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Effect of postharvest treatments on physical characteristics of mango

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Abstract
The present postharvest investigation was aiming to assess the effect of various postharvest treatments on the storage behaviour of Mango cv. Himsagar during the year 2016-17 in the postharvest laboratory of Department of Horticulture and Postharvest Technology, Institute of Agriculture, Visva-Bharati, Sriniketan. Fresh fruits of uniform size, shape, colour, free from disease and bruises were harvested at physiological mature stage and after pre-cooling, desapping and washing were given various postharvest treatment of sodium hypochlorite (NaOCl: 100, 150, 200ppm), 6-benzyladenine (BA: 50, 100, 150ppm) and hot water (52 to 55^{o} C) for 5, 10 and 15 minutes. The fruits were subjected to air dried and kept in 5 ply corrugated boxes (5% ventilation) with newspaper lining and stored in ambient conditions. The fruits were analysed for various physical quality attributes at different storage intervals up to 12 days. The results revealed that minimum physiological loss in weight (0, 3.07, 5.98 and 10.89%) and high surface (shrinkage) score (5, 5, 4.8 and 4.4) of the fruits after 3, 6, 9 and 12 days respectively were observed in BA (100ppm) treated fruits during storage. Moreover, higher flesh firmness retention and palatability rating have best resulted from BA treated fruits during storage. Hot water treatment for 5 minutes was found to be best in controlling the microbial spoilage percentage in all analysis intervals. This study shows that the storability and physical quality of mango cv. Himsagar can be favourably influenced during storage when treated with BA and hot water treatment.

Keywords: Mango, NaOCl, BA, hot water, physical quality, storage

Introduction
Mango (*Mangifera indica* L.) the irresistible fruit indigenous to the Indo-Burma region (Mukherjee, 1958) [27] is the only fruit which lends itself to a smorgasbord of preparations both in its ripe and unripe forms. Due to its excellent dessert quality, adaptability, relatively hardy nature and low cost of raising, mango have spread throughout the length and breadth of India except in the hilly regions above 1400 m above mean sea level. It has a large varietal wealth, delicious taste, attractive fragrance and many health promoting properties (Salunkhe and Desai, 1984) [29]. India ranks first in mango production (19686.9 thousand MT) with a total area of 2262.8 thousand hectares (Anonymous, 2017) [4]. In West Bengal, the area under mango cultivation is 97.93 thousand hectare and production of 836.07 thousand MT (Anonymous, 2017) [4]. The major mango producing districts are Malda, Murshidabad, 24 Parganas North and Nadia (Anonymous, 2017) [4]. Mango cv. Himsagar is the choicest variety and indigenous to West Bengal and has gained extensive popularity for its excellent dessert and keeping quality (Anonymous, 2018) [5]. There is also a considerable amount of mango fruits losses every year during harvest and post-harvest handling which comes up to an average of 9.16 % (Jha *et al.*, 2015) [17]. Fruit rot in storage and on the field condition is the major factor affecting production and marketing worldwide (Jay, 2003; Onuba and Nwagbara, 2011) [15, 11]. In comparisons with other fruits, mangoes have greater problems in storage and transportation because of its perishable nature (Mitra and Baldwin, 1997) [25] so; Amin *et al.* (2008) [3] described its postharvest management major challenges in mango industry. The physical appearance of the fruits is the foremost and primary factor critical to consumer acceptance in the market. So it is very necessary to maintain the physical characteristics of fruits during storage. Appropriate postharvest treatment, storage and processing methods in fruit can curtail the postharvest losses up to 30% and make the fruit available for longer periods (Goyal *et al.*, 2008; Singh *et al.*, 2009) [13, 36]. Postharvest treatment of hot water and sodium hypochlorite are recommended for fungal disinfection of mango fruit for increasing shelf life (APEDA, 2007) [7] whereas, postharvest treatment of BA delays the senescence of many harvested crops (Majeski and Brasley, 1968) [22]. Thus, to control the physical characteristics and overcome the postharvest losses, the present investigation was undertaken to study the effect of various postharvest treatments on the physical characteristics of mango cv. Himsagar.

Materials and methods

Site of study

The present laboratory investigation was carried out in the postharvest laboratory of Department of Horticulture and Postharvest technology, Institute of Agriculture, Visva-Bharati, Sriniketan from 2016 to 2017. The experimental region is located at an elevation of 40 m above mean sea level at 23° 42' N latitude and 87° 47'30" E longitudes, representing humid sub-tropical region under 'Red lateritic' region of West Bengal.

Harvesting, postharvest treatments, storage and observations

Fresh fruits of uniform size, shape and colour of mango cv. Himsagar free from disease and bruises were harvested at the physiological mature stage during the morning hours and brought to the laboratory. After pre-cooling, desapping and washing the fruits were dipped treated in an aqueous solution of a different concentration of sodium hypochlorite (NaOCl: 100, 150, 200ppm) and 6-benzyladenine (BA: 50, 100, 150ppm). Hot water treatments (HWT) were given in a water bath (automatic control) at a temperature of 52 ºC to 55 ºC at different time intervals (5, 10 and 15 minutes). The fruits were air dried and packed in 5 ply corrugated boxes (5% ventilation) with newspaper lining and stored in ambient conditions. A control lot of fruit (kept in 5 ply corrugated box without any treatment) was also stored in the same condition. Observations were taken at an interval of 3 days up to 12 days.

Physiological loss in weight and spoilage percentage analysis

The physiological loss in weight (PLW) of the fruit was determined with the formula given by Srivastava and Tandon (1968) [37] on the basis of the initial weight of the fruit and loss in weight that occurred and was expressed in per cent. Spoilage was assayed by counting the number of fruits get spoiled and/or display fungal mycelia or sporulation and is expressed as per cent spoilage of fruits.

Fruit surface (shrinkage), firmness and palatability rating analysis

The fruit surface (shrinkage) of the mango was evaluated by subjective methods using a rating scale of five points (5 to 1) as described by Talukder *et al.* (2003) [38]; Aguayo *et al.* (2004) [1]. Fruit firmness of flesh was measured on two paired sides of fruits with the help of 'Penetrometer' (Model FT-327, QA Supplies, Norfolk, VA, USA) after removing about 1 cm^2 peel on both sides of the fruits. The pressure required to force a stainless steel probe of 8 mm in diameter into mango flesh was recorded. It was measured in terms of kg/cm^2 force. Palatability rating was determined on the basis of colour and taste of fruits by a panel of 5 judges as per Hedonic scale (1 to 9 points) as described by Amerine *et al.* (1965) [2].

Statistical analysis

The experiment was carried out in a completely randomized block design and each treatment was replicated thrice. The data obtained from various treatments were analysed statistically using OPSTAT ANOVA and means were compared for significance using CD at 5% level (Sheoran *et al*., 1998) [34].

Result and discussion

All the postharvest treatments significantly improved fruit physical characteristics as compared to control and resulted in the corresponding increase of shelf life (Table 1 and 2) of mango fruits.

Physiological loss in weight (%)

The physiological loss in weight (PLW) generally increased as the storage period advanced, rather slowly initially but more rapidly (Table 1). This finding is in conformity with the finding of Mandal *et al*. (2012) [23] in guava; Thokchom and Mandal (2018) [39] in aonla who reported gradual increase in weight loss with the increase in storage period. As persual of data in Table 1, the PLW (0, 3.07, 5.98 and 10.89%) of the fruits in 3, 6, 9 and 12 days respectively remain minimum in BA (100ppm) treated fruits. Control treatment exhibited maximum PLW. Minimum PLW in BA treated fruits might be attributed due to delays of the senescence of harvested crops by decreasing in respiration, decrease desiccation and the retention of an increasing proportion of the total phosphorous in an organic form (Majeski and Brasley, 1968) [22]. This observation is in accordance with the result of Venkatram *et al.* (2014) who reported BA treatment of 100ppm resulted in minimum PLW of custard apple during storage. Recently Jayachandran *et al*. (2007) [16] reported that BA acts as an antioxidant and has free radical quenching property which inhibited ethylene biosynthesis resulting in retardation of senescence and in many cases effectively reduced weight loss and increased storage period in mango.

Spoilage per cent

As persual of data in Table 1, the microbial spoilage of fruits started from 6 days onward of storage. Minimum spoilage per cent (0, 5.47, 12.87 and 22.12%) in 3, 6, 9 and 12 days respectively were observed in hot water treated (5 minutes) fruits as compared to other treatments. The present study demonstrated that all the treatments reduced spoilage per cent as compared to control. As per Jordan (1993) [19]; Sharp (1994) [33] hot water treatment are the reliable methods for killing surface decay organisms and cleaning the fruit of plant exudates. This observation is in accordance with Singh and Sharma (2007) [35] which reported effective hot water treatments temperature ranges between 46 and 60ºC with exposure time ranging from 30 seconds to 10 minutes for fresh fruits to control decay. Many workers (Anwar and Malik, 2007; Molla *et al*., 2011; Mendoza *et al*., 2017) [6, 26, 24] also reported hot water treatments (HWT) as widely used methods for insect and decay control in mango in many countries.

Fruit surface (Shrinkage)

From the results in Table 1, it is evident that the rating score of fruit surface (shrinkage) decreases with prolong storage in all the treatments, this might be due to the loss of moisture through transpiration and utilization of reserve food materials in the process of respiration from fresh fruits after harvesting (FAO, 1989; Tsantili *et al.*, 2002; Ladaniya, 2004) [12, 40, 20]. Highest fruit surface (shrinkage) (5, 5, 4.8 and 4.4) score in 3, 6, 9 and 12 days respectively were observed in BA (100ppm) and HWT (5 minutes) treated fruits. This may be due to the endogenous application of BA which reduced respiration, transpiration and delays ethylene production as well as maintains tissue rigidity and surface shrinkage of the mango fruits. Such a phenomenon has been earlier reported by Wade and Bradley (1973) [42] in Banana and Dhillon *et al.* (1985) [11] in grapes.

Flesh firmness

The continuous decrease of flesh firmness with the advancement of storage period was observed in all the treatments (Table 2). In general, fruit firmness decreases as fruits become more mature and rapidly as they ripen. During fruit ripening, softening occurs due to enzymatic degradation of cell walls (Johnston *et al*., 2002) [18]. Hosakote *et al*. (2006) [14] reported ripening of mango being accompanied by gradual textural softening. During storage BA treatment significantly influence flesh firmness retention. BA @ 100ppm resulted in maximum flesh firmness (0.67 kg/cm^2) at 12 days. Similar, results of BA in increase fruit firmness during storage has been earlier reported by Jayachandran *et al.* (2007) [16] in guava and in custard apple by Chouksey *et al*. (2013) [10] and (Venkatram *et al.,* 2014).

Palatability rating

With the advanced of storage periods, palatability rating of the mango increased and gradually decreases. The increased in palatability rating of mango fruit with advanced ripening is attributed to the production of a complex mixture of volatile compounds and degradation of bitter principles, flavonoids, tannins, related compounds, increased gluconeogenesis, hydrolysis of polysaccharides, decreased acidity and accumulation of sugars and organic acids resulting in an excellent sugar/acid blend (Lizada, 1993) [21]. BA @ 100ppm resulted in highest palatability rating (7.2) at 12 days. The possible reason for obtaining higher palatability rating in BA treated fruits (Table 2) was due to obtaining higher TSS and sugars as the advancement of ripening (due to the high absorption/diffusion of the chemical at higher levels when dipped in an aqueous solution of BA). Similar, results were earlier reported by Sandhbhor and Desai (1991) [30] in ber, Sharma and Dashora (2001) [31]; Sharma *et al*. (2002) [32]; Brahmachari and Rani (2005) [9] in guava and Bhardwaj *et al*. (2010) [8] in orange during storage.

The shelf life of mango goes on decreasing with prolonging storage. BA treatment was found to be best in decreasing physiological loss in weight, retention of fruit surface (shrinkage), maximum flesh firmness and high palatability rating while hot water treatment resulted best in controlling microbial spoilage during storage under ambient conditions.

Table 1: Effect of postharvest treatments on physiological loss in weight (PLW), spoilage per cent and fruit surface (Shrinkage) of mango cv. Himsagar under ambient conditions

Treatments	PLW (%)					Spoilage (%)					Surface shrinkage				
	Storage period (Days)					Storage period (Days)					Storage period (Days)				
	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
NaOCl 100 ppm	0	0	3.20	6.12	11.12	0	0	7.23	19.11	32.50	5	5	4.8	4.4	4
NaOCl 150 ppm	0	0	4.56	7.00	13.17	0	0	7.17	18.32	30.16	5	5	4.8	4.4	4
NaOCl 200 ppm	0	0	3.22	6.14	12.12	0	0	5.52	12.96	22.12	5	5	4.8	4.6	4
BA 50 ppm	0	0	3.18	6.11	11.61	0	0	7.42	19.30	33.43	5	5	5	4.6	4.2
BA 100 ppm	0	0	3.07	5.98	10.89	0	0	6.87	16.32	28.72	5	5	5	4.8	4.4
BA 150 ppm	0	0	3.19	6.12	11.31	0	0	6.96	16.76	28.77	5	5	4.8	4.6	4
HWT (5 mins)	0	0	3.12	6.05	11.55	0	0	5.47	12.87	22.12	5	5	5	4.8	4.4
HWT (10 mins)	0	0	3.10	6.06	11.23	0	0	5.56	13.63	22.18	5	5	5	4.6	4
HWT (15 mins)	0	0	3.18	6.12	12.12	0	0	6.83	14.28	25.63	5	5	4.8	4.4	4
CONTROL	0	0	4.61	9.12	15.42	0	0	9.31	27.42	47.51	5	5	4.6	4.2	4
CD (*P=0.05*)			0.35	0.72	0.61			0.28	0.32	1.25			NA	0.34	0.30
SEm ±			0.12	0.24	0.21			0.10	0.11	0.42			0.12	0.11	0.10

Table 2: Effect of postharvest treatments on flesh firmness and palatability rating of mango cv. Himsagar under ambient conditions

Treatments	Firmness (kg/cm^2)					Palatability rating				
	Storage period (Days)					Storage period (Days)				
	0	3	6	9	12	0	3	6	9	12
NaOCl 100 ppm	8.02	6.32	2.75	0.96	0.46	6.0	7.6	7.6	7.4	6.4
NaOCl 150 ppm	7.95	5.84	3.33	1.00	0.48	6.2	7.6	7.4	7.2	6.6
NaOCl 200 ppm	7.90	5.90	2.72	0.90	0.41	6.0	7.6	7.6	7.0	6.6
BA 50 ppm	7.96	5.87	3.48	1.10	0.65	6.2	7.4	7.8	7.4	7.0
BA 100 ppm	7.95	6.23	3.50	1.14	0.67	6.6	7.2	7.6	7.4	7.2
BA 150 ppm	8.05	6.25	3.67	1.25	0.52	6.4	7.4	8.0	7.2	6.8
HWT (5 mins)	8.00	6.19	3.52	1.23	0.59	6.0	7.2	7.6	7.2	7.0
HWT (10 mins)	7.94	6.24	3.47	1.08	0.50	6.2	7.4	7.8	7.4	7.0
HWT (15 mins)	7.96	5.82	3.36	1.04	0.49	6.6	7.8	8.0	7.0	6.4
CONTROL	7.95	5.84	2.68	0.88	0.40	6.4	7.8	7.8	6.8	6.0
CD (*P=0.05*)	NA	0.19	0.26	0.13	0.12	N/A	N/A	N/A	N/A	0.51
SEm ±	0.08	0.07	0.09	0.05	0.04	0.19	0.23	0.21	0.20	0.18

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