

Chemical composition and repellency activity of essential oil from desert date seeds against the red flour beetle

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Abstract—This study aimed to determine the chemical constituents and repellency activity of essential oil from *Balanites aegyptiaca* (desert date) against adults of *Tribolium castaneum* (red flour beetle). The essential oil was extracted by hydrodistillation and tested for repellent activity against the pest at different concentrations, 8, 4, 2 and 1%, locally made repellency equipment was used for repellency test. The essential oil was analyzed by gas chromatography-mass spectrometry (GC-MS). The analysis results of GC-MS showed a high percentage of oleic acid (94.93%), 6-octadecenoic acid (2.38%) and n-hexadecanoic acid (1.59%). The repellent effect against the pest was observed in all tested essential oil concentrations, the highest concentration (8%) scored the highest percentage of repellent effect (89.95%). The results observed that insect repellency rate increased with the increase in essential oil concentration. The study revealed that the essential oil of desert date possesses repellent activities against adults of red flour beetle which may be used to control the pest.

Keywords—Essential oil, repellent effect, red flour beetle, GC-MS, insects.

I. INTRODUCTION

Insects have emerged on the surface of the earth more than 400 million years ago (El Minshawy and Hegazi, 2001). The majority of insects are very useful to human and environment; some insects are parasitoids or predators on other harmful pests such as *Amphibulus venator* (Klug) prey on *Tribolium castaneum*, some produce important products like honey, silk and medicinal substances. However, less than 0.5 percentage of insect species are harmful insects (pests), and only three orders: Coleoptera, Lepidoptera and Psocoptera contain species are considered as major pests of stored products (Sallam, 1999).

Pests of stored products are currently divided into primary and secondary pests. Primary pests which able to attack whole, unbroken grains, for example, Khapra beetle (*Trogoderma granarium*), granary weevil (*Sitophilus granarius*) and rice weevil (*Sitophilus oryzae*). Secondary pests attack only damaged grain, milled products and dust

such as red flour beetle (*Tribolium castaneum*), confused flour beetle (*Tribolium confusum*) and saw-toothed grain beetle (*Oryzaephilus surinamensis*). These insects can cause many of damage for stored food and grains, for example, loss of weight and quality of products (Rees, 2004; Nayak and Daglish, 2018; Emery and Cousins, 2019 and Yaseen et al., 2019).

The pesticides the major method to control these pests. However, this method have many problems such as toxicity to non-target organisms and unsafety for the environment. Botanical extracts are considered new safe alternative to pesticides, in particular, essential oils, because most of them are not or are slightly toxic to man and animal, safe and will not contaminate the environment. Many previous studies proved the insecticidal and repellent effect of essential oils from different plant against stored product pests. Olivero-Verbel et al. (2010) observed that the essential oils of *Cymbopogon citratus* and *Eucalyptus citriodora* have

good repellent effect against *Tribolium castaneum*. The essential oils of *Mentha microphylla* act as fumigation and in contact against the adults of *T. castaneum* and *Sitophilus oryzae* (Mohamed and Abdelgaleil, 2008). Simalary, the essential oils from *Psidium guajava* and *Schinus terebinthifolius* are more effective as fumigant on adults of *T. castaneum* (El-Sabrou et al., 2019). Hence, to continue in this field to find plant can be used to control the pests, this study aimed to investigate the repellent effect of essential oil from *Balanites aegyptiaca* against *T. castaneum* and to determine the chemical compounds of the oils by Gas chromatography–mass spectrometry (GC-MS).

II. MATERIALS AND METHODS

2.1. Extraction of the essential oil

Mature fruits were collected from naturally grown desert date tree at Omdurman, Khartoum, Sudan. The hard shell of the fruits were broken to obtain the seeds, then the seeds were crushed into fine powders by an electric blender. A weight of 200 grams seeds powder were subjected to hydrodistillation for 3 h in a Clevenger type apparatus to produce the plant oil (López *et al.*, 2011 and Nenaah, 2014). The obtained oil was kept in vials and placed in a refrigerator until used.

2.2. Insect

The red flour beetle cultures were reared under laboratory conditions at 30 ± 2 °C and $65 \pm 8\%$ RH. Adult insects one week old were selected and used for the repellency test.

2.3. Repellency test

We designed locally repellency equipment according to Berndt (1963) to test the repellency effect of the essential oil against the red flour beetle. Four concentrations of the essential oil viz. 8, 4, 2 and 1% were prepared in acetone. The tested concentrations were applied on petri dishes and distributed randomly in the repellency equipment peripheral holes, including the control. Two hundred of red flour beetle insects were introduced in a petri dish and placed in the central hole of the repellency equipment (Elamin and Satti, 2013). After 24 h, the numbers of insects were calculated for each test hole and the control hole and recorded, the experiment was repeated for two consecutive days to get three counts. Consequently, the recorded data of the insects were analyzed to compute the repellency or attractancy efficacy of each concentration based on Leonard and Ehrman formula (1976):

$$A = \frac{No - Nb}{Nt}$$

Where; A = repellency (-) or attractancy (+); No = number of insects in the test hole; Nb = number of insects in the control hole; Nt = the number of insects in test and control holes. The output of this equation ranges from -1 (100% repellent) to + 1 (100% attractant) when compared to the control.

2.4. Gas Chromatography–Mass Spectrometry analysis

The essential oil of the plant was analyzed by means of the GC-MS system (7890B/5977A, Agilent, USA). A capillary column HP-5MS (30m_ 0.25mm ID, df ¼ 0.25 mm) was utilized (Ren *et al.*, 2019). The following temperature program was set for analysis: oven temperature was initially 40 °C for 3 min and kept at 250 °C at 5 °C/min. the pure Helium (flow rate 1 ml/min) was used as carrier gas. The mass spectrometer was executed by the MS system (5977A MSD, Agilent, USA). The temperature of ion source was 270 °C, and 300 °C for transmission line. The chemical compounds were identified by comparison the mass spectrum of the unknown component with the spectrum of the known components in the National Institute of Standards and Technology library.

2.5. Statistical analysis

The obtained data of insects in each treatment were analyzed by one-way (ANOVA). Level of significant differences were selected to be at $P < 0.05$. Duncan's Multiple Range Test was used.

III. RESULTS AND DISCUSSION

3.1. Repellency effect

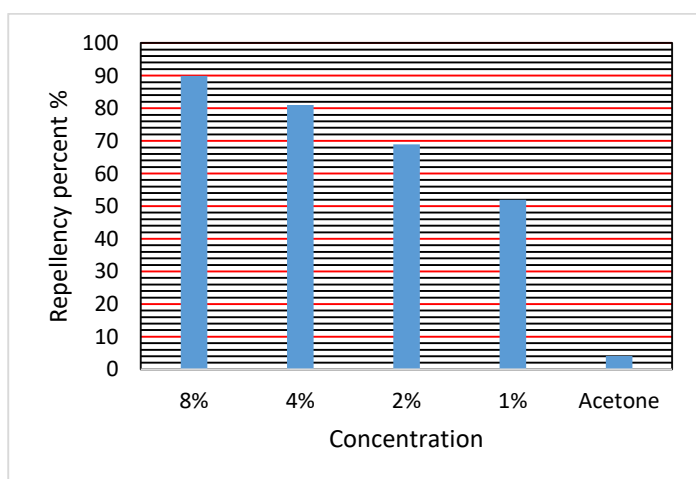
The percentages repellency of the essential oil against *T. castaneum* are presented in the figure and mean of insects in treatment $\pm SE$ in Table 1. All concentrations obtained highly significant repellent effect against the pest compared with the control. The highest percentage of the insects repellent was 89.95% at 8% concentration, followed by 81.00% at 4% concentration. This result is similar to which was recorded by Al-Jabr (2006) who observed that *Matricaria chamomilla* reflected 84.73% repellent percentage at 1% concentration against *T. castaneum*. This little difference could be attributed to the type of the plant and bioassay methods. The repellent effect may be due to high quantity and/or good quality bioactive compounds in the essential oil such as fatty acids as have been confirmed by GC-Mass results. According to Zhu *et al.* (2018) Coconut fatty acids have strong repellency activities against mosquitoes, ticks, biting flies and bed bugs. Moreover, numerous of studies

demonstrated the repellency effect of the essential oils against *T. castaneum* from other plants, for example, *Helianthus petiolaris*, *Artemisia* species, *Ricinus communis*, and *Satureja* species (Liang et al., 2017; Salem et al., 2017; Taban et al., 2017; Anabel et al., 2019). It's clear that the increased concentration led to increased repellent effect. This result agreed with Cao et al. (2018) who reported that the repellent effect of the *Evodia lenticellata* Huang essential oil against *T. castaneum* and *Lasioderma serricorne* increased with the increase in concentrations.

3.2. GC-MS analysis results

The gas chromatography/mass spectrometric analysis results for the essential oil from desert date seed are presented in Table 2. The major components were oleic (9-octadecenoic) acid (94.93%), 6-Octadecenoic (Petroselaidic) acid (2.38%) and n-hexadecanoic (palmitic) acid (1.59%). No data are available on chemical profile of the essential oil from seeds of this plant. However, many fatty acids such oleic acid, palmitic acid were detected in essential oils from seeds for other plants. According to Koufan et al. (2020) the essential oil of *Argania spinosa* (L.) Skeels seeds contains oleic and linoleic acids. Similarly, palmitic and oleic acids were identified from essential oils from seeds of *Zanthoxylum schinifolium* by Oh and Chung (2014). The main fatty acid components of essential oils of *Magnolia grandiflora* seeds are methyl linoleate, methyl oleate and palmitic acid as reported by Ali et al. (2020).

IV. FIGURES AND TABLES



The figure. Percentage of repellency of *B. aegyptiaca* essential oil against *Tribolium castaneum*.

Table 1. Percentage repellency of *B. aegyptiaca* essential oil against *Tribolium castaneum*, during October 2019.

Treatments	Mean ($\bar{X} \pm S.E.$) insects/treatments
Essential oil 8%	0.67 \pm 0.33a
Essential oil 4%	1.33 \pm 0.33a
Essential oil 2%	2.33 \pm 0.33ab
Essential oil 1%	4.00 \pm 0.58b
Acetone	11.67 \pm 0.67c
Control	12.67 \pm 0.88c

*Values represents mean of three replications with 10 insects each.

*Means followed by same letters are not significantly different from each other at $P < 0.05$ level ($F^{5, 12} = 80.847$).

Table 2. Chemical constituents in the essential oil from desert date seeds.

No.	Name of Compound	Molecular Formula	R.T.(Min)	Peak Area %
1	Indole	C ₈ H ₇ N	23.25	0.06
2	Hexadecanoic acid (palmitic acid)	C ₁₆ H ₃₂ O ₂	43.52	1.59
3	Oleic Acid (9-octadecenoic)	C ₁₈ H ₃₄ O ₂	46.66	94.93
4	9,12-Octadecadienoic acid z,z-(linoleic acid)	C ₁₈ H ₃₂ O ₂	50.29	1.10
5	6-Octadecenoic acid (Petroselaidic acid)	C ₁₈ H ₃₄ O ₂	50.55	2.38

V. CONCLUSION

The study detected that the essential oil from desert date have strong repellency activity against the red flour beetle. However, further studies are necessary to investigate its efficacy on the pests in grain storage. Moreover, some fatty acids such as palmitic and oleic acids were detected in the essential oil. Hence, more researches are needed to isolate, identify and characterize

the active ingredients responsible of the repellency effects and its evaluation on the pest and test for safety on humans.

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