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ORIGINAL PAPER

Efficacy of Some Chemicals on Controlling Pear Fruit Rot and Fruit Quality under Storage Condition

Hassan, M.S.S.; Shehata, A.S.F.* and Abdel-Wahed, G.A.

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ABSTRACT

Fruit rot disease caused by *Lasiodiplodia theobromae* Pat. is one of the most widespread fungal diseases that affects pear worldwide. This work was to verify the efficacy of salicylic acid (SA), lemongrass oil, thyme oil, Imazalil 50% EC and the biofungicide Biocontrol T34 12% WP (*Trichoderma asperellum* strain T34) against pear fruit rot and their effect on fruit quality parameters. Imazalil and Biocontrol T34 (*T. asperellum* strain T34) were the best effective treatments, where they completely inhibited the growth of the tested fungus followed by SA. Regarding disease incidence using pre-harvest spray, the highest efficacy was obtained by Imazalil for artificial and natural infection in both 2021 and 2022seasons. All treatments kept fruit quality parameters and had significant effect regarding fruit firmness, total soluble solids (TSS), titratable acidity (TA), total phenolic content (TPC), polyphenoloxidase activity (PPO) and peroxidase activity (PO) for artificial and natural infection in both seasons. The results showed that there was a decrease in pear fruits firmness with increasing the storage period. The decrease in firmness was more noticeable 60 days after storage. The relative high value of pear fruits firmness was obtained due to treatment with each of lemongrass oil and thyme oil with artificial and natural infection. The highest value of total soluble solids % was noted after 60 days storage. In most cases, Imazalil gave the highest TSS values. Pre-harvest treatment with the tested chemicals caused increment TSS values compared with post-harvest treatment. Imazalil gave the highest titratable acidity values. Fruits treated with SA and thyme oil showed the highest values of total phenolic contents in fruits, naturally and/or artificially infected with *L. theobromae*, respectively in both seasons. PPO and PO activity in pear fruits was significantly increased until 30 days of cold storage at 5°C and 90 % RH during 2021 and 2022 seasons then decreased in all tested fruits treated or untreated of naturally and artificially infected, respectively in both seasons. PPO and PO activity of pear fruits was significantly increased due to post-harvest treatment than pre-harvest spray. Fruits treated by SA, Imazalil and Biocontrol T34 recorded the highest values of both enzymes in the two seasons. Meanwhile, the lowest PPO activity was recorded with control (untreated fruits) in both pre-harvest treatment and post-harvest treatment in both seasons. Control fruits showed the lowest firmness values, TSS, total phenolic contents, PPO, and PO activity in all cases.

Keywords: Pear, *Pyrus communis*, fruit rot, essential oils, salicylic acid, biocides, *Lasiodiplodia theobromae*.

***Correspondence: Shehata, A.S.F.**
E-mail: arpp2022@arc.sci.eg
Mabrouk S.S. Hassan
https://orcid.org/0000-0002-3477-339X
Abou-Ghanima, S.F. Shehata
https://orcid.org/0000-0003-1698-7375
Gomaa A. Abdel-Wahed
https://orcid.org/0000-0001-5539-8827

Plant Pathology Research Institute, Agricultural Research Center, 12619, Giza, Egypt.

INTRODUCTION

Pear (*Pyrus communis* L.) is considered one of the most important fruits in Egypt. According to Anon., (2020), the total cultivars area is about 13365 Feddans during 2019 which produced about 68407 metric tons. Meheriuk (1989) stored pear fruit cv. Le conte at 5˚C for 60 days and recorded noticeable weight loss. Stoll (1996) found that pear fruits were of good quality after 3months under 5˚C storage. During handling, transportation, and storage, pear fruits are exposed to the fruit rots, which are considered the most important and economically fungal diseases. They added that *Penicillium expansum* and *Lasiodiplodia theobromae* are the main causal agents for pear fruit rot (Yu *et al*., 2012). During storage conditions calyx-end rot caused by *Botrytis cinerea* which infects flowers of pear fruit during bloom (Anon., 2015). *Colletotrichum gloesporioides* is primarily the causal of an orchard disease. The pathogens can infect pear fruits in the field and can attack fruits after maturing or in starting to ripen (Jones and Aldwinckle, 1990). *Botryosphaeria obtusa* causes black rot of pears in South Africa (Snowdon, 1990). Alternaria rot on pear fruits occurs after latent infection: fruit surface can be asymptomatic within sixty days, but the hyphae are shown in pear fruits after ninety days of storage (Li *et al*., 2007). In Egypt, *Lasiodiplodia theobromae* is one of the most widespread fungal diseases that affects pear after collection, during handling or in storage. Under room condition, Le conte pear fruits were possible storage about 3 weeks. The period could be more than 3 months under cold storage (Kilany, 1982). Also, Mehaisen, (1992) found that cold storage at 5˚C prolonged storage period of Le conte pear fruit up to 130 day provided effective control of post-harvest diseases and enhanced keeping quality. Montasser *et al*. (1993) reported that dipping apple fruits in calcium chloride ($CaCl_2$) as post-harvest treatment was effective in reducing fruit rot and respiration and increased firmness and also the fruits contained more titratable acidity and prolong storage life than control. Post-harvest treatment with yeasts can control pear fruit rot and decay during storage and the quality was improved (Sugar, 1992). Hassan *et al.*, (2021) found that avocado fruits treated with nano copper oxide and Imazalil 50% EC (Imazalil fungicide) and packed in carton boxes recorded a good control fore fruit rot. However, using fungicides for a long time may cause pathogen resistance (Tian, 2006). Additionally, fungicides residues made researchers try to find safe treatments for controlling fruit diseases. He *et al.* (2017) suggested that the effect of salicylic acid SA was attributed to its direct antimicrobial activity and the elicitation of resistant responses, as well maintaining the firmness in mango fruit. The effect of essential oils on postharvest diseases by spraying or dipping fruits have been reported for several fruit crops. Combrinck *et al.* (2011) tested the efficacy of 18 essential oils against widespread postharvest fungal pathogens which were isolated from pear, citrus and avocado fruits caused by *L. theobromae, C. gloeosporioides, P. digitatum* and *Alternaria citri*, they also reported that fungal growth was completely reduced on all tested replicates of the tested essential oils. Additionally, in mango Abd-Alla and Haggag, (2013) evaluated the efficacy of several essential oils on reducing pre and postharvest losses caused by *C. gloeosporioides*. Lemongrass oil has antifungal activity against this fungus. Grosso *et al.* (2010) found that thyme has antioxidants, antibacterial and antiviral effects.

This research was designed to verify the effect of pre- and post-harvest application of salicylic acid, lemongrass oil, thyme oil, Imazalil 50% EC fungicide and the biocontrol agent Biocontrol T34 12% WP biocide (*Trichoderma asperellum* strain T34) against fruit rot on pear caused by *L. theobromae* after harvest and 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022. Besides, estimating their effect on pear fruit quality *i.e.,* fruit firmness (Ib/inch$^{2-1}$), total soluble solids (TSS), titratable acidity (TA), Total phenolic content (TPC), polyphenoloxidase activity (PPO) and peroxidase activity (PO) were also evaluated.

MATERIALS AND METHODS

The pathogen and pathogenicity test:

Pear fruits showing fruit rot symptoms were collected from local markets in Qaliobia and Giza governorates. The infected tissues surface-sterilized in 70% ethanol for 20 sec, 1% NaOCl for 1 min, then planted on PDA. Mycelium growing out from the tissue pieces were sub-cultured onto a new PDA plate, incubated at 25°C for 5 days. The purified isolates were identified depending on their morphological and cultural characters utilizing the descriptions of Punithalingam (1976) and Barnett and Hunter, (1986). Fungal cultures were identified in Plant Pathology Research Institute, ARC, Giza, Egypt. Using Koch's postulates, the pathogenicity test of the fungus was carried out on 'Le Conte' cv. pear fruits.

Conidial suspension:

To prepare inoculum, *Lasiodiplodia theobromae* was grown on PDA in Petri plates at 25°C. Conidia were collected from 7-10 days-old cultures by adding 10 mL of sterile distilled water into (∅9cm) plate and scooping from pycnidia with a heat sterilized spatula to dislodge the conidia. The conidial suspension was filtered through two layers of sterile gauze. The suspension was diluted with sterile distilled water containing 0.5% Tween 80 (v/v) to obtain a final concentration of $1{\times}10^6$ conidia/mL (Hassan *et. al*., 2021).

Tested Compounds:

Salicylic acid (SA) 1mL/liter, lemongrass oil (70% citral or, citrol) 3mL/liter, thyme oil (90% thymol) 3mL/liter were obtained from Cairo Company for Oils and Aromatic Extractions (CCOAE), Egypt, Imazalil 50% EC (fungicide) [chloramizole] 1mL/liter and Biocontrol T34 12% WP (biofungicide) [*Trichoderma asperellum* strain T34] 2g/ liter. The Tween 80 was used for solubilizing the oil. (3 mL oil were added to 1-liter sterilized water and 1 mL Tween 80) (Ismail, 2016).

***In vitro* assessment of different tested chemicals against the causal of pear fruits rot:**

The tested chemicals *i.e*., SA, lemongrass oil, thyme oil, Imazalil and Biocontrol T34 were added to flasks, each containing 250 mL PDA with the desired concentration. Control was PDA flask free of tested chemicals. The supplemented media were poured into sterilized 9cm Petri plates. Mycelial discs (5mm) of *L. theobromae* 7 days old cultures were placed at the center of the prepared Petri plates, then incubated at 25°C. Five plates were used for each treatment. The average of linear growth diameter of colonies was measured when fungal mycelium covered any plate in control treatment and inhibition % was calculated (Guo *et al*., 2006):

% Inhibition = [D-T/D] ×100

Where:

D: control; **T**: treatment.

Effect of pre-harvest spray with the tested chemicals on the development of pear fruit rot under storage conditions:

Field experiments*:*

Pre-harvest experiments were achieved on pear trees cv. Le Conte 10-year- old grown in an experimental farm at El-Qanater El-Khairia, Horticultural Research Station, Agricultural Research Centre, Qaliobia governorate during 2021 and 2022 seasons. Pear trees were designed as three replicates for each treatment (3 trees per replicate). Three sprays of the tested chemicals were applied at bloom stage of pear trees and repeated every 15 days as time interval between sprays. Also, before harvest, treatments were sprayed twice, 14 and 7 days. Salicylic acid (SA), lemongrass oil, thyme oil, Imazalil and biocontrol agent Biocontrol T34 12% WP (*T. asperellum* strain T34) were sprayed at the tested concentrations as mentioned before. Control pear trees were sprayed with water. Pear fruits were harvested at physiological maturity stage, then transported to the laboratory on the same day. Pear fruits were divided into two groups:

(**1**) Artificially infected with *L. theobromae*.

(**2**) Naturally infected.

Pathogenicity test:

Concerning the first group, pear fruits were surface sterilized, allowed to dry at room temperature and wounded by making (2 injuries 2 mm depth 1 mm width) using a nail on two opposite sides of each fruit, then artificially inoculated with the prepared spore suspension of *L. theobromae* (1×10^6 conidia/mL) using an atomizer. Treated fruits were placed on cardboard box and covered with polyethylene bags. 5 replicates each consisted of 10 pear fruits were prepared. All fruits were stored in refrigerator at 5°C with 90% relative humidity for 60 days. Concerning the second group, fruits were exposed to natural infection, pear fruits which were treated using the same tested chemicals in the field were harvested and stored at the same temperature and humidity without any artificial inoculation. At the end of cold storage, disease incidence of pear fruit rot (%), fruit firmness (Ib/inch$^{2-1}$), total soluble solids (TSS), titratable acidity (TA), total phenolic content (TPC), polyphenoloxidase (PPO) and peroxidase (PO) were determined.

Effect of post-harvest treatment with the tested chemicals on the development of pear fruit rot under storage condition.

During 2021 and 2022 seasons, healthy pear fruits cv. Le Conte were collected at mature stage from El-Qanater El-Khayria Horticultural Research Station. Pear fruits were selected for uniform size, color and free from visible wounds, defects rots and decay. The fruits were thoroughly washed under tap water, surface sterilized with 1% sodium hypochlorite solution for 2 min, followed by washing three times in sterilized water. The aforementioned chemicals with the same concentrations were evaluated for controlling pear fruit rot. The fruits were divided into 2 groups: the first group, pear fruits were prepared and artificially inoculated with the tested fungus as previously mentioned. While the second group was exposed to natural infection. 5 replicates were used for each treatment (each replicate consisted of 10 pear fruits). All fruits were cold-stored and assayed as mentioned before.

Assessments:

Disease incidence:

Disease incidence of pear decay was calculated according to Hassan *et al*. (2021).

Fruit firmness (Ib/inch$^{2-1}$):

According to Abdel-Rahman *et al*. (2021) pear fruit firmness (FF) was tested using a hand pressure tester as Ib/inch$^{2-1}$.

Evaluation of biochemical compounds and enzymes activity:

Total soluble solids (TSS):

Percentage of TSS was determined in pear fruit juice using hand Refractometer according to Mehaisen (1999).

Titratable acidity (TA):

Titratable acidity (TA) was evaluated in pear fruit juice by titration against calibrated 0.1 N NaOH using the indicator phenolphthalein. Titratable acidity evaluated as % malic acid according to Abdel-Rahman *et al*. (2021).

Total phenolic content (TPC):

Total phenolic content (TPC) in pear fruit juice was evaluated according to Meighani *et al*. (2014). TPC was tested as mg gallic acid equivalent in 100 mL of pear fruit juice (mg gallic acid /100 mL juice).

Polyphenoloxidase activity (PPO):

Using Spectrophotometer polyphenol oxidase activity was measured according to Matta and

Dimond (1963), 1mL solution of phosphate buffer (pH=7), 1mL catechol, 1mL crude enzyme,1mL pear crude extracts and the tube was completed with distilled water to 5mL to prepare the reaction mixture.

Peroxidase activity (PO):

Using Spectrophotometer, Peroxidase was measured according to Allam and Hollis (1972). 0.5 mL solution of phosphate buffer (pH=7), 0.3 mL pyrogallol, 1 mL H2O2, 0.3mL crude enzyme,1mL pear crude extracts and the tube was completed with distilled water to 5mL to prepare the reaction mixture.

Enzymes activity was expressed as the change in the absorbance of the mixtures every 0.5 min. for 5 minutes at 425 nm to Peroxidase and at 495 nm to Polyphenoloxidase, respectively.

Statistical analysis:

All obtained data during both 2021 and 2022 seasons were subjected to analysis of variance method according to Snedecor and Cochran (1990). Duncan's Multiple Range tested (Duncan, 1955) was used to compare differences among means.

RESULTS

The pathogen and pathogenicity test:

The isolated fungus from naturally infected pear fruits collected from local markets in Qaliobia and Giza governorates was purified and identified using its cultural and morphological characteristics as *Lasiodiplodia theobromae* (Pat). The pathogenicity test showed that *L. theobromae* was able to induce fruit rot on pear fruits (Fig.1). Pathogenicity test was carried out and confirmed on cv. 'Le Conte' pear fruits.

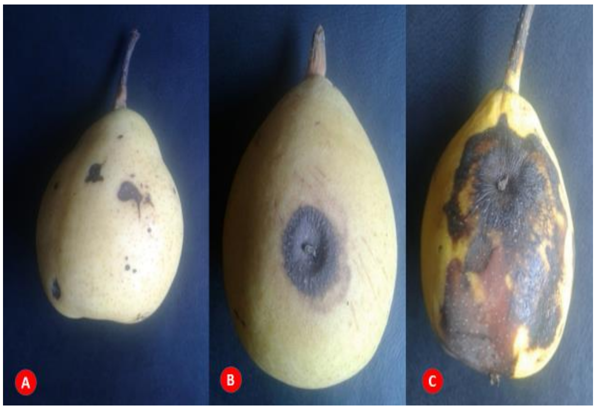

Fig. (1): Pear fruit cv. Le Conte showing external symptoms of natural infection by fruit rot (A), Pear fruit cv. Le Conte after 30 days (B) and after 60 days (C) of storage, under artificial inoculation by *L. theobromae*.

***In vitro* assessment of different tested chemicals against pear fruits causal agent:**

All tested treatments reduced *L. theobromae* growth on PDA medium compared with control (Table, 1). Imazalil and biocontrol agent Biocontrol T34 12% WP (*T. asperellum* strainT34) were the best effective treatments where they completely inhibited the growth of the tested fungus. Lemongrass oil and thyme oil at 3mL/L were the least significant effective in reducing *L. theobromae* growth.

Table (1). Effect of different tested treatments on the linear growth (mm) of *L. theobromae in vitro* after 5 days incubation at 25°C.

Treatment	Concen tration /L	*L. theobromae* linear growth	
		mm	Eff. %
Salicylic acid	1mL	15.00c	83.33
Lemongrass oil	3mL	20.00b	77.77
Thyme oil	3mL	20.00b	77.77
Imazalil	1mL	00.00d	100.00
Biocontrol T34	2g	00.00d	100.00
Control	-	90.00a	-

Within each column, the same letter/s indicates no significant difference among treatments at ($P \leq 0.05$).

mm = Colony growth, millimeters. % Eff. = efficacy to untreated (control).

Effect of pre-harvest spray with the tested treatments on the development of pear fruit rot under storage conditions:

The effects of salicylic acid (SA), lemongrass oil, thyme oil, Imazalil fungicide and Biocontrol T34 12% WP (*T. asperellum* strain T34) against artificial infection by *L. theobromae* on Le Conte pear and also the natural infection are presented in Table (2). Generally, the highest percentage of decay incidence was recorded for control treatment. All treatments were significantly better than the control in reducing the percentages of *L. theobromae* fruit rot. Imazalil performed better as compared to SA, lemongrass oil, thyme oil and Biocontrol T34 for both natural and artificial infections. The highest significant efficacy was obtained due to using Imazalil. In particular, the efficacy due to using Imazalil fungicide was 100, 87.5 and 100, 100 % for artificial and natural infections in 2021 after 30 and 60 days of cold storage at 5°C and 90 % RH, respectively. The efficacy due to using Imazalil fungicide was 100 % for artificial and natural infections in 2022 after 30 and 60 days of the same storage conditions, respectively.

Effect of post-harvest treatments on the development of fruit rot on pear under storage conditions:

The effect of the tested treatments against artificial infection by *L. theobromae* and natural infection on Le Conte pear is shown in Table (3). Generally, the highest percentage of decay incidence was recorded for control treatment. All treatments were significantly better than the control in reducing the percentages of *L. theobromae* fruit rot. Imazalil performed better as compared to SA, lemongrass oil, thyme oil and Biocontrol T34 for both artificial and natural infections. The highest efficacy was obtained due to using Imazalil. In particular, the efficacy due to using Imazalil fungicide was 70, 80 and 50, 80 % for artificial and natural infections in 2021 after 30 and 60 days of cold storage at 5°C and 90 % RH, respectively. The efficacy due to using Imazalil fungicide was 50, 77.77and 50, 75 % for artificial and natural infections in 2022 after 30 and 60 days of the same conditions, respectively.

Effect of the tested treatments on the quality of pre- and post-harvest pear naturally and artificially infected by fruit rot:

Fruit Firmness:

The effect of the tested treatments against artificial and natural infection with fruit rot on Le Conte pear fruit firmness (PFF) (Ib. /inch$^{2-1}$) is shown in Table (4). Data indicates that there was a decrease in PFF with increasing the storage period. Decreasing in firmness was more noticeable after 60 days of storage. Pear fruit firmness (PFF) ranged from 16.55-10 and 16.55-6.5, 14.50-10 and 14.50-6.50 lb. /in.$^{2-1}$ due to pre-harvest and post-harvest sprays under artificial and natural infection, respectively, in 2021 season. Pear fruit firmness (PFF) ranged from 15.50-10 and 15.50-6.00, 14.50-10 and 14.5-6.00 lb. /in.$^{2-1}$ for pre-harvest and post-harvest sprays in the presence of artificial and natural infection, respectively, in 2022 season. High value of pear fruits firmness was obtained from lemongrass oil, thyme oil under artificial and natural infection. Additionally, control fruits showed the lowest firmness values in all cases.

Fruit Total Soluble Solids (TSS %):

Data in Table (5) show that there was fluctuation in pear total soluble solid (TSS %) by increasing storage period**.** The highest value of TSS % was noted after 60 days storage. Also, the use of tested treatments caused increment in TSS %. TSS % values ranged from 10.40-15.00 and 10.40-16.00, 10.40-14.00 and 10.4-15.50 for pre-harvest and post-harvest sprays under natural and artificial infection, respectively, in 2021 season. TSS % values ranged from 11.2-15.50 and 11.20-16.20, 11.20-15.5 0 and 11.20-15.00 due to pre- and post-harvest sprays under natural and artificial infection, respectively, in 2022 season. In most cases, Imazalil gave the highest TSS values. Pre-harvest treatments increased TSS % values compared with post-harvest treatment.

Fruit Titratable Acidity (TA):

Data in Table (6) show that there was noticeable decrease in fruit titratable acidity by increasing storage period**.** Also, using the tested treatments caused increment in (TA). Pear Titratable Acidity (TA) values ranged from 0.44-0.69 and 0.33-0.69, 0.33-0.68 and 0.30-0.64 under the effect of pre-harvest and post-harvest sprays in natural and artificial infection, respectively, in 2021 season. TA values ranged from 0.40-0.72 and 0.33-0.72, 0.38- 0.66 and 0.30-0.70 due to pre-harvest and post-harvest sprays under natural and artificial infection, respectively, in 2022 season. In most cases, Imazali gave the highest titratable acidity values. Pre-harvest treatment with the tested treatments increased TA% values compared with post-harvest treatment.

Fruit total phenolic content (TPC):

TPC values were significantly increased due to the tested treatments during the cold storage at 5°C and 90 % RH during 2021 and 2022 seasons. Data in Table (7) indicate that after 60 days, fruits treated with salicylic acid and thyme oil recorded the highest values of TPC in fruits kept under natural infection and those artificially inoculated with *L. theobromae*, respectively in both seasons. Meanwhile, the lowest phenolic concentration was recorded with control (untreated fruits) in both pre-harvest treatment and post-harvest treatment in the first and the second seasons. Post-harvest treatments increased TPC % values compared with Pre -harvest treatments. TPC values in pear values ranged from 0.58-0.68 and 0.58-0.73, 0.55-0.69 and 0.58-0.77 for pre-harvest and post-harvest treatment in natural and artificial infection, respectively, in 2021 season. TPC values ranged from 0.54- 0.71 and 0.54-0.72, 0.54-0.71 and 0.54-0.79 due to pre-harvest and post-harvest treatment and natural and artificial infection, respectively.

Fruit Polyphenoloxidase activity (PPO):

Polyphenoloxidase activity (PPO) in pear fruits was significantly increased until 30 days of cold storage at 5°C and 90 % RH during 2021 and 2022 seasons then decreased in all tested treatments due to the natural and artificial infection with fruit rot, respectively in both seasons (Table 8). PPO of pear fruits was significantly increased due to post-harvest treatment than the pre-harvest treatment. Fruits treated by SA and Imazalil recorded the highest PPO in the two seasons. Meanwhile, the lowest PPO was recorded with control (untreated fruits) in both pre-harvest and post-harvest treatments in the first and second seasons. PPO values ranged from 0.20 - 0.46 and 0.20- 0.58, 0.20- 0.58 and 0.20-0.59 due to pre-harvest and post-harvest treatment in natural and artificial infection, respectively, in 2021 season. PPO values ranged from 0.18- 0.49 and 0.18 – 0.66, 0.18- 0.58 and 0.18-0.65 due to pre-harvest and post-harvest treatment and natural and artificial infection, respectively during 2022.

Fruit Peroxidase activity (PO):

Peroxidase activity (PO) of pear fruits was significantly increased until 30 days of cold storage at 5°C and 90 % RH during 2021 and 2022 seasons then decreased in all tested treatments and those kept under the natural and artificial infection with fruit rot, respectively in both seasons (Table 9). PO of pear fruits was significantly increased in post-harvest treatment than in pre-harvest treatment, artificial infection than natural infection in 2022 than in 2021. Fruits treated by salicylic acid, Imazalil fungicide and bio agent T34 recorded the highest PO in the two seasons. Meanwhile, the lowest PO activity was recorded with control (untreated fruits) in both pre-harvest and post-harvest treatment in the first and second seasons. PO values ranged from 0.44 - 0.89 and 0.56- 0.97, 0.48- 0.98 and 0.59-0.99 for pre-harvest and post-harvest treatment in natural and artificial infection, respectively, in 2021 season. PO values ranged from 0.50- 0.91and 0.56 – 0.98, 0.55- 0.97 and 0.62-0.99 for pre-harvest and post-harvest treatment and natural and artificial infection, respectively.

DISCUSSION

Le Conte pear is the most widespread cultivar in Egypt (Khedr, 2018). In Egypt pear production varied from orchard to orchard and from year to another. This variation may be due to a lot of reasons *i.e.*, rootstock, fire blight, chilling hours, flowers pollination and fertilization (Khamis *et al*., 2018). Under favored storage conditions, losses of fruits caused by fruit rot is minimized to 1% compared with pad conditions of storage that causes 50% or more (Monroe, 2009).

Several isolates of *Lasiodiplodia theobromae* were obtained from rotted pear fruits in Egypt during the summer season of 1988 and their pathogenicity was proved on healthy pear fruits and other fruits and plant organs under laboratory condition (Gabr *et al*., 1990).

Li *et al*. (2007) found that *A. alternata* caused fruit rot on pear cv. Pingguoli, one of the most important cultivars in China. In the present study, results indicated that all tested treatments reduced *L. theobromae* growth on PDA medium compared with control. Imazalil 50%EC fungicide and Biocontrol T34 12% WP (*T. asperellum* strain T34) were the best effective treatments where each of them completely inhibited the growth of the tested fungus. Lemongrass oil and thyme oil at 3mL/L were the least. Also, in this study the results revealed that all treatments were significantly better than the control in reducing the percentages of *L. theobromae* fruit rot. Imazalil performed better as compared to salicylic acid, lemongrass oil, thyme oil and T34 under both artificial and natural infections. The highest efficacy was obtained for Imazalil 50 % EC. High value of pear fruits firmness was obtained due to using lemongrass oil, thyme oil with artificial and natural infection. Additionally, control fruits showed the lowest firmness values in all cases. In most cases, Imazalil gave the highest titratable acidity (TA) values and total soluble solids (TSS %) in both pre-harvest sprays and post-harvest treatment with naturally and artificially infected with fruit rot after 60 days of cold storage in both seasons. Salicylic acid and thyme oil recorded the highest values of total phenolic content (TPC). Meanwhile, salicylic acid and Imazalil 50% EC as well as biocontrol agents T34 recorded the highest Polyphenoloxidase and Peroxidase activity (PO) in the two seasons. Meanwhile, the lowest value was recorded with control (untreated fruits) after each of pre-harvest and post-harvest treatment in the first and the second seasons.

Salicylic acid (SA) plays a main role in increasing the resistance against a lot of pathogens (Mehrabian *et al*., 2011 and El-Garhy *et al*., 2020). Abd El- Aziz *et al*. (2017) reported that SA was necessary for improving fruit quality of pomegranate trees, from fruit setting to fruit retention. Additionally, maintaining fruit firmness, (Khademi and Ershadi, 2013). A lot of fungicides and bio fungicides successfully controlled postharvest fruit decay with pathogens (Abd-El-Kareem and Abd-Alla, 2002).

SA treatments accelerated the activity of many enzymes (Schieber *et al*., 2001) and it was necessary for diseases resistance of many plants (Pila *et al*., 2010). Spraying tomato plants with SA increased peroxidase (PO) in the leaves, as well as Polyphenoloxidase and increased the postharvest life of fruits (Martinez *et al*., 2004).

Table (2). Effect of pre-harvest treatments on disease incidence (D.I. %) on Le Conte pear fruits naturally and artificially infected with *L. theobromae* after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	*A I						**N I					
		D. I. (%)			Ef. (%)			D. I. (%)			Ef. (%)		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
		Season 2021											
Salicylic acid	1mL	0.00	10.0b	20.0c	0.00	66.66	75.0	0.00	0.00c	10.0b	0.00	100	66.66
Lemongrass oil	3mL	0.00	10.0b	30.0b	0.00	66.66	62.5	0.00	10.0b	10.0b	0.00	50.00	66.66
Thyme oil	3mL	0.00	10.0b	30.0b	0.00	66.66	62.5	0.00	10.0b	10.0b	0.00	50.00	66.66
Imazalil	1mL	0.00	00.0c	10.0d	0.00	100	87.5	0.00	00.0c	00.0c	0.00	100	100
Biocontrol T34	2g	0.00	00.0c	20.0c	0.00	100	75.0	0.00	00.0c	10.0b	0.00	100	66.66
Control(water)	…	0.00	30.0a	80.0a	…	…	…	0.00	20.0a	30.0a	…	…	…
		Season 2022											
Salicylic acid	1mL	0.00	10.0b	30.0c	0.00	66.66	66.66	0.00	0.00c	10.0b	0.00	50.0	75.0
Lemongrass oil	3mL	0.00	10.0b	40.0b	0.00	66.66	55.55	0.00	10.0b	10.0b	0.00	50.0	75.0
Thyme oil	3mL	0.00	10.0b	40.0b	0.00	66.66	55.55	0.00	10.0b	10.0b	0.00	50.0	75.0
Imazalil	1mL	0.00	00.0c	00.0d	0.00	100.0	100.0	0.00	00.0c	00.0c	0.00	100.0	100.0
Biocontrol T34	2g	0.00	10.0b	30.0c	0.00	66.66	66.66	0.00	00.0c	10.0b	0.00	100.0	75.0
Control(water)	…	0.00	30.0a	90.0a	…	…	…	0.00	20.0a	40.0a	…	…	…

Within each column, the same letter/s indicates no significant difference among treatments at ($P\leq 0.05$).

*(A I) = Artificial infection. **(N I) = Natural infection.

Table (3). Effect of post-harvest treatments on disease incidence (D. I. %) on Le Conte pear fruits naturally and artificially infected with *L. theobromae* and naturally infected after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	*A I						**N I					
		D. I. (%)			Ef. (%)			D. I. (%)			Ef. (%)		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
Season 2021													
Salicylic acid	1mL	0.00	20.0b	40.0b	0.00	33.3	60.0	0.00	10.0b	20.0b	0.00	50.0	60.0
Lemongrass oil	3mL	0.00	30.0a	40.0b	0.00	00.0	60.0	0.00	10.0b	20.0b	0.00	50.0	60.0
Thyme oil	3mL	0.00	30.0a	40.0b	0.00	00.0	60.0	0.00	10.0b	20.0b	0.00	50.0	60.0
Imazalil	1mL	0.00	10.0c	20.0d	0.00	70.0	80.0	0.00	10.0b	10.0c	0.00	50.0	80.0
Biocontrol T34	2g	0.00	20.0b	30.0c	0.00	33.3	70.0	0.00	10.0b	20.0b	0.00	50.0	60.0
Control(water)	---	0.00	30.0a	100.0a	---	---	---	0.00	20.0a	50.0a	---	---	---
Season 2022													
Salicylic acid	1mL	0.00	20.0b	40.0b	0.00	50.0	55.5	0.00	10.0b	20.0b	0.00	50.0	50.0
Lemongrass oil	3mL	0.00	20.0b	40.0b	0.00	50.0	55.5	0.00	10.0b	20.0b	0.00	50.0	50.0
Thyme oil	3mL	0.00	20.0b	30.0c	0.00	50.0	66.6	0.00	10.0b	20.0b	0.00	50.0	50.0
Imazalil	1mL	0.00	20.0b	20.0d	0.00	50.0	77.7	0.00	10.0b	10.0c	0.00	50.0	75.0
Biocontrol T34	2g	0.00	20.0b	40.0b	0.00	50.0	55.5	0.00	10.0b	10.0c	0.00	50.0	75.0
Control(water)	---	0.00	40.0a	90.0a	---	---	---	0.00	20.0a	40.0a	---	---	---

Within each column, the same letter/s indicates no significant difference among treatments at (*P≤0.05*).
*(A I) = Artificial infection. **(N I) = Natural infection.

Table (4). Effect of pre- and post-harvest treatments on Le Conte pear fruit firmness (lb./inch^2) naturally and artificially infected with fruit rot after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	Pre-harvest sprays						Post-harvest sprays					
		*N I			**A I			*N I			**A I		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
		Pear fruit firmness, Season 2021											
Salicylic acid	1mL	15.00b	13.50b	12.00b	15.00a	10.00c	8.00b	14.50a	13.00b	12.0b	14.50a	10.0c	9.00c
Lemongrass oil	3mL	16.55a	15.00a	14.00a	16.55a	12.00a	10.00a	14.50a	14.55a	13.50a	14.50a	11.55a	11.00a
Thyme oil	3mL	16.55a	15.00a	14.00a	16.55a	12.00a	10.0a	14.50a	14.55a	13.50a	14.50a	11.55a	10.50b
Imazalil	1mL	14.05c	13.00b	12.00b	14.05b	11.00b	8.00b	14.50a	12.0c	11.00c	14.50a	11.00b	8.50d
Biocontrol T34	2g	14.05c	13.00b	12.00b	14.05b	11.00b	8.00b	14.50a	13.00b	12.00b	14.50a	11.00b	8.55d
Control(water)	---	13.05d	12.00c	10.00c	13.05c	8.05d	6.50c	13.50b	12.00c	10.00d	13.50b	9.50d	6.50f
		Pear fruit firmness, Season 2022											
Salicylic acid	1mL	15.00a	13.00b	12.50b	15.00a	10.00c	9.00b	14.50a	13.50c	11.50b	14.50a	9.50c	8.00b
Lemongrass oil	3mL	15.50a	15.00a	14.40a	15.50a	12.00a	10.00a	14.50a	14.00b	12.55a	14.50a	12.00a	10.00a
Thyme oil	3mL	15.50a	15.30a	14.40a	15.50a	12.00a	10.00a	14.50a	14.00b	12.55a	14.50a	12.00a	10.50a
Imazalil	1mL	14.00b	13.00b	12.00c	14.00b	11.00b	8.50c	14.50a	12.00d	11.00b	14.50a	10.00b	8.00b
Biocontrol T34	2g	14.00b	13.00b	12.00c	14.00b	11.00b	9.00b	14.50a	13.00c	12.00a	14.50a	10.00b	8.00b
Control(water)	---	12.50c	12.00c	10.00d	12.50c	9.00d	6.00d	12.50a	12.00d	10.00c	12.50b	9.50c	6.00c

Within each column, the same letter/s indicates no significant difference among treatments at (*P≤0.05*).
* (N I) = Natural infection. ** (A I) = Artificial infection.

Table (5). Effect of pre- and post-harvest treatments on Le Conte pear fruit TSS % naturally and artificially infected with fruit rot after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	Pre-harvest sprays						Post-harvest sprays					
		*N I			**A I			*N I			**A I		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
		Pear fruit TSS%, Season 2021											
Salicylic acid	1mL	13.50a	13.5b	14.20b	13.50a	15.00a	15.40b	11.00a	12.00c	13.50b	11.00a	15.00a	15.00b
Lemongrass oil	3mL	13.00b	13.00b	14.00b	13.50a	13.50c	15.00b	11.00a	13.00b	14.00a	11.00a	13.50c	15.00b
Thyme oil	3mL	13.00b	13.00b	14.00b	13.00b	14.00b	14.50c	11.00a	13.00b	13.00c	11.00a	14.00b	14.00c
Imazalil	1mL	13.50a	14.50a	15.00a	13.50a	15.50a	16.00a	11.00a	14.50a	13.50b	11.00a	15.50a	15.50a
Biocontrol T34	2g	13.50a	14.50a	14.50b	13.50a	14.50b	16.00a	11.00a	14.50a	13.50b	11.00a	14.50b	15.00b
Control(water)	---	10.40c	10.60c	10.80c	10.40c	10.40d	11.40d	10.40b	10.80d	10.90d	10.40b	11.00d	11.50d
		Pear fruit TSS%, Season 2022											
Salicylic acid	1mL	13.50a	13.00b	14.50b	13.50a	15.00a	15.40b	12.50a	12.50b	14.50b	12.50a	13.00c	15.00b
Lemongrass oil	3mL	13.00b	13.00b	14.50b	13.00b	13.50c	15.00b	12.50a	12.00c	14.50b	12.50a	13.50b	15.00b
Thyme oil	3mL	12.50c	13.00b	14.50b	12.50c	14.00b	14.50c	12.50a	12.00c	14.50b	12.50a	14.00a	14.50c
Imazalil	1mL	13.50a	14.50a	15.50a	13.50a	15.50a	16.20a	12.50a	13.50a	15.50a	12.50a	13.50b	15.00a
Biocontrol T34	2g	13.00b	14.50a	14.50b	13.00b	14.50b	16.00a	12.50a	12.50b	14.50b	12.50a	14.50a	15.00b
Control(water)	---	11.20d	11.60c	11.80c	11.20d	11.40d	12.40d	11.20a	11.20d	11.80c	11.20a	11.40d	12.40c

Within each column, the same letter/s indicates no significant difference among treatments at ($P \leq 0.05$).
* (N I) = Natural infection. ** (A I) = Artificial infection.

Table (6). Effect of pre- and post-harvest treatments on Le Conte pear titratable acidity (TA) in naturally and artificially infected fruits with fruit rot after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	Pre-harvest sprays						Post-harvest sprays					
		*N I			**A I			*N I			**A I		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
		Pear fruit TA, Season 2021											
Salicylic acid	1mL	0.64b	0.64b	0.60b	0.64b	0.60c	0.55b	0.44a	0.64c	0.60b	0.44a	0.60b	0.60a
Lemongrass oil	3mL	0.61c	0.60c	0.58d	0.61c	0.59d	0.55b	0.44a	0.60d	0.55d	0.44a	0.60b	0.55c
Thyme oil	3mL	0.61c	0.60c	0.56e	0.61c	0.60c	0.55b	0.44a	0.60d	0.55d	0.44a	0.60b	0.55c
Imazalil	1mL	0.69a	0.68a	0.62a	0.69a	0.66a	0.60a	0.44a	0.68a	0.62a	0.44a	0.64a	0.60a
Biocontrol T34	2g	0.69a	0.68a	0.60c	0.69a	0.63b	0.55b	0.44a	0.66b	0.58c	0.44a	0.64a	0.58b
Control(water)	---	0.48d	0.44d	0.44f	0.48d	0.36e	0.33c	0.48a	0.44e	0.36e	0.48a	0.32c	0.30d
		Pear fruit TA, Season 2022											
Salicylic acid	1mL	0.66b	0.64c	0.60b	0.66b	0.58c	0.55b	0.44a	0.60c	0.58c	0.44a	0.60b	0.56b
Lemongrass oil	3mL	0.64c	0.60d	0.56d	0.64c	0.58c	0.55b	0.44a	0.60c	0.55c	0.44a	0.57c	0.50b
Thyme oil	3mL	0.64c	0.60d	0.58c	0.64c	0.60b	0.55b	0.44a	0.60c	0.55c	0.44a	0.55c	0.50b
Imazalil	1mL	0.72a	0.68a	0.62a	0.72a	0.66a	0.60a	0.44a	0.66a	0.60a	0.44a	0.70a	0.60a
Biocontrol T34	2g	0.66b	0.65b	0.62a	0.66b	0.60b	0.55b	0.44a	0.64b	0.58b	0.44a	0.60b	0.50b
Control(water)	---	0.40d	0.42e	0.40e	0.40d	0.34d	0.33c	0.40b	0.45d	0.38d	0.40b	0.32d	0.30c

Within each column, the same letter/s indicates no significant difference among treatments at ($P\leq 0.05$).

*(N I) = Natural infection. ** (A I) = Artificial infection.

Table (7). Effect of pre- and post-harvest treatments on Le Conte pear total phenolic content (TPC) in naturally and artificially infected pear fruits with fruit rot after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	Pre-harvest sprays						Post-harvest sprays					
		*N I			**A I			*N I			**A I		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
		Pear fruit TPC, Season 2021											
Salicylic acid	1mL	0.64a	0.65a	0.68a	0.64a	0.67b	0.73a	0.65a	0.68a	0.69a	0.65a	0.72a	0.77a
Lemongrass oil	3mL	0.62b	0.62b	0.64b	0.62b	0.62d	0.64c	0.65a	0.65b	0.68b	0.65a	0.67b	0.75b
Thyme oil	3mL	0.64a	0.65a	0.68a	0.64a	0.68a	0.73a	0.65a	0.68a	0.69a	0.65a	0.72a	0.77a
Imazalil	1mL	0.60c	0.62b	0.63c	0.60c	0.64d	0.64c	0.65a	0.62b	0.66c	0.65a	0.64d	0.66d
Biocontrol T34	2g	0.60c	0.62b	0.64b	0.60c	0.64c	0.65b	0.65a	0.65b	0.65d	0.65a	0.66c	0.69c
Control(water)	---	0.58d	0.60c	0.60d	0.58d	0.60e	0.62d	0.58	0.59c	0.55e	0.58b	0.60e	0.62e
		Pear fruit TPC, Season 2022											
Salicylic acid	1mL	0.67a	0.70a	0.71a	0.68a	0.72a	0.72a	0.60a	0.70a	0.71a	0.60a	0.72a	0.79a
Lemongrass oil	3mL	0.60c	0.62d	0.63d	0.60c	0.62e	0.64d	0.60a	0.65c	0.69c	0.60a	0.67d	0.75b
Thyme oil	3mL	0.65b	0.67b	0.67b	0.65b	0.70b	0.72a	0.60a	0.67b	0.70b	0.60a	0.70b	0.79a
Imazalil	1mL	0.60c	0.62d	0.64c	0.60c	0.66d	0.70b	0.60a	0.62d	0.66d	0.60a	0.62e	0.68d
Biocontrol T34	2g	0.60c	0.64c	0.64c	0.60c	0.68c	0.68c	0.60a	0.65c	0.65e	0.60a	0.68c	0.69c
Control(water)	---	0.54d	0.61e	0.62e	0.54d	0.61f	0.64d	0.54b	0.56e	0.58f	0.54b	0.58f	0.58e

Within each column, the same letter/s indicates no significant difference among treatments at ($P \leq 0.05$).

* (N I) = Natural infection. ** (A I) = Artificial infection.

Table (8). Effect of pre- and post-harvest treatments on Le Conte pear Polyphenoloxidase activity (PPO) due to natural and artificial infection with fruit rot after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	Pre-harvest sprays						Post-harvest sprays					
		*N I			**A I			*N I			**A I		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
		Pear fruit PPO, Season 2021											
Salicylic acid	1mL	0.25a	0.46a	0.24a	0.25a	0.58a	0.26a	0.22a	0.58a	0.25a	0.22a	0.59a	0.28a
Lemongrass oil	3mL	0.21b	0.24c	0.22c	0.21b	0.25d	0.24b	0.22a	0.24b	0.22c	0.22a	0.28d	0.24d
Thyme oil	3mL	0.21b	0.24c	0.22c	0.21b	0.26c	0.24b	0.22a	0.24b	0.22c	0.22a	0.26e	0.24d
Imazalil	1mL	0.25a	0.45b	0.24a	0.25a	0.58a	0.24b	0.22a	0.58a	0.25a	0.22a	0.40c	0.26c
Biocontrol T34	2g	0.23a	0.35d	0.24a	0.23a	0.56b	0.24b	0.22a	0.58a	0.25a	0.22a	0.49a	0.27b
Control(water)	---	0.20c	0.23e	0.23b	0.20c	0.23e	0.22c	0.20b	0.23c	0.23b	0.20b	0.23f	0.20e
		Pear fruit PPO, Season 2022											
Salicylic acid	1mL	0.25a	0.49a	0.29a	0.25a	0.66a	0.43b	0.23a	0.58a	0.25a	0.23a	0.65a	0.28b
Lemongrass oil	3mL	0.23b	0.26e	0.22e	0.23b	0.25f	0.24c	0.23a	0.24c	0.22c	0.23a	0.33d	0.24d
Thyme oil	3mL	0.21c	0.28d	0.22e	0.21c	0.26d	0.24c	0.23a	0.26b	0.23b	0.23a	0.33d	0.24d
Imazalil	1mL	0.23b	0.48b	0.28b	0.23b	0.58b	0.44a	0.23a	0.58a	0.25a	0.23a	0.55b	0.33a
Biocontrol T34	2g	0.23b	0.35c	0.27c	0.23b	0.56c	0.24c	0.23a	0.58a	0.25a	0.23a	0.49c	0.27c
Control(water)	---	0.18d	0.23f	0.23d	0.18d	0.23f	0.22d	0.18b	0.23d	0.23b	0.18b	0.23d	0.20e

Within each column, the same letter/s indicates no significant difference among treatments at (*P≤0.05*).

* (N I) = Natural infection. ** (A I) = Artificial infection.

Table (9). Effect of pre- and post-harvest treatments on Le Conte pear peroxidase activity (PO) in naturally and artificially infected pear fruit with fruit rot after 60 days of cold storage at 5°C and 90 % RH during 2021 and 2022.

Treatments	Con.	Pre-harvest sprays						Post-harvest sprays					
		*N I			**A I			*N I			**A I		
		0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day	0 day	30 day	60 day
		Pear fruit PO, Season 2021											
Salicylic acid	1mL	0.88a	0.89a	0.80a	0.88a	0.97a	0.84a	0.70a	0.98a	0.85b	0.70a	0.99a	0.88a
Lemongrass oil	3mL	0.77c	0.78c	0.55b	0.77c	0.77c	0.67d	0.70a	0.76d	0.55c	0.70a	0.77e	0.67d
Thyme oil	3mL	0.77c	0.78c	0.55b	0.77c	0.77c	0.59e	0.70a	0.74e	0.55c	0.70a	0.79d	0.59e
Imazalil	1mL	0.88a	0.89a	0.80a	0.88a	0.89b	0.81c	0.70a	0.82b	0.89a	0.70a	0.96c	0.80c
Biocontrol T34	2g	0.84b	0.88b	0.80a	0.84b	0.89b	0.82b	0.70a	0.82b	0.89a	0.70a	0.98b	0.82b
Control(water)	---	0.70d	0.70d	0.44c	0.70d	0.70d	0.56f	0.70a	0.77c	0.48d	0.70a	0.73f	0.59e
		Pear fruit PO, Season 2022											
Salicylic acid	1mL	0.90a	0.90b	0.78b	0.90a	0.98a	0.86a	0.70a	0.74b	0.97a	0.70a	0.98b	0.85a
Lemongrass oil	3mL	0.73d	0.78c	0.58c	0.73d	0.77d	0.65c	0.70a	0.74b	0.57e	0.70a	0.77c	0.67d
Thyme oil	3mL	0.72e	0.74e	0.58c	0.72e	0.77d	0.57d	0.70a	0.77a	0.59d	0.70a	0.73e	0.59e
Imazalil	1mL	0.89b	0.91a	0.80a	0.89b	0.92c	0.83b	0.70a	0.74b	0.84c	0.70a	0.99a	0.84b
Biocontrol T34	2g	0.88c	0.90b	0.80a	0.88c	0.97b	0.83b	0.70a	0.74b	0.85b	0.70a	0.99a	0.80c
Control(water)	---	0.70f	0.77d	0.50d	0.75f	0.76e	0.56e	0.70a	0.74b	0.55f	0.70a	0.75d	0.62f

Within each column, the same letter/s indicates no significant difference among treatments at ($P \leq 0.05$).
* (N I) = Natural infection. **(A I) = Artificial infection.

Hassan *et al*., (2021) evaluated some essential oils *i.e.*, thyme, rosemary and lemongrass as well as copper oxide NPS, copper oxide and the fungicide Imazalil and Serenade ASO (*Bacillus subtilis* QST713) to controlling avocado fruit rot *in vitro* and *in vivo*. The highest effect recorded with copper oxide (NPS) and Imazalil fungicide followed by Serenade ASO, while thyme, lemongrass and rosemary recorded the lowest efficacy, respectively. Meanwhile, Cacioni *et al*. (1998) found that active relation against postharvest pathogens of citrus fruits and essential oils. This relationship may be effective for fungicides (Singh *et al*., 1993). Effects of citral on controlling post-harvest pathogenic fungi of citrus fruits reported by Abd-El-Kareem and Abd-Alla (2002) and El-Mohamedy *et al*. (2002) they reported that essential oil as citral gave significantly complete reduction for of *P*. *italicum* and *P*. *digitatum* using 8m1/1 *in vitro*.

Ismail (2016) reported that under field conditions, spraying thyme and lemongrass oil as a foliar spray were significantly highly protective against natural infection by powdery mildew disease of mango and increased fruit set compared with control.

Thymol treatment showed limited necrosis in mango fruits during storage and decried development due to the causal pathogens. Also stimulated polyphenolsoxidase interested resistance to postharvest disease in mango fruit and did not affect fruit maturation and quality (Chillet *et*. *al*., 2020).

Storage in low temperature is a very effective method for prolonging the postharvest life of fruits and keeping their quality (Lin *et al*, 2008). Mehaisen (1999) found that the decay percentage of Le Conte pear fruit was increased by increasing the period of storage. The decay percentage recorded over 50% at 21 days and 28 days for control and post-harvest treated fruit, respectively, stored under room condition. Fruit total soluble solid TSS was increased with the progress of storage period and all tested post-harvest treatments under the different storage temperature (room temperature, 5 or 0°C) failed to affect fruit total soluble solids percentage. All tested post-harvest increased the fruit acidity compared with the control. $CaCl_2$ and fruit wrapping treatments induced a remarkable increment in fruit acidity content under the storage temperature treatments particularly under room conditions. Fruit phenols content was increased with the increase of storage period and the tested treatments, Yeast and $CaCl_2$ had the lowest phenols content.

Total Phenols plays many functions in plant tissue browning, color and flavor characteristics of many fruits and derived products and have a several roles in plant defense, human health metabolism and anticarcinogenic properties (Stich and Rosin, 1984 and Spanos and Wrolstad, 1990). The grade of TPC in pear leaves and or fruits is highly dependent on many factors, such as cultivar, stage of maturity, storage conditions and infection diseases and or pests (Androetti *et al*., 2006).

Venkatesan and Tamilmani (2010) noticed that phenol compounds were decreased during ripening, both in the control and treated fruits, also, the activity of peroxidase (POD) and polyphenoloxidase (PPO) of mango. While the PPO activity of the fruits showed a decrease during post-harvest ripening (Othman, 2012). Salicylic acid (SA) treatment increased the activities of PPO and TPC in mango fruit against postharvest anthracnose, caused by *C. gloeosporioides* during storage period after inoculation (He *et al*., 2017).

CONCLUSIONS

Lasiodiplodia theobromae may be the essential pathogen causing pear fruit rot in Egypt, where artificial inoculation by this fungus induced fruit decay of Le Conte pear with typical symptoms. Also, pear fruits treated pre-harvest sprays and post-harvest treatment with salicylic acid 1mL /liter, lemongrass oil 3 mL /liter, thyme oil 3mL /liter, Imazalil 50%EC fungicide 1mL /liter and biocontrol agent Biocontrol T34 12% WP (*Trichoderma asperellum* strain T34) 2g/L maybe success in controlling pear fruit rots under cold storage at 5°C and 90 % RH. Additionally, this work highlighted the potential for using this treatment in order to keep “Le Conte” pear fruit quality and increase its storability.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

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