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Postharvest Changes in Three Varieties of Mango (*Mangifera indica*) as Affected by Pre and Postharvest Treatments

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ABSTRACT. *At present the postharvest losses of mangoes in Sri Lanka are estimated to be in the range of 40 to 60% of the total harvest. This study was carried out to develop measures to minimize postharvest losses and extend the storage life in three popular varieties of mangoes, Karthacolomban (KC), Vellaicolomban (VC) and Willard grown in Sri Lanka. Preharvest spraying of 10,000 ppm $CaCl_2$ with Teepol extended the storage life of KC by 4 days and VC by 3 days without affecting acceptability. Both hot and cold water double dip and hot benlate treatments of KC resulted in 100% blemish and disease free, good coloured fruits. These treatments however, did not extend the storage life under ambient conditions (25-32°C, 65-75% Relative Humidity (RH)). The storage life of fruits packed in perforated polythene (PP) bags increased by 4 days in Willard, 2 days each in VC and KC mangoes under ambient conditions. The storage life of VC, KC and Willard fruits packed in PP bags increased with the decrease in storage temperature. The same treatments containing vermiculite impregnated with $KMnO_4$ extended the storage life and improved acceptability. In low temperature storage, cold stored fruits (10°C and 85-90% RH) showed higher storage life than refrigerated stored (12-14°C and 70-75% RH) fruits. Furthermore, fruits stored at low temperature had lower total soluble solids (TSS) and pH and higher titratable acidity (TA) in all varieties.*

INTRODUCTION

The world production of mango is over 15 million tonnes. Sri Lanka accounts for about 0.4% of the total production and is about the twentieth

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largest producer in the world (Warbuton, 1994). Ripened mango fruits are consumed fresh mainly as dessert. It is also used for processing of juice, nectar, squash, beverage, syrup, jam, fruit bar, amchoor, chutney and pickle (Salunkhe and Desai, 1984).

The postharvest physiology of mango fruit is characterized by a rapid rate of ripening and senescence (Pantastico *et al.*, 1984). Control of these processes is essential for extending the storage life. Loss in quantity and quality of mangoes begins at harvest and continues until the product reaches the consumer. It was revealed that losses of mangoes in Sri Lanka could amount to 40-60% of total harvest (Shanthi, Pers. Comm., 1995). Hence, reducing postharvest losses is of vital importance. This study was carried out to develop suitable methods that minimize postharvest losses in mango.

The objectives of the study were to study the best storage method to extend the shelf life of fruits with enhanced quality and increased marketability, and to assess both quantitative and qualitative postharvest changes that occur during storage.

Calcium (Ca) is known to be an essential plant nutrient involved in the quality retention of fruit through maintaining firmness, reducing respiratory rate and ethylene evolution (Yuen, 1993). Multiple field spraying of Ca salts directly onto the fruit can improve Ca uptake. Haribabu *et al.*, (1993) reported that the storage life of *Alphonso* mangoes could be extended by preharvest Ca spray. Heat disinfestation treatment is effective in controlling fungal spoilage (60-70%) and achieving uniform ripening (Salunkhe and Desai, 1984). Hot water and hot benlate treatments yield satisfactory result of controlling fungal diseases. The common method employed for increasing the storage life is by storing at reduced temperature. Mango is susceptible to chilling injury when stored at moderately low temperature. Fruits wrapped with perforated polythene (PP) bags may reduce the loss due to transpiration. The inclusion of vermiculite impregnated with potassium permanganate in PP bags have shown to effectively remove ethylene and increase storage life without affecting quality (Peacock, 1984).

MATERIALS AND METHODS

Preharvest treatments

Four, fully bearing branches of Vellaicolomban and Karthacolomban (each representing one replicate) were randomly selected and an aqueous

solution of 10,000 ppm $CaCl_2$ with 0.1% Teepol was sprayed on fruits and leaves. The spray programme commenced after 60 days from full bloom stage and continued at one week intervals until they reached harvesting maturity. A similar set of fruits was selected and maintained without spraying from another tree as control. Fruits (81x4 fruits per treatment) were harvested when they reached harvest maturity and stored at ambient conditions until ripened. Quantitative and qualitative parameters were assessed as below.

Postharvest treatments

Another set of 81 blemish free fruits from varieties of Vellaicolomban, Karthacolomban and Willard were selected with 3 replicates arranged using a Completely Randomized Design for each of the following postharvest treatments.

* Control
* Immersing in hot water at 51-53°C for 10 minutes and cooling at 21-23°C for 5 minutes
* Immersing in Benlate (1000 ppm) at 51-53°C for 5 minutes
* Fruit packed in perforated polythene (PP) bags (150 gauge)and stored under following conditions:
    * 25-32°C (room temperature) and 65-75% RH
    * In the refrigerator (12-14°C, 70-75% RH)
    * In the cold room (10°C, 85-90% RH)
* Fruits packed in PP bags with $KMnO_4$ impregnated vermiculite and stored in the cold room (10°C, 85-90% RH)

Assessment of quantitative and qualitative parameters

Nine fruits per treatment were periodically assessed for quantitative and qualitative parameters such as weight and volume of fruit, weight of peel, stone and pulp, moisture content, total soluble solids (TSS), titratable acidity (TA), pH, colour, firmness and acceptability until fruit ripened. AOAC (1990) method was used to determine moisture%, TSS%, TA% and pH of juice of mangoes. Colour and firmness were scored by visually and by finger pressure respectively on a scale of 1 to 7 (for colour score 1 =totally dark green and 7 = orange; for firmness score 6 = too hard and 1 = over soft). The acceptability of ripened fruits was determined by percentage of fruits that meet the market

requirements considering disease incidence, colour and taste (TSS/TA and tasting panel). Chi-square test was employed to compare the treatment effects in storage life and acceptability of fruits.

RESULTS

Table 1. Effect of treatments on storage life and acceptability of Vellaicolomban, Karthacolomban and Willard mangoes.

Treatments	Vellaicolomban		Karthacolomban		Willard	
	Storage life	Accepta-bility	Storage life	Accepta-bility	Storage life	Accepta-bility
Control	8	70	10	80	7	90
$CaCl_2$ Spray	11	70	14	80	-	-

Karthacolomban fruits showed higher acceptability and longer storage life than Vellaicolomban fruits. $CaCl_2$ spray extended the storage life of both the varieties.

Table 2. Effect of treatments on quality parameters of preharvest treatments.

Treatments	Parameters							
	PSS	MC%	TSS%	TA%	pH%	WL%	VL%	TSS/TA
Variety VC control	3.30[a]	82.94[a]	14.16[a]	0.92[a]	4.32[a]	10.53[a]	7.80[a]	704.60[a]
$CaCl_2$ spray	4.47[a]	84.06[a]	13.77[a]	0.97[a]	4.11[a]	7.77[b]	5.20[b]	33.10[a]
Variety KC control	4.01[a]	82.53[a]	13.60[a]	0.82[b]	4.45[a]	10.91[a]	8.96[a]	51.87[a]
$CaCl_2$ spray	4.14[a]	83.59[a]	13.69[a]	1.02[a]	4.31[a]	7.80[b]	4.68[b]	36.09[a]

Means with same letters along a column are not significantly different (p=0.01).

Table 3. Effect of treatments on storage life (SL) and acceptability (AC) of Vellaicolomban, Karthacolomban and Willard mangoes.

Treatments	Vellaicolomban		Karthacolomban		Willard	
	SL	AC	SL	AC	SL	AC
Control	8	70	10	80	7	90
Hot and cold water double dip	-	-	10	100	-	-
Hot benlate dip	-	-	10	100	-	-
PP packed fruits stored at 25-32°C and 65-75% RH	10	50	12	60	11	60
PP packed fruits stored at 12-14°C and 70-75% RH	18	50	20	60	20	60
PP packed fruits stored at 10°C and 85-90% RH	28	50	36	60	31	60
PP packed fruits stored at 10°C and 85-90% RH with KMnO4 impregnated vermiculite	33	60	39	70	33	80

SL - Storage Life (days) AC - Acceptability (%)

Acceptability of the fruits treated with hot and cold water double dip and hot benlate was higher than the fruits in control. Low temperature stored fruits showed lower acceptability and longer storage life in all varieties.

Table 4. Effect of postharvest treatments of Vellaicolomban mangoes.

Treatments	Parameters							
	PSS	MC%	TSS%	TA%	pH%	WL%	VL%	TSS/TA
Control	3.33^{d}	82.94^{d}	14.05^{a}	1.00^{d}	4.34^{a}	10.55^{a}	7.80^{a}	704.1^{a}
PP packed fruits stored at 25-32°C and 65-75% RH	3.44^{bcd}	84.43^{bcd}	11.10^{b}	1.28^{bcd}	3.95^{b}	5.83^{b}	3.13^{b}	12.0^{b}
PP packed fruits stored at 12-14°C and 70-75% RH	3.61^{abcd}	86.62^{a}	10.00^{b}	1.64^{ab}	3.75^{b}	4.78^{b}	3.11^{b}	10.2^{b}
PP packed fruits stored at 10°C and 85-90% RH	3.62^{abc}	85.69^{abc}	10.37^{b}	1.66^{a}	3.81^{b}	4.68^{b}	3.15^{b}	6.9^{b}
PP packed fruits stored at 10°C and 85-90% RH with $KmnO_4$ impregnated vermiculite	3.00^{c}	85.53^{abc}	11.31^{b}	1.51^{abc}	3.91^{b}	3.63^{b}	2.63^{b}	6.3^{b}

Means with same letters along a column are not significantly different (p=0.01).

Table 5. Effect of Postharvest treatments of Karthacolomban mangoes.

Treatments	Parameters							
	PSS	MC%	TSS%	TA%	pH%	WL%	VL%	TSS/TA
Control	3.97^{b}	83.11^{c}	13.27^{ab}	1.00^{d}	4.34^{a}	10.55^{a}	7.80^{a}	704.1^{a}
PP packed fruits stored at 25-32°C and65-75% RH	3.44^{bcd}	84.43^{bcd}	11.10^{b}	1.28^{bcd}	3.95^{b}	5.83^{b}	3.13^{b}	12.0^{b}
PP packed fruits stored at 12-14°C and70-75% RH	3.61^{abcd}	86.62^{a}	10.00^{b}	1.64^{ab}	3.75^{b}	4.78^{b}	3.11^{b}	10.2^{b}
PP packed fruits stored at 10°C and 85-90% RH	3.62^{abc}	85.69^{abc}	10.37^{b}	1.66^{a}	3.81^{b}	4.68^{b}	3.15^{b}	6.9^{b}
PP packed fruits stored at 10°C and 85-90% RH with $KmnO_4$ impregnated vermiculite	3.00^{e}	85.53^{abc}	11.31^{b}	1.51^{abc}	3.91^{b}	3.63^{b}	2.63^{b}	6.3^{b}

Means with same letters along a column are not significantly different (p=0.01).

Table 6. Effect of postharvest treatments of Willard mangoes.

Treatments	Paramcters							
	PSS	MC%	TSS%	TA%	pH%	WL%	VL%	TSS/TA
Control	3.30[a]	77.38[a]	20.12[bc]	0.5230[ab]	4.30[a]	11.73[a]	10.36[a]	92.77[a]
PP packed fruits stored at 25-32°C and 65-75% RH	3.68[a]	77.75[a]	19.50[c]	0.5764[ab]	4.27[a]	4.52[b]	3.37[b]	42.78[c]
PP packed fruits stored at 12-14°C and 70-75% RH	3.50[a]	77.54[a]	20.03[bc]	0.5965[a]	4.03[b]	4.39[b]	2.86[bc]	39.49[c]
PP packed fruits stored at 10°C and 85-90% RH	3.54[a]	77.93[a]	21.17[a]	0.4899[b]	4.20[ab]	3.69[b]	1.63[c]	56.76[bc]
PP packed fruits stored at 10°C and 85-90% RH with $KmnO_4$ impregnated vermiculite	3.55[a]	76.72[a]	20.95[ab]	0.3893[c]	4.47[a]	3.58[b]	1.60[c]	77.25[ab]

Means with same letters along a column are not significantly different (p=0.01).

Table 7. Effect of treatments on colour development and firmness of Vellaicolomban, Karthacolomban and Willard mangoes after ripening.

Treatments	Vellaicolomban (SR)		Karthacolomban (SR)		Willard (SR)	
	Colour Dev.	Firmness	Colour Dev.	Firmness	Colour Dev.	Firmness
Control	9.0	6.0	20.0	9.0	15	4.5
$CaCl_2$ Spray	9.0	12.0	15.0	9.0	-	-

Treatments	Vellaicolomban (SR)		Karthacolomban (SR)		Willard (SR)	
	Colour Dev.	Firm-ness	Colour Dev.	Firm-ness	Colour Dev.	Firm-ness
Control	9.0	6.0	0.0	9.0	15.0	4.5
Hot and cold water double dip	9.0	12.0	15.0	9.0	-	-
Hot Benlate dip	9.0	6.0	20.0	9.0	15.0	-
PP packed fruits stored at 25-32°C and 65-75% RH	-	-	31.0	5.0	-	9.5
PP packed fruits stored at 12-14°C and 70-75% RH	-	-	31.0	5.0	-	12.0
PP packed fruits stored at 10°C and 85-90% RH	9.0	23.5	3.0	23.5	5.0	9.5
PP packed fruits stored at 10°C and 85-90% RH with $KmnO_4$ impregnated vermiculite	9.0	15.5	9.0	23.5	7.0	9.5

Higher sum of ranks (SR) of colour and firmness indicates higher colour development and higher firmness, respectively.

DISCUSSION

Storage life of fruits which were not subjected to preharvest spray was 8 days in Vellaicolomban and 10 days in Karthacolomban. In Ca sprayed fruits, the storage life was extended by 3 days in VC and 4 days in KC. In the variety *Alphonso* 2-3 days storage life extension by Ca spray has been reported. There was no significant difference ($p=0.01$) observed in PSS, MC, TSS and pH between the control and Ca sprayed VC and KC mangoes. But TA was significantly ($p=0.01$) higher and weight and volume loss were significantly lower in $CaCl_2$ sprayed fruits. Visible colour change was not observed in VC but in KC during ripening. Lesser colour development and no difference in firmness were observed in KC fruits. But in VC fruits higher firmness retention was recorded by Ca spray. There was no effect on acceptability and taste by Ca spray in both varieties though storage life extension was observed.

Storage life was not affected by hot and cold water double dip and hot benlate treatments. PSS, MC, TSS, TA and pH of these treatments were significantly ($p=0.01$) different from the control. Although both treatments showed a slight increase in weight and volume loss, they were not significantly different. Hot and cold water double dip and hot benlate treated fruits had better colour development than control. The hot water treatment appeared to develop attractive yellow colour during ripening. Both treatments had lower firmness and higher acceptability than the control. There was no difference in acceptability and taste between hot and cold benlate treatments.

Storage life extension was reached in all PP packed VC, KC and Willard mangoes. Maximum storage life was in PP packed cold stored fruits with $KmnO_4$ in all three varieties. The inclusion of $KmnO_4$ in sealed bags absorbed C_2H_4 and consequently ripening process was delayed by 2 weeks in *Carabao* mangoes. All PP packed treatments showed significant difference ($p=0.01$) from the control for quality parameters of PSS, MC, TSS, TA, pH, WL, VL and taste of VC, KC and Willard mangoes except PSS and MC of Willard mangoes. Moisture content of PP packed VC and KC was significantly ($p=0.01$) high and it was slightly high but, not significant in Willard. Weight and volume loss were significantly lower in PP packed VC, KC and Willard fruits due to the effect of polythene wrapper and low temperature. In all PP packed treatments, TSS was significantly lower and TA was significantly higher. This suggested that ripening process of PP packed fruits was slower compared to the control as polythene film provided a partial barrier to gas exchange with low temperature reducing the metabolic activities such as starch and acid breakdown.

A slower colour development was noticed in all PP packed KC and Willard fruits except PP packed cold stored KC fruits with $KMnO_4$. PP packed VC, KC and Willard fruits showed higher firmness than the control. Acceptability of all PP packed fruits was lower than control. In low temperature storage, all varieties did not show any symptom of chilling injury in refrigerator storage and cold room storage with $KMnO_4$.

Taste is the balance between TSS and acidity. PP packed fruits had low TSS and high acidity than control after ripening and were found to be slightly sour in taste, but acceptable. In Willard, PP packed cold stored fruits with $KMnO_4$ showed slightly lower value of TSS/TA than control after ripening. But it was significantly different. Among the treatments, cold stored fruits with $KMnO_4$ had maximum storage life, low weight and volume loss and high acceptability.

CONCLUSION

Preharvest spraying of 10,000 ppm $CaCl_2$ with 0.1% Teepol extended the storage life of Vellaicolomban and Karthacolomban by 4 days without affecting storage life.

Both hot and cold water double dip and hot benlate treatments on KC resulted in blemish and disease free attractively coloured fruits. However the storage life of these fruits was not extended.

The storage life of fruits packed in PP bags increased with decreasing temperature. The same treatment containing vermiculite impregnated with $KMnO_4$ further extended the storage life and improved acceptablity. Low temperature storage reduced weight and volume loss.

Cold stored fruits with $KMnO_4$ was found to be the best treatment in all three varieties considering storage life and acceptability.

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