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Some Sensory Attributes of Mango (*Mangifera Indica* L.) Fruit as Influenced by Fruit Size and Harvesting Methods during Storage

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ABSTRACT

Purpose: *A large quantity of mango fruits is lost annually in Adamawa State due to poor harvesting method, sizing, handling, packaging, transportation and storage, and therefore, amelioration becomes necessary. This experiment was carried out to study the effect of harvesting methods and harvested fruit size on some sensory attributes of mango fruit during storage.*

Research Method: *Three harvesting methods were used to harvest the fruits, and the methods were namely, harvested and fell on the ground, harvested with locally fabricated picker and harvested and fell on foam. Two harvested fruit sizes were adopted for the study namely, big and small fruit. The experiment was laid out in a Split Plot Design with fruit size assigned to the main plot while harvesting methods were assigned to the subplots and replicated three times. Treatments consisted of two factors (fruit size and harvesting methods). Data were collected on fruit texture, fruit colour, and fruit marketability, subjectively. The data generated were subjected to Analysis of Variance (ANOVA). Means showing significant F-test were separated using Least Significant Difference (LSD).*

Findings: *Results of the study showed that big fruits harvested with picker had better fruit texture, colour and marketability during storage and therefore, harvesting big mango fruits carefully without letting them drop to hit the ground is recommended for better sensory attributes of mango fruits.*

Research Limitation: *The research determines the impact of harvesting methods and fruit size on the sensory qualities of mango fruit. The study limited itself to only three harvesting methods. Two fruit sizes and one variety of mango (cv Zill).*

Original Value: *This study provides information on some of the possible causes of wide spread high level of postharvest losses of mango fruit during storage in Adamawa State of Nigeria. Among other things, these losses are caused by poor harvesting methods and sizing of fruits.*

Keywords: *Colour, marketability, picker, sensory attributes, texture*

INTRODUCTION

A recent market survey on fresh fruits conducted by the International Trade Centre in Geneva, Switzerland revealed that the volume of trade in fresh mango fruits and juices has increased to over five billion US dollars annually (Anon., 2015). Despite the booming international trade in mango fruits, about 20 – 50 % of mango fruits are wasted due to poor harvesting, sizing, packaging, storage, etc., in developing countries (Singh *et al*., 2014). Postharvest management of mango fruits in Nigeria is generally poor (Ahmed and Abubakar, 2016a); and the fruits are harvested by shaking the tree to force the fruit to drop on the ground, packing without cleaning, sizing and using poor packaging

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materials (Ahmed, 2016). Consequently, these improper postharvest management such as harvesting methods and sizing are partly responsible for the low productivity and large wastage of mango fruits in the country (Ahmed and Abubakar, 2016b).

Efforts have been made to improve mango fruit harvesting such as plucking scissors, sac-bag, basket, bucket with rope (Yahia, 1999) and Israeli auto-empty bags that have been developed in advanced countries to harvest fruits, but all were found to be inaccessible and expensive (Ladaniya, 2008). These problems necessitated this study, with the main objective of determining the effect of harvesting methods and harvested fruit size on sensory attributes of mango fruits during storage and the relationship between harvesting methods and fruit size on some sensory properties of stored mango fruits.

MATERIALS AND METHODS

The experiment was carried out in the Laboratory of the Department of Crop Production and Horticulture of Modibbo Adama University of Technology (MAUTECH), Yola (latitude 9^0 23'N and longitude 12^0 46'E), Adamawa State. Three harvesting methods were used to harvest the fruits, namely the methods of harvested and fell on the ground, harvested with locally fabricated picker without hitting the ground and harvested and fell on foam (soft material to cushion the effect of falling on the ground). All mango fruits were harvested from the same tree at an approximate height of 5m. Fruit samples were divided into two categories of big fruit weighing 320 to 750 gm with a length (distance between nose-end to stem–end of the fruit) of 7.5 cm and above, and Small fruit weighing 150 to 319 gm, and with a length of below 7.5 cm. The treatments consisted of two factors of mango fruit size and harvesting methods that were factorially combined and laid out in a 2×3 Split Plot Design with fruit size assigned to the main plot while harvesting methods were assigned to the subplots and replicated three times. All treatments consisted of 10 fruits and were packaged inside corrugated fibre cardboard carton. The fruits were stored under ambient condition with the temperature range of 30 - 36^0C and the relative humidity was within the range of 45 - 51% throughout the storage period. Data were collected on following parameters:

Skin colour change

Skin colour or peel colour development was monitored after every two days throughout the storage period. The skin colour of the variety (zill) used for the research changed from dark green to golden yellow when ripe. The ripening process was divided into seven stages by colour changes which were assessed by five panelists using 7 point hedonic scale. The points were as follows: 7 = green; 6 = green with a trace of yellow; 5 = greener than yellow; 4 = more yellow than green; 3 = only green tips remaining; 2 = all yellow; 1 = yellow flecked with brown (Anwar and Malik, 2007).

Marketability

Marketability rating of mango fruits was done by the hedonic scale as described by Peryam and Pilgrim (1957) and modified by Ahmed (2016) to from 9 point scale to 7 point scale. A panel of five judges evaluated the appeal of the fruits at the interval of every two days during the research period. The scale used was: like very much = 7, like moderately = 6, like slightly = 5, neither like nor dislike = 4, dislike slightly = 3, dislike moderately = 2 and dislike very much = 1 when the fruit had gone bad.

Fruit texture

Fruit texture was also evaluated using 7 point Hedonic scale (hard = 7, moderately hard = 6, slightly hard = 5, either hard or soft = 4, slightly soft = 3 moderately soft = 2, soft = 1). Fruits were presented to a five- member taste panel of judges who assessed the fruit samples and rated them for general firmness based on whether the mango yielded to thumb pressure as recommended by Anwar and Malik (2007) with little modification by increasing the scale from 5 point to 7 point scale

RESULTS AND DISCUSSION

Fruit size had a highly significant ($P \leq 0.01$) effect on mango fruit texture during storage at days 8, 10 and 12. There was also a significant ($P \leq 0.05$) effect of fruit size on fruit texture during storage at days 4, 6, 14 and 16 (Table 01). This may be due to high respiration rate attributable to large surface- area-to-volume ratio of small fruits. This finding is consistent with Ahmad *et al*., (2007) and Ahmed (2016) who both reported that small fruits have high respiration and transpiration rates because of large surface- area - to - volume ratio that causes rapid respiration, moisture loss and hence quick softening of the fruit.

There was a highly significant ($P \leq 0.01$) effect of harvesting methods on mango fruit texture throughout the storage except in days 2 and 18 as shown in Table 1. This might be because the fruits harvested with picker did not suffer shock and injury and since uninjured fruits have low respiration rate and low ethylene production during storage thus reasoning towards the highly significant difference. The result of this study also agreed with the earlier reports of Kader (1983), Yahia (1999) and Ladaniya (2008) who reported increased physiological activities due to mechanical injury soften fruit texture. In the same, the finding is also in total support of Ezz and Awad (2011) who stated that injured mango fruits have elevated respiration and high level of ethylene production. So also Ahmed and Abubakar (2016a) ascertained that fruits harvested carefully without letting them drop to hit the ground have firmer texture than those that fall the ground during harvesting. There was however, no significant ($P \geq 0.05$) interaction between fruit size and harvesting methods on the texture of mango fruits during storage.

The effect of fruit size on peel colour during storage was highly significant ($P \leq 0.01$) at days 4, 10, and 14 of storage periods (Table 2). There was also, a significant ($P \leq 0.05$) effect of fruit size on the storage of mango fruits at days 12 in storage but no significant ($P \geq 0.05$) effect was observed at days 2, 6, 8, 16 and 18. This phenomenon might be due to elevated respiration, high level of ethylene production associated with smaller fruits during harvesting as a result of high surface-area-to –volume ratio of the fruit, thus leading to rapid ripening. This result is in agreement with Day (1993), AgriInfo (2011) and Ahmed and Abubakar (2016b) who affirmed that small fruits ripen rapidly due to elevated respiration, high amount of ethylene production and respiration rates due high surface-area-to-volume ratio.

Table 01: Effects of Harvesting Methods and Fruit Size on the Texture of Mango Fruit during Storage in 2014

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Fruit size									
Big	6.56	5.78a	4.33	3.67	2.56	1.56	0.89	0.56	0.22
Small	6.33	4.89b	3.44	2.56	1.44	0.78	0.44	0.11	0.00
LSD	1.26	1.26	1.51	0.96	0.48	0.98	0.96	0.96	1.51
Probability of F	NS	*	*	**	**	**	*	NS	NS
Harvesting method									
Ground	6.00	4.33	2.50	1.33	0.33	0.00	0.00	0.00	0.00
Picker	6.83	6.17	5.00	4.50	3.50	2.50	1.67	1.00	0.33
Foam	6.50	5.50	4.17	3.50	2.17	1.00	0.33	0.00	0.00
LSD	1.20	1.00	1.10	0.76	0.60	0.76	0.38	0.76	0.38
Level of Probability	NS	*	**	**	**	**	**	*	NS
Interaction (H×S)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 02: Effects of Harvesting Methods and Fruit Size on Mango Fruit Colour during Storage

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Fruit size									
Big	6.56	6.22	4.67	3.33	2.78	1.89	1.44	0.56	0.56
Small	6.33	5.00	3.89	2.89	1.56	1.00	0.33	0.33	0.44
LSD	2.08	0.48	0.96	1.27	0.96	0.48	0.96	0.48	2.39
Probability of F	NS	**	NS	NS	**	*	**	NS	NS
H/Methods									
Ground	6.17	5.00	3.50	2.17	0.50	0.17	0.00	0.00	0.00
Picker	6.67	6.33	4.33	3.67	3.17	2.17	1.33	0.83	1.67
Foam	6.50	5.50	3.50	3.50	2.83	2.00	1.33	0.50	0.00
LSD	1.00	0.38	1.36	1.58	0.89	0.89	0.38	0.38	2.40
Probability of F	NS	**	*	NS	**	**	.**	**	NS
Interaction (H×S)	NS	*	NS	*	NS	*	**	**	NS

*H/Methods = Harvesting methods .LSD = Least Significant Differences. * = Significant effect ; ** = Highly significant effect NS = No significant effect*

The effect of harvesting methods on mango fruit colour during storage is also presented on Table 02, where, a highly significant ($P \leq 0.01$) effect of harvesting methods on the colour change of mango fruits during storage at days 4, 10, 12, 14 and 16 were seen, however, a significant effect ($P \leq 0.05$) was recorded at days 6 in storage. No significant ($P \geq 0.05$) effect was observed at days 2, 8, and 18 of storage periods. Mango fruit colour was not significantly affected by harvesting methods during storage at days 2 and 8 of storage; this might be because the fruits were harvested at the stage of physiological maturity and all had the same colour at the initial stage of storage. This result is in conformity with Slaughter (2009) who posited that physiologically matured mango fruits can maintain its green colour for up to four days.

At storage period 4, big fruits that fell on ground had higher colour change of 6.0 (Table 03) and even after harvesting method was changed to picker and fell on foam, big fruits still maintained the higher values of 6.7 and 6.0 respectively. However, at day 8, small fruits that fell on ground had a higher colour change (3.3) but when the harvesting method was changed to picker, big fruits had a higher of 4.7 and the same trend continued with fruits that fell on foam. The same pattern also manifested at day 12 of storage. At day 14, both big and small fruits that fell on ground were deteriorated.

Table 03: Interaction of Harvesting Methods and Fruit Size on Mango Fruit Colour during Storage

Fruit Size	Storage period (days)														
	4			8			12			14			16		
	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
Big	6.0	6.7	6.0	1.0	4.7	4.3	0.0	2.7	3.0	0.0	1.7	0.0	0.0	0.0	1.7
Small	4.0	6.0	5.0	3.3	2.7	2.7	0.3	1.7	1.0	0.0	1.0	0.0	0.0	1.0	0.0
LSD		0.5			2.2			1.3			0.5			0.5	
Probability of F		*			*			*			**			**	

*H_1 = Fruit harvested on the ground. H_2 = Fruit harvested with picker. H_3 = Fruit harvested on the foam. * = Significant effect ** = highly significant effect*

However, when the harvesting method was changed to picker, big fruits had the higher value of 1.7 but when harvesting method was changed again, both fruits sizes got deteriorated. The same trend also continued at day 16, where small fruits had higher value of 1.0, only when picker was used to harvest them.

The effect of fruit size on fruit marketability rating during storage was highly significant effect ($P \leq 0.01$) throughout the storage periods except in days 2, 4 and 6 of storage. Fruit size also had a significant effect at days 4 to 6 but no significant effect on fruit marketability at initial stage of storage (2 days). This could be due to the fact the fruits were harvested mature green with firm texture and green colour and the result of this study was supported by Panhwar (2005) who opined that fruits harvested mature green can remain wholesome for a week or more. The significant effect of fruit size on marketability at the subsequent part of the storage periods could be because consumers prefer fruits with bigger size with full ripe golden- yellow colour as confirmed earlier by Kays (1991) and Slaughter (2009) who stated that fruit size affects consumer appeal.

Fruit marketability was highly affected ($P \leq 0.01$) by harvesting method as recorded at days 8 to 18days in storage, a significant effect ($P < 0.05$) at 4 to 6 and marketability was also significantly affected by fruit size at second day of storage (Table 04). The significant and highly significant effects harvesting methods had on fruit marketability at the middle and end of the storage period could be due to high respiration and pathogen infection induced by mechanical injuries sustained during harvesting which led to poor marketability. This result is an inconformity with Panhwar (2005), Ahmed (2016) and Ahmed and Abubkar (2016b) who earlier confirmed that mechanically injured fruits during are less marketable.

Interaction between harvesting methods and fruit size (Table 05) on mango fruit marketability shows highly significant interactions at days 8, 10, 12,16,and 18 of storage: whereas significant interaction was noted at day 14 of storage. At day 8, big and small fruits that fell on ground were completely deteriorated (0.0) but when harvesting method was changed to picker, big fruits had a higher marketability (4.7). However when the harvesting method was changed again to fell on foam, big fruits had their marketability reduced (3.7).

Table 04: Effects of Harvesting Methods and Fruit Size on the Marketability of Mango Fruit during Storage

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Fruit Size									
Big	6.56	5.33	3.66	2.78	2.22	1.78	1.67	0.89	0.56
Small	6.33	4.11	1.89	1.22	0.67	0.33	0.44	0.11	0.00
LSD	2.08	0.48	1.27	0.48	0.48	0.48	0.48	0.48	0.48
Level of Pr.	NS	*	*	**	**	**	**	**	**
Harvesting Methods									
Ground	6.00	4.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00
Picker	6.67	5.67	3.50	3.17	2.50	1.50	1.83	1.17	0.83
Foam	6.67	4.50	3.33	2.83	1.83	1.67	1.33	0.33	0.00
LSD	0.89	1.28	1.83	0.38	0.38	0.38	0.89	0.38	0.38
Level of Pr.	NS	*	*	**	**	**	**	**	**
Inter. (H×S)	NS	NS	**	**	**	**	*	**	**

** = Significant effect, ** = highly significant effect NS = No significant effect*

Table 05: Interaction of Harvesting Methods and Fruit Size on Mango Fruit Marketability during Storage

Fruit Size	Storage period (days)																	
	8			10			12			14			16			18		
	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3	H_1	H_2	H_3
Big	0.0	4.7	3.7	0.0	3.7	3.0	0.00	3.3	2.7	0.0	2.7	2.3	0.0	2.3	0.3	0.0	1.7	0.0
Small	0.0	2.7	1.0	0.0	2.0	0.0	0.00	1.0	0.00	0.0	1.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0
LSD		0.5			0.5			0.5			1.3			0.5			0.5	
Probability of F		**			**			**			**			**			**	

*H_1 = Fruit harvested and fell on the ground. H_2 = Fruit harvested with picker. H_3 = Fruit harvested and fell on the foam. S_1 = Big fruit. S_2 = Small fruit .H/M = Harvesting Methods. F/ Size = Fruit Size. Days = Storage Period. * = Significant effect ** = highly significant effect NS = No significant effect*

The same trend continued at days 10, 12, 14 and 16. However, at sampled period 18, fruits that fell on ground both big and small completely deteriorated but when harvesting method was changed again to harvest with picker, big fruits had a higher marketability (1.7). However, when harvesting method was changed to fell on foam, both fruit sizes got completely deteriorated.

CONCLUSION AND RECOMMENDATION

Conclusively, harvesting methods and fruit size had a significant effect on the sensory attributes and storability of mango fruits. The study therefore, recommends harvesting big mango fruits with picker as the best method for storage and marketing purposes.

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