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Influence of harvesting method on postharvest loss, shelf-life and quality of mango (*Mangifera indica*) fruits

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ABSTRACT

Postharvest losses in mango fruits affect its availability and per capita consumption to consumers. Among the factors causing postharvest losses, improper harvesting method is major one, which affects postharvest quality and shelf life of mango fruits. Hence, an attempt was made to observe the response of mango towards harvesting method. For this study, four commercial cultivars of mango (Amrapali, Chausa, Dushehariand, and Langra) grown at ICAR-IARI, New Delhi were selected. Fruits were harvested manually and mechanically at full maturity, de-saped, pre-cooled and stored in corrugated fibre board boxes (CFB) at ambient conditions for 10 days. Observations on various postharvest loss parameters were recorded, right from harvesting, till the end of shelf-life. Results revealed that significant differences occurred among cultivars and storage days in both manual and mechanically harvested fruits. Further, mechanical harvesting was found efficient not only in controlling quantitative loss but also maintained postharvest quality and increased shelf-life significantly. Interestingly, cultivar Amrapali and Dushehari were recorded as more responsive towards mechanical harvesting as they exhibited for less postharvest losses and maintained better quality than Langra and Chausa. Thus, mechanical harvesting and knowledge of cultivar response towards mechanical harvesting will help growers in reducing postharvest losses and increasing shelf-life and quality of mango fruits.

Key words: Cultivar, Mango, Mechanical harvesting, Postharvest losses, Postharvest quality

Mango (*Mangifera indica* L.), is an important fruit, which is also called as 'King of fruits' in India (Litz 2009, Chattopadhyay 2014). It belongs to genus *Mangifera* and family, Anacardiaceae. It is indigenous to the Indian subcontinent where it is grown abundantly in tropical and sub-tropical regions for over 400 years (Chattopadhyay 2014). Internationally, India stood at first place in mango production, accounting a global share of 56% (Anonymous 2017a). At national level, mango showed a record production of 20.2 MT from an area of 2.26 mha (Anonymous 2017a) and accounted for an annual export of 443 crores in 2017 (Anonymous 2017b). Similar to other tropical fruits, mangoes are physiologically and biologically active even after harvest. Once fruits are harvested, these processes along with other bio-chemical deterioration, decrease the fruit quality very quickly which affects its marketability, becomes highly susceptible to postharvest losses (Roy 1993, Wills *et al.* 2007, Jha *et al.* 2015).

Postharvest losses in this important fruit crop are always a topic of concern for various mango growing countries worldwide (Patil *et al.* 2013, Luo *et al.* 2015), especially South Asian countries including India, as this directly affects its trade and availability to consumers (Chattopadhyay 2014). Till date there is still existence of lack in systematic study on effect of harvesting method on mango postharvest loss and its quality, which is need of hour for mango trade (Pacheco *et al.* 2017). Mango respond very well to mechanical harvesting but on the same time, there is need to carry out extensive studies to find out the effects of harvesting method on the extent to which harvesting methods affect postharvest loss in terms of quantity and quality (Abu-Gaukh *et al.* 2004, Pacheco *et al.* 2017)

Thus, reduction in the extent of postharvest losses will not only improve farmers/growers income but will increase per capita availability of mango fruit to Indian population. The knowledge of mechanical harvesting and cultivar response towards mechanical harvesting will also help growers in reducing postharvest loss in terms of quantitative, qualitative, and pathological loss and increasing shelf-life and quality of mango fruits.

MATERIALS AND METHODS

To study the effect of harvesting technique on mango fruits, four commercially grown mango cultivars such as Amrapali (Dushehari × Neelum), Dushehari, Langra and

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Chausa were selected. The fruits were harvested by two methods, i.e. manually and mechanically (pole mounted mechanical harvester) in two different lots at appropriate maturity (specific gravity > 1) from the orchard of the Institute. After harvesting, fruits were de-saped, precooled and stored in CFB (corrugated fibre board boxes) under ambient storage conditions (25 ± 4º C and 65 ± 5% RH) for normal ripening. Observations on various postharvest loss attributes such as physical loss, physiological loss in weight, pathological loss and quality loss were recorded till the end of storage life at 3 days interval.

Postharvest physical loss (PPL) comprised of fruit loss due to physical bruising injury, abrasion, cuts and induced lesions which occurred while harvesting/handling and appeared during storage. Physical loss was calculated on percentage basis, i.e. by identifying the good fruits than those fruits which were physically injured/unfit, as per given formula:

Postharvest physical loss (%) = Fruit affected by physical loss / Total number of mango fruits × 100.

Physiological loss in weight was calculated by marking individual mango fruit of each lot. High precision electronic balance was used to weigh the fruits, during storage and the cumulative PLW was calculated by using the following formula and expressed in percentage (%).

PLW (%) = (Initial weight–Final weight)/Initial weight × 100

The storage life of mango fruits of each lot, was calculated by using PLW, physiological attributes and sensory score (face value, gloss, taste, flavour etc.) and represented in days. The total soluble solids of mango fruit pulp samples were estimated by using FISHER Hand Refractometer (range 0 to 50), at the room temperature between 18-28ºC and expressed in ºB (AOAC 2006). Titratable acidity was determined by using 0.1 N NaOH, the method as described by Ranganna (1986). For which 5g of fruit sample was weighed and put to 50 ml water. It was thoroughly mixed and then filtered. The filtered sample was titrated against 0.1 N NaOH using a few drops of 1% phenolphthalein solution as indicator. The observed titratable value was used for calculating the values as per cent anhydrous citric acid by using the following formula:

$$\text{Titratable acidity (\%)} = \frac{\text{Titratable value} \times \text{Normality of Alkali} \times \text{Vol. made up} \times \text{Equivalent wt. of acid} \times 100}{\text{Vol. of sample taken for estimation} \times \text{Weight or Volume of sample taken} \times 1000}$$

For determination of pathological loss, the pathogen affected fruits were analyzed and the identification of pathogen associated with postharvest decay was carried out, that based on their morphological characteristics under the

Table 1 Physical loss in various cultivars of mango as affected by harvesting method

Cultivar	Physical loss (%)*							
	Hand harvesting				Mechanical harvesting			
	Storage days			Mean	Storage days			Mean
	0	3	6		0	3	6	
Dushehari	24.4	26.5	27.8	26.3	2.5	3.5	6.8	4.2
Chausa	26.8	28.3	31.3	29.0	3.0	4.5	8.0	5.1
Amrapali	18.7	22.9	24.7	21.8	2.0	3.0	5.4	3.4
Langra	28.4	32.5	34.2	31.3	3.5	5.0	8.3	5.6
Mean	24.6	27.2	29.4	27.1	2.7	4.0	7.1	4.6
CD	Cultivar = 0.63; Storage days = 0.55: Cultivar × storage days = 1.10				Cultivar = 0.67; Storage days = 0.58: Cultivar × storage days = NA			

*Physical losses were assessed upto 6th day only.

Table 2 Physiological loss in weight and shelf-life of mango fruits as affected by harvesting method

Cultivar	Physiological loss in weight (%)								Shelf-life at ambient storage (days)		
	Hand harvesting				Mechanical harvesting				Harvesting method		
	Storage days			Mean	Storage days			Mean	Hand	Mechanical	Mean
	3	6	9		3	6	9				
Dushehari	4.7	9.1	19.7	11.2	4.6	7.8	15.1	9.1	6.0	8.0	7.0
Chausa	5.5	11.5	24.3	13.8	5.5	9.0	17.7	10.7	6.0	7.0	6.5
Amrapali	4.0	8.0	16.8	9.6	4.0	5.7	13.4	7.7	7.0	8.0	7.5
Langra	7.3	13.8	26.5	15.9	7.3	9.5	21.5	12.7	5.0	7.0	6.0
Mean	5.4	10.6	21.8	12.6	5.3	8.0	16.9	10.1	6.0	7.5	
CD	Cultivar = 0.31; Storage days = 0.27: Cultivar × storage days = 0.54				Cultivar = 0.22; Storage days = 0.19: Cultivar × storage days = 0.38				Cultivar = 0.30; Storage days = 0.21: Cultivar × storage days = 0.43		

compound microscope at Division of Plant Pathology and Indian Type Culture Collection Facility, ICAR-IARI. The morphology of spores and fruiting body was compared with standard morphologic figures of the pathogen.

Experiment was carried out by using factorial completely randomized design (2 factor CRD) with three replications, having 100 fruits in each cultivar.

RESULTS AND DISCUSSION

Physical loss

It is evident from Table 1 that physical loss was significantly higher in manually harvested mango fruits (27.1%) than mechanically harvested fruits (4.6%), and the pattern of physical loss was similar in manual and mechanical harvesting in all the four selected cultivars. In manual harvesting, significant differences occurred among selected cultivars for physical loss as fruits of cultivar Langra recorded for maximum loss (31.3%) followed by Chausa (29.0%). Among storage days, maximum physical losses were observed on 6th day of storage (29.4%). Similarly, mechanically harvested fruits of Langra (5.6%) followed by Chausa (5.1%) have shown highest physical loss, while fruits of cultivar Amrapali recorded the least (3.4%). This difference of physical loss among the varieties might be due to the varietal characteristics and resultant of response of mango varieties towards harvesting and storage (Baloch and Bibi 2012, Msogoya and Kimaro 2011). Mechanical harvested fruits have very less physical loss (7.1%) than manually harvested fruits (29.4%) at 6th day of storage (Table 1). These finding corroborate with the DMI Report of postharvest loss profile of mango (Anonymous 2013) which reported that upto 15% postharvest physical loss occur during harvesting in various states of India and supposed to affected by harvesting technique.

Physiological loss

Physiological loss occurs primarily due to loss in weight. It is one of the major factor which affect shelf life of fruits (Kader 2002). Results revealed a steady increase in physiological loss in weight over the storage period, irrespective of harvesting method (Table 2) which might be due to the varietal, genotypic, fruit peel and fruit size characteristic of mango cultivar (Abu-Gaukh *et al.* 2004, Karuna *et al.* 2015). Significant differences have occurred among the varieties and storage days for physiological loss in weight in both manually and mechanically harvested fruits of all four cultivars under study. In general, mechanically harvested fruits exhibited less mean PLW (10.1%) than manually harvested mango fruits (12.6%). In case of manually harvested fruits, irrespective of storage days, highest physiological loss was exhibited by fruits of Langra (15.9%), non-significantly followed by fruits of Chausa (13.8%). Among the mechanically harvested fruits, cultivar Langra (12.7%) recorded the highest physiological loss in weight. Irrespective of harvesting method, Amrapali recorded the lowest physiological loss in weight when

Table 3 Postharvest pathological loss of various cultivars of mango fruits as affected by harvesting method

Cultivar	Anthracnose (%)								Stem-end rot (%)								Total pathological loss (%)							
	Hand harvesting				Mechanical harvesting				Hand harvesting				Mechanical harvesting				Hand harvesting				Mechanical harvesting			
	Storage days			Mean	Storage days			Mean	Storage days			Mean	Storage days			Mean	Storage days			Mean	Storage days			Mean
	3	6	9		3	6	9		3	6	9		3	6	9		3	6	9		3	6	9	
Dushehari	5.3	12.3	18.6	12.1	3.3	6.6	14.3	8.1	2.3	11.3	15.3	9.6	2.3	8.3	12.3	7.6	7.6	23.6	34.0	21.7	5.6	14.9	26.6	15.6
Chausa	6.3	14.6	23.3	14.7	5.6	11.6	15.6	11.0	2.6	8.6	18.6	10.0	2.6	10.6	14.6	9.2	9.0	23.3	42.0	24.7	8.2	22.2	30.2	20.2
Amrapali	3.3	10.6	14.3	9.4	1.6	5.6	11.3	6.2	1.6	5.3	11.3	6.1	1.3	4.3	9.3	4.9	5.0	16.0	25.6	15.5	2.9	9.9	20.6	11.1
Langra	8.3	18.3	25.6	17.4	5.6	12.6	19.3	12.5	4.6	12.6	22.6	13.3	3.6	12.3	15.3	10.4	13.0	31.0	48.3	30.7	9.2	24.9	34.6	22.9
Mean	5.8	14.0	20.5	13.4	4.0	9.1	15.1	9.4	2.8	9.5	17.0	9.7	2.4	8.9	12.8	7.8	8.6	23.4	37.4	23.2	6.4	17.9	27.9	17.2
CD	Cultivar = 0.63; Storage days = 0.54: Cultivar × storage days = 1.09				Cultivar = 0.84; Storage days = 0.73: Cultivar × storage days = 1.46				Cultivar = 0.56; Storage days = 0.48: Cultivar × storage days = 0.97				Cultivar = 0.79; Storage days = 0.69: Cultivar × storage days = 1.38				Cultivar = 0.32; Storage days = 028: Cultivar × storage days = 0.56				Cultivar = 0.33; Storage days = 029: Cultivar × storage days = 0.58			

harvested manually (9.6%) or mechanically (7.7%) (Table 2).

Results indicate that at 9th day of storage, irrespective of cultivars under study, mechanically harvested mango fruits have nearly 4.9% lower PLW than manually harvested mango fruits as mechanically harvested fruits recorded a mean physiological loss in weight of 21.8 and 16.9%, respectively at the end of shelf-life (Table 2). This might be due to the effect of harvesting technique on the fruit softening and ripening process, apart from the basic morphology of fruits, as fruit softening directly affects the physiological process in mango fruits (Abu-Gaukh *et al.* 2004, Msogoya and Kimaro 2011).

Shelf-life

It is evident from Table 2 that mechanically harvested fruits have higher shelf-life by 1.5 days than manually harvested fruits, being 6.0 and 7.5 days, respectively. Increase in shelf life may probably be due to decreased physiological loss in weight (Kader 2002, Baloch and Bibi 2012) and less physical decay (Anonymous 2013) by mechanical harvesting. Further, among the selected cultivars, Amrapali cultivar has shown the highest shelf-life manually (7 days) or mechanically (8 days), whereas, Langra fruits have recorded for the least shelf-life (Table 2). This significant varietal difference in shelf-life might be due to genotypic characteristic of the varieties of mango (Karuna *et al.* 2015, Prasad *et al.* 2016).

Pathological loss

Experimental findings revealed significant differences among varieties, storage days and interaction varieties × storage days for anthracnose and stem end rot incidence and total pathological loss in both manually and mechanically harvested fruits of all four selected cultivars. Manually harvested mango fruits have higher incidence of anthracnose (13.4%), stem end rot (9.7%) and total pathological loss (23.2%) than mechanically harvested mango fruits (Table 3). Furthermore, irrespective of method of harvesting, Langra cultivar exhibited highest incidence of anthracnose (17.4%, 12.5%), stem end rot (13.3. 10.4%) and total pathological loss of 30.7 and 22.9%, respectively and Amrapali cultivar exhibited the least (Table 3). Furthermore, there was an increased incidence of total pathological loss with increase in storage days (Table 3). Significant differences for diseases incidence and total pathological loss among varieties and storage days might be due to varietal host susceptibility to postharvest diseases (Anon 2013, Patil *et al.* 2013, Luo *et al.* 2015, Malik *et al.* 2016). Lower pathological loss in mechanically harvested mango fruits may be due to less injuries by harvesting technique (Msogoya and Kimaro 2011, Anonymous 2013), climate (Malik *et al.* 2016), host specificity and susceptibility (Patil *et al.* 2013, Luo *et al.* 2015) and response of cultivars towards mechanical harvesting (Abu-Gaukh *et al.* 2004, Pacheco *et al.* 2017).

Fruit quality

Among manually and mechanically harvested fruits, irrespective of storage days, highest total soluble solids were recorded in fruits of cultivar Amrapali (22.1 and 22.6 ºB, respectively) (Table 4). Further, irrespective of cultivar and storage day, there was no significant difference in total soluble solids between the manually harvested (20.4 ºB) and mechanically harvested (20.6 ºB) fruits (Table 4). The insignificant difference in TSS might be due to the fact that although manually harvested fruits attained early ripening (Abu-Gaukh *et al*. 2004) but mechanically harvested fruits succeeded in attaining higher TSS with progression of shelf-life (Pacheco *et al.* 2017). The results reveal that postharvest quality is resultant of both varietal fruit characteristic and its response towards harvesting type. Furthermore, the data presented in Table 4 indicates that titratable acidity had shown a decreasing trend as the storage progresses. The decrease in acidity was attributed towards the conversion of citric acid into sugar, which was further utilized by fruit in its metabolic process (Baloch and Bibi 2012). Occurrence of significant changes among the varieties and storage days for titratable acidity was recorded, which is varietal characteristic (Baloch and Bibi 2012). Whereas, irrespective of cultivars and storage day, no significant difference was recorded between manually (0.22%) and mechanically harvested fruits (0.22%). However, the slight differences among the manually and mechanically harvested fruits

Table 4 Fruit quality of various cultivars of mango fruits as affected by harvesting method

Cultivar	Total soluble solids (ºB)								Titratable acidity (%)							
	Hand harvesting				Mechanical harvesting				Hand harvesting				Mechanical harvesting			
	Storage days			Mean	Storage days			Mean	Storage days			Mean	Storage days			Mean
	3	6	9		3	6	9		3	6	9		3	6	9	
Dushehari	18.1	20.8	22.8	20.5	18.1	21.2	23.5	20.9	0.36	0.29	0.20	0.28	0.36	0.30	0.17	0.27
Chausa	16.7	20.6	22.0	19.7	16.6	20.2	22.2	19.7	0.32	0.20	0.13	0.21	0.32	0.20	0.11	0.21
Amrapali	18.9	22.3	25.1	22.1	18.9	22.8	25.9	22.6	0.31	0.14	0.06	0.17	0.31	0.15	0.04	0.15
Langra	16.7	19.3	21.6	19.2	16.7	19.0	21.9	19.2	0.35	0.21	0.15	0.23	0.35	0.20	0.13	0.22
Mean	17.6	20.7	22.9	20.4	17.6	20.8	23.3	20.6	0.33	0.21	0.13	0.22	0.33	0.21	0.11	0.22
CD	Cultivar = 0.27; Storage days = 023; Cultivar × storage days = 0.47				Cultivar = 0.32; Storage days = 028; Cultivar × storage days = 0.57				Cultivar = 0.02 ; Storage days = 0.01; Cultivar × storage days = 0.03				Cultivar = 0.01 ; Storage days = 0.01 ; Cultivar × storage days = 0.02			

during storage days might be due to the response of mango fruit to physical abrasion, stress, physiological and ripening process as reported by Pacheco *et al.* 2017.

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