

Use of essential oils for the control of gray mold on strawberries

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Botrytis cinerea (Pers.), the causal agent of gray mold, is considered the most destructive pathogen responsible for strawberry spoilage and causes considerable economic losses during storage and distribution. While several chemical active ingredients can be used to control infections in the field, in some countries the use of synthetic fungicides is not allowed after harvest. Essential oils (EOs) have gained increasing attention as promising natural antimicrobials due to their broad-spectrum antimicrobial activity and natural origin. This research aims to assess the effectiveness of different concentrations of several EOs in controlling strawberry gray mold during shelf life applying treatments by fruit fumigation with the help of smoke machine

Table 1. Details and concentrations of essential oils tested *in vivo* against *Botrytis cinerea* on strawberries

Plant	Common name	Provider	Concentration tested (µL/L of air)
<i>Origanum vulgare</i>	Oregano	Flora Srl	22.73; 34.09; 45.45
<i>Rosmarinus officinalis</i>	Rosemary	Flora Srl	22.73; 34.09; 45.45; 90.91
<i>Lavandula officinalis</i>	Lavender	Flora Srl	11.36; 22.73
<i>Lavandula hybrida</i>	Lavandin	Flora Srl	11.36; 22.73
<i>Thymus serpyllum</i>	Wild thyme	Flora Srl	22.73
<i>Melaleuca alternifolia</i>	Tea tree	Flora Srl	34.09; 45.45; 90.91
<i>Thymus capitatus</i>	Conehead thyme	Flora Srl	22.73
<i>Citrus bergamia</i>	Bergamot	Flora Srl	11.36; 22.73
<i>Thymus vulgaris</i>	Thyme	GreenVet	11.36; 22.73
<i>Cinnamomum zeylanicum</i>	Cinnamon	GreenVet	22.73; 34.09; 45.45
Mix (25% <i>M. alternifolia</i> , 25% <i>O. vulgare</i> , 25% <i>C. zeylanicum</i> , 25% <i>T. vulgaris</i>)	MIX (AN-50G)	GreenVet	34.09; 45.45; 90.91
<i>Helichrysum italicum</i>	Helichrysum	SAO Srl	22.73; 34.09; 45.45
Control (propylene glycol)	/	/	/



Fig 1. Components of the microemulsion for the treatment composed of EO, propylene glycol and Triton X-100 for each EO tested

Shelf life assessments

$$\text{Disease incidence (\%)} = \left(\frac{n}{N}\right)100$$

$$\text{Disease severity} = \frac{cf}{n}$$

$$\text{McKinney Index (\%)} = \left(\frac{cf}{NX}\right)100$$

n: number of fruits/leaves infected
N: total number of fruits/leaves
c: value of the empirical class
f: frequency of the class
c f: Sum of all the multiplications between classes and frequencies from the lowest class to the highest
X: value of the higher class in the empirical scale

Phytotoxic effects : low, moderate or high

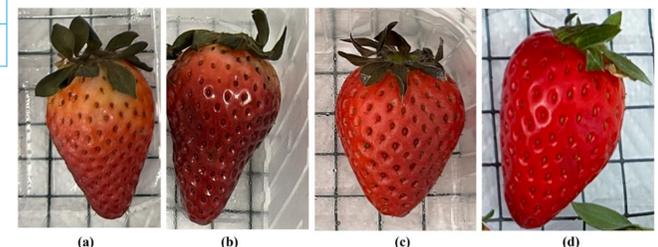


Fig 2. Phytotoxicity assessment on strawberries fumigated with different essential oils: (a) *Malaleuca alternifolia* 90.91 µL/L (b) *Thymus serpyllum* 22.73 µL/L, (c) *Rosmarinus officinalis* 45.45 µL/L, (d) control

Sensory analysis - triangle discrimination tests

Plant	Treatments	
	Common name	Concentration tested (µL/L of air)
<i>Origanum vulgare</i>	Oregano	22.73
<i>Thymus vulgaris</i>	Thyme	22.73
<i>Cinnamomum zeylanicum</i>	Cinnamon	22.73
<i>Melaleuca alternifolia</i>	Tea tree	45.45
<i>Citrus Bergamia</i>	Bergamot	45.45
Control	Propylene glycol	/

- The strawberries were submitted to trials after 24h at room temperature
- Each panelist was presented a set of three fruit. In this set, two of the three fruits had the same treatment, while one was different
- The panelist was asked which fruit was different



Fig 3. Sensory evaluation session of strawberries treated with essential oils indicated in the table

Exposure to volatiles from the EOs of *O. vulgare*, *C. zeylanicum*, MIX, *T. vulgaris* and *R. officinalis* were found to be effective at a dose of 22.73 µL/L while the EO of *C. bergamia* was effective at 34.09 µL/L, *M. alternifolia* at 45.45 µL/L and *T. serpyllum* at 11.36 µL/L. Oils from *L. hybrida*, *L. officinalis*, *H. italicum* and *T. capitatus* were not effective in controlling gray mold. All EOs showed symptoms of phytotoxicity at the highest concentrations tested. Panelists perceived sufficient differences only in comparison between control and strawberries fumigated with *M. alternifolia*

Essential oil	MIC (µL/L of air)	EO concentrations expressed in µL/L				
		11.36	22.73	34.09	45.45	90.91
<i>Origanum vulgare</i>	22.73	/	effective	effective	effective	/
<i>Thymus vulgaris</i>	45.45	ineffective	effective	effective	effective	/
<i>Thymus serpyllum</i>	22.73	effective	effective	effective	effective	/
<i>Cinnamomum zeylanicum</i>	45.45	/	effective	effective	effective	/
<i>Lavandula officinalis</i>	181.82	ineffective	effective	effective	effective	/
<i>Lavandula hybrida</i>	363.64	ineffective	effective	effective	effective	/
Mixture (AN-50G)	45.45	/	effective	effective	effective	/
<i>Malaleuca alternifolia</i>	363.64	/	/	ineffective	effective	effective
<i>Citrus bergamia</i>	363.64	/	/	effective	effective	effective
<i>Rosmarinus officinalis</i>	363.64	/	effective	effective	effective	effective
<i>Thymus capitatus</i>	Not available	/	effective	effective	effective	/
<i>Helichrysum italicum</i>	Not available	/	effective	effective	effective	/

ineffective effective phytotoxic

Fig.4. Summary of the effectiveness and phytotoxicity risks of essential oils-based treatments for controlling gray mold on strawberry during postharvest

Table 3. Numbers of total and correct answers obtained in the triangle discrimination tests using strawberries fumigated essential oils

Essential oils versus Control	EO concentrations expressed (µL/L)	Total answers	Correct answers	Significance threshold
<i>Origanum vulgare</i>	22.73	17	8	9
<i>Thymus vulgaris</i>	22.73	17	5	9
<i>Cinnamomum zeylanicum</i>	22.73	16	1	9
<i>Malaleuca alternifolia</i>	45.45	16	10*	9
<i>Citrus bergamia</i>	45.45	16	3	9

*Sensory comparisons that were significant

EOs fumigation can be a valid alternative for the control of gray mold in postharvest. Further studies are needed to evaluate the antimicrobial activity against *B. cinerea* and the phytotoxic effects of each EO, in relation to variations in the composition and concentration of their chemical constituents