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# Effect of Some Postharvest Treatments on Guava Fruit Rots Caused by *Pestalotia neglecta* and Quality and Storability During Cold Storage

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**Abstract**: Guava fruit rots of Etmani' guava is a major serious decay during cold storage in Egypt and world. Infection of guava fruits *Pestalotia neglecta* mainly attacks the unripe fruits. It reduces fruits quality and marketability of guava during storage. The effect of safe fungicide alternatives (some essential oils and their active ingredients such as clove oil, thyme oil, lavender oil, and its combinations) on growth of *Pestalotia neglecta* were studied during this study. This study was investigated at different concentrations ranged from 0.0125% to 1% amended in PDA *in vitro*. Eugenol+geraniol+thymol formula) at 1-0.0125% completely suppressed the growth of the isolate of *Pestalotia neglecta*. These some essential oils and their active ingredients formula at 1%, were used as postharvest treatment during seasons 2023 and 2024. These some essential oils were adopted at 1% on naturally infected or artificially inoculated fruits after harvest during season 2023/2024. Clove oil, thyme oil, lavender oil, mixed three oils and active ingredient formula were the most effective treatments to control fruits rot disease on guava during cold storage at 8ºC and **90-95%** RH for 3 weeks. Also, all coating treatments had a significant effect on delaying changes of fruit weight loss percentage, color values (L* and h°), hardness, TSS, acidity, and activities of polyphenol oxidase (PPO), peroxidase (POD) and catalase (CAT), especially coating with Clove oil and mixed three oils (clove oil+ thyme oil+ lavender oil). Therefore, it could be recommended that coating guava fruits by clove oil and mixed three oils to improve its quality and storability during cold storage.

**Key words**: Guava, Postharvest, quality and marketability, *Pestalotia neglecta*, essential oils, clove oil, thyme oil and lavender oil.

## 1. Introduction

Guava fruits (*Psidium guajava* L.) Cultivated and widespread in many tropical and subtropical regions. The guava fruits are reach of antioxidants, phytochemical, essential oils, polysaccharides, minerals,

vitamins and enzymes (**Sumra*et al.*, 2018)** and widely used by consumers as a fresh or processed into a variety of value added products in the food industries such as jam, jelly, cheese, nectar, paste and other similar items because of high pectin content of fruits **(Boora, 2012).** Fungal infection on the fruit may occur during the growing season, harvesting, handling, transport or during postharvest processing conditions. Fruits contain high levels of sugars and nutrients, and their low pH makes them vulnerable to fungal decaying **(Singh and Sharma, 2007).**

*Pestalotiopsis* spp. (Pat.) Mordue causes scabby fruit canker, one of the most frequent fruit diseases in guava-growing countries. **Sethi *et al.* (2022)** observed that rots affect all phases of guava fruit development. Scabby fruit canker can significantly reduce fruit yield during growing period or after harvest stage and cause fruit losses during postharvest storage.

*Pestalotia* spp. fungus mainly attacks the unripe fruits to produce dark scab by lesions, 2-4mm in diameter. The scab disfigures the fruits and their market value is considerably reduced**.** Pestalotiopsis species are usually found in tropical and temperate ecosystems (**Jeewon*et al*., 2004; Tejesvi*et al*., 2007 & 2009; Ding *et al*., 2009 and Liu *et al*., 2008 & 2009**) and many cause plant diseases in a variety of plants including canker lesions, shoot dieback, leaf spots, needle blight, tip blight, grey blight, scabby canker, severe chlorosis, fruit rots and leaf spots (**Trapero *et al*., 2003; Sousa *et al*., 2004 and Espinoza *et al*., 2008)**. This disease reduces marketability and quality of guava fruits along with deteriorated yield **Sethi *et al.* (2022).** It has resulted in 30-60 percent losses on average, but in extremely severe cases, the loss might reach 100 percent. **Mathew** (**2010**). Isolation of postharvest pathogen and analysis of diseased guava fruits was carried out and found that the prevalence of maximum fungi found to be *Pestalotia psidii* about 32.16% was the major postharvest pathogen isolated from the samples. **Nongmaithem (2014)** indicated that essential oil possessed antifungal activity in controlling the growth of postharvest fungal pathogen of guava under laboratory condition and can be exploited as an ideal treatment for postharvest fungal disease management of guava.

Essential oils have antioxidant and antimicrobial properties, so it is considered one of the most suitable methods to maintain overall fruit quality, reduce decay and extend the shelf life of fruit during storage **(El-Bana and Ennab, 2023).**This study is conducted to evaluate the effects of postharvest application of some essential oils (clove, thyme, lavender oils and Eugenol +geraniol+ thymol formoula) active ingredient of three oils on disease incidence and its severiety quality maintenance of winter guava fruits such as fruit firmmess, total soluble solide, acidity, ascorbic acid and activities enzymes, polyphenol oxidase, peroxidase and catalase enzymes .

## 2. Materials and Methods

### 2.1. Isolation and identification

*Pestalotia neglecta* was isolated from guava fruits obtained from Market showing brown rots symptoms. Fruit samples cut into (5 mm) and immersed in NaOCl (0.5%) for 5 min rinsed in sterile distilled water, then transfer to blotted dry in sterile paper towels for drying. Samples transferred into 9 cm Petri dishes containing potato dextrose agar (PDA) and incubation at 25C$^{o}$ period for 7 days. Then, confirmed through Koch's postulates were performed to confirm the pathogen city of each isolates. Sub-culturing was carried out at 7 days intervals and conidia from 7 day-old pure cultures were used for inoculations.

### 2.2. Plant materials

Healthy and mature guava fruits 'Etmani'cv. were growing in a private farme in Qalubia Governorate. Uniform and healithy fruits were selected at maturity stage to be used for these experiments.

### 2.3. Tested chemical Treatments

Clove, Thyme and Lavender oils were obtained from El-Hawag company. Bader city while Eugenol, geraniol and thymol formoula was obtained from a Spain producer.

### 2.4. In vitro assay

Effect of Clove, Thyme, Lavender oils, mixed three oils (v/v/v) and Eugenol + geraniol + thymolformoula (active ingredient three oils) isolated of *Pestalotia neglecta* growth was investigated using poisoned food technique. (**Anand*et al.*, 2016; Abd-Alla and Haggag, 2013 and Quiróz-López*et al.*, 2021)**. At serial concentrations, 1, 0.5, 0.25,0.125% for essential oils and for active ingredient formula as incorporated into worm sterile PDA medium before medium solidification, 45-55$^{o}$C, in aseptic conditions providing target concentration. Then Petri plates were inoculated with 5-mm discs from periphery of 7-day-old cultures of such *Pestalotia neglecta*. Isolate by placing fungal discs on solidified medium surface at the centre. Inoculated plain medium with fungus discs was used as a control. Three Petri dishes were used as replications per each tested concentration and the control. Inoculated cultures were incubated at 22$^{o}$C until the growth of control of any isolate covered medium surface in Petri dishes. Average linear growth for each replicate of such treatment was determined (Cm).

### 2.5. Postharvest treatments of guava with Clove, Thyme, Lavender oils and Eugenol + geraniol + thymol formoula

Guava fruits were purchased from commercial orchards in Qalubia Governorate. At maturity stage Uniform and apparently healthy fruits, free from injuries and decay were selected for postharvest experiments. guava fruits were divided into two groups, one for the natural infection investigation and the other for artificial inoculation trials The fruits allocated for artificial inoculation were surface sterilized by dipping in 70% alcohol for 2 min, then washed thoroughly with sterilized distilled water. Surface sterilized fruits were left for air drying at room temperature. Fruits were punctured using a stainless-steel rod with 2-mm diameter and to 2-mm depth, as one puncture for fruit at the middle of one fruit side. Fruits were rinsed in *Pestalotia neglecta* spore suspension of $10^6$ spores/ml for 30 seconds. Control fruits were injured as above and treated with sterile distilled water containing Tween 20. Both artificially inoculated and naturally infected fruits were stored in dark at 7$^{o}$C and 90% RH for 24 hours, then rinsed in solutions containing (1%) concentration of tested moment such Clove, Thyme, Lavender oils and Eugenol+geraniol+thymol formoula respectively for (2 min). The treated fruits were allowed for air drying at room temperature under aseptic conditions, then packed in Carton bags. Four replicates were used for each treatment; each replicate consists of 4 punnets each contained 9 guava fruits. After cold storage for 7 days or 30 days, dry rot disease incidence (%), disease severity, fruit firmness and TSS were determined.

### 2.6. Disease assessment

**Disease incidence (%)**: The disease incidence was calculated for each replicate by relating decayed diseased fruits to the total number of fruits.

**The Disease severity r**ating scale was applied to assess disease severity in different guava according to diagrammatic scale for the stored evaluation of fruits rots severity on guava fruits (Fig. 1) and calculated as follows:

**Disease severity** = ∑decayed area (%) of each fruit X 100/ No. of fruits of each replicate and decayed area (%) for each single fruit was determined as periods.

### 2.7. Physiological Parameters

**Fresh weight losses percentage (FWL%):** The fruits weighed before cold storage to obtain the initial weight. Then, it weighed after each period of cold storage. FWL calculated as a percentage of the initial weight according to the following equation: $FWL\% = \frac{wi - ws}{wi} \times 100$

Where, Wi = Initial fruit weight, Ws = Fruit weight at each sampling period (**Hazali *et al.*, 2013; Ibrahim and Gad, 2015)**

**Fruit firmness**: Firmness was determined using a metec firmness tester with 8-mm probe. Data of firmness were expressed as Ib/inch$^2$.

**Fruit color:** Lightness and hue angle were estimated using Minolta Calorimeter (**Minolta Co. Ltd. Osaka, Japan)** as described by (**McGire, 1992).**

### 2.8. Chemical properties

**Total Soluble solids content (%):** It was determined using a hand refractometer as Brix$^{o}$ **(Hazali *et al*., 2013)**.

**Titratable acidity percentage:** Was determined by titrating 5 ml of the extracted juice against 0.1 N of NaOH using phenolphethalin indicator. Titratable acidity was expressed as percentage of citric acid (g citric acid/100ml juice) according to **A.O.A.C., (2005).**

**Vitamin C (mg/ 100 ml juice):** It was determined by titration against 2, 6 dichlorophenolendophenol and using 2% oxalic acid solution as substrate described by (**Lucass, 1944).**

**Defense-Related Enzymes Activities**

**Polyphenol oxidase activity (PPO, Ug /FW)**: it was measured as mentioned by (**Matta and Diamond, 1963).** The reaction mixture contains 1ml of the crude enzyme + 1ml phosphate buffer solution (7.1pH) + 1ml catechol and completed with distilled water to 6.0 ml. Polyphenol oxidase was expressed as the change in the absorbance of the mixture every 0.5 minute for 5 minutes period at 495 nm by Spectrophotometer. Unit (U) of PPO activity was defined as 1.0 increase in absorbance at 495 nm / min / g FW.

**Determination of peroxidase (POD) activity**: Using guaiacol as a substrate, was assayed by the method described by **Zhang *et al.* (2005)** in a reaction mixture (3 ml) containing 25 µl of enzyme extract, 2.78 mL of 0.05 M phosphate buffer (pH 7.0), 0.1 ml of 20 mM $H_2O_2$, and 0.1 ml of 20 mMguaiacol. An increase in POD activity at 470 nm, due to guaiacol oxidation, was recorded after 2 min. One unit of enzyme activity was defined as the amount that caused a change of 0.01 in the absorbance per minute.

**Determination of catalase (CAT) activity:** It was analyzed according to the methods described by **Wang *et al*. (2005).** The reaction mixture consisted of 2 ml sodium phosphate buffer (50 mmol/ L, Ph 7.0), 0.5 ml $H_2O_2$ (40 mmol/ L), and 0.5 ml enzyme extract. The decomposition of $H_2O_2$ was measured by thedecline in absorbance at 240 nm and 25 ℃. CAT specificactivity was expressed as U/g FW.

### 2.9. Statistical analysis

The data were arranged as a two factorial randomized complete design with three replicates. All data were subjected to statistical analysis according to the procedures reported by **Snedecor and Cochran** (**1990)** and means were compared by Duncan's Multiple range test at the 5% level of probability in the two seasons of experimentation.

## 3. Results

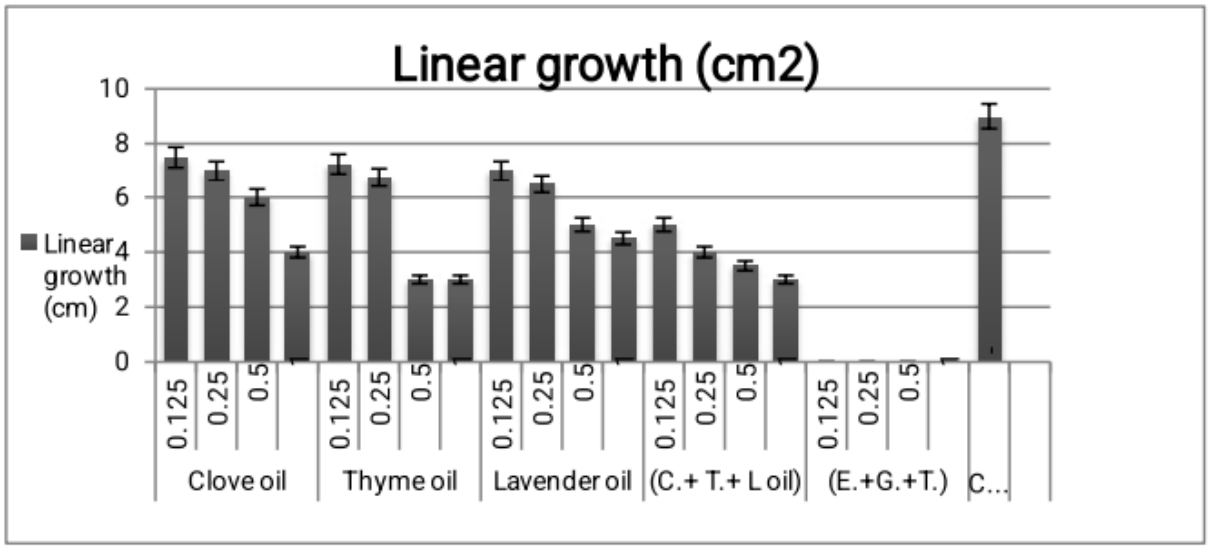
### 3.1. Activity of three essential oils and their three active ingredient formoulaon mycelial growth of *Pestalotia neglecta*

The effect of clove, thyme, lavender oils, mixed three oils (v/v/v) and Eugenol+geraniol +thymol formoula on linear growth of *Pestalotia neglecta*.Eugenol+geraniol+thymol formoula completely inhibited *Pestalotia neglecta* growth at all tested concentrations.mean while other treatments were evaluated applied treatments of concentrations more than ١% significantly decreased mycelial growth of *Pestalotia neglecta* Fig.(1).

### 3.2. Percent diseases incidence of guava fruits

The data on disease incidence percentage revealed that postharvest treatments were significantly effective in controlling the disease incidence percentage of fruit rots from natural infection and artificial infection with *Pestalotia neglecta* over control (Table 1) Minimum mean fruit rots disease incidence (13.3 and 26.6%), respectively. The Clove+ thyme+ lavender oils and Eugenol+geraniol+thymol formoula treatment natural and artificial infection during season 2023 were significantly minimum than rest of treatments. While the highest fruit disease incidence (33.3 and 100%) natural and artificial infection respectively, was observed in control. No fruit decay was observed in Clove+ thyme+ lavender and Eugenol +geraniol+thymol formoula treatment, treated fruits until1week of storage.

**Fig. (1). Effect of Clove, Thyme, Lavender oils, mixed three oils and Eugenol +geraniol + thymol formoula on linear growth of *Pestalotia neglecta***




(C. +T. +L. Oil) = mixed Clove, Thyme and Lavender oil
(E.+G.+T.) = Eugenol+geraniol +thymol formoula

**Table (1). Effect of postharvest treatments on guava fruits disease incidence of natural and artificial infection with *Pestalotia neglecta* during season 2023, then cold storage (8 ± 1°C and RH 90-95%) up for three weeks**

| Treatment | Disease incidence | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Season2023 | | | | | | | |
| | Natural infection | | | | Artificial infection | | | |
| | Initial | 1 week | 2 week | 3 week | Initial | 1 week | 2 week | 3 week |
| **Clove oil** | 0.0 | 6.7 | 20 | 26.7 | 0.0 | 13.3 | 26.7 | 33.3 |
| **Thyme oil** | 0.0 | 13.3 | 26.7 | 33.3 | 0.0 | 20 | 33.3 | 46.7 |
| **Lavender oil** | 0.0 | 6.7 | 13.3 | 20 | 0.0 | 13.3 | 20 | 33.3 |
| **Clove, thyme and lavender** | 0.0 | 0.0 | 6.7 | 13.3 | 0.0 | 0.0 | 13.3 | 26.6 |
| **Eugenol+geraniol+ Thymol formoula** | 0.0 | 0.0 | 0.0 | 6.7 | 0.0 | 0.0 | 6.7 | 13.3 |
| **control** | 0.0 | 20 | 26.7 | 33.3 | 0.0 | 26.7 | 46.7 | 100 |
| **LSD** | - | 0.82 | 1.11 | 0.83 | - | 0.84 | 1.01 | 0.92 |

Postharvest treatments of guava fruits with essential oils (clove, thyme, lavender oils and mixed three oils) and Eugenol, geraniol and thymol formula (active ingredient three oils) on fruit rots disease of guava fruits 'Etmani'cv. during seasons 2024 resulted in significantly control of fruit rots. Disease incidence in naturally and artificial infected fruits stored at 8°C for 3 weeks were markedly affected (Table 2) Minimum mean fruit rots disease incidence (13.3, 6.7 and 13.3%) respectively, natural and artificial infection during season 2024 were observed in Clove+ thyme+ lavender oils and Eugenol+geraniol+thymol formoula treatment, which were significantly minimum than rest of treatments. While the highest fruit disease incidence (33.3 and 100%) respectively, natural and artificial infection was observed in control. No fruit decay were observed in Clove+ thyme+ lavender and Eugenol+geraniol+thymol formoula treatment, treated fruits till 1week of storage.

**Table (2). Effect of postharvest treatments on guava fruits disease incidence of natural and artificial infection with *Pestalotia neglecta* during season 2024, then cold storage (8 ± 1°C and RH 90-95%) up for three weeks**

| Treatment | Disease incidence | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Season 2024 | | | | | | | |
| | Natural infection | | | | Artificial infection | | | |
| | Initial | 1 week | 2 week | 3 week | Initial | 1 week | 2 week | 3 week |
| **Clove oil** | 0.0 | 0.0 | 6.7 | 13.3 | 0.0 | 6.7 | 13.3 | 26.7 |
| **Thyme oil** | 0.0 | 6.7 | 13.3 | 26.7 | 0.0 | 20 | 26.7 | 40 |
| **Lavender oil** | 0.0 | 0.0 | 6.7 | 13.3 | 0.0 | 13.3 | 20 | 33.3 |
| **Clove+ thyme+ lavender** | 0.0 | 0.0 | 3.3 | 6.7 | 0.0 | 6.7 | 13.3 | 20 |
| **Eugenol+geraniol+ thymol formoula** | 0.0 | 0.0 | 6.7 | 13.3 | 0.0 | 0.0 | 6.7 | 13.3 |
| **control** | 0.0 | 13.3 | 20 | 33.3 | 0.0 | 26.7 | 40 | 100 |
| **LSD** | - | 0.82 | 1.21 | 1.12 | - | 0.92 | 1.02 | 1.01 |

Postharvest treatments of guava fruits with essential oils (clove, thyme, lavenderoils, mixedthree oils and Eugenol+geraniol+thymol formula (active ingredient three oils) on fruit rots disease ofn 'Etmani' guava during seasons 2023 resulted in significantly control of fruit rots. Disease severity in naturally and artificial infected fruits stored at 8$^{o}$C for 3weeks were markedly affected (Table 3) Minimum fruit rots (5 and 16.7%), respectively. Natural and artificial infection during season 2023 were observed in Clove+ thyme+ lavender oils treatments significantly minimum results than rest of treatments. While the highest fruit disease incidence (26.7 and 40%), respectively, natural and artificial infection was observed in control. No fruit decay was observed in Clove+ thyme+ lavender oils and Eugenol + geraniol+ thymol formoula treatment treated fruits till 1week of storage.

**Table (3). Effect of postharvest treatments on guava disease severity of natural and artificial infection with *Pestalotia neglecta* during season 2023, then cold storage (8 ± 1°C and RH 90-95%) up for three weeks**

| Treatment | Disease severity | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Season2023 | | | | | | | |
| | Natural infection | | | | Artificial infection | | | |
| | Initial | 1 week | 2 week | 3 week | Initial | 1 week | 2 week | 3 week |
| **Clove oil** | 0.0 | 1.7 | 6.7 | 15 | 0.0 | 3.3 | 13.3 | 25 |
| **Thyme oil** | 0.0 | 6.7 | 15 | 20 | 0.0 | 5 | 16.7 | 30 |
| **Lavender oil** | 0.0 | 3.3 | 6.7 | 13.3 | 0.0 | 3.3 | 10 | 25 |
| **Clove+ thyme+ lavender** | 0.0 | 0.0 | 1.7 | 5 | 0.0 | 0.0 | 6.7 | 16.7 |
| **Eugenol+geraniol+ Thymol formoula** | 0.0 | 0.0 | 1.7 | 6.7 | 0.0 | 0.0 | 6.7 | 16.7 |
| **control** | 0.0 | 5 | 23.3 | 26.7 | 0.0 | 13.3 | 30 | 40 |
| **LSD** | - | 0.91 | 4.32 | 5.41 | - | 1.63 | 2.72 | 2.43 |

**Fig. (2). Diagrammatic scale for the stored evaluation of fruits rots severity on guava fruits**


Results in (Table 4) show the effect of postharvest treatments with essential oils (clove, thyme, lavender oils, mixed three oils) and Eugenol+geraniol+thymol formula (active ingredient three oils) on gauava "Etmani" cv. fruite rots disease during seasons 2024 in this study. After 3weeks of cold storage, fruits treated by Eugenol+geraniol+thymol formula (active ingredient three oils) recorded the lowest value of disease severity percentage (3.3 & 6.7%) in the 2nd seasons, respectively. In natural and artificial infection, the highest value of disease severity percentage was found in untreated fruit (25 & 53.3%) during 2024 season in natural and artificial infection, respectively.

**Table (4). Effect of postharvest treatments on guava disease severity of natural and artificial infection with *Pestalotia neglecta* during growing season 2024, then cold storage (8 ± 1°C and RH 90-95%) up for three weeks**

| Treatment | Disease severity | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Season 2024 | | | | | | | |
| | Natural infection | | | | Artificial infection | | | |
| | Initial | 1 week | 2 week | 3 week | Initial | 1 week | 2 week | 3 week |
| **Clove oil** | 0.0 | 0.0 | 1.7 | 6.7 | 0.0 | 1.7 | 6.7 | 13.3 |
| **Thyme oil** | 0.0 | 1.7 | 6.7 | 13.3 | 0.0 | 5 | 13.3 | 30 |
| **Lavender oil** | 0.0 | 0.0 | 1.7 | 6.7 | 0.0 | 3.3 | 10 | 16.7 |
| **Clove+ thyme+ lavender** | 0.0 | 0.0 | 1.7 | 6.7 | 0.0 | 1.7 | 6.7 | 10 |
| **Eugenol+geraniol+ thymol formoula** | 0.0 | 0.0 | 1.7 | 3.3 | 0.0 | 0.0 | 1.7 | 6.7 |
| **Control** | 0.0 | 3.3 | 10 | 25 | 0.0 | 13.3 | 30 | 53.3 |
| **LSD** | - | 0.52 | 1.30 | 1.71 | - | 1.42 | 1.51 | 3.52 |

### 3.3. Fruit Weight loss percentage

Results in (Table 5) show the effect of clove oil 1%, thyme oil 1%, lavender oil 1%, clove + thyme + lavender oils (v/v/.v) mixed and Eugenol+geranial+thymol formula (active ingredient three oils) on "Etmani"guava fruits weight loss percentage during cold storage conditions in 2023 /2024 seasons.

Fruit weight loss percentage increased gradually toward the end of storage period. All studied treatments significantly decreased weight loss percentage compared with untreated fruits during both seasons of this study either fruits were natural or artificially infected with *Pestalotia neglecta*.

As for natural infection, after 3 weeks of cold storage, fruits treated by clove oil and lavender oil recorded the lowest values of weight loss percentage (6.707&6.537%) in the first and second seasons, respectively. Whereas, untreated fruits exhibited the highest weight loss percentage recorded the values of 12.67% and 13.95 % during 2023 and 2024 seasons, respectively.

On the other hand, artificially infected with *Pestalotia neglecta* fruits treated with clove oil recorded the lowest values of 7.713& 7.357% in the two seasons, respectively. while untreated fruits exhibited the highest values.

### 3.4. Total soluble solid content of fruits

It is represented from the results in (Table 6) that, total soluble solid content of stored fruits was gradually increased with the advance in cold storage. The studied postharvest treatments significantly decreased the TSS increasing rate than untreated fruit during the two seasons in this work. Moreover, the fruits treated with Clove+ thyme+ lavender oils showed the lowest TSS content, while the highest values were recorded with the untreated fruits (control) in both seasons in natural and artificial infection.

As for interaction between two study factors after three weeks of storage, control treatment exhibited the highest value in the two seasons, while, the lowest value recorded by Clove+ thyme+ lavender oils in the both seasons in the natural and artificial infection.

**Table (5). Effect of some postharvest treatments on weight loss % of guava fruits either natural or infected with *Pestalotia neglecta* cold storage at 8 ± 1°C and RH 90-95% during 2023 and 2024 seasons**

| **Natural infection** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **first season** | | | | | **second season** | | | | |
| | 0 | 1 | 2 | 3 | Means (B) | 0 | 1 | 2 | 3 | Means (B) |
| 1 | 0.00 | 2.42 | 4.20 | 6.71 | 3.336 | 0.00 | 2.16 | 4.36 | 6.90 | 3.357 |
| 2 | 0.00 | 1.97 | 4.27 | 6.98 | 3.308 | 0.00 | 2.53 | 5.31 | 9.40 | 4.311 |
| 3 | 0.00 | 2.21 | 4.86 | 7.69 | 3.692 | 0.00 | 2.01 | 4.21 | 6.54 | 3.192 |
| 4 | 0.00 | 2.15 | 4.89 | 8.09 | 3.785 | 0.00 | 1.55 | 4.66 | 7.60 | 3.457 |
| 5 | 0.00 | 2.60 | 6.71 | 10.77 | 5.023 | 0.00 | 3.41 | 6.99 | 10.73 | 5.284 |
| 6 | 0.00 | 5.63 | 9.15 | 12.67 | 6.864 | 0.00 | 6.32 | 9.82 | 13.95 | 7.525 |
| Means (A) | 0.000 | 2.831 | 5.681 | 8.817 | | 0.000 | 2.996 | 5.892 | 9.186 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 1.145 | 0.9349 | 2.290 | | | 1.157 | 0.9445 | 2.314 | | |
| **Artificial infection** | | | | | | | | | | |
| 1 | 0.00 | 1.99 | 4.66 | 7.71 | 3.595 | 0.00 | 2.523 | 4.750 | 7.357 | 3.660 |
| 2 | 0.00 | 4.40 | 7.84 | 10.79 | 5.762 | 0.00 | 4.983 | 7.517 | 9.730 | 5.560 |
| 3 | 0.00 | 2.26 | 4.60 | 7.83 | 3.678 | 0.00 | 2.290 | 5.187 | 7.927 | 3.853 |
| 4 | 0.00 | 1.72 | 5.43 | 8.45 | 3.897 | 0.00 | 2.440 | 5.010 | 8.320 | 3.945 |
| 5 | 0.00 | 2.59 | 5.87 | 8.90 | 4.342 | 0.00 | 3.050 | 6.450 | 9.493 | 4.751 |
| 6 | 0.00 | 5.44 | 8.05 | 11.72 | 6.303 | 0.00 | 4.573 | 9.143 | 11.82 | 6.387 |
| Means(A) | 0.000 | 3.063 | 6.075 | 9.235 | | 0.000 | 3.310 | 6.343 | 9.108 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 0.8810 | 0.7193 | 1.762 | | | 0.7460 | 0.6091 | 1.492 | | |

| Key treatments | | |
|---|---|---|
| 1= Clove oil | 3= Lavender oil | 5= Eugenol+geraniol+thymol formoula |
| 2= Thyme oil | 4= Clove+ thyme+ lavender | 6= control |

**Table (6). Effect of some postharvest treatments on TSS contents of guava fruits either natural or infected with *Pestalotia neglecta* cold storage at 8 ± 1°C and RH 90-95% during 2023 and 2024 seasons**

| **Natural infection** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **first season** | | | | | **second season** | | | | |
| | 0 | 1 | 2 | 3 | Means (B) | 0 | 1 | 2 | 3 | Means (B) |
| 1 | 8.70 | 9.43 | 10.13 | 10.97 | 9.81 | 9.53 | 10.40 | 10.93 | 11.60 | 10.62 |
| 2 | 8.70 | 9.13 | 9.77 | 10.63 | 9.56 | 9.53 | 10.03 | 10.63 | 11.33 | 10.38 |
| 3 | 8.70 | 8.90 | 9.57 | 10.23 | 9.35 | 9.53 | 9.90 | 10.37 | 10.80 | 10.15 |
| 4 | 8.70 | 8.87 | 9.13 | 9.77 | 9.12 | 9.53 | 9.70 | 9.93 | 10.20 | 9.84 |
| 5 | 8.70 | 8.97 | 9.43 | 10.20 | 9.33 | 9.53 | 9.70 | 10.13 | 10.53 | 9.98 |
| 6 | 8.70 | 9.70 | 10.07 | 11.63 | 10.02 | 9.53 | 10.73 | 11.03 | 12.03 | 10.83 |
| Means(A) | 8.70 | 9.17 | 9.68 | 10.57 | | 9.53 | 10.08 | 10.51 | 11.08 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 0.514 | 0.420 | 1.028 | | | 0.392 | 0.320 | 0.784 | | |
| **Artificial infection** | | | | | | | | | | |
| 1 | 8.70 | 9.93 | 10.20 | 11.03 | 9.97 | 9.50 | 10.57 | 10.87 | 11.37 | 10.58 |
| 2 | 8.70 | 9.53 | 9.87 | 10.70 | 9.70 | 9.50 | 10.23 | 10.67 | 10.97 | 10.35 |
| 3 | 8.70 | 9.30 | 9.60 | 10.47 | 9.52 | 9.50 | 9.97 | 10.43 | 10.77 | 10.18 |
| 4 | 8.70 | 8.90 | 9.17 | 10.00 | 9.19 | 9.50 | 9.83 | 10.00 | 10.33 | 9.93 |
| 5 | 8.70 | 9.10 | 9.37 | 10.07 | 9.31 | 9.50 | 9.83 | 10.23 | 10.57 | 10.04 |
| 6 | 8.70 | 9.87 | 10.67 | 11.77 | 10.25 | 9.50 | 10.60 | 11.17 | 11.77 | 10.77 |
| Means(A) | 8.70 | 9.44 | 9.81 | 10.67 | | 9.50 | 10.17 | 10.56 | 10.96 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 0.553 | 0.451 | 1.105 | | | 0.330 | 0.270 | 0.661 | | |
| Key treatments | | | | | | | | | | |
| 1= Clove oil | | | | 3= Lavender oil | | 5= Eugenol+geraniol+thymol formoula | | | | |
| 2= Thyme oil | | | | 4= Clove+ thyme+ lavender | | 6= control | | | | |

### 3.5. Firmness (Ib/inch$^2$)

Data shown in (**Table 7**) clearly indicated that fruit firmness significantly decreased with progress of storage periods in the two seasons in this work either fruits were naturally or artificially infected fruits with *p. neglicata*.

All studied treatments significantly decreased firmness deterioration rate of fruits compared to control fruits. in the natural infection, fruit treated by Clove+ thyme+ lavender oils recorded the highest values in both seasons.

While, in the artificial infection the highest values of firmness exhibited by Clove+ thyme+ lavender oils treatment in the first season and clove oil treatment in the second season.

As for interaction effect, after 3 weeks of storage in the natural infection, fruits treated with Clove+ thyme+ lavender oils had the highest values (10.77&11.17 Ib/inch$^2$) in firmness fruits in the two

seasons in this study, respectively, on contrast, control fruits treatment gave the lowest firmness values (8.83&9.42 Ib/inch$^2$) in the two seasons, respectively.

Concerning the artificial infection, the highest values (10.47&10.93 Ib/inch$^2$) in firmness fruits treated with Clove+ thyme+ lavender oils and clove oil in first and second seasons, respectively. Control treatment gave the lowest values (8.40&9.10 Ib/inch$^2$) in two seasons, respectively.

**Table (7). Effect of some postharvest treatments on firmness of guava fruits either natural or infected with *Pestalotia neglecta* cold storage at 8 ± 1°C and RH 90-95% during 2023 and 2024 seasons**

| **Natural infection** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **first season** | | | | | **second season** | | | | |
| | 0 | 1 | 2 | 3 | Means(B) | 0 | 1 | 2 | 3 | MEANS (B) |
| 1 | 12.20 | 11.37 | 10.80 | 10.43 | 11.20 | 13.17 | 12.63 | 11.37 | 10.63 | 11.95 |
| 2 | 12.20 | 10.80 | 10.10 | 9.80 | 10.73 | 13.17 | 11.60 | 10.90 | 10.00 | 11.42 |
| 3 | 12.20 | 10.37 | 9.77 | 9.47 | 10.45 | 13.17 | 11.17 | 10.50 | 9.93 | 11.19 |
| 4 | 12.20 | 11.80 | 11.30 | 10.77 | 11.52 | 13.17 | 12.83 | 11.87 | 11.17 | 12.26 |
| 5 | 12.20 | 11.10 | 10.47 | 10.07 | 10.96 | 13.17 | 12.30 | 10.87 | 10.27 | 11.65 |
| 6 | 12.20 | 9.83 | 9.17 | 8.83 | 10.01 | 13.17 | 10.90 | 10.00 | 9.43 | 10.88 |
| Means(A) | 12.20 | 10.88 | 10.27 | 9.89 | | 13.17 | 11.91 | 10.92 | 10.24 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 0.445 | 0.363 | 0.890 | | | 0.504 | 0.412 | 1.01 | | |
| **Artificial infection** | | | | | | | | | | |
| 1 | 12.20 | 10.67 | 10.13 | 9.90 | 10.73B | 13.17 | 10.87 | 10.33 | 10.93 | 11.32 |
| 2 | 12.20 | 9.87 | 9.57 | 9.43 | 10.27BC | 13.17 | 10.10 | 9.47 | 7.93 | 10.17 |
| 3 | 12.20 | 9.70 | 9.33 | 9.13 | 10.09CD | 13.17 | 9.83 | 9.37 | 7.77 | 10.03 |
| 4 | 12.20 | 11.50 | 10.97 | 10.47 | 11.28A | 13.17 | 11.13 | 10.73 | 9.70 | 11.18 |
| 5 | 12.20 | 10.20 | 9.73 | 9.60 | 10.43BC | 13.17 | 10.87 | 9.90 | 8.83 | 10.69 |
| 6 | 12.20 | 9.40 | 8.93 | 8.40 | 9.73D | 13.17 | 9.53 | 8.70 | 7.10 | 9.63 |
| Means(A) | 12.20 | 10.22 | 9.78 | 9.49 | | 13.17 | 10.39 | 9.75 | 8.71 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 0.464 | 0.379 | 0.929 | | | 0.520 | 0.425 | 1.041 | | |
| Key treatments | | | | | | | | | | |
| 1= Clove oil | | | | 3= Lavender oil | | | 5= Eugenol+geraniol+thymol formoula | | | |
| 2= Thyme oil | | | | 4= Clove+ thyme+ lavender | | | 6= control | | | |

### 3.6. Titratable acidity (%)

The data presented in (Table 8) showed the effect of essential oil applications on total acidity contents of "Etmani" guava fruits during the storage period at 8 ± 1°C with 90-95% RH either fruits were naturally or artificially infected with *p. neglicata*, acidity contents decreased significantly with the increasing of storage period.

No significant differences between all treatments in the naturally or artificially infected in the two seasons.

As for interaction after 3 weeks of storage, Eugenol+geraniol+thymol formoula treatments resulted highest levels of titratable acidity in guava fruits during the storage period compared with the control recorded the lowest value in the two seasons in the natural infection. On the other side, fruits artificially infected with *p. neglicata*, and treated with clove oil recorded the highest values of titratable acidity in guavas compared to the control which recorded the lowest values in the first and second seasons.

The higher acidity in treated fruits might have been due to reduced hydrolysis of organic acids and subsequent accumulation of organic acids in the fruits which were oxidized at slower rate because of slower respiration rate. During storage, rate of respiration increases which consume organic acid and reduce the fruit acidity that affect the fruit flavor. With advancement of ripening processes, starch is converted into sugar as a result of hydrolysis, which is ultimately responsible for accelerated sugar level and reduction in acidity percent (**Baraiya *et al*., 2014)**.

**Table (8). Effect of some postharvest treatments on Titratable acidity % of guava fruits either natural or infected with *Pestalotia neglecta* cold storage at 8 ± 1°C and RH 90-95% during 2023 and 2024 seasons**

| **Natural infection** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **first season** | | | | | **second season** | | | | |
| | 0 | 1 | 2 | 3 | Means(B) | 0 | 1 | 2 | 3 | Means(B) |
| 1 | 0.66 | 0.57 | 0.54 | 0.48 | 0.56 | 0.43 | 0.41 | 0.36 | 0.35 | 0.39 |
| 2 | 0.66 | 0.50 | 0.40 | 0.33 | 0.47 | 0.43 | 0.40 | 0.37 | 0.34 | 0.38 |
| 3 | 0.66 | 0.50 | 0.44 | 0.40 | 0.50 | 0.43 | 0.38 | 0.33 | 0.30 | 0.36 |
| 4 | 0.66 | 0.56 | 0.54 | 0.49 | 0.56 | 0.43 | 0.40 | 0.36 | 0.32 | 0.38 |
| 5 | 0.66 | 0.62 | 0.50 | 0.50 | 0.57 | 0.43 | 0.40 | 0.37 | 0.36 | 0.39 |
| 6 | 0.66 | 0.56 | 0.46 | 0.30 | 0.49 | 0.43 | 0.39 | 0.38 | 0.30 | 0.37 |
| Means(A) | ٠,٦٦ | ٠,٥٥ | 0.48 | 0.42 | | 0.43 | 0.40 | 0.36 | 0.33 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | N.S. | ٠,١٢٧ | ٠,٣١2 | | | N.S. | N.S. | ٠,٣٠3 | | |
| **Artificial infection** | | | | | | | | | | |
| 1 | 0.66 | 0.60 | 0.57 | 0.50 | 0.58 | 0.43 | 0.40 | 0.36 | 0.34 | 0.39 |
| 2 | 0.66 | 0.63 | 0.50 | 0.48 | 0.57 | 0.43 | 0.38 | 0.35 | 0.30 | 0.37 |
| 3 | 0.66 | 0.56 | 0.52 | 0.46 | 0.55 | 0.43 | 0.41 | 0.38 | 0.33 | 0.39 |
| 4 | 0.66 | 0.63 | 0.53 | 0.42 | 0.56 | 0.43 | 0.39 | 0.36 | 0.30 | 0.37 |
| 5 | 0.66 | 0.60 | 0.58 | 0.48 | 0.58 | 0.43 | 0.40 | 0.37 | 0.32 | 0.38 |
| 6 | 0.66 | 0.62 | 0.53 | 0.46 | 0.57 | 0.43 | 0.41 | 0.32 | 0.30 | 0.37 |
| Means(A) | 0.66 | 0.61 | 0.54A | 0.47 | | 0.433 | 0.398 | 0.359 | 0.316 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | N.S. | 0.107 | 0.270 | | | N.S. | N.S. | 0.262 | | |
| Key treatments | | | | | | | | | | |
| 1= Clove oil | | | | 3= Lavender oil | | | 5= Eugenol+geraniol+thymol formoula | | | |
| 2= Thyme oil | | | | 4= Clove+ thyme+ lavender | | | 6= control | | | |

### 3.7. Vitamin C. Content (represented as mg/ 100 ml juice)

The results in (Table 9) showed that vitamin C content in winter guavas either non-infected or artificially infected with *Pestalotia neglecta* gradually increased with the progress of the storage period during storage at 8±1°C with 90-95% RH for 3 weeks. All studied treatments significantly increased fruit contents of vitamin C in comparison with untreated fruits, more over there was a significant difference between all treatments in the two seasons. The high contents of vitamin C were obtained by clove oil treatment at nature infection and Eugenol+geraniol+thymol formoula at artificial infection in the both seasons. On the other hand, control fruit treatment exhibited the least value of vitamin C in the two seasons respectively. This is agreeing with, **Shaaban and Hussein (2017)** they noted that vitamin c content of guava fruits increased with progress in ripening might be due to the breakdown of starch to glucose which increases the biosynthesis of ascorbic acid.

As for interaction between two study factors, after 3 weeks of storage fruit treated by clove oil reported the highest value of vitamin C in the nature infection and Eugenol+ geraniol+ thymol formoula at artificial infection in the two seasons.

**Table (9). Effect of some postharvest treatments on Vitamin C. Content of guava fruits either natural or infected with *Pestalotia neglecta* cold storage at 8 ± 1°C and RH 90-95% during 2023 and 2024 seasons**

| **Natural infection** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **first season** | | | | | **second season** | | | | |
| | 0 | 1 | 2 | 3 | Means(B) | 0 | 1 | 2 | 3 | Means(B) |
| 1 | 72.00 | 77.33 | 92.75 | 119.5 | 90.40 | 73.60 | 84.67 | 97.97 | 114.8 | 92.75 |
| 2 | 72.00 | 90.67 | 97.97 | 106.2 | 91.71 | 73.60 | 85.33 | 95.65 | 113.3 | 91.98 |
| 3 | 72.00 | 81.33 | 92.75 | 106.2 | 88.07 | 73.60 | 82.00 | 88.12 | 101.4 | 86.29 |
| 4 | 72.00 | 82.67 | 93.33 | 98.57 | 86.64 | 73.60 | 90.67 | 100.90 | 111.0 | 94.02 |
| 5 | 72.00 | 77.33 | 85.22 | 96.19 | 82.69 | 73.60 | 84.00 | 92.75 | 105.7 | 89.02 |
| 6 | 72.00 | 78.67 | 86.96 | 91.91 | 82.38 | 73.60 | 78.67 | 86.96 | 91.91 | 82.38 |
| Means(A) | 72.00 | 81.33 | 91.50 | 103.10 | | 73.60 | 84.22 | 93.72 | 106.30 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 3.696 | 3.018 | ٧,٣٩٣ | | | 3.549 | 2.898 | ٧,٠٩٩ | | |
| **Artificial infection** | | | | | | | | | | |
| 1 | 72.00 | 84.67 | 91.01 | 99.05 | 86.68 | 73.60 | 85.33 | 92.17 | 103.8 | 88.73 |
| 2 | 72.00 | 77.33 | 85.80 | 96.19 | 82.83 | 73.60 | 82.00 | 94.49 | 103.8 | 88.48 |
| 3 | 72.00 | 80.00 | 87.54 | 100.0 | 84.88 | 73.60 | 84.67 | 96.81 | 104.3 | 89.84 |
| 4 | 72.00 | 82.67 | 88.69 | 99.52 | 85.72 | 73.60 | 87.33 | 92.75 | 105.2 | 89.73 |
| 5 | 72.00 | 80.00 | 90.43 | 104.8 | 86.80 | 73.60 | 89.33 | 106.7 | 120.5 | 97.52 |
| 6 | 72.00 | 77.33 | 85.80 | 96.19 | 82.83 | 73.60 | 80.67 | 89.27 | 103.3 | 86.72 |
| Means(A) | 72.00 | 80.33 | 88.21 | 99.29 | | 73.60 | 84.89 | 95.36 | 106.8 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 3.916 | 3.197 | 7.832 | | | 3.762 | 3.072 | 7.524 | | |
| Key treatments | | | | | | | | | | |
| 1= Clove oil | | | | 3= Lavender oil | | 5= Eugenol+geraniol+thymol formoula | | | | |
| 2= Thyme oil | | | | 4= Clove+ thyme+ lavender | | 6= control | | | | |

### 3.8. Fruit Lightness (L*)

Results in Table (10) show that fruit lightness (L*) was gradually decreased towards at the end of the storage periods.

At the end of storage period, fruits treated with lavender oil had the highest values of L* while untreated fruit recorded the lowest values in both seasons at nature infection treatments with significant deference between all treatments.

Concerning to artificial infection no significant deference between all treatments in the first season. and slight significant deference between all treatments in the second one.

As for interaction after three weeks of storage, the highest values of lightness (70.87&70.39) were obtained by fruit treated with thyme oil and clove oil in the first and second seasons, respectively. while the control treatment recorded the lowest values in nature infection.

Concerning to artificial infection, Eugenol+geraniol+thymol formoula and lavender oil exhibited highest values of L*, in the two season respectively. On the other hand, the control treatment recorded the lowest values.

**Table (10). Effect of some postharvest treatments on fruit lightness of guava fruits either natural or infected with *Pestalotia neglecta* cold storage at 8 ± 1°C and RH 90-95% during 2023 and 2024 seasons**

| **Natural infection** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **first season** | | | | | **second season** | | | | |
| | 0 | 1 | 2 | 3 | Means(B) | 0 | 1 | 2 | 3 | MEANS(B) |
| 1 | 76.97 | 74.56 | 73.10 | 70.24 | 73.72 | 76.35 | 74.47 | 72.62 | 70.39 | 73.46 |
| 2 | 76.97 | 73.57 | 71.47 | 70.87 | 73.22 | 76.35 | 72.71 | 70.07 | 66.63 | 71.44 |
| 3 | 76.97 | 76.61 | 75.90 | 70.18 | 74.92 | 76.35 | 76.11 | 74.68 | 69.53 | 74.17 |
| 4 | 76.97 | 75.15 | 73.09 | 66.47 | 72.92 | 76.35 | 73.82 | 72.53 | 67.63 | 72.58 |
| 5 | 76.97 | 74.69 | 74.48 | 69.71 | 73.96 | 76.35 | 76.21 | 75.95 | 69.31 | 74.46 |
| 6 | 76.97 | 71.13 | 68.84 | 62.61 | 69.89 | 76.35 | 73.35 | 70.79 | 59.90 | 70.10 |
| Means(A) | 76.97 | 74.28 | 72.81 | 68.35 | | 76.35 | 74.45 | 72.78 | 67.23 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 1.541 | 1.258 | 3.082 | | | 1.334 | 1.089 | 2.667 | | |
| **Artificial infection** | | | | | | | | | | |
| 1 | 76.97 | 72.72 | 71.06 | 68.32 | 72.25 | 76.35 | 74.51 | 72.04 | 70.39 | 73.32 |
| 2 | 76.97 | 72.04 | 69.78 | 68.31 | 71.78 | 76.35 | 73.46 | 71.09 | 69.45 | 72.59 |
| 3 | 76.97 | 71.98 | 71.20 | 68.54 | 72.27 | 76.35 | 73.72 | 71.96 | 70.70 | 73.18 |
| 4 | 76.97 | 72.07 | 70.53 | 68.40 | 71.99 | 76.35 | 72.91 | 71.77 | 68.02 | 72.26 |
| 5 | 76.97 | 73.80 | 71.06 | 69.19 | 72.75 | 76.35 | 73.19 | 70.96 | 69.52 | 72.50 |
| 6 | 76.97 | 73.31 | 71.03 | 67.69 | 72.17 | 76.35 | 73.09 | 71.45 | 64.82 | 71.43 |
| Means(A) | 76.97 | 72.65 | 70.78 | 68.41 | | 76.35 | 73.48 | 71.55 | 68.82 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | N.S. | 0.9659 | 2.37 | | | 1.30 | 1.06 | 2.59 | | |
| Key treatments | | | | | | | | | | |
| 1= Clove oil | | | | 3= Lavender oil | | | 5= Eugenol+geraniol+thymol formoula | | | |
| 2= Thyme oil | | | | 4= Clove+ thyme+ lavender | | | 6= control | | | |

### 3.9. Fruit color (represented as Hue angle - hº value)

Results in Table (11) show that fruit color represented as Hue angle - hº value was gradually decreased (increase yellow color density) towards at the end of the storage periods.

Slight significant deference between all treatments, fruit treated with thyme oil recorded the highest values (lowest yellow color density) and control exhibited the lowest values (highest yellow color density) in both seasons in natural and artificial infections.

As for interaction after three weeks of storage, the highest values were obtained by fruit treated with Clove+ thyme+ lavender oils and Eugenol+geraniol+thymol formoula in the first and second seasons, respectively. While the control and thyme oil treatments recorded the lowest values in the first and second season, respectively in the nature infection.

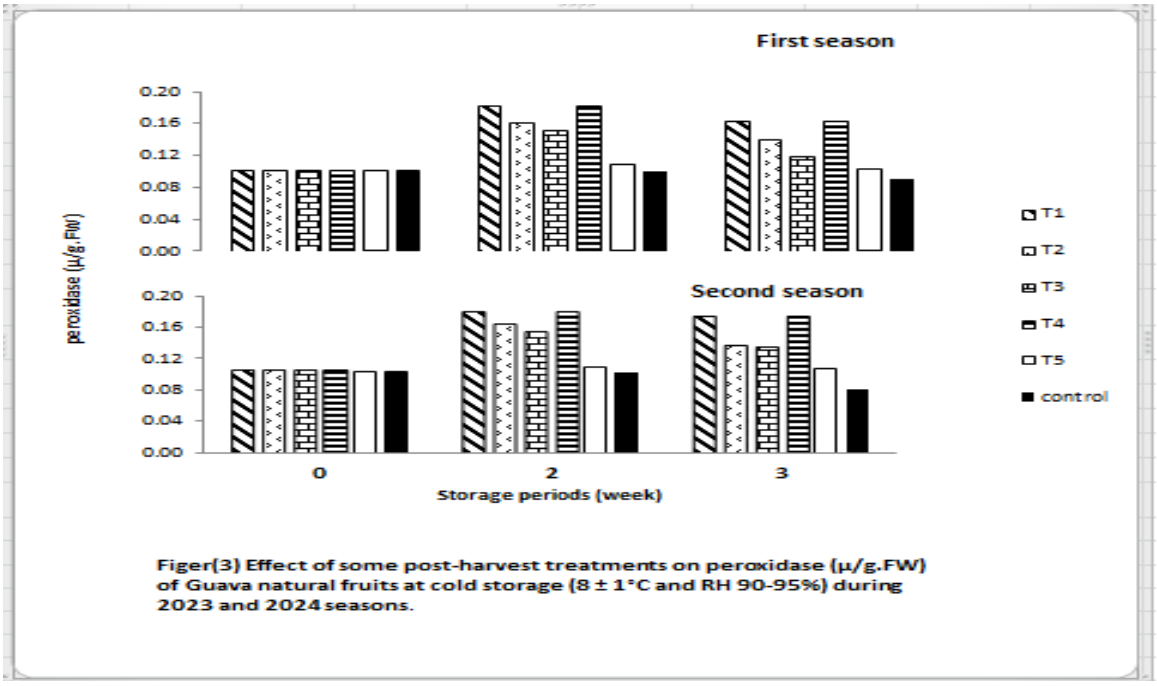
Concerning to artificial infection, Clove+ thyme+ lavender oils treatment exhibited highest values of Hue angle - hº, in the two seasons. On the other hand, the control treatment recorded the lowest values.

**Table (11). Effect of some postharvest treatments on fruit color (represented as Hue angle - hº value) guava fruits either natural or infected with *Pestalotia neglecta* cold storage at 8 ± 1°C and RH 90-95% during 2023 and 2024 seasons**

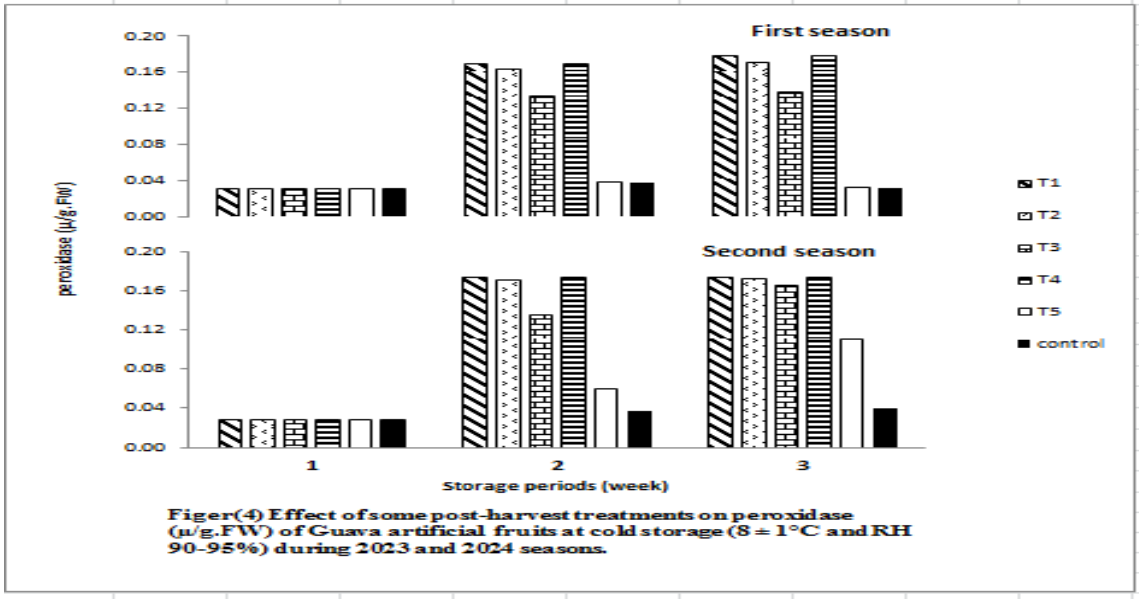
| **Natural infection** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **first season** | | | | | **second season** | | | | |
| | 0 | 1 | 2 | 3 | Means(B) | 0 | 1 | 2 | 3 | Means(B) |
| 1 | 98.69 | 96.07 | 93.93 | 93.09 | 95.44 | 99.03 | 96.88 | 96.32 | 94.30 | 96.63 |
| 2 | 98.69 | 97.50 | 95.58 | 94.36 | 96.53 | 99.03 | 98.08 | 97.34 | 92.68 | 96.78 |
| 3 | 98.69 | 95.91 | 95.00 | 93.47 | 95.77 | 99.03 | 96.01 | 95.26 | 93.82 | 96.03 |
| 4 | 98.69 | 96.84 | 95.55 | 94.75 | 96.46 | 99.03 | 96.84 | 95.77 | 93.36 | 96.25 |
| 5 | 98.69 | 96.59 | 95.56 | 93.31 | 96.04 | 99.03 | 97.16 | 96.03 | 95.16 | 96.85 |
| 6 | 98.69 | 95.25 | 94.30 | 91.95 | 95.05 | 99.03 | 96.11 | 94.15 | 92.76 | 95.51 |
| Means(A) | 98.69 | 96.36 | 94.99 | 93.49 | | 99.03 | 96.85 | 95.81 | 93.68 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 0.891 | 0.727 | 1.781 | | | 0.480 | 0.392 | 0.960 | | |
| **Artificial infection** | | | | | | | | | | |
| 1 | 98.69 | 97.60 | 94.24 | 93.20 | 95.93 | 99.03 | 96.85 | 95.39 | 93.67 | 96.23 |
| 2 | 98.69 | 96.62 | 95.30 | 93.61 | 96.06 | 99.03 | 97.23 | 96.49 | 94.62 | 96.84 |
| 3 | 98.69 | 96.81 | 95.39 | 93.12 | 96.00 | 99.03 | 97.82 | 95.97 | 93.47 | 96.57 |
| 4 | 98.69 | 96.48 | 94.81 | 94.24 | 96.06 | 99.03 | 97.14 | 95.92 | 94.63 | 96.68 |
| 5 | 98.69 | 96.55 | 93.88 | 90.93 | 95.01 | 99.03 | 96.35 | 95.74 | 92.92 | 96.01 |
| 6 | 98.69 | 96.37 | 94.95 | 88.57 | 94.65 | 99.03 | 95.74 | 94.64 | 92.45 | 95.47 |
| Means(A) | 98.69 | 96.74 | 94.76 | 92.28 | | 99.03 | 96.86 | 95.69 | 93.63 | |
| LSD | (B) | (A) | A*B | | | (B) | (A) | A*B | | |
| | 1.168 | 0.9537 | 2.336 | | | 0.6385 | 0.5213 | 1.277 | | |
| Key treatments | | | | | | | | | | |
| 1= Clove oil | | | | 3= Lavender oil | | | 5= Eugenol+geraniol+thymol formoula | | | |
| 2= Thyme oil | | | | 4= Clove+ thyme+ lavender | | | 6= control | | | |

### 3.10. Peroxidase (POD) activity

As shown in Fig. (3& 4), the activity of peroxidase in guava fruits increased gradually throughout the storage periods. There was a significant difference between all studied treatments in its effect on activity of peroxidase during the two seasons of study as they increased the rate of peroxidase activity during storage either fruits were artificially infected or non-infected with *Pestalotia neglecta*. Fruits coated by clove oil or mixed three oils treatment recorded the highest values of POD activity (0.182 and 0.173 U/g FW) in the first and the second season respectively, while the control fruits treatment had the lowest values (0.09 and 0.08 U/g FW) in the both seasons, respectively. On the other side, inartificially infected, the highest value of POD activity was recorded in fruits coated with clove oil and (clove oil+ thyme oil+ lavender oil) treatment (0.178 and 0.173 U/g FW) in the two seasons, respectively while the control treatment recorded the lowest value of POD activity (0.032 and 0.040 U/g FW) in 2023 and 2024 seasons, respectively.



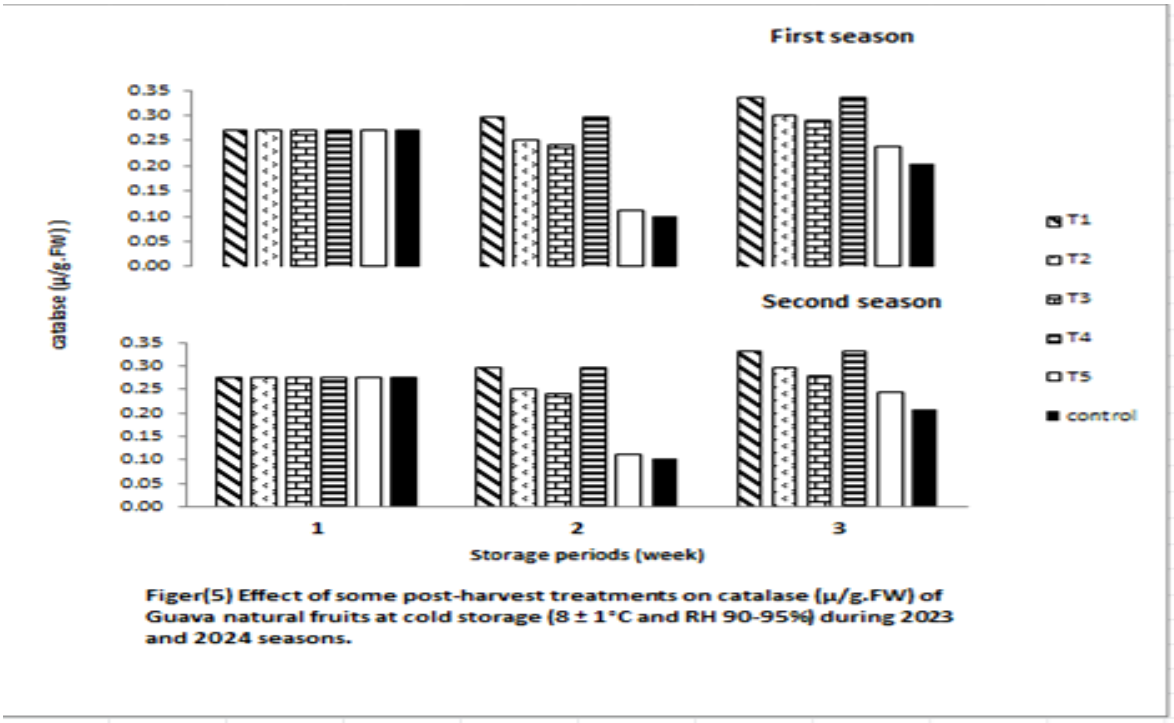

Figer(3) Effect of some post-harvest treatments on peroxidase (µ/g.FW) of Guava natural fruits at cold storage (8 ± 1°C and RH 90-95%) during 2023 and 2024 seasons.



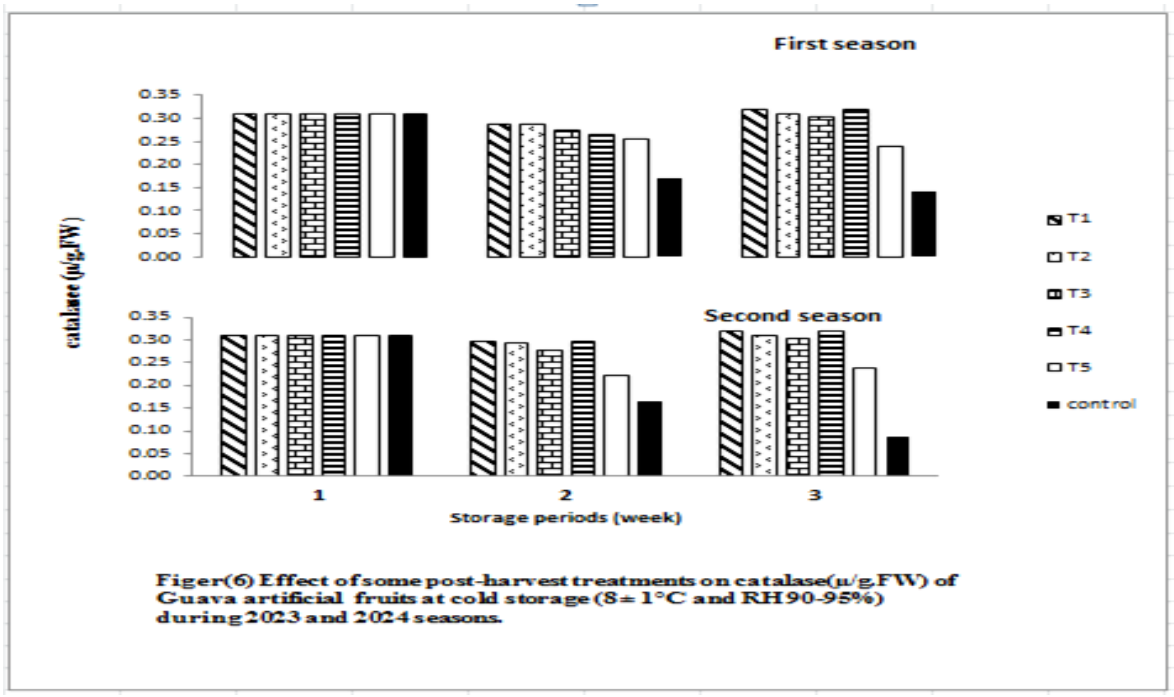

Figer(4) Effect of some post-harvest treatments on peroxidase (µ/g.FW) of Guava artificial fruits at cold storage (8 ± 1°C and RH 90-95%) during 2023 and 2024 seasons.

### 3.11. Catalase Activity

Data in Fig. (5&6) indicated that, catalase activity gradually decreased with the advanced of the storage period in the two seasons with differences in the effect on catalase activity in the most cases. After 3weeks of storage period, the highest values were recorded in natural infection fruits treated by clove oil and mixed three oils in the both seasons. On the contrary, all treatment in the artificial infection had no effect on catalase activity in two seasons. After 3 weeks of storage period all treatments increase while Eugenol+geraniol+thymol formula and control decreased in first and second seasons.



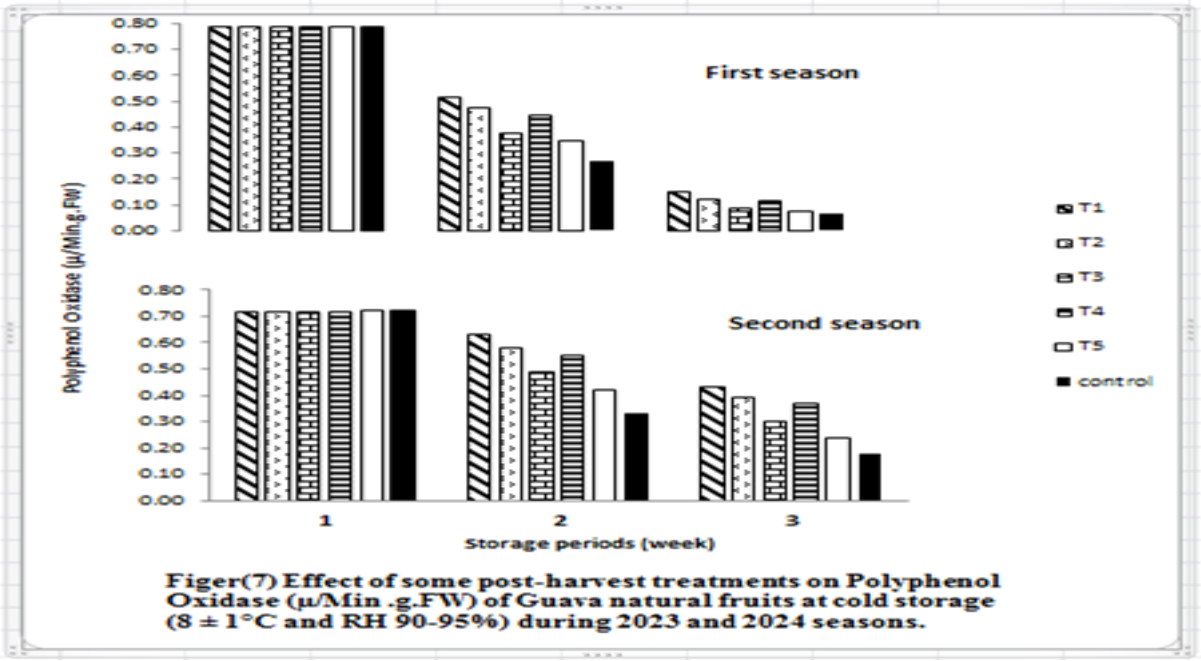

Figer(5) Effect of some post-harvest treatments on catalase (µ/g.FW) of Guava natural fruits at cold storage (8 ± 1°C and RH 90-95%) during 2023 and 2024 seasons.



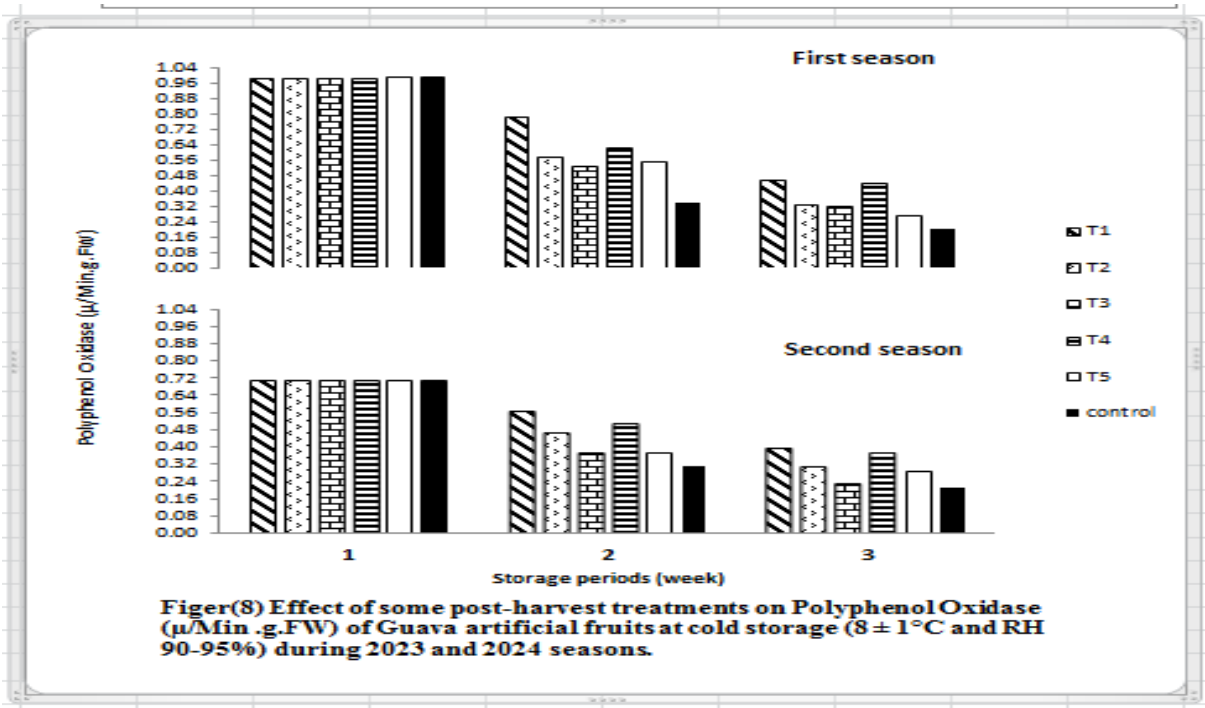

Figer(6) Effect of some post-harvest treatments on catalase(µ/g.FW) of Guava artificial fruits at cold storage (8± 1°C and RH 90-95%) during 2023 and 2024 seasons.

### 3.12. Polyphenol oxidase activity (PPO)

Polyphenol oxidase activity (U/min.g FW) of guava fruits were decreased gradually until 3 weeks of storage in all treatments in both natural and artificial infections in both seasons (Fig.7&8). In both natural and artificial infections, fruits treated by mixed three oil clove +lavender+ thyme oils recorded the highest PPO in the two seasons while the untreated fruit recorded the lowest PPO.




**Figer(7) Effect of some post-harvest treatments on Polyphenol Oxidase (µ/Min .g.FW) of Guava natural fruits at cold storage (8 ± 1°C and RH 90-95%) during 2023 and 2024 seasons.**




**Figer(8) Effect of some post-harvest treatments on Polyphenol Oxidase (µ/Min .g.FW) of Guava artificial fruits at cold storage (8 ± 1°C and RH 90-95%) during 2023 and 2024 seasons.**

### 4. Discussions

This study research investigated whether coating 'Etmani' guava fruits by clove, lavender, thyme oils, mixed clove +thyme +lavender oils and Eugenol+ geraniol+ thymol formula (active ingredient three oils) mixed three oils or Eugenol+ geraniol+ thymol formula enhance the bio-control efficacy of

against *Pestalotia neglecta* both *in vitro* and *in vivo*. In vitro, the reduction in liner growth of *Pestalotia neglecta* was positive correlated to the type and concentrations of oils used in study. The Eugenol+ geraniol+ thymol formula (active ingredient three oils) had significantly high efficacy against *Pestalotia neglecta*. This finding could be explained by **Nabakishor Nongmaithem (2014**) who indicated that, essential oil possessed antifungal activity in controlling the growth of postharvest fungal pathogen of guava under laboratory condition and can be exploited as an ideal treatment for postharvest fungal disease management of guava. **Marc-Chillet (2020)** found that treatment with thymol limits the necrosis development resulted from the pathogen and attributed to that thymol treatment can stimulate some polyphenols biosynthesis particularly gallic acid and resorcinol synthesis, involved in fruit resistance to postharvest disease. Eugenol has antimicrobial activity against a variety of food-borne **(Rhayour *et al*., 2003).** Eugenol showed morphological changes, including cytoplasmic coagulation and vesiculation. Shriveled hyphae were commonly observed in eugenol-treated mycelia, compared with the normal mycelia (**Wang *et al*., 2010). Tang *et al*. (2018)** found that, geraniol displayed inhibitory effectiveness against *A. flavus* predominantly by inducing the intracellular ROS accumulation and showed toxicity against *A. ochraceus* principally by changing cell membrane permeability. Presentedthe highest antioxidant activity and antimicrobial activity on several microorganisms. The disease incidence of guava fruits rot decaying the fruits by reduces the growth, number, viability of *Pestalotia neglecta* spores and the diameter of fruits rot lesions, as well as motivating the host-defense responses and suppressing the malondialdehyde (MDA) accumulation with enhancing the activities and gene expressions of defense related enzymes. Treated guava fruits with clove +thyme +lavender oils and Eugenol+geraniol+thymol formula completely inhibited fruits rot of guava incidence compared to untreated fruits in natural and artificial infection could be due to the coating.

The clove essential oil used in the present study consisted mainly of eugenol and eugenyl acetate. These phenolic compounds are potent antioxidants known to possess antimicrobial, local antiseptic, **Anesthetic Jadha *et al*. (2004).**

The quality of fruit is determined by the combination of different physical, chemical, and physiological characteristics, a high quality fruits are firm, colored and without any defects.

In this study, the loss of water in control fruit increased gradually during storage (Table 5). Weight loss in coated fruit remained at a significantly low level compared to the control fruit at all-time points examined.

The coating with clove oil recorded the lowest value of weight loss percentage (6.73& 6.55%) in the two seasons, clove oil at 1%, delay changes related to ripening, such as softening, color changes, respiration rate, acidity changes and decrease in weight.

This may be attributed to that coating fruits by clove oil provides a partial barrier to the movement of moisture on the surface of fruits thereby minimizing moisture loss during storage. It has been reported similar results by **Shaaban *et al*. (2022**); **Shaaban** and **Hussein (2017).**

After 3 weeks of storage. Similar responses were reported by **El-Bana** and **Ennab (2023)** on winter guava fruits. **Wijewardana *et al*. (2014)** found that TSS on guava fruits has increased with the time, which is due to the hydrolysis of starch to simple (soluble) sugars higher during fruit ripening. Rate of increase in TSS under coating treatment may be due to delaying of ripening. The coating treatments had higher effect in maintaining of TSS% probably due to edible coating film that may have formed on the surface of the fruits and barrier to moisture loss, thus delaying dehydration and improve quality. Excessive increase in TSS observed in control fruits indicates quality deterioration, may be attributed to the utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits or due to breakdown of complex polymer into simple sugars by hydrolytic enzymes which might be further metabolized during respiration and level decreased during subsequent storage.

After 3 weeks of storage, fruits coated with clove oil and lavender oil showed higher firmness, which may be due to the effect of this film in delaying the ripening changes of guava fruits during cold storage. Fruit coating film form a partial barrier for oxygen and carbon dioxide (low oxygen retention and high concentrations of carbon dioxide), this reduces the activities of pectin-esterase and polygalactonase enzymes that cause the decomposition of the insoluble proto-pectins in.

**Yaman and Bayoindirli (2002)** noticed that, the retention of firmness which occurred during storage could be explained by retarded degradation of insoluble protopectins to the more soluble pectic acid and pectin. During fruit ripening depolymerization or shortening of chain length of pectin substances occurs with an increase in pectinesterase and polygalactronase activities.

At the end of storage period, fruits treated with lavender oil had the highest values of L* while untreated fruit recorded the lowest values in both seasons at nature infection treatments with significant deference between all treatments.

As for interaction after three weeks of storage, the highest values (70.87&70.39) were obtained by fruit treated with thyme oil and clove oil in the first and second seasons, respectively. While the control treatment recorded the lowest values in nature infection.

Concerning to artificial infection, Eugenol+geraniol+thymol formoula and lavender oil exhibited highest values of L*, in the two season respectively. On the other hand, the control treatment recorded the lowest values.

This result agrees with **Vila *et a*l. (2007)** noted that the biofilm at the concentration of clove oil and lavender oil was more effective in delaying the ripening of guavas. Also, **Wijewardana *et al.*, (2014**) on guava fruits. The total soluble solid (TSS) increased slightly during storage probably due to the water loss, activity of hydrolytic enzymes, or the decrease in respiration rate and conversion of sugars in $CO_2$ and $H_2O$ during the storage period and the hydrolysis of fruit starch is completed (**Shaaban *et al.*, 2022**). Titratable acidity (TA) estimates the organic acid content of fruit which generally decreases during postharvest storage due to the use of organic acids as substrates for respiratory metabolism **Shaaban and Hussein, 2017).**

Oxidative damage and resulted RO accumulation throughout the plants‟ cell are common cross talk between different unfavorable abiotic conditions such as chilling stress. In this regard, plants have efficient enzymatic and non-enzymatic strategies for ROS scavenging (**Babalar *et al.*, 2017**) POD and CAT are two of the most important antioxidant enzymes in the plant cell, acts as a component of the first line defense system against ROS. Accordingly, activities of these enzymes were evaluated at the present work as important antioxidant enzymes. The results showed that POD and CAT activity in guava juice increased in the clove oil and mixed three oils treated and control fruit, but in treated fruit was significantly higher than the control and reached its highest value at the end of the storage period during the both seasons of study. The toxicity of ROS is due to their reactions with numerous cell components causing a cascade of oxidative reactions and consequent inactivation of enzymes including SOD, CAT and POD (**Scandalios, 1993**) which is thought to be a major mechanism of resistance to senescence (**Imahori *et al***., **2008** and **Sevillano *et al***., **2009)**. Our results suggest that the activities of these enzymes, to some extent, were induced by treatments. These results are in accordance with previous studies, which reported that coating treatments may be an effective method to induce the activities of CAT and POD to enhance the oxidation resistance of strawberries fruit (**Badawy *et al*., 2017**). It worth noting that, the resistance to fruits rot of "Etmani" guava fruits caused by *Pestalotia neglecta* in the natural and artificial infections exhibited in the present study was accompanied by a prominent activation of the three enzymes activities mentioned above in the coated fruit. This is consistent with previous reports regarding the gene expressions of defense-related enzymes in fruits subjected to fungal infections such as 'Valencia' orange fruit **(Waewthongrak *et al.*, 2014)** and 'Shogun' mandarins coated with Aloe Vera gel **(Banani *et al*., 2018).**

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