J. Hortl. Sci.
Vol. 10(2):229-232, 2015

Short communication

Chemical constituents during the main and off-season in mango (*Mangifera indica* L.) cv. Royal Special

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ABSTRACT

Evaluation and quantification of fruit quality parameters like carbohydrates, phenolics, flavonoids, ascorbic acid, titrable acidity, Total Soluble Solids (TSS), carotenoids and lycopene content was done in fruits of mango cv. Royal Special, at ICAR-Indian Institute of Horticultural Research, Bengaluru, India, during the off-season (October, 2012) and main-season (June, 2013), respectively. 'Royal Special' is a typical off-season bearing cultivar, often characterized by multiple flushing and flowering under South Indian conditions. Major phytonutrients such as total sugars, reducing sugars, starch, total carotenoids, lycopene, total phenols, flavonoids, ascorbic acid, TSS, titrable acidity and average fruit yield per plant, were recorded during the off- and main- seasons. Results indicated that fruits from off-season were higher in the major chemical constituents studied compared to the main-season crop, except for fruit yield per plant. This may be attributed to poor competition for nutrients among the developing fruits which act as a sink, besides fluctuating environmental conditions during the off-season, compared to the main-season.

Key words: Mango, cv. Royal Special, off-season, fruit yield, carbohydrates, pigments, total phenols, flavonoids

Off-season mango production is predominant in tropical countries, mainly Thailand, Philippines, Indonesia, and some parts of peninsular India especially, Kanyakumari and areas of Tamil Nadu, due to the prevalent high temperature and relative humidity. Demand for off-season mango fruits is gaining prominence in the international markets of Asia and North America. Productivity of off-season fruits is negligible compared to the main-season mango under Indian conditions. The benefit of off-season mango production is higher profits to the farmer by avoiding a market glut. In off-season mango production, cv. Royal Special is the only variety bearing fruits during September-October (considered off-season) and in May-June, which is the main-season under South Indian conditions, owing to its multiple flushing and flowering pattern. Round fruits, yellowish-red in color, with a thick skin, abundant fiber, good Total Soluble Sugar (TSS) content (16.8^{0}Brix), with average fruit weight of 197.5g are the desirable traits in 'Royal Special' mango (Dinesh *et al,* 2012).

Several authors have reported beneficial properties of the fruit such as lycopene, carotenoids, curcumins, phenolics, flavonoids and sugars, including their chemo-preventive role (Lakshminarayana *et al*, 1970; Kubo and Matsumoto, 1984; Lechaudel and Joas, 2007; Ojewole, 2005; Rodeiro *et al*, 2007). Most table-varieties exhibit an average TSS of 7.5-28.0^{0}Brix (Dinesh *et al,* 2012) under various climatic conditions. In addition to several other components, total carotenoids and ascorbic acid contribute are high in the mango pulp (Ross, 1999). Malundo *et al* (2001) reported that an ideal sugar:acid blend makes it favorable for flavonoid perception in ripe fruits. Pulp of Haden, Tommy Atkins and Uba varieties is a good source of total carotenoids, phenolics and ascorbic acid – components with antioxidant properties (Varakumar *et al,* 2011). Potential nutritional and health benefits of mango have gained great importance in fruit quality and marketing strategy of the fruit. As for fruit quality parameters, most of the earlier studies are restricted to the main-season, and information on off-season fruit quality parameters is scanty. Therefore, we aimed at a comparative study of off-season and main-season fruit quality parameters such as ascorbic acid content, total carotenoids, lycopene, total phenols, flavonoids, titrable acidity (TA), TSS, total sugars, reducing sugars, starch and fruit yield/plant in cv. Royal Special.

The study was conducted at ICAR-Indian Institute of Horticultural Research, Bengaluru, India, on 21-year old,

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uniformly-grown mango trees of cv. Royal Special, planted at 10m × 10m spacing having average canopy diameter of 8.0m. The experimental farm is located at 914.4m above mean sea level, with average temperatures ranging from 13.3 -32.4^{0}C during the year. The soil is sandy loam with available soil-nutrients N:250 kg/ha, P:30 kg/ha, K:300 kg/ha, at pH 7.2, average silt 9% and clay 21.5%. The trees were raised under rainfed conditions. Six trees were selected randomly for sampling fruits. Samples of five mature fruits from each tree were drawn during early October, 2012 and late June, 2013. These were ripened at room temperature in both the seasons. During the fruit ripening, the average maximum and minimum temperature was 27.8/19.4^{o}C and 30.1/20.8^{o}C and ripening duration 5 and 8 days in October and June, respectively. Appearance of desired skin colour in the fruit peel, and olfactory perception of fruit aroma, were employed as indices of fruit ripening for laboratory analysis. Ripe fruits were then completely peeled-off, pooled, sliced, the kernel removed, weighed and samples subjected to further analysis for fruit pulp traits.

TSS was estimated using a hand-held ERMA refractrometer, while TA was estimated as per Association of Official Analytical Chemists (AOAC) method, using phenolphthalein as an indicator. Total sugars in fresh samples were estimated following Hansel and Moller (1975). Reducing sugar content was determined by Somagyi (1952) method, and amount of reducing sugars calculated using a glucose standard. Non-reducing sugars were estimated by subtracting reducing sugars from the total sugar content. Starch content in fresh samples was determined using anthrone reagent, as per Hedge and Hofreiter (1962). For determining the content of total phenols and flavonoids, 1.0g fresh pulp was finely ground with 5.0ml 80% ethanol, centrifuged at 10000rpm for 10 min, supernatant collected and volume readjusted to an initial volume with 80% ethanol. Total phenols were estimated spectrophotometrically using Folin-Ciocalteu reagent (Bray and Thorpe, 1954) with gallic acid as the standard. The values were expressed as mg/100g fresh weight. Total flavonoid content was estimated using catechin as the standard, and the values were expressed as mg/100g fresh weight (Zhishen *et al*, 1999). Total carotenoids and lycopene content was estimated spectrophotometrically (Jensen, 1978; Ranganna, 1976). Molar extinction coefficient of 2500M^{-1} cm^{-1} at 450nm for total carotenoids, and 1.72x10^5 M^{-1} cm^{-1} at 503nm for lycopene was used for calculating their respective content. Ascorbic acid was estimated by extracting the fruit pulp in 5% metaphosphoric acid, and titrated with 0.05% aqueous 2,6-dichlorophenol-indophenol as per Harris and Olliver (1942). Data were statistically analyzed using ANOVA, and significance (p>0.01) was determined for comparing treatments.

Total sugar content increased up to 50% during the off-season, at 132.95 mg/g in October, 2012, and 81.98 mg/g in June, 2013. Significant variation was observed in the content of reducing sugars during off-season (63.09mg/g), while, during the main-season, 26.45mg/g was recorded (Table 1). Analogous to total and reducing sugars, the non-reducing sugars, the starch and TSS were found to be significant. Maximum content recorded was 69.89mg/g, 28.3mg/g and 21^{0}Brix, respectively, while minimum content recorded was 55.53mg/g, 17.2mg/g and 14^{0}Brix, respectively, during off-and on-seasons, respectively. Differences among carbohydrate and starch content can be attributed to differences in competing growth-aspects in the developing /ripening fruits. Increase in carbohydrate content can be correlated with increase in TSS in the fruit, noticed in the present study. Fruit development during September-October was perhaps facilitated optimally due to less fruit-load on the trees. These trees had been affected by the previous year's crop-load. In simple terms, more the crop-load, higher the competition among developing fruits, and vice-versa. On the contrary, Burdon *et al* (2007) reported that carbohydrate status in avacado fruit was the same, irrespective of the season, under New Zealand conditions. In our studies earlier, non-reducing sugars were monitored at various stages in mango (Reddy *et al*, 2014). There is an added complication in fruit crops, especially in mango, in interpreting carbohydrate status of the fruit, due to asynchronous flowering.

Titrable acidity (TA) had no determining role during either the main or the off-season. However, higher titrable acidity was recorded (0.32%) during off-season, and

Table 1. Carbohydrates, TSS and ascorbic acid content in mango fruit

Season	Total sugars (mg/g)	Reducing sugars (mg/g)	Non-reducing sugar (mg/g)	Starch (mg/g)	TSS (^{o}Brix)	Ascorbic acid (mg/100g)	Titrable acidity (%)
Off-season	132.95±0.577	63.09±0.578	69.89±0.057	28.3±0.173	21±1.173	0.87±0.011	0.32±0.057
Main-season	81.98±0.562	26.45±0.259	55.53±0.303	17.2±0.577	14±1.154	0.67±0.011	0.25±0.056

(*p* significant >0.01, n=3)

Table 2. Total flavonoids and phenols in mango fruit

Season	Phenols (mg/100g)	Flavonoids (mg/100g)
Off-season	0.817±0.009	0.481±0.047
Main-season	0.653±0.003	0.123±0.013

(*p* significant >0.01, n=3)

Table 3. Carotenoids, lycopene content and average fruit yield in mango

Season	Carotenoids (mg/100g)	Lycopene (mg/100g)	Average fruit yield (kg/plant)
Off-season	4.47±0.288	1.01±0.144	5.0±2.603
Main-season	2.33±0.191	0.45±0.025	40.0±5.773

(*p* significant >0.01, n=3)

minimum TA (0.25%) was recorded in the main-season crop. Ascorbic acid content was 0.87mg/100g in off-season, and 0.67mg/100g in the on-season. Ascorbic acid content was 20% higher in off-season fruits. Higher content of phenolics and flavonoids was recorded during off-season (Table 2). The difference seen in flavonoid content between seasons can be directly correlated with sugar:acid blend. In support of our findings, a study by Malundo *et al* (2001) states that sugars and acids enhance human perception of specific flavor-notes in mango, including the aromatics. On the other hand, lower TSS:acid ratio is directly related to higher sourness (Lechaudel and Joas, 2007).

Total carotenoid and lycopene content increased in off season fruits compared to the on-season ones, at a maximum of 4.47mg/100g and 1.01mg/100g, respectively while, minimal content recorded was 2.33mg/100g and 0.45mg/100g during the off- and on- season, respectively. These results were found to be significant (Table 3) increase in content of carotenoids and lycopene during the off-season can be directly correlated with fluctuating environment (stress), viz., temperature, light intensity, leaf photosynthetic capacity and rainfall, along with poor competition for nutrition demand in a growing fruit on the tree. Also, lower day temperatures were often seen to be associated with higher pigmentation in apple (Solovchenko *et al*, 2006). We too observed this in our study.

Average fruit yield per plant reduced considerably during the off-season. Maximum fruit yield (40kg/plant) and minimum fruit yield (5kg/plant) was recorded in the on- and off-season, respectively, and these differences were significant. The present study revealed that differences in crop yield during the on- and off- years influenced biochemical factors in the fruit, especially carbohydrates, along with others like phenolics, flavonoids and carotenoids.

Fig. 1. 'Royal Special' mango tree in different stages of growth

Fig. 2. Ripe fruits of mango cv. Royal Special

Prior to this study, none of the research works on mango have shown clear-cut accumulation pattern and development of fruit quality parameters during main and off season grown mango fruits especially, in cv. Royal Special, which is erratic in flowering. From this study, it can be inferred that fruits grown in the off-season are richer in phytonutrients than those grown during the main-season crop. It is worthwhile to promote off-season production in mango cv. Royal Special.

ACKNOWLEDGEMENT

The authors are thankful to Director, ICAR-IIHR, for providing facilities and grateful to NAIP, ICAR New Delhi, India, for financial support. Thanks go out to National Coordinator-4 for providing encouragement in the course of the study. Active support of H.L. Jayaram, Technical Officer, T.N. Nagaraj, Field Technician, H.S. Naveen, Skilled Assistant and J. Varun, NAIP Project is gratefully acknowledged.

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(MS Received 20 January 2015, Revised 27 August 2015, Accepted 08 September 2015)