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Health promoting compounds in Aonla (*Phyllanthus emblica* Linn.) genotypes growing under Indian semi-arid conditions

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Abstract
Eleven different Aonla genotypes grown in semi-arid conditions of North India were evaluated for biochemical attributes related to health promoting properties *viz*., TSS, organic acids, sugars, ascorbic acid, tannin content (%) and astringency during the year 2017-18. TSS and sugars content was observed highest in BSR 1. Organic acid content (citric acid equivalent) was recorded lowest (1.87%) in NA 6 and high (2.67%) in Seedling 2. The ascorbic acid content among the genotypes was ranged from 308.74 to 565.88 mg/100 pulp. It was recorded maximum (565.88 mg/100 g pulp) in fruit pulp of genotype Chakaiya and minimum in Seedling 1. Tannin content was recorded maximum (3.60%) in genotype NA 10 and minimum in NA 7. Orgonoleptic evaluation showed high astringency in genotypes Chakaiya, Krishna, NA 10, Seedling 1 and Seedling 2, whereas the genotypes CHES 1, NA 6, NA 7, NA 20, G 1 and BSR 1 were categorised as medium astringent.

Keywords: Antioxidants, ascorbic acid, bioactive compounds, Indian gooseberry, sugars, tannins

1. Introduction
The Indian gooseberry or Aonla (*Phyllanthus emblica* Linn. syn *Emblica officinalis* Gaertner) is an important indigenous minor fruit crop belongs to the family Phyllanthaceae [1]. Indian subcontinent is the home of Aonla and a rich diversity (wild as well as cultivated) is present across the country. The plant has spacious adaptability to withstand adverse climatic conditions of arid and semi-arid ecosystem. Owing to its hardiness, high productivity (15-20 t/ha) and its utilization in cosmetic, pharmaceutical and processing industry, the fruit has immense possibility for commercial exploitation in the dry zones and marginal soils, where only a few fruits can be grown [2].

The Aonla fruit has high neutraceutical and medicinal value, thus recognized as 'Amrit-Phal' in traditional medicinal system. Aonla is the second richest sources of ascorbic acid (vitamin C) content among the fruit crops which helps in prevention of scurvy disease, besides ascorbic acid it is also rich source of polyphenols and hydrolysable tannins (emblicanin A and B) which are considered to be responsible for their antioxidant properties [3]. Aonla fruit contains a substantial amount of riboflavin, thiamine, minerals (iron, phosphorus and calcium) and amino acids *viz*., lysine (5%), alanine (5%), proline (14%), glutamic acids (29%) and aspartic acid (8%) [4, 5]. It is reported to containing a wide array of phenolics having antioxidant, antimicrobial, anti-inflammatory, antipyretic, adaptogenic, antiulcerogenic, hepatoprotective, antitumor and antidiarrheal properties [6-10]. Therefore, Aonla fruit is widely used in traditional medicinal systems of Ayurveda and Chinese/Tibetan medicine. The two important Ayurveda products *viz*., Trifla and chavanprash, are well known for their revitalizing health properties. Fresh and dry fruit is used for the treatment of jaundice, diabetes, diarrhea and inflammations [11]. The fruits are also processed into various products such as preserves (murabba), candy, dried flecks, etc and notably these processed products retains substantial amount of ascorbic acid.

Some of the selected seedling strains were become a base of commercial cultivation of Aonla in India such as Chakaiya, Banarasi, NA 4, NA 5, NA 6, NA 7, BSR-1 and NA 20. However, their performance varied with region and climatic conditions [12]. Based on availability of health promoting compounds of different germplasm, the suitable genotype may be selected for systematic cultivation in the arid and semi-arid region. Furthermore, the results of the experiment could be helpful for breeders in the crop improvement programmes.

Therefore, the present experiment was carried out to comparative study the health promoting components of Aonla genotypes under the semi-arid condition of Indian state Haryana.

2. Material and Methods

The present study was conducted at the experimental orchard at Regional Research Station, Bawal (28º10´ N and 76º50´ E; 266 m above the mean sea level), CCS Haryana Agricultural University during the year 2017-18. The climate of the experimental site is characterized as hot semi-arid climate with receiving 450-500 mm mean annual rainfall.

In the present investigation, 11 Aonla genotypes, *viz*., CHES 1, BSR 1, Krishna, NA 6, NA 7, NA 10, NA 20, Chakaiya and G 1, along with two seedling selections (Seedling 1 and Seedling 2) were undertaken for the performance study. The details of these genotypes were presented in the Table 1. All these selected Aonla genotypes were budded on the seedling rootstocks and planted during July 2006 at a spacing of 6 m × 6 m in square planting system and received uniform cultural practices. The experiment was conducted on the layout of randomized block design and all determinations were performed in triplicates. The fruit Physico-chemical parameters were recorded from the mature fruits. For judging the correct maturity stage translucent fruit surface, the appearance of fibre on stone and seed colour turn to brown were taken as maturity indices [13]. Mature fruits were harvested from tagged branches from all the four directions (North, South, East and West) from 15th, November to 15th January in different genotypes as per their maturity period. These fruits were subjected to TSS, organic acid (citric acid equivalent), ascorbic acid, tannins and total sugars estimation. Total soluble solids (TSS) were measured using hand refractometer and expressed in °Brix. Organic acid content i.e., titratable acidity (citric acid equivalent %) of Aonla fruit pulp was determined by titration of squeezed juice against 1N NaOH. Total sugars (%), ascorbic acid (mg/100 g pulp) and tannins (%) content were determined as per the methods suggested by Ranganna [14]. Orgonoleptic evaluation of fruits was carried out by untrained panelist and based on astringency level of fruits germplasm were categorised as low, medium and high astringent. Statistical analyses for fruit biochemical parameters were performed using the SAS package (9.3 SAS Institute, Inc., Cary, USA) and P-value ≤ 0.05 were considered as significant.

Table 1: Aonla genotypes evaluated under semi-arid conditions and their origin.

Genotype	Description
CHES 1	Selection from Gujarat
Chakaiya	Seedling Selection
Krishna	Chance seedling from cultivar Banarasi
NA 6	Chance seedling from cultivar Chakaiya
NA 7	Seedling selection, from open pollinated strain of Francis
NA 10	Chance seedling from cultivar Banarasi
NA 20	Seedling selection at NDUAT, Faizabad
G 1	Seedling selection from Gujarat
BSR 1	Seedling selection from Bhavanisagar, Tamil Nadu
Seedling 1	Seedling at RRS, Bawal, Haryana
Seedling 2	Seedling at RRS, Bawal, Haryana

3. Results and Discussion

The results pertaining to variation in biochemical characteristics of various Aonla germplasm have been depicted in Table 2 and Fig 1. Perusal of data reveal a substantial degree of variations for nutritional and health promoting constituent.

TSS (total soluble solids) values of all the germplasm ranged between 8.40 °B and 18.27 °B. It was observed highest (18.27 °B) in cultivar BSR 1 however, on the other hand the lowest (8.40 °B) TSS was observed in Seedling 1, which was statistically at par with Seedling 2 (8.70 °B). The results regarding variation in TSS among different germplasm are in accordance with the previous findings of Pandey *et al.* [15], who reported the TSS content, which was ranged from 10.17°B to 17.40 °B in the Aonla genotypes collected from Panna region of Indian state Madhya Pradesh. Higher TSS content in BSR 1 was also reported by Kumar *et al.* [16] and Tripathi *et al.* [17]. Higher TSS content in BSR 1 might be due to the genetic background and relatively lower moisture content in the pulp at fruit maturity. However, above mentioned studies reported comparatively lower range for TSS (7.6-12 °B and 7.9-11.5°B) in the Aonla fruits under humid tropical condition. Thus dry condition and prevailing high temperature in the arid and semi-arid conditons seems to favourable for quality Aonla fruit production [18]. On the other hand lower TSS content under tropical condition may be attributed to the occurrence of rainfall during fruit maturity *i.e.*, August- September, which might have increased the moisture content in the fruit and dilution of carbohydrates. The higher TSS content in fruit also enhances storage life by decreasing the availability of free moisture for microbial decomposition [19].

The organic acid content (citric acid equivalent %) was recorded lowest (1.93%) in NA 6 and it was recorded highest (2.73%) in Seedling 2, which was statistically at par with the acid content of genotype NA 10 (2.66%). These results on acid content are in agreement with previous findings [2, 15]. However, Tripathi *et al.* [17] reported higher acid content (2.12-3.53) per cent, under humid tropical conditions and they concluded that the higher acidity in humid region might be the results of prevailing mild temperature throughout the year and high humidity of Western Ghats. These organic acids have numerous health benefits such as helps in activating stomach enzymes; suppression of harmful gram- microbes in the gastro-intestinal tract; improved energetic utilization through act as intermediate in metabolism reactions. Some organic acids also directly act as nutrients themselves such as ascorbic acid (vitamin C) and amino acids [20].

Table 2: Biochemical attributes of Aonla genotypes.

Genotype	TSS (°B)	Organic acid (%)	Total sugars (%)	Ascorbic acid (mg/100 g pulp)	Tannin (%)	Astringency
CHES 1	15.0^{c}	2.13^{bc}	10.20^{b}	442.00^{e}	2.30	Medium
Chakaiya	10.5^{e}	2.33^{ab}	7.69^{f}	565.88^{a}	3.30	High
Krishna	10.6^{e}	2.17^{bc}	7.61^{f}	491.74^{bc}	3.10	High
NA 6	11.1^{e}	1.87^{c}	8.35^{e}	373.49^{f}	2.85	Medium
NA 7	9.0^{f}	2.33^{ab}	7.20^{g}	515.20^{b}	2.15	Medium
NA 10	14.2^{c}	2.63^{a}	9.49^{c}	473.91^{cd}	3.60	High
NA 20	13.0^{d}	2.23^{b}	8.97^{d}	451.39^{de}	2.70	Medium
G 1	17.4^{b}	2.47^{ab}	11.50^{a}	425.11^{e}	2.80	Medium
BSR 1	18.3^{a}	2.40^{ab}	11.87^{a}	321.88^{g}	2.80	Medium
Seedling 1	8.4^{f}	2.37^{ab}	6.39^{i}	308.74^{g}	3.10	High
Seedling 2	8.7^{f}	2.67^{a}	6.79^{h}	327.51^{g}	2.60	High

The value of total sugars content in fruit of different genotypes was ranged from 6.39% to 11.87%. The genotype BSR 1 was recorded with maximum (11.87%) sugars content which was at par with G 1 (11.50%) and the value of sugar in flesh of genotype Seedling 1 was recorded minimum (6.39%); followed by Seedling 2 (6.79%). Previous studies also revealed significant variations in similar range for total sugars content in different Aonla cultivars under different agro-climatic conditions [21-25]. Sugars are major constituent of total soluble solids content and responsible for sweetness of fruit pulp besides they are energy giving component of fruit.

A substantial level of variation for ascorbic acid content was observed among all the genotypes studied, it ranged from 308.74 to 565.88 mg/100 pulp in the genotypes included in the present investigation (Table 1). Ascorbic acid content was recorded highest (565.88 mg/100 gpulp) in Chakaiya and the lowest (308.74 mg/100 gpulp) in Seedling 1, which was at par with value of genotype BSR 1 (321.88 mg/100 g pulp) and Seedling 2 (327.51 mg/100 g pulp) (Fig 1a). The observed ascorbic acid content in Aonla fruits during the present investigation were in consonance with previous findings on Aonla fruits [19, 25-27]. In previous study Aonla fruit also have been reported to contain maximum ascorbic acid content of 700 mg/100g pulp in cultivar Chakaiya [28]. The difference in the ascorbic acid content of Aonla cultivars at different locations may be attributed to different agro climatic conditions of particular locality and may be due to different conditions during ripening and harvesting period. However, in general ascorbic acid content was reported in lower range in tropical condition which could be due to prevailing mild temperature and humid environment at the time of fruit maturation that might have affected enzymatic anabolism [29, 30]. The higher ascorbic acid content is a preferred character, as Aonla is mainly consumed for intake of ascorbic acid. The antioxidant property of Aonla fruit is chiefly due to ascorbic acid and tannin (total phenols) content. The superior germplasm with higher ascorbic acid content have immense potential to be used either for cultivation and processing or as a superior gene source in future Aonla breeding programmes for combining useful traits.

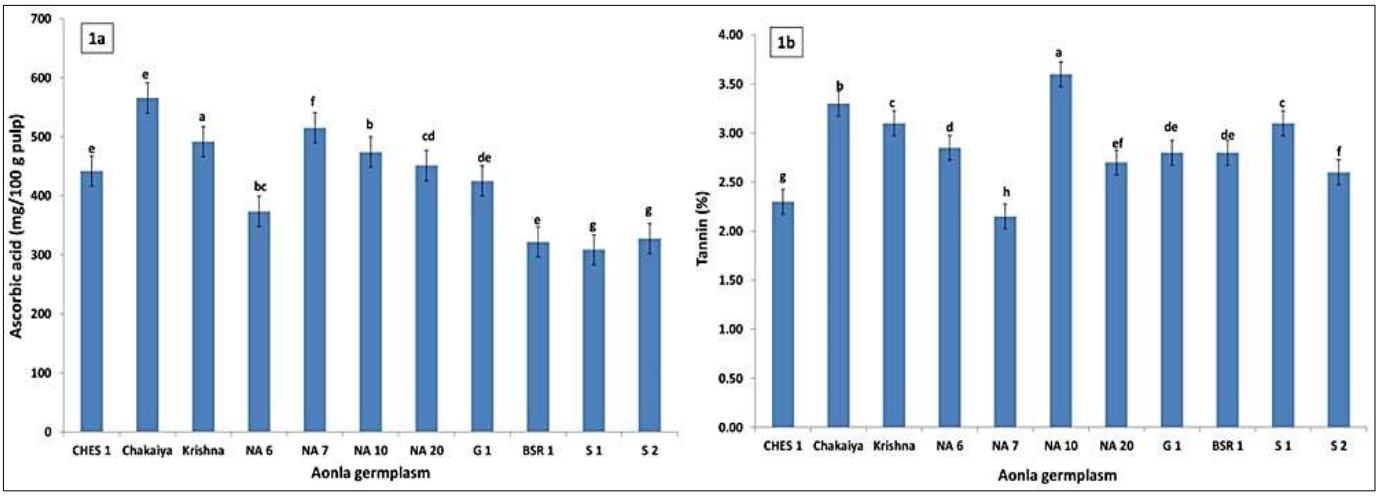

Fig 1: Comparison of Aonla germplasm for ascorbic acid and tannin content. (1a) Ascorbic acid content (mg/100 g pulp). (1b) Tannin content.

Tannin content also varied significantly among the Aonla genotypes. The highest tannin content (3.60%) was recorded in NA 10 on the other hand it was recorded lowest (2.15%) in genotype NA 7 (Fig 1b). These results were in agreement with previous studies which reported tannin content in the range of 2.30-6.76% in fruit of different Aonla accessions by [31-33]. Tannins are water-soluble polyphenols that are present in many plant foods. Though tannins are also contributing to astringent taste of fruit, higher tannin content is a desired character as helps in retention of ascorbic acid during processing and tannin of Aonla also reported to exhibit antioxidant properties [27]. They act by neutralize the harmful free radicals thus preventing oxidative stress and helps to keep human body healthy [34].

Orgonoleptic evaluation of fruits by untrained panelist categorised the astringency in different genotypes as medium and high astringency. Astringency of fruit were noted high in Chakaiya, Krishna, NA 10, Seedling 1 and Seedling 2, whereas, it was medium in cultivar CHES 1, NA 6, NA 7, NA 20, G 1 and BSR 1. These results were line with Singh *et al.*

[35], who demonstrated that astringency of Aonla fruits may vary from medium to high, depending on the cultivar/genotype. Interestingly, in the present investigation the cultivar namely NA 7 showed medium astringency in contrast to the findings of Kumar *et al.* [36], who reported a low level of astringency in the same cultivar. The contradiction in the results of astringency with Kumar *et al.* [36] might be due to the prevailing dry environmental conditions of semi-arid region and/or genotype x environment effects.

4. Conclusion

Finding of present study concluded that Aonla is a potential source of natural antioxidants and health promoting properties. Based on observations on quality attributes (TSS, organic acid, ascorbic acid, tannins and total sugars) among the Aonla genotypes under investigation, it may be inferred from the study that the different genotypes exhibited wide range of variability with respect to the these traits. Thus an effective selection can made based on qualitative characters for further improvement in Aonla through breeding programme.

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