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ANTIFUNGAL ACTIVITY OF SOME ESSENTIAL OILS AGAINST POST-HARVEST FRUIT ROT OF SWEET PEPPER

Amira M. Tawfik[1], Sayed E. Younis; Ali M. Koriem and M. I. Elian
Department of Plant Production, Faculty of Technology & Development, Zagazig University, Egypt.
Corresponding author E-mail: amt2222@yahoo.com Mobile: +201062951792

ABSTRACT

A laboratory experiment was conducted using some essential oils, i.e., Eucalyptus globulus, Eugenia caryophyllata, Cinnamomum cassia and Zingiber officinale to study their effects at different concentrations (1, 2, 3, 4% v/v) on the radial growth and spore germinations of, Ulocladium chartarum, Aspargillus niger , Fusarium semitectum and Geotrichum candidum , which were Isolated and identified of postharvest rots pepper fruits obtained from local markets using potato dextrose agar. The obtained results generally indicated that the tested essential oils significantly inhibit growth of the tested fungi. Eugenia caryophyllata oil was the most effective one, followed by Eucalyptus globulus of all tested concentrations, flowed by Cinnamomum cassia and Zingiber officinale oils at high concentrations. Moreover, some of the tested fungi were affected by all used essential oils, while Aspargillus niger was the most resistant fungi.

Conclusively; *it could be concluded that the tested essential oils were effectively inhibited the growth of the tested fungi that cause postharvest fruit rot diseases of sweet pepper at different concentrations tested (1, 2, 3, 4%).*

Keywords: Essential oil, postharvest, pepper, fungi.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) is one of the most important vegetable crops (Berke, 2002). Nevertheless, it is a very perishable vegetable with a short shelf life and high susceptibility to fungal diseases (Hardenburg *et al.*, 1990), and popular vegetable crops are grown for both local consumption and exportation. Peppers contain a nutrient list of plant nutrient that is found to have disease preventing and health-promoting properties (Howard *et al.*, 2000) because peppers contain phytochemicals which assist in the prevention of

cancer, stroke and other diseases when consumed in diets (Ademoyegun *et al.*, 2011). Moreover, pepper is essential as a food, medicinal and industrial crop (Ashilenje, 2013).

In a related context, pepper fruits commonly encounter postharvest problems, such as quality degradation, chilling injury when stored below 7ºCand shriveling associated with rapid loss of weight (Maalekuu *et al.*, 2002; Meir *et al.*, 1996; Paull, 1990; Smith *et al.*, 2006). Previous investigators showed that sweet peppers are harvested at the mature green stage and storage at 7.5ºCor above is recommended to minimize the risk of chilling injury (Kader, 2002; Lin, 2005; Meir *et al.*, 1996). This may be because a chilling injury occurs at lower temperatures and decay was higher at 10ºC (Lin, 2005).

Moreover, sweet pepper is one of the most important extracts from the pepper is also used as a botanical pesticide for the control of insect pests and diseases of economic crops in organic farming systems. Peppers are used in pickles, for flavoring sauces and in canned products. They are also used for confectionery products like bread, meat pie, and burger. The fungal pathogens of postharvest rots of pepper were carried out on rotted pepper fruits obtained from markets using potato dextrose agar. *Aspergillus niger* was frequently isolated with 34.7%, followed by *Aspergillus flavus*, *Botrytis cinerea*, *Colletotrichum* capsici and *Phytophthora capsici* with 21.3%, 20%, 10% and 10.7% respectively (Sarkhosh *et al.*, 2017). On the other hand, essential oils are promising alternative compounds which have an inhibitory activity on the growth of pathogens. Essential oils could be used in plant disease control as the main or as adjuvant antimicrobial compounds (Kaur & Arora, 1999). It established that some plants contain compounds able to inhibit microbial growth (Naqui *et al.*, 1994).

Essential oils are gaining popularity and drawing the attention of scientists around the world cause to their biodegradable, eco-friendly, economical and safe properties. Vaughn & Spencer (1991) and Caccioni & Guizzardi (1994, (Macias *et al.*, (1997). reported that the essential oils exhibit antimicrobial, allelopathic, antioxidant and bio-regulatory properties. Therefore essential oils can be ideal candidates for use as pesticides Also, Wilson *et al.* (1997a, b), Meepagala *et al.* (2002) and Imelouane *et al.* (2009) mentioned that the essential oils obtained from different plants and have indicated fungicidal properties. It suppressed fungal growth and development *in vitro* and *in vivo* in different fresh produce. Also, it being safer for the environment than synthetic fungicides.

Several essential oils currently in use, are approved by the FDA as flavoring agents, and also were widely used in the food industry. Their FDA-approved status and their wide availability have facilitated the rapid commercialization of essential oils-based pesticides (pests and insects). Koul *et al.* (2008) confirmed that the continuous application of synthetic fungicides could cause resistance to developing in fungal strains while it is likely that the resistance will develop more slowly during the application of bio-based essential oils because of the composition of the different chemical components that characterize these oils.

Besides, the Essential oils contain compositions of terpenes, sesquiterpenes,, ketones and phenolic components . Thyme oil was reported to exhibit 100% control of *B. cinerea*, *Rhizopus stolonifer*, *Alternaria alternata* (Plotto *et al.,* 2003) and *C. gloeosporioides*, (Sellamuthu *et al.,* 2013) during *in vitro* tests. 'Satsuma' mandarins inoculated with *Geotrichum citri-aurantii* and treated with thyme oil reduced the incidence of sour rot to 14.1%, whereas the untreated control fruit revealed an incidence of 78.1%. In naturally infected fruit, thyme oil reduced the decay by 76% after 30 days at 20ºC. *In vitro* tests also revealed that cinnamon oil effectively controlled *C. gloeosporioides* in bananas (Maqbool *et al.,* 2010).

Therefore, the objectives of this study were to evaluate the effects of antifungal activity of some essential oils against post-harvest fruit rot of pepper (*Capsicum annuum* L.) and evaluate their effects on the development and suppression of this pepper fruits rot diseases.

MATERIALS AND METHODS

1. Fungal isolate

The isolates of *Ulocladium chartarum, Aspargillus Niger, Fusarium semitectum and Geotrichum candidum* were obtained from an infected sweet pepper fruit and cultured on potato dextrose agar. The identification was confirmed by the Department of Disease Survey and Mycology, Plant Pathology Institute, Agricultural Research Center, Giza, Egypt.

2. Pathogenicity test

To test the pathogenicity of various fungi isolated, the approach of Balogun *et al.* (2005) was employed. Healthy matured pepper fruits, California wonder, Bravo 'Triple 4' Capino and Cadia were surfaced sterilized with 0.5% sodium hypochlorite for 30 seconds and then rinsed in three changes of sterile distilled water. With a 5mm diameter flame sterilized corn

borer, cylindrical cores were removed from each fruit then inoculated aseptically with 5mm diameter disc from the edge of 7day–old fungal culture of the tested isolate. Vaseline jelly was smeared to completely seal the surface of each of the inoculated pepper fruit to prevent external infection before incubating for 10 days, three replicates were used. The controls were inoculated with the disc of solidified potato dextrose agar media.. Rot symptoms developed with different fungal isolates were compared to the natural original rot. The pathogens were re–isolated and identified using the same procedures described above.

3. ***Estimation of rot severity***

Observation for the level of fungal growth and fruit rot was made daily for 10 days and results were recorded, as percentage rot severity according to adopting the method of Balogun *et al.,* (2005). In this study, a fungus was considered pathogenic on the fruit if new mycelia emerged and extended radially and upwards from the originally inoculated disc and became visible outside the original wound hole on the fruit surface thereby causing fruit rot. On this basis, growth and pathogenicity were rated as follows; low (rot covered less than 25% of the fruit surface); medium (covered 25– 50% of the fruit surface); high (51– 75% covered) and very high (covered 75% and above). Percentage of rot severity was determined using the formula below.

4. Essential oils

Essential oils (Table 1) of *Eucalyptus globulus, Eugenia caryophyllata, Cinnamomum cassia* and *Zingiber officinale* were purchased from International Flavors and Plant oils Inc., Giza, Egypt, and from Delta Aromatic Co., Cairo, Egypt. These essential oils were stored in dark bottles at 4ºC for further studies.

Table (1): Essential oils and their source p plants used to control sweet peppers fruit rot fungal disease.

Scientific name	Family	Common name	Tissue type
Eucalyptus globulus Labill	Myrtaceae	Eucalyptus	Leaves
Eugenia caryophyllata Thunb	Myrtaceae	Clove	Flower buds
Cinnamomum cassia (Nees& T. Nees)	Lauraceae	Cinnamon	Dried bark
Zingiber officinale Roscoe	Zingiberaceae	Ginger	Rhizome

5. Effect of essential oils on fungal growth

The essential oils, *i.e., Eucalyptus globulus, Eugenia caryophyllata, Cinnamomum cassia* and *Zingiber officinale* at different concentrations (1%, 2%, 3% and 4%. v/v) were evaluated for their inhibitory effect on fungal radial growth, through *in vitro*. Emulsified stocks at high concentrations of tested essential oils were prepared by dissolving in sterilized distilled water. A few drops of the emulsifier Tween 20 (Sigma Co.) were added to the essential oil volumes to obtain an emulsion feature.

Different volumes of the essential oil emulsion were added to conical flasks containing 100 ml of sterilized potato dextrose agar media before solidification, to obtain the proposed concentrations. The supplemented media were poured into Petri plates (10 cm Ø) about 20 ml each. Then plates were individually inoculated at the center with equal disks (5 mm Ø) of 10–days old culture of the tested fungi. A set of inoculated plates free of tested essential oils used as controls. Five plates were used as replicates for each particular treatment. Inoculated plates were incubated at 25 – 28 ^{oo}C±1^{o}. The average linear growth of fungi tested was calculated when controls reached full growth.

6. Effect of essential oils on spore germination:

Spore suspensions of each pathogen (1 ml; 9X 105 spore /ml) were placed in micro-tubes containing 5 ml of potato dextrose broth amended with test salt or un-amended (control). The pH of potato dextrose broth varied with the salt used and was not changed unless stated otherwise. Micro-tubes were incubated at 24 °C for one day. The germination of spores was determined using a hemocytometer. Spores with germ tubes at least half the length of the spore was considered as germinated. Inhibition of spore germination was calculated as follows:

$$\mathbf{ISG} = \frac{\text{control spore germination} - \text{salt amended spore germination}}{\text{control spore germination}} \times 100 \; [Eq.2]$$

Three replicates were used.

7. Statistical analysis:

Statistical analyses of all experimental data were done using the statistical software SAS package, all comparisons were first subjected to one–way analysis of variance (ANOVA).

Significant differences between treatment means was determined using Duncan's multiple range test at P <0.05 as the level of the significance (Duncan, 1955).

RESULTS AND DISCUSSION

The obtained result as shown in Table 2 illustrates that test of the pathogenicity of the fungus post the inoculation process during several different days. Data indicated that the process of pathogenicity test was more effective at seven and ten days post inoculation with all tested fungi except with *Geotrichum candidum*.

Data presented in Table 3 indicated a significant effects of *Eucalyptus globulus* oil on the radial growth of all tested fungi when used at concentrations of 3 and 4%, and its effects were clear on the growth of Geotrichum *candidum* and *Aspergillus niger* . While the *Eugenia caryophyllata* oil significantly reduced the radial growth of all tested fungi. *Cinnamomun cassia* oil at 4% was effective on radial growth of *Geotrichum candidum* and *Aspergillus niger*, but *Zingiber officinale* had a relatively limited effect compared to other oils tested. *Geotrichum candidum* was the most affected fungi. The obtained results in Table 4 indicated that the most effective oil in inhabited radial growth of the tested fungi was *Eugenia caryophyllata* oil because it completely inhibited growth of all tested fungi compared to the control treatment.

The spore germination of the studied fungi was affected by the *Eucalyptus globulus* oil (Table 5) at concentrations of 3 and 4% compared to the lower concentrations, while the *Eugenia caryophyllata* oil completely inhibited spore germination of fungi tested with all used concentrations. In contrast, *Cinnamomun cassia* and *Zingiber officinale* oils had a relatively limited effect on spore germination compared to the control treatment. Moreover, the obtained results in Table 6 indicated that inhibition percentage of spore germination of the studied fungi. *Eugenia caryophyllata* oil in all its concentrations was the most effective, followed by Eucalyptus *globulus* oil with a concentration of 3 and 4%, and *Cinnamomun cassia* oil at 4%, .*Zingiber officinale* oil has an effective impact but it is relatively limited compared to other studied oils.

Results of the statistical analysis presented in Table **7** indicated the effect used oils at concentrations of 1, 2, 3 and 4% in had a clear significant effects on inhibition growth of tested fungi, especially the higher effect of *Eugenia caryophyllata* oil, followed by *Eucalyptus globulus* oil, and the weakest of them is of *Zingiber officinale* oil. On the other side, results of the

concentrations of used oils presented in the same table for the statistical analysis indicated that the higher concentration of these oils is the most

Table (2): Pathogenicity test of the isolated fungi on sweet pepper fruits after 3, 7 and 10 days.

Fungi isolated	severity % of infected rot after different periods (days)								
	Three days		Seven days		Ten days		mean		Grand mean
	R	Y	R	Y	R	Y	R	Y	
A. niger	57.00	54.28	85.71	88.84	95.00	100.00	79.23	81.04	**80.13**
U. chartarum	40.00	57.14	80.28	82.85	100.00	100.00	73.42	79.99	**76.70**
F. semitectum	35.71	25.15	78.57	57.13	80.71	80.25	66.66	57.17	**61.91**
G. candidum	25.71	22.10	30.00	26.71	35.78	30.14	30.49	26.33	**28.41**
Control	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00	**00.00**
Mean	**39.60**	**39.66**	**68.64**	**63.88**	**77.87**	**77.68**	**62.45**	**61.13**	
Grand mean	**39.63**		**66.26**		**77.77**				

*R; Red fruit., *Y; Yellow fruits.

Table (3): The interaction effect among fungi, oils source and oil concentrations on the radial growth of the tested fungi.

Fungi	*Eucalyptus globulus* (%)				*Eugenia caryophyllata* (%)				*Cinnamomun cassia* (%)				*Zingiber officinale* (%)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Ulocladioum chartarum	2.267	1.233	0.466	0.000	0.000	0.000	0.000	0.000	3.266	2.266	1.700	0.866	6.766	5.366	4.166	3.333
Aspergillus niger	1.500	1.000	0.000	0.000	0.000	0.000	0.000	0.000	2.266	2.000	0.533	0.000	5.166	3.133	2.233	1.300
Fusarium semitectum	2.633	1.333	0.700	0.000	0.000	0.000	0.000	0.000	4.266	3.366	2.233	0.000	6.433	5.366	3.366	2.166
Geotrichum candidum	1.333	0.466	0.000	0.000	0.000	0.000	0.000	0.000	1.466	1.000	0.000	0.000	2.666	2.200	1.333	1.000
Control	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000	9.000

Table (4): The interaction effect among fungi, oils source and oil concentrations on % inhibition of radial growth of the tested fungi.

Fungi	*Eucalyptus globulus* (%)				*Eugenia caryophyllata* (%)				*Cinnamomun cassia* (%)				*Zingiber officinale* (%)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Ulocladioum chartarum	74.81	86.29	94.81	100.0	100.0	100.0	100.0	100.0	63.70	74.18	81.11	90.37	24.81	40.36	53.70	62.96
Aspergillus niger	83.33	88.88	100.00	100.0	100.0	100.0	100.0	100.0	74.81	77.77	94.07	100.00	42.59	65.18	75.18	85.55
Fusarium semitectum	70.73	85.18	92.22	100.0	100.0	100.0	100.0	100.0	52.59	62.59	75.18	100.00	28.51	40.36	62.59	75.92
Geotrichum candidum	85.18	94.81	100.00	100.0	100.0	100.0	100.0	100.0	83.70	88.88	100.00	100.00	70.37	75.55	85.18	88.88
Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table (5): The interaction effect among fungi, oils source and oil concentrations on spore germinations of the tested fungi.

Fungi	*Eucalyptus globulus* (%)				*Eugenia caryophyllata* (%)				*Cinnamomun cassia* (%)				*Zingiber officinale* (%)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Thielaviopsis chartarum	22.33	14.00	0.00	0.00	0.00	0.00	0.00	0.00	13.33	10.67	0.00	0.00	81.67	72.67	64.33	53.33
Aspergillus niger	11.67	6.33	0.00	0.00	0.00	0.00	0.00	0.00	24.33	17.67	10.00	0.00	75.67	64.67	48.33	43.33
Fusarium semitectum	27.33	17.33	0.00	0.00	0.00	0.00	0.00	0.00	38.33	31.00	17.33	0.00	82.67	73.00	61.67	51.67
Geotrichum candidum	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.33	19.33	0.00	0.00	51.67	43.33	33.67	20.00
Control	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table (6): The interaction effect among fungi, oils source and oil concentrations on % spore germinations of fungi.

Fungi	*Eucalyptus globulus* (%)				*Eugenia caryophyllata* (%)				*Cinnamomun cassia* (%)				*Zingiber officinale* (%)			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Thielaviopsis chartarum	77.67	86.00	100.00	100.00	100.00	100.00	100.00	100.00	86.67	89.33	100.00	100.00	18.33	27.33	35.67	46.67
Aspergillus niger	88.33	93.66	100.00	100.00	100.00	100.00	100.00	100.00	75.67	82.33	90.00	100.00	24.33	35.33	51.67	56.67
Fusarium semitectum	72.66	82.66	100.00	100.00	100.00	100.00	100.00	100.00	61.67	69.00	82.67	100.00	17.33	27.00	38.33	48.33
Geotrichum candidum	94.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	72.67	80.67	100.00	100.00	48.33	56.67	66.33	80.00
Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table (7): Effect of the tested essential oils and with different concentrations on the radial growth of the tested fungi, inhibition the radial growth% of fungi, spore germination and inhibition of spore germination % of the studied fungi.

Treatments	Radial growth of fungi	Inhibition radial growth of fungi %	Spore germination	Inhibition of spore germination of fungi (%)
Fungi (A)				
Ulocladium chartarum	1.981[a]	77.983[d]	20.771[b]	79.229[c]
Aspergillus niger	1.196[c]	86.710[b]	18.875[c]	81.125[b]
Fusarium semitectum	1.992[ab]	77.868[c]	25.021[a]	74.979[d]
Geotrichum candidum	0.717[d]	92.034[a]	12.583[d]	87.417[a]
LSD (0.05)	**0.052**	**0.573**	**0.665**	**0.665**
Oils (B)				
Eucalyptus globulus (Eucalyptus)	0.808[c]	91.015[b]	6.563[c]	93.438[b]
Eugenia caryophyllata (Clove)	0.000[d]	100.000[a]	0.000[d]	100.000[a]
Cinnamomun cassia (Cinnamon)	1.577[b]	82.474[c]	13.083[b]	86.917[c]
Zingiber officinale (Ginger)	3.500[a]	61.106[d]	57.604[a]	42.396[d]
LSD (0.05)	**0.052**	**0.573**	**0.665**	**0.665**
Concentrations (C)				
1%	2.502[a]	72.196[d]	28.896[a]	71.104[d]
2%	1.796[b]	80.042[c]	23.125[b]	76.875[c]
3%	1.046[c]	88.378[b]	14.708[c]	85.292[b]
4%	0.542[d]	93.980[a]	10.521[d]	89.479[a]
LSD (0.05)	**0.052**	**0.573**	**0.665**	**0.665**
Interactions				
A × B	**	**	**	**
A × C	**	**	**	**
B × C	**	**	**	**
A × B × C	**	**	**	**
***LSD of interactions*:**				
A×B =	0.1732	1.9235	1.1170	1.11705
A×C =	0.8384	9.3156	4.8506	4.8506
B×C =	1.7703	19.671	17.1345	17.1345
A×B×C =	0.9062	10.0714	10.9033	10.9033

** P < 0.01

effective on inhibition of radial growth of fungi. The interaction among studied factors, results of the statistical analysis indicated to a significant interaction relationship among the studied factors, and all these interactions were significant. Based on the obtained results, it can be concluded that the used oils have important effect in inhibiting the growth and spores ermination of fungi, especially *Eugenia caryophyllata* oil, *Eucalyptus globulus* at all used concentrations, and 4 %concentration of the *Cinnamomun cassia* and *Zingiber officinale* oil were the most effective.

Similar results with Sarkhosh *et al.* (2017) who indicated that *Cinnamomun cassia* oil completely inhibited the mycelial growth of some fungi *i.e., F. solani* at a concentration of 0.1%, and the highest concentration applied (0.15%) completely inhibited growth of *P. palmivora*. It also observed that cinnamon oil inhibited growth of *Botryosphaeria* spp. and *C. gloeosporioides* substantially. Also broad–spectrum anti–fungal activity and control of late leaf spot and crown rot in peanut, of *Cinnamomun cassia* oil was foun. It inhibited *in vitro* spore germination of the *Cercospora arachidicola*, *Phaeoisariopsis personata*, and *Puccinia arachidis* and reduced the incidence of crown rot caused by *Aspergillus niger* (Kishore & Pande 2007). *Cinnamomun cassia* oil applied in its volatile form also inhibited conidial germination of *C. gloeosporioides in vitro* and reduced the lesion diameter on inoculated pepper fruits (Hong *et al.,* 2015). Similarly, Moghaddam *et al.* (2013) found that essential oil from the many species, tested on three different fungus species from those that we tested, was most effective for inhibiting in vitro mycelial growth at a concentration 0.16%. In Sarkhosh *et al.,* (2017) found, some essential oil was primarily composed of these two chemical compounds, collectively representing 69.9% of the chemical constituents. Zambonelli *et al.* (1996) found that mint essential oil was most effective inhibiting mycelial growth of several fungi, including *F. solani* at a concentration of 0.16% in vitro.

It can attribute the increase of inhibition% of both radial growth and spore germination of tested fungi to the concentration of active components in the essential oils and their chemical structure are responsible for the aroma and antimicrobial activities in pepper's fruit. Because the essential oils yield greater antibacterial activity than their major constituents when separately tested (Burt, 2004). Moreover, the essential oils inhibit postharvest pathogens mainly due to their direct effect on the mycelial growth of the pathogens and

spore germination by affecting the cellular metabolism of these pathogens (Serrano *et al.,* 2005; Tzortzakis, 2007a, b; Regnier *et al.,* 2010).

CONCLUSION

Based on obtained results, it can be concluded indicated that the tested essential oils had significant effects on the growth of studied fungi and the more effective of oils was *Eugenia caryophyllata* oil, then *Eucalyptus globulus* in all their concentrations, while *Cinnamomum cassia* and *Zingiber officinale* oils had a clear effective effect but, only at high concentrations of its. Moreover, *Aspargillus niger* relatively was more resistant compared to other ones.

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التأثير المضاد لبعض الزيوت على فطريات أعفان ما بعد الحصاد لثمار الفلفل

أميرة توفيق، علي كريم، سيد يونس، محمد عليان
قسم الانتاج النباتى – كلية التكنولوجيا والتنمية – جامعة الزقازيق - مصر

أجريت تجربة معملية باستخدام بعض الزيوت مثل زيت الكافور *Eucalyptus globulus*، وزيت القرنفل *Eugenia caryophyllata*، وزيت القرفه *Cinnamomun cassia*، وزيت الزنجبيل *Zingiber officinale* بتركيزات 1 ، 2 ، 3 ، 4٪ (حجم/حجم)، وذلك لدراسة تأثير تلك الزيوت على نمو وإنبات جراثيم الفطريات االتى تم عزلها وتعريفها وهي فطر *Ulocladium chartarum* وفطر *Aspargillus niger* وفطر *Fusarium semitectum* وفطر *Geotrichum candidum*. وقد تم

عُزلتتعريف تلك الفطريات من ثمار فلفل مصابة بالأعفان بعد الحصاد ، و التي تم الحصول عليها من الأسواق. وقد تم العزل استخدام بيئة تحتوى على الأجاروالدكستروز والبطاطس. وقد اظهرت النتائج التي تم الحصول عليها بشكل عام إلى أن هذه الزيوت المختبرة كان لها تأثير معنوي في تثبيط نمو الفطريات المختبرة. وكانت الزيوت الأكثر فاعلية هي زيت القرنفل *Eugenia caryophyllata* ، ثم زيت الكافور *Eucalyptus globulus* بجميع تركيزاتها ، بينما كان لزيت القرفة *Cinnamomum cassia* والزنجيل Zingiber officinale تأثير واضح مع التركيزات العالية فقط. علاوة على ذلك ، تأثرت بعض الفطريات المختبرة بجميع الزيوت المستخدمة، وكان أكثر الفطريات مقاومة هو *Aspargillus niger*.

التوصية: من النتائج السابقة نوصى باستخدام الزيوت العطرية كان فعالاً في تثبيط نمو الفطريات المسببة لأعفان ما بعد الحصاد للفلفل الحلو بتركيزات 1، 2، 3، 4٪ من هذه الزيوت.

الكلمات الدالة: زيت النباتية ، ما بعد الحصاد. اعفان الثمار. الفلفل.