

## ***In vitro* antifungal properties of essential oils: future applications.**

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The incidence of new diseases is related to "biological invasions". These are in most cases a phenomenon closely linked to human activities, to increasingly global trade and to climate change. The excessive use of synthetic pesticides to control diseases has caused over time the selection of pathogens resistant strains; environmental pollution and a decrease in useful insects, especially pollinator insects. A possible alternative are essential oils. They have been tested to numerous plant pathogens. The main chemical component of essential oils are (i) terpenic hydrocarbons, consisting of monoterpenes and sesquiterpenes; monoterpenes represent 80% of the composition of essential oils, whereas terpenes are composed of multiples of five-carbon isoprene units that originate in the pathway of mevalonate; (ii) oxygenated compounds, consisting mostly of alcohols, phenols, aldehydes, and esters. Essential oils are synthesized from aromatic plants and are localized and stored in the cavities and channels of epidermal cells or glandular hairs. The essential oils extracted from *Eucalyptus* hybrid (*E. camaldulensis* × *E. globulus*) from Ugnano (Firenze), commercial *Origanum vulgare* and commercial *Thymus vulgare*, as well as the hydrolate obtained from the *Eucalyptus* hybrid wastes, were selected to investigate their antifungal in vitro-effectiveness against pathogenic fungi including: *Alternaria alternata*, *Fusarium solani*, *Heterobasidion annosum*, *Ophiostoma novo-ulmi* and the oomycete *Phytophthora cinnamomi*. The oils and the hydrolate were applied to a plate lid to ensure indirect contact with pathogens, and the mycelial average increment was determined every 36 hours. The essential oils and the hydrolate were found to have a suppressive effect on the growth of pathogens in the plates. After a week from the treatment, pathogen vitality tests were carried out to verify whether the oils and the hydrolate had a fungicidal or fungistatic effect. Results showed that the oil treatments have different effectiveness: *T. vulgare* and *Eucalyptus* oils, as well as the *Eucalyptus* hydrolate, were found to have fungistatic properties. On the other hand, *O. vulgare* oil exhibited fungicidal properties against *O. novo-ulmi* and *P. cinnamomi* and fungistatic properties against *A. alternata*, *F. solani* and *H. annosum*. From these preliminary in vitro results, we confirm that some of these oils can be used as potential pathogen-control methods. Moreover, the hydrolate, obtained from cosmetics and pharmaceutical wastes, can be used as a sustainable alternative approach in circular economy.

**Keywords:** *Eucalyptus* hybrid, *Thymus vulgare*, *Origanum vulgare* Essential oils, *Eucalyptus* hybrid hydrolate, pathogenic fungi, sustainable alternative, biological invasions.