

*Full Length Research Paper*

# Sensory attributes, microbial quality and aroma profiles of off vine ripened mango (*Mangifera indica* L.) fruit

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The need to develop the best off vine mango ripening technique for both consumption and processing was investigated. Sensory quality and microbial contamination was studied on mature green Dodo mangoes before and during a 3- and 6-day ripening period by Smoked Pit Ripening (SPR), Ethylene (fruit generated) Pit Ripening (EPR), Untreated Pit Ripening (UPR) and Room Temperature Ripening (RTR) as a control method. The post harvest ripening changes in the quality characteristic of ripe mangoes were correlated among treatments and compared with similar changes in other mango varieties. The results showed insignificant differences in sensory attributes among the employed techniques. Microbial quality was significantly different within the treatments, while with aroma profiles there were considerable differences of detected aromatic compounds between raw and ripe mango fruits. Increased number of aromatic compounds reflected the most significant sensory scores at ripening stage.

**Key words:** Mango, microbial quality, flavour, ripening, aroma.

## INTRODUCTION

Mango is one of the favoured fruit in the tropical and subtropical regions. It has an excellent flavour, attractive fragrance, delicious taste, and high nutritional value that have made it one of the best fruits (Pal, 1998). The fruits are very much relished for their succulence, exotic flavour and delicious taste. Beyond being rich in vitamins, minerals and antioxidants, mangoes contain an enzyme

with stomach soothing properties similar to papain (Stewart and Straus, 2000).

In most mango growing countries, the bulk of mango produced is generally consumed as fresh fruit, fresh from the harvest and mostly in the ripened form. However the fruits are not always allowed to ripen on the tree before picking since the practice has been found to aggravate post harvest losses due to over-ripening during distribution leading to low market value (Joseph and Aworth, 1991). Furthermore natural ripening has been found to take longer time to develop a full ripe colour unlike accelerated ripening. The fruit position on the tree is also reported to affect colour development, which is greatest on the exposed faces of the tree (Johnson et al., 1997). In order to avoid market losses due to tree ripening, and enhance the process and ensure uniform

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**Abbreviations:** SPR, Smoked Pit Ripening; EPR, Ethylene (fruit generated) Pit Ripening; UPR, Untreated Pit Ripening; RTR, Room Temperature Ripening.

ripening, fruits are ripened off the plants and various ripening techniques are employed. Aroma and flavour are also special consumption attributes critical to consumer acceptability of mangoes. The objective of this study was to assess the sensory attributes and microbial quality of the various ripening techniques in order to recommend a comparatively better technique.

## MATERIALS AND METHODS

### Procurement and sampling of fruits

Fully mature ripe mango fruits of the local Tanzanian cv Dodo obtained from Milengwelengwe village in Morogoro rural district, Tanzania. The fruits were plucked directly from the same tree and studied during the 2001/02 fruiting season. The sorting of the fruits were such that only undamaged fruits having uniform size and free from visible symptoms of infection were selected for the study. On arrival, the fruits were cleaned with pre-boiled water to remove dirt and latex. A total of 240 fruits were selected and randomly divided into four groups of 60 mangoes each. The fruits were further randomly subdivided into subgroups of 20 fruits. The 20 fruits in each subgroup formed replicates in each of the four groups. One group was kept as a control, that is, room temperature ripening (25 – 30°C; RTR) whilst the remaining 3 groups were subjected to the following treatments: (i) Smoked Pit Ripening (SPR), (ii) Untreated Pit Ripening (UPR) and (iii) Ethylene (fruit generated) Pit Ripening (EPR).

### Preparation of ripening pits and the ripening process

All the three pits were dug with same measurements i.e. 45 cm width, 60 cm length and 45 cm depth. Hardboard lids measuring 47 cm width and 62 cm length each were made to securely cover each pit. For the Smoked Pit Ripening method, the pits were warmed before use by burning half a bucket of dry mango leaves at the bottom of each pit as it is done traditionally. Clean dry, previously sterilized banana leaves were then spread on the pit floor as beddings. Mango fruits were put on top of the banana leaves and again covered with the same leaves. Smoke was introduced in the pits for about 5 minutes by burning the same amount of dry mango leaves as before and directing the smoke into the pits by a chimney like devise. The lids were then replaced immediately adding a lump of soil on top of the lid.

With the Ethylene (fruit generated) Pit Ripening method, banana leaves were spread at the bottom of the pit and mangoes were mixed with seven bananas in their initial ripening stage for natural ethylene generation. The fruits were covered with banana leaves; the lid was replaced and covered with soil on top. In the Untreated Pit Ripening method the procedure followed was similar to Ethylene (fruit generated) Pit Ripening except no bananas were added. For the control method, fruits were kept at ambient condition in bamboo woven baskets lined with clean dry banana leaves at the bottom and covered with the same material. Fruits were assessed

at three-day interval in three phases designated as D<sub>0</sub>, corresponding to initial time before ripening storage; D<sub>3</sub> during three days ripening; and D<sub>6</sub> at the end of the sixth day ripening period. For D<sub>0</sub> and D<sub>3</sub> samples of mango fruit were evaluated for microbial count, while for D<sub>6</sub> evaluation was done on sensory quality, aroma profile and microbial count.

### Sensory evaluation procedure

Sensory evaluation based on the ripening indices was organized and conducted by using a seven 7 point hedonic scale (where 1 = dislike very much and 7 = like very much) by 35 panellists. Panelists were undergraduates' students. Fruits were assessed for flesh colour, flavour, texture and overall acceptability. Mango slice samples were at room temperature at time of sensory evaluation. The evaluation was conducted in the Laboratory of Food Science and Technology at the Sokoine University of Agriculture at about 11.00 am. The samples for evaluation were presented in a random order placed into 3-digit coded plates with lids. Panellists were instructed to open the lid from each mango sample plate to rate the ripening attributes. Distilled water was provided for panellists to cleanse their palates between samples. In any given session panellists were asked to rate the ripening attributes of 4 mango samples.

### Microbial quality assessment

The Swab-Rinse method described by Jay (1992) was used to determine the microbial counts of mangoes ripened by different post harvest ripening techniques. Five mangoes were sampled at random from each ripening methods and the samples were prepared for microbial analysis by swabbing on the fruit surfaces. The swabbing sticks were slowly rotated on the surfaces and repeated the second time at right angle to the first one. After each swab, the swabbing sticks were deeped in test tubes containing 0.1% peptone water. Samples were thoroughly mixed and three serial dilutions prepared in each case. Dilutions were made in 0.1% peptone water as needed, and 1 ml pour plated on nutrient agar. The plates were then incubated for three days at 30° C.

### Aroma recovery process

Samples of ripe fruits from each treatment at each analytical stage were prepared for analyses. Fifteen fruits taken from each lot (five mangoes per replication) were washed in preboiled water and then cleansed with distilled water. The fruits were hand peeled and the edible portion separated from peels and stones by using a stainless steel knife. The mango homogenate was distributed among glass containers which were immediately capped.

A 100 g mango pulp was diluted with 50 mL of distilled H<sub>2</sub>O. Steam was passed through the pulp from a steam generator. Mixture of steam and volatiles were condensed and collected in 20 mL of hexane. The water was separated from hexane by density difference and further traces of water were separated by freezing the mixture to -10°C. The 20 mL of aroma extracts were concentrated to about 1 mL in a vacuum evaporator type (Heidolph VV 2000, Germany) operating at 45° C and 30 rpm. The aroma concentrates of mango obtained in the aroma recovery unit were used in the chromatographic aroma profile analysis.

**Table 1.** Effect of ripening treatments on sensory characteristics of mango pulp after 6 days of ripening.

Sensory descriptors/attributes	Ripening treatment and sensory attribute score			
	SPR	UPR	EPR	RTR
Colour	5.83 <sup>a</sup>	5.80 <sup>a</sup>	5.57 <sup>a</sup>	5.63 <sup>a</sup>
Texture	5.43 <sup>a</sup>	5.46 <sup>a</sup>	5.26 <sup>a</sup>	5.37 <sup>a</sup>
Flavour	5.57 <sup>a</sup>	5.77 <sup>a</sup>	5.63 <sup>a</sup>	5.26 <sup>a</sup>
Overall acceptability	5.57 <sup>a</sup>	5.71 <sup>a</sup>	5.54 <sup>a</sup>	5.43 <sup>a</sup>

Mean scores obtained from 35 untrained panellists using a 7-point hedonic scale. Mean values in a row with the same superscript are not significantly different at ( $P \leq 0.05$ ).

**Table 2.** Effect of ripening treatments on mango surface microbial population.

Parameter	Ripening period (days)	Initial value	Ripening method			
			SPR	UPR	EPR	RTR
Microbial count (Log cfu ml)	3	2.716 <sup>a</sup>	3.320 <sup>b</sup>	3.629 <sup>c</sup>	3.652 <sup>c</sup>	3.286 <sup>b</sup>
Microbial count (Log cfu ml)	6		3.499 <sup>b</sup>	3.638 <sup>c</sup>	3.663 <sup>c</sup>	3.490 <sup>b</sup>

Mean values in a row with the same superscript are not significantly different at ( $P \leq 0.05$ ).

### Gas chromatography

The aroma distillates were analysed for esters (methyl acetate, ethyl acetate, n-butyl acetate, acetaldehyde and benzaldehyde). The choice of these standards was based on literature reports that esters are by far the major group of volatiles for all mango cultivars. The gas chromatograms of the flavour isolates were obtained using a Varian 3003, USA instrument of the Government Chief Chemist's Laboratory in Dar es Salaam equipped with FID and a 20 ft x 1/4 in. glass open tubular column packed with Carbowax 20M. The temperature was programmed from 80 to 200°C at 5 mL/min for the whole run. Nitrogen flow rate was at 30 mL/min. Detector and injection point heaters were 260 and 240°C, respectively. The identities of 5 components of aroma concentrates from among the resolved components were based on comparison of retention times with that of the corresponding synthetic ester standards.

### Statistical analysis

All analyses were conducted in triplicate. Descriptive statistics was done on sensory attributes and microbial counts. Analysis of variance was done at 95% confidence interval ( $P < 0.05$ ) using Tukeys Honestly significant difference. This analysis was done using SPSS for windows computer software.

## RESULTS

### Sensory evaluation

Sensory score results are summarised in Table 1. The SPR mangoes were rated superior in terms of colour whereas the EPR mangoes were the most inferior in this

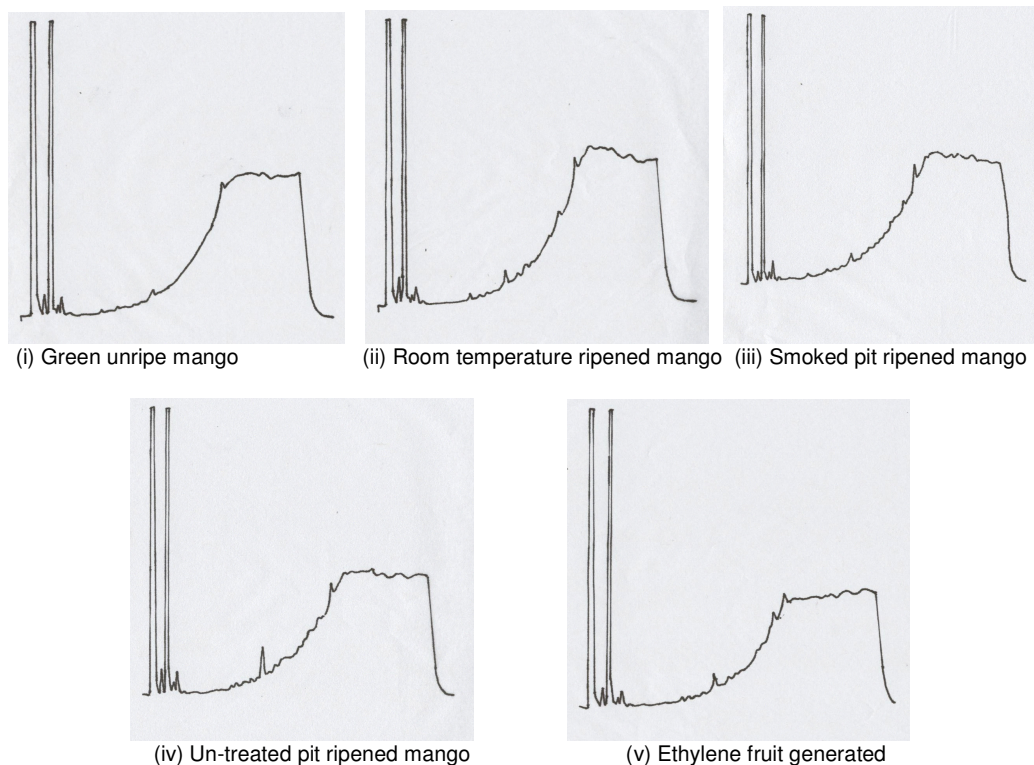
parameter. The highest texture score was observed in the UPR mangoes while the lowest score was observed in the EPR mangoes. The score for flavour was highest in the UPR mangoes and lowest in the RTR mangoes. The overall acceptability score was minimum in the RTR mangoes, whereas maximum score was observed in the UPR mangoes. However, no significant ( $P > 0.05$ ) variations among treatments were observed.

### Microbiological quality

Mean microbial counts (cfu/mL) for pour plate counts are summarised in Table 2. The various ripening techniques showed significant ( $P < 0.05$ ) effect on the microbial counts. The highest microbial counts were in the UPR mangoes and lowest in the RTR mangoes. The changes in microbial counts were, however, not significant ( $P > 0.05$ ) between the UPR mangoes and the EPR mangoes and between the RTR and the SPR mangoes but significant ( $P < 0.05$ ) between the two methodical groups.

### Aroma volatile profiles

The most important feature of these results is the considerable difference in the number of detected aromatic compounds between the ripe fruit and the raw/green mango at maturity (Figure 1). The number of



**Figure 1.** Aroma profiles for the treated mangoes.

the important volatile constituents was lower in the unripe fruits and more peak constituents were detected in the ripe fruit samples. Whereas only 7 volatile aroma profile peaks were resolved for the raw green mango (Figure 1i), 16 peak components were resolved in the SPR (Figure 1iii) and the UPR mangoes (Figure 1iv). For the EPR mangoes, the volatile aroma profile consisted of 14 peaks (Figure 1v), while 12 peaks were generated from the RTR mangoes (Figure 1ii).

## DISCUSSION

Panellists ascribed sourness and mushy texture in fruits to reduced overall fruit acceptability whilst sweetness and optimum ripeness were linked to increased overall fruit acceptability. The comments by panellists could be attributed to the degree of ripeness at which a fruit was consumed as it plays a major role in the assessment of its sensory qualities and acceptability. The reduced texture scores in the SPR mangoes and the EPR mangoes could be due to over ripening leading to

excessive softening and hence a mushy flesh. While poor sensory score in the RTR fruits could be attributed to the poor performance of the method in initiating and advancing ripeness as compared to other methods. Conducting sensory assessment before reaching a minimum ripening period of nine days at room temperature ( $26\pm 2^{\circ}\text{C}$ ) could be another reason for unoptimum ripeness (Subramanyam et al., 1976). Ripe fruit characters and flavour intensity are reported to increase with storage (MacRae et al., 1989). Nevertheless, fruits from all treatments scored above normal score (4 points), implying that were acceptable. Smoking did not affect the flavour of smoked pit ripened mangoes as had been reported previously by the consumers. This is possibly due to the used source of smoke, in this case the mango leaves.

An increase in natural microbial population could be attributed to contamination and further multiplication in the ripening storages. The higher microbial count in pit ripened mangoes than in the control mangoes ripened in ambient conditions could be attributed to a more favourable growth environment (Simmonds, 1959). The

lowest microbial count in the SPR mangoes among the pit methods could be accredited to the preservative effect of smoke through deposition of bacteriostatic chemicals such as phenol and formaldehyde in the system (Venugopal, 1995). The highest microbial count in the EPR samples could probably be associated with the presence of half ripe banana fruits producing a sweet and readily utilizable food source for fungal growth.

The greatest change in flavour components detected in the unripe fruits and in the ripe fruits indicates that ripening is associated with a sharp increase in volatile components (MacLeod and Snyder, 1985; Gomez-Lim, 1997). The variation among the ripe fruits would suggest their differing stages of ripeness and may further reinforce the assumption that marked changes in the concentration of different aromatic compounds during ripening may be responsible for the alteration of flavour during ripening. This is demonstrated in the results of the present study, which showed that fruits, which received the most effective ripening methods, showed a greater number of aromatic compounds. On the other hand, if the results of the aroma profile are linked to the results of the sensory analysis it can be shown that there is a positive relationship between fruit sample acceptability with the number of aromatic volatiles in the pulp. It would also seem from these results that the 7 detected peaks for aromatic compounds in unripe mango are possibly characteristic of the typical aroma of unripe cv. Dodo and that treatment with the highest numbers of aromatic components peaks had possibly reached a post-climacteric phase at the time of analysis (Tressel et al., 1975).

Among the aromatic volatiles, only n-butyl acetate and methyl acetate were identified in all the ripe test samples. N-butyl acetate was also identified in the unripe mangoes. Benzaldehyde was identified in the EPR and in UPR mangoes while acetaldehyde was found in the RTR and the UPR mangoes. Ethyl acetate was identified in the EPR mangoes and the unripe mangoes. From these results it may be deduced that an abundance of methyl acetate and n-butyl acetate is a characteristic of dodo cultivar in the ripe form although more data may be needed to draw a firm conclusion. The failure to identify other aromatic volatiles other test samples could be explained by changes in composition of produced mango volatiles components as a consequence of ripening stages attributable to the ripening treatments. Earlier workers (MacLeod and Snyder, 1985) have reported considerable differences (qualitative as well as quantitative) between the aroma volatiles of the over ripe

fruit and those of the much more alike ripe and green mango.

This study provides evidence that off vine ripening treatment of mangoes does not induce significant negative alterations in sensory, aroma profile and microbial quality. An in depth examination of the factors contributing to spoilage in pit ripening needs attention so as to optimise the ripening conditions and minimize the losses encountered during ripening. However, increased number of aromatic compounds reflected the most significant sensory scores at ripening stage.

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