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Physico-chemical changes during fruit growth and maturation in aonla cultivars

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ABSTRACT

The present study was carried out at Punjab agricultural University, MS Randhawa Fruit Research Station, Gangian, (Dasuya) during 2017-19. Fruits of six aonla cultivars: Krishna, Kanchan, Neelum, Chakaiya, Balwant and Desi (local seedling) were evaluated for changes in physico-chemical characteristics at different stages of fruit growth and maturation. Observations were recorded at 15 days interval starting from 120 days after fruit set (DAFS) up to 255 (DAFS). Results of different parameters revealed that fruit size, weight and stone weight showed gradually exponentially upward growth trends from initial stages of maturity up to final harvest. Similarly, TSS and ascorbic acid content were found maximum at final maturity and minimum during initial stages of fruit development. Total phenol content showed a decreasing trend with the maturity of the fruits. Reducing sugar and total sugars was increased with the advancement of maturity. Among different cultivars, fruit size, weight, stone weight and TSS attributes were higher in Kanchan and minimum in Desi seedlings. Juice, ascorbic acid and total phenol content was recorded in fruits of Desi seedlings. Total sugar and reducing sugars were significantly the highest in Kanchan and Krishna aonla cultivars. The varieties were characterized as early, mid and late season on the basis of physico-chemical parameters.

Key words: Aonla, Growth and developmental stages, Physico-chemical

Aonla (*Phyllanthus emblica* Gaertn.) also known as Indian gooseberry has high nutraceutical, dietary, pharmacological and nutritive properties. It is hardy fruit crop and can be grown in dry regions of arid zone, poor soils, salt affected soils, marginal soils etc. Fruit is highly nutritive and is the richest sources of vitamin C after Barbados cherry and contains about 500-1500 mg of ascorbic acid/100 g of pulp (Kore *et al.* 2013). Fruit set in aonla occurs in the month of April-May and, embryo remains dormant and does not exhibit any visible external growth until mid-August. The diameter and volume of the fruits increase rapidly thereafter, and the maximum growth is achieved up to November and subsequently, show negligible enhancement in fruit physical parameters. The growth of the fruit during initially stages is due to the cell division, cell enlargement of the mesocarp and endocarp cells lignified to form the hard-stone cells. Performance of cultivars vary from one region to another and cultivar which perform better at specific locality, may not necessarily behave in a similar way under different agro climatic conditions. Fruit harvest at proper stage of maturity is desirable for maintaining the quality and consumer preferences (Chander *et al.* 2003). Maturity indices like firmness, flesh colour, starch breakdown, acid, sugars ethylene and carbon dioxide production are used to define maturity stages and fruit quality traits in aonla (Watkins 2003). The rate of change of these maturity variables is dependent on the physiological and biochemical changes that occur during maturation and ripening, in which the environment, soil patterns and sunlight also plays a vital role (Lotze and Bergh 2005). The texture, size and physico-chemical composition are the main attributes, which decide the quality of aonla fruits. So, the present investigation was carried out to ascertain the performance of six aonla cultivars growing under sub mountainous regions of Punjab. These cultivars were evaluated for physico-chemical characteristics to determine the proper stage of maturity and to study the changes in these characters during the various stages of development.

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MATERIALS AND METHODS

An experiment was conducted for Krishna, Kanchan, Neelum, Chakaiya, Balwant and Desi (local seedling) aonla cultivars at Punjab Agricultural University, MS Randhawa Fruit Research Station, Gangian (Dasuya), Hoshiarpur during 2017-19 which is situated in the sub mountane zone of Punjab. After fruit set, the branches with uniform fruit set were tagged on all four directions of the selected tree. Samples were collected at fortnight interval for two seasons starting from 20 August 2017 to 2 January 2018 and 20 August 2018 to 2 January 2019 on 120, 135, 150, 165, 180, 195, 210, 225, 240 and 255 days after fruit set (DAFS). About 10 to 15 fruits on each sampling date were harvested randomly from all directions of the trees and

analyzed for different quality parameters. The length and breadth of the fruit was measured with Vernier calipers. Fruit weight was estimated by weighing ten fruits by using electronic balance and the values were expressed in gram. Stone weight was worked out by separating and weighing the stones of the above collected fruits. TSS was determined by using a Erma hand refractometer and the values were expressed as degree Brix (°Brix). Visual titration method was used for estimating titratable acidity from 2 ml juice of aonla as reported by Ranganna (2007). Ascorbic acid, sugars and total phenols were estimated by standard procedures described by AOAC (2000). The experiment was laid out as randomized block design (RBD) with three replications. The data were analyzed using SPSS software.

RESULTS AND DISCUSSION

It is evident (Table 1) that a continuous increment in fruit length, diameter, fruit weight and stone weight were observed till final harvest stages in all the aonla cultivars. Immediately after initiation of fruit growth, a rapid and significant growth in fruit size (fruit length, diameter), fruit weight and stone weight was observed from 120-225 DAFS; however, thereafter, they exhibited a slow growth rate during later stages of fruit maturation. Among all cultivars,

Table 1 Change in physical parameters of aonla cultivars during fruit growth and maturation

Fruit parameter	Cultivars (A)	Days After Fruit Set (DAFS) (B)									
		120	135	150	165	180	195	210	225	240	255
Fruit length (cm)											
	Krishna	1.62	1.64	2.32	2.72	3.48	3.57	3.85	3.85	3.87	3.87
	Kanchan	2.14	2.22	2.90	3.22	3.37	3.72	3.87	3.87	4.00	4.12
	Neelam	1.60	1.62	2.62	2.72	3.06	3.08	3.17	3.90	3.90	3.90
	Chakaiya	1.64	1.71	2.50	3.12	3.35	3.72	3.72	3.72	3.87	3.89
	Balwant	1.62	1.78	2.60	3.02	3.05	3.25	3.68	3.70	3.92	3.94
	Desi Seedling	1.20	1.80	1.95	2.02	2.44	2.44	2.48	2.50	2.50	2.50
		CD (P=0.05) : A=0.08±0.03, B=0.11±0.04, A × B :0.26±0.09									
Fruit diameter (cm)	Krishna	1.70	1.74	2.50	2.82	3.51	3.95	4.25	4.26	4.27	4.27
	Kanchan	2.02	2.10	2.92	3.37	3.54	4.10	4.15	4.31	4.30	4.40
	Neelam	1.56	1.60	2.51	2.60	2.98	3.09	3.20	4.10	4.10	4.18
	Chakaiya	1.45	1.51	2.36	3.02	3.36	3.76	3.85	3.95	4.00	4.04
	Balwant	1.55	1.68	2.64	3.00	3.08	3.30	3.68	4.07	4.20	4.20
	Desi Seedling	1.24	1.85	2.00	2.52	2.55	2.56	2.60	2.62	2.62	2.64
		CD (P=0.05) : A=0.12±0.04, B=0.15±0.05, A × B :0.26±0.13									
Fruit weight (g)	Krishna	3.50	3.60	11.5	16.8	26.0	30.5	35.5	36.4	36.4	36.5
	Kanchan	4.00	4.10	14.5	18.8	25.3	37.7	37.9	38.5	39.6	39.6
	Neelam	2.00	3.50	9.5	15.5	21.5	25.1	28.4	29.6	32.0	32.8
	Chakaiya	2.40	4.50	8.2	15.5	20.7	22.0	27.5	29.1	29.5	30.4
	Balwant	2.02	4.00	10.3	15.0	21.9	26.0	30.2	30.7	31.5	31.6
	Desi Seedling	1.98	2.74	3.5	4.00	4.80	4.82	4.91	4.99	5.60	5.70
		CD (P=0.05) : A=1.13±0.40, B=1.15±0.51, A × B :3.5±1.30									
Stone weight (g)	Krishna	0.22	0.20	1.00	1.00	1.30	2.50	2.86	2.86	2.88	2.88
	Kanchan	0.25	0.25	1.00	1.45	2.42	2.60	2.80	2.90	3.02	3.32
	Neelam	0.20	0.25	0.54	0.90	1.20	1.66	1.87	2.05	2.06	2.06
	Chakaiya	0.25	0.24	0.50	0.90	1.00	1.15	1.22	2.02	2.02	2.04
	Balwant	0.19	0.25	0.50	1.00	1.25	1.67	1.95	2.08	2.15	2.16
	Desi Seedling	0.10	0.18	0.25	0.35	0.56	0.60	0.65	0.68	0.69	0.69
		CD (P=0.05) : A=0.12±0.04, B=0.16±0.06, A × B :0.39±0.14									

significantly maximum fruit length, diameter, fruit weight and stone weight was recorded in Kanchan and minimum in Desi seedlings during different stages of fruit growth and development. Variability in fruit size and weight growth rate trends indicate that during initial development stages, there was a predomination of cell division, whereas during the final fruit maturation stages, it was due to accumulation of carbohydrates and cell enlargement. A significant variation in fruit size, fruit weight and stone weight was observed in all cultivars and genetic variability might be the reason for these types of variations. Our results are in confirmation with the findings of Ghosh *et al.* (2003) and reported that genetic variability, climatic factors and management practices may be the main reasons for the variation in fruit weight in aonla. Chiranjeevi *et al.* (2018) reported that length and breadth of fruits are highly variable traits. Similarly, Muralidhara *et al.* (2016) noticed variation in fruit diameter of datepalm. The aonla cultivars are classified into different maturity groups, i.e. Balwant is an early season cultivar which matures in mid-November, Krishna and Neelum as

Table 2 Change in bio-chemical parameters of aonla cultivars during fruit growth and maturation

Fruit parameter	Cultivars (A)	Days after fruit set (DAFS) (B)									
		120	135	150	165	180	195	210	225	240	255
TSS (°Brix)	Krishna	8.0	8.2	8.6	8.4	8.82	8.7	9.4	9.5	9.7	9.7
	Kanchan	8.0	8.2	8.5	8.8	9.2	9.2	9.8	10.0	10.0	10.2
	Neelam	7.2	7.5	7.8	8.2	9.0	9.5	9.6	9.7	9.7	9.7
	Chakaiya	7.2	7.5	7.7	8.0	8.6	8.8	9.0	9.2	9.2	9.4
	Balwant	7.0	7.5	8.0	8.8	9.4	9.5	9.4	9.9	9.9	10.0
	Desi seedling	2.5	2.6	2.8	3.2	3.5	3.7	3.8	4.0	4.0	4.2
	CD (P=0.05) : A=0.17±0.06, B=0.22±0.08, A × B :0.53±0.19										
Juice acid (%)	Krishna	0.65	1.32	1.55	2.05	2.10	2.14	2.53	1.85	1.55	1.55
	Kanchan	0.57	0.63	1.62	1.85	2.70	2.77	2.62	1.98	1.68	1.59
	Neelam	1.04	1.75	2.14	2.20	2.25	2.12	2.02	1.67	1.58	1.55
	Chakaiya	0.65	0.88	1.55	2.33	2.48	2.39	1.98	1.95	1.55	1.54
	Balwant	0.66	0.75	1.78	2.20	2.50	2.62	1.85	1.55	1.50	1.42
	Desi seedling	1.45	1.54	2.85	3.05	3.75	4.02	3.80	3.55	3.02	2.95
	CD (P=0.05) : A=0.15±0.05, B=0.19±0.07, A × B :0.47±0.17										
Ascorbic acid (mg/100g of pulp)	Krishna	110.1	230.4	350.2	470.4	470.4	496.6	520.8	545.5	560.5	568.8
	Kanchan	104.8	200.2	340.6	450.5	462.4	480.8	541.5	558.8	570.5	572.8
	Neelam	90.9	170.7	310.5	342.4	398.1	450.0	492.5	515.2	523.3	535.7
	Chakaiya	100.7	180.8	220.5	298.7	320.4	398.5	467.7	490.3	518.7	530.0
	Balwant	100.5	240.5	305.4	387.9	462.2	505.3	525.0	545.4	550.5	552.4
	Desi seedling	99.9	167.4	330.2	398.0	470.6	520.7	532.4	562.5	580.6	605.5
	CD(P=0.05) : A=2.63±0.93, B=3.40±1.20, A × B :8.32±2.94										
Total sugar (%)	Krishna	1.87	2.15	2.40	3.90	4.92	5.12	5.30	5.42	5.60	5.75
	Kanchan	1.83	2.14	2.43	3.93	4.90	4.50	5.50	5.55	5.72	5.75
	Neelam	2.50	2.78	3.04	3.44	3.69	4.41	4.68	4.80	4.85	4.87
	Chakaiya	2.16	2.70	3.15	3.25	3.50	3.94	4.08	4.14	4.50	4.55
	Balwant	2.51	2.78	3.07	3.42	3.76	3.85	4.50	4.85	4.87	4.90
	Desi seedling	1.02	1.52	1.82	2.05	2.45	3.45	3.75	4.02	4.20	4.25
	CD (P=0.05) : A=0.19±0.07, B=0.24±0.09, A × B:0. 59±0.21										
Total phenols (%)	Krishna	4.25	3.95	3.57	2.52	1.75	1.38	0.84	0.80	0.70	0.69
	Kanchan	4.10	3.85	3.37	2.52	1.55	1.38	0.94	0.75	0.75	0.74
	Neelam	4.02	3.54	3.67	2.55	1.78	1.62	0.87	0.87	0.85	0.84
	Chakaiya	4.88	4.50	4.10	3.12	1.95	1.54	0.85	0.85	0.67	0.65
	Balwant	4.12	3.95	3.47	2.52	1.50	1.32	0.74	0.74	0.65	0.64
	Desi seedling	5.52	4.23	3.05	2.80	2.50	2.45	1.93	1.45	1.45	1.28
	CD (P=0.05) : A=0.10±0.04, B=0.13±0.05, A × B :0.31±0.11										

mid-season cultivars during end November and; Kanchan and Chakaiya as late season cultivars during mid-December under Punjab conditions.

TSS (°Brix) content in different aonla cultivars showed upwards trend and minimum TSS was recorded during initial development stages and thereafter, its values increased up to final fruit harvest stage (Table 2). Improvement in TSS during different fruit development stages is due to degradation of starch and rapid metabolic transformations in soluble compounds, mainly into sugars. Among various cultivars, Kanchan showed maximum TSS, whereas minimum TSS was observed in Desi seedlings. However, less variation in values during final harvest stages was registered for TSS content in all cultivars except Desi seedlings. The results in agreement with Singh *et al.* (2006). Juice acidity (%) increased almost consistently till 195 DAFS and it was declined up to final fruit harvest stages (Table 2). These results are corroborated with the results reported by Mehta *et al*. (2002), Gupta *et al.* (2003), Singh *et al.* (2004), Meghwal and Azam, (2004) and Singh *et al.* (2005). Average lower acid content was found in Balwant cultivar and the highest in Desi seedlings. Higher juice acid content during initial fruit development is due to biosynthesis of organic acids and conversion of organic acids into sugars during final harvesting stages. Highest juice acid content was noted in the fruits of Desi seedling at final harvest stage and minimum in Balwant cultivar. Likewise, ascorbic acid content (%) also varied between different cultivars and growth stages which improved exponentially in linear pattern with the advancement of harvest maturity (Table 2). Variation in vitamin C content among different aonla cultivars has also been reported by Mehta *et al.* (2002), Gupta *et al.* (2003), Singh *et al.* (2004), Meghwal and Azam (2004) and Singh *et al.* (2005). The variation in vitamin-C content is associated with inherited characters of aonla cultivars.

Sugar is an indicator of sweetness and total sugars content improved substantially from the initial stages of maturity till final fruit harvest (Table 2). Among different cultivars, highest total sugars was observed in Kanchan and Krishna cultivars at final harvest maturity stages followed by Balwant and Neelum cultivars and minimum in Desi seedlings. Patel *et al.* (2014) also reported an exponential increase in total sugars content during fruit maturation in the most of fruits due to accumulation of photosynthates in the fruits or conversion of starch into sugars. In aonla the presence of phenolic compounds are responsible for astringency and flavor of the fruits. Total phenol content decreased with the advancement of the maturity (Table 2). Among all cultivars, fruits of Desi seedlings contained highest phenol content followed by Neelum, Kanchan and Krishna cultivars. Varietal difference in total phenol content could be partially due to harvest of fruits at different stages, genetical inheritance characters and agronomic conditions (Wang and Zheng 2001). It is suggested that fruits of Balwant mature up to mid-November, Krishna, Neelam, up to end November and Kanchan and Chakaiya up to mid-December under sub mountainous zone of Punjab.

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