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Standardization of suitable time of harvest Aonla (*Emblica officinalis* garten.) cvs. NA-7 and Chakaiya fruit on storage and quality

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Abstract
An experiment was carried out in the aonla orchard farm K.N.K. college of Horticulture Mandsaur, Madhya Pradesh, during 2015 – 16 to 2016 – 17. The meteorological data revealed that the minimum temperature ranged from 8.7 0C to 26.6 0C and 9.6 0C to 28.4 0C and maximum temperature from 22.8 0C to 42.8 0C and 24.5 0C to 43.0 0C during 2015 – 16 and 2016 – 17, respectively. The highest and lowest relative humidity were recorded in the 44.1 % and 92.1 % and 43.0 % and 87.0 %, 2015 – 16 and 2016 – 17, respectively. Total rainfall 744.8 mm and 844.7 mm were recorded during 2015 – 16 and 2016 – 17, respectively. In randomized block design (RBD) with sixteen treatments consisting of foliar spray of Borax, Planofix, Bayleton, Calcium Nimicidine, and control trees were sprayed with water. Various substances, which were applied 15-20 days before the expected date of harvest. Fresh fruits of each cultivar from all sampling dates were stored under ambient conditions and following observations pertaining to changes in physico-chemical characteristics of the fruit were recorded at weekly were recored. Changes in fruit colour from green to yellowish green, with a subsequent increase in its intensity was observed in both the cultivars occurred after 238 and 288 DFFB in the cvs. NA-7 and Chakaiya. Maximum significant pulp: stone ratio was observed in NA-7 and Chakaiya and recorded pulp-stone ratio of 21.97 and 21.33, respectively.

Keywords: Pre-harvest sprays, Storeability, Shelf life, Physiological quality, Anola. To standardize the suitable time of harvest of aonla Cv.NA-7 & Chakiya Fruits.

Introduction
Aonla {*Emblica officinalis* (L). Gaertn} is an important indigenous emerging fruit crop owing to its hardiness and ability to withstand adverse soil and climatic conditions and belongs to the family Euphorbiceae sub-family Phyllanthoideae (Arun *et al.,* 2009) [1]. India ranks first in area and production of aonla crop (Priya and Khatkar, 2013) [12] in the world. In India, it occupied an area of 108 thousand hectare, production of 1266 thousand tonnes with 11722.20 kg/ha productivity (Anonymous, 2014) [2] and (NHB, 2014). Among the fruits next to Barbados cherry and also useful for general improvement of health and medicinal purpose (Ram Kumar *et al.,* 2011) [14]. It is an important component of the famous Indian Ayurvedic medicines Chyavanprash and Trifla. It has played an important therapeutic role from time immemorial and is frequently recommended for its synergistic effects in both the ayurvedic and unani systems of medicine (Agarwal and Chopra, 2004). The major aonla growing states in India are Uttar Pradesh, Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Tamil Nadu, Karnataka, Punjab and Himachal Pradesh. Uttar Pradesh, Gujarat and Tamil Nadu, contributing over 55 per cent to the total area and production of aonla in the country (Singh *et al*., 2010). Its intensive plantation is in salt affected areas of Uttar Pradesh, including ravinous areas in Agra, Mathura, Eatwah, Fatehpur, and semi-arid track of Bundelkhand. It can thrive well even under highly sodic soil and drought stress. Thus, it has been recognised as the King of arid fruits due to its in-built resistance to the most adverse soil and climatic conditions.

Being a member of Euphorbiaceae, to which most of the xerophytes, the cacti and succulents belong; aonla is a hardy drought resistant fruit tree. A rare combination of character is its ability to withstand water stagnation too. The fruit is highly nutritive for human consumption. It is the richest source of vitamin C (500-1500 mg/100g) (Pokharkar, 2005) [13] and nutrients such as polyphenols, pectin, iron, calcium and phosphorus (Khopde *et al*., 2001) [10] and (Yadav *et al*., 2012) [16]. The aonla fruit is a potent antioxidant, hypolipidemic and antibacterial, it also has antiviral and antacid properties. Aonla has been reported to be hepato-protective and possesses expectorant, purgative, spasmolytic, antibacterial, hypoglycemic and hypolipidemic activities (Mishra *et al*, 2010) [11]. However, owing to its highly acidic and astringent taste, low total soluble solids (TSS), poor flavor and colour, it is not popular as a

table fruit (Jain and Khurdiya, 2004) [9]. Due to its astringent nature, consumers are hesitant to eat it in raw form. Attempts are being made to produce value added products which are not only nutritious but also accepted by consumers (Goyal *et al*., 2008) [7]. Aonla becomes ready for harvesting from mid-November to first week of February. The produce remains in market for a very short span. Huge harvest of produce during peak harvesting season create glut and the growers are compelled to sell their produce at distress prices. Appropriate storage and processing methods can curtail the post-harvest losses to 30 per cent (Goyal *et al*., 2008) [7] and make the fruit available for longer period. Plant growth regulators, certain chemicals and fungicides play a great role in increasing the storage life (Dhumal *et al*., 2008) [6]. The excellent nutritive and therapeutic value as well as owing to restricted availability and high perishability of aonla fruit, value addition through processing would be the only effective tool for economic utilization of increased production of aonla in future. Pre-harvest calcium application is one of the most important practices of new strategies applied in the integrated fruit production systems, improving fruit characteristics and minimizing fungicides sprays towards the end of the harvest period. Bakshi *et al*. (2005) [4] reported that the role played by Ca in cell wall integrity is an established fact. Its application retains fruit firmness, which is an important quality parameter during storage.

Though some work has been done to standardize the cultural practices for different cultivars, yet no systematic research work has been done to standardize the various pre harvest handling techniques to prolong the storage life of fruits. Foliar application of calcium nitrate, fungicides, planofix, borax increases the yield and quality of aonla. Simultaneously, surface coating and proper packing of aonla inceases the duration and quality of aonla. Dehydation of aonla is the fruitful factor which also increases the quality and durability of the aonla.

Several new varieties of aonla have been introduced in the Malwa region of Madhya Pradesh. Though some work has been done to standardize the cultural practices for different cultivars, yet no systematic research work has been done to standardize the various pre harvest handling techniques to prolong the storage life of fruits. Keeping the above facts in view, the present study Suitable time for harvest of fruits of in relation to storage and quality is being proposed to be undertaken

Materials and Method

To examine the pre-harvest sprays of in the aonla orchard farm K.N.K. college of Horticulture Mandsaur, Madhya Pradesh, during 2015 – 16 to 2016 – 17. The meteorological data revealed that the minimum temperature ranged from 8.7 0C to 26.6 0C and 9.6 0C to 28.4 0C and maximum temperature from 22.8 0C to 42.8 0C and 24.5 0C to 43.0 0C during 2015 – 16 and 2016 – 17, respectively. The highest and lowest relative humidity were recorded in the 44.1 % and 92.1 % and 43.0 % and 87.0 %, 2015 – 16 and 2016 – 17, respectively. Total rainfall 744.8 mm and 844.7 mm were recorded during 2015 – 16 and 2016 – 17, respectively. Data were analyzed by completely randomized design (CRD) as per standard methods while effects of preharvest treatments on physico chemical characteristics of fruit analyzed by Randomized Block Design (RBD) with sixteen treatments consisting of foliar spray of Borax, Planofix, Bayleton, Calcium nitrate, Nimicidine, and control trees were sprayed with water. Various substances, which were applied 15-20 days before the expected date of harvest. Fresh fruits of each cultivar from all sampling dates were stored under ambient conditions and following observations pertaining to changes in physico-chemical characteristics of the fruit were recorded at weekly were recored. The collected data were analyzed through statistical procedure suggested by as described by Cochran and Cox (1967) [5] and Gomez and Gomez (1984) [8].

Results & Discussion

During the present investigations it was observed that in both the culiivars fruit size (length and diameter) and weight increased substantially during long period and ultimately became non-significant towards the close of sampling. Increase in fruit size and weight on successive harvest dates can be expected as the fruits get more time for the accumulations of photosynthates, nutrients, water, etc. which are primarily responsible for increase in fruit size and weight. Such increases in the constituents are conducive for growth and enlargement of cells of mesocarp tissue which are responsible for increase in fruit size (Gupta *et al*. 2003 and Garg, 2007). Significant increases in fruit size and weight were generally observed upto the 4th sampling date in the cvs. NA-7 which corresponded to 223 days from full bloom (DFFB) and upto the 3rd sampling date, corresponding to 258 DFFB in Chakaiya. Subsequent increases in these parameters were smaller and non-significant. Aonla fruits are reported to follow a double sigmoidal growth patten and therefore decrease in rates of increases in size and weight of fruit with approaching maturity is on expected lines. As in the present studies variations in fruit size and weight among different cultivars have also been observed by Gupta *et al*. (2003) and Singh *et al*. (2006). It was observed that the specific gravity in both the cultivar tended to increase as the fruits coursed through maturity with the values stabilizing towards the close of sampling. Whereas the moisture content remained almost unaffected showing only slight but non-signficant decreases with each subsequent sampling date. The increase specific gravity and decreased in moisture content might be due to the additional inflow of photosynthates into the fruit with each passing sampling dates resulting in an increase in the dry matter. Content constituting total soluble solids, sugars and organic acids (Pathak, 2003). Garg (2007) also observed similar trends in changes in specific gravity of fruits if different aonla cultivars with advancing maturity. Juice yield was also observed to be affected by fruit maturity in both the cultivars with the differences becoming smaller between progressive sampling dates. Juice yield were also prominent with yields from Chakiya being maximum, followed by NA-7. In having higher moisture content lower juice yield during the initial sampling dates may be due to the difficulty in breaking of cells to release their juice. With maturity the cell size in the mesocarp tissue increases (Gupta *et al*., 2003) which is accompanied by a decrease in the pectin content, therefore, making it easier to break the cells, enabling sample extraction of juice from more number of cells, and hence resulting in juice yields. Variation in juice yields from different cultivars may also be due to variation in the structure and composition of the cells. Similar variations in juice yield among different varieties have been reported earlier by Ghosh *et al*. (2002). Changes in fruit colour from green to yellowish green, with a subsequent increase in its intensity was observed in both the cultivars. Such a pattern is generally degraded during maturation of most fruits exposing the underlying

pigments. Similarly seed colour from creamy white to brown black occurred after 238 and 288 DFFB in the cvs. NA-7 and Chakaiya. Similar changes in the fruit and seed colour have been reported by Pathak (2003). The present study reveal that pulp: stone ratio increased gradually upto 3rd sampling dates in NA-7 and Chakaiya and thereafter the increase was not significant. Maximum significant pulp: stone ratio was observed in NA-7 and Chakaiya and recorded pulp-stone ratio of 21.97 and 21.33, respectively. The present findings are substantiated to the observation of Gupta *et al*. (2003) who also recorded increase in pulp: stone ratio of Chakiya.

Table 1: Harvest dates and the corresponding days from full bloom (DFFB) to harvest for different aonla cultivars

2015 – 16				2016 – 17				Mean			
NA-7		Chakaiya		NA-7		Chakaiya		NA-7		Chakaiya	
Harvest dates	DFFB	Harvest dates	DFFB	Harvest dates	DFFB	Harvest dates	DFFB	Harvest dates	DFFB	Harvest dates	DFFB
Oct-6th	179	Jan-6th	227	Oct-6th	177	Jan-6th	229	Oct-6th	178	Jan-6th	228
Oct-20th	195	Jan-20th	241	Oct-20th	191	Jan-20th	245	Oct-20th	193	Jan-20th	243
Nov-6th	207	Feb-6th	259	Nov-6th	209	Feb-6th	257	Nov-6th	208	Feb-6th	258
Nov.-20th	224	Feb-20	272	Nov.-20th	222	Feb-20th	274	Nov.-20th	223	Feb-20	273
Dec-6th	237	March-6th	286	Dec-6th	239	March-6th	290	Dec-6th	238	March-6th	288

Table 2a: Effect of harvest maturity on the physical characteristics of NA-7 aonla fruit

Sampling dates (DFFB)	Length (cm)	Diameter (cm)	Weight (g)	Specific gravity	Pulp-stone ratio	Moisture (%)	Juice* yield (%)	Fruit Colour	Seed colour
2015 – 16									
Oct-6th (178)	2.82	2.97	24.11	1.04	18.14	86.82	26.78	149B	159C
Oct-20th (193)	3.40	3.52	33.58	1.07	20.50	86.58	35.54	149C	159B
Nov.6th (208)	3.87	4.10	40.99	1.09	22.63	86.36	43.57	149C	159B
Nov.206th (223)	3.89	4.12	41.46	1.10	22.69	86.16	43.85	149C	206
Dec-6th (238)	3.91	4.14	41.48	1.10	22.69	86.15	43.85	149C	206B
CD (P=05)	0.12	0.09	0.16	0.06	1.64	NS	3.28	-	-
2016 – 17									
Oct-6th (178)	2.66	2.79	22.71	0.98	17.08	81.76	25.22	141B	149C
Oct-20th (193)	3.20	3.32	31.62	1.01	19.30	81.54	33.47	141C	149B
Nov.6th (208)	3.65	3.86	38.61	1.03	21.31	81.32	41.03	141C	149B
Nov.206th (223)	3.67	3.88	39.04	1.04	21.37	81.14	41.29	141C	194C
Dec-6th (238)	3.69	3.90	39.06	1.04	21.37	81.13	41.29	141C	194B
CD (P=05)	0.10	0.07	0.14	0.04	1.62	NS	3.26	-	-
Mean									
Oct-6th (178)	2.74	2.88	23.41	1.01	17.61	84.29	26.00	145B	154C
Oct-20th (193)	3.30	3.42	32.60	1.04	19.90	84.06	34.50	145C	154B
Nov.6th (208)	3.76	3.98	39.80	1.06	21.97	83.84	42.30	145C	154B
Nov.206th (223)	3.78	4.00	40.25	1.07	22.03	83.65	42.57	145C	200C
Dec-6th (238)	3.80	4.02	40.27	1.07	22.03	83.64	42.57	145C	200B
CD (P=05)	0.11	0.08	0.15	0.05	1.63	NS	3.27	-	-

Table 2b: Effect of harvest maturity on the physical characteristics of Chakaiya aonla fruit

Sampling dates (DFFB)	Length (cm)	Diameter (cm)	Weight (g)	Specific gravity	Pulp- stone ratio	Moisture (%)	Juice* yield .(%)	Fruit Colour	Seed colour
2015 – 16									
Jan-6th (228)	2.80	2.93	18.03	1.03	17.00	84.58	24.72	149A’	159
Jan-20th (243)	3.21	3.56	24.93	1.04	20.64	84.30	33.99	149B	159C
Feb-6th (258)	3.54	3.83	32.27	1.07	21.97	84.05	41.20	149C	159B
Feb-20th (273)	3.55	3.85	32.29	1.08	22.00	84.02	41.46	149C	206C***
March-6th (288)	3.56	3.85	32.30	1.08	22.01	83.96	41.51	149C	206B
CD (P=05)	0.06	0.06	2.73	NS	0.86	NS	0.19	-	-
2016 – 17									
Jan-6th (228)	2.64	2.75	16.98	0.97	16.01	79.66	23.28	141A’	149
Jan-20th (243)	3.03	3.36	23.47	0.98	19.44	79.38	32.01	141B	149C
Feb-6th (258)	3.34	3.61	30.39	1.01	20.69	79.15	38.80	141C	149B
Feb-20th (273)	3.35	3.63	30.41	1.02	20.72	79.12	39.04	141C	194C***
March-6th (288)	3.36	3.63	30.42	1.02	20.73	79.06	39.09	141C	194B
CD (P=05)	0.08	0.08	2.71	NS	0.84	NS	0.19	-	-
Mean									
Jan-6th (228)	2.72	2.84	17.50	1.00	16.50	82.12	24.00	145A'	154
Jan-20th (243)	3.12	3.46	24.20	1.01	20.04	81.84	33.00	145B	154C
Feb-6th (258)	3.44	3.72	31.33	1.04	21.33	81.60	40.00	145C	154B
Feb-20th (273)	3.45	3.74	31.35	1.05	21.36	81.57	40.25	145C	200C***
March-6th (288)	3.46	3.74	31.36	1.05	21.37	81.51	40.30	145C	200B
CD (P=05)	0.07	0.07	2.72	NS	0.85	NS	0.19	-	-

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