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Effect of harvesting time and desapping on sapburn and quality in mango (*Mangifera indica*) cv. Langra

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ABSTRACT

Sapburn is one of the most important problems in mango (*Mangifera indica* L.) which severely downgrade its quality and reduces its market value. In the present study, two experiments were conducted to study the effect of harvesting time on sap flow quantity; and its control through simple desapping treatment. The sap flow was recorded higher from the mango fruits (cv. Langra) harvested during morning hours. For the second experiment, mature mango fruits were harvested with 8 – 10 cm pedicel attached and treated with aqueous solutions of sodium hydroxide (1% and 2%) and potassium hydroxide (1% and 2%) by immersion method, after removing the pedicel. For control, sap was allowed to flow freely over the fruit surface. During storage of fruit at ambient condition (25±2°C) for 12 days, fruits desapped with 1% sodium hydroxide (NaOH) showed about 11-fold lower sapburn injury than control. Treatment with NaOH did not significantly affect TSS, acidity and carotenoids content in the fruit. However, it maintained significantly higher ascorbic acid, total phenolics content and antioxidant activity than control.

Key words: Desapping, Mango, Sapburn, Sodium hydroxide

India is the largest producer of mango (*Mangifera indica* L.) in the world contributing about 50% of total production worldwide. In the Asian countries mango is commonly known as 'King of fruits' due to its delicious taste, appealing aroma and pleasant flavour. Several quality determining factors are responsible for the acceptance of mango fruit to the consumer. Among these, sapburn is considered to be one of the most important factors which severely affect the appearance. Commercially, mango fruits are harvested at maturity well before they are actually ripe. At this stage, a sticky viscous sap exudes out from the pedicel end of the fruit which spreads over the fruit surface and causes sapburn in the fruit (Negi *et al*. 2002). The symptoms appear as brownish-black streaks or blotches on the peel which become vividly distinct as fruit ripens and develop yellow colour (Loveys *et al*. 1992). Fruits once affected with sapburn fetch lower price in the market, which becomes a major quality concern for mango producers as well as exporters especially for international markets (Barman *et al*. 2013). Occurrence of sapburn in mango fruit ranges from about 5–50%, the magnitude of which varies depending upon cultivars, maturity stage, harvesting condition etc. (Barman *et al*. 2011). Apart from lowering the consumer appeal, the sap also attracts soil particles and microorganisms due to its sugary and sticky nature. Consequently, the sapburn affected area becomes a site for secondary infection which further reduces its storage life (Campbell 1992).

Under standard postharvest handling system, the harvesting of mango fruit is recommended with 8 – 10 cm pedicel attached to avoid sap flow from the fruit. Desapping of mango is carried out by holding the fruit upside down and cutting the stalk to 0.5 – 1.0 cm followed by placing it on racks or trays in an inverted position for about 45 minutes till the sap flow is over (Holmes *et al*. 1993). This process is very cumbersome which requires skilled workers as well as large floor area for placing the racks or trays. Therefore, in the present study, mango fruits were desapped with aqueous solutions of sodium hydroxide or potassium hydroxide by simple immersion (dipping) method which also facilitates washing of the fruit at the same time. Further, the effect of desapping treatments on fruit quality and bioactive antioxidants of mango were also evaluated.

MATERIALS AND METHODS

Mango fruits (*Mangifera indica* L.) of cv. Langra were harvested at physiological maturity stage from the orchard of Horticulture Garden, Bihar Agricultural University, Sabour, Bhagalpur.

Ten mango fruits were harvested along with 8–10 cm pedicel attached at three different times of day: morning (6.00 AM), noon (12.00 Noon) and evening (6.00 PM).

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Following harvesting, pedicels were cut back to 1.0 cm and immediately placed into a beaker in inverted position to collect the sap. The sap collected was measured with a disposable syringe.

Mango fruits were harvested along with 8–10 cm pedicel during morning hours (6.00 AM) of the day. Uniform sized healthy fruits, free from disease, pest and visual blemishes, were selected for the experiment. The experiment was conducted in a completely randomized design with five treatments each with three replications. In total, 125 fruits were selected and divided into five lots each of 25 fruit for the treatments. The treatments were performed by cutting the fruit pedicel and immediately dipping in aqueous solutions of sodium hydroxide (NaOH, 1% or 2%) and potassium hydroxide (KOH, 1% or 2%) for 5 min. In control, pedicels were cut back and the sap was allowed to flow freely and spread over the fruit surface. Following treatment, fruits were air-dried, packed in corrugated fibreboard (CFB) boxes and stored at ambient condition (25 ± 2°C, 85 ± 5% RH) for 9 days. At three days interval, fruit from each treatment were sampled at random for analysis of physico-chemical parameters.

Sapburn in mango fruit was assessed visually following a score ranging from 0 to 4, where 0 = no injury, 1 = very mild (injury area <1 cm^2), 2 = mild (injury area ≥ 1 < 2 cm^2), 3 = moderate (injury area ≥ 2 < 4 cm^2), 4 = severe (injury area ≥ 4 cm^2) as per the method described by Maqbool *et al*. (2007). The sapburn injury was calculated by multiplying the number of fruits in each category by the respective score, summing the products and dividing by the total number of fruits.

To determine total carotenoids content in the fruit pulp, a mixture of petroleum ether and acetone (3:1) was used to extract carotenoid pigments from the pulp. After that, the absorbance was recorded at 452 nm in a spectrophotometer (HALO DB-20S, UV-VIS Double beam spectrophotometer, Australia) and the results were expressed as mg/100g FW (Roy 1973). Total phenolics content in the pulp was estimated spectrophotometrically using Folin–Ciocalteu reagent (Singleton *et al*. 1999). To 0.1 ml of sample extract (in 80% ethanol), 2.9 ml distilled water, 0.5 ml Folin–Ciocalteu reagent and 2.0 ml of 20% sodium carbonate solution was added. After 90 min, the absorbance was measured at 760 nm in a spectrophotometer and the results were expressed µg gallic acid equivalent/g FW.

The cupric ion reducing antioxidant capacity (CUPRAC) was determined following the method of Apak *et al*. (2004). To 0.1 ml sample extract (in 80% ethanol), 1 ml each of copper (II) chloride solution (1.0×10^{-2} mol/L), neocuproine alcoholic solution (7.5×10^{-3} mol/L), ammonium acetate buffer solution (1 mol/L, pH 7.0) and distilled water were added. Mixture was then allowed to stand for 30 min and after that absorbance was recorded at 450 nm in a spectrophotometer. Finally, the results were expressed as µmol Trolox equivalent/g FW.

Ascorbic acid content in the fruit was determined following 2, 6-dichlorophenol indophenol dye method of AOAC (2000). For this, 10 g pulp was homogenized with 3% metaphosphoric acid solution. Then the extract was made up to 100 ml with metaphosphoric acid solution and centrifuged at 3000 rpm for 15 min. The supernatant was then titrated against the dye (2, 6-dichlorophenol indophenol) to a pink end point. The titre value was recorded, calculated and the results were expressed as mg/100g FW (fresh weight). Total soluble solids (TSS) was analysed by digital refractometer (Atago, Tokyo, Japan) and results were expressed as °Brix. Titratable acidity was estimated following titration method of AOAC (2000). For this, 2 g of fruit pulp was crushed in 100 ml distilled water and titrated against 0.1 N sodium hydroxide solution, with phenolphthalein as indicator. The results were expressed as percentage (%) citric acid.

The results obtained under different treatments in respect to various parameters were subjected to analysis of variance. Mean comparison among the different treatments were performed using the Duncan's multiple range test at a significance level of P £ 0.05. All analysis was carried out with SAS software package version 9.2 for windows.

RESULTS AND DISCUSSION

Effect of harvest time on sap flow in mango

In the present study, following harvesting when pedicels of fruit were removed, the spurt sap exuded rapidly for the initial 10 – 15 seconds, later ooze sap came out slowly from the pedicel end of fruit (Table 1). In the present experiment, it was observed that the flow of sap was higher (0.96 ml) from the fruits harvested during morning time (6.00 AM) than those harvested during noon (0.90 ml) and evening (0.82 ml). However, no significant differences in quantity of sap flow were observed between fruits harvested during morning and noon. This might be attributed to higher turgor pressure in the resinous canal of the fruit and pedicel during early morning hours (Maqbool *et al*. 2007). With the progress of day, the temperature increases which results in higher transpiration from the fruit and consequently reduced the amount of total sap flow from the fruit (Bagshaw 1989).

Table 1 Effect of harvest time on total sap flow quantity in mango

Harvest time	Sap quantity (ml)
Morning (6.00 AM)	0.96 ± 0.040a
Noon (12.00 Noon)	0.90 ± 0.031ab
Afternoon (6.00 PM)	0.82 ± 0.037b

Values are mean ± standard error (n = 10). Values followed by the same letter are not significantly different (P ≤ 0.05).

EFFECT OF DESAPPING TREATMENTS ON SAPBURN AND FRUIT QUALITY IN MANGO

Effect on sapburn injury

Treatment of mango fruit with desapping agents

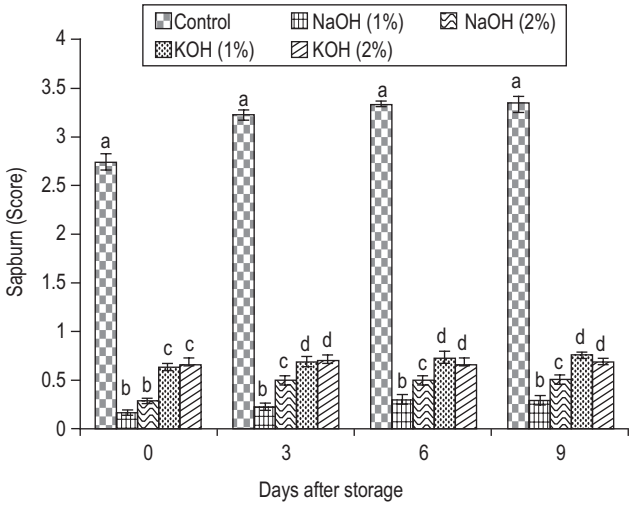

Fig 1 Effect of desapping treatments on sapburn injury in mango

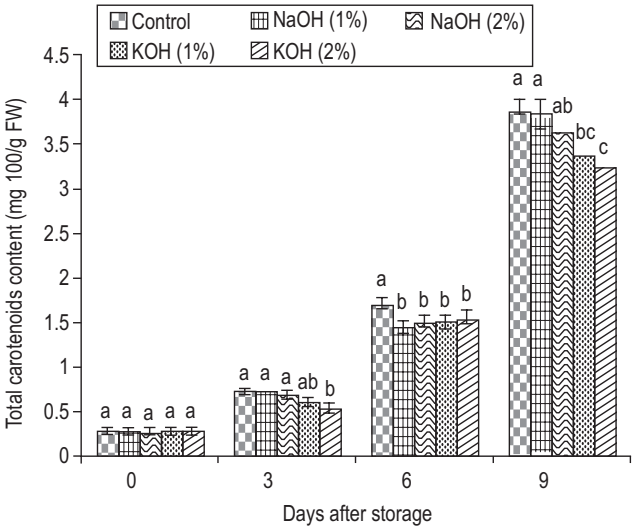

Fig 2 Effect of desapping treatments on total carotenoids content in mango

(NaOH and KOH) was found highly effective in reducing sapburn in mango (Fig 1). Control fruits showed significantly higher sapburn (2.73 score) in mango than treated fruits at the initial day of storage. The symptoms became more prominent as ripening progressed. Among the treatments, application of 1% NaOH (0.29 score) followed by 2% NaOH (0.51 score) proved best in minimizing sapburn in mango after 9 days of storage. However, significant differences were not observed between 1% and 2% KOH treated fruits. The mango sap exudes out from pedicel-end of the fruit just after harvesting is highly acidic in nature, having pH of about 4.3 (John *et al*. 2003). Desapping of fruit with NaOH (1%) markedly reduced the sapburn injury in mango. It is a strong alkali (pH = 13.2) widely used for lye peeling of fruits and vegetables (Barman *et al*. 2013). When mangoes were dipped in NaOH (1%) solution after destemming, it neutralized the acidic sap exuded from the stem-end and thus minimized the sapburn in mango. As a result, the sap did not show any symptom even it came in contact with the fruit peel during dipping, as the sap was already neutralized. With the onset of ripening, the peel colour of fruit changed from green to yellow. At this stage, the intensity of sapburn on the peel of mango was found more prominent. Maqbool and Malik (2008) have also reported that symptoms of sapburn injury increases with the progress of ripening due to higher PPO enzyme activity (Menezes *et al*. 1995).

Effect on total carotenoids content

Total carotenoids content in the fruit pulp increased progressively with the advancement of storage period (Fig 2). At 6th day of storage, carotenoids content in the pulp was recorded higher in control than the treated fruits. Later, 9th day after storage no significant differences were observed between control (3.85 mg/100g FW) and NaOH treated fruits. However, fruits treated with 1% KOH (3.36 mg/100 g FW) and 2% KOH (3.23 mg/100g FW) showed significantly lower carotenoids content than other treatments. This might be due to negative effect of KOH on fruit ripening. As a result, fruits desapped with KOH synthesized lower carotenoids than control fruits during postharvest storage.

Effect on total phenolics content

It is evident from the result that with the progress of ripening, total phenolics content decreased in all the treated and control fruits (Fig 3). However, this declining trend was much pronounced in control than treated fruits. After 3 days of storage, no significant differences were observed in total phenolics content among the treatments. However, at 9th day of storage lowest phenolics content (129.26 µg GAE/g FW) was recorded in control mango fruits while it was recorded highest (214.21 µg GAE/g FW) in 2% KOH treated fruits. No significant differences in total phenolics content were observed between NaOH and 1% KOH treated fruits. Decrease in total phenolics content in the stored mango fruits was due to onset of ripening (Briante *et al*.

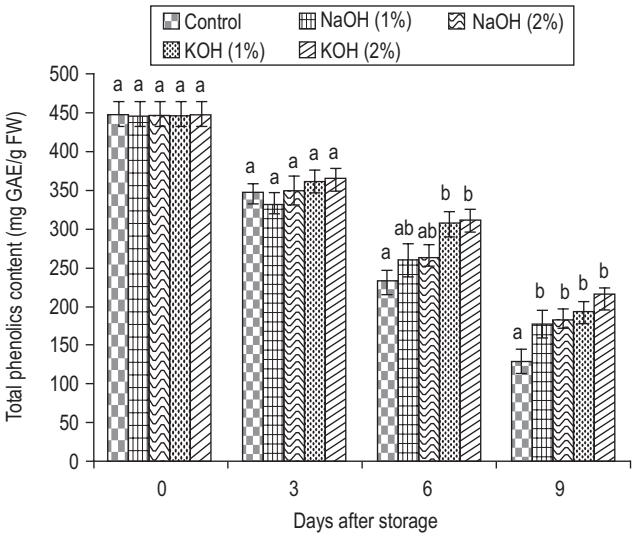

Fig 3 Effect of desapping treatments on total phenolics content in mango

2002). However, higher content of phenolics in 2% KOH treated fruit was due to delay in ripening process. This was further supported by lowest content of carotenoid pigment and slower increase in total soluble solids in the fruit.

Effect on antioxidant activity

The effect of desapping treatments on total antioxidant activity of mango is presented in Fig 4. An increase in antioxidant activity was recorded under all the treated and control mango fruit during postharvest storage. Control mango fruits were having lowest (6.19 µmol TE/g FW) antioxidant activity after 9 days of storage while, maximum antioxidant activity (6.79 µmol TE/g FW) was recorded in fruits treated with 1% NaOH. However, no significant difference was recorded between control and treated fruits. The antioxidant activity in mango is mainly attributed to presence of phenolic compounds, ascorbic acid and carotenoids (Asrey *et al*. 2013). Similarly, in other fruits like pomegranate (Barman *et al*. 2014a) and litchi (Barman *et al*. 2014b), ascorbic acid and phenolics are mainly responsible for antioxidant activity. Therefore, higher level of antioxidant activity in NaOH treated fruit was due to higher retention of ascorbic acid, carotenoids and phenolic compounds.

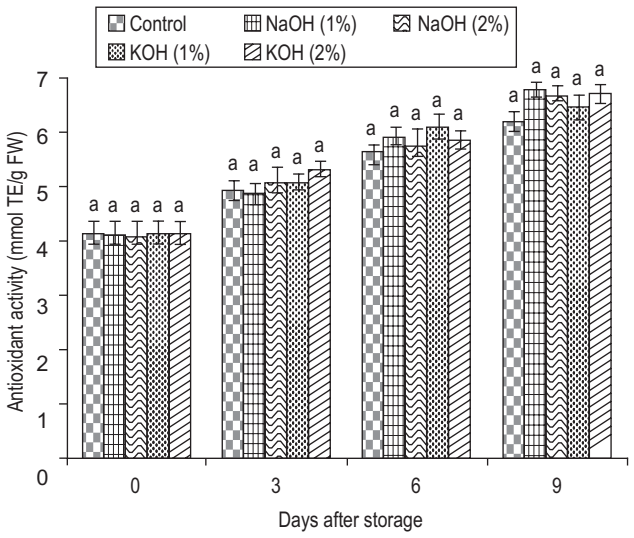

Fig 4 Effect of desapping treatments on antioxidant activity in mango

Effect on ascorbic acid, total soluble solids and acidity

Irrespective of treatments, a decline in ascorbic acid content in fruit was recorded following treatment with desapping agents (Table 2). The ascorbic acid content in the control mango fruits was found to decrease faster than other treatments. Up to 6 days of storage, no significant differences were recorded between control and treated fruits. However, at 9th day of storage control mango fruit were recorded lowest (25.82 mg/100g FW) ascorbic acid content while no significant differences were observed between NaOH and KOH treated fruit. This result indicated that desapping treatment did not affect ascorbic acid content in the fruit. Total soluble solids content in the fruit increased rapidly irrespective of treatments up to end of the storage period (Table 2). Up to 6 days of storage, no significant differences in TSS content were observed among the treated (NaOH and 1% KOH) and control fruits. However, fruits desapped with 2% KOH were recorded lower increase in TSS content than other treatments. These fruits (2% KOH treated) also showed lowest TSS (18.9°Brix) content after 9 days of storage while it was highest (20.73°Brix) in 1% NaOH treated fruit which was at par with 2% NaOH and control fruits. A progressive decrease in acidity was recorded under all the treatments with storage (Table 2). Control mango fruits exhibited much rapid decline in acidity than other treatments. However, 6th day onwards no significant differences in acidity were recorded among the treated and control (0.15%) mango fruits. These findings revealed that desapping treatment affected fruit quality parameters during storage. However, NaOH treatment did not alter desired fruit quality attributes during storage.

It was concluded that sapburn is a serious concern to the external fruit quality of mango which severely downgrade the fruit quality and consumer acceptance. In the present study, sapburn injury in mango was greatly reduced by simple postharvest dipping treatment in 1%

Table 2 Effect of desapping treatments on fruit quality parameters of mango

Parameters	Days after storage	Control	NaOH (1%)	NaOH (2%)	KOH (1%)	KOH (2%)
Total soluble solids (°Brix)	3	10.70 ± 0.26a	10.33 ± 0.26a	10.66 ± 0.17a	10.53 ± 0.08a	9.50 ± 0.17b
	6	18.93 ± 0.26a	18.70 ± 0.32a	19.33 ± 0.14a	19.30 ± 0.20a	17.60 ± 0.17b
	9	20.43 ± 0.17a	20.73 ± 0.26a	20.7 ± 0.32a	19.7 ± 0.20b	18.9 ± 0.20c
Titratable acidity (%)	3	0.65 ± 0.03a	0.84 ± 0.04b	0.79 ± 0.00b	0.88 ± 0.04b	0.86 ± 0.05b
	6	0.25 ± 0.04a	0.24 ± 0.04a	0.37 ± 0.04a	0.36 ± 0.11a	0.35 ± 0.12a
	9	0.15 ± 0.00a	0.15 ± 0.00a	0.15 ± 0.00a	0.15 ± 0.00a	0.19 ± 0.04a
Ascorbic acid content	3	32.03 ± 0.65a	33.27 ± 1.04a	33.97 ± 1.34a	34.02 ± 1.20a	33.69 ± 0.74a
(mg 100/g FW)	6	29.47 ± 1.15a	30.72 ± 0.35a	32.38 ± 1.04a	33.25 ± 0.77a	30.99 ± 1.40a
	9	25.82 ± 0.98a	29.85 ± 0.82b	29.75 ± 0.53b	29.38 ± 1.09b	28.89 ± 0.46b

Values are mean ± standard error (n = 3). Treatment values followed by the same letter in a particular day after storage are not significantly different (P ≤ 0.05). Initial values: TSS = 5.73 ± 0.29, Titratable acidity = 1.24 ± 0.01, Ascorbic acid = 37.99 ± 0.74.

sodium hydroxide solution. This desapping treatment did not affect the TSS, acidity and formation of carotenoid pigments in the fruit. In addition, it maintained functional quality of fruit by retaining higher ascorbic acid, total phenolics and antioxidant activity than control.

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