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Influence of de-blossoming treatments on physico-chemical characteristics of selected mango varieties during off-season fruit production under South Gujarat conditions

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Abstract
A trial was undertaken under South Gujarat conditions to assess the effect of de-blossoming in six mango varieties during regular flowering season on off season fruiting characters. The investigation consisted of four de-blossoming treatments i.e. foliar sprays of NAA @ 400 and 800 ppm, hand-deblossoming and untreated trees which were imposed on six mango varieties *i.e.* Amrapali, Baramasi, Neelphanso, Neelum, Ratna and Totapuri during 2013-14 and 2014-15. De-blossoming was done at full bloom stage for induction of off season flowering. Results revealed that in the regular season cv. 'Neelphonso' recorded significantly the highest Total Soluble Solids while, minimum titrable acidity was recorded by Totapuri. Whereas, reducing sugar was significantly the highest in 'Amrapali' and ascorbic acid content was significantly the highest in 'Neelum' variety. With regard to off-season fruiting, significantly maximum Total Soluble Solids and minimum acidity was recorded in cultivar 'Neelphonso'. The maximum reducing sugar was observed in 'Ratna' cultivar. Ascorbic acid was significantly the highest in 'Neelum' during first year and in 'Ratna' during the second year. Hand de-blossoming was found superior over control for Total Soluble Solids content in the varieties selected for this study under South Gujarat conditions. De-blossoming did not exert a significant influence on acidity, reducing sugar and ascorbic acid of the fruits.

Keywords: Mango, De-blossoming, Off-season, TSS, sugars, acidity, ascorbic acid

Introduction
India is acclaimed for its rich genetic diversity of mango (*Mangiferaindica* Linn.) and has the largest available germplasm wealth of about 1,300 varieties (Mitra, 2016) [12]. Nearly, 30 varieties of mango are commercially grown throughout the country (Yadav and Rajan, 1993) [21]. Also regarded as "King of Fruits", it is widely grown in India for its excellent and delicious flavor, taste, aroma and nutritional properties. It originated from the Indo-Burma region and has been cultivated for thousands of years in India. Mango covers an area of 2.26 million hectares in India, with annual production of 19.68 million tonnes (Anon., 2017) [1]. Major mango growing states of India are Uttar Pradesh, Andhra Pradesh, Karnataka, Telangana and Bihar. In Gujarat, total area under mango cultivation is about 1.53 lakh ha and production is about 12.41 lakh tonnes. Navsari, Valsad and Dang districts in South Gujarat are major producers of mango.

There is an urgent need to extend the period of availability for mango which can help consolidate demand in domestic markets as well as increase our share in foreign markets. Presently, many local and hybrid cultivars *i.e.* Baramasi, Ratna, Neelum, Neelphonso *etc* flower two to three times in a year in the coastal climate of Valsad district of Gujarat. In such varieties, de-blossoming of seasonal flowers may lead to flowering in off season.The objective of this trial was to assess physico-chemical characteristics of off-season mango fruits in South Gujarat. Data generated would help identify suitable parents and potential mango varieties for further evaluation, conservation and utilization in mango improvement programmes.

Materials and methods

This study was carried out during the fruiting season of 2013-2014 and 2014-15 at Agriculture Experimental Station (AES), Paria, Navsari Agricultural University (NAU), Gujarat. The experimental material comprised of ten year old healthy mango trees spaced at 10 × 10 m. The experiment was analyzed in a Randomized Block Design with factorial concept. The investigation consisted of four de-blossoming treatments *i.e.* foliar sprays of NAA @ 400 and 800 ppm, hand-deblossoming and untreated trees which served as control along with six varieties *i.e.* Amrapali, Baramasi, Neelphanso, Neelum, Ratna and Totapuri. In all, there were 24 treatment combinations which were replicated thrice. Varieties were selected according to their flowering behavior, late flowering habit and parentage of selected varieties. Deblossoming was done at full bloom stage for induction of off season flowering. Plants were maintained under uniform conditions as per the recommended package of practices advocated by Navsari Agricultural University. For the estimation of physico-chemical parameters during each season, randomly selected fruits were brought to the laboratory and ripened at room temperature. Total Soluble Solids of mango pulp was measured using a digital hand refractometer (0-32^{o}Brix) at room temperature. The titrimetric method proposed by Lane and Eynon as described by Ranganna (1986) [16] was adopted for estimation of reducing sugars (%). Ascorbic acid (mg/100 g) and titratable acidity (%) were also estimated as per methods suggested by Ranganna (1986) [16]. Significance differences among treatments were compared using the Fisher's analysis of variance at the 95% probability level (Panse and Sukhatme, 1967) [13]. All differences reported were significant at $p \leq 0.05$ unless otherwise stated.

Results and discussion

Regular season fruiting

In the present study, there was a wide variation in the physico-chemical composition of fruits for the varieties studied and these differences were found to be statistically significant in regular fruiting season during 2013-14 and 2014-15 (Table-1).

In the present study, Total Soluble Solids content of varieties ranged from 13.81 to 21.49 ^{0}Brix. Total Soluble Solids which mainly imparts sweetness to the pulp was found significantly the highest in cv. Neelphonso (20.82 and 21.49 ^{0}Brix) and the lowest in cv. Totapuri (13.81 and 13.82 ^{0}Brix) during year 2013-14 and 2014-15 (Table-1). The TSS content of cultivars like Ratna (19.89 and 20.19 ^{0}Brix) and Amrapali (19.76 and 19.57 ^{0}Brix) were appreciably low and were at par with Neelphonso during 2013-14 and 2014-15, respectively. This variation in T.S.S is obvious as it is an inherent character of the variety. The hydrolysis of polysaccharides and its conversion into sugars gives an indication of Total Soluble Solids. Mobilization of carbohydrates to organic acids may be the possible cause behind the inherent T.S.S. of a particular variety (Bakshi *et al.*, 2013) [2]. Rymbai *et al.* (2015) [18], Bhamini *et al.* (2018) [3] and Souza *et al*. (2018) [20] also reported that Total Soluble Solids content varies significantly amongst the varieties.

The sugar content in mango which is mainly composed of sucrose, glucose and fructose impart sweetness to the pulp. Of the varieties studied, maximum reducing sugars content (4.34 and 4.46%) was observed in variety Amrapali, which was at par with Ratna in first year only (4.16%). While, significantly lower reducing sugar (3.21 and 3.23%) was noted in Baramasi during 2013-14 and 2014-15. Chanana *et al.* (2005) [5] reported that mango cultivars exhibited a variation in reducing sugar content and Langra excelled in this parameter. According to Kulkarni and Rameshwar (1981) [10] reducing sugar was 43 per cent sweeter than non-reducing sugar and attributed the sweetness of certain mango cultivars to their slightly higher reducing sugar content. The reducing sugar percentage depends upon the genotype and climatic conditions where, genotypes play a larger role in defining the quality characters. The results of the present study are in harmony with the research findings of several studies in the past for example Khara *et al.* (2016) [9]; Bora *et al.* (2017) [4] and Patel *et al.* (2017) [14]. They observed variation in reducing sugar percentage in different mango varieties.

Fruit acidity is dependent on the ripening stage of the variety. With respect to titratable acidity, the lowest acid content (0.179 and 0.192%) was noticed in variety Totapuri in both years, and also (0.192%) in variety Neelphonso in second agronomical year. While during first year variety Neelphonso was at par (0.188%) with Totapuri variety, respectively. However, highest acidity content (0.241%) during first year was recorded in variety Ratna. During the second year it was significantly the highest (0.228%) in Neelum variety. However, a wide range of variability in acidity might be due to the genetic and climate differences. Previous reports by Singh *et al.* (2012) [19]; Roshan *et al.* (2013) [17] and Souza *et al*. (2018) [20] also revealed wide variations in titratable acidity content for pulp of mango varieties. Kumar *et al.* (1992) [11] suggested that this might be due to the conversion of acids into salts and sugars by enzymes particularly invertase. According to Bakshi *et al.* (2013) [2] time of harvest and prevailing agro-climatic conditions affect the acidity content of mango fruits.

Results indicated that among the varieties studied the ascorbic acid composition varied significantly from cultivar to cultivar. The highest ascorbic acid content (28.40 and 28.13 mg/100g) was recorded in Neelum variety which was at par with cultivar Ratna *viz.*, 26.13 and 25.47 (mg/100g) during 2013-14 and 2014-15 while, Baramasi variety had significantly the lowest ascorbic acid (20.67 and 20.40 mg/100g) in period of study. Variation in ascorbic acid content could be attributed to the nature and extent of genetic variability present in the experimental material. Khara *et al.* (2016) [9]; Bora *et al.* (2017) [4] and Hada and Singh (2018) [6] also observed variation in mango varieties for ascorbic acid content.

Table 1: Physico-chemical characteristics of selected mango cultivars during the regular flowering season

Varieties	Total Soluble Solids (^{0}Brix)		Reducing sugar (%)		Titrable acidity (%)		Ascorbic acid (mg/100g of pulp)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
V_1 :Amrapali	19.76	19.57	4.34	4.46	0.214	0.221	23.33	23.60
V_2 : Baramasi	14.08	13.88	3.21	3.23	0.217	0.218	20.67	20.40
V_3 : Neelphonso	20.82	21.49	3.86	4.03	0.188	0.192	24.27	23.47
V_4 : Neelum	17.73	18.68	4.02	3.94	0.237	0.228	28.40	28.13
V_5 : Ratna	19.89	20.19	4.16	4.10	0.241	0.227	26.13	25.47
V_6 : Totapuri	13.81	13.82	4.05	4.07	0.179	0.192	22.27	22.00
S.Em.±	0.381	0.599	0.084	0.057	0.007	0.003	1.021	1.242
C.D. at 5%	1.20	1.89	0.26	0.18	0.022	0.010	3.22	3.91

Off season fruiting

The effect of de-blossoming on physico-chemical characters of resultant fruiting in selected mango varieties is presented in Table 2. Results indicated thatHand de-blossoming had a significant impact on Total Soluble Solids as expressed during the off-season in 2013-14 and 2014-15. While, other parameters *viz.* acidity, reducing sugar and ascorbic acid were found non-significant. Significantly higher values for Total Soluble Solids content (18.25 and 18.22 ^{0}Brix) were recorded in fruits harvested from hand de-blossoming trees as compared to fruits from untreated trees during both years, respectively. These results clearly indicated that chemical characteristics of fruits were genetically governed and that environment had little influence on these parameters. Optimum distribution of sugar reserves and their assimilation may have resulted in high TSS in off-season fruits. This finding was substantiated by Yeshitela *et al.* (2003) [22] as they reported an improvement in TSS due to de-blossoming in cv. Tommy Atkins over two seasons.

Significant differences were noticed in off-season chemical parameter of selected varieties during 2013-14 and 2014-15. The maximum Total Soluble Solids (21.11 and 21.06 ^{0}Brix) and the minimum acidity (0.200 and 0.201%) were recorded in cv. Neelphonso. Whereas, the lowest Total Soluble Solids (13.83 and 13.69 ^{0}Brix) was observed in variety Baramasi. Titrable acidity was the highest (0.238%) in Neelum cultivar. Further the maximum percentage of reducing sugars (4.01 and 4.11%) was recorded in Ratna variety, while, minimum reducing sugar (3.20 and 3.17%) was noticed in Neelum variety during the period of study.

Table 2: Effect of de-blossoming on physico-chemical characteristics of selected mango varieties for off season fruiting

Treatments	Total Soluble Solids (^{0}Brix)		Reducing sugar (%)		Titrable acidity (%)		Ascorbic acid (mg/100g of pulp)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
De-blossoming ##								
T_3: Manually (hand de-blossoming)	18.25	18.22	3.74	3.76	0.225	0.227	24.03	22.70
T_4 : Control	17.65	17.55	3.71	3.73	0.224	0.223	23.10	23.17
S.Em.±	0.18	0.21	0.02	0.03	0.003	0.005	0.42	0.52
C.D. at 5%	0.53	0.62	NS	NS	NS	NS	NS	NS
Varieties (V)#								
V_2 : Baramasi	13.83	13.69	3.20	3.17	0.224	0.222	20.53	21.07
V_3 : Neelphonso	21.11	21.06	3.93	3.96	0.200	0.201	23.67	21.67
V_4 : Neelum	17.44	17.33	3.77	3.74	0.238	0.238	25.40	23.67
V_5 : Ratna	19.43	19.46	4.01	4.11	0.237	0.241	24.67	25.33
S.Em.±	0.25	0.29	0.03	0.04	0.004	0.007	0.59	0.73
C.D. at 5%	0.75	0.88	0.10	0.13	0.01	0.02	1.80	2.22
Interaction effect (T×V)								
S.Em±	0.35	0.41	0.05	0.06	0.006	0.010	0.84	1.04
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS

(#) denotes removal of selected treatment and its combination from statistical analysis and data were analysed using remaining treatment combinations.

Amrapali (V_1) and Totapuri (V_6) did not flower in the off-season after imposition of de-blossoming treatments

Trees subjected to treatment T_1(NAA-400 ppm) and T_2 (NAA-800 ppm) did not carry their fruits to maturity

With regard to ascorbic acid, significantly the highest content (25.40 mg/100g) was found in variety Neelum while, Neelphonso and Ratna were at par (23.67 and 24.67 mg/100g, respectively) during first year. Whereas, during second year it was significantly maximum (25.33 mg/100g) in variety Ratna and variety Neelum was statistically at par (23.67 mg/100g). However, significantly the lowest ascorbic acid content (20.53 and 21.07 mg/100g) was observed in Baramasi variety during the period of investigation. The reported variation in chemical parameters clearly indicated that genetic inheritance of the cultivar and climatic conditions influenced chemical parameters. It is a well-known fact that variation among cultivars can be attributed to differences in genetic makeup and its constituents. These genetic factors express their physiochemical differences when different cultivars are grown under identical conditions.

Variation among different varieties in Total Soluble Solids was observed by Rajan *et al.* (2014) [15]. Similarly, high variability for ascorbic acid content and acidity has been reported by Kaviarasu and Vanilarasu (2014) [7] in off-season mango fruits. Results regarding reducing sugar stand confirmed by earlier reports from Kaviarasu *et al.* (2017) [8].

The present investigation highlights the possibility of employing hand-de-blossoming to regulate the fruiting time and chemical traits in mango cultivars exhibiting off-season flowering *viz.*, Baramasi, Ratna, Neelum and Neelphonso under South Gujarat conditions. These varieties can be further evaluated and used in mango breeding programmes, to meet the demand for mango fruits during the off season.

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