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CONTROL OF THE CAROB MOTH *ECTOMYELOIS CERATONIAE* WITH ESSENTIAL OIL FUMIGATION

Jouda Mediouni Ben Jemâa[1*], Soumaya Haouel[1], Mohamed Larbi Khouja[2]

[1]Laboratoire de Biotechnologies Appliquée à l'Agriculture, Institut National de la Recherche Agronomique de Tunisie, Université de Carthage.
[2]Laboratoire d'Ecologie et d'Amélioration Sylvo-pastoral, Institut National de Recherche en Génie Rural, Eaux et Foret, Université de Carthage.
*Corresponding author's e-mail: *j_mediouni@hotmail.fr*

ABSTRACT

In Tunisia, date palm is of great socio-economic importance. The carob moth, *Ectomyelois ceratoniae* is among the most important and destructive insects attacking dates in storage. Currently, chemical control using fumigation is the most used tool for managing this pest in postharvest treatment. However, the use of fumigants is controversial due to human health and environmental concerns. Therefore, this work was undertaken to investigate chemical composition and fumigant activity of essential oils from *Eucalyptus camaldulensis* (Dehnh) collected at summer and winter seasons.
Oils were tested for their toxicities against adults and last instar larvae of *E. ceratoniae*. Amounts were 0.5, 1, 3 and 5 µl in each of the Plexiglas bottle with 38 ml capacity, corresponding to concentrations 13.16, 26.31, 78.95 and 131.58 µl/l air. Chemical composition was assessed by GC-MS analyses.
Results showed that chemical composition varied between summer and winter seasons. 1,8 cineole (20.62%) and α-pinene (16.49%) were the major components during the summer season whereas, O-cymene (18.12%), spathulenol (13.35%), aromadendrene (9.55%) and α-pinene (8.7%) were major for plants collected in winter. As expected, insect mortality increased as the doses of essential oils and exposure period increased. Although desirable fumigant activities against the pest were achieved with essential oils from both seasons, *E. camaldulensis* summer oil was found to be more effective against larvae and adults with respective LC_{50} values of 34.08 and 73.80 µl/l air against 56.39 and 110.23 µl/l air respectively for winter oil.

Key words: Fumigation, Essential oil, Stored dates, Carob moth, Tunisia, *Eucalyptus*

INTRODUCTION

In Tunisia, date palm is of great socio-economic importance. Dates and their secondary products are the main agricultural products of the oases having a major role in local economy (Mediouni-Ben Jemâa, 2008). Tunisia is currently the tenth largest world producer and the foremost exporter of dates in terms of value (Besbes et al., 2009). The carob moth, *Ectomyelois ceratoniae* Zeller 1881 (Lepidoptera: Pyralidae) is the most important and destructive insect attacking dates in storage in Tunisia (Mediouni et al., 2004). The use of fumigants is the most economical tool for managing these stored-date pests (Azelmat et al., 2006). Methyl bromide is still the primary insecticide used in post-harvest insect control for dates in Tunisia and in several other countries (Zare et al., 2002). However, the use of this pesticide is to be phased out due to human health and environmental concerns (Bell, 2000). Recently, adoption of natural pest control methods including essential oils is becoming a promising prospect (Batish et al., 2008). Essential oils exhibit various and variable insecticidal properties (Prabuseenivasan et al., 2006). The interest in essential oils has regained momentum during the last decade due to their fumigant and insecticidal activities (Isman, 2006).

MATERIALS AND METHODS

Insect rearing

A laboratory rearing colony was established from infested field-collected dates. The moth was reared on an artificial diet based on wheat bran (Mediouni and Dhouibi, 2007). Rearing was conducted in plastic boxes (20×15×10 cm) placed in a rearing room. The rearing conditions were: temperature of 28 ± 1°C, photoperiod of 16: 8 (L: D) and 65 ± 5% relative humidity.

Plant material

Leaves from *E. camaldulensis* were collected from the arboretum of Korbous (north Tunisia) during summer and winter seasons (2010). The harvested material was air-dried at room temperature (20-25°C) for one week and then stored in cloth bags.

Essential oil extraction & analysis

The essential oils were extracted by hydrodistillation of dried plant material using a Clevenger-type apparatus for 4 h. The oils were dried over anhydrous sodium sulphate and stored in sealed glass vials at 4-5°C prior to analysis. Yield based on dry weight of the sample was calculated. Chemical analyses were performed using an Agilent-Technologies 6890 N Network GC system equipped with a flame ionization detector and HP-5MS capillary column (30 m × 0.25 mm, film thickness 0.25 µm; Agilent-Technologies, Little Falls, CA, USA). The injector and detector temperatures were set at 220 and 290°C, respectively. The column temperature was programmed from 80 to 220°C at a rate of 4°C/min, with the lower and upper temperatures being held for 3 and 10 min, respectively. The flow rate of the carrier gas (Helium) was 1.0 ml/min. A sample of 1.0 µl was injected, using split mode (split ratio, 1:100). All quantifications were carried out using a built-in data-handling program provided by the manufacturer of the gas chromatograph. The composition was reported as a relative percentage of the total peak area. The identification of the essential oils constituents was based on a comparison of their retention times to n-alkanes, compared to published data and spectra of authentic compounds. Compounds were further identified and authenticated using their mass spectra compared to the Wiley version 7.0 library.

Toxicity bioassays

To assess fumigant toxicity of *E. camaldulensis* essential oils, 2 cm diameter filter papers (Whatman No.1) were impregnated with a range of oil doses. Amounts were 0.5, 1, 3 and 5 µl in each of the Plexiglas bottles which were of 38 ml capacity, corresponding to concentrations of 13.16, 26.31, 78.95 and 131.58 µl/l air. The impregnated filter paper was then attached to the screw caps of bottles. Caps were screwed tightly on the vials, each of which contained either 10 unsexed adults (0-24 hours old) or 10 unsexed five instar larvae. Each treatment and control was replicated five times. Mortality was calculated using Abbott's correction formula (Abbott, 1925). Probit analysis (Finney, 1971) was used to estimate LC_{50} values.

RESULTS AND DISCUSSION

Essential oils yield and chemical composition

Results showed that essential oil yields strongly varied according to the season of collection. High yield was obtained from leaves collected at the summer season (1.32%) compared to winter season (0.76%). Table 1 reports major components of *E. camaldulensis* essential oils collected during summer and winter seasons.

Table 1. Major components (%) from the two essential oils

E. camaldulensis essential oil	
Summer collect	Winter collect
1,8 cineole (20.62%) α-pinene (16.49%) Spathulenol (2.36%) Aromadendrene (3.93%) O-cymene (0%)	1,8 cineole (0.5%) α-pinene (8.7%) Spathulenol (13.35%) Aromadendrene (9.55%) O-cymene (18.12%)

Results showed that chemical composition varied between summer and winter seasons. 1,8 cineole is predominant during the summer season whereas winter season oil was characterized by O-cymene as the principal component. Results also showed that α-pinene is a major common component for the two oils with respective percentages of 16.49 and 8.7% for summer and winter seasons.

Fumigant toxicity

Results revealed that *E. camaldulensis* summer oil was more toxic to *E. ceratoniae* adults and larvae compared to the winter oil. Moreover, bioassay results showed that adults of the carob moth were more sensitive to the essential oils than were last instar larvae (Table 2).

Table 2. Median Lethal Concentration LC_{50} (µl/l air) values calculated for mortality within 24 h of exposure of *E. ceratoniae* adults and larvae to *E. camaldulensis* summer and winter oils

Summer collect		Winter collect	
Adults	Larvae	Adults	Larvae
34.08	73.80	56.39	110.23

Our study showed some similarity regarding chemical composition of the essential oils. Indeed, quantitative rather than qualitative variations in the composition were observed. The chemical variation of the essential oil could be due to many factors besides harvest time (Perry et al., 1999). On the other hand, few previous data reported the insecticidal and fumigant toxicity of *E. camaldulensis* essential oil against adults and larvae of the carob moth *E. ceratoniae*. In this respect, Haouel et al., (2010) reported that essential oils from *E. rudis* and *E. camaldulensis* exhibited high fumigant toxicity against adults of *E. ceratoniae*. Similarly, Mediouni-Ben Jemâa et al., (2012) indicated the toxicity of five *Eucalyptus* essential oils against adults of *E. ceratoniae*.

To summarize, we can propose that variations in insecticidal toxicity of the two essential oils against *E. ceratoniae* could be related to changes in the active component amounts from one oil to another, depending on seasonal variations. This work provides data to support the use of *E. camaldulensis* essential oil as an alternative to the fumigant methyl bromide for treating stored-date commodities in Tunisia.

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