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Effect of hot water treatment on the incidence of lenticel browning and quality of mango fruits

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ABSTRACT

The present investigation was undertaken to evaluate the effect of hot water treatment on the incidence of lenticel browning (LB) in mango, which is becoming one of the main problems in handling and trade of fresh fruits. Fruits of four selected mango varieties (Indian – 'Dashehari', 'Langra'; Exotic – 'Sensation', 'Eldon') which were found susceptible to LB, were subjected to hot water treatment (HWT) at different levels (45°, 50° and 55°C for 30 min.). After treatment, the fruits were stored at ambient conditions (35 ± 4ºC and 65 ± 5% RH) for 10 days. At the end of storage period, observations were recorded on various parameters. Our results revealed that fruits of 'Langra' exhibited 100% LB, followed by 'Dashehari' (52.8%), 'Sensation' (35.9%) and 'Eldon' (28.3%). All levels of hot water treatment reduced the LB to a greater extent as well as improved fruit quality attributes significantly over untreated fruits. The best results were obtained with HWT at 50°C for 30 min. for reducing LB and fruit decay in different mango varieties and maintaining better quality over untreated fruits. Thus, it can be concluded that hot water treatment at 50°C for 30 min. could be recommended for reducing incidence of LB in mango.

Keywords: Enzymes, fruit quality, mango, hot water treatment, lenticel browning.

INTRODUCTION

Mango (*Mangifera indica* L.), commonly called as the 'King of fruits' and traditional fruit of India (Chattopadhyay, 2). It is being grown for over 400 years and its production accounts for over 45% of the global mango production. At national level, its importance can be judged from the fact that mango alone contributes 34.7% of the total fruit production (Anon, 1). Mango export has been increased from Rs. 209 crores in 2011-12 to Rs. 285 crores in 2014-15, representing a growth of about 35 per cent. The major five importing countries of Indian mangoes are UAE, UK, Saudi Arabia, Kuwait and Qatar, which comprises around 80% of total export. Mango export is becoming a competitive affair between the countries, but from the time-to-time, there has been occurrence of several hurdles in export (Chattopadhyay, 2). Several factors affect the fruit appeal and quality during trade, but lenticel browning (LB) is responsible for quality loss of mango fruits at both domestic trade and export from the country (Rymbai *et al*., 11).

Lenticels are macroscopic openings present on fruit peel, and stem of fruit plants (Wenneker and Kohl, 17). These play significant role in physiological processes like transpiration and exchange of gases, but their browning and discoloration has greater effect on fruit appeal, which makes farmers to bear the loss in economic terms. It also affects the fruit quality (Rymbai *et al*., 11). Once its initiation starts, several other factors, favour its expansion further on the fruit (Cronje, 3).

Mango fruits respond well to postharvest hot water treatment, especially for the management of diseases (Joyce *et al*., 6) but no attempt has been made to study its impact on LB. Hence, keeping this fact in mind, we attempted different levels of postharvest hot water treatments on mango fruits to observe its effects on LB.

MATERIALS AND METHODS

The fruits of different mango varieties were procured from the Experimental Orchard of the Division of Fruits and Horticultural Technology, ICAR-IARI, New Delhi and the study was undertaken in the Division of Food Science and Postharvest Technology, during 2014-15. On the basis of preliminary screening study, two most susceptible Indian ('Langra' and 'Dashehari') and exotic ('Sensation' and 'Eldon') varieties of mango were selected for this study. Fruits were subjected to hot water treatment (HWT) at three levels, *i.e.*, HWT at 45°, 50° and 55°C temperature for 30 min., and a simple tap water dip was given to fruits under control. Hot water treatment was given to 50 fruits of each variety, replicated three times. After treatment, the fruits were stored at ambient conditions (35 ± 4ºC

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and 65 ± 5% RH) for 10 days. At the end of storage period, observations were recorded on the incidence of LB, fruit decay, total phenols content and activity of polyphenol oxidase and peroxidase enzymes and fruit quality attributes.

Lenticel browning in mango fruits was estimated by counting the number of lenticels browned on the peel present per cm^2 and represented as percentage. Fruit decay was estimated by counting the disease-infected fruits among healthy ones, and represented as percentage. Total phenolic content was estimated using Sharma *et al*. (12) method, and expressed as mg GAE g^{-1} fresh weight. Polyphenol oxidase (PPO) enzyme activity was estimated by method developed by Sharma *et al.* (13). The enzyme activity was recorded at the interval 30 sec. and the PPO activity was expressed as ΔA_{410} OD $min^{-1}g^{-1}$.

Peroxidase (POD) enzyme extraction was also carried out at 4°C. First, 0.15 ml of 4% guaiacol was added to 0.15 ml of 1% hydrogen peroxide, 2.6 ml of 0.1 M phosphate buffer was added to this and the pH was maintained at neutral, *i.e*. 7.0. To this mixture, 40 µl of enzyme extract was added. The absorbance of this reaction mixture was recorded at 410 nm at room temperature and the POD activity was expressed as ΔA_{470} O.D. $min^{-1}mg^{-1}$.

Under quality attributes, total soluble solids of mango fruit pulp were estimated at room temperature by using Fisher's hand refractometer having range 0 to 50 and results were expressed in ºBrix. The total carotenoids content was estimated by homogenising 5 g pulp in 15 ml acetone. Crushing was continued till the pulp turned totally white, which shows the complete removal of pigments. The sample was then put in separating funnel to separate the clean golden coloured carotenoids. Petroleum ether was then added with 2-3 pinches of sodium sulphate. The separating funnel was kept undisturbed after a vigorous shaking. Golden coloured pigment solution layer was collected in volumetric flask. The sample was further taken in cuvette and the absorbance was recorded on spectrophotometer at 452 nm wavelength. The carotenoid contents were expressed as mg 100 g^{-1} pulp.

The data obtained from the experiment were analysed, using factorial CRD design (two factor CRD) with each treatment consisting of three replications. The online statistical software of ICAR-IASRI, New Delhi and CCSHAU, Hisar were used for the analysis of data and the results were compared from ANOVA table by calculating the critical difference.

RESULTS AND DISCUSSION

All treatments of HWT reduced lenticel browning over control fruits, but fruits treated with HWT at 50°C for 30 min. had the lowest incidence of lenticels browning (11.2%) (Table 1). Reduction in lenticels browning by hot water treatment at appropriate time-temperature combination may be because of induction of resistance developed against water entry and damage, as reported in mango by Joyce *et al.* (6). Significant reduction in LB at HWT (50°C) may also be attributed to significant reduction in PPO and POD activities in comparison to other treatments and control.

Irrespective of treatment, significant differences occurred among varieties with respect to incidence of lenticel browning. 'Langra' exhibited the highest incidence of lenticel browning (100%) and 'Eldon' the lowest (4.8%) (Table 1). These differences in LB among varieties may be attributed to genetic differences among them. In an earlier study, 'Tommy

Table 1. Effect of hot water treatment on lenticel browning and postharvest decay in mango at 10th day of storage under ambient conditions (35 ± 4ºC and 65 ± 5% RH).

Treatment	Lenticel browning (%)				Mean	Postharvest decay (%)				Mean
	Indigenous		Exotic			Indigenous		Exotic		
	Dashehari	Langra	Sensation	Eldon		Dashehari	Langra	Sensation	Eldon	
Control	52.8	100	35.9	28.3	54.2	53.3	66.6	60.0	53.0	58.3
HWT @ 45°C for 30 min.	40.0	52.8	12.7	13.3	29.7	30.0	43.3	30.0	23.0	31.5
HWT @ 50°C for 30 min.	15.0	18.0	7.1	4.8	11.2	12.0	13.3	16.4	13.3	13.7
HWT @ 55°C for 30 min.	56.2	82.3	25.0	26.6	47.5	43.3	40.2	33.5	23.3	35.0
Mean	41.0	63.2	20.1	18.2	-	34.6	40.8	34.9	28.2	-
$CD_{0.05}$	Variety (V) = 1.8; Treatment (T) = 1.8 and V × T = 3.6					Variety (V) = 5.5; Treatment (T) = 5.5 and V × T = 11.0				

Atkins' and 'Keitt' mango have been reported to be more susceptible, while 'Kent' to be less susceptible to LB in South Africa (Oosthuyse, 9). Furthermore, irrespective of variety, treatment had significantly influenced the incidence of lenticel browning in mango, as it was the highest in untreated (control) fruits (54.2%) and lowest in fruits treated with hot water treatment at 50°C for 30 min. (11.2%) (Table 1). The interaction between variety and treatment (V x T) was also effective as untreated (control) fruits of 'Langra' exhibited the maximum incidence of lenticel browning (100%) and 'Eldon' fruits treated with hot water treatment at 50°C for 30 min. exhibited the lowest incidence of lenticel browning (4.8%) (Table 1). This may be due to synergistic and interactive influence of genotype and HWT on LB.

Postharvest decay is directly related to the incidence of lenticel browning and was recorded to be having significant differences among the varieties and treatments. Among varieties, 'Langra' has shown the highest postharvest decay (66.6%) significantly followed by 'Sensation (60.0%) and minimum in 'Eldon' (53.0%). This variation in postharvest decay among different mango varieties may be due to genetic variability existing among them. The highest postharvest decay was recorded in control fruits (58.3%) and minimum in fruits, which received hot water treatment at 50°C for 30 min. with a decay of 13.7% (Table 1). The interaction of variety x treatment (V x T) was also significant as untreated (control) fruits of 'Langra' have shown maximum postharvest decay (66.6%) and 'Dashehari' fruits treated with hot water at 50°C for 30 min. showed the minimum postharvest decay (12.0%) (Table 1). The higher incidence of postharvest decay at a higher temperature might be due to tissue breakdown, which shows that time-temperature combination of hot water treatment is also equally important in mango as reported by Jabbar *et al.* (5).

Phenolic content increased with hot water treatment but up to a certain limit of hot water, *i.e.*, up to 50°C for 30 min., above which, it had displayed a decrease in phenolic content. This indicates that increase in total phenolic content was inversely related with the incidence of lenticel browning. Whereas increase in the phenolic content up to certain time-temperature combination of hot water treatment supports the findings of Xu *et al.* (18) who reported that hot water treatment increased phenol content of citrus but only up to a certain limit. With respect to varieties and treatments, significant differences were observed in total phenolic content of the mango fruit peel (Table 2). Among varieties, irrespective of the treatment, the highest total phenolic content was recorded in fruits of 'Sensation' variety (16.54 mg GAE/100 g), whereas the lowest value was exhibited by the fruits of 'Langra' variety (9.33 mg GAE/100 g). This finding is in supportive of conclusions drawn by Sogi *et al.* (15) who reported that differences among different mango varieties for the phenolic content may be due to the differences in the composition of polysaccharides in them. In the similar way, treatments were also found to be have significant differences for total phenolic content, as highest content among treatments was recorded in fruits receiving HWT at 50°C for 30 min. (15.55 mg GAE/ 100 g) and lowest in fruits treated with hot water treatment at 55°C for 30 min. (12.30 mg GAE/ 100 g). Similarly, interaction of variety and treatment (V x T) was also found to be having significant differences as fruits of 'Sensation' receiving hot water treatment of 50°C for 30 min. exhibited the highest total phenol content (20.44 mg GAE/100 g), whereas the lowest content was recorded in untreated (control) fruits of 'Langra' (Table 2).

There was a significant difference in polyphenol oxidase activity for varieties and treatments. Among varieties, the highest polyphenol oxidase activity was recorded in the fruits of 'Langra' (1.084 ΔA_{410} OD min^{-1} mg^{-1}) and among treatments the highest polyphenol activity was exhibited by untreated (control) fruits (0.791 ΔA_{410} OD min^{-1} mg^{-1}). The interaction of variety x treatment was also found significant as 'Eldon' fruits treated with hot water treatment at 50°C for 30 min. had displayed the lowest polyphenol oxidase activity (0.268 A_{410} OD $min^{-1}mg^{-1}$), whereas untreated (control) fruits of 'Langra' exhibited the highest polyphenol oxidase activity (1.267 A_{410}OD $min^{-1}mg^{-1}$) (Table 2). Peroxidase enzyme activity showed a pattern similar to polyphenol oxidase activity, which was significant among the treatments and varieties. In case of treatments, untreated (control) fruits exhibited the highest peroxidase enzyme activity (0.119 ΔA_{470}OD $min^{-1}mg^{-1}$), whereas fruits of 'Langra' have shown the maximum peroxidase enzyme activity (0.123 ΔA_{470}OD $min^{-1}mg^{-1}$) (Table 2).

With respect to polyphenol oxidase (PPO) and peroxidase (POD) enzymatic activities, our findings indicate that polyphenol oxidase (PPO) and peroxidase (POD) enzymatic activities in mango was directly influenced by the occurrence of lenticel browning as significant differences were observed both by varieties and treatments, which can be correlated directly with the incidence of lenticel browning and the treatments which collaborates with the work of Prasad *et al.* (10). Among varieties, the highest polyphenol activity was recorded in 'Langra' fruits and among treatments, the highest polyphenol activity was exhibited by untreated (control) fruits (Table 2). Our findings corroborate with the findings

Table 2. Total phenolic content, polyphenol oxidase (PPO) and peroxidase (POD) activities in mango varieties as influenced by hot water treatment at 10th day of storage at ambient conditions (35 ± 4°C and 65 ± 5% RH).

Treatment	Total phenolic content (mg GAE/100 g)				Mean	Polyphenol oxidase activity (Δ A_{410}O.D $min^{-1}g^{-1}$)				Mean	Peroxidase activity (Δ A_{470}O.D. $min^{-1}mg^{-1}$)				Mean
	Indigenous		Exotic			Indigenous		Exotic			Indigenous		Exotic		
	Dashehari	Langra	Sensation	Eldon		Dashehari	Langra	Sensation	Eldon		Dashehari	Langra	Sensation	Eldon	
Control	11.83	9.33	16.54	13.07	12.69	0.816	1.267	0.608	0.476	0.791	0.134	0.197	0.093	0.054	0.119
HWT @ 45°C for 30 min.	12.96	10.95	18.93	14.92	14.44	0.653	1.096	0.515	0.366	0.657	0.091	0.106	0.055	0.037	0.072
HWT @ 50°C for 30 min.	14.31	11.94	20.44	15.54	15.55	0.524	0.853	0.361	0.268	0.501	0.034	0.073	0.025	0.022	0.038
HWT @ 55°C for 30 min.	11.81	8.92	15.55	12.93	12.30	0.715	1.122	0.582	0.426	0.711	0.107	0.116	0.075	0.043	0.085
Mean	12.72	10.28	17.86	14.11		0.513	1.084	0.516	0.384	-	0.091	0.123	0.062	0.039	-
$CD_{(0.05)}$	Variety (V) = 0.04; Treatment (T) = 0.04 V × T = 3.21					Variety (V) = 0.002; Treatment (T) = 0.002 V × T = 0.005					Variety (V) = 0.002; Treatment (T) = 0.002 V × T = 0.004				

drawn by Menezes *et al.* (8) who showed decline in PPO activity with the increase in the temperature of hot water treatment in mango fruits. However, on the other hands, our results reveal that there was increase in polyphenol oxidase enzyme activity at further higher level of time-temperature combination, *i.e.* hot water treatment of 55°C for 30 min. This increase in enzyme activity at high temperature might be related with pericarp browning (Sivakumar *et al.*, 14).

Our findings showed that peroxidase activity was highest in fruits of 'Langra' (Table 3). In case of treatments, untreated (control) fruits exhibited the highest peroxidase activity (0.120 Δ A_{470} OD $min^{-1}mg^{-1}$) and there was a gradual decrease in POD enzyme activity with increase in temperature but only upto 50°C. Increase in temperature, POD enzyme activity increased, which corroborate with the work done of Varit and Songsin (16) in banana. Under studied quality parameters, soluble solids content (SSC) in mango varieties were significantly influenced (Table 3), which might be attributed by the genetic differences existing among the varieties as highest soluble solids content was observed in 'Langra' (19.2°B) and lowest in 'Eldon' (14.0°B) (Table 3). Further, the results indicated that total soluble solids among the treatments were non-significant. Although an increasing pattern of total soluble solids were observed with HWT at 45 and 5°C but it deceased with the increase in hot water treatment to 55°C. These findings are in line with these of Kumah *et al.* (7).

The carotenoid contents were also observed to be having significant differences among the varieties and within treatments. Among the varieties, 'Dushehari' was recorded for the maximum carotenoid content (5.2 mg/100 g pulp), and 'Sensation' the minimum (2.6 mg/100 g pulp). These differences in carotenoid content among varieties may be due to varietal characteristics. In treatments, hot water treatment at both the levels, *i.e.* at 45° and 50°C had shown the highest carotenoid content (4.0 mg/100 g pulp), which was significantly different to control (3.8 mg/100 g pulp). This shows that at an increasing temperature, there was an increase in total carotenoids but up to certain temperature, and thereafter, there was a decline. These results are in line with the work of Djiouaa *et al.* (4) who reported that up to a specific increase in temperature of hot water treatment (45-50°C), there was an increase in total carotenoids content. We have also observed similar results. This decrease in total carotenoids content might be due to isomerisation of carotenoids at higher temperature (Djiouaa *et al.*, 4).

Table 3. Effect of hot water treatment on total soluble solids and total carotenoids in mango at 10th day of storage at ambient conditions (35 ± 4ºC and 65 ± 5% RH).

Treatment	Soluble solid contents (°B)				Mean	Total carotenoids content (mg 100 g^{-1} pulp)				Mean
	Indigenous		Exotic			Indigenous		Exotic		
	Dashehari	Langra	Sensation	Eldon		Dashehari	Langra	Sensation	Eldon	
Control	15.0	19.0	18.0	13.0	16.2	5.2	3.3	2.6	4.1	3.8
HWT @ 45°C for 30 min.	16.0	19.5	15.0	14.0	16.1	5.6	3.9	2.8	3.8	4.0
HWT @ 50°C for 30 min.	15.0	20.5	16.0	15.0	16.6	5.1	4.2	3.1	3.6	4.0
HWT @ 55°C for 30 min.	16.0	18.0	15.0	14.0	15.7	4.8	3.1	2.8	3.6	3.5
Mean	15.5	19.2	16.0	14.0		5.2	3.6	2.8	3.7	
$CD_{0.05}$	Variety (V) = 0.8; Treatment (T) = N.A. V × T = 1.7					CD (0.05) Variety (V) = 0.15; Treatment (T) = 0.15 V × T = 0.3				

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