

The essential oils of thyme, sage and peppermint against strawberry anthracnose

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- **Abstract:** Strawberry *Colletotrichum* spp. is a significant strawberry pathogen with yield losses of up to 50 %, due to agrometeorological conditions change its spread in a temperate climate is growing. The demand for alternative measures for biological protection is growing because of the increasing pathogens resistance and pesticides harm for human and environment. The findings of antimicrobial activities, low toxicity and biodegradability of essential oils (EO) make them suitable for biological protection against pathogens. This study aims to evaluate the inhibition of *Colletotrichum* spp. by thyme, sage and peppermint EO *in vitro* and on detached strawberry leaves. Thyme EO inhibited *Colletotrichum* spp. completely above 200 $\mu\text{L L}^{-1}$ concentration *in vitro*.

- Our findings could potentially help to manage *Colletotrichum* spp.; however, the detached strawberry leaves assay showed that EO efficacy was relatively low on tested concentrations and should be increased.

- **Keywords:** biocontrol, inhibition, *Mentha piperita*, *Salvia officinalis*, *Thymus vulgaris*



Results and Discussion

Thyme EO totally inhibited *Colletotrichum* spp. mycelial growth *in vitro* above 200 $\mu\text{L L}^{-1}$. In an investigation conducted by Duduk et al. [34], thyme EO showed good antifungal efficacy against *C. acutatum* on strawberry fruit.

T. vulgaris EO

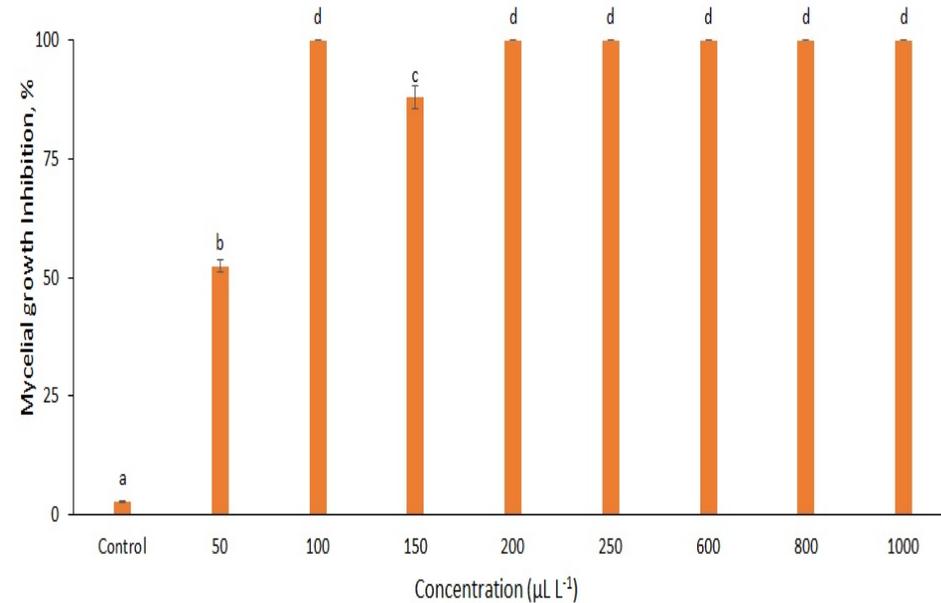
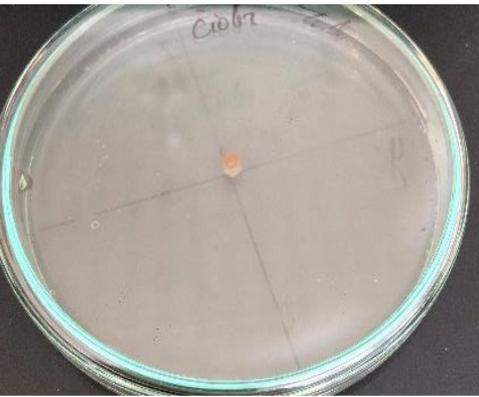
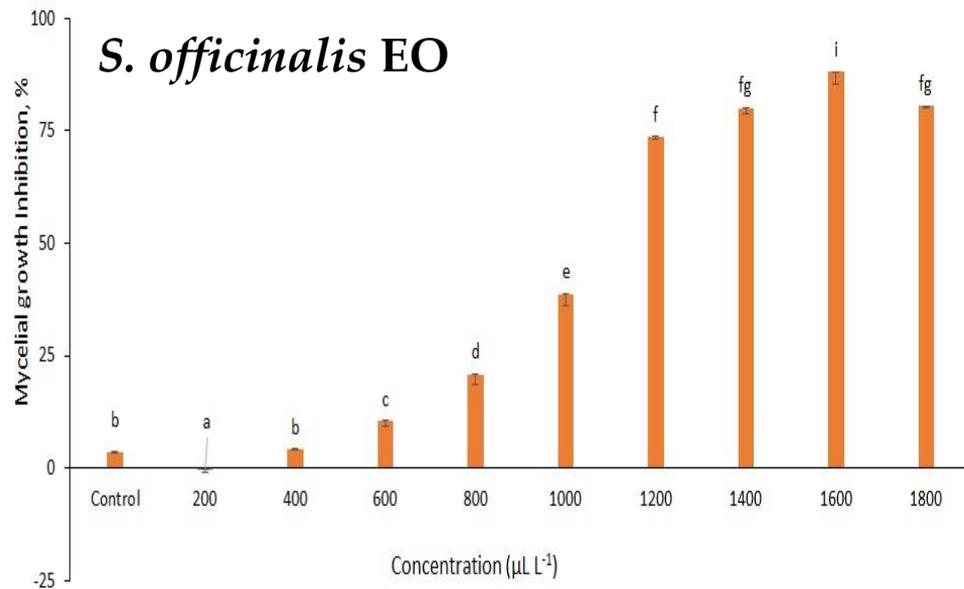


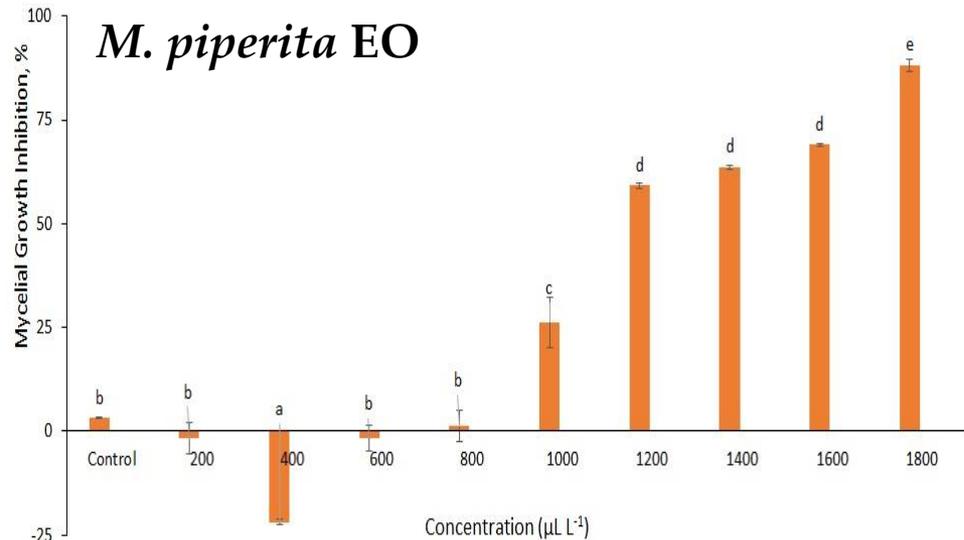
Figure 1. Inhibition (%) of *Colletotrichum* spp. mycelial growth by thyme (*T. vulgaris*) EO at 4 days after inoculation (4 DAI). Results are presented as means ($n = 4$). The same letter indicates no significant differences between treatments ($p < 0.05$).





Antifungal activity of sage EO against *Colletotrichum* spp. achieved highest effect 88.14% at 1800 $\mu\text{L L}^{-1}$. These results were comparable to the Yilmaz et al. [40] investigation, there sage EO resulted slight inhibition on mycelial growth of *C. gloeosporioides*.

Figure 2. Inhibition (%) of *Colletotrichum* spp. mycelial growth by sage (*S. officinalis*) EO at 4 days after inoculation (4 DAI). Results are presented as means (n = 4). The same letter indicates no significant differences between treatments ($p < 0.05$).



In our research peppermint EO highest antifungal activity reached at 1600 $\mu\text{L L}^{-1}$ (88%). In comparison, Oliveira et al. [35] reported, that 5 $\mu\text{L/mL}$ peppermint EO resulted in 100% MGI on all tested *Colletotrichum* stains.

Figure 3. Inhibition (%) of *Colletotrichum* spp. mycelial growth by peppermint (*M. piperita*) EO at 4 days after inoculation (4 DAI). Results are presented as means (n = 4). The same letter indicates no significant differences between treatments ($p < 0.05$).



EO result on detached strawberry leaves assay showed less positive effect of reducing spread of anthracnose. 1000 $\mu\text{L L}^{-1}$ concentration of peppermint EO (15.8%) and 800 $\mu\text{L L}^{-1}$ concentration of thyme (5.3%) reduced the infection on strawberry leaves at 4 DAI, compared to inoculated control.

In the future research, a higher concentration of these EO should be investigated for higher effectiveness. The effect of plant EOs as volatile compounds on the surface of strawberry leaves may induced a stressful environment [11,33].

Treatments	Disease severity (%)	Disease reduction (%)
Inoculated control	79.2±0.2	n.a.*
Thymus vulgaris 800 $\mu\text{l/L}$	75±0.3	5.3
Salvia officinalis 1000	80.6±0.2	0
Mentha piperita 1000 $\mu\text{l/L}$	66.7±0.2	15.8

Table 1. The disease severity and reduction of anthracnose regarding strawberry cultivar 'Deluxe' by different essential oils concentrations at 4 days after inoculation. Means n=18



Conclusions

- ❖ Thyme EO, showed total inhibition against *Colletotrichum* spp. *in vitro*. Peppermint and sage EOs showed significant antifungal activity at highest concentrations.
- ❖ Infection of anthracnose on detached strawberry leaves was slightly reduced by application of thyme EO and more suppressed by peppermint EO at tested concentration. Sage EO did no influence the spread of *Colletotrichum* spp. on detached strawberry leaves.
- ❖ The detached strawberry leaves assay showed that the investigated essential oils were not equally effective and needed further investigations with higher concentrations.



Thank you for attention!



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