jpht www.jpht.info

Journal of Postharvest Technology
2020, **08**(3): 96-105
www.jpht.in

RESEARCH ARTICLE

# Impact of postharvest use of essential oils on quality and shelf life of Indian pineapple

**Debashis Mandal* and Chhangte Vanlalawmpuia**

Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl-796004, Mizoram, India.

Received: 03.06.2020 Accepted: 17.07.2020

## ABSTRACT

Present study was performed to assess the effect of different essential oils viz. cinnamon, citronella, peppermint, eucalyptus, lavender, thyme, rosemary and basil, on physico-chemical qualities and shelf life of stored pineapple cv. Giant Kew at ambient (temperature: 25±3$^0$C; relative humidity: 75±5%) condition. It was found that treatment with eucalyptus oil (0.5% v/v) significantly controlled the physiological weight loss, fruit shrinkage, textural degradation and maintained good flesh colour (L:86.48, a:-6.64, b:39.48), translucency (score: 2.25) and crown condition (score: 1.50). Besides, after 9 days of storage; TSS (13.52$^0$Brix), titratable acidity (0.95%), total sugar (10.18%), total phenol (64.49 µg g$^{-1}$), ascorbic acid (22.24 mg 100g$^{-1}$) and antioxidant activity (71.48±1.02 % inhibition DPPH) was found highest under this treatment compared with others. No fruits got decayed under this treatment up to nine days and caused maximum shelf life (16.75 days). However, the shelf life was also high (16.25 days) for basil oil treated pineapple fruits.

**Keywords:** antioxidant, decay, essential oil, eucalyptus, pineapple, shelf life

**Citation:** Mandal, D. and Vanlalawmpuia, C. 2020. Impact of postharvest use of essential oils on quality and shelf life of Indian pineapple. *Journal of Postharvest Technology*, **8** (3): 96-105.

## INTRODUCTION

Pineapple, the most important, exquisite, juicy and appealing fruit of Bromeliaceae, is profusely cultivated in tropical World. Though Indian fruit production mostly dominated by banana, mango, citrus, papaya, guava, grapes etc. however, 2038 thousand metric tons of pineapple was produced from an area of 121 thousand hectares to made it 7$^{th}$ largest producer in the globe (Anon., 2017). Around 5208 metric tons of Indian pineapple was exported mainly to Gulf countries to earn approximately 3.47 million US$ in 2016-17. Though a good amount of pineapple is sliced and canned but for table purpose mostly traded as whole fruit in ambient condition and undergoes postharvest losses of 15-25% (Hossain and Bepary, 2015). Further, storage at ambient condition (23±2$^0$C and 65±5% relative humidity) caused low (10.30 days) shelf life (Mandal et al., 2015) while low temperature (10$^0$C) storage was reported (Joseph-Adekunle et al., 2009) to increase shelf life (33 days) but with chilling injury and internal browning (Nukuntornprakit et al., 2015). Plant chemicals like gibberellins (Kabir et al., 2010) and salicylic acid (Lu et al., 2011) was found effectively influencing ambient storage life however, recent development of consumer preference for chemical free, safe and eco-friendly processed food products put forth the need for alternative approach towards shelf life and postharvest quality management in pineapple. Essential oils (EO) as plant aroma volatiles are extracted and reported to exhibit antimicrobial effect (Govaris et al., 2010; Damjanovic-Vratnica et al., 2011); thus EO's like lemon grass (Tzortzakis and Economakis , 2007), thyme (Kumar et al., 2008), eucalyptus (Javed et al., 2012), clove (Shao et al., 2015), oregano (Plotto et al., 2003) etc was reported to control postharvest pathogen and was found to

* *For correspondence: D. Mandal* (Email: debashismandal1982@gmail.com)
**ISSN: 2348-4330**

influence storage of food. Mint (Bitencourt et al., 2014) and lemon grass (Azarakhsh et al., 2014) oil enriched edible coating was used in fresh cut pineapple for extending shelf life.

Therefore, the study was performed for evaluating influence of different essential oils on shelf life and postharvest quality of pineapple during storage at ambient condition.

## MATERIALS AND METHODS

Mature green freshly harvested pineapple cv. Giant Kew was collected from local grower of Thingsulthliah, Aizawl district, Mizoram, India. Fruits with uniform shape, size, colour, firmness, free from disease, pest and mechanical injuries were further sorted for using as experimental material. Surface cleaning of the fruits was done with running tap water followed by 30 seconds dipping in ethanol (70% v/v) and subsequently rinsed in sterile double distilled water. Fruits were kept in a stream of dehumidified air for 10 minutes to remove the surface moisture.

Ten treatments viz. T1: cinnamon (Cinnamomum zeylanicum) oil, T2: citronella (Cymbopogon nardus) oil, T3: peppermint (Mentha piperita) oil, T4: eucalyptus (Eucalyptus globulus) oil, T5: lavender (Lavandula angustifolia) oil, T6: thyme (Thymus vulgaris) oil, T7: rosemary (Rosmarinus officinalis) oil, T8: basil (Ocimum basilicum) oil, T9: coconut (Cocos nucifera) oil, T10: control (water dipped) were used with four replication under this study. Four fruits with crown, in each replication were kept in ventilated cardboard box and stored at ambient condition (temperature: 25±3$^0$C; relative humidity: 75±5%) at Postharvest Technology Laboratory, Department of Horticulture, Aromatic and Medicinal Plants, School of Earth Science and Natural Resources Management, Mizoram University, Aizawl, India.

Hydro-distilled, pure (100%) essential oils of cinnamon (bark), citronella (leaves and stems), peppermint (leaves, flowers and buds), eucalyptus (leaves), lavender (flowers), thyme (leaves and flowers) and rosemary (leaves, flowers and buds) manufactured by Mesmara Essential Oil, Ramachandrapuram, Sangareddy District, Telangana, India and USDA certified, natural and organic extra virgin coconut oil (manufactured by Earthon Products Pvt. Ltd., Mustafa Bazar, Byculla, Mumbai , India.) were purchased and used for preparation of treatments. Respective EO coating was prepared by mixing EO (0.5% v/v) with glycerol (1.2% v/v) and coconut oil (80% v/v) along with sterile water. All formulations were mixed in homogenizer for 5 minutes at 24,500 rpm to form the emulsion for coating by dipping the fruits for 2 minutes whereas; coconut oil (100%) and water dipping were followed in T9 and T10, respectively.

Observations on physiological weight loss (using digital balance), fruit length and diameter (using digital slide caliper), firmness (using digital penetrometer), and biochemical parameters viz. total carbohydrates, protein and total phenol were determined as per method described by Sadasivam and Manickam (2005), total soluble solids (TSS; using handheld refractometer), total sugar and titratable acidity (AOAC, 2012), ascorbic acid content (Ranganna, 1997) were recorded at 3, 6 and 9 days after storage (DAS) whereas, fruit flesh colour (using digital colour meter for L*,a*,b* ), antioxidant activity (DPPH scavenging activity, Kato et al., 1988) and fruit decay (Pila et al., 2010) were determined at 9 DAS. Scoring was done for flesh translucency [1: 100% opaque, 2: opaque with slight translucent (less than 50%), 3: opaque with moderate translucent (more than 50%), 4: 100% translucent ] and crown condition (1: good, green and fresh; 2: good with tips slightly yellow; 3:moderate, dry tips, yellowing; 4: bad, dry tip, much yellowing; 5: severe yellow) at 9 DAS (Mandal et al., 2015). Evaluation of shelf life (days) was done based on the decay percentage and physico-chemical qualities of fruit and counting day of maximum edible, visual and marketable quality from the date of harvest (Moneruzzaman et al., 2009; Mandal et al., 2018).

Experiment was laid down in complete randomized design (CRD) with 10 treatments and 4 replications. Analysis of variance (ANOVA) was performed to study the variation in the means of the parameters and statistical significance level were determined at p ≤0.05 (Easterling, 2015).

## RESULTS AND DISCUSSION

### Physiological weight loss

During the entire storage period, physiological weight loss percentage of the stored pineapple got increased. Techavuthiporn et al. (2017) reported of having increased loss in physiological weight of 'Phulae' pineapple during ambient storage. Transpiration, surface evaporation and respiration of the stored pineapple were considered factors for weight loss (Selvarajah and Hearth, 1997). After 3 days of ambient storage, it was observed that pineapple fruits treated with eucalyptus oil (T4) had the minimum weight loss (1.56%) followed by treatment with basil oil (2.09%) compared with control (7.42%) (Table 1). At 9DAS, highest weight loss (18.75%) was recorded in control fruits, whereas, it was found minimum when treated with eucalyptus oil (6.98%). It was found that essential oil treated fruits were having low weight loss compared with control which may be because of reduced respiration and evaporative surface moisture loss. Coconut oil enriched with essential oil may have created a surface barrier in moisture loss. Tzortzakis (2007) observed reduced weight loss in stored strawberry and tomatoes when treated with eucalyptus oil.

**Table 1: Effect of postharvest essential oil treatments on physiological weight loss, decrease in fruit length and diameter**

| Treatments | Physiological Weight Loss (%) | | | Decrease in fruit length (%) | | | Decrease in fruit diameter (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3DAS | 6DAS | 9DAS | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS |
| **$T_1$: Cinnamon Oil** | 4.71 | 7.32 | 11.29 | 2.94 | 4.73 | 5.08 | 2.81 | 3.25 | 4.32 |
| **$T_2$: Citronella Oil** | 2.24 | 5.28 | 8.75 | 1.96 | 2.35 | 3.87 | 1.48 | 2.21 | 3.42 |
| **$T_3$: Peppermint Oil** | 4.25 | 6.93 | 10.51 | 2.71 | 4.29 | 4.83 | 2.56 | 3.12 | 4.23 |
| **$T_4$: Eucalyptus Oil** | 1.56 | 4.29 | 6.98 | 1.07 | 1.34 | 2.78 | 0.96 | 1.51 | 2.39 |
| **$T_5$: Lavender Oil** | 3.71 | 6.79 | 9.32 | 2.45 | 3.78 | 4.58 | 2.27 | 2.93 | 4.12 |
| **$T_6$: Thyme Oil** | 2.93 | 5.45 | 8.26 | 2.32 | 3.28 | 4.52 | 1.85 | 2.75 | 3.82 |
| **$T_7$: Rosemary Oil** | 2.68 | 5.32 | 8.35 | 2.18 | 2.93 | 4.17 | 1.72 | 2.42 | 3.58 |
| **$T_8$: Basil Oil** | 2.09 | 4.95 | 7.52 | 1.82 | 2.12 | 3.54 | 1.18 | 1.78 | 3.17 |
| **$T_9$: Coconut Oil** | 5.23 | 9.76 | 14.32 | 3.21 | 5.17 | 5.83 | 3.05 | 4.27 | 5.16 |
| **$T_{10}$: Control** | 7.42 | 11.52 | 18.75 | 4.31 | 5.87 | 6.34 | 3.92 | 5.08 | 6.17 |
| **SEm±** | **0.2166** | **0.3321** | **0.6355** | **0.0846** | **0.2836** | **0.1364** | **0.0917** | **0.1206** | **0.1452** |
| **CD at 5%** | **0.3736** | **0.5729** | **1.0962** | **0.1460** | **0.4892** | **0.2354** | **0.1582** | **0.2080** | **0.2505** |

### Percent decrease in fruit length and diameter

During ambient storage of pineapple fruits, it was found that length and diameter of the fruits got gradual decrease. At 3DAS, fruits treated with eucalyptus oil (1.07%, 0.96%); basil oil (1.82%, 1.18%) and citronella oil (1.96%, 1.48%) had lower percentage decrease in length and diameter compared with control (4.31%, 3.92%). After 9 days of ambient storage, eucalyptus oil treated fruits had minimum percent decrease in fruit length and diameter (2.78%, 2.39%) compared with other treatments (Table 1). During storage, increase respiration and evaporative loss of surface moisture had resulted shrinkage of fruits and caused gradual decrease in length and diameter. However, essential oils coupled with coconut oil, had given a

protective layer on fruits which reduced the moisture loss and decreased the rate of shrinkage. Prabowo and Mawarani (2020) reported to have less shrinkage and weight loss of stored tomatoes with eucalyptus oil.

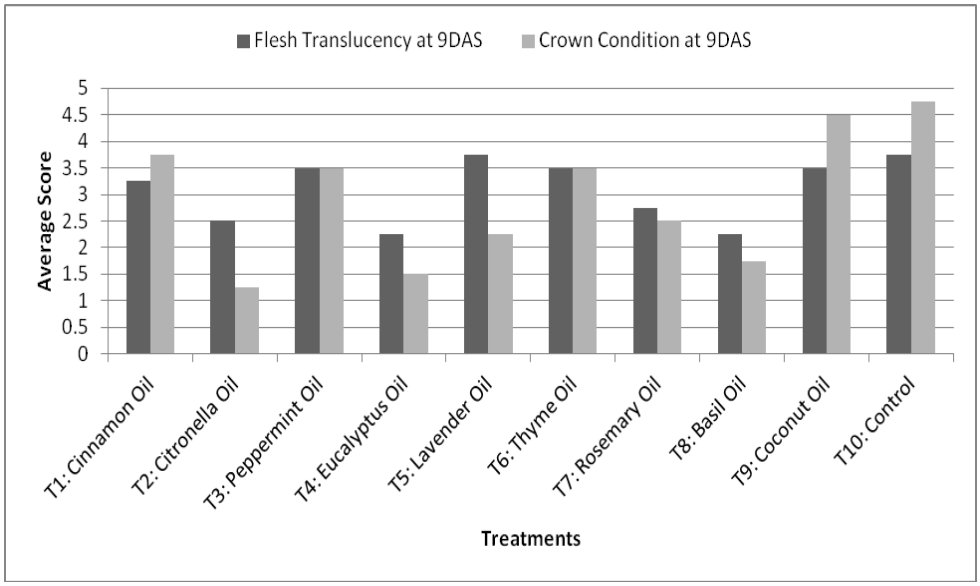


**Fig. 1: Effect of postharvest essential oil treatments on average score for flesh translucency and crown condition**

### Flesh translucency and crown condition

Scoring for flesh translucency of the stored pineapple revealed that fruits treated with eucalyptus oil, basil oil, citronella oil and rosemary oil had low score (2.25-2.75; opaque with slight translucent) compared with control (3.75; opaque with more than 50% translucent) at 9DAS (Fig.1). Increased sugar accumulation, enhanced electrolyte leakage coincides with highest flesh translucency in pineapple (Chen and Paull, 2000). For crown condition, citronella oil and eucalyptus oil coated crowns had very low score (1.25-1.50; good, fresh and green) compared with control (4.75; severe yellowing). Essential oil enriched coconut oil layer created a protective smear on fruit and crown and caused less desiccation and resulted in low crown condition score, whereas, it may have influenced the electrolyte leakage of stored fruit to have less translucent flesh.

### Fruit texture and flesh colour

Texture of the pineapple fruits reduced to become soft while storage. Fruit texture ranged between 34.33 to 56.25 $Ncm^{-2}$ at 3 DAS which decreased and ranged between 20.28 to 42.43 $Ncm^{-2}$ at 9 DAS (Table 2). It was found that fruits coated with eucalyptus oil had good fruit texture (42.43 $Ncm^{-2}$) compared with other treatments at 9 DAS. Jhalegar et al. (2015) opined that essential oils have marked influence on texture of the stored fruit and found that eucalyptus and lemon grass essential oil positively influence the texture of stored kinnow mandarin. At 9DAS, fruits coated with eucalyptus oil had white colour flesh (L:86.48, a:-6.64, b:39.48), basil oil had white with yellow tinged flesh (L:85.57, a:2.31, b:9.51) compared with control (L:71.44, a:8.20, b:67.10; brown yellow). Essential oil impacted the respiration and ripening of the stored pineapple and delayed the flesh colour accumulation. Rabei et al. (2011) reported that essential oils caused low ethylene production in treated 'Jonagold' apple.

**Table 2: Effect of postharvest essential oil treatments on fruit texture and colour**

| Treatments | Texture ($Ncm^{-2}$) | | | Flesh Colour at 9 DAS | | |
|---|---|---|---|---|---|---|
| | 3DAS | 6DAS | 9DAS | L | a | b |
| $T_1$: Cinnamon Oil | 37.53 | 32.36 | 28.74 | 87.36 | 0.68 | 40.44 |
| $T_2$: Citronella Oil | 44.27 | 40.23 | 36.24 | 81.59 | 0.49 | 10.57 |
| $T_3$: Peppermint Oil | 38.47 | 33.56 | 29.42 | 77.06 | 3.92 | 61.80 |
| $T_4$: Eucalyptus Oil | 56.25 | 47.91 | 42.43 | 86.48 | -6.64 | 39.48 |
| $T_5$: Lavender Oil | 39.21 | 35.45 | 30.23 | 78.54 | 2.37 | 62.53 |
| $T_6$: Thyme Oil | 40.53 | 36.21 | 31.54 | 83.75 | 1.81 | 15.32 |
| $T_7$: Rosemary Oil | 42.17 | 38.32 | 33.27 | 73.13 | -6.66 | 42.08 |
| $T_8$: Basil Oil | 47.23 | 42.14 | 38.09 | 85.57 | 2.31 | 9.51 |
| $T_9$: Coconut Oil | 35.14 | 27.41 | 22.92 | 79.27 | 2.53 | 56.17 |
| $T_{10}$: Control | 34.33 | 25.83 | 20.28 | 71.44 | 8.20 | 67.10 |
| **SEm±** | **0.8839** | **1.0463** | **0.9920** | **-** | **-** | **-** |
| **CD at 5%** | **1.5248** | **1.8049** | **1.7112** | **-** | **-** | **-** |

### Total Soluble Solids (TSS), titrable acidity and TSS:acid ratio

It was found that TSS and titrable acidity content of the pineapple fruits gradually decreased during storage. Dropping of TSS and acidity may have marked the senescence. At 3 DAS, TSS content was ranged between 14.87 and 16.72 $^0$Brix but it got reduced and ranged between 9.32 and 13.52$^0$Brix after 9 days of ambient storage (Table 3). Nilprapruck et al. (2008) found to have decreased in TSS content of stored pineapple. At 9 DAS, pineapple fruits treated with eucalyptus oil had highest TSS (13.52$^0$Brix) followed by T8 (12.92$^0$Brix) and T2 (12.75$^0$Brix) compared with control (9.32$^0$Brix). Essential oil treated fruits had better retention of TSS content than control fruits. Similarly, titrable acidity was high and ranged between 0.92% and 1.15% at 3 DAS, but got decreased and ranged between 0.74% and 0.95% at 9DAS. Dhar et al. (2008) reported to have declined tritable acidity content in stored pineapple fruits. Fruits treated with eucalyptus oil had high acidity (0.95%) compared with control (0.74%). Essential oil treated fruits reported to have reduced respiration and ethylene release (Rabei et al., 2011; Jhalegar et al., 2015), which may have resulted better retention of TSS and acidity. After 9 days storage, TSS:acid ratio was found maximum in $T_5$( 17.72) compared with control (12.59). TSS: acid ration was recorded higher (14.04 to 17.72) in fruits treated with essential oils.

### Total sugar, reducing sugar and total carbohydrate

During the storage study of pineapple, it was observed that total sugar, reducing sugar and total carbohydrate content markedly decreased. It was observed may be due to the effect senescence in the stored fruits. At 3DAS, range of total sugar (10.86-12.72%), reducing sugar (8.33-11.04%) and total carbohydrate content (11.96-14.25%) was found high which got drastic reduction and ranged as total sugar (5.71-10.18%), reducing sugar (4.76-9.28%) and total carbohydrate content (7.32-11.83%) at 9DAS (Table 4). Hong et al. (2013) observed that total sugar, glucose, fructose value of stored pineapple consistently decreased during the period of ambient storage (25$^0$C).

**Table 3: Effect of postharvest essential oil treatments on TSS, acidity and TSS:acid ratio of pineapple**

| Treatments | TSS ($^0$ Brix) | | | Titrable Acidity (%) | | | TSS : Acid Ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3DAS | 6DAS | 9DAS | 3DAS | 6DAS | 9DAS | 3DAS | 6DAS | 9DAS |
| $T_1$: Cinnamon Oil | 15.72 | 12.72 | 11.08 | 0.97 | 0.92 | 0.72 | 16.21 | 13.83 | 15.39 |
| $T_2$: Citronella Oil | 15.25 | 13.08 | 12.75 | 1.08 | 1.02 | 0.86 | 14.12 | 12.82 | 14.83 |
| $T_3$: Peppermint Oil | 14.92 | 12.76 | 11.52 | 0.97 | 0.93 | 0.82 | 15.38 | 13.72 | 14.05 |
| $T_4$: Eucalyptus Oil | 15.85 | 14.27 | 13.52 | 1.15 | 1.08 | 0.95 | 13.78 | 13.21 | 14.23 |
| $T_5$: Lavender Oil | 14.87 | 12.81 | 11.34 | 1.01 | 0.92 | 0.64 | 14.72 | 13.92 | 17.72 |
| $T_6$: Thyme Oil | 16.34 | 12.87 | 11.62 | 0.98 | 0.95 | 0.78 | 16.67 | 13.55 | 14.90 |
| $T_7$: Rosemary Oil | 15.56 | 12.95 | 11.87 | 1.02 | 0.97 | 0.81 | 15.25 | 13.35 | 14.65 |
| $T_8$: Basil Oil | 15.38 | 13.45 | 12.92 | 1.12 | 1.02 | 0.92 | 13.73 | 13.19 | 14.04 |
| $T_9$: Coconut Oil | 16.18 | 11.82 | 9.75 | 0.95 | 0.89 | 0.68 | 17.03 | 13.28 | 14.34 |
| $T_{10}$: Control | 16.72 | 11.25 | 9.32 | 0.92 | 0.88 | 0.74 | 18.17 | 12.78 | 12.59 |
| **SEm±** | **0.2102** | **0.3572** | **0.2622** | **0.0286** | **0.0296** | **0.0355** | **0.6126** | **0.1615** | **0.1390** |
| **CD at 5%** | **0.3625** | **0.6162** | **0.4522** | **0.0493** | **0.0510** | **0.0613** | **1.0568** | **0.2785** | **0.2398** |

**Table 4: Effect of postharvest essential oil treatments on total sugar , reducing sugar and carbohydrate content of pineapple**

| Treatments | Total Sugar (%) | | | Reducing Sugar (%) | | | Total Carbohydrate (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3DAS | 6DAS | 9DAS | 3DAS | 6DAS | 9DAS | 3DAS | 6DAS | 9DAS |
| $T_1$: Cinnamon Oil | 11.32 | 10.08 | 6.94 | 9.16 | 8.18 | 5.78 | 12.16 | 11.72 | 7.95 |
| $T_2$: Citronella Oil | 12.08 | 10.95 | 9.56 | 10.48 | 9.32 | 8.85 | 13.52 | 11.96 | 10.71 |
| $T_3$: Peppermint Oil | 11.09 | 9.89 | 7.78 | 9.08 | 8.32 | 6.84 | 12.21 | 11.86 | 10.63 |
| $T_4$: Eucalyptus Oil | 12.72 | 11.35 | 10.18 | 11.04 | 10.42 | 9.28 | 14.25 | 12.15 | 11.83 |
| $T_5$: Lavender Oil | 11.72 | 10.34 | 8.45 | 9.32 | 8.81 | 7.56 | 12.25 | 11.95 | 10.22 |
| $T_6$: Thyme Oil | 11.67 | 10.56 | 9.08 | 9.85 | 8.64 | 8.08 | 12.32 | 11.62 | 9.73 |
| $T_7$: Rosemary Oil | 11.85 | 10.72 | 9.32 | 10.15 | 8.85 | 8.32 | 12.57 | 11.83 | 10.16 |
| $T_8$: Basil Oil | 12.45 | 11.12 | 9.72 | 10.52 | 9.84 | 8.96 | 13.92 | 12.05 | 10.83 |
| $T_9$: Coconut Oil | 11.15 | 9.32 | 6.24 | 8.85 | 7.12 | 5.25 | 11.98 | 10.17 | 7.68 |
| $T_{10}$: Control | 10.86 | 8.25 | 5.71 | 8.33 | 6.67 | 4.76 | 11.96 | 9.89 | 7.32 |
| **SEm±** | **0.1310** | **0.3390** | **0.1941** | **0.4544** | **0.1972** | **0.1976** | **0.2713** | **0.2208** | **0.2728** |
| **CD at 5%** | **0.2259** | **0.5848** | **0.3348** | **0.7838** | **0.3402** | **0.3409** | **0.4679** | **0.3809** | **0.4706** |

Fruits treated with eucalyptus oil and basil oil had better retention of total sugar (10.18%, 9.72%), reducing sugar (9.28%, 8.96%) and total carbohydrate content (11.83%, 10.83%) compared with other treatments. Rabei et al. (2011) found that essential oils influenced the respiration and ethylene production in stored fruits, which may have caused better retention of sugar due to delayed senescence.

### Total phenol, ascorbic acid and antioxidant activity

Pineapple fruits stored at ambient condition had increased in total phenol content during storage and found that at 9DAS, eucalyptus oil treated fruits got maximum total phenol content (64.49 µg $g^{-1}$) followed by fruit treated with basil oil (62.75 µg $g^{1}$) compared with control (33.92 µg $g^{-1}$). Nilprapruck et al. (2008) found that pineapple cv. Pattavia fruits gained in total phenolics

during storage. Ascorbic acid content of the pineapple fruits got decreased during the period of ambient storage. It was found to range between 18.37 and 28.68 mg 100g$^{-1}$ at 3DAS, which reduced and ranged between 12.68 and 25.18 mg 100g$^{-1}$ at 6DAS and further reduced to range between 10.58 and 22.24 mg 100g$^{-1}$ at 9DAS (Table 5). Kabasakalis et al. (2002) opined that ascorbic acid content of fruit juice reduced in storage due to oxidation. After 9 days of storage at ambient temperature, ascorbic acid content was found maximum (22.24 mg 100g$^{-1}$) in case of the fruits treated with eucalyptus oil compared with control (10.58 mg 100g$^{-1}$). It was observed that essential oil treated pineapple fruits got better retention of vitamin-c than control. Similarly, antioxidant activity was found highest (71.48±1.02 % inhibition DPPH) in eucalyptus oil treated pineapples compared with control (23.46±0.85 % inhibition DPPH) at 9DAS (Table 5). Cenobio-Galindo et al. (2019) reported that essential oils are able to enhance the antioxidant activity as signaling compound.

**Table 5: Effect of postharvest essential oil treatments on total phenol, ascorbic acid content and antioxidant activity of pineapple**

| Treatments | Total Phenol (µg g$^{-1}$) | | | Ascorbic Acid (mg 100g$^{-1}$) | | | Antioxidant activity (% Inhibition DPPH) |
|---|---|---|---|---|---|---|---|
| | 3DAS | 6DAS | 9DAS | 3DAS | 6DAS | 9DAS | 9 DAS |
| $T_1$: Cinnamon Oil | 25.72 | 32.39 | 38.75 | 21.56 | 15.34 | 13.45 | 34.23±1.12 |
| $T_2$: Citronella Oil | 42.78 | 51.56 | 59.73 | 24.29 | 19.29 | 19.78 | 61.23±1.24 |
| $T_3$: Peppermint Oil | 28.72 | 35.36 | 42.29 | 21.85 | 17.51 | 15.51 | 38.76±0.73 |
| $T_4$: Eucalyptus Oil | 47.56 | 56.39 | 64.49 | 28.68 | 25.18 | 22.24 | 71.48±1.02 |
| $T_5$: Lavender Oil | 31.18 | 38.72 | 49.71 | 22.08 | 18.32 | 16.25 | 38.94±2.11 |
| $T_6$: Thyme Oil | 35.26 | 45.55 | 52.18 | 22.54 | 18.76 | 16.53 | 46.11±1.82 |
| $T_7$: Rosemary Oil | 38.75 | 46.37 | 55.25 | 23.52 | 20.18 | 18.76 | 50.49±1.19 |
| $T_8$: Basil Oil | 45.48 | 53.92 | 62.75 | 26.35 | 24.17 | 20.56 | 65.24±1.53 |
| $T_9$: Coconut Oil | 24.51 | 30.38 | 33.75 | 19.85 | 14.56 | 11.28 | 25.89±1.91 |
| $T_{10}$: Control | 22.56 | 28.75 | 33.92 | 18.37 | 12.68 | 10.56 | 23.46±0.85 |
| SEm± | 0.8411 | 0.8892 | 0.9684 | 0.5808 | 0.7341 | 0.6524 | - |
| CD at 5% | 1.4510 | 0.8892 | 1.6705 | 1.0020 | 1.2663 | 1.1253 | - |

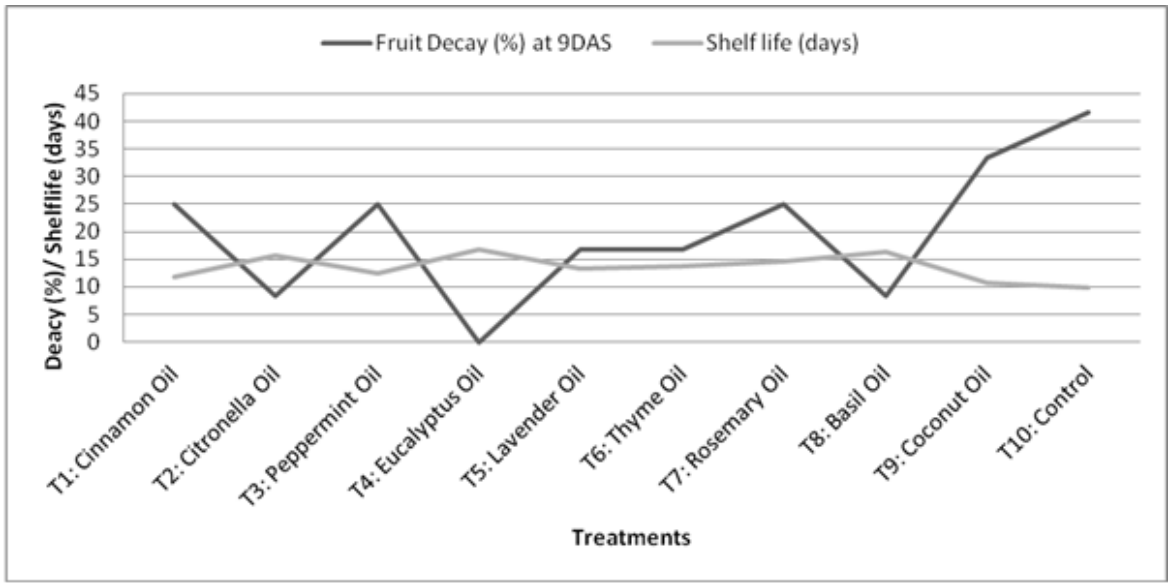


**Fig. 2: Effect of postharvest essential oil treatments on percentage of fruit decay and shelf life of pineapple**

### Decay percentage

Present study revealed that pineapple fruit treated with essential oils had lesser fruit decay (ranged between 0 to 25%) compared with control (41.67%). Sivakumar and Bautista-Banos (2014) suggested that essential oils are effective in controlling postharvest fruit decay due its antimicrobial and fungicidal activities. No fruits got decayed (0.00%) up to 9 DAS, in eucalyptus oil treatment, whereas, fruits treated with citronella and basil oil had low decay percentage (8.33%), however, fruit at control got maximum fruit decay (41.67%) at 9DAS (Fig. 2). Batish et al. (2008) reported that constituents of eucalyptus oil showed toxicity against a variety of bacterial and fungal post-harvest pathogen.

### Shelf life

Maximum shelf life (16.75 days) was recorded in eucalyptus oil coated fruits, followed by pineapple fruits treated with basil oil (16.25 days) and citronella oil (15.75 days) compared with control (9.75 days). Fruits coated with eucalyptus oil had recorded 7 days more shelf life than the untreated fruits (Fig. 2). Solgi and Ghorbanpour (2014) reported that postharvest treatment with basil oil enhanced shelf life of banana while cinnamon and eucalyptus oil for tomatoes and strawberries.

## CONCLUSION

Present study revealed that pineapple fruits when coated with eucalyptus oil (0.5%) had minimum weight loss, fruit shrinkage and textural loss while having good crown condition, flesh colour and flesh translucency. Besides, it was resulted with fruits having high TSS, titrable acidity, total and reducing sugar, carbohydrate and total phenol content with better retention of ascorbic acid and antioxidant activity. Thus, it may be considered as the best treatment to extend shelf life of pineapple at ambient storage while maintaining its physico-chemical qualities.

## REFERENCES

Anonymous. 2017. Horticultural Statistics at a Glance 2017. Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India. pp. 147-441.

AOAC. 2012. Official Methods of Analysis. 19th edn, Association of Analytical Chemists (A.O.A.C.) International, Rockville, USA.

Azarakhsh, N., Osman, A., Ghazali, H.M., Tan, C.P. and Mohd Adzahan, N. 2014. Lemongrass essential oil incorporated into alginate-based edible coating for shelf-life extension and quality retention of fresh-cut pineapple. Postharvest Biology and Technology, 88: 1–7. https://doi.org/10.1016/j.postharvbio.2013.09.004

Batish, D.R., Singh, H.P., Kohli, R.K. and Kaur, S. 2008. Eucalyptus essential oil as a natural pesticide. Forest ecology and management, 256: 2166–2174.

Bitencourt, R.G., Possas, A.M.M., Camilloto, G.P., Cruz, R.S., Otoni, C.G., Soares and N. de F.F. 2014. Antimicrobial and aromatic edible coating on fresh-cut pineapple preservation. Ciência Rural, 44: 1119–1125. https://doi.org/10.1590/S0103-84782014000600027

Cenobio-Galindo, A. de J., Ocampo-López, J., Reyes-Munguía, A., Carrillo-Inungaray, M.L., Cawood, M., Medina-Pérez, G., Fernández-Luqueño, F. and Campos-Montiel, R.G. 2019. Influence of bioactive compounds incorporated in a nanoemulsion as coating on avocado fruits (*Persea americana*) during postharvest storage: Antioxidant activity, physicochemical changes and structural evaluation. Antioxidants, 8: 500.

Chen, C.C. and Paull, R.E. 2000. Sugar Metabolism and Pineapple Flesh Translucency. Journal of the American Society for Horticultural Science, 125: 558–562. https://doi.org/10.21273/JASHS.125.5.558

Damjanović-Vratnica, B., Đakov, T., Šuković, D. and Damjanović, J. 2011. Antimicrobial effect of essential oil isolated from Eucalyptus globulus Labill. from Montenegro. Czech Journal of Food Sciences 29: 277–284. https://doi.org/10.17221/114/2009-CJFS

Dhar, M., Rahman, S.M. and Sayem, S.M. 2008. Maturity and post-harvest study of pineapple with quality and shelf-life under red soil. International Journal of Sustainable Crop Production, 3: 69–75.

Easterling, R.G. 2015. Fundamentals of Statistical Experimental Design and Analysis. John Wiley and Sons., United Kingdom, pp.91-121.

Govaris, A., Solomakos, N., Pexara, A. and Chatzopoulou, P.S. 2010. The antimicrobial effect of oregano essential oil, nisin and their combination against Salmonella Enteritidis in minced sheep meat during refrigerated storage. International Journal of Food Microbiology, 137: 175–180. https://doi.org/10.1016/j.ijfoodmicro.2009.12.017

Hossain, M. and Bepary, R.H. 2015. Post-harvest handling of pineapples: A Key role to minimize the post-harvest loss. International Journal of Recent Scientific Research, 6: 6069–6075.

Javed, S., Shoaib, A., Mahmood, Z., Mushtaq, S. and Iftikhar, S. 2012. Analysis of phytochemical constituents of Eucalyptus citriodora L. responsible for antifungal activity against post-harvest fungi. Natural Product Research, 26: 1732–1736. https://doi.org/10.1080/14786419.2011.607451

Jhalegar, MD.J., Sharma, R.R. and Singh, D. 2015. In vitro and in vivo activity of essential oils against major postharvest pathogens of Kinnow (Citrus nobilis × C. deliciosa) mandarin. Journal of Food Science and Technology, 52: 2229–2237. https://doi.org/10.1007/s13197-014-1281-2

Joseph-Adekunle, T.T., Okelana, M.A. and Adekoya, I.A. 2009. Storage of pineapple fruits under different conditions: implication on shelf life. Nigerian Journal of Horticultural Science, 14: 76–82. https://doi.org/10.4314/njhs.v14i1.62161

Kabasakalis, V., Siopidou, D. and Moshatou, E. 2000. Ascorbic acid content of commercial fruit juices and its rate of loss upon storage. Food chemistry, 70: 325–328.

Kabir, H., Howlader, J., Ghosh, T.K., Goswami, C.and Haque, M.A. 2010. Effect of different maturity phases and postharvest treatments on the shelf life of pineapple. International Journal of Bio Research, 2: 11–16.

Kato, K., Terao, S., Shimamoto, N. and Hirata, M. 1988. Studies on scavengers of active oxygen species. 1. Synthesis and biological activity of 2-O-alkylascorbic acids. Journal of Medicinal Chemistry, 31(4): 793-798.

Kumar, A., Shukla, R., Singh, P., Prasad, C.S. and Dubey, N.K. 2008. Assessment of Thymus vulgaris L. essential oil as a safe botanical preservative against postharvest fungal infestation of food commodities. Innovative Food Science & Emerging Technologies, 9: 575–580. https://doi.org/10.1016/j.ifset.2007.12.005

Lu, X., Sun, D., Li, Y., Shi, W. and Sun, G. 2011. Pre-and post-harvest salicylic acid treatments alleviate internal browning and maintain quality of winter pineapple fruit. Scientia Horticulturae, 130: 97–101.

Mandal, D., Lalremruata, Hazarika, T.K. and Nautiyal, B.P. 2015. Effect of Post-harvest Treatments on Quality and Shelf Life of Pineapple ( *Ananas comosus* [L.] Merr. 'Giant Kew') Fruits at Ambient Storage Condition. International Journal of Bio-resource and Stress Management, 6: 490-496. https://doi.org/10.5958/0976-4038.2015.00072.X

Mandal, D., Sailo, L., Hazarika, T.K. and Shukla, A.C. 2018. Effect of edible coating on shelf life and quality of local mango cv. Rangkuai of Mizoram. Research on Crops, 19(3): 419-424.

Moneruzzaman, K.M., Hossain, A.B.M.S., Sani, W., Saifuddin, M. and Alenazi, M. 2009. Effect of harvesting and storage conditions on the postharvest quality of tomato (*Lycopersicon esculentum* Mill.) cv. Roma VF. Australian Journal Crop Science, 3:113-121.

Nilprapruck, P., Pradisthakarn, N., Authanithee, F. and Keebjan, P. 2008. Effect of exogenous methyl jasmonate on chilling injury and quality of pineapple (Ananas comosus L.) cv. Pattavia. Silpakorn University Science and Technology Journal, 2(2): 33–42.

Nukuntornprakit, O., Chanjirakul, K., van Doorn, W.G. and Siriphanich, J. 2015. Chilling injury in pineapple fruit: Fatty acid composition and antioxidant metabolism. Postharvest Biology and Technology, 99: 20–26. https://doi.org/10.1016/j.postharvbio.2014.07.010

Pila, N., Gol, N.B and Ramana Rao, T.V. 2010. Effect of Post-harvest Treatments on Physicochemical Characteristics and Shelf Life of Tomato (*Lycopersicon esculentum* Mill.) Fruits during Storage. American-Eurasian Journal of Agricultural and Environmental Sciences, 9: 470-479.

Plotto, A., Roberts, D.D. and Roberts, R.G. 2003. Evaluation of plant essential oils as natural postharvest disease control of tomato (*Lycopersicon esculentum*). Acta Horticulturae, 628: 737–745. https://doi.org/10.17660/ActaHortic.2003.628.93

Prabowo, A.S. and Mawarani, L.J. 2020. Edible Coating Development of Durian Seeds Starch and Glucomannan with The Addition of Essential Oil As An Antimicrobial to Increase Shelf Life of Tomato and Cauliflower. IOP Conference Series: Materials Science and Engineering, 833: 012034. https://doi.org/10.1088/1757-899X/833/1/012034

Rabiei, V., Shirzadeh, E., Rabbi Angourani, H. and Sharafi, Y. 2011. Effect of thyme and lavender essential oils on the qualitative and quantitative traits and storage life of apple Jonagold cultivar. Journal of Medicinal Plants Research, 5: 5522–5527.

Ranganna, S. 1997. Handbook of Analysis and Quality Control for Fruits and Vegetable Products. Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Sadasivam, S. and Manickam, A. 2005. Biochemical methods, 2nd edn. New Age Int. (P) Ltd., New Delhi, India. pp. 8-193.

Selvarajah, S. and Herath, H.M.W. 1997. Effect of an edible coating on some quality and physico-chemical parameters of pineapple during cold storage. Tropical Agricultural Research, 9: 77-89.

Shao, X., Cao, B., Xu, F., Xie, S., Yu, D. and Wang, H. 2015. Effect of postharvest application of chitosan combined with clove oil against citrus green mold. Postharvest Biology and Technology, 99: 37–43. https://doi.org/10.1016/j.postharvbio.2014.07.014

Sivakumar, D. and Bautista-Baños, S. 2014. A review on the use of essential oils for postharvest decay control and maintenance of fruit quality during storage. Crop Protection, 64: 27–37.

Solgi, M. and Ghorbanpour, M. 2014. Application of essential oils and their biological effects on extending the shelf-life and quality of horticultural crops. Trakia Journal of Sciences, 12: 198–210.

Techavuthiporn, C., Boonyaritthongchai, P. and Supabvanich, S. 2017. Physicochemical changes of 'Phulae' pineapple fruit treated with short-term anoxia during ambient storage. Food Chemistry 228: 388–393. https://doi.org/10.1016/j.foodchem.2017.02.028

Tzortzakis, N.G. 2007. Maintaining postharvest quality of fresh produce with volatile compounds. Innovative Food Science & Emerging Technologies, 8: 111–116. https://doi.org/10.1016/j.ifset.2006.08.001