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ANTI-SAP CHEMICALS AND HOT WATER QUARANTINE TREATMENT EFFECTS ON STORAGE LIFE AND FRUIT QUALITY OF MANGO CV. SAMAR BAHISHT CHAUNSA

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Abstract

This study aimed at testing the combined effects of anti-sap chemicals and hot water quarantine treatment (HWQT: 48°C-60min) on a commercial mango cv. Samar Bahisht (S.B.) Chaunsa, as potential protocol for export to China. The physiologically mature mango fruit were harvested along with 4-5 cm pedicel. After de-stemming, the fruits were treated with potential anti-sap chemicals: calcium hydroxide [$Ca(OH)_2$], potassium aluminium sulphate [$KAl(SO_4)_2.12(H_2O)$], Tween-80 [$C_{64}H_{124}O_{26}$]. After chemical application, half of the fruit lot was subjected to HWQT as per protocol, while the remaining half was kept without HWQT. The fruit after treatments were air dried, packed in cardboard boxes and stored (13±1°C, 85% RH) for 21 days. Sapburn injuries were scored after 24, 48, 72 hrs and 21days of storage. After storage the fruit were allowed to ripe at room temperature and assessed for physical disorders and disease incidence. Fruit were also analysed for firmness, peel colour, sugars, titratable acidity, total carotenoids, ascorbic acid contents and organoleptic characteristics (pulp colour, texture, taste, aroma, flavour). Sapburn injury score showed significant differences for chemicals and chemical-HWQT interactions. De-stemming under lime [Ca $(OH)_2$] followed by HWQT showed least sapburn injury with more firm fruit. HW treated fruit showed significantly lower anthracnose disease incidence (1.68 vs 2.42), while higher sugars (18.32 vs 14.56%) with more pulp browning (0.74 vs 0.48) and higher total carotenoids (67.0 vs 56.1µg/g) compared to without HWQT. Organoleptic evaluation revealed smoother pulp texture in fruit without HWQT. It was concluded that mango desapping with 1.0% lime solution, followed by HWQT (48°C-60min), did not significantly impair quality during 21 days of storage, beside controlling sapburn injury and meeting market access requirement. However, in view of the exhibited heat induced effects, more studies are needed on HWQT effects on various maturity levels and improving post-storage colour development in mango cv. S.B. Chaunsa, for its export to China, by sea or road, using refrigerated containers.

Introduction

Mango fruit besides local consumption is a foreign exchange earning commodity. Pakistan is the 4^{th} largest mango exporter in the world. Pakistan exported about 73.57 thousand tonnes of mango, worth US$ 28.30 million during 2009 (FAO, 2009).

Pakistan is quite suitable for producing good quality mangoes if proper production and postharvest management is practiced. Unfortunately, mango is subjected to a large no of disorders right from the plants in the nursery to the fruit in transit and storage, which ultimately results in low yield with poor quality fruit (Chacko, 1991). To sustain the high level of production of superior quality fruit, many problems need to be overcome. Among such problems the postharvest diseases, disorders and sapburn injuries are the most important issues which result in poor quality fruits ultimately lowering the prices especially in international market.

Problem of sapburn could be avoided by various approaches including de-sapping in water or in circulating sprays, in detergents, or calcium hydroxide solution etc., (Landrigan *et al.*, 1991; Amin *et al.,* 2008; Maqbool & Malik, 2008). Initial studies on management of mango sapburn injury revealed that sap quantity and severity varies among cultivars (Maqbool *et al.,* 2007). Important anti-sap chemicals have been evaluated for their efficacy to control sapburn injury in mango fruit with calcium hydroxide and Tween-80 showing good results (Maqbool & Malik, 2008). More recently, optimum lime dose (0.5%) and relationship of harvesting and sapburn injury have also been studied (Amin *et al.,* 2008). However, the interaction of anti-sap chemicals and prolonged hot water quarantine treatment (HWQT) has not been tested on mangoes, especially in locally grown commercial cultivars.

Like many mango exporting countries, Pakistani mango industry is also facing problem of market access due to prevalence of fruit fly and importing countries are imposing restrictions like USA (irradiation) and China (HWQT) as pre-requisites for export to respective countries. Among different quarantine treatments, use of hot water as a disinfestation treatment, has been widely adopted because of its efficacy (Jacobi *et al*., 1995) and low cost. China has set mango HWQT protocol (48°C-60min) to allow import of mangoes from Pakistan but effects of such treatments alone and in combination with potential anti-sap chemicals are yet to be tested. Previous studies on HWQT with different cultivars showed that the effects depend upon a number of factors including maturity stage, cultivar, HWQT temperature and duration etc. Spalding & Reeder (1972) reported that 80% of mango fruit treated with hot water at 55°C for 5 minutes had injuries. Spalding *et al*., (1988) reported that the quality of 'Tommy Atkins' and 'Keitt' mangoes was not affected when fruits were treated with hot water at 46°C for 90 minutes and then stored for 3 days at 13°C and subsequently ripened at 24°C. But, Becerra (1989) reported fruit injury in 'Tommy Atkin' mangoes treated with hot water at 46.1°C for 90 minutes. In Pakistan, the work related to the effect of HWQT on mango fruit is generally lacking.

Among commercial mango cultivars of Pakistan, cv. S.B. Chaunsa is most widely grown. However, its higher sap contents (Maqbool *et al*., 2007); lower shelf life and fruit fly issues (Anwar & Malik, 2007) limit its export potential. Further, the export to China through land or sea routes provide a better alternative to enormous air freight charges, but it certainly takes extended transport time. Keeping in view the importance of industry issues, these research investigations were undertaken to evaluate the combined effects of anti-sap chemicals and prolonged HWQT as required by Chinese Quarantine authorities, on storage life, and quality (physical, bio-chemical and organoleptic characteristics) of mango cv. S.B. Chaunsa.

Materials and Methods

Uniformly mature mango fruit of cv. S.B. Chaunsa were harvested with 4-5 cm fruit pedicel attached from a commercial orchard located in district Multan (30° 10'N, 71° 36'E), Punjab province, Pakistan. Immediately after harvest fruits were treated with one of the chemicals (Table 1).

Table 1. Chemical compounds and handling methods

Treatment	Description
$T_{1:}$	1.0 % Calcium hydroxide [$Ca(OH)_2$] (Lime), [De-stemming under lime]
$T_{2:}$	1.0 % Potassium aluminium sulphate [$KAl(SO_4)_2.12(H_2O)$] (Alum), [Cut + Dip]
$T_{3:}$	1.0 % Tween-80 [$C_{64}H_{124}O_{26}$], [Cut + Dip]
$T_{4:}$	Control

Mango fruit were clipped manually, taking care that pedicel of the fruit remained attached, while fruit for control treatment (T_4) were harvested as per farmer practice (traditional harvesting technique). Fruit were treated as detailed in the Table 2. After application of treatments fruits were air dried and packed in cardboard boxes and then transported to laboratory where half of the anti-sap chemicals treated fruit were subjected to HWQT (48ºC-60min) and the remaining half were kept without hot water quarantine treatment (Without HWQT) application and then fruit of all treatments (HWQT and without HWQT) were stored (13±1°C & 85±5% RH) for 21 days.

Table 2. Effect of anti-sap chemicals combined with HWQT on sapburn injury score after storage

Treatment	After 24 hrs			After 48 hrs			After 72 hrs			After 21 days		
	HWQT	WHWQT	Means	HWQT	WHWQT	Means	HWQT	WHWQT	Means	HWQT	WHWQT	Means
T_1(1% Lime)	0.13de	0.10e	0.12C	0.30NS	0.23NS	0.26C	0.36NS	0.20NS	0.28C	0.43NS	0.13NS	0.28C
T_2(1% Alum)	0.530c	0.70c	0.62B	0.73NS	1.00NS	0.86B	1.00NS	1.10NS	1.05B	1.33NS	1.32NS	1.32B
T_3(1% Tween 80)	0.460c	0.43cd	0.45B	0.70NS	0.93NS	0.82B	1.13NS	1.16NS	1.15B	1.52NS	1.56NS	1.54B
T_4(Control)	2.03b	2.83a	2.43A	2.56NS	3.23NS	2.90A	2.96NS	3.46NS	3.22A	3.35NS	3.53NS	3.44A
Means	**0.79B**	**1.02A**		**1.08B**	**1.35A**		**1.36NS**	**1.48NS**		**1.66NS**	**1.64NS**	

HWQT: Hot water quarantine treatment; WHWQT: Without hot water quarantine treatment
Means not sharing similar letters are significantly different ($P \leq 0.05$)
Small letters used for interaction effects, while capital letters for treatment effects

Assessment of sapburn injury, postharvest physical disorders and disease incidence: Sap burn injury score was recorded after 24, 48, 72 hrs and 21 days during storage (Brown *et al*., 1986, Maqbool & Malik, 2008). Various postharvest physical disorders were observed by using different scales of assessment: Internal discoloration and skin shriveling [1 = 25% affected area; 2 = 50% affected area; 3 = 75% affected area; 4 = 100% affected area], chilling injury [0 = no injury; 1 = very mild (<1cm^2); 2 = mild (>1cm^2 <2cm^2); 3 = moderate (>2 cm^2 <4cm^2); 4 = severe (>4 cm^2)]. The postharvest diseases like anthracnose and soft nose were rated [1 = none; 3 = traces (after careful observation); 5 = slight; 7 = moderate and 9 = severe], while stem end rot was observed according to the method devised by Akhtar & Alam (2002).

Physico-chemical characteristics and organoleptic evaluation

Physical characteristics: After storage for 21 days fruit were allowed to ripe at room temperature (25±1°C). Fruit softness assessment was based on subjective scoring of whether the mango yielded to thumb pressure using scale rated as: 1, hard; 2, sprung; 3, slightly soft; 4, eating soft; and 5, over ripe. Peel colour development score was assessed according to Miller &McDonald, (1991) and Malik & Singh (2005).

Bio-chemical characteristics: The extracted juice from representative fruit samples were homogenized in a blender and analysed for total soluble solids (TSS) using Atago RX 5000 Digital Refractometer (Atago, Japan) according to AOAC, (Anon., 1990), titratable acidity (TA) was determined by methods given by Hortwitz (1960), ascorbic acid (Vitamin C) contents were estimated by the Indophenol's titration method (Ruck, 1963) while sugars (reducing, non-reducing and total) as described by Hortwitz (1960). Total carotenoids were estimated following the method of Lalel *et al*., (2003) and were expressed as mg.g^{-1} of β-carotene equivalent from a standard curve of β -carotene.

Organoleptic evaluation: Organoleptic evaluation of the fruit for taste, pulp colour, aroma and flavour was done using the Hedonic scale method (Peryam & Pilgrim, 1957; Jacobi & Wong, 1991). All judges were asked to score the above mentioned parameters using the 9 point Hedonic scale: 9 being like extremely and 1 dislike extremely.

Experimental design and statistical analysis: Experiment was designed as two factor factorial Completely Randomized Design (CRD). The data were subjected to analysis of variance (ANOVA) using GenStat® Release 8.2 (Lawes Agricultural trust, Rothmsted Experimental Station, UK) and Least Significant Difference (LSD) test was used to compare differences between treatments at 95% confidence level of each variable (Steel & Torrie, 1980).

Results and Discussion

Sap burn injury: The anti-sap chemicals in combination with HWQT showed significant differences for control of sapburn injury (Table 2). Maximum sapburn injury score (2.83) was found in T_4 (Control without anti-sap chemical and HWQT) followed by T_4 (Control with HWQT) after 24 hrs. Minimum sapburn injury score (0.10) was recorded in T_1 (Lime with HWQT) followed by the same treatment but without HWQT. T_2 (Alum) and T_3 (Tween-80) were at par with each other. It was evident that according to order of sapburn injury reduction during storage, T_1 (De-stemming under Lime) was found superior to all other treatments in both cases (HWQT and without HWQT), followed by T_2 (Alum) and T_3 (Tween-80). However, HWQT helped reduce the sapburn injury as compared to fruit without HWQT (Fig. 1), which may be due to the washing/cleaning effect of hot water. In this context, O'Hare *et al*., (1992) reported that destemming mango fruit in a 1% Cold Power® (detergent) solution reduced sap injury to fruit, but was not as effective as 1% Calcium hydroxide solution. Our previous studies showed Lime as an effective anti-sap chemical (Maqbool & Malik, 2008); however, present studies also show its synergistic effect in combination with HWQT in controlling sapburn injury. The interaction effect of anti-sap chemicals and HWQT after 48, 72 hrs and after 21 days of storage was statistically non-significant.

Physical characteristics: Anti-sap chemicals showed significant effect on fruit firmness, as fruit treated with Lime (1%) were more firm followed by Tween-80 and Alum, as compared to control. HWQT also affect fruit firmness during storage, since fruit without HWQT remained comparatively more firm than fruit having HWQT (Table 3).

The interaction effect of anti-sap chemicals and HWQT was also highly significant. Maximum fruit firmness (less softness score) was recorded in T_1 (Lime) with HWQT, while minimum fruit firmness (more soft) was recorded in T_4 (Control with HWQT), followed by T_4 (Control without anti-sap chemical and HWQT) (Table 3). It is clear that fruit treated with Lime and then subjected to HWQT were more firm as compared to others, after 21 days of storage. T_1 (destemming under Lime) was found superior with more firmness to all other treatments in both HWQT and without HWQT. In this context Maqbool & Malik (2008) reported that fruit of cv. Sindhri destemmed under lime were more firm as compared to fruit treated with Tween-20, Tween-80 and Sodium Carboximethyl Cellulose (CMC). More firmness in lime treated fruit may be the effect of Ca (Calcium) contents, which usually causes the cell walls strengthening and infection resistance (Kirkby & Pilbeam, 1984; Poovaiah *et al*., 1988) as in the cell wall 60% of the total cell calcium is found (Tobias *et al*., 1993). Fruit firmness has been attributed to the pectin substances, involved in cementing the cell wall, while softening is characterized by the solubilisation of these substances in middle lamellas (Roe & Bruemmer, 1981).

Effect of anti-sap chemicals on fruit colour development was statistically significant and fruit of T_2 (Alum) and T_4 (Control) were statistically at par with each other, and showed maximum fruit colour score (3.27 and 3.23 respectively) during storage (Fig. 2). Over all the effect of HWQT and without HWQT on fruit colour development during storage was statistically non significant.

Results clearly exhibited that during storage fruit treated with lime showed better firmness and less fruit colour development, while alum treated fruit showed comparatively less firmness and more fruit colour development. So, it can be concluded that Alum enhanced the fruit ripening process, so fruit attained more colour during storage, in comparison with lime and Tween-80 treatments. In general, post-storage colour score in cv. S.B. Chaunsa remained low, and more research is needed to understand and resolve the issue of post-storage colour development in this cultivar.

Biochemical characteristics: Irrespective of HWQT effect, maximum TSS (29.65 °Brix) was recorded in fruit of T_4 (Control), while minimum TSS (26.63 °Brix) in T_1 (De-stemming under lime) and the results of other treatments were statistically at par with each other (Fig. 3). In this context, Maqbool & Malik (2008) reported that in case of cv. S.B. Chaunsa, de-stemming under $Ca(OH)_2$ showed low TSS level as compared to control. The lower TSS level in lime treated fruit may be due to its effect on the ripening process. Since, TSS of fruit is increased or decreased with the progress of ripening process, it means that lime may have slowed down the ripening process or may be due to the calcium contents responsible for high firmness and infection resistance (Poovaiah *et al*., 1988) during storage, ultimately affected the ripening process in cv. S.B. Chaunsa. The effect of HWQT alone or in combination with anti-sap chemicals on TSS was statistically non-significant (Table 4).

It was observed that fruit subjected to HWQT have less total titratable acidity (0.12%) as compared to fruit stored without HWQT (0.15 %) (Fig. 4). Individual treatment effect was statistically non-significant, may be due to the fact that HWQT generally induces the ripening process (Ram *et al*., 1983) of fruit which ultimately reduces the percentage of total titratable acidity. In this context, Yahia & Pedro-Campos (2000) reported that conditioning fruit at 40°C for up to 16 hours before hot water treatment accelerated the fruit ripening, as reflected in higher total soluble solids and lower titratable acidity levels.

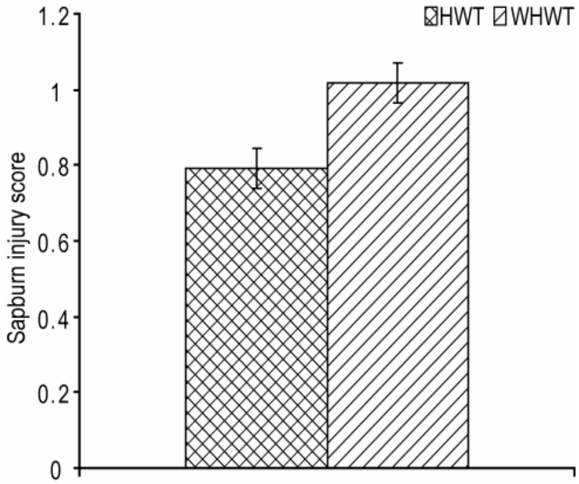

Fig. 1. Effect of different HWQT on sapburn injury after storage (± SE).

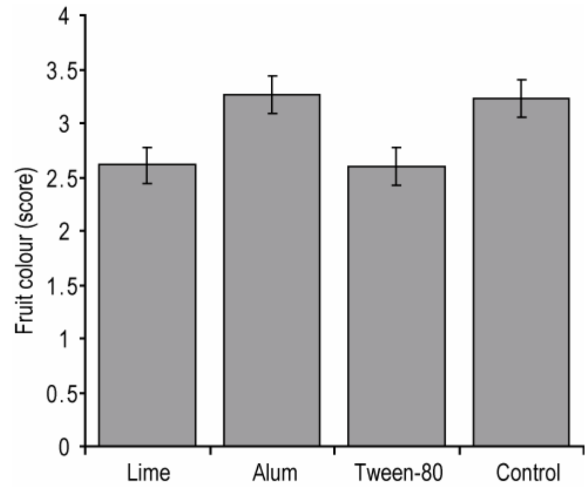

Fig. 2. Effect of anti-sap chemicals on fruit colour development (± SE).

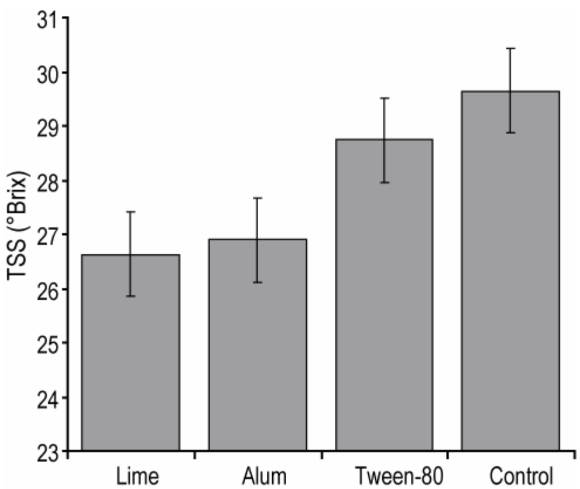

Fig. 3. Effect of anti-sap chemicals on total soluble solids (± SE).

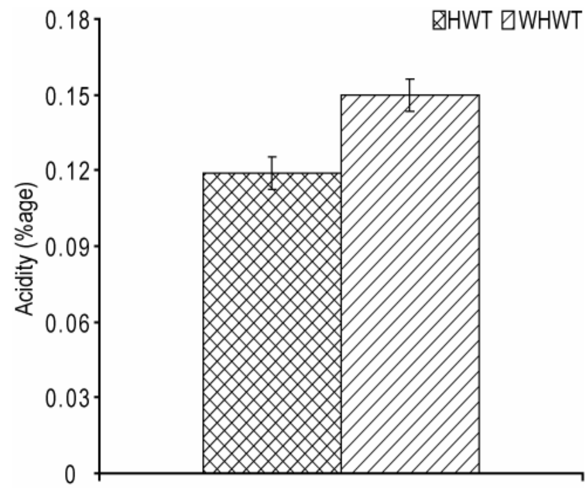

Fig. 4. Effect of HWQT on total titratable acidity (± SE).

Table 3. Mean values for mango fruit firmness after storage.

Treatment	HWQT	WHWQT	Means
T_1 (1% Lime)	2.85d	3.08cd	2.96C
T_2 (1% Alum)	3.53ab	3.26bc	3.40B
T_3 (1% Tween 80)	3.63ab	2.82d	3.22BC
T_4 (Control)	3.88a	3.62ab	3.75A
Means	3.48A	3.19B	

HWQT: Hot water quarantine treatment; WHWQT: Without hot water quarantine treatment
Means not sharing similar letters are significantly different
Small letters used for interaction effects, while capital letters for treatment effects

Table 4. Effect of HWQT and WHWQT on fruit colour and bio-chemical characteristics of mango fruit after storage.

Treatment	Fruit colour		TSS (°Brix)		Total acidity (%)		Non-Reducing Sugars (%)		Total sugars (%)		Total Carotenoids (μg/g)		Vitamin C (mg/100ml)	
	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT
T_1 (1% Lime)	2.2	3.0	26.4	26.8	0.12	0.18	12.1	11.1	16.2	14.8	67.9	61.6	49.2	38.3
T_2(1% Alum)	2.9	3.6	26.4	27.4	0.10	0.14	13.2	11.4	17.9	15.4	62.3	51.0	35.8	45.0
T_3 (1% Tween-80)	2.7	2.4	28.2	29.3	0.14	0.12	13.2	10.2	18.4	14.6	63.9	56.4	42.5	40.8
T_4(Control)	3.3	3.2	28.1	31.2	0.12	0.15	14.7	9.7	20.7	13.4	73.4	53.7	31.7	38.3
At $P\leq0.05$	NS		NS		NS		NS		NS		NS		NS	

HWQT: Hot water quarantine treatment; WHWQT: Without hot water quarantine treatment

Results of reducing sugars in fruit were significant, and maximum reducing sugars (4.41%) were present in T_4 (Control) with HWQT, followed by T_3 (Tween-80) with HWQT (3.80%). While minimum reducing sugars (2.55%) were recorded in T_1 (De-stemming under Lime) without HWQT, followed by T_4 (Control) without HWQT (Table 5). Over all, maximum reducing sugars, non-reducing sugars (Fig. 5) and total sugars (Fig. 6) were recorded in fruit having HWQT than without HWQT, indicating the heat induced acceleration of ripening process. Treatment effect on non-reducing sugars was statistically non-significant, since as ripening progresses the content of reducing sugars in fruit are increased. Ram *et al*., (1983) found that in cultivar 'Dashehari', hot water treatment induced ripening without impairing taste and flavour. There was no appreciable difference in treated and untreated fruits in the levels of pH, ascorbic acid and total sugars. It is known that during ripening, sugars are produced due to the hydrolysis of starch in chloroplast which continues until complete ripening (Medlicott *et al*., 1990). HWQT induces the ripening process in fruit by accelerating normal metabolic process of starch hydrolysis, which ultimately increases the sugars (%) in fruits. As reported by Lakshminarayana *et al*. (1970) that treating Alphonso mangoes with water at 54±1°C for 5 minutes to reduce microbial postharvest spoilage also accelerated ripening by hastening the onset of the respiratory climacteric and HWQT treated fruit pulp retained its flavour with high sugars. On the other hand, Anwar & Malik (2007) reported that in cv. Sindhri, hot water resulted in lower sugars production, which is in contradiction to our findings in cv. S.B. Chaunsa, that HWQT accelerates ripening process with higher sugars. It is may be due to varietal difference. However, the effect of HWQT on ripening process needs further investigations.

Table 5. Mean values of reducing sugars in mango fruit.

Treatment	HWQT	WHWQT	Means
T_1 (1% Lime)	2.78cd	2.55d	2.66B
T_2 (1% Alum)	3.28bc	2.74cd	3.01B
T_3 (1% Tween 80)	3.80b	3.16c	3.48A
T_4 (Control)	4.41a	2.68cd	3.55A
Means	3.56A	2.78B	

HWQT: Hot water Quarantine treatment; WHWQT: Without hot water Quarantine treatment
Means not sharing similar letters are significantly different ($P\leq0.05$)
Small letters used for interaction effects, while capital letters for treatment effects

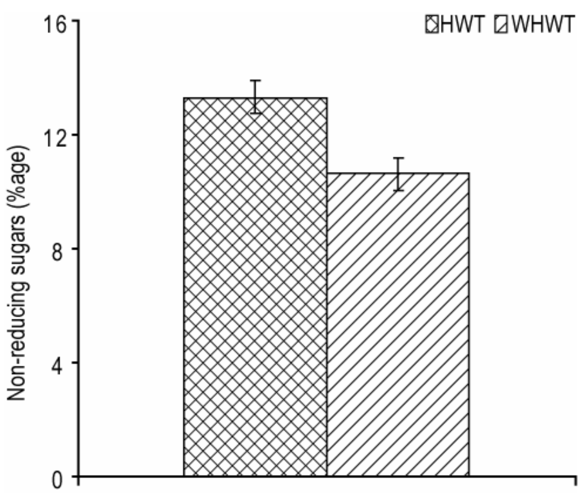

Fig. 5. Effect of HWQT on non-reducing sugars (± SE).

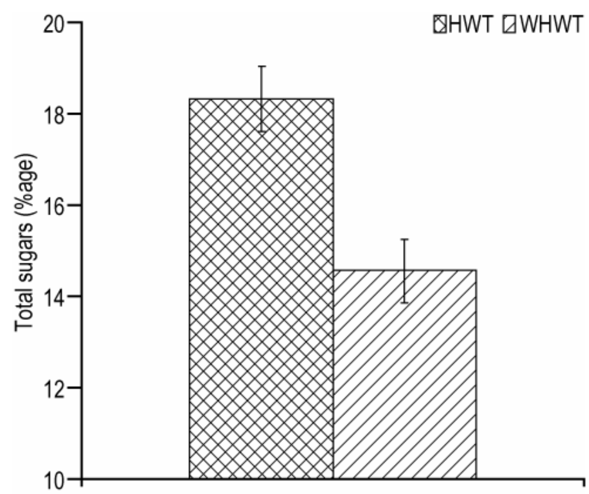

Fig. 6. Effect of HWQT on total sugars (± SE).

Mean values of total carotenoids under the effect of HWQT and without HWQT on fruit quality showed highly significant results. Maximum total carotenoids (67.0µg/g) were recorded in fruit subjected to HWQT as compared to fruit stored without HWQT (56.1µg/g) (Fig. 7). As HWQT increased the ripening process of the fruit during low temperature storage so the amount of total caroteniods also increased under the effect of increased ripening compared to without HWQT. In this context, Yahia & Pedro-Campos (2000) reported that HWQT for 60 minutes increased the carotene contents after storage for 21 days in 10°C and after one week at 10°C followed by one week at 20°C. While, Anwar & Malik (2007) reported that higher total caroteniods contents was recorded in mango fruit subjected to HWQT at 45°C-75min as compared to HWQT 48°C-60min. So the treatment time and temperature have influencing effect on total caroteniod contents of fruit during storage. Results for the effect of anti-sap chemicals on total carotenoids were statistically non-significant.

The results for vitamin C were statistically non-significant (Table 4).

Organoleptic evaluation: Organoleptic evaluation showed that the fruit stored without HWQT had better pulp texture score (5.38) as compared to fruit stored with HWQT (5.00) (Fig. 8). It can be concluded that HWQT affects texture of mango fruit as fruit without HWQT gave smoother texture at ripe stage. It may be due to the fact that HWQT advances ripening and therefore consistency of pulp texture is also effected. Non significant difference was recorded for the effect of anti-sap chemicals and HWQT on fruit pulp colour, texture, taste, aroma and flavour (Table 6). In this regard earlier Ram *et al*., (1983) also revealed that HW induced ripening in cv. Dashehari, without impairing taste and flavour of fruit.

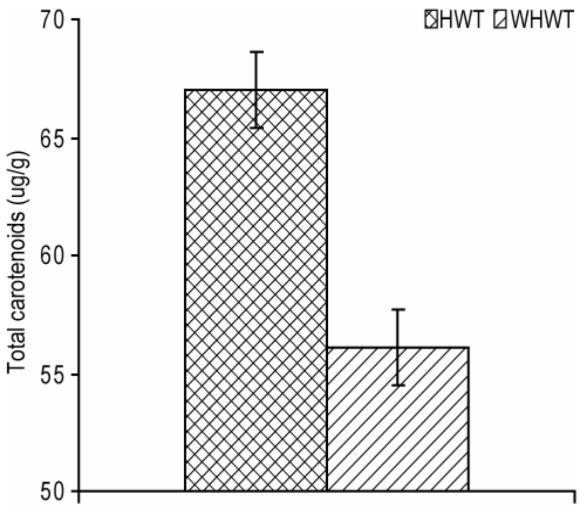

Fig. 7. Effect of HWQT on total carotenoids (± SE).

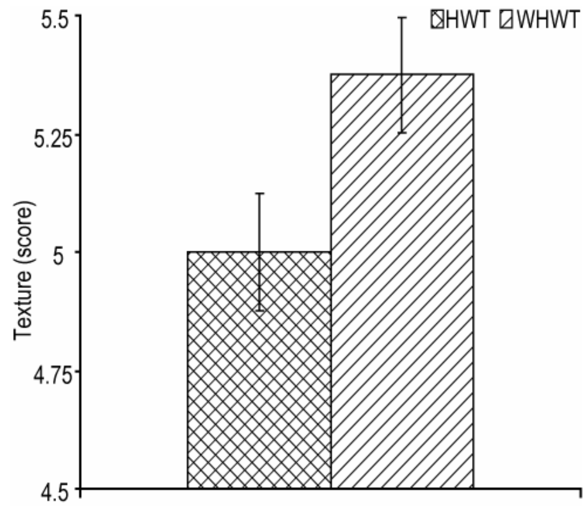

Fig. 8. Effect of HWQT on fruit pulp texture (± SE).

Table 6. Effect of HWQT and WHWQT on organoleptic characteristics of mango fruit.

Treatment	Pulp colour		Texture		Taste		Aroma		Flavour	
	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT
T_1 (1% Lime)	5.96	6.21	5.08	5.62	5.37	5.12	5.87	5.87	5.16	5.50
T_2 (1% Alum)	5.08	6.23	5.04	5.42	4.50	5.54	5.58	5.08	4.70	5.39
T_3 (1% Tween 80)	5.75	5.81	5.16	5.46	5.29	4.79	5.58	5.08	5.54	5.08
T_4 (Control)	5.79	5.71	4.70	5.00	4.54	5.17	5.42	5.50	4.66	5.00
At $P\leq 0.05$	NS		NS		NS		NS		NS	

HWQT: Hot water quarantine treatment; WHWQT: Without hot water quarantine treatment**;** NS: Non significant

Diseases and disorders: Occurrence of pulp browning among different anti-sap chemical treatments was significant and higher pulp browning score was recorded in fruit treated with Tween-80 (0.96) as compared to control (T_4) (0.60), while the treatments T_1 & T_2 were at par with each other (Fig. 9). The data showed that there was more pulp browning (0.74) in fruit with HWQT, while fruit stored without HWQT showed lesser degree of pulp browning (0.48). Fruit subjected to HWQT and then stored at low temperatures for 21 days showed more pulp browning or internal discoloration of the fruit. In this context, Medlicott *et al*., (1990) reported that fruit stored at low temperature for longer time may develop chilling injury; symptoms include inhibition of ripening, pitting, increased susceptibility to decay, internal discoloration, increased water loss and detrimental changes in flavour, which lead to drastic reduction in fruit quality and increase spoilage. In this study the pulp browning developed in fruit, may be due to the effect of HWQT that advanced fruit ripening during storage.

Incidence of anthracnose under the effect of various anti-sap chemicals and HWQT interaction (Table 7) were non-significant. Maximum anthracnose incidence score (2.38) was recorded in untreated fruit followed by T_1 (lime) (2.32), while minimum anthracnose incidence (1.73) was scored in fruit treated with Alum followed by Tween-80 (1.80). However, HWQT showed significant difference compared to control. Higher incidence of anthracnose (2.42) were observed in fruit which were not treated with hot water, while minimum score (1.68) was recorded in fruit having hot water quarantine treatment (Fig. 10). Although, the current HWQT was meant for fruit fly disinfestation but it also helped to reduce anthracnose disease incidence. Earlier finding of Korsten (2006) revealed that to control disease incidence, heat treatments (44°C-55°C), mainly as short-term (few minutes) dips, and the more recent longer exposure dipping times (hours) at slightly lower temperatures (38°C-46°C) have been proved to be effective. These treatments have been particularly effective for control of latent infections caused by *Colletotrichum gloeosporioides*, which causes anthracnose on mango.

The results of skin shrivelling, freeze injury, soft nose and stem-end rot were statistically non significant (Table 7).

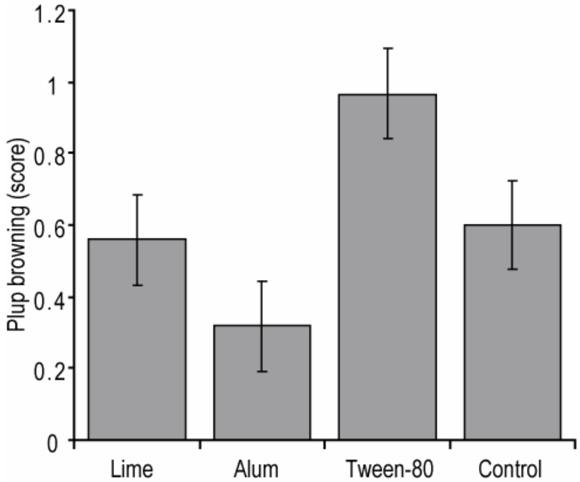

Fig. 9. Effect of anti-sap chemicals on pulp browning (± SE).

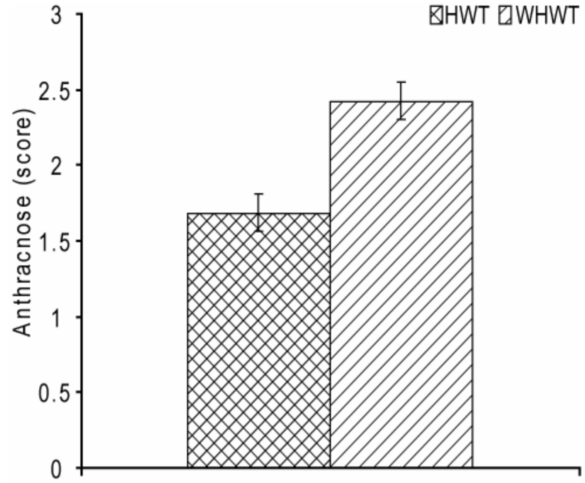

Fig. 10. Effect of HWQT on anthracnose (± SE).

Table 7. Effect of HWQT and WHWQT on disorders and diseases of mango fruit during storage.

Treatment	Pulp browning		Skin shrivelling		Chilling injury		Soft nose		Anthracnose		Stem end rot	
	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT	HWQT	WHWQT
T_1 (1% Lime)	0.80	0.32	0.10	0.10	0.00	0.00	2.07	2.07	2.20	2.33	1.73	1.00
T_2 (1% Alum)	0.43	0.20	0.10	0.16	0.00	0.10	1.53	1.80	1.26	2.43	1.00	1.00
T_3 (1% Tween 80)	0.93	1.00	0.30	0.06	0.58	0.00	2.07	1.67	1.22	2.23	1.00	1.87
T_4 (Control)	0.78	0.42	0.20	0.06	0.20	0.00	2.07	1.40	2.05	2.70	1.00	1.80
At $P\leq 0.05$	NS		NS		NS		NS		NS		NS	

HWQT: Hot water quarantine treatment; WHWQT: Without hot water quarantine treatment; NS: Non-significant

Conclusion

The results revealed that mango desapping with 1% Lime solution followed by prolonged hot water quarantine treatment (48°C-60min), did not significantly impair mango fruit quality attributes during 21 days of storage, although heat induced ripening was observed. The anti-sap chemicals particularly destemming under lime in combination with hot water treatments yielded satisfactory results in controlling sapburn injury as well as helped reducing anthracnose incidence during storage period. These treatments improved cosmetic look of the fruit. However, further work is required on HWQT on various maturity levels, and post-storage colour development in this cultivar, for export to China, by sea or road, using refrigerated containers.

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