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EFFICACY OF PRE AND POST HARVEST APPLICATIONS OF SOME ESSENTIAL OILS AND STORAGE TEMPERATURES FOR CONTROLLING OF BOTRYTIS ROT (GREY MOLD) ON STRAWBERRY

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ABSTRACT: *The effect of essential oils of Eugenia caryophyllata L., Thymus vulgaris L. and Melaleuca alternifolia, produced by clove, thyme and tea tree plants in reduction strawberry (Fragaria ananassa Duch.) post harvest losses was evaluated. The antifungal activity against Botrytis cinerea at various concentrations ranging (0.0 to 2.0% v/v) was in vitro evaluated compared to different concentrations of switch 62% (Fludioxonil+Cyprodinil). Clove oil 2.0% (v/v) inhibited mycelial growth as similar as switch 62% at the highest concentration (500 ppm). Also, the clove oil as well decreased conidia germination at the afore – mentioned concentration and to less extent at concentrations below 2% v/v. Thyme oil inhibited mycelia growth and conidia germination from 30.80 to 65.40 and from 33.87 to73.36%, respectively. Preharvest treatment of fruits under natural infection conditions with 2% (v/v) essential oils and switch 62% was used at recommend dose had different effects in reducing infection, though significantly fruit rot infection after storage at either 5 or 15˚C for 14 days. Postharvest application of fruit under artificial inoculation stress and storage at different temperatures showed variable effect in reducing fruit rot infection. The promising effect of clove oil application and spraying switch 62% of fruits kept at either 5 or 15˚C are beneficial for completely reduction of postharvest Botrytis fruit rot after storage at 5˚C followed at 15˚C. Moreover, application clove and thyme oils at 2% (v/v) after harvest (postharvest) had the least effect of infection percentage of Botrytis fruit rot with the averages of 5.92 and 10.83% after storage at5˚C for 14 days compared with control (sprayed only with conidia of the pathogen) with an average of 60.0%, respectively. On the other hand, postharvest application of essential oils 14 days after storage at 25˚C did not show any significantly reduction of the percentage infection of fruist rot disease. In retrospect, pre and post-harvest clove and thyme at 2% (v/v) caused the highest effect in reducing strawberry fruit rot stored at 5 and 15 ˚C for 14 days.*

Key words: *Strawberry, grey mold, essential oils, storage temperature.*

INTRODUCTION

Strawberry (*Fragaria ananassa* Duch.) is one of the most important favorite and delicious fruits of which the demand has been increases in Egypt for local consumption and exportation. Under Egyptian conditions all over the world, strawberry fruits are vulnerable to infection by many destructive pathogens that cause fruit-rots (Khafagi, 1982; Abada *et al*., 2002 and El-Neshawy *et al*., 2003). Grey mould rot caused by *Botrytis cinerea* is the most important preharvest and post harvest disease of strawberry, since apparently healthy fruit develop lesions during shipping and storage, causing server losses, due to their high pH, water content and the large amount of nutrients and enormous reproduction rate by conidia and its high genetic adaptability (McFeeter and McFeeters, 2012 and Zamani-Zadch *et al*., 2014). Moreover, recent study from the FAO (FAO, 2011) estimated that with respect to the total amounts of fruit and vegetables produced globally, somewhere between 15and 50% are lost at the postharvest stage, before even reaching the tables of the consumers. The highest losses were recorded in the developing countries of Africa and Asia, which lack the necessary technologies to prolong the storage life of fresh produce. The postharvest use of chemicals as fungicides is restricted most countries (Serrano *et al.,* 2005). Consumer demand for agricultural commodities without pesticide residues is high (Cutler and Culter, 1999 and Serrano *et al.*, 2005); however, pesticides may also kill various beneficial organisms and their forms may persist in soil (Haye and Laws, 1991) and increase the incidence of resistance among pathogens towards synthetic chemicals (Cakir *et al.*, 2005 and Ramezani *et al.*, 2002). *B. cinerea* has been classified as a high risk pathogen with respect to resistance (Agrios, 2005) with many strains resistant to multiple (up to six) fungicides (Leroch *et al.*, 2013). The application of higher concentrations of chemicals in an attempt to overcome this problem increases the risk of high level toxic residues in the products, which is particularly serious because fruits and vegetables are consumed in relatively short time after harvest (Elad, 2004).

Thus, new preservation technologies are needed, which have to be considered as human-safe and environmentally friendly (Duru *et al.*, 2003) and food safety is one of the major issues related to fresh fruit and vegetables (Antunes and Cavaco, 2010). The development of natural crop protective products as alternatives to synthetic fungicides is currently in the spotlight (Combrink *et al.*, 2011). In recent years, numerous studies have documented the antifungal effect of plant essential oils to control food spoilage fungi *in vitro* and *in vivo* (Amiri *et al.*, 2008 and Tian *et al.*, 2011).

Extracts and oils alike of plant such as thyme, clove, cinnamon, oregano, lemongrass and many others, have all been proven to possess anti-microbial properties and able to suppress the development of many postharvest pathogens *in vitro* and *in vivo* (Barbosa *et al.*, 2009, Camele *et al.*, 2012 and Shao, *et al.*, 2015). Furthermore, the use of naturally derived plant compounds, mainly essential oils, is an importance is an efficient method to address areas where pathogens have developed resistance against pre-existing synthetic pesticides (Castillo *et al.*, 2014). In this regard, the antifungal activity of essential oils from oregano and thyme showed significant efficacy in apple fruits infected with *B. cinerea* and *Penicillium expansum* (Lopez-Reyes *et al.*, 2010). In addition, the antifungal activity of clove oil in apples was evaluated against *B. cinerea, P. expansum* and *P. vagabunda* (Amiri *et al.*, 2008).

This study aimed to evaluate the effectiveness of clove, thyme and tea tree oils as alternative method and switch 62% (WG) fungicide against growth and spore germination of *B. cineara* the causal agent of grey mould rot disease of Festival strawberry fruits under *in vitro* and *in vivo* conditions. The relation to surrounding temperature conditions was also considered.

MATERIALS AND METHODS

In vitro studies:

a- Pathogen culture:

Rotten strawberry fruits were collected from different fields (fresh planting system) at El-Tahreer district. Fruits showed different types of rots were also collected at15th October. Diseased fruits were rinsed several times in sterilized water; surface disinfected using 70% ethyl alcohol for two minutes and dried between sterilized filter papers, cut into small pieces, each containing rotten tissues with adjacent healthy ones. The cut pieces were cultured on PDA medium, and incubated for 4 days at 24 °C. Developed mycelium was transferred and kept on PDA slants. The growing fungi were sub cultured and purified by using the hyphal tip technique and were identified according to their morphological features, using the description of Gilman (1957) and Barnett and Hunter (1972). Conidial - spore suspensions of *B cinerea* were prepared by removing the spores from old culture after7-8 days with a bacteriological loop. The conidial suspension was filtered through three layers of sterile cheese cloth, and adjusted to 1×10^6 spores/mL with sterile water containing 1% (v/v) Tween-80 using a hemocytometer (Asghari *et al.*, 2009).

b- Source of essential oils:

Essential oils of clove oil (*Eugenia caryophyllata* L.), thyme (*Thymus vulgaris* L.) and tea tree oil *(Melaleuca alternifolia*) were purchased from International Favors and Plant oils Inc., Giza., Egypt. These essential oils were stored in dark bottles at 4°C for use on request.

c- Screening of essential oils and fungicide inhibition of *B. cinerea*.

The antifungal tests were carried *in vitro* according the method described by Pitarokiti *et al* (2003) using petri dishes 9 cm in diameter containing potato dextrose agar (PDA). The essential oils were dispensed individually as an emulsion in sterilized water using Tween 80 (1%) and added to PDA immediately cooled to 45-50°C. The concentrations tested were 0.0, 0.25, 0.50, 1.0 and 2.0%. Switch 62% was used as a reference at concentration of 25, 50, 150 and 250 ppm. The control included the same quantity of Tween 80 mixed with PDA. The fungi disks were inoculated in dishes by placing in the center of PDA plates. The petri dishes were incubated in dark at 25°C. Mean growth rates were calculated from five replicates of complete fungal growth, the percentage mycelia growth inhibition was calculated by the following formula:

$$\% \text{ mycelia inhibition} = (dc-dt)/dc \times 100$$

Where dc is mean colony diameter of control sets and dt is mean colony diameter of treatment set. Conidial germination was performed by the cavity slide technique and the results were expressed in percentage (Cronin *et al.*, 1996).

In vivo studies:

a- Efficacy of essential oils on preharvest strawberry grey mould fruit rot and infection percentage during storage:

Strawberry fruits cv. Festival was collected from field at El-Tahreer district, El Beheira Governorate, Egypt. At the end of February, foliar application with the tested essential oils at the concentration of 2.0% v/v before harvested (preharvest) were carried out twice at 10 and 17 June at the beginning of the flowering stage (Blacharsk *et al.*, 2001). Also switch 62% was used at recommend dose (75gm/100L water); check treatment was sprayed with equivalent amount of water. Fruits were collected after 7 days from the second spray treatment, and placed in sterilized plastic container.

b- Efficacy of essential oils on postharvest strawberry grey mould fruit rot and infection percentage during storage:

For postharvest application, strawberry fruits were harvested from the untreated plants from the same field or region (on the harvest date of preharvest essential oils application trial). Fresh harvested healthy fruits were collected from apparently healthy plants and free from physical damage. Fruits were washed with running tap water and kept on a layer of 3-4 clean tissues in order to drain off the excess water, and then surface sterilized with 0.1% sodium hypochlorite solution and again washed with distilled water then left for air-drying on filter paper. Fruits were sprayed with clove, thyme and tea tree oils, by spraying at the concentration of 2.0% (v/v). Fruits were sprayed with spores suspension (1×10^6 spores/mL). Spore suspension was sprayed using a sterilized atomizer on fruit surfaces. Four replicates were used for each treatment them placed in sterilized plastic container. Control treatment was sprayed only with the pathogen. Percentages of fruit rot infection were calculated. Nine treatments were carried out as following:

1- Preceding harvest spraying with thyme oil
2- Preceding harvest spraying with clove oil
3- Preceding harvest spraying with tea tree oil
4- Preceding harvest spraying with switch 62%.
5- Control (sprayed with tap water)
6- Post harvest spraying with thyme oil
7- Post harvest spraying with clove oil
8- Post harvest spraying with tea tree oil
9- Control (sprayed only with the spore of the pathogen)

The fruits of both pre and postharvest trials were subjected to different temperatures storage and kept incubated at 5, 15 and 25°C for 14 days, with daily examination (Hongyin *et al.*, 2007). Decayed fruits were counted and the percentage of infection was recorded at the end of storage.

$$\text{Infection (\%)} = \frac{\text{Number of rotten fruits}}{\text{Total number of tested fruits}} \times 100$$

Statistical analysis:

Data collected were subjected to the statistical analysis according to the standard methods recommended by Gomez and Gomez (1984) using the computer program (costate). Means were compared using L.S.D tested at the level of probability.

RESULTS AND DISCUSSION

In-vitro test:

Retardation effects of essential oils and fungicide on radial growth and spore germination of *B. cinerea*:

The effect of the tested essential, clove, thyme and tree tea oils on linear growth and spore germination of *B. cinerea* are presented in Table (1) and Figure (1). Clove oil at all concentrations significantly reduced the fungal linear growth and the percentage of spore germination compared with other tested essential oils. At low concentration (0.25%) clove oil inhibited fungal growth and spores germination with averages of 39.02 and 47.14%, respectively. Moreover, at 0.50%, inhibition of fungal growth and spores germination was recorded 53.40 and 56.91%, respectively. The highest concentration dose (2.0%) a complete reduction was expressed in mycelia linear growth, and inhibition of spore germination. It should be observed that the radial growth of fungi on plates was decreased with increasing the concentration of clove oil compared with untreated (zero) treatment (Figure, 2). The above data are in agreement with the results obtained by Anjum and Akhtar (2012) who revealed that the essential oils of cumin and clove have the potential to inhibit mycelial growth of *Penicillium italicum* completely at concentrations of 12 and 48 µl/ml. Plooya *et al.* (2009) reported that eugenol is a major component (approximately 85%) of clove oil. Sub-lethal concentrations of eugenol have been found to inhibit production of amylase and proteases by *B. cinerea*. Cell wall showed also deterioration and a high degree of cell lysis. Essential oils such as carvacrol, eugenol and thymol that contain more phenol compounds in their chemical structure; exhibited the strongest antimicrobial properties against fungal pathogens (Lambert *et al.*, 2001). Phenols can also interfere with membrane stricter and functions (Fung *et al.*, 1977). Yahyazadeh *et al.* (2008) and da Cruz *et al* (2013) suggested that thyme and clove essential oils completely inhibited *P. digitatum* growth either when added into medium or by their volatiles per petri dish. *In vitro* mycelial growth assay showed fungistatic and fungicidal activity by clove and thyme essential oils. Furthermore, thyme oil had an inhibitory effect where it ranged between 30.80 - 65.40% for linear growth and from 33.87 to 73.36 spore germination percentage. Generally, results showed that, when the essential oils concentration increased, visible reduction in the percentage of linear growth and spore germination was observed. This result is in agreement with findings of Abd-Alla *et al.* (2011) who reported complete inhibition of linear growth and spore germination of *B. cinerea* with lemongrass oil and thyme oil either as vapor or as liquid phases *in vitro*. Moreover, Vitoratos *et al.* (2013) reported that thyme essential oil exhibited strong antifungal effect against important postharvest pathogens; *B. cinerea*, *Penicillium italicum* and *P. digitatum in vitro*. In contrast, tea tree oil showed a lower effect at all concentration compared with another two oils treated. In contrast, Jobling (2000) reported that tree tea oil concentration between 100 and 500 ppm were able to prevent the growth of *B. cinerea in vitro*. The statistical analysis showed that the differences between oils, concentrations and the interaction between them were split plot highly significant.

Data in Table (2): show the effect of the tested concentrations of switch 62% on growth of *B. cinerea*. There is an inverse relationship between switch concentration and fungal growth since inhibition was 66.29, 78.62, 90.03 and 100% for the concentrations of 50, 150, 250 and 500 ppm respectively. This result is in harmony with the finding of Khafagi (1982) and Ellis *et al* (2008) reported that the fungicide switch 62% had protection effect against *B. cinerea* the causal agent of grey mold disease.

Table (1): Effect of various concentrations of some essential oils on the linear growth and spores germination of *B. cinerea*.

Treatment	Concentration (%) v/v	Linear growth (cm)	Inhibition (%)	Spore germination	Inhibition (%)
Clove oil	0	8.97	--	95.92	-
	0.25	5.47	39.02	50.70	47.14
	0.50	4.18	53.40	41.33	56,91
	1.00	3.00	66.56	28.96	69.81
	2.00	0.00	100.00	12.37	87.10
Thyme oil	0	8.67	-	96.33	-
	0.25	6.00	30.75	63.70	33.87
	0.50	5.33	38.85	53.33	44.64
	1.00	4.60	46.96	42.77	55.60
	2.00	3.00	65.40	25.67	73.36
Tea tree oil	0	8.6	-	96.33	-
	0.25	7.13	17.12	71.07	26.22
	0.50	6.06	29.52	60.00	37.71
	1.00	5.64	34.46	55.53	42.35
	2.00	4.31	49.84	35.13	63.53
L.S.D 0.05%	Oils (O) = 0.136 Concentration (C) = 0.175 O× C = 2.78			(O) = 0.79 (C) = 3.45 O × C = 2.00	

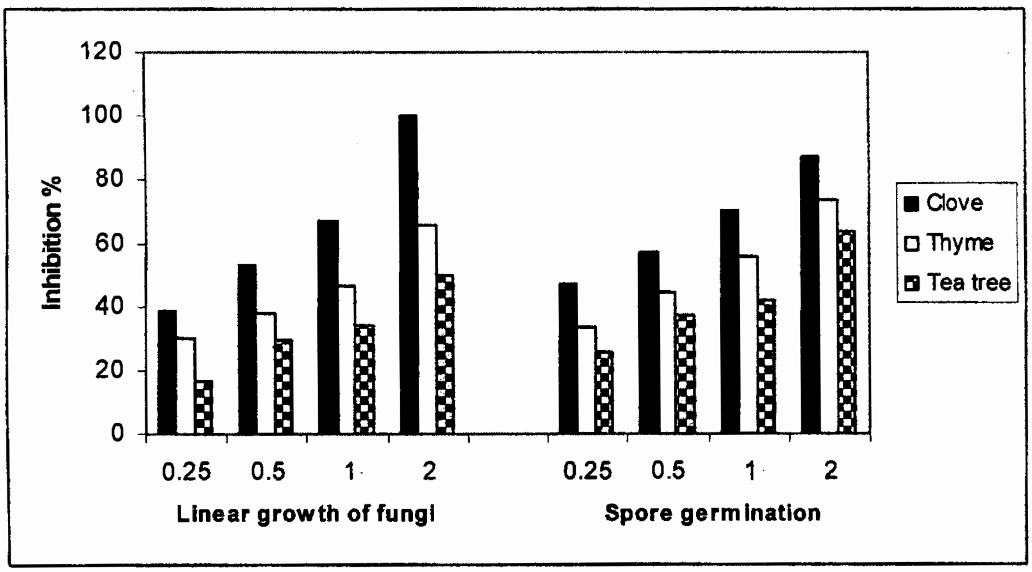


Fig. (1): Effect of different concentrations of some essential oils on linear growth and spore germination of *B. cinerea*.

Figure (2): Radial growth of *B. cinerea* after 7 days incubation with different concentrations of clove oil A: untreated control (zero oil), B: 0.25% treatment: The fungal colony is small, C and D: 0.5 and 1.0% treatments: little growth was observed, E: 2% treatment: completely inhibited and colony is unmeasurable.

Table (2): Effect of different concentrations of switch 64% on mycelium linear growth of *B. cinerea*.

Fungicide concentrations (ppm)	Mycelial growth (cm)	Inhibition (%)
0	8.9	--
50	3.00	66.29
150	1.90	78.65
250	0.89	90.00
500	0.00	100
L.S.D 0.05%	0.438	

In vivo treatments:

Effect of essential oils on natural infection:

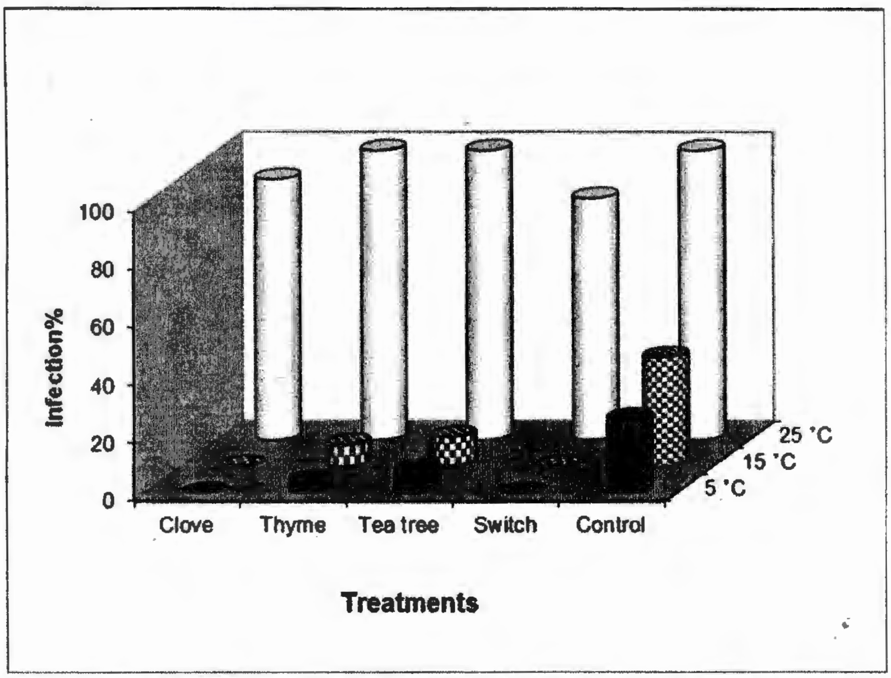
The effect of preharvest spray of some essential oils in reducing the natural infection of strawberry fruit rot stored at 5, 15 and 25°C. Table (3) and Figure (3and4) indicate that application of commercial fungicide switch 62% and 2% clove oil caused complete elimination (100%) of strawberry fruits rot after storage at 5°C and 15°C for 14 days. These findings are in agreement with the findings of Ellis *et al.* (2008) who mentioned that application of fungicides Elevate 50 WG and switch 62% WG to red raspberry. Results indicate that pre-harvest fungicide sprays are beneficial for controlling post-harvest fruit rot, especially when coupled with cold-temperature storage. Botrytis fruit rot is initiated in the field as flower infections (Bristow *et al.*, 1986), and fungicide treatments that protect flowers from infection by *B. cinerea* are essential to reduce postharvest disease (Wileox and Seem, 1994 and Blacharsk *et al.*, 2001). In addition, Anjum and Akhtar (2012) found that clove and cumin oils showed complete inhibition of *P. italicum* at concentrations of

24 and 48 µl/ml when applied on citrus fruits. From Table (4) it is clear that thyme and tree tea oils reduced percentage of infection with the averages of 4.25 and 8.00% after storage at 5°C and 7.67 and 10.38% after storage at 15°C, respectively. Control fruit treatment (water treatment) which stored at 5°C and 15°C had significantly higher percentages. Mark (2014) reported that thyme oil volatiles proved to be highly effective in reducing gray mold incidence in strawberry fruits. In addition, the sprayed treatments preceding harvest with switch 62% and clove oil had lowest effect in reducing infection percentage, after storage at 25°C for 14 day, respectively, compared to other treatments. While the thyme and tea tree oils applied preceding harvest had no effect on reducing the infection after storage at25°C. These results are in harmony with the findings of Hongyin *et al.* (2007) who suggested that the optimum temperature required for the development of *B. cinerea* fruit rot was 25 and 20°C, which rapidly infect the fruit tissues and increased the infection percentage.

Table (3): Effect of some essential oils and fungicide preharvest treatments on the control of natural infection with *B. cinerea* of Festival strawberry fruits, after storage at different degree of temperatures.

Treatment	5°C		15°C		25°C	
	I%	R%	I%	R%	I%	R%
Clove	0.00	100.00	0.00	100.00	90.00	16.67
Thyme	4.25	83.65	7.67	79.73	100.00	0.00
Tea tree Switch 65	8.00	69.23	10.38	72.56	100.00	0.00
Control	0.00	100	0.00	100.00	83.33	10.00
	26.00	-	37.83	-	100.00	-
L.S.D 0.05% Treatment (T) = 1.494		Temperature (C) = 1.157			T×C = 2.03	

I% = Infection percentages of rotted fruits R% = Reduction of control



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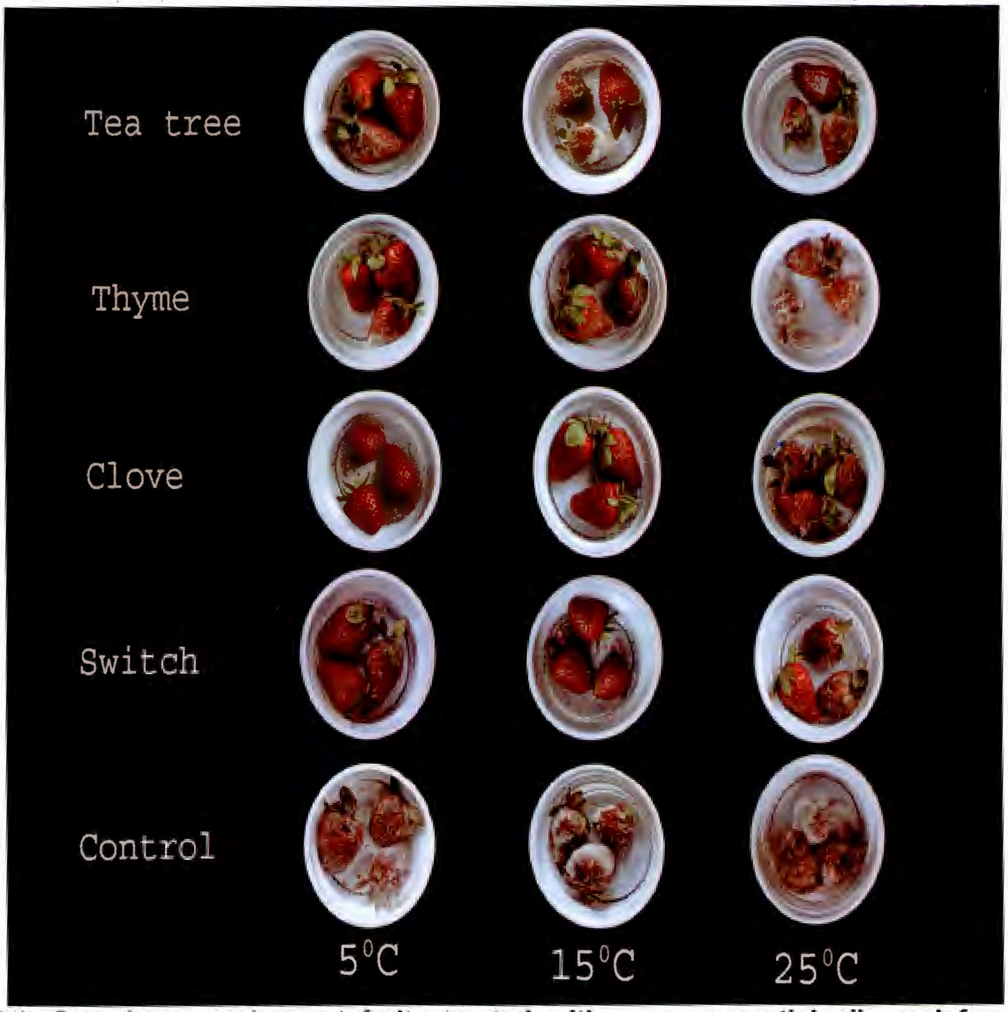

Fig. (4): Strawberry preharvest fruits treated with some essential oils and fungicide following storage at 5, 15 and 25°C for 14 days.

Effect of essential oils on artificially inoculated fruits:

Evaluation of some essential oils postharvested strawberry fruits sprayed with 2% of clove, thyme and tea tree oils. The sprayed fruits were artificially inoculated with a conidial suspension of *B. cinerea* and then kept at 5, 15 and 25°C for 14 days. Table (4) and Figure (5) showed that, the best treatments are postharvest fruits sprayed with clove and thyme oils (2%) significantly reduced percentage of fruit rot after storage at 5°C with the averages of 5.92 and 10.83 followed by their storage at 15°C with the averages of 8.23 and 25.43%, respectively. Tea tree oil treatment had greater infection fruit rot after storage at 5 and 15°C for 14 days. Abd-Alla *et al.* (2011) reported complete disease reduction produced by artificially infected banana with *Fusarium semitectum* producing crown rot disease incidence and severity when treated with cinnamon and thyme oils. In addition, Ibtesam *et al.* (2011) found that treated orange fruits 15 days before harvest and after harvest or only after harvest (natural and artificial infection of fruits) by thyme, lime and camphor oils at concentration of 10% (v/v) significantly reduced the disease severity of fruits stored at 5°C. While, non-significant difference was found between essential oils treatment after harvest (postharvest) and control (untreated) under artificially infected after storage at 25°C for

14 days. Generally, strawberry fruits treated with essential oils after storage at low temperature 5°C reduced the artificially or natural development of decay of strawberry and to less extent those stored at 15°C. These results may suggest that cold temperature being unsuitable for development and growth of pathogenic fungi. So, essential oils may have a control efficacy to reduce the infection percentage of Botrytis fruit rot of strawberry.

In conclusion, results show that some essential oils and switch 62% which used pre-harvest and post-harvest applications before beginning flower stage are beneficial for controlling Botrytis fruit rots of strawberry when combined with cold storage. So, essential oils can be used as a potential source of sustainable eco-friendly botanical fungicides after successful completion of wide range trials. Further investigations are needed.

Table (4): Effect of postharvest spraying essential oils on the control of grey fruit rot caused by *B. cinerea* in artificially inoculated Festival strawberry fruits, at different degree of temperatures in stores.

Treatment	5°C		15°C		25°C	
	I%	R%	I%	R%	I%	R%
Clove	5.92	90.13	8.23	88.70	100	0.00
Thyme	10.83	81.95	25.43	65.08	100	0.00
Tea tree	19.03	68.28	30.58	58.01	100	0.00
Control	60.00	-	72.83	-	100	-
L.S.D 0.05% Treatment (T) = 0.971	Temperature (C) = 0.841			T×C = 2.11		

I% = Infection percentages of rotted fruits R% = Reduction of control

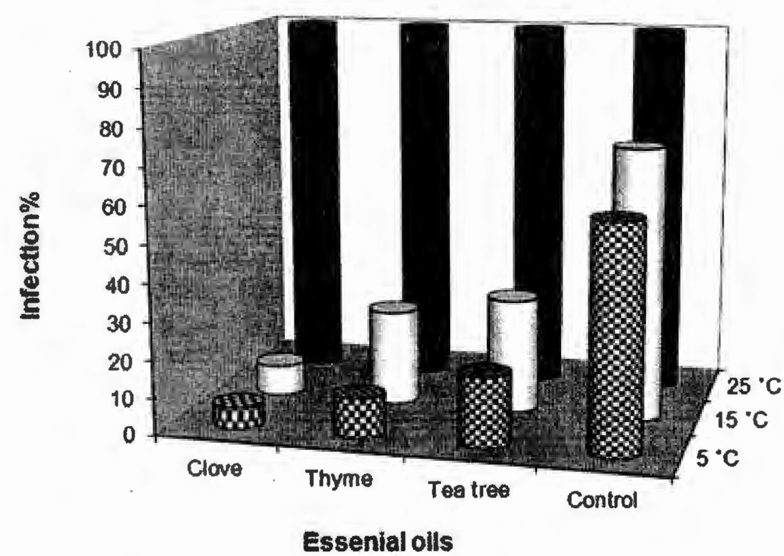

Fig. (5): Effect of postharvest spraying essential oils on the control of grey fruit rot caused by *B. cinerea* in artificially inoculated of Festival strawberry fruits at different degree of temperatures in stores.

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فاعلية المعاملة ببعض الزيوت النباتية قبل وبعد الحصاد والتخزين تحت درجات حرارة مختلفة لمكافحة عفن الثمار الرمادى فى الفراولة

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الملخص العربى

يعتبر محصول الفراولة فى الوقت الحالى أحد المحاصيل الإقتصادية الهامة حيث تستخدم ثمارة إما للإستهلاك المحلى أو بغرض تصديره للخارج. أجريت الدراسة لتقدير فاعلية زيت القرنفل وزيت الزعتر وزيت الشاى بالإضافة إلى المبيد الفطرى سويتش ٦٢% لمكافحة عفن الثمار الرمادى فى ثمار الفرولة بعد الحصاد. أثبتت النتائج المعملية أن التركيزات المستخدمة للزيوت النباتية من (صفر إلى ٢,٠ % حجم/حجم) والتركيزات المستخدمة للمبيد الفطرى سويتش ٦٢% من (صفر إلى ٥٠٠ جزء فى ألمليون) قللت النمو المسليومى للفطر وكذلك النسبة المئوية للإنبات الجراثيم الكونيدية للفطربوترايتس سنيريا. وجد أن زيت القرنفل بتركيز ٢% حجم/حجم والمبيد سويتش ٦٢% بتركيز ٥٠٠ جزء فى المليون قد أديا إلى تثبيط كامل للنمو السليومى للفطر. وكذلك أنقص زيت القرنفل النسبة المئوية للإنبات الكونيديات.عند التركيز الأعلى (٢ % حجم/حجم) . ويلية زيت الزعتر فقد خفض النمو السليومى للفطر وكذلك قلل نسبة إنبات الكونيديات وتراوحت هذة النسبة بين ٣٠.٧٥ إلى ٦٤,٤٠% لنمو السليومى و ٣٣,٨٦ إلى ٧٣,٣٦ % لإنبات الجراثيم على الترتيب. تم دراسة تأثير معاملة الثمار تحت ظروف العدوى

الطبيعية قبل الحصاد بالزيوت النباتية بتركيز ٢% والمبيد سويتش بالتركيز الموصى بة تجاريا وكذلك معاملة الثمار بعد الحصاد بالزيوت النباتية تحت ظروف العدوى الصناعية وذلك تحت ظروف تخزين مختلفة وجدت تأثيرات متباينة فى تقليل شدة الإصابة بأعفان الثمار. ووجد أن كل المعاملات قبل الحصاد بالزيوت النباتية والمبيد الفطرى قد قللت من النسبة المئوية لأعفان الثمار المتسبب عن فطر البوتريتس سينيريا تحت ظروف التخزين عند درجة ٥- ١٥° م لمدة ١٤ يوم. وجد أن رش المبيد الفطرى وزيت القرنفل قبل الحصاد قد أعطيا تثبيط كامل.فى نسبة أعفان الثمار وذلك تحت ظروف التخزين عند درجة ٥- ١٥° م. وكذلك وجد أن الثمار المعاملة بزيت القرنفل والزعتر بعد الحصاد وتحت ظروف العدوى الصناعية بالفطر البوتريتس سينيريا قلل نسبة للإصابة إلى ٥,٩٢ و١٠,٨٣ % مقارنة بالثمار المعدية بالفطر المسبب فقط (٦٠%) على الترتيب. وذلك تحت ظروف التخزين عند درجة ٥° م لمدة ١٤ يوم. وجد أنة تحت ظروف العدوى الصناعية بعد الحصاد وعند التخزين على درجة ٢٥° م لا يوجد فروق معنوية بين المعاملات المستخدمة. بصفة عامة وجد أن معاملة الثماربعض الزيوت النباتية أو المبيد سويتش (فبل الحصاد أو بعد الحصاد) تقلل النسبة المئوية لعفن الثمار المتسبب عن فطر البوترايتس سنيريا لثمار الفراولة وذلك تحت ظروف التخزين عند درجة٥- ١٥° م لمدة ١٤ يوم.