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Effect of ethylene absorbents on compression injury and quality of Santa Rosa Japanese plum (*Prunus salicina*) during transportation

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Plum is considered as one of the most important stone fruits of temperate origin. The climatic conditions of India favour the cultivation of Japanese plum (*Prunus salicina* Lindl.) because it is hardy in nature and thrives well under adverse edaphic and climatic conditions. In India, Japanese plum varieties like Beauty, Santa Rosa and Mariposa are grown commercially under sub-temperate climatic conditions, but Santa Rosa dominates because of its self-fruitfulness, prolific bearing habit and characteristic flavour (Chattopadhyay 2008).

After ripening, plum has a limited shelf-life of about 3-4 days only. Although under cold storage conditions, it can be stored for about 18-20 days. In India, plums are usually produced in far-flung areas located in different terrains and at high altitudes, and then transported to plains for marketing. Thus, its shelf-life or market life is further reduced drastically due to rough handling and poor storage conditions. Thus, such an important and valuable fruit remains in the market for a very limited period, and there is urgent need to extend its availability in the market through proper postharvest management practices.

Several practices and experiments have been conducted for proper postharvest management of plums. Among different postharvest management strategies, use of ethylene absorbents has been reported to be very useful in some fruits (Thakur *et al.* 2005). Ethylene absorbents counteract the deleterious effects of ethylene on fruit ripening, and softening and thereby enhance the postharvest life and quality drastically, which helps in extending the marketability of fruits (Thakur *et al.* 2005, Glahan 2006, Jang *et al.* 2006). Hence, the studies have been conducted to observe the effect of ethylene absorbents on compression injury and postharvest quality of Santa Rosa plums during transportation.

The studies were conducted in the Division of Post Harvest Technology, IARI, New Delhi in 2010. The plums of Santa Rosa variety were harvested at two stages of maturity, ie, climacteric (ready-to-eat) and pre-climacteric (ready-to-ripe) in the month of June, from a private orchard at Katrain, Kullu (Himachal Pradesh), and then packed in corrugated fibre board boxes (5 kg capacity) by placing different ethylene absorbent ($KMnO_4$ impregnated chalks, $KMnO_4$ impregnated newspaper shreds, ethylene absorbent sachets) at bottom, middle and top of fruits. Plums packed traditionally served as control. After packing, plums were transported to Delhi by road. In the lab, observations on compression injury, weight loss, fruit firmness, total soluble solids, acidity, and ascorbic acid content were recorded. Compression injury was recorded by counting the fruits damaged by pressure during transportation, and represented as percentage (%). The physiological loss in weight was determined by subtracting the final fruit weight from the initial weight and represented as percentage (%). Fruit firmness was determined by using a texture analyzer (model: TA+Di, Stable micro systems, UK) and represented as N (Newton). Total soluble solids were estimated by using Fisher Hand Refractometer (0-50) and expressed as Degree Brix (ºB) at 20°C. Titratable acidity was determined by titrating a known amount of fruit sample against 0.1 N NaOH using a few drops of 1% phenolphthalein solution as indicator, and expressed as percentage (%). Ascorbic acid content were determined as per method of Ranganna (1999), and represented as mg of ascorbic acid/100 g fruit pulp. The experiment was laid out in factorial CRD design with each treatment consisting of 60 fruits with 5 replications. The data obtained from the experiments were analysed as per design and the results were compared from ANOVA by calculating the critical difference (CD) (Panse and Sukhatme 1984).

The compression injury in Santa Rosa plums during transportation was significantly lower in pre-climacteric stage of maturity (5.6%) than climacteric stage of maturity (15.5%) (Fig 1). Further, the compression injury was significantly

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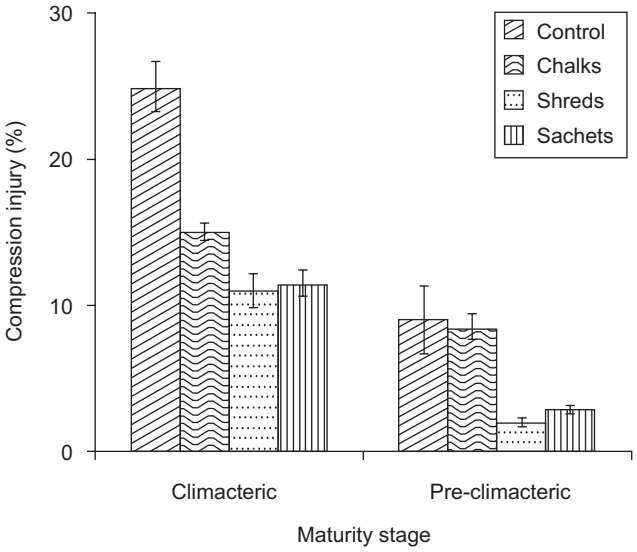

Fig 1 Effect of ethylene absorbents on compression injury (%) in Santa Rosa plum during transportation

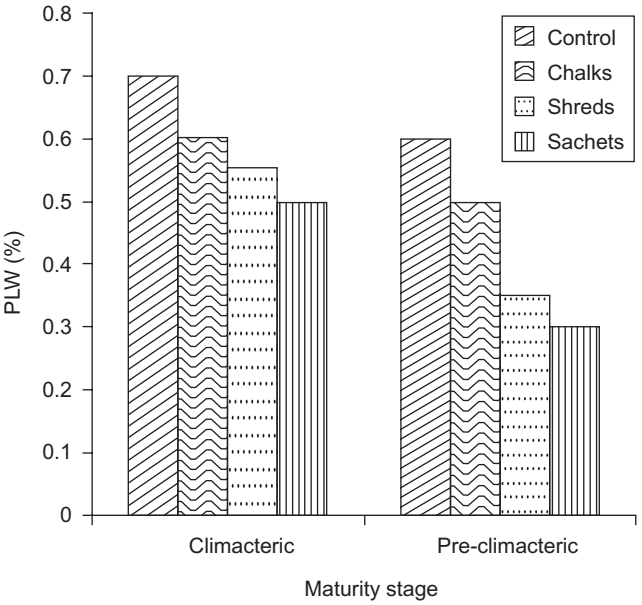

Fig 2 Effect of ethylene absorbents on physiological loss in weight (%) in Santa Rosa plum during transportation

higher (16.8%) in untreated (control) plums and the least (6.5%) in plums in which $KMnO_4$ impregnated newspaper shreds were placed. Higher compression injury in plums of climacteric stage than pre-climacteric stage may be due to fact that such plums were fully mature and ripen having lower firmness and thus more prone to pressure injury than that of pre-climacteric stage. Similarly, higher compression injury in untreated plums may be ascribed to lower firmness of such fruits in comparison to those in which ethylene absorbents were placed. Similarly, ethylene absorbents might have reduced fruit softening by absorbing liberated ethylene and thereby it reduced compression injury. Although there is no literature to support these findings, however, Thakur *et al.* (2005) reported that apples in which ethylene absorbents like ethysorb, purafil and green keeper were placed, had lesser injury during transportation. The interaction, stage × treatment for compression injury was also significant, indicating that ethylene absorbent and stage of maturity has synergistic influence on reducing the compression injury and thereby the marketable fruits.

The physiological loss in weight (PLW) in plums during transportation was significantly higher in climacteric stage (0.59 %) than pre climacteric stage (0.44 %). The physiological loss in weight was significantly higher (0.65 %) in untreated (control) plums than those in which different ethylene absorbents were placed, being the least in plums (0.40 %) in which $KMnO_4$ impregnated newspaper shreds were placed (Fig 2). Higher PLW in plums of climacteric stage than that of pre-climacteric stage or untreated ones may be due to fact that these plums were metabolically more active in respect to respiration and ethylene evolution, thereby they lost higher amount of water from them during transportation in comparison to those in which ethylene absorbents, especially when $KMNO_4$ impregnated newspaper shreds or sachets were placed. Placement of ethylene absorbents in the packaging boxes has been reported to reduce such water loss during transportation of Starking Delicious apples (Thakur *et al.* 2005).

Fruit firmness of Santa Rosa plums during transportation was significantly lower in climacteric stage of maturity (18.6 N) than pre-climacteric stage of maturity (25.8 N) (Table 1). Similarly, fruit firmness was significantly lower (21.8 N) in untreated (control) plums than those in which ethylene absorbents were placed, being the highest (22.9 N) in plums in which $KMnO_4$ impregnated newspaper shreds were placed (Table 1). Fruit firmness is an important characteristic, which governs the postharvest life of fresh horticultural produce. Lower firmness in plums of climacteric stage of maturity may be ascribed to their higher respiration and ethylene evolution rates, higher activities of enzymes like polygalacuronase, lipoxygenase and pectin methyl esterase, which are responsible for fruit softening at a faster rate than of pre-climacteric stage, which were packed with ethylene absorbents, were firmer than untreated fruits. Higher firmness in plums in which ethylene absorbents, primarily $KMNO_4$ impregnated newspaper shreds or sachets were placed, may be due to their lower metabolic activities, rendering them to be less soft or firmer (Sharma *et al.* 2010, Jhalegar *et al.* 2011). Ishaq *et al.* (2009) have also reported that apricots packed with ethylene absorbents were firmer than untreated fruits. Singh *et al*. (2011) have reported better firmness in strawberry coated with *Aloe vera* gel. Further, the interactive influence of stage of maturity and ethylene absorbents might have favoured higher fruit firmness in Santa Rosa plums during transportation.

Table 1 Effect of ethylene absorbents on fruit firmness and quality attributes of Santa Rosa plum during transportation

Treatment	Fruit firmness (N)			Total soluble solids (%)			Titratable acidity (%)			Ascorbic acid (mg/100 g pulp)		
	Climac-teric	Pre-climacteric	Mean	Clima-cteric	Pre-climacteric	Mean	Climac-teric	Pre-climacteric	Mean	Climac-teric	Pre-climacteric	Mean
Control	18.5	25.2	21.8	13.5	10.5	12	2.06	2.32	2.19	3.2	3.1	3.15
$KMnO_4$ impregnated chalks	18.6	25.3	21.9	13.5	10.6	12.1	2.07	2.34	2.2	3.24	3.2	3.22
$KMnO_4$ impregnated newspaper shreds	18.8	27	22.9	13.4	10.5	11.9	2.09	2.37	2.23	3.29	3.24	3.27
Ethylene absorbent sachets	18.6	26.7	22.7	13.5	10.4	11.9	2.1	2.37	2.23	3.28	3.2	3.24
Mean	18.6	25.8		13.5	10.5		2.08	2.35		3.25	3.19	
CD (P= 0.0.5)	Stage 0.19, Treatment 0.27, S × T 0.33			Stage 0.39, Treatment NS, S × T, NS			Stage 0.02, Treatment 0.03, S × T, NS			Stage 0.044, Treatment 0.062, S × T NS		

The total soluble solids (TSS) were higher in plums harvested at climacteric stage (13.5 ºB) than those harvested at pre-climacteric stage (10.5 ºB), however, the treatments have no significant effect on total soluble solids (Table 1). Similarly, the interaction, stage × treatment was also not significant. Higher total soluble solids in plums of climacteric stage than that of pre-climacteric stage might be due to the fact that plums of climacteric maturity were riper and there must have been hydrolysis of starch into simple sugars at a faster and better rate than plums of pre-climacteric stage. Thakur *et al.* (2005) have reported slower increase in TSS content in Starking Delicious apples, especially with the use of purafil, an ethylene absorbent. Similarly, Glahan (2006) observed that litchies packed in polyethylene bags containing ethylene absorbents retained higher TSS than those in which no ethylene absorbent was placed. Singh *et al.* (2011) reported lower sweetness in strawberry during storage.

The untreated fruits of Santa Rosa plum during transportation have the lower titratable acidity (2.19 %) than those in which ethylene absorbents were placed (Table 1). Further, the titratable acidity was higher in plums of pre-climacteric stage (2.35%) than climacteric stage (2.08%). Among treatments, both ethylene absorbent sachets and $KMnO_4$ impregnated newspaper shreds were equally effective (2.23%) in maintaining significantly higher levels of titratable acidity. The interaction effect of stage × treatment was however, non-significant (Table 1). Higher acidity in plums of pre-climacteric stage or those with ethylene absorbents may be due to the fact that they were not ripened in comparison to plums of climacteric stage and untreated plums, respectively. Moreover, un-ripened or immature fruits always contain higher amounts of acids, which contribute to higher acidity. Hence, our results are in accordance with the studies of Shorter *et al.* (1992) who had reported that Granny Smith apples in polyethylene bags with ethylene absorbents had higher acidity than untreated ones. Similarly, Thakur *et al.* (2005) had reported that 'Starking Delicious' apples showed slower decrease in TA when ethylene absorbents like ethysorb, purafil and green keeper were placed in CFB boxes.

Ascorbic acid content was significantly higher in plums harvested at climacteric stage of maturity (3.25 mg/100 g pulp) than those harvested at pre-climacteric stage of maturity (3.19 mg/100 g pulp) (Table 1). The untreated plums have significantly lower content of ascorbic acid (3.15 mg/100 g pulp) than those in which ethylene absorbents were placed. The interaction, stage × treatment was not significant. The higher retention of ascorbic acid in plums of climacteric stage may be ascribed to efficient accumulation of ascorbic acid in them due to higher and better metabolic activities, lower ascorbic acid content in untreated plums might be due to utilization of ascorbic acid in several processes. Thus, our observations are similar to the findings of Thakur *et al.* (2005) who reported higher ascorbic acid content in Starking Delicious apples in which ethylene absorbents like ethysorb, purafil and green keeper were used.

SUMMARY

Experiments were conducted to observe the effect of different ethylene absorbents during transportation of Santa Rosa plums of two maturity group, ie climacteric and pre-climacteric. Different ethylene absorbents (Control, $KMnO_4$ impregnated chalks, $KMnO_4$ impregnated newspaper shreds, ethylene absorbent sachets) were placed in CFB boxes containing plums, and then transported to Delhi by road. After transportation, observations were recorded on several parameters. Our results revealed that untreated plums have very heavy loss during transportation due to compression injury in both stages of maturity, being quite higher in climacteric stage than pre-climacteric stage. Similarly, there was a significant effect of maturity stage on quality parameters like total soluble solids, ascorbic acid, fruit firmness and titratable acidity, all being better in climacteric stage of maturity than pre-climacteric stage. In all, ethylene sachets

or $KMnO_4$ sachets were better in reducing compression injury and maintaining quality parameters during transportation of plums.

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