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Insecticidal and Repellent Activities of Four indigenous medicinal Plants Against Stored Grain Pest, *Tribolium castaneum* (Herbst) (Coleoptera:Tenebrionidae)

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ABSTRACT

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Objective: The present investigation was aimed to assess the impact of four indigenous plants for their insecticidal and repellent activity against *Tribolium castaneum* (Herbst), a stored grain pest and they were tested in the laboratory. **Methods:** Four widely distributed plants (*Artemisia vulgaris*, *Sphaeranthus indicus*, *Tephrosia purpurea*, and *Prosopis juliflora*) were sequentially extracted with increasing polarity of organic solvents such as, hexane, chloroform and ethyl acetate were evaluated for their insecticidal and repellent activities against *Tribolium castaneum* by adapting the standard protocol in in vitro. **Results:** Data pertaining to the present investigation clearly revealed that the percentage of mortality was maximum in (72 hr 58%) hexane extract of *A. vulgaris*, chloroform extract (72 hr 34%) of *S. indicus*, and ethyl acetate extract (72 hr 52%) of *T. purpurea*. Repellent activities of plant extracts were tested against *T. castaneum*, repellent activity was maximum in hexane extract of *P. juliflora*, (EPI value for *P. juliflora* in 2.5% was – 0.11 and – 0.33 at 1hr and 6 hr respectively) chloroform extract of *T. purpurea* (2.5% was –0.17 at 6 hr) and ethyl acetate extract of *S. indicus* (2.5% was –0.65 at 6 hr) against *T. castaneum*. **Conclusions:** The present work for botanical products to control the insect pest of stored grain *Tribolium castaneum* (Herbst). These results suggest the presence of actives toxic substances acting after consumption or topical application.

1. Introduction

Insects are a problem in stored grain throughout the world because they reduce the quantity and quality of grain. The stored pest red flour beetle, *Tribolium castaneum* (Herbst) can be a major pest in anthropogenic structures used for the processing and storage of grain based products (e.g. flour mills, warehouses, retail stores). This species has a long association with human stored food and has been found in association with a wide range of commodities including

grain, flour, peas, beans, nuts, dried fruits and spices [1]. The use of synthetic compounds to control insect pests has lead to several adverse effects, including water and soil contamination, insect resistance and toxicity to non target specie. Therefore, there is an urgent need to develop safe, convenient, environmental and low cost alternatives. Plant extracts are considered to be non-pollutant, less toxic and easily bio-degradable. However, because of the increasing problems associated with the use of toxic synthetic pesticides, such as loss of efficacy, development of pest resistance, regulatory restrictions as a result of adverse effects on non-target organisms, human and eco-toxicity[2] there has been a pressing need for the development of safer, alternative crop protectants such as botanical insecticides, repellents and antifeedants[3].

The insecticidal activity of a large number of essential oils

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and other plant extracts has been assessed against several major agricultural pests [4]. Moreover, products from several floral species have been demonstrated to act as repellents, toxicants and antifeedants against a number of coleopteran that attack stored products [5]. Biological control may be an effective strategy for stored-product pest management in inaccessible locations, because some natural enemies can actively seek out pests in these hidden habitats or may be applied in a manner similar to chemical pesticide. *Murraya exotica* was found to possess insecticidal activity against the maize weevil, *Sitophilus zeamais* and red flour beetle, *Tribolium castaneum* [6]. (R)-Carvone and D-limonene showed strong contact toxicity against *S. zeamais* and *T. castaneum* [7]. Two synthetic volatile compounds (benzaldehyde and propionic acid) and two volatile oils (camphor and eucalyptus) were screened individually and in combinations against different life stages of *Tribolium castaneum* [8]. This study specifically aimed to determine the insecticidal action, and repellency of extract plant of *Artemisia vulgaris*, *Prosopis juliflora*, *Sphaeranthus indicus* and *Tephrosia purpurea* against *Tribolium castaneum* (Herbst).

2. Materials and Methods

2.1. Collection and preparation of plant extracts

In this study four plants such as *Artemisia vulgaris* (Mugwort), *Prosopis juliflora* (Honey mesquite), *Sphaeranthus indicus* (East Indian Global Thistle) and *Tephrosia purpurea* (Wild indigo) were collected in and around Chennai and Yercaud Hills of Tamil Nadu.

The plant materials were collected from in and around Chennai and Yercaud Hills were brought to the laboratory and shade dried. The dried plant materials were powdered using electric blender and sieved through kitchen strainer and the fine powder was used for extraction using Soxhlet extraction apparatus. The powders were extracted with different solvent in increasing polarity viz., hexane, chloroform, ethyl acetate. The residues from the crude extract were dried well for complete evaporation of the solvent and the residue was collected in brown colour vials and preserved at 4 °C. Appropriate concentrations, (0.5%, 1%, 2.5% and 5%) was prepared by mixing the solvent residue with acetone. The diluted concentration was used for subsequent experiments.

2.2. Culture of *Tribolium castaneum*

The adult *Tribolium castaneum* was collected from infested grains purchased from local market and brought to the laboratory. The culture was established using rava in a plastic container of 25 × 10 cm and maintained at room temperature 30±2 °C and relative humidity of 70–75%. Sieving the culture separated the adult insects and the adults were used for

subsequent experiment. The culture was continuously maintained in the containers throughout the study period.

2.3. Bioassays

2.3.1. Repellent activity of Plant extracts against *Tribolium castaneum*

To study the repellent activity of plant extracts, filter paper strips (6X4 cm) was dipped in 2.5% and 5% concentration of each solvent extracts and air-dried for few minutes. For control filter paper dipped in acetone was used. Then the filter paper was placed inside the plastic jar and attached into the arm of olfactometer. After the attachment of all the plastic vials with the arms, fifty newly emerged adults of

T. castaneum were introduced into the olfactometer and EPI values was calculated as using the formula of [9].

Where N_t = Number of insects in the treated sample side and
 N_c = Number of insects in the control sample side

2.3.2. Insecticidal activity of Plant extract

Two week-old adults *T. castaneum* were collected from the laboratory colony and transferred to the petridishes in batches of 20 each. The beetles were sprayed directly with 1ml of different concentrations (0.5, 1, 2.5 and 5%) of a crude extract under Potters's Precision tower at a pressure of 2.5 kg/cm². The control was sprayed with acetone. After drying of the droplets on petridishes, the beetles were provided with maize flour. Mortality was recorded every 24hr for 3 days and the percentage of mortality was calculated by using Abbot's percent corrected formula [10]. Three replications were carried out for each concentration and untreated control.

3. Results

3.1. Repellent activity of Plant extracts against *Tribolium castaneum*

Repellent activity of different solvent extract of *A. vulgaris*, *S. indicus*, *T. purpurea* and *P. juliflora* were tested at 2.5 and 5% concentrations against *T. castaneum*. The result indicates variation among the plant extracts against the selected insect pest. In general, majority of the extracts showed attractant activity at lower concentration at 1 hr duration. But the trend had changed when the duration and concentrations increased. Highest activity was observed at higher concentration of the all the plant extract. In controversy ethyl acetate extract of *S. indicus* showed higher activity at lower concentration than higher concentration. EPI value ranged from -0.43 to -0.60 at 1 hr and 6 hr in 5% concentration and -0.65 EPI value at 6 hr in 2.5% concentration. In hexane extract of *P. juliflora* showed

higher repellent activity EPI value ranged from -0.11 and -0.33 in 2.5% concentration at 1 hr and 6 hr duration respectively. On the other hand chloroform extract of *T. purpurea* showed highest repellent activity against *T. castaneum*. EPI value of chloroform extract of *T. purpurea* was ranging from -0.55 to -0.63 at 5% concentration, this was followed by *A. vulgaris* EPI value at 5 % concentration of *A. vulgaris* showed -0.31 to -0.21 at 1h and 6h duration respectively. Chloroform extract of other plants showed very lesser activity, when compared to all other extracts. Ethyl acetate extract of *S.indicus* notably showed highest activity at lower concentration against the *T.castaneum*. EPI value was -0.45 and -0.65 at 1h and 6 h duration respectively. And at higher concentration the value was -0.43 and -0.60. Next to *S. indicus*, showed moderate activity. Ethyl acetate extract of other plants showed very low/ nil activity (Table 1).

Table 1

Impact of plant extract on the Excess Proportion Index (EPI) of *Tribolium castaneum**

S. No	Plant Name	Concentration			
		2.5 %		5 %	
		Durations			
		1h	6h	1h	6h
Hexane					
1	<i>Artemisia vulgaris</i>	+0.24	-0.17	-0.38	+0.24
2	<i>Sphaeranthus indicus</i>	+0.38	-0.13	+0.24	+0.24
3	<i>Tephrosia purpurea</i>	-0.03	-0.12	+0.24	+0.24
4	<i>Prosopis juliflora</i>	-0.11	-0.33	+0.24	+0.24
Chloroform					
1	<i>Artemisia vulgaris</i>	+0.30	-0.08	-0.31	-0.21
2	<i>Sphaeranthus indicus</i>	+0.41	-0.10	-0.09	-0.08
3	<i>Tephrosia purpurea</i>	+0.20	-0.17	-0.55	-0.63
4	<i>Prosopis juliflora</i>	+0.16	+0.09	-0.03	-0.11
Ethyl acetate					
1	<i>Artemisia vulgaris</i>	+0.24	+0.06	-0.25	-0.05
2	<i>Sphaeranthus indicus</i>	+0.24	-0.65	-0.43	-0.60
3	<i>Tephrosia purpurea</i>	+0.24	+0.03	-0.09	-0.05
4	<i>Prosopis juliflora</i>	+0.24	+0.15	-0.20	-0.14

* values represents mean of five replications.

3.2. Insecticidal activity of Plant extracts against *Tribolium castaneum*

Insecticidal activity of selected medicinal plants against *T. castaneum* were depicted in Figures 1–4. Figure 1 shows percentage of insecticidal activity of different solvent extracts of *A. vulgaris* against *T. castaneum*. Percentage of mortality was increased according to the increase of the hours and concentration. Hexane extract of this plant showed highest mortality 58% at 72 hr after treatment. This was followed by chloroform extract at higher concentration. Ethyl acetate extract showed very low activity. The other two extracts showed very poor activity against the tested insect. In general very lowest insecticidal activity was observed in all solvent

extracts of *S. indicus* (Figure 2). Maximum mortality (34%) was observed in chloroform extract. Data pertaining to insecticidal activity of different solvent extracts of *T. purpurea* against *T. castaneum* was presented in Figure 3. The result revealed that the higher percentage of mortality (52%) at 5% concentration of ethyl acetate extract of *T.purpurea*. Chloroform extract of this plant showed 48% of mortality at higher concentration. The hexane extract showed they low activity against *T.castaneum*. Insecticidal activity different solvent extracts of *P. juliflora* was presented in Figure 4. Ethyl acetate extract of *P.juliflora* showed 30% mortality. The other two extracts did not show any effect against *T. castaneum*.

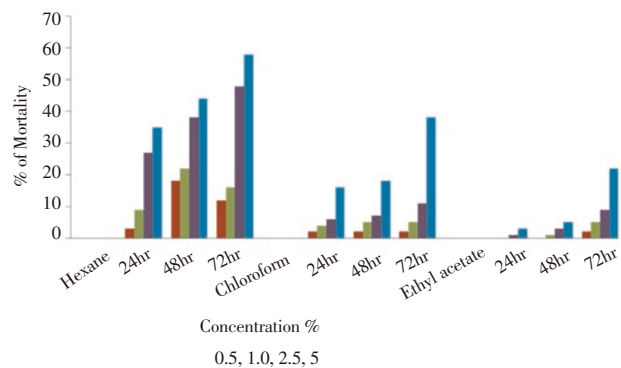


Figure 1. Insecticidal activity of different solvent extract *Artemisia vulgaris* of aganist *Tribolium castaneum*

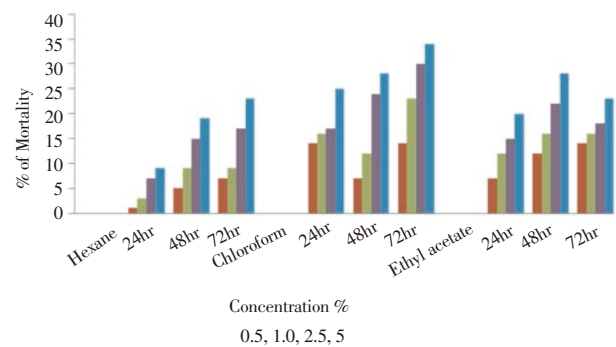


Figure 2. Insecticidal activity of different solvent extract *Sphaeranthus indicus* of aganist *Tribolium castaneum*

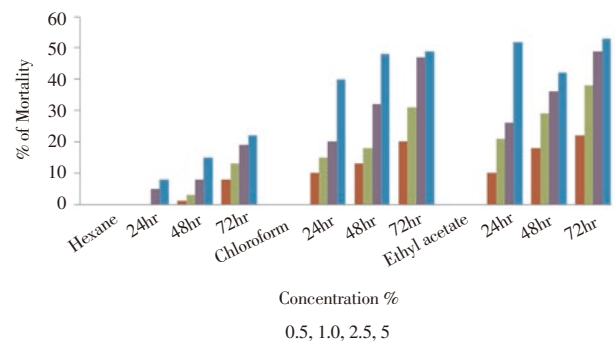


Figure 3. Insecticidal activity of different solvent extract *Tephrosia purpurea* of aganist *Tribolium castaneum*

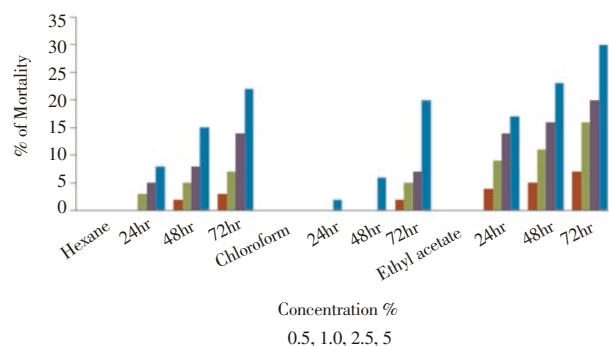


Figure 4. Insecticidal activity of different solvent extract *Prosopis juliflora* of aganist *Tribolium castaneum*

4. Discussion

Plant products having considerable potential as insecticidal compounds are gaining tremendous importance in recent years. Particularly for the management of stored products as these compounds are environmentally safe and often do not leave their residues in the stored food products meant for human consumption. Efficacy of various plant products have been reported by several authors against the stored grain pests [11]. In order to find out a newer botanical, the isolation of the compound is necessary for final product development. It may be possible because of the plants containing maximum of flavonoids, alkaloids and other secondary metabolites.

Repellent activity increases the potential value of the materials in protecting grains from the attack by stored product insect pest. Excessive Proportion Index (EPI) values gives an idea about the repellency or attractancy of chemical substance against an animal tested. The plant extracts showed both attractant and repellent activity. At lower concentration the plant extracts showed attractant and which in turn showed moderate higher repellent activity when the concentration was increased. The reason for this kind of both repellent and attractant at two different concentrations is unknown. In the present study ethyl acetate extract of *S. indicus* showed highest activity in lower concentration than higher one. It may due to the potentiality of the compounds present in lower concentration which are enough to repellent the insect.

Controlling adults is also another important biological parameter to protect post harvest production. If the plant extracts have the insecticidal compounds that kill the adult insects, the egg-laying and progeny development are consequently reduced.. The presence of volatile compounds having strong odour that could be block the tracheal respiration of the insects leading to their death. Similar observation was also observed by [12] against *Sitophilus zeamais* and *Tribolium castaneum*. Plant extract are also having higher insecticidal activity. The potential compounds present in the plant may leach out according to the polarity of the solvent used. Lower

molecular weight compounds can be isolated by the lower polar solvent and vice versa. In our present study hexane extract of *A. vulgaris* showed higher insecticidal activity then the rest of the solvent extract. This may be due to the potential compounds was present in hexane extract of the *A. vulgaris*. On the other hand Chloroform extract of *T. purpurea* and ethyl acetate extract of *Sphaeranthus indicus* and *A. mexicana*, showed higher insecticidal activity against *T. castaneum*. These results are in corroborating with the result of [11]. These studies support to screen more plants possessing the insecticidal compounds. There is a wide scope for the discovery of more effective plant products because the plant kingdom is still an untapped reservoir of new molecules having potential biopesticidal compounds. The activity of essential oils mainly depends upon the major volatile components they possess. In eucalyptus oil the major component is 1,8-cineole and this compound is responsible for the oil's biological activity[13]. [14] Showed similar results by evaluating essential oil compounds from *Cymbopogon citratus* (DC) Stapf. and *Eucalyptus citriodora* (Hook) and identified the monoterpenes, linalool, 1,8- cineole, neral and geranial among compounds with repellent activity against

In the olfactometer study maximum repellent activity was observed in the plant powders of *T. purpurea* showed higher EPI values against *T. castaneum* [1]. [15]Fumigant toxicity of *Origanum* essential oils against insect pests is well known. Turkish *Origanum acutidens* oil obtained from hydrodistillation caused 37% mortality of *Tribolium confusum* adults after 96 h of exposure [16] Similar results were reported by [17]. [18]reported that linalool from the essential oil of *Origanum vulgare* L. at a concentration of 0.03 mg/cm² produced 83% repellency against *T. castaneum*. The volatile toxicity of some monoterpenoids against *S. oryzae*, *R. dominica* and *Cryptolestes pusillus* Schönherr, three serious stored-product pests, has also been demonstrated[19]. It has been demonstrated to possess insecticidal activity against several stored-product insects such as the cowpea weevil (*C. maculatus*), lesser grain borer (*R. dominica*), flat grain beetle (*C. pusillus*), rice weevil (*S. oryzae*), maize weevil (*S. zeamais*) and red flour beetle (*T. castaneum*) [20]. In the present study, an attempt was made to screen locally available plants. Yet further screening of other plants may reveal the presence of insecticidal and repellent properties in them, which might lead to their improvement as protectants in direct application assays. However, In our present study hexane extract of *A. vulgaris* showed higher insecticidal activity then the rest of the solvent extract. This may be due to the potential compounds was present in hexane extract of the *A. vulgaris*.

Conclusion

This study demonstrates that the bioefficacy of selected plant

extracts against *T. castaneum* adults. These findings suggest that there may be different constituents in the individual extracts possessing different bioactivities but their identities are yet to be determined. The isolation and identification of the bioactive compounds in the selected plant extracts are of utmost importance so that their potential application in controlling stored-product pests can be fully exploited. However, the present findings could be used to control insects in stored products to minimize the pest infestation.

Conflict of interests

The authors declare that there is no conflict of interests.

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