Postharvest Quality and Shelf Life of Mango (*Mangifera Indica* L.) Fruit: As Affected by The Degree of Exposure to Sunlight

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Abstract

The mango fruit was harvested at the hard green stage of maturity from different (orientation) sides of the tree East, West, North, and South and was stored at 30°Cthe till ripening. The results indicated that the quality was best and water percent was lowest for the fruit harvested from South (sun exposure time for the fruit was maximum) orientation of tree; the shelf life was longest and weight percentage was lowest for North direction as compared to others, irrespective of the variety. The obtained results showed that East and West values of various parameters were almost the same whereas, these were significantly different for the North and South sides, irrespective of the variety. It was also noted that the Langra variety is more responsive to sun exposure than compared to Samar Bahisht Chaunsa variety.

***Keywords**:* Mango fruit quality; sunlight exposure; shelf life; waste percent.

Introduction

Mango, a climacteric, and highly perishable fruit have a very short shelf life. It generally reaches to respiration peak of the ripening process within three to four days after harvesting at ambient temperature and two to three weeks in cold storage at 13°C but certainly depends upon variety, temperature, and transportation conditions (Narayana *et al*., 1996; Carrillo-Lopez *et al*., 2000). It is therefore generally harvested at the mature green stage and ripens during the marketing, storage period, and consumption process. In addition to these market constraints, the high variability of pre-harvest and post-harvest factors affects its quality. Some

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of the major factors play the role in heterogeneity in size, quality, wastage, and shelf life of the fruit. However, scientists are up to now concentrating on the maturity at the harvest stage and the apparent quality of the fruit so that it must attract consumers and/ or on postharvest management (Baloch and Bibi, 2012: Nunes *et al*., 2007; Label *et al*., 2003; Hoa *et al*., 2002; Jacobi *et al*., 1995).

The ripening of the fruit may change in structural polysaccharides causing softening, increase in respiration and/ or ethylene production, degradation of chlorophyll, developing pigments by carotenoids biosynthesis, change in carbohydrates or starch into sugars, lipids, phenolic and volatile compounds, and organic acids (Herianus *et al*., 2003). Therefore, small variations in pre-harvest environment, harvesting techniques, storage, and transportation conditions may greatly affect the shelf life and/or quality of the fruit (Sati and Qubbaj, 2021; Hmmam et al., 2021; Jitjak and Sanoamuang, 2021; Abera et al., 2019; Wong et al., 2016) Diseasesase caused by virus, fungi and bacteria, physiological disorders, nutrition deficiencies, parasites, injuries occur due to the environment, and diseases of postharvest due to pre-harvest environment, transit, and storage (Ishaq *et al*., 2004; Iqbal *et al*., 2004). These factors, amongst others and combined with the high perishability of fresh produce, contributed to higher (20-30%) spoilage and unnecessary losses. Wastage of mango fruit due to anthracnose and stem end rot limits the storage potential of mango fruit up to large extent (Narayana *et al*., 1996).

To explore the effect of sun exposure, the mango fruits were harvested at the hard green stage of maturity from different (orientation) sides of the tree i.e. East, West, North, and South, and stored at 30°C.

Material and Methods

Sampling

The research experiment was conducted over Langra and Samar Bahisht Chaunsa (S.B. Chaunsa) mango fruit varieties. The fruit was harvested randomly by hand from Government Fruit Nursery Farm, Agriculture Extension Department, Dera Ismail Khan, Pakistan. The harvested fruits were washed and cleaned to eliminate all external materials such as dust, dirt, etc. The collected fruits were similar in size, had a good appearance, and were free from damage or infection.

Treatments

The mango fruits were harvested at the hard green stage of maturity from different (orientation) sides of the tree i.e. East, West, North, and South. The fruits were stored at 30°C with relative humidity (RH) of 64% till ripening, using a Hot Pack incubator (Philadelphia, PA).

Analysis

Two hundred and fifty fruits of mango were collected for every test and variety. Every analysis was carried out three times and the data presented is the average of the repeated analysis over the period of three years. The fruits of mango were analyzed for various parameters at harvest as well as at the ripened stage. The two-factor experiment was laid out in a Completely Randomized Design (CRD) with three replications.

Organoleptic evaluation

The skin color, aroma, and flavor were determined for all the samples using the Hedonic scale (Larmond, 1977). A panel of twenty-one experts whose age was 20-45 years was prepared. Twenty-one fruits of mango for every sample were randomly selected and cut into six parts. The obtained material was divided equally amongst the experts. Panelists were sent to various compartments which were constructed for the determination and had adequate light to judge the real color of the sample. The panelists scored the various samples by assigning the numbers from 0-10 (0-2 means extremely disliked, 2.1-4.0 fair, 4.1-6.0 good 6.1-8.0 very good, and greater than 8 means excellent aroma and flavor). The skin color of mango samples was categorized as 0-2 means green, 2.1-4.0 light green, 4.1-6.0 light yellow, 6.1-8.0 yellow, and 8.1-10 full yellow.

Measurements of ascorbic acid

The pulp of five mango fruit was taken and thoroughly mixed and it was used for the evaluation of ascorbic acid. The ascorbic acid contents were measured by titrating ten grams of mixed pulp sample against the standard 2, 6 dichlorophenol dyes, following the method outlined in (AOAC, 2000).

Measurements of total carotenoids and total sugar

The total carotenoid content of flesh was measured according to the procedure of Anwar et al., (2008) and was stated as μg/g of β-carotene equivalent to a standard curve of β-carotene. Total sugar was estimated by evaluating the refractive index using a digital refractometer.

Measurement of ripened stage

The fruit ripened stage was noticed through the difference in color, sugar, contents, and firmness with the passage of time (Shorter and Joyce, 1998).

Marking of fruit as waste

Fruit waste was measured as when its value of firmness was lesser than 4 on the Hedonic scale and/or it was either infected by a disease.

Statistical analysis

Each value was expressed as the mean of three independent experiments. Data were assessed by analysis of variance (ANOVA) through Duncan's multiple range tests using SPSS software (SAS Institute Inc., Cary, NC).

Results and discussions

The fruits were harvested at the mature green stage from the different (East, West, North, and South) orientations/sides of a tree to evaluate the impact of duration of exposure to the sun on the quality and shelf life of mango. It was noted that the sun rises from the Northeast and sets in the Northwest of the trees and hence South of the tree remained exposed to the sun for a longer time (Figure 1) during the summer season of the Dera Ismail khan region.

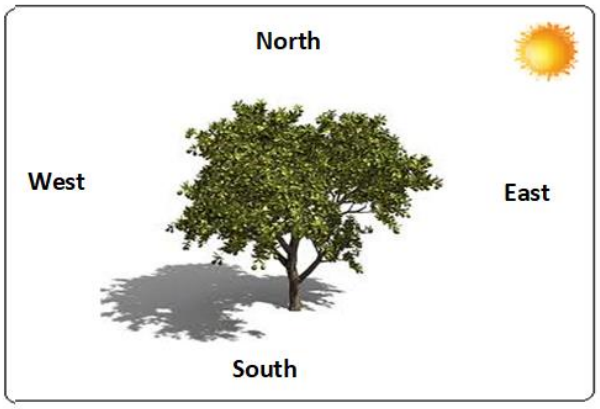

Figure 1: Fruit exposure to sunlight on the tree.

The organoleptic parameters (colour, aroma, and flavor) and chemical constituents (sugar, carotenoids and ascorbic acid) were measured at the time of harvest and listed in Table 1. The results obtained at the harvest time showed that East and West values of various parameters were almost the same whereas, these were significantly different for the North and South sides, irrespective of the variety (Tables 1). The color, aroma, and flavor measured at the ripened stage were highest for South and lowest for North, but the results of East and West were almost the same, irrespective of the variety (Table 2). This means that the longer the exposure time of the fruit to the Sun, the better the quality was as expected.

The sunlight provided UV radiations as well as heat/energy that help in chlorophyll synthesis and accelerated most of the reactions needed by the fruit for ripening (Saengnil *et al*., 2011; Cecchi *et al*., 2005; Farquhar *et al*., 1980; Lechaudel and Joas, 2007).

Sugar and carotenoid contents measured at the ripened stage for (Langra and Samar Bahisht Chaunsa) fruit were highest for the South and lowest for the Northern side of the tree; but these parameters were almost the same for East and West, irrespective of the variety (Table 2). The mango fruit remained exposed to more sunlight on the Southern side and hence the sugar and carotenoids contents of the fruit were high (Saengnil *et al*., 2011; Cecchi *et al*., 2005; Lechaudel and Joas, 2007; Farquhar *et al*., 1980). The ascorbic acid content was highest in the North and lowest in the South direction. The values of North were significantly different from other treatments, but East and South were non-significant under the limit $P < 0.05$.

Table 1
The average value of organoleptic and chemical parameters values obtained at harvest time for Langra and Samar Bahisht Chaunsa mango.

Variety	T*	Color	Aroma	Flavor	Total sugar (%)	TC (µg/g)	AA (mg/100g)
Langra	East	$1.25^{b\dagger}$	1.12^{a}	1.15^{a}	$4.49^{b\dagger}$	26.62^{b}	288.42^{b}
	West	1.21^{b}	1.08^{a}	1.08^{a}	4.38^{b}	26.48^{b}	288.74^{b}
	North	0.51^{c}	0.44^{b}	0.42^{b}	3.71^{c}	24.89^{c}	290.68^{a}
	South	1.77^{a}	1.16^{a}	1.22^{a}	5.18^{a}	27.45^{a}	287.65^{c}
S.B.Chaunsa	East	1.46^{b}	1.12^{a}	1.22^{a}	5.48^{b}	58.55^{b}	181.44^{b}
	West	1.41^{b}	1.11^{a}	1.16^{a}	5.37^{b}	58.35^{b}	181.75^{b}
	North	0.73^{c}	0.62^{c}	0.56^{b}	4.69^{c}	56.59^{c}	183.82^{a}
	South	1.99^{a}	1.19^{a}	1.44^{a}	6.22^{a}	59.22^{a}	180.59^{c}

*T, TC and AA stand for treatments, total carotenoids and ascorbic acid, respectively.
†Values having different superscripts in the columns are significantly different under the limit of $P < 0.05$. The comparison has been made within the variety.

The time required by the fruit to reach at the ripened stage located at the North of the tree was more compared to other sides. The shelf life of mango was longest for The North and lowest for South and East directions, irrespective of the variety (Figure 2). The ripening process becomes very sensitive to temperature, exposure to sunlight energy available in the system, humidity and harvesting days, etc (Baloch et al., 2011; Zheng *et al*., 2007; Frylinck and Dubery, 1998; Ali *et al*., 1995).

Table 2

Average values of organoleptic and chemical parameters measured at the ripened stage for Langra and Samar Bahisht Chaunsa mango stored at 30°C temperature.

Variety	T*	Color	Aroma	Flavor	Total sugar (%)	TC (µg/g)	AA (mg/100g)
Langra	East	$7.96^{b\dagger}$	7.99^{b}	7.95^{b}	$22.11^{b\dagger}$	62.89^{b}	79.01^{b}
	West	7.78^{b}	7.81^{b}	7.84^{b}	21.89^{b}	62.61^{b}	79.14^{b}
	North	7.16^{c}	7.25^{c}	7.22^{c}	20.75^{c}	61.22^{c}	80.05^{a}
	South	8.42^{a}	8.46^{a}	8.53^{a}	22.84^{a}	63.496^{a}	78.41^{c}
S.B. Chaunsa	East	8.12^{b}	8.01^{b}	8.11^{b}	24.62^{b}	87.89^{b}	66.07^{b}
	West	7.99^{b}	7.97^{b}	8.04^{b}	24.41^{b}	87.77^{b}	66.28^{b}
	North	7.29^{c}	7.42^{c}	7.52^{c}	23.49^{c}	86.24^{c}	67.21^{a}
	South	8.64^{a}	8.53^{a}	8.61^{a}	25.39^{a}	88.48^{a}	65.55^{c}

*T, TC and AA stand for treatments, total carotenoids and ascorbic acid, respectively.
†Values having different superscripts in the columns are significantly different under the limit of $P < 0.05$. The comparison has been made within the variety.

The weight loss percent of mango fruit was lowest for the North compared to other directions (Figure 3). The reason behind such a trend can be the difference in the average temperature among different sides of the tree. The waste percent of mango was lowest for South and highest for the North compared to other sides (Figure 4). This was attributed to the attacks of pests which were high at the North side. Infection caused by microorganisms is a serious issue of post-harvest losses in mango fruit (Ishaq *et al*., 2004; Iqbal *et al*., 2004).

Conclusion

The results showed that the quality was best and waste percent was lowest for Southern side; with more shelf life and lowest weight loss percent for the Northern direction as compared to the remaining sides. But the results of East and West were almost the same for both varieties of the mango fruit. It was also concluded that the Langra variety is more responsive to sun exposure as compared to the Samar Bahisht Chaunsa variety.

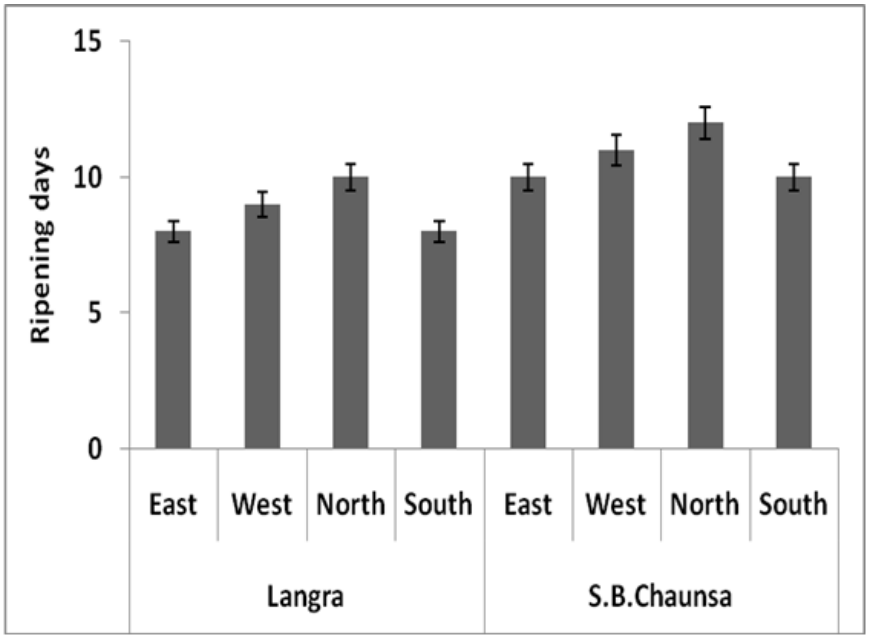

Figure 2: Time required by the fruit to reach at the ripened stage as a function of treatment and at 30°C storage temperature

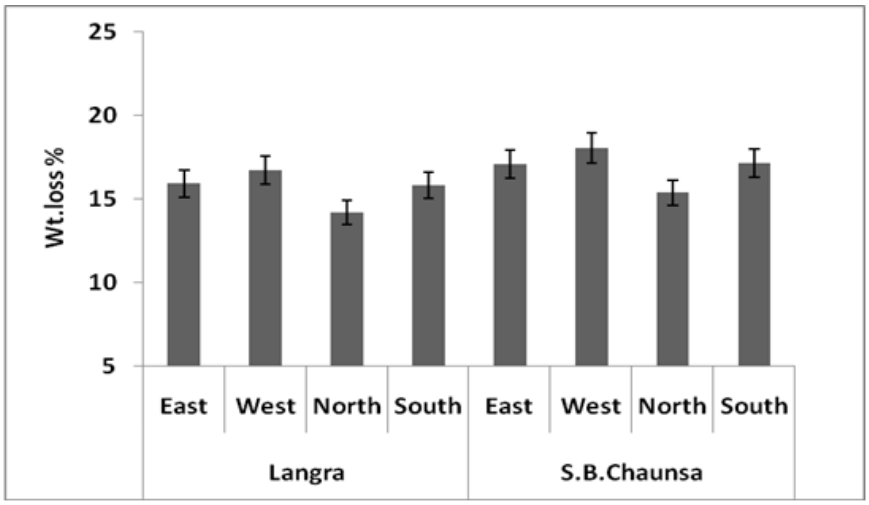

Figure 3: Weight loss percent (Wt. loss %) of mango fruit measured at the ripened stage as a function of treatment and at 30°C storage temperature

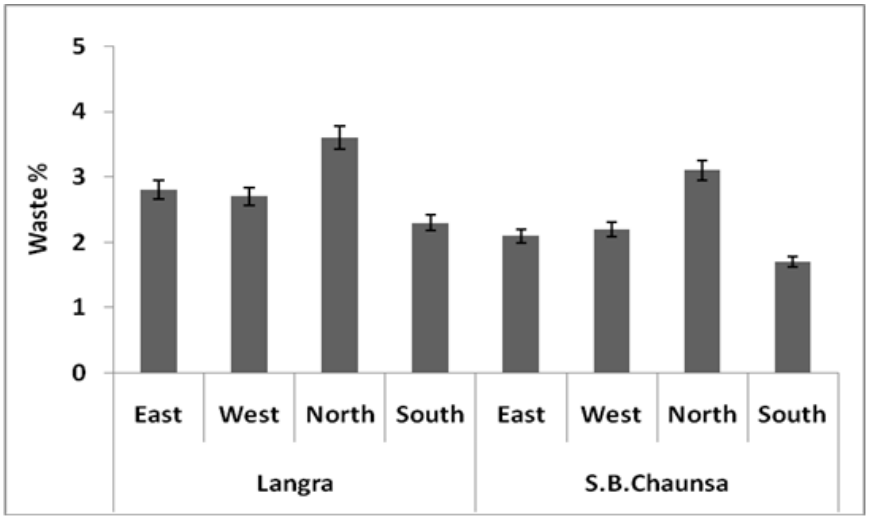

Figure 4: The waste percent of the fruit during the ripening process stored at 30°C

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