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(RESEARCH ARTICLE)

Insecticidal activity of essential oils from five Moroccan plants on three insect pests of stored cereals

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Abstract

Essential oils from five Morrocan plants belonging to different botanical families (Asteraceae, Myrtaceae and Cupressaseae), were prepared by hydrodistillation. These essential oils, which have a long tradition in adjuvant therapy, were tested for insecticidal activity by the method of microcomputer-atmosphere against three major pests of stored products: *Rhyzopertha dominica* (F), *Sitophilus oryzae* (L) and *Tribolium castaneum* (herbst). Results showed that the essential oil of *Eucalyptus camaldulensis* possessed significant insecticidal properties against the pests studied.

Keywords: Essential oils; Insecticidal activity; *Rhyzopertha dominica*; *Sitophilus oryzae*; *Tribolium castaneum*

1. Introduction

In order to search for new natural resources that could fight against insect pests that damage cereals and find new active ingredients extracted from plants as an alternative treatment to insecticides of chemical origin, we tested the insecticidal effect of the essential oils of five Moroccan plants, *Artemisia arborescens* L (*A. arborescens*), *Artemisia herba alba* Asso (*A. herba-alba*), *Cupressus sempervirens* L (*C. sempervirens*), *Eucalyptus camaldulensis* L (*E. camaldulensis*) et *Tanacetum anuum* L (*T. anuum*). During storage, cereals were attacked by different types of insect pests. Among these insects, in Morocco, there were *Rhyzopertha dominica* F (*R. dominica*), *Sitophilus oryzae* L (*S. oryzae*) and *Tribolium castaneum* H (*T. castaneum*) which cause enormous damage and therefore a decrease in the quantity and profitability of cereals. This scourge was of interest to all those involved in the production and storage of cereals and grains in the world [1, 2]. Chemical substances, insecticides used in this fight, such as glyphosate, phosphine-based substances and malathion, had not only developed resistance but also caused harmful effects for humans and the environment [3, 4]. Currently, control of stored-product insects of cereals in store were generally achieved by fumigation and application of insecticides [5-9]. Nevertheless, the use of chemical agents becoming less popular because of fears about potential harmful effects on Man and the appearance of many resistant strains [3, 10]. Throughout the world, scientific experiments were focused on fining natural alternatives molecules with less or no negative effect on man and the environment. Traditionally certain species of plants had been used to combat the insects damaging stored food products [11, 12], thus there was a need to search out new insecticides origin plants. Previous research has shown certain plants contained substances which were either repellent, antifeedant or toxic [13-18]. Therefore, Antifeedant properties of

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Sandoricum koetjape Merr were used against the moth *Spodoptera frugiperda* [19], of *Eucalyptus globules* (Labill), *Lavandula stoechas* (L) and *Artemisia vulgaris* (L) against *T. castaneum* (Herbst) [16, 20] was reported. Thereafter, essential oils could show insecticidal activity, thus the essential oil extracted from five different Citrus species appeared toxic to *Sitophilus zeamais* Motschulsky, *Prostephanus truncates* Horn and *T. castaneum* [21] and the oil of *Acorus calamus* Linn (Acoraceae) was toxic to *Sitophilus granarius* L, *S. oryzae* and *Callosobruchus chinensis* L [22, 23]. This work presented the study of the insecticidal properties of five essential oils of some Moroccan plants against the adults of *R. dominica*, *S. oryzae* and *T. castaneum*.

2. Material and methods

2.1. Insects

The insects used were *R. dominica*, *S. oryzae* and *T. castaneum*.

The breeding of the three species was carried out on wheat in transparent plastic boxes of 1 liter. The boxes were placed in an enclosure with temperature maintained at 30 °C and relative humidity at 70 %.

2.2. Extraction of essential oil

Essential oils tested were extracted from five Moroccan plants, *A. herba-alba*, *A. arborescens*, *C. sempervirens*, *E. camaldulensis* and *T. anuum* by hydrodistillation using a distiller of the type Clevenger.

2.3. Chromatographic analyses

The analyses were carried out on a HP 5790 gas chromatograph coupled to a HP 5972 mass spectrometer, the apparatus functions in electronic impact. Fragmentation was carried out in an electronic field of 70 eV. The column used was a DB5 capillary tube containing molten silica 30 m in length and 0.25 mm in the internal diameter; the thickness of film was 0.25 mm. The conditions of the analysis were as follows:

The temperature of the oven was programmed to heat from 50 °C to 250 °C at a rate of 5 °C/min. Temperature (250 °C) was maintained during 10 min.

The carrier gas Helium was used with a flow of 1 ml/min. The temperature of the injector was 250 °C and that of the detector was 280 °C. The quantity injected of essential oil was 5 µl diluted in pentane. The spectrum of mass obtained was compared with computerized library spectra of masses of reference NBS 75 K.

2.4. Bioassay

The applied procedure was similar to that described in the 1977 by Hamraoui and Regnaut-Roger [24]. Tests of toxicity of essential oils were carried out on Whatman paper in an experimental room containing 20 adult insects, in triplicate. Doses corresponding to 0.21 µl/cm^3, 0.11 µl/cm^3 and 0.053 µl/cm^3 of each essential oil were deposited separately on to filter papers. Treated papers were introduced into experimental chamber containing 10 g of wheat and 20 adult insects (each species was tested separately). The tests were conducted in semi-aerated medium at 25 °C and 10 % relative humidity (R.H.). Three replicates were employed for each sample and the mortality was recorded every 24 h for 4 days.

3. Results and discussion

In this study, the vapor toxicities of five essential oils, extracted from Moroccan plants, were tested at various concentrations against *R. dominica*, *S. oryzae* and *T. castaneum*. The result showed that mortality was influenced by several factors including the plant species, the duration of exposure the insect species and the concentration of essential oil.

Against *R. dominica* the essential oil of *E. camaldulensis* proved to be the most toxic oil with 100 % mortality after the first day of exposure at concentration 0.21 and 0.11 µl/cm^3 (Table 1). This toxicity decreases at the concentration of 0.053 µl/cm^3 and drops to 23 % at day four.

Table 1 Mean percent of *R. dominica* after exposure to essential oils

Dose in µl/cm³	**0.21**				**0.11**				**0.053**			
Day	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
E. camaldulensis	100	100	100	100	98	100	100	100	8	18	20	23
A. arborescens	100	100	100	100	41	41	55	66	0	5	8	13
A. herba-alba	91	98	100	100	26	46	86	90	1	3	6	11
T. anuum	20	40	46	50	11	23	26	33	6	10	20	20
C. sempervirens	3	5	6	11	0	1	1	3	1	1	1	3

The essential oils *of A. arborescencs* and *A. herba alba* showed mortality of 100 % at concentration of 0.21 µl/cm³, activity that decreases at lower concentrations more for *A. arborescens* than *A. herba alba.* Other essential oils showed relatively low insecticidal activity (20 % of mortality) at 0.053 µl/cm³.

Mortality of *S. oryzae* showed that the essential oil of *E. camaldulensis* has a very significant insecticidal activity with a mortality of 100 % at concentration of 0.21 µl/cm³ after 1 day of exposure (Table 2). This mortality decreased to 98 % at the fourth day at concentrations of 0.11 and 0.053 µl/cm³.

Table 2 Mean percent mortality of *S. oryzae* after exposure to essential oils

Dose in µl/cm3	**0.21**				**0.11**				**0.053**			
Day	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
E. camaldulensis	100	100	100	100	65	86	95	98	30	66	83	98
A. arborescens	43	56	86	96	3	33	53	83	0	13	33	61
A. herba-alba	96	100	100	100	26	61	85	100	26	36	53	66
T. anuum	1	28	80	91	5	21	75	100	5	18	58	78
C. sempervirens	6	13	20	41	1	8	15	26	3	11	21	43

Similar results were reported by using the essential oil of sage against *S. oryzae*, essential oil of Bay-tree, lavender and Rosemary against *R. dominica* [6]. The essential oils of *A. herba alba* presented similar insecticidal effects and very significant on *S. oryzae* a percentage of mortality of 100 % after 4 days at concentration of 0.11 µl/cm³ (Table 2). Meanwhile, the essential oil of *T. anuum* showed a mortality of 78 % at 0.053 µl/cm³ on *S. oryzae*. On this last strain, 43 % of mortality showed after four days of exposure when used the essential oil of *C. sempervirens* (0.053 µl/cm³).

Table 3 Mean percent mortality of T. castaneum after exposure to essential oils

Dose in µl/cm3	**0.21**				**0.11**				**0.053**			
Day	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
E. camaldulensis	100	100	100	100	90	90	90	90	90	93	93	93
A. arborescens	36	46	50	56	16	16	16	16	10	10	10	10
A. herba-alba	0	3	3	10	0	0	0	0	0	0	0	0
T. anuum	3	3	3	6	0	0	0	3	0	0	0	0
C. sempervirens	3	3	3	3	0	0	0	6	0	0	0	0

With regard to *T. castaneum*, only the essential oil of *E. camaldulensis* showed a toxic effect with a mortality of 100 % for the concentration of 0.21 µl/cm^3 and of 93 % at the concentration of 0.053 µl/cm^3 after the 4th day of exposure. The essential oils of the other plants *A. herba alba*, *T.anuum*, and *C. sepervirens* did not show insecticidal activity.

The essential oils tested, *E. camaldulensis* was the most active with 100 % mortality on the different insects. According to the results obtained, it appeared that at all doses the maximum mortality was obtained after the 4th day.

Finally the percentage of mortality of different species of insects varies clearly according to the concentration used. The sensitivity of the three insects showed that *S. oryzae* had the greatest sensitivity followed by *R. dominica* while *T. casataneum* was sensitive only to the essential oil of *E. camaldulensis* at all concentration (Figure 1).

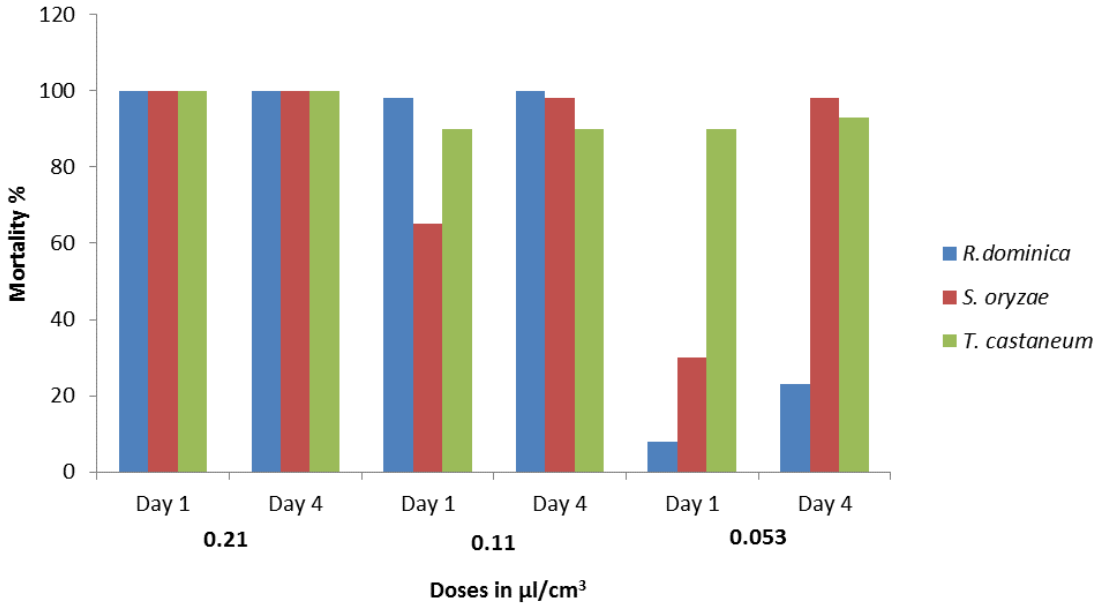

Figure 1 Percent mortality for the three insects at different concentrations of *E. camaldulesisis* on the first and fourth day of exposure

4. Conclusion

In this work extended to the search of insecticidal activity of essential oils from five Moroccan plants on three pests of stored cereals *R. dominica, S. oryzae* and *T. castaneum.* According to the results obtained, the highest insecticidal activity to the three parasites was the essential oil of *E. camaldulensis*, followed by *A. herba-alba* and *A. arborescens*. This toxicity was relatively variable depending on the species tested. *T. castneum* was the most resistant insect to all essential oils tested. Thus, the essential oils studied could be used as an insecticide to replace chemical substances and to overcome the problem of storage of cereals and grains.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have declared that no competing interest exists.

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