

# IN VITRO ANTIFUNGAL ACTIVITY OF ESSENTIAL OILS ON GROWTH OF PHYTOPATHOGENIC FUNGI

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## SUMMARY

**Eleven essential oils (clove, rosemary, cinnamon leaf, sage, scots pine, neroli, peppermint, aniseed, caraway, lavender, common thyme) were tested for in vitro antifungal activity on twelve plant pathogenic fungi (*Fusarium graminearum*, *F. verticillioides*, *F. subglutinans*, *F. oxysporum*, *F. avenaceum*, *Diaporthe helianthi*, *Diaporthe phaseolorum* var. *caulivora*, *Phomopsis longicolla*, *P. viticola*, *Helminthosporium sativum*, *Colletotrichum coccodes*, *Thanatephorus cucumeris*). The results indicated that all oils except scots pine and neroli had antifungal activity against some or all tested fungi. The best antifungal activity had common thyme, cinnamon leaf, clove and aniseed oils. When compared to control, scots pine, neroli and sage oils stimulated mycelium growth of some investigated fungi.**

**Key-words: essential oil, inhibition, plant disease, mycelial growth**

## INTRODUCTION

More than 1300 plant species are known to be potential sources of antimicrobial components but only some of them have been studied scientifically (Wilkins and Board, 1989, Paster et al., 1990.). For instance, some previous studies evaluated the inhibitory activity of essential oils on fungi. Cardwell and Dongo (1994) tested extracts from nine plant species on mycelial growth of *Apergillus flavus* L.; Manohar et al. (2001) researched origano commercial oil against *Candida albicans* (Robin) Berkhout; Marin et al. (2004) tested cinnamon, clove, oregano, palmarosa and lemongrass oils against *Fusarium graminearum* Schw., Hadizadeh et al. (2009) analyzed antifungal potential of five essential oils against *Alternaria alternata* (Fr.) Keissl. Burgiel and Smaglowski (2008) described complete growth inhibition of *Fusarium culmorum* (W.G. Smith) Sacc. and *B. cinerea* on media with a 0.5% addition of tea tree oil. In addition, some studies reported positive effect of essential oils in reducing mycotoxin accumulation in maize grain (Marin et al. 2004, Velluti et al. 2004).

The aim of this research was to test in vitro the effect of 11 commercial essential oils on mycelial growth of 12 plant pathogenic fungi.

## MATERIAL AND METHODS

The effect of clove (*Eugenia caryophyllus* (Sprengel) Bullock & Harr.), rosemary (*Rosmarinus officinalis* L.), cinnamon leaf (*Cinnamomum verum* Presl.), sage (*Salvia officinalis* L.), scots pine (*Pinus sylvestris* L.), neroli (*Citrus aurantium* L. ssp. *amara* Engl.), peppermint (*Mentha piperita* L.), aniseed (*Pimpinella anisum* L.), caraway (*Carum carvi* L.), lavender (*Lavandula angustifolia* Mill. ssp. *angustifolia*) and common thyme (*Thymus vulgaris* L.) oils on growth of *F. graminearum*, *Fusarium verticillioides* (Sacc.) Nirenberg, *Fusarium subglutinans* (Wollenw. & Reink.) Nelson, Toussoun & Marasas, *Fusarium oxysporum* Schlecht. emend Snyder and Hansen, *Fusarium avenaceum* Fr. Sacc., *Diaporthe helianthi* Munt.-Cvet. et al., *Diaporthe phaseolorum* var. *caulivora* (Lehman) Wehmeyer, *Phomopsis longicolla* Hobbs., *Phomopsis viticola* (Sacc.) Sacc., *Helminthosporium sativum* Pamm., King and Bakke, *Colletotrichum coccodes* (Wallr.) Hughes and *Thanatephorus cucumeris* (Frank) Donk was evaluated. Fungi were isolated from wheat grains (*F. graminearum*, *F. avenaceum*, *H. sati-*

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vum), maize stalks (*F. verticillioides*, *F. subglutinans*, *F. oxysporum*), sunflower stalks (*D. helianthi*), soybean stalks (*D. phaseolorum* var. *caulivora*), soybean grains (*P. longicolla*), grape canes (*P. viticola*), common bean roots (*T. cucumeris*) and *Abutilon theophrasti* Med. roots (*C. coccodes*). The essential oils were produced in Pranarom International (Belgium) and analysed in Pranarom laboratory by GC-MC (gas chromatography-mass spectrometry). Antifungal assays were carried out in vitro according to Saikia et al. (2001). A 5-mm diameter sterilized filter paper disc was placed in the center of Petri dish (9 cm diameter) with PDA and loaded with 5 µl of essential oil. Four discs (5 mm diameter) of mycelial plugs were cross placed into each Petri dish. Petri dishes were kept in thermostat at 22°C and for 12/12 h light/dark regime. The inhibition zones around the paper

disc were measured after eight days as the distance from the margin of the colony to the filter paper. The experiment was performed in four replications. Research results were analyzed statistically by ANOVA and LSD using Statistica for Windows version 9.

## RESULTS AND DISCUSSION

The inhibitory effect of twelve essential oils against some economically important plant pathogenic fungi are shown in Table 1. Our research showed that all investigated oils except scots pine and neroli had antifungal activity against some or all researched fungi. The highest degree of antifungal activity showed common thyme oil followed by cinnamon leaf oil (Photo 1), clove oil and aniseed oil.

**Table 1. Inhibition zone (mm) eight days after inoculation**

Tablica 1. Zona inhibicije (mm) osam dana nakon inokulacije

|                             | DPC   | PV    | DH    | PL    | HS    | CC    | TC   | FO    | FA    | FG    | FS    | FV    |
|-----------------------------|-------|-------|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|
| Clove/ klinčičevac          | 23.06 | 27.13 | 26.38 | 20.75 | 21.63 | 23.25 | 0    | 16.70 | 8.50  | 0     | 7.81  | 10.50 |
| Rosemary/ ružmarin          | 0.56  | 7.50  | 10.13 | 0     | 12.25 | 9.75  | 0    | 0     | 0     | 0     | 1.19  | 0     |
| Cinnamon leaf / list cimeta | 18.56 | 32.31 | 28.06 | 22.82 | 18.38 | 22.25 | 0    | 16.80 | 8.80  | 0     | 7.00  | 8.50  |
| Sage/ kadulja               | 1.75  | 8.88  | 2.94  | 0     | 4.44  | 11.90 | 0    | 0     | 0     | 0     | 0.88  | 4.44  |
| Scots pine/ bor             | 0.63  | 10.50 | 4.06  | 0     | 3.94  | 8.31  | 0    | 0     | 0     | 0     | 1.13  | 0     |
| Neroli/ gorka naranča       | 1.06  | 7.31  | 4.94  | 0.56  | 17.25 | 8.19  | 0    | 0     | 0     | 0     | 0.50  | 0     |
| Peppermint/ metvica         | 1.63  | 18.75 | 11.31 | 0     | 9.50  | 12.75 | 0    | 9.80  | 0     | 3.25  | 4.00  | 8.06  |
| Aniseed/ anis               | 6.06  | 17.69 | 16.75 | 11.69 | 19.38 | 21.44 | 2.63 | 17.20 | 25.00 | 0     | 8.88  | 8.63  |
| Caraway/ kim                | 1.00  | 17.75 | 17.69 | 0.38  | 17.50 | 14.38 | 0    | 4.70  | 0     | 0     | 6.31  | 3.69  |
| Lavander/ lavanda           | 1.63  | 14.50 | 10.31 | 1.31  | 3.56  | 10.94 | 0    | 0     | 0     | 0     | 0.81  | 1.81  |
| Common thyme/ timijan       | 35.00 | 35.00 | 35.00 | 34.38 | 29.31 | 31.50 | 0    | 24.50 | 16.00 | 24.38 | 26.00 | 24.38 |
| Control/ kontrola           | 0.31  | 8.25  | 10.88 | 0     | 0     | 1.50  | 0    | 0     | 0     | 0     | 8.06  | 0     |
| LSD 0.05                    | 2.50  | 3.51  | 3.48  | 2.02  | 1.09  | 2.22  | 1.73 | 1.90  | 1.10  | 3.44  | 3.13  | 1.10  |
| 0.01                        | 3.29  | 4.61  | 4.57  | 2.65  | 1.43  | 1.43  | 2.28 | 2.60  | 1.40  | 4.52  | 4.12  | 1.45  |

DPC - *D. p. var. caulivora*; PV - *P. viticola*; DH - *D. helianthi*; PL - *P. longicolla*; HS - *H. sativum*;

CC - *C. coccodes*; TC - *T. cucumeris*; FO - *F. oxysporum*; FA - *F. avenaceum*; FG - *F. graminearum*; FS - *F. subglutinans*; FV - *F. verticillioides*

They had a statistically significant negative impact on mycelium growth of all investigated fungi except *T. cucumeris* and *F. graminearum*.

Common thyme essential oil showed complete inhibition on mycelial growth of *D.p. var. caulivora*, *D. helianthi*, *P. viticola*, 98.23% inhibition on mycelial growth of *P. longicolla* and 90% inhibition on mycelial growth of *C. coccodes*. Those results are in accordance with the strong toxic properties of thyme oil and its active compounds, such as thymol and carvacrol, against a large number of microorganisms described by Soliman and Badea (2002). The major compounds found in the thyme oil used in our research were thymol (38.61%) and

p-cymene (25.02%). In our research cinnamon leaf oil showed 53.02, 80.17 and 92.31% inhibition on mycelial growth of *D.p. var. caulivora*, *P. viticola* and *D. helianthi*, respectively. The major compound of our cinnamon leaf oil was eugenol (75.43%) having, according to Wang et al. (2010), strong inhibitory effect against *Botrytis cinerea* (De Bary) Whetzel and *Sclerotinia sclerotiorum* (Lib.) De Bary. Edris and Ferrag (2003) indicated synergistic effect of different compounds present in natural essential oils. Bartyńska and Budzikur-Ramza (2001) described high toxicity of eucalyptus, lavender and rosemary oils against *Fusarium* spp. On the contrary, in our research lavender (linalol 37.04%) and rosemary (1-8 cineole 44.40%) oils did not have inhibitory effect on

mycelium growth of the investigated *Fusarium* species. Only thyme oil showed statistically significant inhibition on mycelial growth of all researched *Fusarium* species.

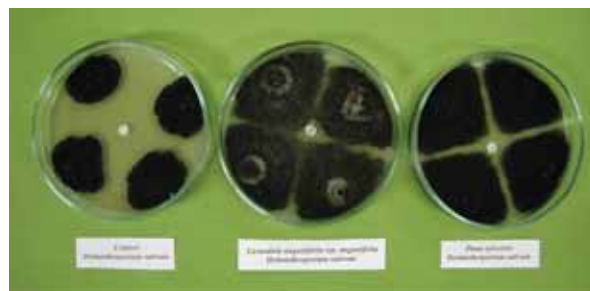
On the other hand, only aniseed oil (anethole 83.50%) had statistically significant negative impact on mycelium growth of *T. cucumeris* and peppermint (menthol 41.06%) and common thyme oils on mycelium growth of *F. graminearum*.



**Photo 1. Influence of common thyme and cinnamon leaf essential oils on mycelium growth of *P. viticola***

*Slika 1. Utjecaj eteričnog ulja timijana i cimeta na porast micelija *P. viticola**

When compared to control, scots pine, neroli and sage oils stimulated mycelium growth of *D. helianthi*, scots pine, sage, peppermint and lavender oils stimulated mycelium growth of *H. sativum* (Photo 2) while rosemary oil stimulated mycelium growth of *F. subglutinans*.



**Photo 2. Influence of lavender and scots pine essential oils on mycelium growth of *H. sativum***

*Slika 2. Utjecaj eteričnog ulja lavande i bora na porast micelija *H. sativum**

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## References

- Bartyńska M. and Budzikur-Ramza R. (2001): The action of some essential oils on fungi. Bull. Polish Acad. Sci. Biol. Sci. 49(4): 327-331.
- Burgiel Z.J., Smagłowski M. (2008): Fungistatyczne właściwości olejku z drzewa herbacianego [Fungistatic properties of tea tree oil]. Zesz. Probl. Post. Nauk Roln. 529: 13-18.
- Cardwell, K.F., Dongo, L. (1994): Effect of extracts from nine plant species found in Africa on the mycelial growth of *Aspergillus flavus* Link. Proc. of the 6<sup>th</sup> IWCSPP, Canberra, Australia. 978-980.
- Edris, A.E., Ferrag, E.S. (2003): Antifungal activity of peppermint and sweet basil essential oils and their major aroma constituents on some plantpathogenic fungi from the vapor phase. Food 47(2): 117-121.
- Hadizadeh, I., Pivastegan, B., Hamzehzarghani, H. (2009): Antifungal activity of essential oils from some medicinal plants of Iran against *Alternaria alternata*. Am. J. Applied Sci., 6: 857-861.
- Manohar, V., Ingram, C., Gray, J., Talpur, N.A., Echard, B.W., Bagchi, D., Preuss, H.G. (2001): Antifungal activities of origanum oil against *Candida albicans*. Mol. Cell. Biochem. 228: 111-117.
- Marin, S., Velluti, A., Ramos, A.J., Sanchis, V. (2004): Effect of essential oils on zearalenone and deoxynivalenol production by *Fusarium graminearum* in non-sterilized maize grain. Food Microbiology 21: 313-318.
- Paster N., B.J. Juven, E. Shaaya, M. Menasherov, R. Nitzan, H. Weisslowicz, U. Ravid (1990): Inhibition effect of oregano and thyme essential oils applied as fumigants against fungi attacking stored grain. Journal of Food Protection 58: 81-85.
- Saikia D., S.P.S. Khanuja, A.P. Kahol, A.P. Gurta, S. Kumar (2001): Comparative antifungal activity of essential oils and constituents from three distinct genotypes of *Cymbopogon* spp. Current Science 80: 1264–1266.
- Soliman K.M., Badea R.I. (2002): Effect of oil extracted from some medicinal plants on different mycotoxigenic fungi. Food. Chem. Toxic. 40: 1669-1675.
- Velluti, A., Sanchis, V., Ramos, A.J., Turon, C., Marin, S. (2004): Impact of essential oils on growth rate, zearalenone and deoxynivalenol production by *Fusarium graminearum* under different temperature and water activity conditions in maize grain. Jour. of Applied Microbiology 96: 716-724.
- Wang, C., Zhang, J., Chen, H., Fan, Y., Shi, Z. (2010): Antifungal activity of eugenol against *Botrytis cinerea*. Tropical Plant Pathology 35(3): 137-143.
- Wilkins K.M., R.G. Board (1989): Natural antimicrobial systems. In G.W. Gould (Eds.), Mechanisms of Action of Food Preservation Procedures. Elsevier, London

## ANTIFUNGALNO DJELOVANJE ETERIČNIH ULJA NA PORAST FITOPATOGENIH GLJIVA IN VITRO

### SAŽETAK

*U radu je testiran utjecaj jedanaest vrsta eteričnih ulja (klinčićevac, ružmarin, list cimeta, kadulja, bor, gorke naranče, metvica, anis, kim, lavanda, timijan) na porast micelija dvanaest fitopatogenih gljiva (*Fusarium graminearum*, *F. verticillioides*, *F. subglutinans*, *F. oxysporum*, *F. avenaceum*, *Diaporthe helianthi*, *Diaporthe phaseolorum* var. *caulivora*, *Phomopsis longicolla*, *P. viticola*, *Helminthosporium sativum*, *Colletotrichum coccodes*, *Thanatephorus cucumeris*). Sva eterična ulja koja smo koristili, izuzev ulja bora i gorke naranče, pokazala su određeno inhibitorno djelovanje prema nekim ili svim istraživanim gljivama. Najbolje antifungalno djelovanje imala su ulja timijana, lista cimeta, klinčićevca i anisa. U usporedbi s kontrolom, ulja bora, gorke naranče i kadulje pozitivno su utjecala na porast micelija nekih gljiva.*

**Ključne riječi:** eterična ulja, inhibicija, biljna bolest, porast micelija

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