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RESEARCH ARTICLE

Potential toxicity assessment of novel selected essential oils for management of the subterranean termite, *Psammotermes hypostoma* Desenex

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Abstract

The subterranean termite, *Psammotermes hypostoma* Desenex is a significant pest in Qena governorate, Egypt. With regard to *P. hypostoma* pest, we determined the toxicity of four essential oils: caraway, cinnamon, neem, and anise. The bioassay was conducted under laboratory conditions by used five concentrations [62.5, 31.25, 15.62, 7.8 and 3.90 ppm] from each oil. After 24h from treatment the results showed the LC_{50} values of caraway, anise, neem and cinnamon oils were 5.79, 7.3, 11.86 and 23.07 ppm, respectively, while toxicity index were 100, 78.72, 48.82 and 18.94 respectively. These results showed that the most effective one was caraway oil on the other hand the least effective one was cinnamon oil. The neem oil and anise oil were located in between. We recommend that these essential oils be included in the integrated termite control programs as an environmentally safe and healthy means for humans compared with comical pesticides

Keywords: bioassay; essential oils; subterranean termite; *Psammotermes hypostoma*.

1. Introduction

Dangerous pest called subterranean termites does significant harm to buildings, furniture, and all cellulose-containing objects. Many of Egypt's governorates, particularly New Valley, Fayoum, Aswan, Giza, and Qena, suffer from destruction in building, furniture and financial caused by subterranean termites (Beal, 1979; Rizk *et al.*, 1982; Ahmed, 1997; El-Sebay, 2008; Ahmed and El-Sebay, 2008; Mohanny and Ahmed, 2010). Subterranean termites are located under four families *Rhinotermitidae, Hodotermitidae, Kolotermitidae* and Termitidae these families belonged to order Isopteran. There are 8 species of termites in Egypt, 4 from it belong to genus *Psammotermes* (Kaschef and El-Sherif, 1971; Hafez, 1980).

The sand termites *Psammotermes hypostoma* (Desneux) were distribution in the arid and semi-arid of Upper Egypt. On the other hand it is prefer soil of high sand content, places have e high warm temperature and moisture content (Hafez, 1980; Moharram *et al.*, 1992; Abushama and Al-Houty, 1988). However, traditional pesticides or traditional methods of pesticide successes control to termite but using them cause a lot of hazards on environment and human the chlorpyrifos pesticide is used to control termite's damage and affects on beneficial insects such as bees also the insects show resistance to it as a result of repeated use (Parman and Vargo, 2010; Neoh *et al.*, 2014; Rondeau *et al.*, 2014; Ahmed *et al.*, 2015). To developing saving and eco-friendly strategies to control the sand termites *P. hypostoma*. The traditional management strategies used to control it must be developed.

Essential oils offer safer alternative ways for termite management. Aly *et al.* (2012). They studied the deferent kind of essential oils against subterranean termites *P. hypostoma.* Caraway, onions, garlic, clove, peppermint, basil,

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eucalyptus (camphor), sesame, tar and fenugreek oils were tested in the laboratory and filed conditions. The rustles cleared that the caraway oil was the most influential of other oils with the highest mortality rate (100 worker/hour) under laboratory conditions. Also, the caraway, basil and garlic oils were taking the same trend under filed conditions. The mean number of individuals worker caught from the traps treated with the oils mentioned above was 0.0%. Seo *et al.* (2009), who tested plant essential oils from 26 plant species for their insecticidal activities against the Japanese termite, *Reticulitermes speratus* Kolbe, using a fumigation bioassay.

2. Materials and methods

2.1. The study site

This study was carried out at the South Valley University, Faculty of Agriculture, Plant Protection Department to study the impact of essential oils on termites' *P. hypostoma*

2.2. The trap used in the study

In this study using EL-Sebay modified trap for collected the termites. It consists of cardboard corrugated cardboard in the form of roll length of 12 cm and 5-7 cm a diameter height covered with polyethylene sheath saving the lowermost 2 cm without cover. The polyethylene sheath was fixed with the rubber band.

Table 1. Essential oils used in the study.

Essential oils	Scientific name
Caraway oil	*Carum carvi*
Cinnamon oil	*Cinnamomum verum/osmophloeum*
Neem oil	*Azadirachta indica* (A.Juss., 1830)
Anis oil	*Pimpinella anisum* L.

2.3. The insect collection

The subterranean termites, *P. hypostoma* were collected from the site of infection at the University of South Valley using EL-Sebay modified trap. The traps sent to the site of infection after fifteen days. Traps were removed from the infested sites then transfer to the laboratory. The workers were removed from the trap using a soft brush and save them in Petri dishes with pieces of paper providing wet cardboard as a source of cellulose with the necessary termites' humidity for seven days in incubator adjusted at 27±1°C. The daily inspection was carried out and eliminated dead or moribund individuals. The healthy workers were used to the evaluation.

2.4. The laboratory essential oils bioassay

The evaluation was conducted for five concentrations [62.5, 31.25, 15.62, 7.8 and 3.90 ppm] from each oil. By quantity of the oil add in a liter of distilled water to make the solution concentration standard 1000ppm and then conducted dilution required for the test concentrations. Three replicates for each concentration or treatment of any nine replicates for each oil in addition to the three replicates of control. Treated filter paper previous concentrations and then placed in ten workers in Petri dishes size 9 cm for each replicate. The dead workers were accounted after 24 hours. Where use a soft brush to move the insect did not show any movement its parties are dead.

2.5. Data Analyses

Mortalities were calculated for each concentration, observation time and colony combination, and they were corrected for natural mortality (control) with Abbott's correction as the following: corrected % = (% in treatment _ % in control)/ (100 _ % in control) * 100 (Abbott, 1925).

3. Result and discussion

There Table (2) and Fig. (1) Showed the LC_{50}, LC_{90} and toxicity index to the essential oils (*C.carvi, P. anisum ,A. indica, C. verum*) against the subterranean sand termite, *P. hypostoma* workers. The LC_{50} values were 5.794, 7.36, 11.867 and 23.078 ppm to *C. carvi, P. anisum, A. indica* and *C. verum* respectively. Also, the LC_{90} values were in the same trend 54.168, 84.807, 194.964 and 289.347 ppm. The toxicity index compared with the caraway oils which were 100, 78.723,48.824 and 25.106 to *C. carvi, P., anisum, A. indica* and *C. verum* respectively.

Table 2. Effect of the essential oils on subterranean termite, *Psammotermes hypostoma* after 24 hr. of treatment.

Line name	LC_{50}	Lower limit	Upper limit	Toxicity Index	RR	Slope	Slope +/-	LC_{25}	LC_{90}
Carum carvi	5.794	2.683	8.818	100	1	1.32	0.297	1.787	54.168
Pimpinella anisum	7.36	3.62	11.196	78.723	1.27	1.207	0.269	2.033	84.807
Azadirachta indica	11.867	6.402	19.667	48.824	2.048	1.054	0.315	2.72	194.964
Cinnamomum verum	23.078	13.35	41.649	25.106	3.983	1.167	0.356	6.098	289.347

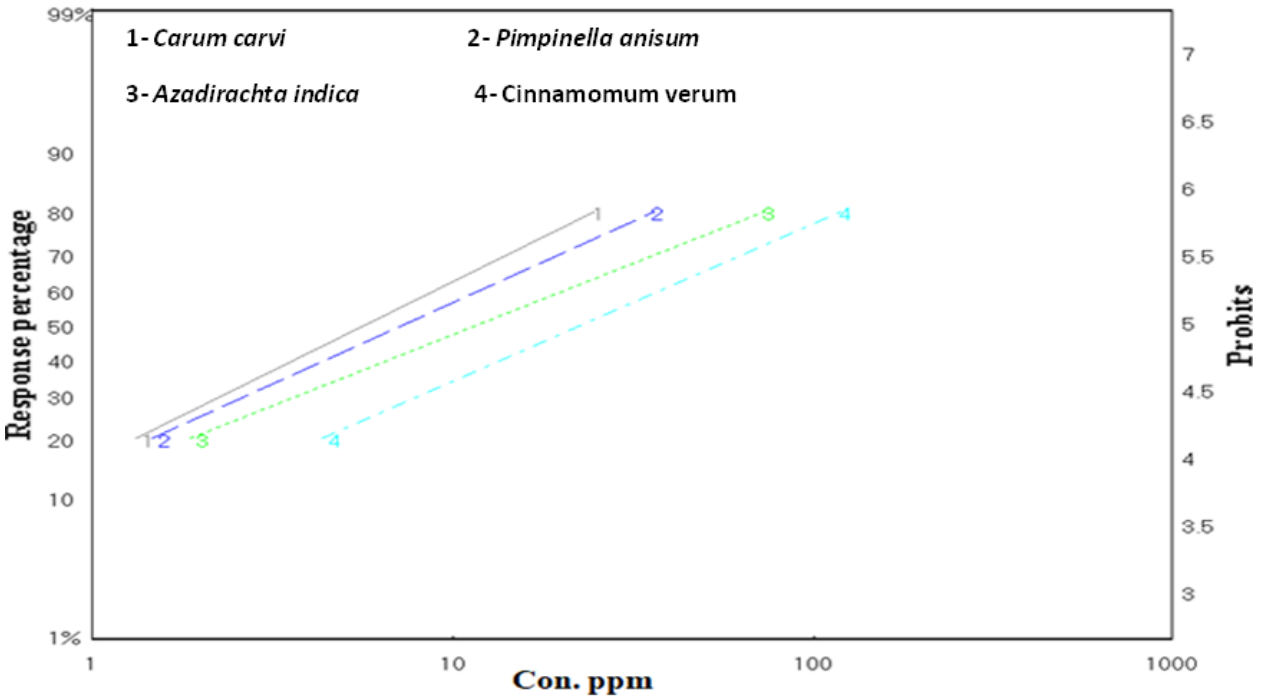

Figure 1. Toxicity lines of essential oils after 24h of treatment.

The results illustrated that the *C. carvi* oil was most efficient while, the *C. verum* was lowest efficient whereas, the *P. anisum, A. indica* oil were moderate efficient. These rustles agree with Aly *et al*. (2012). Evaluated effect of 10 type of oils on the sand termites *P. hypostoma* under laboratory conditions. types of oils included the Garlic, Peppermint, Eucalyptus, Sesame, Fenugreek, Onions, Caraway, Basil, Tar and Clove with additive 3 other treatments were used

[Alum, Propolis and Neem seeds extraction]. Results showed that the caraway oil was more influence with highest mortality than anther treatment and oils. Rothbaecher, and Suteu (1975)., indicated that the caraway oil content on the dihydrocarveol, carveol, cis-carveol, neodihydrocarveol and isodihydrocarveol. Iacobellis *et al*. (2005)., reported that the limonene, carvone, germacrene and trans-dihydrocarvone were major constituents. It's components main effect as insecticidal against many orders of insect. Seo *et al.* (2009)., studded that more than 20 essential oils from various plant species were used to determine their activities against the Japanese termite, *Reticulitermes speratus* Kolbe by fumigation bioassay. The caraway (*C. carvi*), ajowan (*Trachyspermum ammi*), geranium (*Pelargonium graveolens*), allspice (*Pimenta dioica*), dill (*Anethum graveolens*), and litsea (*Litsea cubeba*) were the highest effectivity among the evaluated essential oils. as well as revere that the phenol compounds was the most effective as insecticidal on *R. speratus* Kolbe whears, the hydrocarbons group less toxicity than aldehyde and alcohol groups. Also the anethole consider miner component in *P.ansim* essential oils and several studies pointed that the anethole represent 96.11%, Khubeiz and Zahraa (2020)., (trans-anethole) 80-95% Nikolić *et al* (2015), Tisserand and Young (2014), (E-Anethol) (76.56%), Amini *et al.* (2018) and Benelli, *et al.* (2018). Related with our results Shahriari *et al.* (2018), reported that trans-anethole was the major constitutes of *P.ansim* essential oil. So, play important role in burying the defense system in insects by inhibiting the cytochrome P450, glutathione-S-transferases, and acetylcholine esterase (AChE). Additionally many authors refer that strongest the influence *P.ansim* essential oils as insecticides on cutworm *Spodoptera littoralis, housefly Musca domestica , Culex quinquefasciatus, and potato aphid Myzus persicae* Benelli *et al.* (2018). Achieved 100% mortality of *Tribolium castaneum* (Herbst) adult with concentrate 1.50 ml cm^{-2}. Nenaah and Ibrahim (2011). Also, Allam *et al.* (2022) evaluate the toxicity of aqueous plant extracts and their green synthesized silver nanoparticles compared with mineral oil, *Beauveria bassiana*, and chlorpyrifos on *P. hypostoma*. The result showed that chlorpyrifos was the most toxic compound, whereas black peper aqueous extract was the least toxic one, however, *B. bassiana*, K. Z. oil, Garlic aqueous extract, Chili pepper AgNPs, turmeric aqueous extract, Turmeric AgNPs, Garlic AgNPs, Black peper AgNPs, and Chili pepper aqueous extract lie in between Awadalla *et al.* (2017)., indicate that applied a concentrate of 100000ppm, *P.anisum* essential oils occurs a complete percentage mortality after 96hours of exposure, for each *Sitophilus oryzae* (L.) *and Tribolium castaneum* (Herbst). On the same previous pests Amini *et al*. (2018)., investigated that fumigant toxicity essential oils of *P. anisum* L., *C. sativum* L., *F. vulgar* Mill, and *P.hortense* . from obtained data, *P. anisum* L., *C. sativum* L. were the most fumigant toxicity. Also, Schmutterer (1988)., conclusion that the tetranortriterpenoid azadirachtin and other extractives were constitute of the *A. indica* A. Juss (Meliaceae), (Neem tree). as well as neem produces have been delayed effect, stomach insecticides and a chitin synthesis inhibitor. Grace and Yates (1992)., showed that behavioral impact of neem insecticide including 3% azadirachtin and neem oil 14% on the Formosan subterranean termite, *Coptotermes formosanus.* results cleared less toxicity, slow mortality, repellent and antifeedant toward it. on the other hand, the strongest mortality was achieved on concentrate 100PPM. In addition to Srivastava *et al*. (2021)., detected that effectiveness of the clover leaf essential oil, Neem essential oil, Garlic essential oil, and Orange essential oil as insecticides against adult individuals' termites. neem oil was less toxicity than clove, garlic, and orang oils. Moreover, Roszaini, (2022)., mentioned that applied the essential oil of *Cinnamomum zeylanicum, Cinnamomum*

rhyncophyllum and Litsea elliptica with concentrates ranged between 0.5%: 4% ability protected *Hevea brasiliensis* wood from attacks subterranean termite *Coptotermes curvignathus*. *C.zeylanicum* was appearing highly repellent effective, antifeedant, and the rate of survival was lowest (0%:9.8%) in the no-choice test than other oils used in the test. Chang and Cheng (2002)., reported that the aldehyde group was more effusion as antitermitic. Also, among compounds, cinnamaldehyde has the most potent activity and occur 100% mortality of *C. formosanus* at concentrates 5mg/g after 1day. many paper recorded that the major constitute of the EO of *C.verum* was trans-cinnamaldhyede (73.21 %) Moungthipmalai *et al*. (2023)., E-Cinnanaldehyde (55.75%) Al-Zereini *et al*. (2022)., (43.446: 44.955) Phu *et al.* (2022)., (80.09%) Badr *et al*. (2022). So These compounds play an effective role against termites. We hope in the future to conduct more studies on the effect of essential oils against sand termite, *P. hypostoma* Desneux.

4. Conclusion

On the light of the previous results, it could be recommending that the alternative of insecticide control of subterranean termite *P. hypostoma* are *C. carvi*, *C. verum*, *A.indica* and *P.anisum* as bio-pesticide. So, it should be considered in integrated pest management (IPM) programs for control this pest.

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The authors disclosed no conflict of interest starting from the conduct of the study, data analysis, and writing until the publication of this research work.

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