

Comparison of quality attributes of mango fruits produced from two contrasting agro-ecological zones of Kenya

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Abstract

Mango (*Mangifera indica*) is a tropical fruit adapted to a wide range of agro-ecological conditions. In Kenya, mango fruits are produced across various agro-ecological zones (AEZs); from sub-humid to semi-arid. The diverse production conditions found in these AEZs variably affects fruit growth and subsequently the postharvest qualities. This study was conducted to compare the quality attributes of two mango varieties ('Apple' and 'Ngowe') produced under two different AEZs. Embu County (a high potential AEZ) and Makueni County (a low potential AEZ) are major mango-producing counties in Kenya. The study was conducted over two seasons between 2013 and 2014. 'Apple' and 'Ngowe' mango fruits were harvested from the two AEZs at four successive maturity stages; from the earliest physiological maturity (stage 1) to the tree-ripened stage (stage 4). In stage 1 fruits, the flesh was mostly cream and had just started turning yellow around the seed. The subsequent maturity stages were determined at 10-day intervals from stage 1 as stages 2, 3 and 4. For all the maturity stages, initial quality attributes were determined immediately after harvest and the again at a predetermined end stage following ripening at ambient room conditions (Temperature: $25 \pm 1^\circ\text{C}$ and RH: $60 \pm 5\%$). The quality attributes determined include sugars (fructose, glucose, and sucrose), °Brix, %TTA, vitamin C, beta carotene and mineral nutrients (Potassium, Magnesium, Calcium). For sensory evaluation, diced fruits were scored for various attributes including acidity, sweetness, mouth feel, flavor, aroma, color and general acceptability by a panel of 33 untrained panelists. For all the parameters evaluated, there was significant interaction ($P < 0.05$) between maturity stage, variety and AEZ. Levels of TTA decreased gradually with the stage of maturity irrespective of variety and AEZ. Overall, Embu fruits had higher initial TTA levels for all maturity stages. Although Apple fruits (all stages) had higher initial TTA, at the end of ripening TTA levels were relatively lower compared to Ngowe. Initial beta carotene levels increased while vitamin C levels decreased with maturity stage. Significantly higher beta carotene and vitamin C levels (initial and end stage) were observed in Makueni fruits. Initial and end stage Ca, Mg and K levels decreased with maturity stage, irrespective of variety or AEZ. Stage 1 and 2 fruits retained the highest Ca and Mg levels at the end stage. The highest sugar levels and end stage °brix levels were observed in stage 4 fruits (regardless of AEZ and variety). Overall, Makueni fruits had relatively higher end stage °brix levels compared to Embu fruits. In 'apple', Makueni fruits scored higher than Embu fruits for all the sensory attributes. On the contrary in 'Ngowe',

Embu fruits received higher scores than Makueni fruits for all sensory attributes except mouth feel and general acceptance. These findings show that production location and harvest maturity have a significant effect of nutritional and sensory qualities of mango fruits.

Key words: AEZ, *Mangifera indica*

Résumé

La mangue (*Mangifera indica*) est un fruit tropical adapté à un large éventail de conditions agro-écologiques. Au Kenya, des mangues sont cultivés dans différentes zones agro-écologiques (ZAE), du semi humide au semi-aride. Les conditions de productions diverses trouvées dans ces ZAE affectent variablement la croissance du fruit et par la suite les qualités post-récolte. Cette étude a été menée pour comparer les caractéristiques de qualité de deux variétés de mangue («pomme» et «Ngowe») produites dans deux zones agro-écologiques différentes. Le comté d'Embu (un fort potentiel AEZ) et le comté de Makueni (un faible potentiel ZAE) sont les principaux comtés de production de mangue au Kenya. L'étude a été menée sur deux saisons entre 2013 et 2014. Les fruits de mangue «Pomme» et «Ngowe» ont été récoltés dans les deux zones agro-écologiques à quatre stades de maturité successifs; à partir de la première maturité physiologique (stade 1) à l'étape d'arbres mûrs (étape 4). Dans l'étape 1 de fruits, la chair était principalement crème et venait commencer à tourner jaune autour de la graine. Les stades de maturité suivante ont été déterminés à intervalles de 10 jours à partir de l'étape 1 en scène 2, 3 et 4. Pour tous les stades de maturité, les caractéristiques initiales de qualité ont été déterminées immédiatement après la récolte et le nouveau à un stade prédéterminé de fin d'étape, suivant la maturation aux conditions ambiantes (température: $25 \pm 1^\circ\text{C}$ et HR: $60 \pm 5\%$). Les propriétés de qualité déterminées comprennent les sucres (fructose, glucose, saccharose), et °Brix, % TTA, la vitamine C, le bêta-carotène et les minéraux (potassium, magnésium, calcium). Pour l'évaluation sensorielle, fruits en dés ont été marqués pour divers attributs, y compris l'acidité, la douceur, la sensation dans la bouche, la saveur, l'arôme, la couleur et l'acceptabilité générale par un panel de 33 experts sans formation. Pour tous les paramètres évalués, il y avait une interaction significative ($P < 0,05$) entre le stade de la maturité, de la variété et ZAE. Les niveaux de TTA diminuaient progressivement avec le stade de maturité, indépendamment de la variété et de ZAE. Dans l'ensemble, les fruits d'Embu avaient des niveaux plus élevés de TTA initiaux pour tous les stades de maturité. Bien que les fruits Pomme (tous les stades) aient le TTA initial plus élevé, à la fin de la maturation, les niveaux TTA ont été relativement plus faibles que Ngowe. Les niveaux initiaux de bêta-carotène ont augmenté tandis que les niveaux de vitamine C ont diminué avec le stade de maturité. D'une manière significative les niveaux plus élevés de bêta-carotène et de vitamine C (stade initial et de la fin) ont été observés dans les fruits de Makueni. Les niveaux initiaux et la fin d'étape Ca, Mg et K diminuaient avec l'étape de maturité, quelle que soit la variété ou ZAE. Les étapes 1 et 2 des fruits conservaient les plus hauts niveaux de Ca et Mg au stade final. Les niveaux les plus élevés de sucre et le stade final degrés de Brix ont été observés à l'étape 4 des fruits (indépendamment de la variété ZAE). Dans l'ensemble, les fruits de Makueni ont relativement les niveaux les plus élevés à la fin d'étape Brix par rapport aux fruits Embu. Dans «pomme», les fruits de Makueni ont marqué des scores plus élevés que

les fruits Embu pour tous les attributs sensoriels. Au contraire dans «Ngowe », les fruits d'Embu ont reçu des scores plus élevés que les fruits de Makueni pour tous les attributs sensoriels, sauf la sensation dans la bouche et l'acceptation générale. Ces résultats montrent que le lieu de production et la maturité de récolte ont un effet significatif des qualités nutritionnelles et sensorielles des mangues.

Mots clés: ZAE, *Mangifera indica*

Background

Mango (*Mangifera indica*) is one of the popular fruits in tropical countries like Kenya and is ranked second after avocado (*Persea americana*) among the export fruits in Kenya. Various mango cultivars are widely grown and consumed in Kenya. Mango is well adapted to the different AEZs of Kenya ranging from sub-humid to semi-arid. The variation in production conditions across the different AEZs variably affects fruit growth and development and the resultant final quality (Hewett, 2006). The quality attributes of mango fruits including soluble sugars, vitamins and mineral nutrients are influenced preharvest production conditions. Some of the preharvest production conditions known to influence fruit growth and resultant quality at harvest include water availability, temperature, light intensity and carbon concentration. Past studies show that climatic factors and cultural practices influence post-harvest performance of mango fruit (Hofman *et al.* 1995). The location of production and the season in which the fruits are grown can determine their nutritional composition including the carotene, ascorbic acid, thiamine and flavonoid contents (Silva *et al.*, 2008). Environmental conditions that induced water stress and greater light exposure increased the total and reduced ascorbate contents, regardless of the maturity stage in mango (Lechaudel *et al.*, 2012).

Mango is a climacteric fruit which can continue ripening if harvested at physiological maturity. Mangos destined for distant markets (export) are often harvested at mature green stage when still firm to facilitate postharvest handling and extend the marketing period. The fruits are then ripened upon arrival at destination (wholesale, retailer, or consumer level), (Kader and Mitcham, 2008). The quality and the postharvest life of mango fruit depend on the maturity stage at harvest. Therefore, the fruit has to be harvested at the suitable stage of maturity in order to develop the optimum sensory quality attributes and extended postharvest life (Yahia, 1998a). Fruits harvested at immature stage have a longer shelf life but often fail to attain optimal sensory qualities. On the other hand fruits harvested at advanced maturity are known to have better sensory qualities but may deteriorate quickly after harvest (Lechaudel and Joas, 2007).

Objective

The objective of this study was to compare quality attributes (nutritional and sensory) of 'Apple' and 'Ngowe' mango fruits produced in two different agro-ecological zones of Kenya and harvested at different stages of maturity.

Study description

The study was conducted in two contrasting agro-ecological zones (AEZs) of Kenya namely Embu County and Makueni County. Embu County is semi-humid and high potential AEZ (III) which lies at an altitude of 1200 m above sea level. The region has a mean annual temperature of 19°C with the annual rainfall ranging between 950 mm to 1350 mm. Makueni County is a low potential AEZ (V) that lies at 450 m above sea level and receives an annual average rainfall of 550 mm or less. The mean annual temperature varies between 26°C to 35°C.

Two popular commercial varieties of mango, 'Apple' and 'Ngowe' produced in commercial orchards were used in the study. The fruits were harvested at 4 stages of maturity from 6 - 8 year old trees. For each maturity stage, a homogenous batch of 60 fruits was selected from a pool of fruits and used for the evaluation of various quality parameters. For each quality parameter, 3 to 5 fruits were randomly sampled from the batch and used to determine the initial values. The remaining fruits were left to ripen at ambient room conditions to a predetermined end stage when evaluation of the same quality parameters after ripening was done. The parameters evaluated include; Titratable acidity – TTA (% citric acid equivalent) by titration; total soluble solids – TSS (^oBrix) using a digital refractometer; main soluble sugars (fructose, glucose and sucrose) by HPLC; Vitamin C (by AOAC, 1996 protocol), Beta-carotene (by chromatography (Heionen, 1990) with slight modification. Fruit tissue mineral nutrients (Calcium and Magnesium) were determined using atomic absorption spectrophotometer while potassium was determined using flame emission photometer.

Tree ripened fruits of 'Apple' and 'Ngowe' from both locations were diced and subjected to sensory evaluation by 33 untrained panelists. The panelists scored the diced fruits for various sensory attributes including acidity, aroma, sweetness, mouth feel, flavor, color and general acceptability on a hedonic scale of 1 – 7 (where 1 = worst: 7 = Best). The same panel was used to evaluate sensory qualities of juice blended from fruits of different maturity stages (after they ripened to a predetermined end stage).

Results

All the fruit quality attributes evaluated were significantly affected by production location (AEZ), variety and stage of maturity. There was significant interaction ($p < 0.05$) between maturity stage and AEZ for most of the parameters evaluated. Levels of TTA decreased gradually with the stage of maturity irrespective of variety and AEZ. Overall, Embu fruits had higher initial TTA levels for all maturity stages. Although 'Apple' fruits (all stages) had higher initial TTA, at the end stage TTA levels were relatively lower compared to 'Ngowe'. Initial beta carotene levels increased while vitamin C levels decreased with maturity stage.

Significantly higher beta carotene and vitamin C levels (initial and end stage) were observed in Makueni fruits. Initial and end stage Ca, Mg and K levels decreased with maturity stage, irrespective of variety or AEZ. Stage 1 and 2 fruits retained the highest Ca and Mg levels at the end stage. The highest sugar and ^obrix levels were observed in stage 4 fruits, regardless

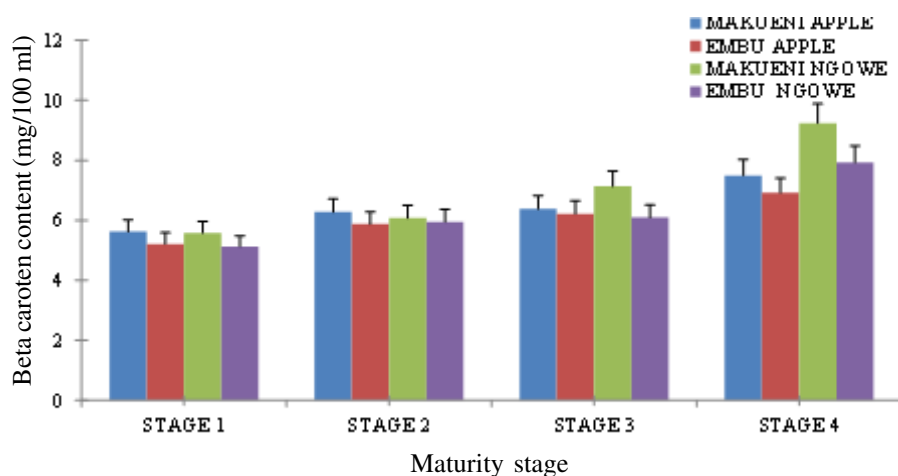


Figure 1. Beta-carotene levels (mg/100ml) for ‘Apple’ and ‘Ngowe’ mango varieties harvested at 4 different maturity stages from Embu and Makueni and ripened at ambient room conditions to a pre-determined end stage.

Table 1. Total sugar content (g/100ml) of ‘Apple’ and ‘Ngowe’ harvested from ‘Makueni’ and ‘Embu’ at 4 different maturity stages measured at a pre-determined end stage.

Location*Variety	Maturity stage			
	1	2	3	4
Makueni apple	10.0a	12.5a	14.5a	14.8a
Makueni ngowe	9.4b	11.2a	13.3a	13.8a
Embu apple	7.6c	11.6a	13.1a	13.8b
Embu ngowe	6.8c	9.6b	10.2c	11.2b
LSDs	1.130	1.075	1.427	1.832

*Values presented in the table are means of 5 fruits individually analyzed. Means followed by the same letter in a column are not significantly different by Fisher’s least significant difference test at $p = 0.05$.

of AEZ and variety (Table 1). Overall, Makueni fruits had relatively higher end stage °brix levels compared to Embu fruits. In ‘Apple’, Makueni fruits scored higher than Embu fruits for all the sensory attributes. On the contrary in ‘Ngowe’, Embu fruits received higher scores than Makueni fruits for all sensory attributes except mouth feel and general acceptance.

Discussion

The results of this study revealed that mango fruit final quality is significantly ($p < 0.05$) affected by the environmental conditions in the AEZ where they are produced and maturity stage at harvest. Fruits from Makueni (a low potential – high temperature and low rainfall) had significantly ($p < 0.05$) higher levels of most of the quality attributes evaluated including

total sugar levels, beta carotene and vitamin C, compared with Embu fruits. Studies in other fruits show that preharvest climatic conditions greatly affect fruit quality. Probably longer periods of exposure to sunlight and higher temperatures in Makueni which favored photosynthetic activities and carbohydrate accumulation could have contributed to the observed results. These findings concur with previous studies in other fruits such as apples and avocado which showed that fruits harvested from regions receiving full sunlight and high temperatures had better quality attributes such as high sugar levels than those from regions receiving less sunlight (Ferguson *et al.*, 1999).

The results show the variation in quality as affected by production conditions, a factor that should be considered by all value chain actors. It is particularly critical for exporters and processors of mango fruits because consistency in the quality of fruits and/or processed products is affected by maturity of the fruits.

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