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Effects of Harvesting Methods on the Shelf- Life of Mango (*Mangifera Indica* L.) Fruits

[1]**Mohammed Ahmed &**
[2]**Abubakar, M. S**
[1]*Department of Crop Science, Adamawa State University, Mubi, Adamawa State*
[2]*Department of Soil Science, Federal University Dutse Jigawa State*

Abstract

Mechanical injury is found in most harvested mango fruits in Nigeria which usually originate during harvesting. It is a common practice to drop fruit from different height on to the ground or shake the tree during harvesting with all the attendant consequences on its shelf life. These shortcomings necessitated this research to determine the effects of harvesting method on the Shelf life of mango fruits. The experiment consisted of three harvesting methods namely: harvested and fell on ground, harvested and fell on foam and with a picker. Data were collected on percentage change in fruit diameter, fruit texture, percentage weight loss, colour changes, rate of deterioration, percentage deterioration and marketability. Data generated were subjected to analysis of variance (ANOVA). Results showed that fruits harvested and fell on ground had shorter storage life of less than 6 days while fruits harvested with picker had longest shelf life of 18 days. And fruits harvested with picker had the best texture and marketability. The study therefore, concludes that harvesting method had significant effect on the shelf life of mango fruit and the best harvesting method is by using picker. Consequently, the following recommendations were made: mango fruits should be harvested carefully without falling on the ground and harvesting mango fruits with picker help to increase the shelf life.

Keywords: *Harvesting methods, percentage change in fruit diameter, fruit percentage weight loss, fruit marketability*

Corresponding Author Mohammed Ahmed

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Background to the Study

Mango (*Mangifera indica* L.) fruit is one of the major fruits produced in tropical and subtropical countries including Nigeria. It is a fleshy drupe fruit that is consumed raw when ripe or used to prepare chutney, pickles and other dishes. Mango is rich in Vitamins A, C, D and essential nutrients such as potassium, copper and good levels of 17 amino acids (Ilesanmi *et al*., 2011). It is also a source of raw material for the production of fruit juices and other confectioneries. Although Nigeria is the 8th largest producer of mango fruits in the world yet the fruits cannot be exported due to poor quality arising from poor postharvest management (FAOSTAT, 2007). Bulk of the fruits is produced by subsistence farmers who lack the resources and information to manage and export their produce. Poor harvesting methods, handling, transportation and storage of mango fruit in the country are attributable to the non patronage of the country's mango produce in the international market.

A lot of efforts had been made to extend the shelf life of fresh mango which include reduction of storage temperature (Gosbee and Jessup, 2001), treating mango fruits with plant growth regulators (Panhwar, 2005), hot water treatment (Anwar and Malik, 2007), packaging fruits in polyethylene bag (Ilesanmi *et al.*, 2011) and treating mango fruits with putrescine (Jawandha *et al.*, 2012). These efforts focus less on harvesting methods which is the most critical and crucial operation in postharvest handling of fruits. Traditional mango harvesting methods are employed in most part of the developing countries Nigeria inclusive, which basically involve plucking, hitting or shaking of the tree which causes cuts, bruises, abrasion, injuries and contact with pests and diseases (Yahia, 1999). These problems necessitate this research; it will seek to determine the effect of harvesting methods on postharvest shelf life of 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, Yola, Nigeria (Latitude 9°23'N and Longitude 12° 46'E at an altitude of 220 m above sea level), to study the effect of harvesting methods on the shelf life of mango fruits. Mature green mango fruit (zill variety) was used for the research and were harvested using three methods namely:

1. Harvested from an average height of 5m and fell on the bare ground using long hook,
2. Harvested from an average height of 5m and fell on the foam (mattress) using long hook
3. Harvested using picker (with sharp hook and small bag attached to collect the fruit after harvesting without touching the ground).

The harvested fruits were pre cooled in a shade, packaged in cardboard cartoon and stored under ambient condition. The treatments were laid in a Split Plot Design and all treatments consisted of 10 fruits with fruits harvested and fell on ground as control. The temperature of the storage facility was between 30 - 36°C and the relative humidity was within the range of 45 - 51% during the storage period, quality was monitored closely after every two days throughout the period of the research, appropriate data were taken on the
Following parameters using both objective and subjective methods:

1. ***Percentage weight loss:*** Percentage weight loss was obtained by weighing individual fruit from initial day of storage to the final day. Measurements were taken using Ohaus triple bar chemical balance model 700/800, the difference between original and final weights were calculated then divided by the original weight and expressed in percentage after every two days during the study. Percentage cumulative weight loss was calculated using the expression.

$$\%\ Weight\ loss\ = \frac{original\ weight\ -\ new\ weight\ \text{x}\ 100}{original\ weight}$$

2. ***Percentage deterioration:*** Percentage deterioration of fruits was calculated by counting the deteriorated fruits out of the total fruits in each treatment after every two days of storage interval and expressed in percentage. Fruits with visibly infected surface area which were not edible were considered as deteriorated. The percentage deterioration was calculated according to Jawandha *et al*. (2012) as follows:

$$\%\ Deterioration\ = \frac{number\ of\ fruits\ rotten\ \text{x}\ 100}{total\ number\ of\ fruits}$$

3. ***Percentage change in diameter:*** The fruit diameter refers to the width of the fruit midway between the nose and the stem ends of the fruit, it is determined by measuring the diameter midway between the stem and nose ends of the fruit using vernier clipper (Anwar and Malik, 2007). The fruit percentage change in diameter was obtained by finding the difference between original and final diameter, divided by the original diameter and then expressed in percentage after every two days during the study.

   Percentage change in diameter was calculated using the expression:

$$\%\ Change\ in\ diameter = \frac{original\ diameter\ -\ new\ diameter\ \text{x}\ 100}{original\ diameter}$$

4 ***Rate of deterioration***: The time it took a fruit to deteriorate during storage is the rate of deterioration of the fruit. Rate of deterioration for this research was obtained by dividing number of deteriorated fruit by the number of days it took each mango fruit to deteriorate from initial day of storage to the final day of spoilage

$$Rate\ of\ deterioration = \frac{number\ of\ rotten\ fruits}{days\ taken\ to\ rot}$$

5. ***Peel colour***: Skin colour or peel colour development was monitored after every two days throughout the storage period. The skin colour was divided into seven colour which were assessed by five panelists using 7 point hedonic scale. These are 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.

6. ***Skin texture***: Fruit texture was observed using 7 point Hedonic scale (hard = 7, moderately hard = 6, slightly hard= 5, neither hard nor soft = 4, slightly soft = 3 moderately soft = 2, soft = 1). Fruits were presented to a five member test panel that assessed the fruit samples and rated them for general firmness based on whether the mango yielded to thumb pressure.

7. ***Marketability***: A panel of five judges evaluated the sensory quality of the fruits at the interval of every two days during the research period using 7 point hedonic scale. 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.

Data collected were subjected to analysis of variance (ANOVA) using SAS system for windows (SAS v8, 2000) and values having significant effect were separated using Less Significant Difference (LSD)

Results and Discussion

Harvesting methods had highly significant ($P \leq 0.01$) effect on percentage weight loss of mango fruits at all the days of the storage periods except at days 2 (Table 1). Mango fruits percentage water loss reduced with increasing days of storage for all harvesting methods and fruits harvested with picker had the lowest percentage water loss. The significant effect may be because fruits harvested with picker were not subjected to physical and mechanical injuries as such the fruits have lower percentage water loss and this is in line with Abu-Goukh and Mohammed (2004) who had earlier reported that harvesting methods affect water loss in mango fruit during storage.

There were significant ($P < 0.05$) effects of harvesting methods on percentage deterioration of mango fruits during storage only in days 16 and 18 (Table 2). Percentage deterioration mostly increased with increasing storage periods until the fruits deteriorated completely for all harvesting methods. The significant effect might be due to the fast deterioration of fruits harvested on the ground caused by mechanical damage and infection suffered by the fruits. Earlier, Anwar and Malik (2007) reported similar findings that fruits that fall on the ground sustain injury which increased respiration rate and provide entry point for pests and diseases. The result of this study also agreed with Ladaniya (2008) who reported that, the best harvesting method that will prolong shelf life of fruit is by careful harvesting without the fruit hitting the ground.

The results of effect of harvesting methods on percentage change in fruit diameter showed that there was highly significant ($P \leq 0.01$) effect of harvesting methods on mango fruit percentage change in fruit diameter at the sampled periods 10, 12 and 14 (Table 3). Significant effect was also recorded at day 16, percentage change in diameter decreased with increasing sampled period. The significant effects might be due to increased transpiration, respiration rate and subsequent water loss from the fruits. Fruits that fell on the ground might have sustained mechanical damage which increased physiological activities (wound healing) thereby increasing water loss as a result, the fruit percentage change in diameter was

adversely affected. The finding of this study is in agreement with Jawandha *et al*. (2012) who posited mechanical damage significantly increased water loss and susceptibility to infection by postharvest pathogens.

Harvesting methods had highly significant ($P \leq 0.01$) effect on the rate of deterioration of mango fruit during storage at day 18 as shown in Table 4, likewise in days 8 and 16 significant ($P \leq 0.05$) effects were recorded. Fruits harvested with picker had the slowest rate of deterioration followed by fruits harvested on the foam and the fastest were fruits harvested on the ground during the experiment. This may be due to shock and mechanical injury suffered by the fruits harvested on the ground and the injury points provide entry avenues for rotting agents which hasten rate of deterioration. this finding conform with that of Singh *et al.* (2014) who affirmed that wounded mango fruit tissue lead to rapid quality loss. In the same vein, this result agreed with Savikumar *et al*. (2011) that poor harvesting method caused decay, pest attack and physiological breakdown.

Highly significant ($P \leq 0.01$) effect of harvesting methods on the colour of mango fruits during storage were recorded at sampled periods 4, 10, 12, 14 and 16. Significant ($P \leq 0.05$) effect was also recorded at sampled period 6 (Table 5). Full colour development did not occurred in the fruits that were harvested on the ground before they became rotten; this might be because of the injuries on the fruit peel that permitted infection which shorten the shelf life of the fruits to just 8 days. In the case of the fruits harvested with picker, full peel colour developed during the 18 days of storage. This result is tandem in with Yahia (1999) who reported that physical injured mango fruits have poor colour development due to rapid decay.

There was highly significant difference between harvesting methods on mango fruit texture during storage periods 6, 8, 10, 12, and 14 whereas significant difference occurred at days 4 and 16 (Table 6). Fruit texture decreased with increased storage periods. Mango fruit harvested with picker gave the best textures followed by fruits harvested on the foam. Very soft fruit texture was recorded earliest on the fruits harvested on the ground at days 10 of storage. The significant effect of harvesting methods on fruit texture may be due to the injuries sustained during harvesting. Fruits that fell on the ground might be bruised or cut; these softened the texture of the fruits in just 8 days of storage. On the contrary, fruits harvested with picker took longer time to soften (16 days). This might be attributed to low respiration rate of the fruits since injured fruits have elevated respiration rate and high ethylene production during storage. The result of this study agreed with Kader (1983) and Ladaniya (2008) who reported increased physiological activities due to mechanical injury soften fruit texture.

There was a highly significant effect of harvesting methods on fruit marketability during all the storage periods except at days 2, 4 and 6 however, significant effect was obtained at days 4 and 6 (Table 7). Marketability rating decreased with increased storage period throughout the sampled periods. Mango fruits harvested with picker gave the highest marketability rating throughout the storage periods and the least rated fruits on marketability were those harvested on ground. This might be due to fruit injury or infection and pest attack suffered during harvesting. This is in agreement with Panhwar (2005) who earlier reported that injury free fruit peel increased mango fruit marketability during storage.

Conclusion and Recommendation

From the results of this study it is concluded that harvesting methods had significant effect on the quality and shelf life of mango fruit. Harvesting with picker improved quality and extended the shelf-life of mango fruits. The following were recommended: Mango fruits should be harvested carefully without falling on the ground Harvesting mango fruits with picker help to prolong shelf-life and maintain quality.

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APPENDIXES

Table 1: Effects of Harvesting Methods on the Percentage Weight Loss of Mango Fruit during Storage in 2014.

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Harvesting method									
Ground	1.33	5.88	5.48	2.03	1.88	0.00	0.00	0.00	0.00
Picker	0.25	3.08	2.82	2.57	2.33	2.12	1.87	0.67	0.57
Foam	1.12	5.27	4.95	4.58	4.25	3.23	2.95	1.57	0.00
LSD	2.49	0.59	0.74	0.52	0.46	1.52	1.38	0.42	1.28
Probability of F	0.50	< .001	0.001	< .001	< .001	0.01	0.01	0.001	0.01

Table 2: Effects of Harvesting Methods on the Percentage Deterioration of Mango Fruit during Storage in 2014.

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Harvesting Method									
Ground	0.33	1.00	6.67	0.00	0.00	0.00	0.00	0.00	0.00
Picker	0.00	0.00	0.00	0.00	0.00	0.00	10.00	16.67	16.67
Foam	0.33	0.67	3.33	26.67	5.00	11.67	0.00	0.00	0.00
LSD	1.20	2.95	17.72	29.99	11.33	13.62	13.09	9.99	15.11
Probability of F	0.69	0.66	0.62	0.11	0.44	0.12	0.16	0.02	0.05

Table 3: Effects of Harvesting Methods on the Mango Fruit Percentage Change in Diameter during Storage in 2014.

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Harvesting Methods									
Ground	8.03	7.70	6.77	5.40	1.95	0.00	0.00	0.00	0.00
Picker	7.33	7.10	7.37	7.03	6.68	6.67	6.40	3.90	1.78
Foam	7.97	7.68	7.42	7.18	6.90	4.50	2.37	0.00	0.00
LSD	0.601	0.819	0.968	2.315	1.919	2.060	2.745	2.494	2.023
Probability of F	0.103	0.183	0.232	0.173	0.003	0.002	0.007	0.019	0.112

Table 4: Effects of Harvesting Methods on rate of Deterioration of Mango Fruit during Storage in 2014

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Harvesting Method									
Ground	0.67	1.33	1.00	5.33	1.67	0.00	0.00	0.00	0.00
Picker	0.00	0.00	0.00	0.00	0.00	0.00	2.33	8.00	12.00
Foam	0.50	0.83	1.00	1.00	3.33	4.00	4.67	2.83	0.00
LSD	2.07	3.83	3.93	4.72	3.78	7.85	8.36	6.46	6.24
Probability of F	0.68	0.65	0.73	0.05	0.160	0.360	0.391	0.05	0.009

Table 5: Effects of Harvesting Methods on Mango Fruit Colour during Storage in 2014

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Harvesting Method									
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	0.44	0.002	0.024	0.10	0.002	0.002	.< 001	0.009	0.48

Table 6: Effects of Harvesting Methods on the Texture of Mango Fruit during Storage in 2014.

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
Harvesting methods									
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
Prob. of F	0.26	0.017	0.008	<. 001	<.001	0.002	<.001	0.03	0.11

Table 7: Effects of Harvesting Methods on the Marketability of Mango Fruit during Storage in 2014.

Treatment	Storage period (days)								
	2	4	6	8	10	12	14	16	18
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
Prob. of F	0.17	0.05	0.05	0.0001	0.0001	0.0005	0.01	0.002	0.006