amount of meta-phosphoric acid and titrated rapidly with indo-phenol dye. Similarly standard ascorbic acid solution and meta-phosphoric acid (blank) solution titrated against the indo-phenol dye.

Total polyphenol was determined according the method of Anesini *et al.* (2008) with some modification. Extraction was done with distilled water in boiling water bath. The extract (1 ml) was taken in test tube and to this 0.5 ml of Follin Ciocalteaue reagent was added, after 3 min 1 ml of saturated sodium carbonate solution was added and volume was made 10 ml with distilled water. Absorbance was taken at 760 nm after 30 min. Standard curve was prepared using the graded concentration (20 to 100 ppm) of the gallic acid standard and with reference to the standard curve concentration of total polyphenols was determined as gallic acid equivalent.

Total sugar content was estimated by the method of Yemm and Will (1954). Extraction of total sugar was carried out using 80% ethanol. Sample extract (0.1 ml) was taken in triplicate in each test tube and anthrone reagent (10 ml) was pipetted in empty test tubes placed in ice-cold water bath. Then early dilutions were added to anthrone reagent and test tubes were placed in boiling water bath for 10 min for colour development. After cooling, absorbance was noted at 625 nm. Standard curve was prepared using the graded concentration of glucose solution (25 to 250 ppm). Reducing sugar was determined by the Grewal's (2001) method using Nelson's reagent. Extract (1 ml) was taken in blood sugar test tubes and 0.1 ml of mixed copper reagent was added and heated for 20 min in boiling water bath and 1 ml Nelson's reagent was added mixed thoroughly and diluted to 25 ml with distilled water. Stable blue colour was read at 520 nm against blank. Standard curve was prepared using graded concentration (20 to 100 ppm) of glucose solution (100 ppm). Non reducing sugar content was measured by difference method (Total sugar (%) - Reducing sugar (%)). Starch content of the samples was determined by using method AOAC (2000).

Pectin content was estimated in the form of calcium pectate using method described by Rangana (1986).

Pectin was extracted using 0.05 N hydrochloric acid and 1 N sodium hydroxide, was added to the extract for neutralisation. After overnight storage, 50 ml of 1 N acetic acid and 25 ml of 1 N calcium chloride were added. Solution was filtered through the dry and pre-weighed Whatman filter paper no.4. After washing, precipitates were dried overnight at 100$^0$C in hot air oven and reported as (%) calcium pectate.

*Mineral estimation of aonla fruits*

Mineral content and heavy metal estimation was done using atomic absorption spectrophotometer (Advance Scientific, Australia). Sodium, potassium, zinc, calcium, iron and heavy metals such as lead, mercury were estimated using wet ashing method.

*Statistical analysis*

The data obtained in present investigation was subjected to statistical analysis of variance (ANOVA) techniques using Duncan test SPSS 16.0 Software. The data were expressed as means ± SD.

**Results and Discussion**

*Physical properties*

Processing of fruits into different kind of products depend on their physical properties as they affect the final appearance and quality of the end product. In this study, five different varieties were assessed for their physical characteristics. The fruit colour of all the varieties was yellowish green except of Desi variety, which was green in colour. Shape of the varieties was round to oblate. Similar colour and shape was observed by Ali (2010); Dahiya and Dhawan (2001); Ghorai and Sethi (1996) and Kalra (1988). The data (Table 1) revealed that size of fruit varied according to the variety. A wide gap in weight that ranged from 14.27 to 49.97 g was observed among the fruits of five varieties. The fruit of Banarasi variety was having the highest weight followed by NA-7, Kanchan, Chakaiya and Desi varieties. The fruit weight in range from 37.2 to 42 g was reported by Anon. (1988) and Ganachar *et al.* (2012). A considerable gap in the length of fruits from 25.12 to 41.10 mm and in the width from 29.38 to 44.85 mm was observed among the varieties. The fruit of Banarasi variety had the maximum width followed by Chakaiya, NA-7, Kanchan, and Desi. Similar data was observed by Ram *et al.* (1983); Kalra *et al.* (1988); Goyal *et al.* (2007) and Ali *et al.* (2010). A huge fluctuation in the weight, length and width among the fruits of different varieties might be due to different agro-climatic conditions. The fruit of Desi variety was the most firm along the stem side followed by variety NA-7 and Banarasi (Table1). Significant variation ($p < 0.05$) was noted among the varieties due the difference in their genetic makeup and environmental conditions. Firmness of Desi variety was the maximum due to their small size, compact and highly fibrous structure, while the fruit of Banarasi variety was the largest in size with less fibre content. The observed data was supported by the work of Ali *et al*. (2010).

Table 1. Physical properties of the fresh fruits of aonla varieties

| Variety | Weight (g) | Length (mm) | Width (mm) | Firmness (g) |
|---|---|---|---|---|
| Banarasi | 49.97±0.61 | 41.10±0.77 | 44.85±0.72 | 253.13±13.86 |
| Chakaiya | 34.96±1.37 | 32.18±0.27 | 42.24±0.29 | 274.93±15.57 |
| Desi | 14.27±0.03 | 25.12±0.39 | 29.38±0.50 | 583.27±65.25 |
| Kanchan | 37.36±0.45 | 32.37±0.37 | 41.10±0.36 | 288.22±30.43 |
| NA-7 | 39.05±0.74 | 36.90±0.50 | 41.34±0.32 | 358.31±22.46 |

The values are mean ±SD of determinations made in triplicates

*Chemical analysis*

Evaluation of proximate composition of a food commodity is done for judging the nutritional quality. Moisture content is an important parameter in assessing the quality of fresh fruits and vegetables. The average value of moisture contents of aonla varieties reported in Table 2, ranged from 81.26 to 84.65%. In the present investigation, it was found that the fruit of variety NA-7 had the highest moisture contents followed by Chakaiya, while the fruit of variety Desi had the lowest value. In moisture content significant difference among varieties was observed due to the difference in maturity stage and genetic makeup. Moisture content was reported in the range from 80 to 87% by various researchers (Ghori and Sethi, 1996; Singh *et al.*, 2006; Garg, 2010). Significant variation in ash content was also noted which ranged from 2.24 to 3.08%. Fruits of Desi variety had the highest values and the fruits of Kanchan variety had the lowest values. Protein contents among the varieties varied from 2.05 to 3.17%. Fruits of variety Banarasi had the maximum values followed by NA-7 and the fruits of the Chakaiya variety had the lowest values. The observed data was in agreement with values reported in different studies (Singh *et al.*, 1987; Barthakur and Arnold, 1991; Pragati and Dhawan, 2001; Singh *et al*., 2006; Khan, 2009; Garg, 2010). Less variation in fat contents of fruits was observed among the varieties (Table 2). Fruits of Desi variety had the highest fat content of 0.48% followed by Chakaiya, Kanchan, NA-7 and Banarasi. Reported values of fat contents by Singh (2012) and Singh (2009), were in the range of 0.10 to 0.12% on fresh weight basis. Fruits are recommended as a good source of

Table 2. Proximate analysis of the fresh fruits of aonla varieties

| Variety | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Fibre (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| Banarasi | 82.50±0.05b | 2.37±0.00 b | 3.17±0.01 d | 0.36±0.01 a | 7.18±0.01a | 87.12±0.01d |
| Chakaiya | 84.24±0.10d | 2.55± 0.10c | 2.05± 0.01a | 0.46± 0.01c | 11.14±0.02b | 84.25±0.02c |
| Desi | 81.26±0.26a | 3.08± 0.01d | 2.12± 0.01a | 0.48± 0.00c | 22.35±0.02d | 73.75±0.02a |
| Kanchan | 83.36±0.39c | 2.24± 0.00a | 2.66± 0.01b | 0.42± 0.00b | 17.04±0.02c | 77.62±0.02b |
| NA-7 | 84.65±0.05e | 2.51± 0.00c | 2.99± 0.01c | 0.39±0.00ab | 16.87±0.02c | 77.52±0.01b |

[a] The values are mean ±SD of determinations made in triplicates. Mean values followed by different letters within a same column differ significantly (p>0.05)
[b] Carbohydrate content was calculated by difference
[c] All the data except moisture is reported on dry wt. basis

Table 3. Nutritional composition of the fresh fruits of aonla varieties

| Variety | Acidity (%) | pH | TSS (°Brix) | Ascorbic acid (g/100g) | Polyphenols (%) | Total sugar (%) | Reducing sugar (%) | Non-reducing sugar (%) | Pectin (%) | Starch (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Banarasi | 11.63±0.09b | 2.84±0.01b | 14.43±0.05c | 3.15±1.05d | 25.77±0.81a | 29.33±0.01a | 17.80±0.02a | 11.52±0.02a | 2.41±0.02a | 16.07±0.02a |
| Chakaiya | 11.08±0.01a | 2.88±0.01b | 12.10±0.10a | 2.83±0.81c | 28.81±0.08b | 36.91±0.04c | 22.17±0.16b | 14.73±0.12c | 2.98±0.02b | 29.23±0.01c |
| Desi | 12.06±0.00c | 2.71±0.01a | 15.06±0.11d | 3.29±0.63e | 31.80±0.18c | 28.01±0.06a | 16.33±0.01a | 12.67±0.01b | 11.19±0.02c | 19.34±0.01b |
| Kanchan | 11.59±0.00b | 2.82±0.00b | 14.20±0.11b | 1.93±0.55a | 25.33±0.47a | 28.84±0.02a | 18.19±0.02a | 10.65±0.02a | 2.28±0.01a | 16.42±0.01a |
| NA-7 | 11.57±0.05b | 2.82±0.01b | 12.13±0.00a | 2.26±0.55b | 26.94±0.02a | 32.85±0.02b | 17.58±0.04a | 15.26±0.02c | 2.25±0.01a | 18.49±0.01b |

[a]The values are mean ±SD of determinations made in triplicates.Mean values followed by different letters within a same column differ significantly (p>0.05)
[b] All the data except the value for pH and TSS are reported on dry wt. basis

dietary fibres. The term crude fibre generally includes polysaccharides cellulose, hemicelluloses and lignin. Crude fibre was observed maximum in the fruit of Desi variety and minimum in Banarasi (Table 2). Results were comparable to the reported results by Singh *et al.* (1987); Pragati and Dhawan (2001) and Khan (2009).

*Nutritional composition*

In the present study, acidity of fruits ranged from 11.08 to 12.06%. Fruits of the variety Desi showed the maximum values for acidity followed by Banarasi, Kanchan, NA-7 and Chakaiya. Reported values by Anon. (1988) and Singh (2012) of acidity were found in the range of 1.5 to 2.5% on fresh weight basis. Ascorbic acid is an important nutritional component for human health. Consumption of aonla fruit is increasing in raw as well as in processed form due to its high ascorbic content. Ascorbic acid showed significant variation ($p < 0.05$) among the varieties. The fruit of Desi variety had the maximum value (Table 3) followed by Banarasi and the fruit of the Kanchan had the minimum value. Ascorbic acid content was within the range of 400 to 900 mg/100 g on fresh weight basis reported by various researchers in different studies. Less variation was found in pH and TSS value compared to other parameters. The results showed agreement with the data reported by Singh *et al.* (1987); Barthakur and Arnold (1991); Ghori and Sethi (1996); Pragati and Dhawan (2001); Singh *et al.* (2006); Goyal *et al.* (2008) and Garg (2010). Potent antioxidant properties are observed in aonla due to high ascorbic acid and polyphenol content that is credited with prevention of the oxidation of ascorbic acid (Goyal *et al.*, 2008). Polyphenol content as gallic acid equivalent was observed maximum in the fruit of Desi variety (Table3), followed by Chakaiya and Banarasi. However, the fruit of Kanchan had the minimum value. The results were comparable with data reported by Mehta and Tomar (1979); Pragati and Dhawan (2001) and Mishra *et al*. (2009). Total sugar content ranged from 28.01 to 36.91%. The fruits of Chakaiya variety were found to have the highest value followed by NA-7. On the contrary, the fruit of Desi variety had the lowest value. Same pattern was noted in observed value of reducing sugar. Observed data was in agreement with data reported in the literature by various researchers (Singh *et al.*, 1987; Mehta and Tomar, 1979; Ghori and Sethi, 1996; Singh *et al*., 2006). Pectin content ranged from 2.25 to 11.19%. Fruits of Desi variety had the maximum value followed by Chakaiya and NA-7 had the minimum value. Study by Goyal *et al.* (2008) supported observed data while deviation was found from the work done by Mehta and Tomar (1979). Deviation observed was due to the varietal difference and agro-climatic conditions. Starch content varied from 16.07 to 29.23%. The fruits of Chakaiya variety showed the maximum value followed by Desi variety, and Banarasi variety had

Table 4. Mineral profile of the fresh fruits of aonla varieties

| Variety | Iron (mg/100g) | Zinc (ppm) | Sodium (ppm) | Potassium (mg/100g) | Calcium (mg/100g) | Lead (ppm) | Mercury (ppm) |
|---|---|---|---|---|---|---|---|
| Banarasi | 1.77±1.0a | 45.66±0.10a | 53.71±1.0a | 58.22±1.0b | 17.84±2.51a | n.d. | n.d. |
| Chakaiya | 3.10±1.0e | 65.56±0.50c | 69.37±0.57c | 62.20±1.52c | 25.02±2.0d | n.d. | n.d. |
| Desi | 1.86±1.0b | 49.65±0.30b | 58.72±1.0b | 43.67±2.0a | 28.40±2.0e | n.d. | n.d. |
| Kanchan | 2.46±1.0c | 50.48±0.36b | 71.51±1.0c | 64.36±1.0e | 24.73±1.52c | n.d. | n.d. |
| NA-7 | 2.73±1.0d | 53.09±0.10b | 64.49±1.0c | 63.90±1.0d | 21.385±3.0b | n.d. | n.d. |

[a] The values are mean ±SD of determinations made in triplicates.Mean values followed by different letters within a same column differ significantly (p>0.05)
[b] All the data reported on dry wt. basis

the lowest value. Variation among the varieties was observed due to the difference in their maturity stages, genetic make-up.

*Mineral profile*

Mineral composition was observed to have significant varietal differences (Table 4). Iron, calcium and potassium were observed in higher concentration and considered as macro elements while sodium and zinc concentration were found in lesser quantities and are considered as micro elements. Iron and calcium content ranged from 1.77 to 3.10 mg/100 g and 17.84 to 28.40 mg/100 g, respectively in the fruit samples. The fruit of variety Chakaiya showed the highest value for iron and zinc content and the lowest value was found in variety Banarasi. Zinc content was observed in range from 45.66 to 65.56 ppm. Significant variation was also noted in potassium and calcium contents of different varieties (Table 4). Results for iron and calcium were comparable to the study by Barthakur and Arnold (1991); Pragati and Dhawan (2001); Murthy and Joshi (2010) and Singh (2012) while zinc, sodium and potassium content showed deviation from the literature. It might be due to the variation in environmental conditions.

## Conclusions

It can be concluded that aonla is a rich source of ascorbic acid and other nutrients, therefore it can be utilised in the form of value added product. The fruit of variety Desi had the maximum nutrient contents such as ascorbic acid, fat, polyphenol, pectin content. However, astringency and fibrous nature of this variety restricts the utilisation of the fresh fruit as table food. The fruit of variety Banarasi had the largest size with good nutritional value and it can be processed into different kind of aonla products like juice, squash, ready to serve beverage. All varieties had considerable amount of ascorbic acid and polyphenols which are credited for antioxidant activity and other health benefits.

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