Study of Physicochemical Properties and Antioxidant Content of Mango (*Mangifera indica* L.) Fruit

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Abstract

The objectives of this study were to determine the physicochemical properties and antioxidant composition of four mango varieties (Tommy Atkins, Apple, Keitt, and Kent) grown in Ethiopia and to compare their composition to previously reported results on mangoes grown in other parts of the world. The Keitt variety had the highest fruit weight, fruit length, fruit diameter, and juice volume content. The pH, TSS, TA, and TSS/TA and proximate composition (moisture, ash, fat, fiber, and protein) showed significant differences among the varieties at $p \leq 0.05$. Minerals such as Na, Mg, K, Ca, Fe and Zn were also evaluated and potassium had the highest concentration among the minerals with the grand mean of 267.44 mg/100 g. Varieties also differed in antioxidant content such as total carotenoids and vitamin C with values ranging from 0.6 to 4.8 µg/g and 14.2 to 36.4 mg/100 g, respectively. Apple, Kent and Keitt mango varieties are good sources of vitamin C. The four mango varieties had similar physicochemical properties and antioxidant content compared to mangoes grown in other countries.

Keywords: acidity, mango, total carotenoids, vitamin C

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INTRODUCTION

Mango (*Mangifera indica L.*) is one of the most important tropical fruits commercialized and consumed worldwide. The fruit may be used fresh or processed and possesses an attractive color and distinct taste and aroma (Singh et al., 2000). It is a nutritionally rich fruit that provides health benefits to humans. Mango is not only delicious but is also rich in prebiotic dietary fiber, vitamins, minerals, antioxidant compounds such as polyphenols and carotenoids. Mango also possesses medicinal properties, and is a very good source of both vitamins A and C (Ajila et al., 2007; Altemimi et al., 2017; Alsaad et al., 2019). The physicochemical properties of mango varieties are varied across the world due to different factors such as maturity and ripening stage, type of variety (Othman and Mbogo, 2009), cultivation practices (Hofman, 1995), climatic conditions (Léchaudel and Joas, 2006), ripeness at harvest (Jacobi et al., 1995; Lalel et al., 2003), and postharvest storage and treatment (Hofman et al., 1997; Nunes et al., 2007).

Nowadays, there are four varieties of mango widely distributed throughout Ethiopia with the help of the Melkassa Agricultural Research Center. The Center has been doing research on the improvement of fruit productivity and its quality. There are a number of varieties in the research stations which are available but the most widely distributed and most consumed varieties are Kent, Keitt, Apple, and Tommy Atkins. Physiochemical properties and sensory profiles of mango varieties are very important quality parameters for promoting mango export in a highly competitive international market. Quality traits have been studied in almost all major mango-producing countries around the world. However, in Ethiopia, information is lacking on mango quality. Therefore, in view of the importance of mango fruit and the abundance of mango studies worldwide, the present research was carried out to assess the different mineral contents, physiochemical and antioxidant properties of four mango varieties at ripeness.

MATERIAL and METHOD

Study area

Studies were conducted in the Food Science and Nutrition research laboratory of the Melkassa Agricultural Research Center, one of the research centers of the Ethiopian Institute of Agricultural Research. The Center is located in the Ethiopian rift valley, 117 km away from Addis Ababa in the southeast direction located at 8°24'N and 39°12'E and an altitude of 1550 m. The mean minimum and maximum temperature of the environment are 13.8°C and 28.6°C, respectively. The Center receives a mean of total annual rainfall of 825.9 mm with erratic distribution, having a high coefficient of variation. The soil contains volcanic ash but is mainly sandy loam with a pH range of 6-8.

Sample collection

Four mango varieties (Apple, Tommy Atkins, Keitt, and Kent) were used for this study. The fruits were cultivated in horticultural research stations at the Melkassa Agricultural Research Center. The samples were collected from ten different mango trees for each variety and the mango skin color was found to be pink with red, red with some yellow and deep red.

The fruits were free from mechanical damage, insect infestation, disease, and physiological deterioration. The samples were stored at room temperature of 25-30°C for 5 d during which ripening and subjective observation of softness, peel color (Crisosto, 1994) and TSS value were monitored.

Sample preparation

Ripe samples of mango were subjected to sample preparations with the aid of a clean sharp knife. The peel and seed (kernel) of the fruit were removed and the pulp was homogenized. The mango puree was lyophilized, stored at –20°C and protected from light until analysis of antioxidants. The fresh fleshes were processed into juice to measure some parameters. The tests were performed in triplicate except for the mineral content.

Methods

The physical parameters of the fruit such as the color of skin and flesh, fruit weight, fruit diameter, fruit length, and juice volume were measured by a color chart, analytical balance, digital caliper and graduated cylinder, respectively.

pH

pH was measured with an electronic pH tester (HI 98106 Champ®, Hanna Instruments, Woonsocket, RI, USA).

TSS (total soluble solids)

TSS was determined using a hand-held refractometer (Model 9099, Atago Co., Ltd., Tokyo, Japan). A drop of homogenized mango pulp was placed on the prism of the refractometer (previously calibrated), the lid closed and TSS read from the digital scale at 20 ± 1°C. The results were expressed in °Brix.

TA (titratable acidity)

0.01 M NaOH was titrated against 10 mL of filtered juice using phenolphthalein indicator. The end of the titration was indicated by a change in color of the sample to pink. The amount of acid in mg/100g was calculated using the following equation (Horwitz, 2000):

$$\text{Titratable acidity} = (0.01 * 0.0064 * T * 10 * 1000)/(\text{Ft} * \text{S}) \quad (1)$$

Where 0.01 is the molarity of NaOH used; 0.0064 represents the conversion factor for citric acid since it is main acid present in mango, T is the titer value, Ft is the quantity of filtrate used, S is the sample amount, 10 is the dilution factor, and 1000 is the conversion to mg/100g.

Moisture determination

Moisture was determined using an oven drying method (Horwitz, 2000). Mango flesh (2 g) was transferred to a dried and tared dish. Sample containing dishes were placed in the drying oven and dried for 1 h at 130°C or until constant weight was attained. The dried samples were removed from the drying oven and then cooled in desiccators at room temperature. Moisture (%) was calculated using the following equation:

$$\text{Moisture (\%)} = ((W1 - W2) * 100)/SW \quad (2)$$

Where W1 is the weight of dish and fresh sample, W2 is the weight of dry sample and dish, SW is the sample weight.

Ash determination

Four grams of lyophilized mango flour was placed into a clean crucible of predetermined weight. The sample containing crucible was placed in a muffle furnace and heated to 550ºC. The samples were ignited until the powder turned a light gray or until constant weight was obtained (Horwitz, 2000). Ash (%) was calculated using the following equation:

$$\text{Ash (\%)} = ((W1 - W2) * 100)/SW \quad (3)$$

Where W1 is the weight of ash + crucible after ashing, W2 is the weight of empty crucible, SW is the sample weight.

Crude fat determination

Crude fat was determined using a previously described method (Horwitz, 2000). Mango flour (2 g) was placed into a previously prepared extraction thimble. The sample was extracted with petroleum ether (b.p. 35-60°C) for 4 h. The last traces of the solvent were evaporated in an oven at 103ºC for 30 min. The dried flasks containing fat were cooled in desiccators and then reweighed. Crude fat was calculated using the following equation:

$$\text{Crude Fat (\%)} = ((Wf - W) * 100)/SW \quad (4)$$

Where Wf is the weight of the flask and fat, W is the weight of flask, SW is the sample weight.

Crude fiber determination

Two grams of sample was transferred into a one-liter beaker. The sample was digested on a hot plate for 1 h with a sequential digestion with 2.5 M H_2SO_4 followed by an equal volume of 2.5 M NaOH. Sample filtering was aided by the addition of a small portion of ethanol. The precipitate was quantitatively transferred to a porcelain crucible and dried with an oven at 100ºC until constant weight was obtained. The crucible contanining precipitate was cooled and weighed (W1). The crucible containing precipitate was incinerated at 600ºC for 3 h in a muffle furnace. The crucible containing ash was removed, cooled and weighed (W2) (Horwitz, 2000). Fiber (%) was calculated using the following equation:

$$\text{Fiber (\%)} = ((W1 - W2) * 100)/SW \quad (5)$$

Where W1 is the weight of crucible and sample before ashing, W2 represents the weight of crucible containing ash, SW is the weight of the sample.

Protein determination

The test was performed by the Kjeldahl method of Horwitz (2000). Mango flour sample (0.5 g) was weighed in a 50 mL Kjeldahl flask followed by the addition of 8 mL of concentrated H_2SO_4 with 5 g of (copper and potassium sulfate) mixture catalyst. Samples were digested until pure colorless solution observed. Digested samples were distilled and the distilled vapor gas (ammonia) was collected in a conical flask containing 25 mL of 2% boric acid solution containing mixed indicator. The distilled sample was titrated against 0.1 N HCl until a pink color persisted. Crude protein was calculated using the following equation:

$$\text{Crude protien} = ((a * b * 14 * 6.25) * 100)/w \quad (6)$$

Where a is the normality of the acid, b represents the volume of standard acid used (mL), corrected for the blank (i.e., the sample titer minus the blank titer), w is the sample weight (g), and 6.25 is the conversion factor for protein from % nitrogen.

Total carbohydrates

The total carbohydrate content was determined by the difference (the measured protein, fat, ash and moisture was subtracted from 100%). (Pearson, 1976).

$$\text{TC} (\%) = 100 - \{\text{Moisture} (\%) + \text{Protein} (\%) + \text{Fat} (\%) + \text{Ash} (\%)\}. \quad (7)$$

Gross food energy was estimated by the following equation (Edeoga et al., 2003):

$$\text{FE} \left(\frac{Kcal}{g}\right) = (\%\text{TC} - \%\text{CF}) * 4 + (\%\text{TF} * 9) + (\%\text{CP} * 4) \quad (8)$$

Where FE is the food energy, TC is the total carbohydrate content, CF is the crude fiber, TF is the total fat and CP is the crude protein.

Total carotenoids

Total carotenoids was performed spectrophotometrically using the method described by Rodriguez-Amaya and Kimura (2004). Lyophilized samples of mango (5 g) were ground with cold acetone with a mortar and pestle until the residue became colorless and then vacuum-filtered using a Büchner funnel. The extract was partitioned with petroleum ether, then each fraction was washed with distilled water for complete acetone removal. The extracts were made up to a volume of 50 mL with petroleum ether. All of the procedures were performed in dim light. The extracted carotenoids were collected and measured at 450 nm using a UV spectrophotometer. Total carotenoids were calculated with the following equation:

$$\text{Total carotenoids} (\mu g/g) = (A * \text{volume (mL)} * 10000)/ \text{A1cm1\%} * \text{sample weight (g)}) \quad (9)$$

Where A is the absorbance, volume is the total volume of extract (50), A1cm1% is the absorption coefficient of β-carotene in petroleum ether.

Ascorbic acid (vitamin C) determination

Ascorbic acid was determined spectrophotometrically using trichloroacetic acid as extraction chemical (Horwitz, 2000). Vitamin C was calculated using the following equation:

$$\text{Vitamin C (mg/100g)} = (\text{As} - \text{Ab}) * 10/([\text{A10}\mu\text{g Std} - \text{Ab}] \quad (10)$$

Where As is the sample absorbance, Ab represents absorbance of blank, $A_{10\mu g\ Std}$ is the absorbance of 10 µg AA standard.

Analysis of the mineral composition

Mango powder (0.5 g) was digested with nitric acid (HNO_3) and perchloric acid ($HClO_4$). The digested sample was filtered and made up to 100 mL in a volumetric flask. An atomic absorption spectrophotometer was used to determine all of the minerals using appropriate lamps (Horwitz, 2000).

Statistical analysis

Statistical analysis of the data was carried out using analysis of variance (ANOVA) technique of completely randomized design (CRD) and all pair-wise comparisons test whereas the least significant difference test was used for comparison of the treatment means at $p \leq 0.05$.

RESULTS and DISCUSSION

Physical properties of mango fruit

Physical properties of mango such as skin and flesh color, fruit weight, fruit diameters, fruit length and juice volume content of the pulp were evaluated. Mango flesh color is an important indicator of maturity and ripeness. Most of the mango varieties develop orange and yellow pigments in the flesh with maturity and ripening but changes in skin color are not always correlated with maturity and ripeness. During ripening peel color may change from green to yellow or deep orange depending on the cultivar, or may remain green. Likewise, changes in the firmness of the skin is another indicator of maturity and ripeness. The three physical parameters, fruit weight, fruit length, and juice volume showed significant differences among tested varieties of mango at $p \leq 0.05$ while fruit width was not significantly different. The fruit weight ranged from 433.5 to 727.3 g. In fruit weight, the Keitt variety was significantly heavier ($p \leq 0.05$) than the other varieties.

The length of the fruit ranged from 93.2 and 137.3 mm with Keitt having the longest length. The extracted juice volume of mango varieties varied from 316.5 to 540.0 mL. The Keitt variety had significantly higher juice volume than the other varieties. Keitt had the highest fruit weight, fruit length and juice volume while Apple had the lowest values (Table 1). Fruits which have high juice volume are appreciated by consumers and food processors. The weight and length of the mango varieties studied are consistent with the previous study of Rodríquez Pleguezuelo et al. (2012) who found that the average weight and length of nine mango varieties ranged from 143 to 792 g and 72.1 to 133.8 mm, respectively.

Rodríquez Pleguezuelo et al. (2012) also found that the mango fruit diameter ranged from 67.9 to 98.9 mm which is similar to our findings. In most cases the fruit weight is not a determining factor for quality but medium-sized fruits are more appreciated by consumers. The size and weight variation observed among the varieties might be due to different growing conditions and genetic variability.

Physicochemical characteristics

pH values were significantly different among the varieties ($p \leq 0.05$) with their values ranging from 3.86 to 4.73. Among the four varieties, Apple (3.86) was the most acidic while Tommy Atkins (4.73) was the least acidic (Table 2). pH of the fruit pulp plays an important role in flavor as well as preservation (Okoth et al., 2013). Fruit with lowest pH value are preserved longer than the fruit with higher pH value. This study is in agreement with Kansci et al. (2008) who found that the pH values of four mango varieties varied from 3.91 to 4.35. In this study the pH of Tommy Atkins was 4.73; this result was similar to that reported by Rodríquez Pleguezuelo et al. (2012) for Tommy Atkins (4.9).

Titratable acidity is presented in terms of citric acid concentration since it is the major organic acid present in mango fruit (Ueda et al., 2000). The Apple variety had significantly higher titratable acidity (6.40 g/L) than the other varieties. Titratable acidity (citric acid content) of the four mango varieties ranged from 3.48 to 6.40 g/L.

Total soluble solids (TSS) (°Bx) of the four mango varieties were significantly different at $p \leq 0.05$. Kent had the highest TSS (18.97°Bx), followed by Apple (18.07°Bx) while Keitt had the lowest (13.60°Bx). TSS in fruit is an index used to determine fruit maturity and is a strong indicator of harvesting time. Previous studies on mango have reported different TSS which may be due to genetic variations and varied climatic conditions. However, the results of this study are comparable to those of Othman and Mbogo (2009) and Rodríquez Pleguezuelo et al. (2012) who reported that TSS ranged from 14.5 to 30.1°Bx and 15.7 to 20.0°Bx, respectively. Kansci et al. (2008) also found that the total simple sugar content of mango pulp varied between 9.43 and 15.16°Bx (using hot 80% ethanol for extraction). Mango pulp with higher sugar content is good for food processing because they require the addition of less sugar. Kent may have advantages due to its high TSS.

The TSS/TA of Kent (49.62) was significantly higher ($p \leq 0.05$) than the other varieties while Apple (28.45) had a significantly lower TSS/TA than the other varieties. TSS/TA indicates the degree of sweetness of the fruit, giving information about the flavor, whether sweet or sour or a balance of the two. This ratio is one of the most used methods of evaluating taste, being more representative than the isolated measures of sugars or acidity. Fruit with a higher TSS/TA suggests good quality whereas lower TSS/TA fruit indicates lower quality (Rodríquez Pleguezuelo et al., 2012).

Proximate compositions of mango

Moisture, ash, protein, fiber and fat content of mango are presented in Table 3. All parameters showed significant differences among the varieties at $p \leq 0.05$. Tommy Atkins (83.62%) had the highest moisture while Keitt (79.48%) had the lowest moisture. Fruit with high moisture content has low dry matter.

Moisture content of mango ranged from 79.48 to 83.62%. Fruit with a higher moisture content has a shorter shelf life. In general, fruits and vegetables deteriorate within a short period of time due to their high moisture content. On the other hand, the edible pulp of fruit with high moisture content can be used for juice production.

Dry matter content ranged from 16.38 to 20.52%. Keitt (20.52%) had the highest dry matter content followed by Kent (18.61%) whereas Tommy Atkins (16.38%) had the lowest dry matter content. Results were comparable to the reports of Kansci et al. (2008) and Saranwong et al. (2002) who had reported that dry matter content of mango ranged from 13.30 to 17.28% and 16.89 to 19.22%, respectively. Low dry matter content of fruit has a negative impact on nutrition and shelf life (Kansci et al., 2008). Mango fruit with a higher dry matter content such as Keitt could be best for mango-based food products. The ash content of the tested mango varieties ranged from 0.31 to 0.57% with significant variations occurring among the varieties (Table 3). Our results are in accord with those reported by Kansci et al. (2008) who reported ash content ranging from 0.32 to 0.49%. Keitt (0.57%) had the highest ash content while Apple (0.31%) had the lowest. The fat and protein content ranged from 0.14 to 0.47% and 0.29 to 0.56%, respectively. Keitt (0.47%) and Tommy Atkins (0.42%) had the highest fat content. Fat content found in this study was comparable to the results of Kansci et al. (2008) who reported ranges of 0.17 to 0.33 g/100 g FW. There were significant differences in protein content among the varieties ($p \leq 0.05$). The protein content noted in this study was similar to that reported by Kansci et al. (2008) who found protein content ranging from 0.16 and 0.24 g/100 g FW.

The crude fiber content of the four mango varieties ranged from 0.37 to 0.79% and significant differences were observed at $p \leq 0.05$. Fiber has interesting properties, such as water and oil holding capacity (WHC and OHC, respectively; useful in products that require hydration), yield improvement, and modification of texture and viscosity (Elleuch et al., 2011). The fiber content of mango offers the potential for its use in bakery products (Vergara-Valencia et al., 2007). Keitt (18.9%, 80.7 Kcal/g) had the highest carbohydrate and energy content while Tommy Atkins (15.3%, 62.9 Kcal/g) had the lowest (Table 3). Significant differences were observed among the varieties at $p \leq 0.05$. Many studies have shown that fruits and vegetables are not good sources of protein and fat and this study also showed that mango has a low protein and fat content (Table 3).

Antioxidants

Antioxidants are substances capable of preventing oxidative damage caused by free radicals (Flora, 2009). They include polyphenols, carotenoids, and vitamins which gives health-promoting properties to mango due to their antioxidant activities (Dorta et al., 2012; Sogi et al., 2012; Siddiq et al., 2013). Mango is considered to be a good source of dietary antioxidants such as ascorbic acid, carotenoids and phenolic compounds (Schieber et al., 2000). In this study, mango antioxidants such as carotenoids and vitamin C were analyzed.

Carotenoids are bioactive substances with powerful antioxidant activity. They have a role in the enhancement of immune response and reduction of the risk of degenerative diseases such as cancer, cardiovascular diseases, cataracts, and macular degeneration.

In most cultivars of mango fruit (*Mangifera indica L.*), β-carotene accounts for more than half of the total carotenoid content (Chen et al., 2004) and it substantially contributes to provitamin A supply in tropical and subtropical countries. The total carotenoid content of mango fruit ranged from 0.6 to 4.8 μg/g with significant differences among the varieties at $p \leq$

0.05 (Table 4). Apple (4.8 μg/g) had the highest carotenoid content followed by Keitt (3.2 μg/g) while Kent (0.6 μg/g) had the lowest content. Previous reports on mango have shown different total carotenoid content which may be due to differences in storage time and ripening stage (Ellong et al., 2015). Rocha Ribeiro et al. (2007) reported that the total carotenoid content of mango fruit ranged from 1.91 to 2.63 mg/100 g while Haque et al. (2015) found that the total carotenoid content varied from 94.22 to 444.66 μg/100 g.

Vitamin C is an essential human diet component, required for scurvy prevention, required for the biosynthesis of collagen, L-carnitine, and certain neurotransmitters, improves inorganic iron absorption, inhibits nitrosamine formation, and contributes to immune defense. Ascorbic acid acts as an antioxidant and therefore offers some protection against oxidative stress-related diseases (Diplock et al., 1998). Keitt (36.4 mg/100 g) had the highest vitamin C content while Tommy Atkins (14.2 mg/100 g) had the lowest concentration (Table 4). The tested varieties of mango had statistically different vitamin C content at $p \leq 0.05$. Previous studies reported wide variations in vitamin C content in mango. Rocha Ribeiro et al. (2007) reported that vitamin C content ranged from 9.79 to 77.71 mg/100 g, Carvalho et al. (2004) found ranges from 31.7 to 56.7 mg/100 g while Vinci et al. (1995) reported 25.3 mg/100 g in mango. Our study found vitamin C content of a similar magnitude to these reports. Other studies reported lower vitamin C content with an average value of 15.97 mg/100 g (Tommy Atkins) and 9.1 to 16.8 mg/100 g, respectively (Sogi et al., 2012; Sulaiman and Ooi, 2012). Apple, Kent and Keitt varieties met the minimum vitamin C requirement of 15 mg/100 g recommended by EU/WHO for fruit groups (Ellong et al., 2015). Differences in total carotenoid content and vitamin C content variations compared to previous studies can be attributed to genotypic variation, and preharvest factors including climatic conditions, agricultural practices, and ripening stage (Lee and Kader, 2000). This research work also verified previous information that mangoes are a good source of antioxidants.

Mineral composition of mango

Potassium was the most abundant electrolyte in mango with the maximum value of 369.25 mg/100 g. Keitt had the highest potassium and magnesium content whereas Kent had the highest sodium and iron content. Potassium and sodium content ranged from 218.97 to 369.25 mg/100 g and 0.36 to 13.32 mg/100 g, respectively. Magnesium, calcium, and iron content ranged from 8.07 to 14.28 mg/100 g, 6.44 to 9.29 mg/100 g and 0.78 to 2.55 mg/100 g, respectively. Zinc was not detected in Kent and Keitt whereas Tommy Atkins and Apple had values of 0.96 and 0.39 mg/100 g, respectively (Table 5).

CONCLUSIONS

Four varieties of mango were evaluated for their physicochemical properties and they showed significant variations at $p \leq 0.05$. This study provided evidence that the physicochemical properties and antioxidant contents of mangoes grown in Ethiopia were not different from mangoes grown in other countries. Apple, Kent, and Keitt are good sources of vitamin C with moderate total carotenoid content. Keitt had the highest antioxidant and nutritional value of the tested varieties. Mango fruit has the potential to be used as a source of functional ingredients and natural antioxidants to the food industry.

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Table 1. Physical properties of mango fruit.

Variety	skin color	flesh color	Wt. (g)	F_d (mm)	L (mm)	J_v (mL)
Apple	Yellow with red	Yellow	$433.5^b \pm 99.5$	$91.2^a \pm 9.5$	$93.2^b \pm 7.1$	$316.5^b \pm 59.7$
Keitt	Pink with red	Golden-yellow	$727.3^a \pm 50.6$	$93\ 8^a \pm 3.6$	$137.3^a \pm 17.9$	$540.0^a \pm 13.9$
Kent	Yellow with red	Orange-red	$458.9^b \pm 62.9$	$96.7^a \pm 4.8$	$99.8^b \pm 5.2$	$368.2^b \pm 20.1$
Tommy Atkins	Red purple	Yellow orange	$466.9^b \pm 51.5$	$87.7^a \pm 6.9$	$108.6^b \pm 5.3$	$333.7^b \pm 25.6$
Mean			521.7	92.3	109.7	389.6
CV			13.2	7.1	9.4	8.9
LSD			106.4	10.1	15.9	53.4

Means with different superscripts are significantly different at $p \leq 0.05$; Wt. is the fruit weight, F_d represents fruit diameter, L is the fruit length, J_v is the juice volume.

Table 2. Results of pH, TSS (°Bx), TA (g/L) and TSS/TA.

Varieties	pH	TSS (°Bx)	TA (g/L)	TSS/TA
Apple	3.86 ± 0.06^d	18.07 ± 0.35^b	6.40 ± 0.64^a	28.46 ± 3.40^c
Keitt	4.00 ± 0.01^c	13.60 ± 0.26^d	3.48 ± 0.39^b	39.44 ± 4.56^b
Kent	4.29 ± 0.01^b	18.97 ± 0.29^a	3.84 ± 0.32^b	49.62 ± 4.15^a
Tommy Atkins	4.73 ± 0.02^a	15.03 ± 0.21^c	3.54 ± 0.16^b	42.51 ± 2.11^b
Grand Mean	4.22	16.42	4.31	40.01
CV	0.69	1.72	9.60	9.18
LSD	0.05	0.53	0.78	6.92

Means with different superscripts are significantly different at $p \leq 0.05$.
TA is the titratable acidity (citric acid), TSS /TA is the total soluble solids to titrable acidity ratio.

Table 3. Proximate composition of mango varieties.

Variety	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	CHO(g/100g)	FE(Kcal/g)
Apple	82.49 ± 1.13^{ab}	0.31 ± 0.04^c	0.29 ± 0.02^b	0.68 ± 0.10^{ab}	0.31 ± 0.02^c	16.6 ± 1.1^{bc}	67.6 ± 4.2^{bc}
Keitt	79.48 ± 0.85^c	0.57 ± 0.07^a	0.47 ± 0.07^a	0.37 ± 0.06^c	0.56 ± 0.02^a	18.9 ± 0.8^a	80.7 ± 3.2^a
Kent	81.39 ± 1.17^b	0.44 ± 0.08^b	0.14 ± 0.04^c	0.62 ± 0.09^b	0.38 ± 0.02^b	17.6 ± 1.0^{ab}	70.9 ± 4.3^b
Tommy Atkins	83.62 ± 0.55^a	0.39 ± 0.05^{bc}	0.42 ± 0.05^a	0.79 ± 0.07^a	0.29 ± 0.01^c	15.3 ± 0.5^c	62.9 ± 2.3^c
Grand Mean	81.74	0.43	0.33	0.61	0.38	17.11	70.52
SEM	0.55	0.04	0.03	0.05	0.01	0.50	2.02
LSD	1.78	0.12	0.09	0.15	0.04	1.62	6.59

Means with different superscripts are significantly different at $p \leq 0.05$.
CHO is the total carbohydrate content, FE is the food energy.

Table 4. Total carotenoids and ascorbic acid concentrations of four mango varieties.

Variety	TC (µg/g)	AA (mg/100 g)
Apple	4.8 ± 0.2[a]	27.5 ± 2.9[c]
Keitt	3.2 ± 0.1[b]	36.4 ± 2.5[a]
Kent	0.6 ± 0.3[d]	32.8 ± 4.7[b]
Tommy Atkins	2.2 ± 0.3[c]	14.2 ± 3.6[d]
Grand Mean	2.7	27.7
SEM	0.1	1.0
LSD (p <0.05)	0.5	3.4

Means with different superscripts are significantly different at $p \leq 0.05$
TC is the total carotenoids, AA is ascorbic acid.

Table 5. The mineral composition of mango fruit (mg/100 g).

Variety	Na	Mg	K	Ca	Fe	Zn
Kent	13.32	9.76	257.80	6.44	2.55	ND
Keitt	0.36	14.28	369.25	8.99	0.78	ND
Tommy Atkins	3.47	8.07	218.97	7.75	1.72	0.96
Apple	3.94	9.08	223.75	9.29	1.09	0.39

ND is not detected.