Effect of Essential Oils on Postharvest Shelf Life and Quality of Mandarin

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Abstract

An experiment was carried out to assess the effect of different concentration of essential oils on postharvest quality of mandarin. The various essential oils used were ; lemongrass (Cymbopogan citratus) oil, mint (Mentha arvensis) oil, cinnamomum (Cinnamomum zeylanicum) oil and eucalyptus (Eucalyptus globulus) oil, each @ 0.5 %, @ 1 % and @ 2 % concentration and the fungicide used was Diathane M-45 @ 0.2 % concentration. The experiment was conducted in ambient room condition at Regional Agricultural Research Station (RARS), Lumle Kaski, Nepal in January 2016. Fully ripened mandarin fruits harvested from Raangkhola, Syangja were transported to RARS, Lumle and store at room conditions. The temperature and relative humidity was 11±2 ^{0}C and 56-87 % respectively. Minimum physiological loss in weight (7.16 %) and decay loss (16.66 %) was observed in the fruits treated with Eucalyptus oil @ 2 %. Maximum firmness (3.86 kg/cm^2) was recorded in the fruits treated with lemongrass oil @ 0.5 % followed by the fruits treated with mint oil @ 2 %. The highest TSS (12.13 °Brix) was recorded in the untreated fruits. The highest vitamin c content (29.76 mg/100 ml) was obtained in fruits treated with Eucalyptus oil @ 2 %. The highest titratable acidity (0.97 %) was recorded in fruits treated with Cinnamomum oil @ 2 % followed by Eucalyptus oil @ 2 %. The minimum decrease in juice recovery percentage (39.90 %) during the storage was observed in the fruits treated with Cinnamomum oil @ 2 %. It can be concluded that application of Cinnamomum oil @ 2% and Eucalyptus oil @ 2%gave the better postharvest retention of mandarin orange.

Keywords: *Cinnamomum, Eucalyptus*, lemongrass, mint, titratable

Introduction

Mandarin (*Citrus reticulata* Blanco.) is one of the most important sub-tropical fruits grown in the mid-hills of Nepal. The agro-climatic condition in the mid-hills (800-1500 m) is considered suitable for quality citrus fruit production. There are many citrus species in Nepal, however mandarin (*Citrus reticulata* Blanco), sweet orange (*Citrus sinensis* Osbeck) and acid lime (*Citrus aurantafolia* Swingle) are cultivated in commercial scale. Productive area, production and productivity of mandarin in Nepal is 16,527ha, 149315.5ton, 8.8 t/ha respectively (MOAD, 2014). Mandarins being loose skinned fruits are very susceptible to postharvest damage during harvesting and subsequent handling. They lose their freshness and firmness relatively faster than other citrus species. Ladaniya (2001) reported that nearly 20-25% of citrus fruit loss is due to faulty methods of harvesting, packing, transport and marketing.

Postharvest management is the technology of handling agricultural produce after harvest to prolong the shelf life along with freshness and attractive appearance. In Nepal, postharvest loss for fruits is 20 to 35% (Kaini, 2000). The widespread use of pesticides has significant drawbacks including increased cost, handling hazards, concern about pesticide residues on food, and threat to human health and environment. Thus, the potential value of essential oils as secondary preservatives is considered for the safe extension of perishable products shelf life and these substances can be used to delay or inhibit the growth of microorganisms. The essential oils are reported to have some fungicidal properties against certain postharvest diseases of tropical fruits and vegetables (Meepagala et al.,2002). Recently, the exploitation of natural products to control fruit rot and prolong storage life of perishables commodities have received more attention (Tripathi & Dubey, 2003).

The qualitative loss is more serious when pathogens, and deep penetration of decay, make the infected produce unsuitable for human consumption (Singh & Jain, 2004). Natural or biological products such as essential oil have been reported to have antibacterial and antifungal activity. Due to the perceived health risks associated with the use of chemicals, there is an increasing public concern on the use of essential oils on postharvest treatments.

Thus, this research was conducted to find out the proper postharvest handling practices and to discover effective, safe and economical treatments to reduce the postharvest fruit losses of mandarin.

Materials and Methods

Fruits were brought from farmer's orchard located at Raangkhola, Syangja which is one of the pocket area of mandarin production in Nepal. The cultivar selected for the experiment was the local cultivar popular in that locality. The fruit of uniform maturity stage turned to yellow colour were harvested and carefully collected in cardboard boxes. The experiment was conducted at Regional Agricultural Research Station, Lumle. RARS, The experiment was conducted from January 12 to 27, 2016. The experiment was carried out in completely randomized design, comprising fourteen treatments replicated thrice. The treatments were ; T1= lemongrass oil @ 0.5 %, T2= lemongrass oil @ 1%, T3= lemongrass oil @ 2%, T4= mint oil @ 0.5 %, T5= mint oil @ 1 %, T6= mint oil @ 2 %, T7= *Cinnamomum* oil @ 0.5%, T8=*Cinnamomum* oil @ 1%, T9=*Cinnamomum* oil @ 2%, T10=*Eucalyptus* oil @ 0.5%, T11=*Eucalyptus* oil @ 1%, T12=*Eucalyptus* oil @ 2%, T13= Diathane M-45 @ 0.2 %, T14= control. Different Essential oils (lemongrass oil, mint oil, *Cinnamomum* oil, *Eucalyptus* oil) at concentration (0.5 %, 1 %, 2 %) was prepared . Also the fungicidal solution of Diathane M-45 @ 0.2 % was prepared by mixing 2 g in one liter of distilled water. Then the fruits were dipped in the designated solution for 10 minutes and dried well. The dried treated fruits were kept in the plastic tray during the storage period in the ambient room condition. Twenty fruits were used as non-destructive sample and ten fruits were used as destructive sample. Following parameters were evaluated during the storage period.

Physiological Loss in Weight (%)

The weight loss was calculated according to the formula:

$$PLW = [(W0 – Wt) / W0] \times 100\ \%$$

Where PLW is the physiological loss in weight, W0 is the initial weight of fruit and Wt is the weight of the fruits at the designated time.

Fruit firmness (kg/cm^2)

Four reading were taken on opposite sides of each fruit after the peel was removed from each point. Firmness was expressed in kilograms per square centimeter.

Total Soluble Solids (˚ Brix)

TSS was measured with the help of hand held refractometer.

Titratable acidity (TA)

TA was measured with the help of titration method using standardized 0.1 N NaOH solution and phenolphthalein as indicator as outlined by AOAC (2005).

TA percentage was calculated by using the formula given below.

$$\text{Titratable acidity (\%)} = \frac{\text{ml of NaOH used} \times \text{Acid factor} \times 100}{\text{ml of juice taken}}$$

Ascorbic Acid (Vitamin C) Content

The ascorbic acid of the fruit was measured by volumetric method.

$$\text{Amount of ascorbic acid (mg/100ml sample)} = \frac{0.5\text{mg} \times V_2 \times 100 \times 100}{V_1 \times 5\text{ml} \times \text{volume of juice}}$$

Where, V_1= amount of dye consumed during the titration

V_2 = amount of dye consumed when the supernatant was titrated with 4% oxalic acid

Juice Recovery (Percentage)

Juice from the sample fruit was extracted and its volume was measured at designated interval till the termination of storage. Juice recovery was measured as:

Juice Recovery (%) = Volume of the juice obtained/weight of the fruit *100 %

Decay loss (%)

The percentage of disordered fruits included all of the spoiled fruits resulted from rots, fungus, bacterial and pathogens were assessed and the defects were calculated as follows:

Decay (%)= No of decayed fruit/No of fruit at the beginning of the storage *100

Statistical Method

The data were statistically analyzed using MSTAT-C software. Duncan's Multiple Range Test (DMRT) for mean separations was done from the reference of Gomez and Gomez (1984).

Results and Discussion

Physiological loss in weight:

The effect of different postharvest treatment on physiological loss in weight expressed in percentage is displayed in Table 1. Physiological loss in weight (PLW) was significantly increased in all the treatments with the advancement of the storage period. At the end of the storage period maximum PLW (15.64 %) was observed with control fruits followed by the fruits treated with lemongrass oil @ 2 %. Minimum PLW (7.16 %) was observed in the fruits treated with *Eucalyptus* oil @ 2 % followed by *Cinnamomum* oil @ 2 % and *Cinnamomum* oil @ 1 %. Thus, essential oil emulsion might have been an effective treatment to reduce weight loss by checking the stomata and lenticels of the cell wall of the fruits which reduces the rate of transpiration and respiration. The positive effect of essential oils in reduction of weight loss in different crops were reported by Mohammadi and Aminifard (2012) of Anise, Ammi, ziziphora and Cinnamomum oils on peach, (Hassani et al.,, 2012) of thyme and clove essential oils on apricot fruits, (Salimi et al., 2013) of Basil, Wild Mint and Ajowan oils on Rasha grape.

Table 1. Effect of postharvest treatments on physiological loss in weight of mandarin fruit during storage at ambient room conditions (11± 2ºC) January, 2016.

Treatments	Physiological loss in weight on days indicated (%)				
	3	6	9	12	15
Lemongrass oil @ 0.5%	1.46^{ab}	3.43^{b}	5.31^{b}	6.98^{b}	8.27^{bc}
Lemongrass oil @ 1%	1.09^{b}	2.87^{b}	5.22^{b}	6.88^{b}	8.60^{bc}
Lemongrass oil @ 2%	1.61^{ab}	3.70^{ab}	6.31^{b}	8.88^{b}	11.75^{b}
Mint oil @ 0.5%	0.98^{b}	3.56^{ab}	5.98^{b}	7.74^{b}	8.92^{bc}
Mint oil @ 1%	1.39^{ab}	3.25^{b}	5.43^{b}	6.97^{b}	8.44^{bc}
Mint oil @ 2%	0.98^{b}	2.87^{b}	4.96^{b}	6.76^{b}	9.17^{bc}
Cinnamomum oil @ 0.5%	1.34^{b}	3.11^{b}	5.63^{b}	7.67^{b}	8.79^{bc}
Cinnamomum oil @ 1%	1.36^{b}	2.81^{b}	4.93^{b}	6.59^{b}	7.69^{c}
Cinnamomum oil @ 2%	1.10^{b}	2.52^{b}	4.69^{b}	6.19^{b}	7.62^{c}
Eucalyptus oil @ 0.5%	1.19^{b}	2.73^{b}	5.21^{b}	7.06^{b}	8.12^{bc}
Eucalyptus oil @ 1%	1.02^{b}	2.66^{b}	5.23^{b}	7.03^{b}	9.60^{bc}
Eucalyptus oil @ 2%	1.08^{b}	2.55^{b}	4.62^{b}	6.05^{b}	7.16^{c}
Diathane M 45 @ 0.2 %	1.32^{b}	3.14^{b}	5.80^{b}	7.33^{b}	9.29^{bc}
Control	2.25^{a}	5.14^{a}	9.56^{a}	13.44^{a}	15.64^{a}
Grand Mean	1.30	3.17	5.63	7.54	9.22
$LSD_{(at\ 5\ \%)}$	0.79	1.56	2.25	2.85	3.14
SEM(±)	0.27	0.53	0.77	0.98	1.08
CV(%)	36.39	29.43	23.89	22.64	20.35

Means within the column followed by the same letter do not differ significantly different at 5% level of significance by DMRT. LSD = Least Significant Difference, SEM = Standard error of mean, and CV = Coefficient of variation.

Decay Loss

The data showed that the decay loss was increased significantly with the storage period irrespective of the treatments (Table 2). The decay loss was noticed higher in untreated fruits. At the end of the storage the minimum decay loss (16.66 %) was noticed in the fruits treated with *Eucalyptus* oil @ 2 % followed by mint oil @ 0.5 % against fruits in control with the maximum decay loss (41.66 %). This decreasing in decay loss was probably due to increase defense by essential oils on surface of fruits and delaying pathogenic infection where the main components in essential oils (terpenes, terpenoids) play a major role in the antimicrobial/biological effect of essential oils (Bakkali et al., 2008).

Table 2. Effect of postharvest treatments on decay loss percentage of mandarin fruit during storage at ambient room conditions(11± 2ºC) January, 2016

Treatment	Decay loss on days indicated (%)		
	9	12	15
Lemongrass oil @ 0.5%	5^{bc}	11.66^{bc}	20^{cd}
Lemongrass oil @ 1%	13.33^{ab}	20^{ab}	30^{bc}
Lemongrass oil @ 2%	11.66^{abc}	18.33^{abc}	38.33^{ab}
Mint oil @ 0.5%	6.66^{abc}	11.66^{bc}	18.33^{d}
Mint oil @ 1%	10^{abc}	16.66^{bc}	26.66^{cd}
Mint oil @ 2%	3.33^{c}	13.33^{bc}	25^{cd}
Cinnamomum oil @ 0.5%	6.66^{abc}	10^{c}	21.66^{cd}
Cinnamomum oil @ 1%	6.66^{abc}	16.66^{bc}	20^{cd}
Cinnamomum oil @ 2%	5^{bc}	13.33^{bc}	21.66^{cd}
Eucalyptus oil @ 0.5%	10^{abc}	15^{bc}	25^{cd}
Eucalyptus oil @ 1%	5^{bc}	11.66^{bc}	25^{cd}
Eucalyptus oil @ 2%	6.66^{abc}	11.66^{bc}	16.66^{d}
Diathane M-45 @ 0.2 %	3.33^{c}	11.66^{bc}	26.66^{cd}
Control	15^{a}	25^{a}	41.66^{a}
Grand Mean	7.73	14.76	25.47
$LSD_{(at\ 5\ \%)}$	8.26	7.52	8.84
SEM(±)	2.85	2.59	3.05
CV(%)	63.83	30.47	20.76

Means within the column followed by the same letter do not differ significantly different at 5% level of significance by DMRT. LSD = Least Significant Difference, SEM = Standard error of mean, and CV = Coefficient of variation.

Firmness

The mean data related to the firmness of postharvest treated fruits are presented in Table 3. The fruit firmness was decreased with the advancement of the storage period in all the treatments. At the end of the storage period the maximum firmness (3.86kg/cm^2) was recorded in fruits treated with lemongrass oil @ 0.5% followed by mint oil @ 2% and the minimum firmness (2.41 kg/cm^2) was observed in control fruits. Essential oils work as a protective layer of against different bacteria and fungi and therefore stopped up of damaged fruits (Serban et al.,2011). It also maintained cell wall carbohydrate metabolism during storage which is associated with decreased susceptibility to infection by fungal pathogens and therefore improves quality, but firmness in control probably decreased by fungal infection due to hydrolyze pectin and cell wall break down by progress of time.

Table 3. Effect of postharvest treatments on firmness of mandarin fruit during storage at ambient room conditions (11± 2ºC) January, 2016

Treatments	Firmness of fruit on days indicated (kg/cm^2)					
	0	3	6	9	12	15
Lemongrass oil @ 0.5%	5.40	5.25	4.98^{a}	4.78^{a}	4.21^{abc}	3.86^{a}
Lemongrass oil @ 1%	5.40	5.03	4.88^{ab}	4.63^{ab}	4.10^{abc}	3.58^{abc}
Lemongrass oil @ 2%	5.40	5.10	4.58^{ab}	4.16^{abcd}	3.48^{cde}	2.91^{cd}
Mint oil @ 0.5%	5.40	5.23	4.98^{a}	4.43^{abc}	4.06^{abcd}	3.70^{ab}
Mint oil @ 1%	5.40	5.06	4.65^{ab}	4.33^{abc}	4.00^{abcd}	3.70^{ab}
Mint oil @ 2%	5.40	5.23	4.98^{a}	4.73^{a}	4.25^{ab}	3.85^{a}
Cinnamomum oil @ 0.5%	5.40	4.83	4.33^{b}	3.80^{cd}	3.56^{bcde}	3.01^{bcd}
Cinnamomum oil @ 1%	5.40	4.96	4.43^{ab}	4.50^{abc}	3.91^{abcd}	3.40^{abc}
Cinnamomum oil @ 2%	5.40	5.15	4.91^{ab}	4.60ab	4.33^{a}	3.75^{ab}
Eucalyptus oil @ 0.5%	5.40	4.93	4.58^{ab}	3.93^{bcd}	3.55^{bcde}	3.21^{abc}
Eucalyptus oil @ 1%	5.40	4.96	4.65^{ab}	4.28^{abcd}	4.06^{abcd}	3.70^{ab}
Eucalyptus oil @ 2%	5.40	5.06	4.83^{ab}	4.41^{abc}	3.95^{abcd}	3.63^{abc}
Diathane M-45 @ 0.2 %	5.40	4.73	4.50^{ab}	4.21^{abcd}	3.33^{de}	2.45^{d}
Control	5.40	4.75	4.31^{b}	3.63^{d}	2.88^{e}	2.41^{d}
Grand Mean		5.02	4.68	4.31	3.83	3.37
$LSD_{(at\ 5\ \%)}$		0.43	0.54	0.61	0.63	0.66
SEM(±)		0.15	0.18	0.21	0.21	0.22
CV(%)		5.19	6.97	8.44	9.92	11.80

Means within the column followed by the same letter do not differ significantly different at 5% level of significance by DMRT. LSD = Least Significant Difference, SEM = Standard error of mean, and CV = Coefficient of variation.

Total soluble solids (TSS)

For mandarin fruits TSS is one of the major indicators for quality determination. The influence of the postharvest treatments on the TSS value is presented in Table 4. TSS increased with the increasing storage period in all the treatments and the increasing trend was higher in untreated fruits (control) than the treated fruits with different essential oil and chemical fungicide. At the end of the storage period highest TSS (12.13 °Brix) was recorded in control fruits. Among the oils treatment *Cinnamomum* oil @ 2 % recorded the higher TSS content (11.40 °Brix) in the fruits. In control fruits as the increase of microbial spoilage, degradation of fruits and over senescence led to an increase respiration rate and metabolic activity. These results are in agreement with some essential oils positively affected on total soluble solids, such as Anise, Ammi, Ziziphora and *Cinnamomum* oils on peach fruits (Mohammadi & Aminifard, 2012). Salimi et al. (2013) reported the positive effect of Basil, Wild mint and Ajowan oils on TSS content of table grape fruit.

Table 4. Effect of postharvest treatments on total soluble solids (TSS °Brix) of mandarin fruit during storage at ambient room conditions (11± 2ºC) January, 2016

Total Soluble Solids on days indicated (°Brix)						
Treatments	**0**	**3**	**6**	**9**	**12**	**15**
Lemongrass oil @ 0.5%	9.60	9.65^{de}	9.88^{de}	10.03^{def}	10.30^{def}	10.53^{d}
Lemongrass oil @ 1%	9.60	9.66^{de}	9.86^{de}	9.93^{ef}	10.17^{ef}	10.40^{de}
Lemongrass oil @ 2%	9.60	9.58^{e}	9.66^{e}	9.80^{f}	10.07^{f}	10.17^{e}
Mint oil @ 0.5%	9.60	9.66^{de}	10.08^{abcd}	10.20^{cde}	10.33^{def}	10.47^{d}
Mint oil @ 1%	9.60	9.73^{cde}	10.20^{ab}	10.62^{a}	10.72^{abc}	11.00 ^{c}
Mint oil @ 2%	9.60	9.70^{de}	9.83^{de}	10.17^{cde}	10.43^{cde}	10.67^{d}
Cinnamomum oil @ 0.5%	9.60	9.70^{de}	9.96^{bcd}	10.12^{cde}	10.23^{ef}	10.37^{de}
Cinnamomum oil @ 1%	9.60	9.81^{bcd}	9.95^{cd}	10.23^{cd}	10.35^{def}	11.07^{c}
Cinnamomum oil @ 2%	9.60	9.93^{abc}	10.27^{a}	10.53^{ab}	10.80^{ab}	11.40^{b}
Eucalyptus oil @ 0.5%	9.60	9.68^{de}	9.93^{cd}	10.13^{cde}	10.33^{def}	10.60^{d}
Eucalyptus oil @ 1%	9.60	9.71^{de}	9.85^{de}	10.07^{cde}	10.27^{ef}	10.60^{d}
Eucalyptus oil @ 2%	9.60	10.07^{a}	10.23^{a}	10.52^{ab}	10.67^{bc}	11.27^{bc}
Diathane-M 45 @ 0.2%	9.60	9.95^{ab}	10.15^{abc}	10.33^{bc}	10.60^{bcd}	11.00^{c}
Control	9.60	10.07^{a}	10.27^{a}	10.60^{a}	11.00^{a}	12.13^{a}
Grand Mean		9.78	10.01	10.23	10.44	10.83
$LSD_{(at\ 5\%)}$		0.19	0.21	0.23	0.27	0.26
SEM(±)		0.06	0.07	0.08	0.096	0.091
CV(%)		1.21	1.30	1.39	1.60	1.45

Means within the column followed by the same letter do not differ significantly different at 5% level of significance by DMRT. LSD = Least Significant Difference, SEM = Standard error of mean, and CV = Coefficient of variation.

Titratable acidity (TA)

Titratable acidity content is an important parameter to assess flavour and nutritive value of mandarin fruit. The mean (TA %) of the fruit treated with different essential oils at different concentration has been presented (Table 5). The results revealed thateffect of different levels of treatments to the Titratable acidity (TA %) was significant at the end of the storage of mandarin. At the end of the storage period the highest Titratable acidity (0.97 %) was observed in *Cinnamomum* oil @ 2 % followed by *Eucalyptus* oil @ 2 %. Peppermint oil increased acidity of the Valencia orange fruit (Fatimi et al., 2011). Also, Hassani et al. (2012) reported that Thyme oil had significant effect on fruit quality retention as with titratable acidity. Aminifard and Mohammadi (2013) demonstrated that Black Caraway, Fennel and Peppermint essential oils showed positive effects on titratable acidity of plum fruits.

Table 5. Effect of postharvest treatments on titratable acidity (%) of mandarin fruit during storage at ambient room conditions (11± 2ºC) January, 2016

Treatments	Titratable Acidity on days indicated (%)					
	0	3	6	9	12	15
Lemongrass oil @ 0.5%	1.12	1.09^{ab}	1.06^{abc}	1.03^{ab}	0.99^{ab}	0.96^{ab}
Lemongrass oil @ 1%	1.12	1.08^{ab}	1.04^{cd}	0.98^{c}	0.95^{c}	0.92^{b}
Lemongrass oil @ 2%	1.12	1.00^{cd}	0.96^{ef}	0.92^{de}	0.87^{de}	0.83d
Mint oil @ 0.5%	1.12	0.99^{cd}	0.96^{efg}	0.92^{de}	0.88^{d}	0.85^{cd}
Mint oil @ 1%	1.12	1.01^{c}	0.98^{e}	0.94^{d}	0.91^{d}	0.87^{c}
Mint oil @ 2%	1.12	1.09^{ab}	1.05^{abcd}	1.02^{ab}	0.98^{abc}	0.95^{ab}
Cinnamomum oil @ 0.5%	1.12	0.98^{d}	0.93^{g}	0.90^{e}	0.86^{e}	0.84^{d}
Cinnamomum oil @ 1 %	1.12	0.98^{d}	0.95^{fg}	0.90^{e}	0.88^{de}	0.85^{cd}
Cinnamomum oil @ 2%	1.12	1.10^{a}	1.07^{a}	1.04^{a}	1.01^{a}	0.97^{a}
Eucalyptus oil @ 0.5%	1.12	0.98^{d}	0.94^{fg}	0.92^{de}	0.89^{d}	0.86^{cd}
Eucalyptus oil @ 1%	1.12	1.07^{b}	1.03^{d}	0.98^{c}	0.96^{bc}	0.92^{b}
Eucalyptus oil @2%	1.12	1.10^{a}	1.07^{ab}	1.04^{a}	1.01^{a}	0.96^{a}
Diathane-M 45 @ 0.2%	1.12	1.09^{d}	1.05^{bcd}	1.00^{bc}	0.96^{c}	0.92^{b}
Control	1.12	0.93^{e}	0.88^{h}	0.83^{f}	0.78^{f}	0.73^{e}
Grand Mean		1.03	1.36	0.96	0.92	0.89
$LSD_{(at\ 5\ \%)}$		0.020	0.022	0.028	0.031	0.030
SEM(±)		0.00	0.0078	0.0099	0.010	0.010
CV(%)		1.23	1.001	1.80	2.01	2.21

Means within the column followed by the same letter do not differ significantly different at 5% level of significance by DMRT. LSD = Least Significant Difference, SEM = Standard error of mean, and CV = Coefficient of variation.

Vitamin C

The vitamin c content of the fruit at harvest prior to imposition of treatments was recorded to be 37.14 mg/100 ml. The results revealed that the effect of treatments to the vitamin c was found significant and decreasing with the advancement of the storage period in all the treatments (Table 6). The decreasing trend in the vitamin c was probably due to degradation of the ascorbic acid during the storage. At the end of the storage period the highest vitamin c content (29.76 mg/100 ml) was obtained in *Eucalyptus* oil @ 2 %. Also, Davarynejad et al.(2013) obtained similar results on apricot fruits. In this experiment, we found the maximum retention of vitamin-c with essential oils applications. This might be due to reduced oxidation in the fruits. The main compounds of oils may have antioxidant properties and this inhibits oxidation of ascorbic acid.

Table 6. Effect of postharvest treatments on Vitamin c (mg/100ml) of mandarin fruit at different days during storage at ambient room conditions (11± 2ºC) January, 2016

Treatments	Vitamin C on days indicated (mg/100ml)					
	0	3	6	9	12	15
Lemongrass oil @ 0.5 %	37.14	36.42	35.00	33.33^{a}	30.95^{ab}	27.61^{abc}
Lemongrass oil @ 1 %	37.14	35.47	33.80	32.14^{ab}	30.23^{ab}	28.57^{abc}
Lemongrass oil @ 2 %	37.14	35.23	34.52	33.57^{a}	29.04^{ab}	25.00^{cd}
Mint oil @ 0.5 %	37.14	35.71	35.00	33.80^{a}	32.38^{a}	28.33^{abc}
Mint oil @ 1 %	37.14	35.23	33.80	32.38^{ab}	30.47^{ab}	25.71^{bcd}
Mint oil @ 1 %	37.14	36.19	34.52	33.09^{a}	31.42^{a}	27.85^{abc}
Cinnamomum oil @ 0.5 %	37.14	35.47	33.80	31.90^{ab}	30.00^{ab}	28.09^{abc}
Cinnamomum oil @ 1 %	37.14	35.95	34.52	33.09^{a}	31.90^{a}	28.80^{ab}
Cinnamomum oil @ 2 %	37.14	36.66	34.52	32.61^{ab}	30.95^{ab}	28.80^{ab}
Eucalyptus oil @ 0.5 %	37.14	35.23	33.80	32.61^{ab}	28.80^{ab}	26.19^{abcd}
Eucalyptus oil @ 1 %	37.14	35.00	33.09	31.42^{ab}	30.00^{ab}	27.85^{abc}
Eucalyptus oil @ 2 %	37.14	35.95	34.76	33.57^{a}	32.14^{a}	29.76^{a}
Diathane M-45 @ 0.2 %	37.14	35.47	34.52	33.09^{a}	31.19^{a}	27.14^{abc}
Control	37.14	34.04	31.90	29.047^{b}	27.14^{b}	23.57^{d}
Grand Mean	37.14	35.57	34.11	32.55	30.47	27.38
$LSD_{(at\ 5\ \%)}$		NS	NS	3.36	3.37	3.13
SEM(±)		0.79	0.92	1.16	1.16	1.08
CV(%)		3.85	4.48	6.18	6.62	6.84

Means within the column followed by the same letter do not differ significantly different at 5% level of significance by DMRT. LSD = Least Significant Difference, SEM = Standard Error of Mean, and CV = Coefficient of variation, ns = non significant

Juice Recovery (Percentage)

The influence of the postharvest treatments on the juice recovery is presented in the Table 7. Results showed that juice recovery was decreased with storage time in all the treatments. The maximum (39.90 %) juice recovery during the storage was observed in the fruits treated with *Cinnamomum* oil @ 2 % and the control fruits recorded minimum juice recovery (25.03 %). There was significant decrease in the juice percentage of untreated fruits (control) than treated fruits. This might be due to the fact that the essential oils act as a barrier which had checked the losses of the moisture from the fruit surface.

Table 7. Effect of postharvest treatments on juice recovery percentage of mandarin fruit during storage at ambient room conditions (11± 2ºC) January, 2016

Treatment	Juice recovery percentage on days indicated (%)				
	3	6	9	12	15
Lemongrass oil @ 0.5 %	46.72^{abc}	42.50^{ab}	41.67^{ab}	38.49^{ab}	35.40^{ab}
Lemongrass oil @ 1 %	50.05^{ab}	44.88^{a}	41.91^{ab}	38.77^{ab}	33.62^{b}
Lemongrass oil @ 2 %	49.56^{abc}	45.96^{a}	42.84^{a}	38.41^{ab}	33.74^{b}
Mint oil @ 0.5 %	48.20^{abc}	45.14^{a}	40.96^{ab}	36.58^{b}	33.32^{b}
Mint oil @ 1 %	45.95^{bc}	41.97^{ab}	40.36^{ab}	38.44^{ab}	36.67^{ab}
Mint oil @ 2 %	51.02^{a}	45.92^{a}	43.85^{a}	38.32^{ab}	36.54^{ab}
Cinnamomum oil @ 0.5 %	46.45^{abc}	43.13^{ab}	41.37^{ab}	36.34^{b}	33.46^{b}
Cinnamomum oil @ 1 %	46.51^{abc}	42.87^{ab}	37.69^{bc}	36.44^{b}	33.18^{b}
Cinnamomum oil @ 2 %	49.26^{abc}	46.49^{a}	42.77^{ab}	41.65^{a}	39.90^{a}
Eucalyptus oil @ 0.5 %	48.53^{abc}	44.42^{ab}	44.62^{a}	41.39^{a}	34.67^{b}
Eucalyptus oil @ 1 %	47.15^{abc}	43.59^{ab}	39.73^{ab}	38.01^{ab}	35.51^{ab}
Eucalyptus oil @ 2 %	47.65^{abc}	44.71^{a}	41.51^{ab}	38.76^{ab}	34.25^{b}
Diathane-M 45 @ 0.2 %	48.98^{abc}	44.93^{a}	40.81^{ab}	36.45^{b}	33.89^{b}
Control	44.90^{c}	40.20^{b}	33.50^{c}	27.90^{c}	25.03^{c}
Grand Mean	47.92	44.05	40.97	37.57	34.23
$LSD_{(at\ 5\ \%)}$	4.16	3.91	4.37	3.73	4.30
SEM(±)	1.43	1.35	1.51	1.29	1.48
CV(%)	5.19	5.31	6.38	5.94	7.52

Means within the column followed by the same letter do not differ significantly different at 5% level of significance by DMRT. LSD = Least Significant Difference, SEM = Standard error of mean, and CV = Coefficient of variation.

Conclusions

Essential oils treatment can be beneficial for the increasing postharvest fruit quality without the chemical residues that increases the consumer's acceptability of mandarin. To reduce the spoilage loss and disease incidence, application of *Eucalyptus* oil @ 2% and *Cinnamomum* oil @ 2%could be an appropriate option.

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