Journal of Animal &Plant Sciences, 2013. Vol.17, Issue 3: 2608-2618
Publication date 29/4/2013, http://www.m.elewa.org/JAPS; ISSN 2071-7024

Evaluation of physical and sensory quality attributes of three mango varieties at three stages of ripeness, grown in lower eastern province of Kenya - part 1

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Key words: Mango varieties, stage of ripeness, physical, sensory attributes, technological utilization.

1 SUMMARY

Physical attributes at three stages of ripeness (unripe, intermediate and fully ripe) and sensory quality at full ripe stage of Apple, Ngowe and Kent mango varieties grown in Lower Eastern Province (Machakos and Kitui) of Kenya were evaluated. They were stored under ambient temperatures of 25°C and relative humidity of 65-70. Apple and Ngowe ripened fully after 7 days whereas Kent took 10 days. The weight and firmness decreased with increasing ripeness and was accompanied by notable colour change for all the varieties. Kent had the most firm skin (5.8KN) and flesh (3.7KN) whereas the softest was Apple with a skin and flesh firmness of 0.6KN and 0.07KN respectively. There were clear differences in skin and flesh color in different varieties (p≤0.05). At the unripe stage, Ngowe exhibited the greenest colour on the skin, however with increasing ripeness, the skin and flesh colors turned from green to yellow/orange; the most yellow variety being Kent. The heaviest variety was Ngowe (>625g) at unripe stage, while Apple had the lowest weight (363.46g) at the ripe stage. All the varieties lost weight with increasing ripeness, with Kent varieties exhibiting the most remarkable total mean weight loss (>15g). The highest and lowest varieties in pulp yield were Apple (75%) and Ngowe (70%) respectively. The most and least preferred skin fruit colour Kent and Ngowe varieties with a mean score of 6.54±1.5 and 5.61±1.7 respectively. The most preferred flesh colour, flavor, taste, texture and overall acceptability was the Apple varieties, followed by the Ngowe and lastly Kent variety. This clearly showed that different varieties have different physical and sensory characteristics where Apple varieties would be most suitable for fresh consumption and in processing due to it higher yields than the rest. This study revealed that variety and stage of ripeness had influence on physical and sensory attributes of the varieties analyzed.

2 INTRODUCTION

Mango (Mangifera indica) of the family ancardiaceae is a tropical, subtropical and frost-free fruit. It is the fifth largest fruit crop produced worldwide after banana, grapes, apples and oranges. It is the second most important tropical fruit with 27 million tons being produced annually worldwide (Bally *let al.*, 2009). It originated from the foothills of the

Himalayas of India and Burma and has been cultivated in that region for at least 4,000 years. The United States is the largest single-country importer of mangoes and has developed the most popular cultivars traded on the international market (FAOSTAT, 2007).

In Kenya, mango fruit has been the third most important in terms of area and total production after bananas, including plantains and pineapples for the last ten years (HCDA, 2010). The hectares under mango production, production output (ton) and the revenue earned have continued increasing over years. Hectarage increased from 36,304 to 59,260; production from 528,815 (MT) to 636,585 and revenue earned increased from USD 104,616297 to 139,836,268; (HCDA, 2011). There are two varieties of mango grown in Kenya, the local (Ngowe, Dodo, Boribo and Batawi) and the exotic or improved (Apple, Kent, Keit, Tommy Atkins, Sabine, Van dyke, Hadden, Sensation) varieties. The exotic varieties are of superior qualities; they have higher juice yields, no strings, colour, and flavor. They are grown targeting the export market. The local varieties grown in Kenya are high in fiber hence "stringy"; with the exception of Ngowe variety, and thus are less preferred for fresh, processing and export markets. They are relatively cheap compared to the exotic varieties and require less attention in their growing. Postharvest losses of mango fruits in Kenya are estimated to be 40-50% through it market value chain to consumption and less than 1% is processed to value added products (FAO, 2006). The main challenges facing mango farming as a business in Kenya includes; poor farm management, improper harvesting and post harvesting handling, lack of refrigerated transportation and storage facility at both the farm and market places. Also minimal value addition technologies and lack of viable markets of the fresh fruit as well as high competition of the processed mango products from artificial juices and imported juices.Value addition of mango fruit to curb high losses may be utilized to offer high priced products and alleviate poverty through enhanced food and nutrition security in terms of quantity, quality, safety, and variety (Abe *et al*., 1997). This can be done by using applicable postharvest technologies which preserves the fruits' qualities. This include practices like hand harvesting, refrigerated transportation tracks, proper cleaning, cooling/refrigerated storage, drying, packaging and labeling, pulp extraction, preservation and processing to various products like juices, jams, concentrates, nectars, powders and slices. The value-added products offer higher return, open new markets, create brand recognition, and add variety to a farm operation (Bachmann, 2001).

Physical properties of mango fruits play a major role into their selection as a raw material for fresh consumption and processing. The weight of the fruit has an economical implication on the fruit trading depending on who is to pay for the fruit. Yellow/ orange colour gives an attraction to fresh fruit consumers thus determining the kind of processed product the pulp can be used for like juices, nectar, jam, dried mango chips and slices (Vasquez-Caicedo *et al*., 2004; Germain *et al*., 2008). Firmer skin and flesh textures are desirable during transportation of the fruits to minimize damages on pressure application. Pulpy mango fruits are highly desired for processing for they bring higher returns to the processor. High viscosity of the ripe fruit pulps is desirable for production of high consistency products like nectar, jam, and concentrates. Consumer preference for the fruit is of benefit to the farmers in attaining local and external market. Processors to rely on the same qualities in choosing fruits for processing. Thus this paper focuses on profiling of physical and sensory quality attributes of Apple, Ngowe and Kent mango varieties grown in Lower Eastern province Kenya, in order to evaluate their potential for technological and nutritional utilization locally and internationally.

3 MATERIALS AND METHODS

3.1 Mango varieties used in the study: Three mango varieties namely; Apple, Ngowe, and Kent (Plate 1) were harvested at similar maturity stage (mature green) from two different growing zones (Machakos and Kitui) of Lower Eastern Province of Kenya.

Apple variety Ngowe variety Kent variety

Plate 1: Three mango varieties harvested at mature green stage.

Kitui ecological zone was found to be hotter and drier most of the year with temperatures ranging from 16 to 34ºC; the rainfall ranged from 500-760mm per year. The soils were found to be of loam type and the altitude ranged between 600-900m above sea levels (Mwingi district development plan 2002-2008; Kitui statistics). On the other hand Kaiti division, Machakos zone was found to be a low land between several hills namely; Iuani, Mbooni, Kilungu, Makuli and Nthangu. It was cooler (14-26ºC) than Kitui, with rainfall amounts ranging from 700-1050mm per year. The altitude ranged from 900 to 1100m above sea levels and the soils were found to be of sandy and clay in nature, Sombroek, et al., (1982). The harvested mango fruits were transported to Jomo Kenyatta University of Agriculture and Technology (JKUAT) in the laboratories of Department of Food Science and Technology. They were stored at ambient temperature of about 25ºC±2 and relative humidity of 65-70, to simulate the uncontrolled storage condition (temperature and relative humidity) experienced in most of the mango value chain situations. Stage of ripeness was objectively determined based on both physical and chemical parameter namely skin and flesh colour (Hue angle, Hº), firmness, total soluble solids content (TSS), total titratable acidity (TTA), and pH, however only the physical attributes are discussed in this paper (part 1) and chemical attributes will be discussed in part 2 of this paper.

Table1: Maturity index description

Ripeness stage	**Description of maturity index**
Unripe	0-1day after harvest, pH range (3.00-3.3), raised shoulders, hard in firmness, no depression on hand pressing and deep green in color.
Intermediate	4-5 3-4 days after harvest for Apple and Ngowe; 5-6 days after harvest for Kent variety, pH range (3.30-3.7), little or no depression in firmness on hard- pressing, pale / partial yellow color on the skin and in the flesh.
Ripe stage	6-7 days after harvest for Apple and Ngowe and 9-10 days after harvest for Kent variety, pH range (3.90-4.6), perfume like scent development, lesser firm on hand – press and orange/ yellow in color on the skin and in the flesh.

2.2 Physical characterization of the fruit with changing maturity stage

2.2.1 Fruit weight (g): Three fruits of average weight were weighed in triplicate immediately on arrival at the laboratory after harvesting at the mature green stage. They were then ripened at ambient temperature to intermediate and finally fully ripe with weights being recorded at the respective stages. The Physiological weight loss (PWL) was determined as indicated in the equation:

$$PWL\% = \frac{[\text{Initial weight} - \text{Final weight}]}{\text{Initial weight}} \times 100$$

2.2.2 Fruit colour: The colour of both the flesh and skin were measured using the Minolta colour difference meter (Model CR-200, Osaka, Japan) after calibrating it with a white and black tile. L*, a* and b* coordinates were recorded and the L* a* and b* values converted to hue angle (H°) according to McGuire, 1992 and Mclellan *et al*., 1995 formulation where (Hue angle (Hº) = $\tan^{-1}$b*/a*).

2.2.3 Fruit firmness: Firmness of the skin and the flesh was measured in KN using a penetrometer (Model CR-100D, Sun Scientific Co. Ltd Japan) as described by the procedure in Jiang *et al*., 1992 at the three stages of ripeness.

2.2.4 Proportionate fruit part (%): The three main parts of a ripe mango fruit namely flesh, skin and stone were determined. Five ripe fruits from each variety were weighed gravimetrically (g) using a standard top loaded balance, peeled and the flesh separated from the stone using a kitchen knife. The three parts were weighed separately and the percentage weights calculated accordingly and this was repeated three times.

2.2.5 Viscosity measurements: Five mango fruit were peeled using a kitchen knife and homogenized for three seconds using a kitchen blender, the pulps' viscosity was then determined using Brookfield viscometer (model B type BM, Japan). Three readings from each sample were taken and an average determined as described by Keogh *et al*., 1998.

2.3 Sensory evaluation: Sensory evaluation of the ripe fruits was done using 30 untrained panelists sourced from staff and students of Jomo Kenyatta University of Agriculture and Technology (JKUAT), Food Science Department. It was based on the 9 hedonic score (1-Dislike extremely; 2-Dislike it very much. 3- Dislike moderately; 4-Dislike it; 5- Neither like it nor dislike it. 6- Like it; 7-Like it moderately; 8- Like it very much; 9- Like it extremely). The parameter evaluated were, skin and flesh color, flavor, taste texture and overall acceptability of the fruit (Larmond, 1977).

2.4 Statistical data analysis: All the data was statistically analyzed for variance (ANOVA) using Genstat® computer program14th Edition. The comparison for means, standard deviations at 5% level of significant were done using Duncan's Multiple Range Tests (DMRT) as described by Steel *et al*., 1997.

3. RESULTS AND DISCUSSION

3.1 Mango photos showing three stages of ripeness for the three mango varieties are shown on plate 2.

3.2.1 Changes in fruit weight with ripening: The fruit weight ranged from 363.46g to 631.65g. Ngowe varieties, both from Kitui and Machakos were found to be the heaviest at 631.649g and 629.09g respectively, at the unripe, maturity stage. Apple varieties from the two ecological zones were found to be the lightest all through the ripening stages. Physiological weight loss differed from one stage of maturity to another. The highest total loss, 16.58% was exhibited by Kent variety from Kitui and the least; 6.28% by Ngowe variety, also Kitui. Weight of given fruits is an important quality aspect that affects the farmers and traders revenue returns, where purchases are done on the fruit weight. It is also a quality aspect influences the transportation costs of the traders. These results compared well with those obtained by German Kansci *et al*., 2008, Doreyappa *et al*., 1994, on indigenous variety, Amelioree varieties and Alphonso varieties respectively, that variety and stage of maturity determines the weight of the fruit but not the ecological zone of production. Physiological weight loss is brought about by biochemical activities like respiration, transpiration of water through peel tissue. The rate of weight loss, which in turn leads to weight loss, is influenced by several factors like temperature of storage, the relative humidity, the surface area volume ratio of the fruit and the thickness of the peel. Similar trends were reported by Rathore *et al*., (2007); Hulmer, 1971; Doreyappa-gowda and Huddar (2000) who observed that Alphonso mango variety and other seven (7) varieties weight loss was influenced by size of the fruit, storage temperature, variety and reduction in length and thickness of fruit during ripening process. Weight loss was influenced by the variety but not by the ecological zone.

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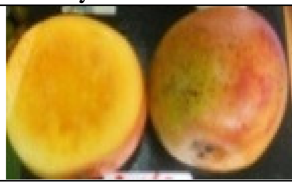
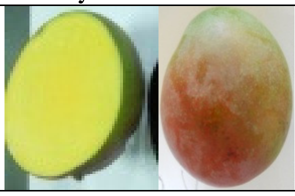
	Unripe	Intermediate	Fully ripe
Days after harvest ⇨	**O day**	**3-4 days**	**6-7 days**
Apple variety			
Days after harvest ⇨	**O day**	**3-4 days**	**6-7 days**
Ngowe variety			
Days after harvest ⇨	**O day**	**5-6 days**	**9-10 days**
Kent variety			

Plate 1: Selected mango fruit varieties at three stages of ripeness. It was observed that Apple and Ngowe took an average of 7 days to reach acceptable ripeness while Kent took an average of 10days to attain full ripeness at ambient temperatures of 25±2°C and Relative humidity of 60-70%.

3.2 Change in Physical attributes with ripening:

Table 2: Physical quality attributes of Apple, Ngowe and Kent mango skin and flesh at unripe, intermediate, and ripe stages of ripeness

Variety	Ecological zone	Stage of maturity	Weight (g)	PWL (%)	Colour Skin (H°)	Colour Flesh (H°)
Apple	Machakos	Unripe	411.78^{e}	0	96.18±4.0^{c}	94.46±0.2^{d}
		Inter	378.90^{f}	7.09	91.94±1.2^{d}	92.01±1.9^{de}
		Ripe	363.46^{g}	4.04	77.84±0.8^{g}	82.57±0.4^{g}
	Kitui	Unripe	399.20^{e}	0	91.3±2.8^{d}	95.93±0.9^{a}
		Inter	382.94^{f}	4.07	79.75±9.5^{f}	88.62±1.5^{f}
		Ripe	363.46^{g}	5.44	77.18±3.4^{g}	82.99±0.9^{g}
Ngowe	Machakos	Unripe	629.09^{a}	0	111.0±2.6^{a}	94.17±1.1^{d}
		Inter	598.47^{b}	4.87	98.22±9.4^{c}	90.87±0.9^{e}
		Ripe	584.52^{b}	2.35	94.81±6.2^{d}	88.72±0.8^{f}
	Kitui	Unripe	631.64^{a}	0	102.4±2.6^{b}	96.10±2.6^{c}
		Inter	608.02^{a}	3.73	96.62±9.1^{c}	90.88±1.1^{e}
		Ripe	592.62^{b}	2.55	88.21±7.6^{e}	88.67±1.6^{f}
Kent	Machakos	Unripe	513.04^{c}	0	72.45±1.3^{h}	98.47±0.5^{d}
		Inter	461.09^{d}	10.13	60.14±8.7^{k}	91.98±0.6^{f}
		Ripe	441.29^{de}	4.49	61.10±1.0^{k}	86.88±2.3^{fg}
	Kitui	Unripe	471.54^{d}	0	71.70±1.3^{h}	99.35±2.2^{b}
		Inter	452.68^{d}	7.94	65.67±1.3^{i}	91.31±0.8^{e}
		Ripe	430.01^{e}	8.63	64.56±6.5^{j}	87.60±3.1^{f}

Mean (±SD) having same superscript letters in a column are not significantly different at p≤0.05; (n=5)
Inter: Intermediate stage of ripeness; PWL: Physiological Weight Loss

3.2.2 Changes in fruit colour with ripening: Colour showed a decreasing trend with fruits ripening for all the varieties and for both the skin and flesh. The decrease in hue angle that was interpreted as the colour changes from green to yellow. This indicated a synthesis and accumulation of β -carotene (Azzolini *et al.*, 2005) in parallel to degradation of chlorophyll and a possibility of unmasking of the yellow/red colour. The most green and most yellow/orange red varieties for the skin colour were Ngowe Machakos (111.0 H°) and Kent Machakos (61.10 H°) at their unripe and ripe stages respectively. Variety and stage of maturity were found to greatly influence the final colour (hue angle) of the fruit.

3.2.3 Flesh and skin Firmness change with ripening: Firmness results were shown on figure 1 and 2 for flesh and skin respectively.

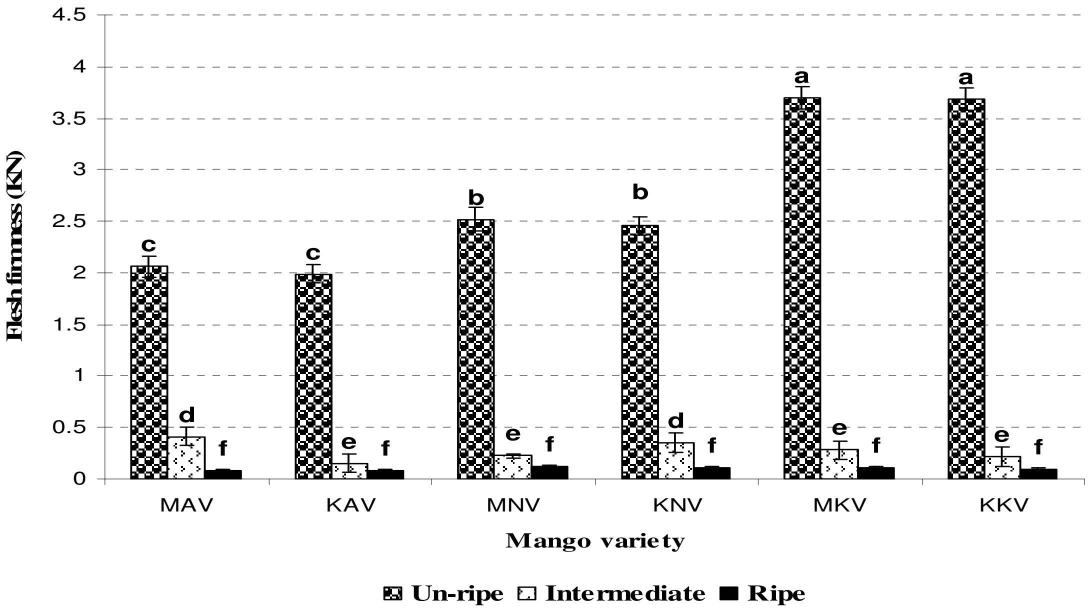


Figure 1: Flesh firmness of Apple, Ngowe and Kent mango varieties at three stages of ripeness
MAV: Apple variety Machakos, KAV: Apple variety Kitui, MNV: Ngowe variety Machakos; Ngowe variety Kitui; MKV: Kent variety Machakos, KKV: Kent variety Kitui.

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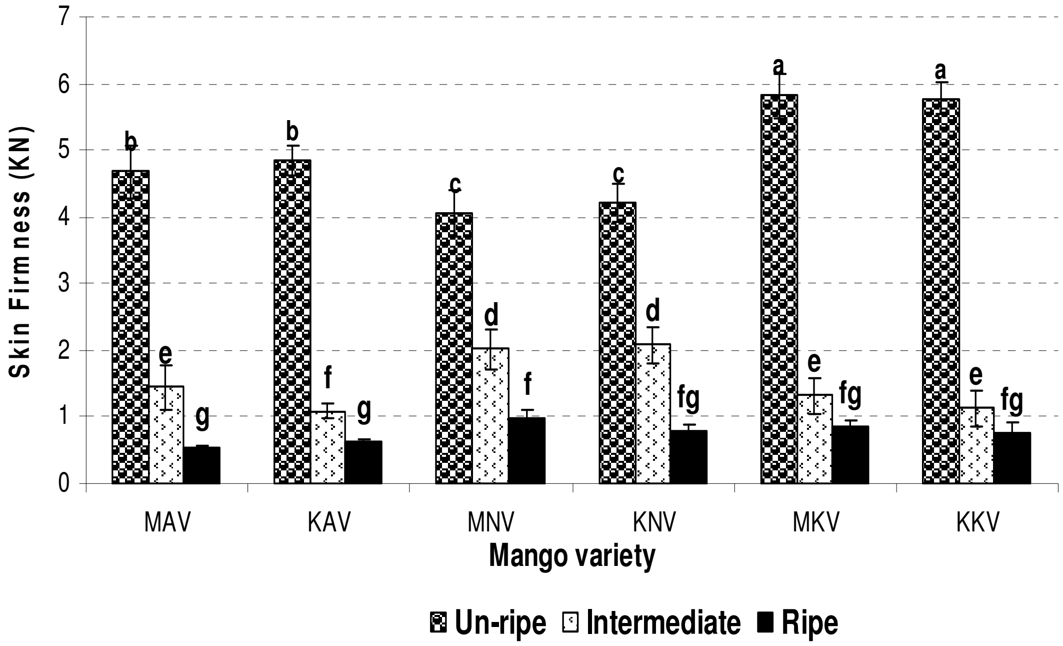

Figure 2: Skin firmness of Apple, Ngowe and Kent mango varieties at their three stages of ripeness
MAV: Apple Variety Machakos, KAV: Apple Variety Kitui, MNV: Ngowe variety Machakos; Ngowe variety Kitui; MKV: Kent Variety Machakos, KKV: Kent Variety Kitui.

A decreasing trend with ripening for both skin and flesh firmness for all the varieties analyzed irrespective of their ecological zone was observed. Kent varieties from Machakos and Kitui were most firm, both for the flesh (3.7KN) and skin (5.8KN) respectively. There was no significant difference between varieties at their ripe stage for the skin firmness. The firmness of the skin and flesh is strongly depended on the maturity stage. Firmness is a measure of hardness of the mango fruit and it plays a crucial role in postharvest activities like stacking, packaging, transportation towards the fruits perishability arising from mechanical damages. The fruit is best harvested, transported to the point of use at the unripe stage to maximize the advantage of the firmness. The softer the fruit, the more prone it is to mechanical damage when external pressure is applied and thus puncturing occurs, this may lead to eventually disease infestation. Flesh firmness is useful in parameter processing. The firmer the flesh of the fruit, the more they are suitable for firmer processed products like mango slices, chips nectar, jam and other preserves. Kent variety would produce better chips, slices or pickles compared to the rest if firmness is considered to be important quality characteristic. The softer it is at the ripe stage, the better it is in making less firm products like mango fruit juices. Ngowe and Apple varieties are best suited for these kinds of products. Firmness decrease observed in the flesh and skin was brought about by hydrolysis and depolymerization of carbohydrates (starch, pectin and hemicelluloses) present in the fruits, Tharanathan *let al.*, (2006).

3.2.4 The proportionate ripe fruit parts: The percent proportion of pulp (yield), peel and stone of Apple, Ngowe and Kent at the ripe stage are shown on Figure 3.

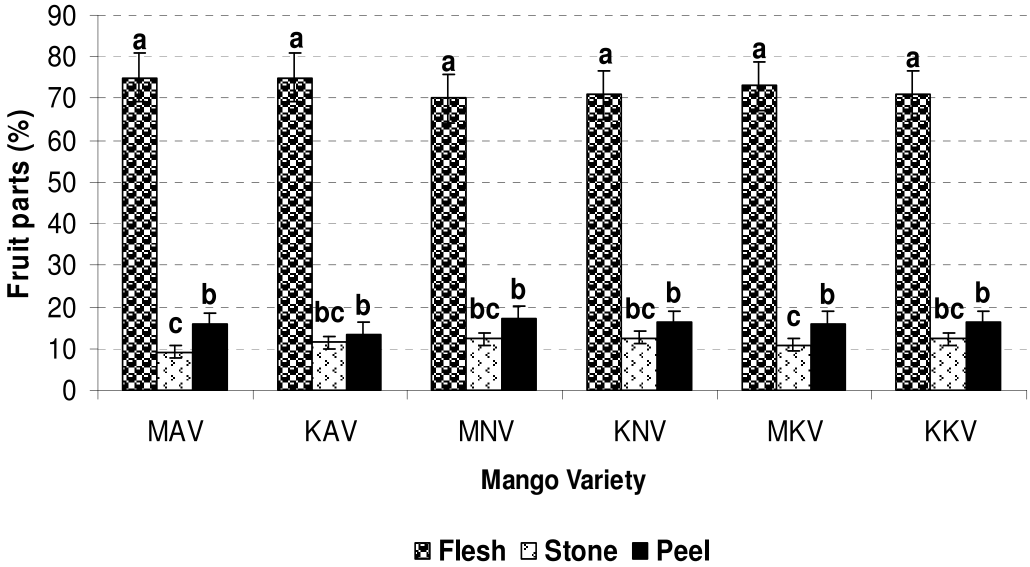

Figure 3: Percent fruit parts: Pulp (%), Peel (%) and stone (%) of Apple, Ngowe and Kent mango varieties at the ripe stage. MAV: Apple variety Machakos, KAV: Apple variety Kitui, MNV: Ngowe variety Machakos; Ngowe variety Kitui; MKV: Kent variety Machakos, KKV: Kent variety Kitui.

The highest amount of pulp was obtained from Apple variety (75%) whereas the lowest was the Ngowe varieties (70%) by the weight of the whole fruit. The stone percent weight ranged from 9.20-12.70% as shown by Apple variety from Machakos zone and Ngowe variety Kitui zone respectively. The peel ranged from 13.50% to 17.30% as was exhibited by Apple variety Kitui and Ngowe variety Machakos respectively. Pulp content (yield %) is an important quality aspect to both fresh mango fruit consumers and processors. The higher the pulp yield, the better the value for money. Mango varieties with 70% and above pulp yield are best for processing economically. The three mango varieties from Kitui and Machakos ecological zones qualified for both fresh and processing utilization. Germain *et al.*, 2008 found out that indigenous mango varieties had the least pulp 58% (w/w), compared to four improved varieties grown in Nigeria, while Keitt variety had the highest pulp content of 62% (w/w). Variety had a stronger influence on percent fruit yield than ecological zone of origin.

3.2.5 Rheological properties of the fruit pulp: Viscosity results for the mango fruit pulps at their three stages of maturity are shown in Figure 4.

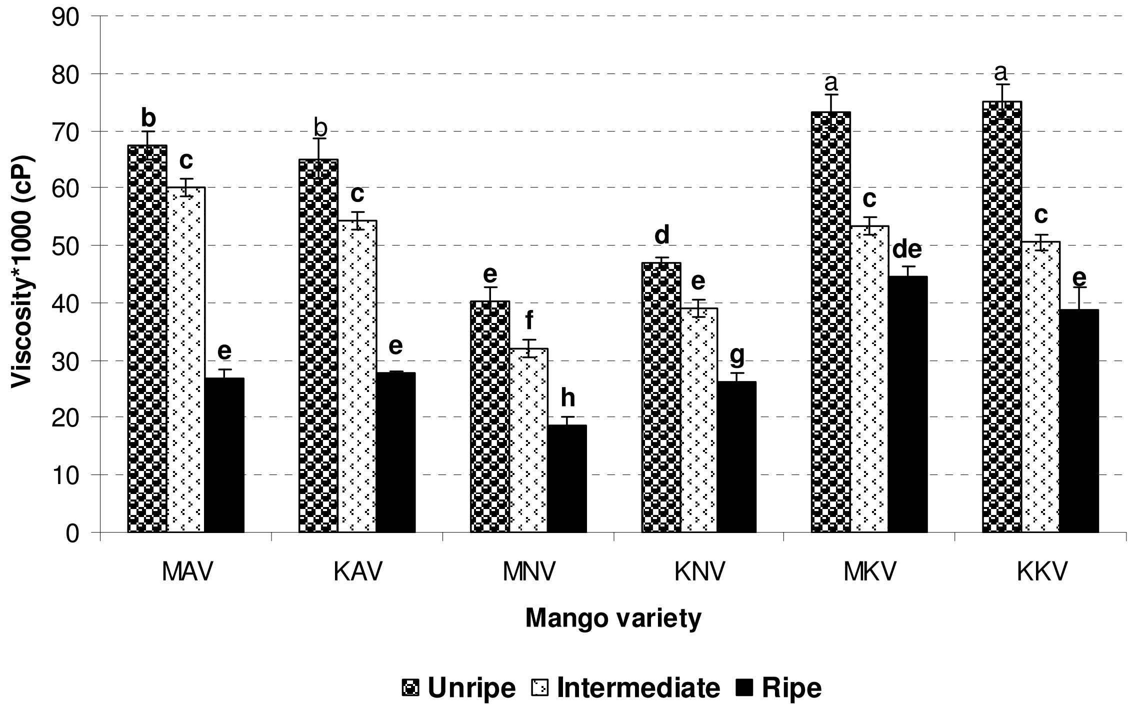

Figure 4: Viscosity (Centipoises) of Apple, Ngowe and Kent mango varieties at three stages of ripeness
MAV: Apple variety Machakos, KAV: Apple variety Kitui, MNV: Ngowe variety Machakos; Ngowe variety Kitui; MKV: Kent variety Machakos, KKV: Kent variety Kitui.

A decreasing trend in viscosity with ripening for all the varieties irrespective of their ecological zone of origin was observed. Viscosity ranged from 190*1000 (cP) to 760*1000 (cP) as was exhibited by Ngowe variety from Machakos at the ripe stage and Kent variety from Kitui at its unripe stage. As ripening increased, viscosity decreased with the Ngowe varieties recording the least viscosities at all the stages of ripeness, while the Kent varieties showed the highest viscosities at the unripe stage and was not statistically different with Apple varieties at intermediate stages of ripeness. Viscosity highly influences rheological quality properties of the mango pulps and purees during processing. High viscosity mango pulps are favorable for processing products of high consistency like jam, juice concentrates, nectar and spreads. Low viscosity pulps are suitable in light products like fruit juices and drinks. Increase in viscosity could be as a result of increase in fiber, pectin type and amounts present (German *et al.*, 1981). Technological potential for the mango pulp mainly depends on the native pectin content of the pulps and the distribution of the various fractions especially the water-soluble fraction that plays major role in pulp and juice viscosities as well as mouth feel (German *et al.*, 1981).

4 Sensory characteristics of the ripe fruits:

Sensory evaluation results obtained are on indicated on Table 3. Different varieties on skin color, flesh color, flavor and taste were observed to be different ($p \leq 0.05$). Apple varieties from the two ecological zones were rated the best overall. These results were in agreement with those obtained from With reasonable price levels, the Apple variety could be utilized best for both fresh consumption and processing purposes due to its 1st rating organoleptically and high pulp content (75%). Ngowe and Kent from the two ecological zones rated 2nd overall and were not significantly different at $p \leq 0.05$ from each other on the overall acceptability.

Table 3: Sensory attributes of Apple, Ngowe and Kent mango varieties at the ripe stage of ripeness

Variety	Ecological zone	Skin colour	Flesh colour	Flavor	Taste	Texture	Overall Acceptability
Apple	Machakos	6.42±1.0[b]	7.28±0.5[a]	7.76±0.6[a]	7.50±0.5[a]	7.00±0.5[a]	7.81±0.5[a]
	Kitui	6.39±0.5[b]	7.30±0.0[a]	7.80±0.7[a]	7. 48±0.7[a]	6.95±0.5[a]	7.79±0.2[a]
Ngowe	Machakos	5.70±0.5[c]	5.10±0.9[c]	5.15±0.9[c]	5.30±0.8[b]	5.40±0.3[b]	6.02±0.4[b]
	Kitui	5.61±0.7[c]	5.16±0.7[c]	5.13±0.7[c]	5.35±0.5[b]	5.36±0.5[b]	5.99±0.4[b]
Kent	Machakos	7.53±0.5[a]	6.69±0.4[b]	5.95±1.0[b]	5.05±0.6[c]	5.17±0.5[c]	5.95±0.2[b]
	Kitui	7.55±0.5[a]	6.55±0.5[b]	6.00±0.5[b]	5.08±0.7[c]	5.14±0.5[c]	5.93±0.5[b]

Mean (±SD) **having same superscript letters in a row are not significantly different at p≤0.05; (n=5)**

Colour of the skin and flesh is an important quality aspect, which creates the first impression of the fruit on sight to the consumer; it greatly influences degree to which it is purchased for either fresh consumption and/or for processing purposes. The overall flavor is described as a result of perception by the taste buds in the mouth and the aromatic compounds detected by the epithelium in the olfactory organ in the nose (Rathore *et al*., 2007; Saeed *et al*., 2009). Taste is a sensation which is brought about by the sweetness as a result of sugar and sourness due to acid ratios in the fruits, as it is perceived by the taste buds on the tongue (Rathore *et al*., 2007; Saeed *et al*., 2009) are the dominant components in the taste of many fruits like mangoes. As much as sugar and acids are important for taste; pH, acidity and TSS contribute to the overall taste as they influence sourness and astringency (Malundo *et al*., 2001). Overall, all the varieties scored above 5.00 in all the parameters indicative of desirable characteristics for fresh consumption.

5 CONCLUSION

This study established that different varieties had different desirable physical and sensorial quality characteristics, which qualified them for different economical and nutritional utilization. Kent varieties portrayed longer shelf life (9-10 days) and firmer textures for its flesh and skin at unripe stage with moderate weights (g) and excellent pulp yield of 73%; this showed that it would be best utilized for export market. Apple and Kent varieties at their intermediate and ripe stages of ripeness had the best viscosity than Ngowe and would be most promising for processing high viscous and firm mango products like Mango puree, concentrate, nectar, jams and spreads. Ngowe being the least in viscosity would be best utilized in processing of less viscous products like mango juices and mixed fruit drinks. The Apple variety was best preferred in the overall acceptability rating as the most acceptable thus was most promising for fresh consumption compared to Ngowe and Kent varieties.

6 ACKNOWLEDGEMENT

We are grateful to the Horticultural Crop Development Authority (HCDA) and The Ministry of Agriculture for their collaboration and facilitation of mango sample collection, the Department of Food Science and Technology, JKUAT for allowing us to carry out all the analytical work in their laboratories and lastly to National Council of Science and Technology (NCST) and Jomo Kenyatta University of Agriculture Technology (JKUAT) for funding the research work.

7 REFERENCES

Abe K, Mathooko, F.M., Kiiyukia, C., Mwaniki, M.W., Mungai, C. W. and Koaze, H. (1997).
Surveillance of Postharvest Handling of Perishable Food Crops part I- case study of Kenya. JICA technical report- department of food science and Postharvest Technology, Jomo Kenyatta University of agriculture and technology Nairobi, Kenya 235-240.

Analysis for multiquandrant hunter L*, a, b* data. Journal for Food Quality, **18**(3). Annual Report 2010, Horticultural Crops Development Authority (HCDA), Ministry Annual Report 2011, Horticultural Crops Development Authority (HCDA), Ministry of Agriculture, Nairobi

AOAC (Association of Official analytical Chemists), (2000). Official Methods of Analysis Approach, 3rd Edition Mcgraw Hill Book Co. New York, USA.

Azzolini, M., Jacomino, A.P., Bron,. IU., Kluge, R,A. and Schiavinato, M.A., (2005). Ripening of "Pedro Sato" guava: a study on its climacteric and non-climacteric nature. Brazilian Journal plant physiology, 17: 87-95

Bachmann. J, (2001). Adding value to farm produce: An overview. Appropriate Technology

Bally, I., Lu P. and Johnson, (2009). Mango breeding in Jain, S.M and Priyadarshan P.M (eds), Breeding plantation tree \crops: Tropical Species Springer Science; Business Media.

Doreyappa-Gowda, L.N.D. and Huddar, A.G. (2001). Studies on ripening changes in mango (*Magnifera indica* L.) fruits. Journal of Food Science & Technology mysore, **38**: 135-137.

Duncan, D.B. (1955). Multiple Range and Multiple F-Test. Biometrics, 11:42

Germain, K., Benoit, B.K. and Israel, L.M. (2008). Biochemical and Physicochemical properties of four mango varieties and some quality characteristics of their Jam. *Journal of Food Processing and preservation.* **32**:644-655.

Griesbach, J. (2003). Mango growing in Kenya. World Agroforestry Centre (ICRAF) publication.

Hulmer, A.C. (1971). The biochemistry of fruits and their products. Academic press, London.

Jiang, Y., Joyce, D.C. and Macnish, A.J. (1999). Extension of the shelf life of banana fruit by 1-methlcyclopropene bags. Postharvest Biology and Technology, **16**: 187-193.

Larmond, E. (1977). Laboratory Methods of sensory Evaluation of food Research Branch Canada, Department of Agriculture publications P: 44-46

Malundo, T.M., Shewfelt, R.L., Ware, G.O and Baldwin EA: 2001. Sugars and acids influence flavor properties of mango (Magnifera indica L). Journal of American Society Horticulture Science. 126: 115-121.

McGuire, R. (1992). Reporting of objective colour measurements. Horticulture Sciences, **27**: 1254-1255.

Mclellan, M.R. Lind, I.R. and Kime, R.W. (1995). Hue angle determination and statistical

Mukherjee, S.K. (1972). Origin of mango (Mangifera indica). Economic Botany, **26**:260-264.11:49.

Rathore, H.A., Masud, S. and Soomro, H.A. (2007). Effect of storage on physico-chemical composition and sensory properties of mango (*Magnifier indica* L.) varierty, Dosehari. *Pakistan Journal of Nutrition*, **6**: 143-148.

Saeed, A.N., Seema, M.S., Muhammad, N. and Muhammad, T.S. (2009). Sensory evaluation of mangoes (Magnefera indica L.) grown in different regions of Pakistan. Pakistan journal Botany, **41** (6): 2821-2829.

Steel R, Torrie, J. and Dicky, D. (1997). Principals and procedures of statistics. Mc Grow Hill Book Company, page 633.

Yashoda, H.M., Prabha, T.N., Tharanathan, R.N. (2006). Mango ripening: changes in cell wall constituents in relation to textural softening. Journal of Science, Food and Agriculture, **86**:713-721.