**Estimation of vitamin C, beta carotene, total phenolics, total flavonoids and total antioxidant activity in mango (*Mangifera indica* L.) cultivars grown in Telangana state**

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**Abstract**

Mango is one of the most important, nutritious, tropical fruit grown throughout the world. It has plenty of natural antioxidant compounds like ascorbic acid, carotenoids, phenols, flavonoids. The present study was conducted to estimate antioxidants in different mango (*Mangifera indica* L.) cultivars commercially grown in Telangana state, India during the subsequent years of 2018-19 and 2019-20. The experiment was carried out in completely randomized design with three replications in fifty mango cultivars collected from fruit research station, Sangareddy, Telangana and subjected to evaluation of antioxidant properties in selected mango cultivars. The results of antioxidants were significantly (< 0.05) varied among all mango cultivars. The antioxidant compounds ranged from 19.09-31.97 g/100g (vitamin C), 1.11-2.81 mg/100g (beta carotene), 24.03-331.11 mg of QE/100g (total flavonoid content), 64.72-173.20 mg GAE/100g (total phenolics) and total antioxidant activity 91.74-326.38 µg/100g. Among fifty cultivars, Allampur Baneshan was found to be maximum vitamin C (31.97 mg/100g), beta carotene content was recorded highest in Lalmuni (2.81 mg/100g) and Yerra Mulgoa (331.11 mg of QE/100g) was recorded maximum total flavonoid content, Mahamooda Vikarabad (173.20 mg GAE/100g) was noticed maximum total phenolic compounds and Dashehari-35 was recorded highest total anti-oxidant activity (326.38 µg/100g). The results showed that a wide variation among the cultivars studied and recorded significant amounts of antioxidant compounds. Hence, all these varieties may be suitable in daily diet at commercial level will impart more health benefits.

**Key words:** Mango, Antioxidant compounds, Free radicals, Daily diet, Health benefits

**Introduction**

Mango (*Mangifera indica* L.) is one of the most important and nutritious fruit of tropical regions, native to South East Asia. It is cultivated throughout the tropical and subtropical world due its sweet taste, juicy, succulence, nutritional and antioxidant properties, hence called as “Super fruit” and “King of fruits”. Major mango growing states in India are Uttar Pradesh, Andhra Pradesh, Odisha, Karnataka and Telangana. Mango is an excellent source of different anti-oxidant compounds like provitamin A, vitamin C, dietary fibre, polyphenols, flavonoids and antioxidants (Lemmens *et al.,* 2013) are well known to be unique constituents in human diet and also have been associated with reducing the risk of several disorders, different types of cancers, cardiovascular diseases (Stahl and Sies, 2003). Antioxidants are chemicals that can prevent or slow cell damage. Thus, intake of raw mangoes increases the antioxidants in the human diet. These natural properties of mango fruit vary from cultivar to cultivar, many researchers were analysed the bioactive compounds of different mango varieties from previous reports (Rajput and Pandey, 1997; Hamdard *et al.,* 2004; Akhter *et al.,* 2010).

In recent trends, estimation of these antioxidant compounds is increasingly relevant in the field of nutrition as they help in human body against different disorders, diseases and oxidative damage by free radicals (Halliwell, 1997). There is a need to estimate different antioxidant compounds present in various cultivars of mango are grown in Telangana state, considering the above fact, the present study was planned to estimate antioxidant compounds in pulp of fifty mango cultivars grown in Telangana state to recommend their use in daily diet at commercial level.

**Material and Methods**

**Sample collection and preparation**

The present investigation was conducted to estimate antioxidants of fifty mango cultivars grown in Telangana state during the subsequent years of 2018-19 and 2019-20 at FRS, Sangareddy, College of Horticulture, SKLTSHU, Rajendranagar and Quality Control Laboratory, PJTSAU, Rajendranagar. Experimental material consists of fifty mango cultivars were harvested at their maturity stage based on °Brix values of each variety and procured from the Fruit Research Station, SKLTSHU, Sangareddy. The firm and well-developed fruits of uniform size, shape, colour and mature, free from blemishes and pest & diseases were selected and harvested manually from the tree. The fruits were subjected to ripening with en-ripe (ethylene powder for ripening). The fresh pulp from each variety in accurate quantity was weighed as required for evaluation of antioxidant properties in all varieties. The experiment was done in Completely Randomized Design with three replications.

**Determination of antioxidant compounds**

Vitamin C (ascorbic acid) content in mango pulp was determined by 2,6-Dichlorophenol-indophenol titration method as described by AOAC (1997) method. Beta carotene was determined using method described by Srivastava and Sanjeev Kumar (2002). The absorbance was measured at 452 nm optical density using petroleum ether as blank in spectrophotometer. Results were expressed in mg per 100 g of pulp. Total phenols content of mango was quantified by Folin-Ciocalteu method (Singleton and Rossi, 1965) using gallic acid as a standard and results were expressed as milligram gallic acid equivalents (GAE/100g) and the absorbance was measured at 750 nm against deionized water on a spectrophotometer. Total flavonoid content was determined by aluminium chloride calorimetric method described by Park *et al.* (2008) by using quercetin as a standard and absorbance was measured against the blank at 520 nm using spectrophotometer. Results were expressed in milligram quercetin equivalent (QE)/100g fresh pulp of mango. Total antioxidant activity was determined by TBARS method as per the reference given by the Ottolenghi (1959). The absorbance activity of the reaction mixture was measured at 552 nm.

**Statistical analysis**

Results were expressed as mean ± SEM and all the analysis was performed in triplicate. The statistical analysis of data was carried out by using one way analysis (ANOVA) with p value significant at *p<*0.05 using WINDOWSTAT software version 9.2.

**Results**

**Results of vitamin C (mg/100g)**

Vitamin C or ascorbic acid is the predominant antioxidant in mango. Significant variation (p <0.05) and a decreasing trend of vitamin C from harvest to ripening was observed among the fifty mango cultivars are presented in fig. 1. It is seen from the results that, vitamin C values ranged from 19.09-31.97 g/100g and maximum was observed in Allampur Baneshan (31.97 mg/100g) followed by Goa Bander (30.97 mg/100g), Baneshan (29.90 mg/100g) and Shendriya (29.52 mg/100g) and it was minimum in Pandurivari Mamidi (19.09 mg/100g) followed by Kaju (19.74 mg/100g), Rumani (20.16 mg/100g) and Chinnarasam (20.76 mg/100g). Such variation in vitamin C content could be attributed to the nature and extent of genetic variability present in the experimental material. Similar vitamin C contents were also previously reported for various mango varieties by Abourayya *et al.* (2011), Anowar Hossain *et al.* (2014) and Himabindu *et al.* (2018) in mango.

**Results of beta carotene content (mg/100g)**

Carotenoids are the most important parameters attributing yellow to orange colour in pulp, the greater the carotenoids, the better the nutritional quality of the fruit. Beta carotene content was differed significantly (< 0.05) among all the varieties of mango and it ranged from 1.11-2.81 (mg/100g) as shown in fig. 2. The results showed that significantly the highest beta carotene content was recorded in Lalmuni (2.81 mg/100g) followed by Zardalu (2.74 mg/100g), Dashehari-35 (2.63 mg/100g), Suvarnarekha (2.62 mg/100g) and Yerra Mulgoa (2.60 mg/100g), while lowest was in Nazeem Pasand (1.11 mg/100g), Ranitellakaya (1.15 mg/100g) and Panchavarnam (1.18 mg/100g). The results were in agreement with Abirami *et al.* (2004), Ajila *et al.* (2007), Nehra and Sharma (2012) and Monaco *et al.* (2014) in mango.

**Results of total flavonoid content (mg of QE/100g)**

Flavonoids are also the most promising polyphenolic compounds which exhibit antioxidant activity Zuhair *et al.* (2013). Total flavonoid content increases significantly from harvest to ripening and all values were found be varied significantly (p<0.05) among fifty mango cultivars as shown in fig. 3*.* It is seen that total flavonoid content ranged from 24.03-331.11 (mg of QE/100g). The highest total flavonoid content was noticed in Yerra Mulgoa (331.11 mg of QE/100g) followed by Pulihora (263.02 mg of QE/100g), while lowest was in Kalepahad (24.03 mg of QE/100g) followed by Sora (47.32 mg of QE/100g) and Peddarasam (48.06 mg of QE/100g) which was at par with Vanraj (50.56 mg of QE/100g) and Nazeem Pasand (50.92 mg of QE/100g). The present observations are in agreement with the results of Ajila *et al.* (2007), Hana Kim *et al.* (2010) and Kuganesan *et al.* (2017) in mango.

**Results of total phenols content (mg of GAE/100g)**

Total phenol content in fruits steadily decreases and then increases during the ripening process (Miletic *et al.,* 2012). Significant variation (p<0.05) was found for total phenols content of fifty mango cultivars as shown in fig. 4. It was observed that total phenols content among fifty mango cultivars ranges between 64.72 (mg GAE/100g) to 173.20 (mg GAE/100g). Mahamooda Vikarabad was found with highest total phenols content (173.20 mg GAE/100g) followed by Shendriya (164.73 mg GAE/100g) and Sannakulu (160 mg GAE/100g), while lowest was in Shajahan (64.72 mg GAE/100g) followed by Ranitellakaya (66.91 mg GAE/100g), Kesar (67.22 mg GAE/100g) and Dilpasand (67.71 mg GAE/100g). The final quantity of total phenols can also be affected by factors such as ripeness, species, cultivation techniques, geographic origin, stage of growth and harvesting and storage conditions (Soares, 2008; Sousa *et al.,* 2012).

**Results of total antioxidant activity (µg/100g)**

The results of total antioxidant activity of fifty mango cultivars showed significant (p<0.05) variation and it ranged from 91.74 µg/100g to 326.38 µg/100g as given in fig. 5. Significantly the highest total antioxidant activity was found in Dashehari-35 (326.38 µg/100g) followed by Kothapalli Kobbari (285.41 µg/100g) which was on par with Panakalu (285.01 µg/100g), while lowest was found in Azam Us Samar (91.74 µg/100g). The findings are in agreement with those reports of Aiyegoro and Okoh (2010) and Pisoschi *et al*. (2009) in mango.

**Discussion**

Mangoes are valuable source of vitamin C (Thomas and Oke, 1980; Mamiro *et al.,* 2007; Othman and Mbogo, 2009). Vitamin C was highest just after harvest and gradually declined with the passage of time, while it was lowest at last edible stage (Azad *et al.*, 2009). This decreasing trend was due to conversion of acid into sugars and their further utilization in metabolic process of the fruit. Present results are also in line with Lokesh Bora *et al.* (2017) who reported that Langra cultivar possessed the higher amount of ascorbic acid content (55.62 mg/100g) followed by Pusa Surya (46.25 mg/100g) and Pusa Arunima (45.63 mg/100g). However, lower amount of vitamin C recorded in Vanraj (24.38 mg/100g) and Sabri (24.60 mg/100g). According to Deepa *et al*. (2017) the cultivar Alphonso contained significantly higher (24.31 mg/100g) ascorbic acid compared to Kesar (22.01 mg/100g) and Totapuri (20.97 mg/100g).

 The amount of beta carotene was increased with the progress of storage and it was the minimum after harvest, maximum at last edible stage (Azad *et al.,* 2009), it’s due to degradation of chlorophyll and synthesis of carotenoids or xanthophylls takes place simultaneously during fruit ripening process. The carotenoid composition in mango can be affected by many factors such as growth conditions, maturity, cultivar, geographical origin and processing conditions (Chen *et al.* 2007). According to Veda Supriya *et al.* (2007) the beta-carotene content in ripe mango ranged from 0.55 ± 0.03 mg/100 g (Malgoa) to 3.21 ± 0.25 mg/100 g (Badami). These results were consistent with the findings of Aradhna Singh *et al.* (2017) and Richa Pritwani and Pulkit Mathur (2017) in mango; Nidhi Budhalakoti (2018) in banana.

Variation in flavonoid content of mango cultivars is strongly influenced by extrinsic factors such as fruit type and growth, season, climate, degree of ripeness, according to Lakenbrink *et al.* (2000). A was study done by Zuhair *et al.* (2013) who reported that total flavonoid content increases significantly during the ripening of papaya through different maturity stages. Katike Umamahesh *et al.* (2016) reported that, mango cultivar Sindhura peel showed higher TFC value (15.6±0.23 mg of QE/g), than the aqueous extracts of Rumani peel (14.4±0.15 mg of QE/g), Malgua peel (12.8±0.47 mg of QE/g), Alphonso peel (11.5±0.19 mg of QE/g) and Banisha peel (8.7±0.32 mg of QE/g).

 The phenolic compounds are mainly responsible for the total antioxidant capacity of the fruits. Mango is one of the rich sources of these phenolic compounds. The present results are in line with John *et al.* (2017) who reported the highest total phenolic content was observed in Paparanda (436.44 mg/100g) followed by Peter (243.93 mg/100g) and the lowest total phenolic content was found in Julie (237.13 mg/100g) mango; Akhtar *et al.* (2013), Khan *et al*. (2010), Zhang *et al.* (2014) in mandarin.

 The antioxidant activity exhibited in fruits is mainly due to the phenolic compounds, which have redox properties, and can play an important role in absorbing and neutralizing free radicals, quenching singlet and triplet oxygen or decomposing peroxides (Mishra *et al.*, 2010). Present results are in agreement with the findings of Kabir *et al.* (2017) and Muralidhara *et al.* (2019).

**Conclusion**

The present study showed that almost all mango varieties are good source of antioxidant properties such as vitamin C, beta carotene content, total flavonoid content, total phenols content and total anti-oxidant activity and varies from cultivar to cultivar. Among all fifty cultivars Allampur Baneshan was found to be maximum vitamin C, Lalmuni contained high beta carotene content, Yerra Mulgoa had highest total flavonoid content, Mahamooda Vikarabad was recorded maximum total phenols and total anti-oxidant activity was observed highest in Dashehari-35. All other varieties also had good amounts of anti-oxidant properties. Hence, these varieties may be suitable in daily diet industries at commercial level will impart more health benefits.

**Acknowledgement**

The authors thank the College of Horticulture, SKLTSHU, Mulugu for providing financial support and Fruit Research Station, Sangareddy for providing fruits and also MFPI-Quality Control Laboratory (PJTSAU, Rajendranagar) for technical support.

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**Fig. 1: Mean Vitamin C (mg/100g) of fifty mango cultivars**

**Fig. 2: Mean beta carotene (mg/100g) of fifty mango cultivars**

**Fig. 3: Mean total flavonoid content (mg QE/100g) of fifty mango cultivars**

**Fig. 4: Mean total phenols content (mg of gallic acid/100g) of fifty mango cultivars**

**Fig. 5: Mean total antioxidant activity (µg/100g) of fifty mango cultivars**