International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG(USA) Volume 5, Issue 9 - 2018

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2018.05.09.015

Insecticidal property of *Solanum trilobatum* L. Extract against stored-grain pests

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Abstract

Sitophilus oryzae (L.) and *Tribolium castaneum* (Herbst.) are two destructive pests causing important economic losses to stored grains and minimize the quality of grains. Plants products are alternatives to control pests as they contain rich sources of bioactive molecules. The present study explored the fumigant, repellent, ovicidal and antifeedant activity with leaf extracts of *S. trilobatum*. Dried leavesextracts with 2.98% yield was analyzed by GC-MS and major properties were identified. Fumigant toxicity was observed in 0.200 mg mL^{-1}on adults of both the pests, highest against *S. oryzae*.LC_{50} and LC_{90} values for both pests were tested. The extracts had effective repellency activity of 95% and 97% while the oviposition deterrency was of 97% and 95% respectively. Extracts also reduced the relative growth rate, and efficiency conversion of ingested food in adults. In addition, extracts produced a feeding stimulant effect in *T. castaneum* adults, and they had a feeding deterrent action against *S. oryzae*. *Solanum trilobatum* leaf extracts has insecticidal activities on mortality and other behavioural effects on stored-grain pests.

Keywords: *Solanum trilobatum*, Insecticidal activity, *Tribolium castaneum*, *Sitophilus oryzae*

Introduction

Tribolium castaneum Herbst. (Coleoptera: Tenebrionidae) and *Sitophilus oryzae* L. (Coleoptera: Curculionidae)are two major paramount pests for stored grain products, which feed on wheat flour oats, rye, barley, sorghum and other food products (Hagstrum et al., 2012). These insect pest causing serious losses in both quantity and quality of stored commodities at a global level (Rees, 2004), estimated to cause losses about 10-40% of the total worldwide (Phillips and Thorne, 2010) and nearly 20%–25% food grain damage in India (Rajashekar and Shivanandappa, 2010). Prevention of these insect pest population infestations in stored grains is primarily dependent on synthetic insecticides such as phosphine, chloropyrifos, malathion, and pyrethroids (Kiran and Prakash, 2015). However, extensive use of synthetic

insecticides has led to many contradictory effects of environmental concern, toxicity to human health, other non-target animals, insecticidal resistance and residue problems (Stefanazzi et al., 2010). Further, due to the persisting problem caused by insecticide usage, researches concentrating on natural botanical products as possible alternatives to synthetic chemical insecticides are on the rise.

In this aspect, botanical insecticides take part in a decisive role in controlling of the insect pest and its non-toxic effects and moderate efficacy, without discarding any residues in the environment. In addition GRAS (Generally Regarded As Safe)by the U.S. Food and Drug Administration, had approved some of the plant product and their bioactive compounds in this regard. For instance, the plant products and their chemical compounds are reported for augmentation which implies a suppressing activity against insect pests(Abdurrahman et al., 2008; Upadhyay and Jaiswal, 2007).Several plant products and their bioactive compounds have extensively been studiedagainst stored product insects for their inherent biological properties such as toxicity, (Prkash et al., 2013; Jaya Sing et al., 2014) repellent, (Kedia et al., 2014; Nerio et al., 2010) antifeedant, andovicidal activities (Shukla et al., 2011; Kiran and Prakash, 2015) and may affect some biological parameters such as growth rate, life span and reproduction (Stefanazzi et al., 2010).

Solanum trilobatum Linn. (Solanaeace) is a thorny shrub that is widely spread in India. These plants have been intensively studied for various activities including mosquitocidal activity (Rajkumar et al., 2014; Sakthivadivel et al., 2014), antioxidant (Ganesan et al., 2017), antibacterial, antifungal, anticancer (Ramar et al., 2015; Govindarajan and Chinnachamy,2014), anti-inflammatory (Pandurangan et al., 2011), antidiabetic (Ahmed et al., 2016), antinociceptive (Pandurangan et al., 2010), hepatoprotective (Shahjahan et al., 2005), and anti-ulcerogenic (Amir and kumar, 2004). In addition, this plant have been used to treat several human diseases sincepacifies dyspnea, anorexia, worm infestation, cough, bronchitis, skin diseases and UTI (Urinary Tract Infections) (Kirthikar and Basu, 2006; Chopra et al.,2006).However, there are no earlier studies about the efficacy of *S. trilobatum* as a potential biopesticide against the pests affecting grains. Therefore, the present study was designed to investigate the toxic, repellent and feeding deterrent activity of the extract from the leaves of *Solanum trilobatum* against two storage pests: rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae) and rust red flour beetle, *Tribolium castaneum* Herbst. (Coleoptera: Tenebrionidae). Outcomes of the study will be useful in promoting research aiming at the development0 of a new promising biofumigantas a component of integrated pest management.

Materials and Methods

Insects Rearing

The adult *Tribolium castaneum* and *Sitophilus oryzae* was collected from naturally infested grain purchased from a local market of Coimbatore, India. The insects pest were reared on clean and uninfested wheat grain. Both adult insect pests were released in 500g of wheat grain in a kilner jar capped with muslin cloth to ensure ventilation. The jar was established in a growth chamber at a controlled temperature of 28±1 °C and relative humidity (RH) 70-75 % under a 16:8h light: dark at the Department of Zoology, Bharathiar University, Coimbatore, India. Both Adult insects were used for the each test parameter.

Plant materials

Healthy mature leaves of *Solanum trilobatum* were collected around the study area Coimbatore, India (11º16’ N 76º96’ E). The plants were authenticated by Botanical Survey of India (BSI), Coimbatore (BSI/SRC/5/23/2017/Tech-3034). The leaves were cut into small pieces, dried at 40º C and ground to a powder form which was subsequently extracted by soaking in ethanol using a Soxhlet apparatus. Each extract was filtered using a vacuum pump and dried using a rotary evaporator attached with ultra-cryostat and stored at 4º C until further use in the experiments. The recovery percentage yield was calculated using the formula(Santos et al., 2012):

$$\text{Yield (\%)} = W/W_0 \times 100$$

where W is the weight of dried extract and W_0 is the weight of the sample.

Gas chromatography-mass spectrometry

Extract of *S. trilobatum* obtained was subjected to GC-MS (The Trace GC Ultra and DSQII model MS with inbuilt pre-filter to reduce the neutral particles, Thermo Fisher Scientific Company Pvt. Ltd.) analysis for the identification of various secondary

phytochemical compounds. The Clarus 680 GC used in the analysis employed a fused silica column, packed with Elite-5MS (5% biphenyl 95% dimethylpolysiloxane, 30 m × 0.25 mm ID × 250µm df) and the components were separated using helium as carrier gas at a constant flow of 1 ml/min. The injector temperature was set at 260°C during the chromatographic run. The 1µL of extract sample was injected into the instrument. The oven temperature was set as follows: 60 °C for 2 min followed by upto300 °C at the rate of 10 °C min^{-1}; and 300 °C, where it was held for 6 min. The mass detector conditions were: transfer line temperature 240 °C, ion source temperature 240 °C and ionization mode electron impact at 70 eV, a scan time of 0.2 sec and scan interval of 0.1 sec. The fragments from 40 to 600 Da. Peaks resolved with relative abundance of 0-100 were considered as major compounds. The spectrums of the components were compared with the database of spectrum of known components stored in the GC-MS NIST (2008) library.

Insecticidal fumigant toxicity assay

Fumigant toxicity of *S. trilobatum* leaf extract was tested against adults of *T. castaneum* and *S. oryzae* by impregnated paper assay (Park et al., 2002) with slight modification. Plastic jars of 500 mL capacity with screw lids were used as treatment chambers. Samples of 12.5, 25.0, 50.0, 75.0 and 100.0 $mgmL^{-1}$ extracts were dissolved separately in (0.25 mL) ethanol and applied to filter paper (Whatman No. 1, 2.0 cm diameter). The treated filter papers were then placed into the plastic jars to achieve final concentrations of 0.025, 0.050, 0.100, 0.150 and 0.200$mgmL^{-1}$and control had only ethanol. Ethanol was evaporated by keeping the jars in a fume chamber for 10 min at room temperature, the filter paper was attached to the inner surface of the screw lid of the jar using adhesive tape. Twenty adults of each test pests were released into each jar containing 100g wheat grains. Three replicates were used in all experimental and control set up. They were incubated at 27±2 °C and 70±5 % relative humidity. Extracts of each concentration was used for an exposure period of 24 h. After exposure, the insects were separated from the treatment jars and numbers of dead and alive insects were counted. Active insects were transferred to clean vials with culture media and kept in an incubator for the determination of end point mortality.Final mortality was calculated following Abbot's formulaof percent corrected mortality:

$$\text{Mortality }, P(\%) = \frac{T-C}{100-C} \times 100$$

where *P* is the % corrected mortality, *T* is the% killed in the treatment group, and *C* is the % killed in the control.

LC_{50} values were calculated by Probit analysis using SPSS v 16.0 (Finney 1971).

Oviposition deterrent activity

Aliquots of 12.5, 25.0, 50.0, 75.0 and 100.0 mg extracts were dissolved separately in 0.25 mL of ethanol and applied to filter paper (Whatman No. 1, 2.0 cm diameter) which generate concentrations of 0.025, 0.050, 0.100, 0.150 and 0.200 mg mL^{-1} in plastic jars (500 mL) and control had ethanol. Ten male and female both pests were placed into all treatment jarscontaining 100g wheat grains. Exposure period of 24 h was used for each concentration. After exposure to the oil vapours, the pest were separated from the treatment jar and grains were placed in clean and untreated jars for 3 days for the prominent appearance of eggs laid on grains. Total number of eggs was counted on the treated and control wheat grains. The % deterrency of ovipositions was calculated according to the equation:

$$\text{Deterrency} = \frac{NC-NT}{NC} \times 100$$

where *NC* is the number of eggs laid on control grains, and *NT* is the number of eggs laid on treated grains.

Repellency activity

The repellency activity was assessed(Liu et al.2006) with some modifications. A bioassay system consisting of 3 glass jars (2 extract treatments, 1 control) was connected using 30×10 cm nylon tube and a 5 cm diameter circular hole was cut at the middle of the mesh for the introduction of test insects. Samples (100g) of wheat grains were separately mixed with the individual extracts and the mixture in the glass jars were at concentrations of 25, 50, 100 and 200 mg g^{-1} (extract/ grains) kept at 27±2 °C for 24 h. Ethanol was used as negative control. Experiments were replicated for three times. After 24h, the beetles of each treated and control group was counted and the repellency (%)was calculated by the following formula:

$$\text{Repellency}(\%) = \frac{C-E}{T} \times 10$$

Where *C* is the insect numbers in the control, *E* is the insect numbers in the experimental and *T* is the number of total insects.

Nutritional indices and antifeedant activity

The antifeedant activity and alteration in nutritional physiology were analyzed (Stefanazzi et al., 2010) with slight modification. Taking aliquots (200µL) from a wheat flour suspension in water and putting on plastic dishes that were placed in a chamber at 25ºC temperature and 70% RH overnight. The discs were weighed, registering values between 70 and 78 mg. Ethanol solution of the extracts were prepared at concentration of 0, 1, 2 and 4 mg $disc^{-1}$. Ethanol treated discs was used as control group. Ten adult insects were allowed into each container. After maintaining them for 72 h in controlled conditions as mentioned above, the weight of the discs, mortality and the weight of insects alive were recorded. Three replicates were carried out and nutritional indices were calculated:

the relative growth rate (RGR):

$$RGR = \frac{A-B}{B \times day}$$

where *A* is the weight of insects alive on the third day divided by number of insects alive on the third day, and *B* is the original weight of insects divided by total number of insects;

the relative consumption rate (RCR):

$$RCR = \frac{D}{B \times day}$$

where *D* is the biomass ingested (mg) divided by number of insects alive on the third day;

the efficiency of conversion of ingested food (ECI %):

$$ECI = \frac{RGR}{RCR} \times 100$$

the antifeeding effect (AE):

$$AE\ (\%) = \frac{C-T}{C} \times 100$$

where *C* is the consumption of control discs (mg) and *T* is the consumption of treated discs (mg). Positive values expressed a feeding deterrent effect and negative values expressed a feeding stimulant effect.

Results

Extraction yields and Chemical constituent

The percentage yield of the crude extracts with methanol was 2.98%.The color of methanol extract was darker. *S. trilobatum* extracts was analyzed by GC-MS and was found to contain 13chemical compounds. This methanolic extract had: 1-Octadecyne (21.06%), N-Hexadecanoic acid (16.39%), Cholesta-8, 24-Dien-3-ol, 4-Methyl-, (3.Beta., 4.Alpha.) (14.95%) and Tetradecane, 1-Chloro (12.78%).Other compounds were detected with a percentage between 1 to 10 % (**Table 1; Figure 1)**.

Table 1. Chemical composition of ethanolic *Solanum trilobatum* leaf extracts.

No.	Compounds	Formula	RT (min)	Relative Percentage
1	Phytol	$C_{20}H_{40}O$	17.594	1.564
2	N-Hexadecanoic acid	$C_{16}H_{32}O_2$	19.195	16.394
3	Eicosanoic acid	$C_{20}H_{40}O_2$	19.720	1.302
4	Oleic acid	$C_{18}H_{34}O_2$	20.566	6.243
5	1-Octadecyne	$C_{18}H_{34}O_2$	20.741	21.066
6	Tritetracontane	$C_{43}H_{88}$	21.291	3.602
7	Tetratriscontane	$C_{34}H_{70}$	22.857	1.704
8	1,2-Benzenedicarboxylic Acid, Mono(2-Ethylhexyl) Ester	$C_{16}H_{22}O_4$	23.377	10.044
9	Heptacosane, 1-chloro-	$C_{43}H_{88}$	24.377	1.281
10	Octadecane, 1-Chloro	$C_{18}H_{37}Cl$	27.303	2.592
11	Vitamin E	$C_{29}H_{50}O_2$	27.989	6.477
12	Tetradecane, 1-Chloro	$C_{14}H_{29}Cl$	29.119	12.780
13	Cholesta-8,24-Dien-3-ol, 4-Methyl-, (3.Beta.,4.Alpha.)-	$C_{28}H_{46}O$	29.864	14.951

RT - Retention Time.

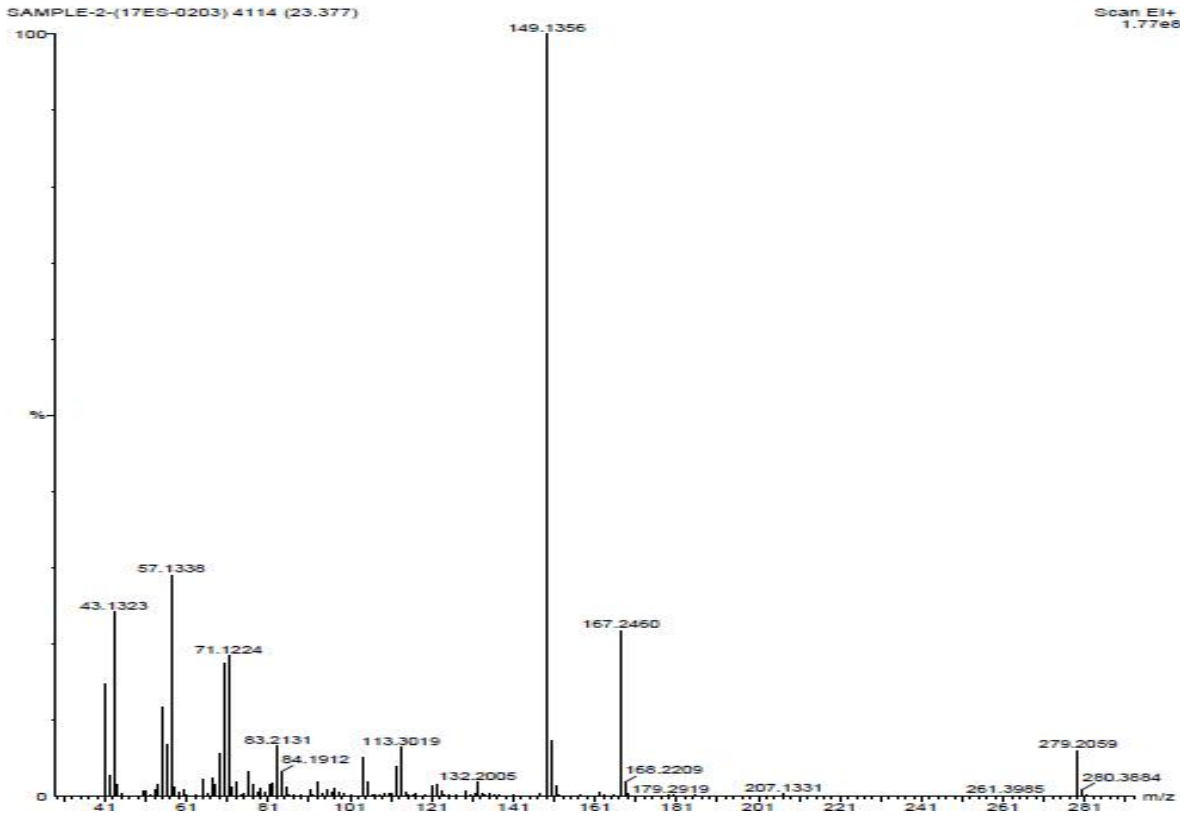

Figure 1. Representative chromatogram of leaf extracts of *Solanumtrilobatum*. Peaks 0–100 indicate the extract components identified (Table 1).

Fumigant toxicity

Results of fumigant toxicity of *S. trilobatum* extracts to adults of *S. oryzae* and *T. castaneum* are shown in **Table 2**. Dose of 0.200 mg mL^{-1} treatment delivered100% mortality in *S. oryzae*. In *T. castaneum* it caused 89.4% mortality at 24 h. Also, theLC_{50} and LC_{90} values obtained was found to be significantly effective in *S. oryzae* (42.80; 82.35) compared to *T. castaneum* (51.44; 99.67).

Table 2. Fumigant toxicity of *Solanum trilobatum* extracts on *Sitophilus oryzae* and *Tribolium castaneum* after 24 h.

Species	Concentration ($mgmL^{-1}$)	Mortality (%) ± SE	LC_{50} (LCL-UCL)	LC_{90} (LCL-UCL)	Slope	Regression equation	X^2 (*d.f.*)
Sitophilus oryzae	0.025	28.5 ± 1.2^{e}	42.78 (29.57-52.7)	82.35 (69.74-107.91)	1.04	y = 8.51+0.94x	6.89 (4) n.s.
	0.050	41.2 ± 1.5^{d}					
	0.100	68.7 ± 1.8^{c}					
	0.150	86.3 ± 0.5^{b}					
	0.200	100.00 ± 1.4^{a}					
Tribolium castaneum	0.025	19.7 ± 0.5^{e}	51.44 (46.50-56.03)	99.67 (91.98-110.08)	1.10	y = 3.11+0.89x	2.12 (4) n.s.
	0.050	38.2 ± 0.9^{d}					
	0.100	59.3 ± 0.8^{c}					
	0.150	78.5 ± 1.2^{b}					
	0.200	89.4 ± 1.7^{a}					

Each value is a Mean ± SE of four replicate analysis, within each row means with different superscript letters are statistically significant at P<0.05 (one way ANOVA and subsequently post hoc multiple comparison with DMRT).
LCL – Lower Concentration Limits.
UCL – Upper Concentration Limits.

Oviposition assay

The percentage of ovipositor deterrency was amplified when increasing the concentration of the *S. trilobatum* leaf extracts in treatments**(Table 3)**. Significant differences in the number of laid eggs were found between treated and untreated wheat with different concentration. At 0.200 mg mL^{-1}, the extract of *S. trilobatum* allowed *S. oryzae* to lay only 10 eggs and *T. castaneum* laid 12 eggs compared to the control which laid 302 and 310 eggs, which proved to be the most effective concentration, with 97 % and 94 % deterrency respectively.

Table 3. Oviposition deterrent activity of *Solanum trilobatum* extracts on *Sitophilus oryzae* and *Tribolium castaneum*.

	Dose (mgmL^{-1})					
	Control	**0.025**	**0.050**	**0.100**	**0.150**	**0.200**
Sitophilus oryzae	302.7 ± 7.08^{a}	22.69^{f} (234.0±3.09)	34.22^{e}(199.1±3.36)	56.39^{d} (132.0±2.45)	84.24^{c} (47.7±2.70)	96.95^{b} (9.2±2.81)
Tribolium castaneum	310.1± 7.24^{a}	19.27^{f} (250.3±4.14)	30.85^{e}(214.4±3.23)	43.64^{d} (174.7±3.18)	77.49^{c} (69.8±3.44)	94.64b(11.9±3.07)

Each value is a Mean ± SE of four replicate analysis, within each column means with different superscript letters are statistically significant at P<0.05 (one way ANOVA and subsequently post hoc multiple comparison with DMRT).

Repellency activity

The extracts of *S. trilobatum* exhibited repellent activity to *S. oryzae* and *T. castaneum* with an overall repellency in the range of 95 to 97% **(Figure 2)**. The concentration of 200mg g^{-1}showed the highest repellent activity to both *S. oryzae and T. castaneum.*

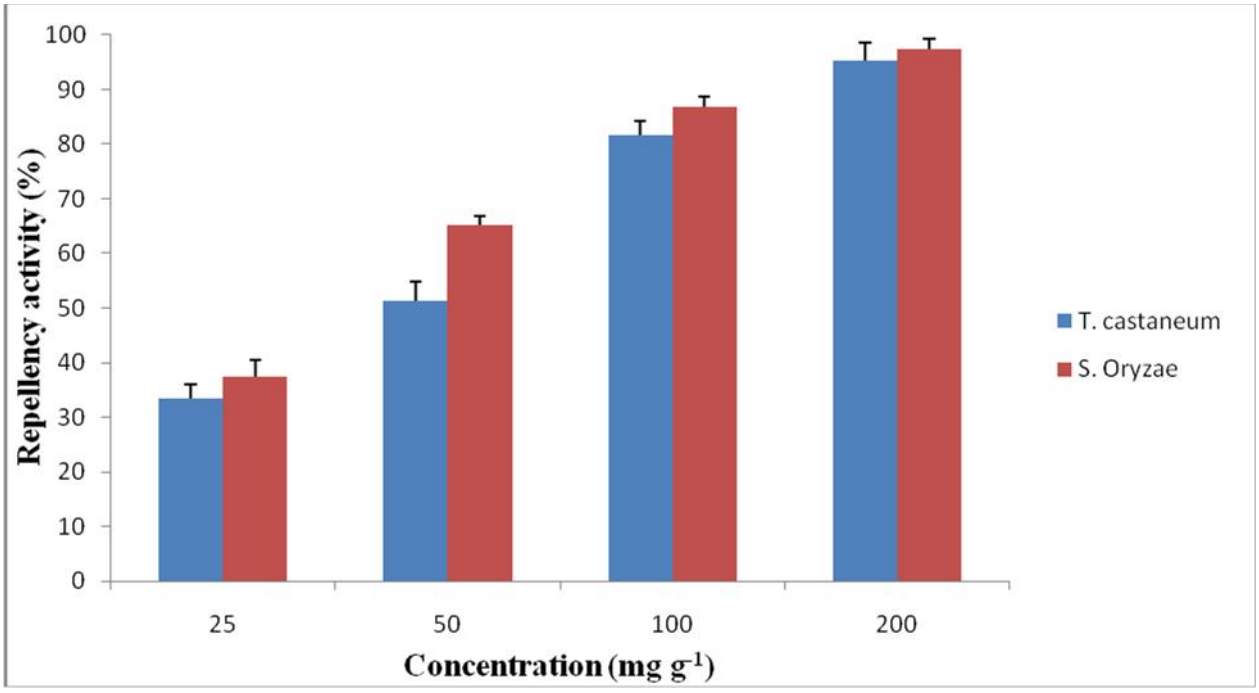

Figure 2. Repellency activity of *Solanum trilobatum* leaf extracts against two species of stored-grain pests treated.

Nutritional indices and antifeedant activity

For *S. oryzae* adult, there was a significant reduction in the relative growth rate *(*RGR*)*, relative consumption rate (RCR) and in efficiency of conversion in ingested food (ECI) at all concentrations of *S. trilobatum* extracts (Table 4). Feeding deterrence indices showed strongest at the highest concentration of 4 mg $disc^{-1}$. In *T. castaneum* adult, all concentrations of the extract modified the nutritional indices wherein, the relative growth rate, relative consumption rate and the efficiency of conversion of ingested food was significantly reduced. The concentration of 4 mg $disc^{-1}$ had strong feeding deterrent actions **(Table 4)**.

Table 4. Nutritional and antifeedant deterrence indices of adult *Sitophilus oryzae* and *Tribolium castaneum* exposed to *Solanum trilobatum* leaf extracts.

Insects	Concentration (mg $disc^{-1}$)	RGR (mg $mg^{-1}disc^{-1}$)	RCR (mg $mg^{-1}disc^{-1}$)	ECI (%) ± SE	FCI (%) ± SE
S.oryzae	0	0.449 ± 0.01^{a}	0.324 ± 0.01^{a}	139.22 ± 6.80^{a}	-
	1	0.345 ± 0.01^{b}	0.276 ± 0.01^{ab}	125.50 ± 3.82^{a}	9.77 ± 2.68^{ab}
	2	0.293 ± 0.009^{bc}	0.248 ± 0.03^{ab}	121.55 ± 14.53^{a}	17.20 ± 6.52^{a}
	4	0.254 ± 0.02^{c}	0.216 ± 0.02^{b}	118.42 ± 9.54^{a}	14.93 ± 1.89^{a}
T .castaneum	0	0.395 ± 0.06^{a}	0.249 ± 0.04^{a}	161.3 ± 12.93^{a}	-
	1	0.242 ± 0.01^{b}	0.163 ± 0.03^{ab}	148.53 ± 10.54^{a}	16.94 ± 3.09^{c}
	2	0.185 ± 0.04^{b}	0.151 ± 0.05^{b}	122.36 ± 13.58^{b}	34.55 ± 7.48^{b}
	4	0.166 ± 0.04^{b}	0.135 ± 0.02^{b}	150.75 ± 9.06^{a}	53.22 ± 11.33^{a}

Each value is a Mean ± SE of four replicate analysis, within each row means with different superscript letters are statistically significant at $P<0.05$ (one way ANOVA and subsequently post hoc multiple comparison with DMRT).

Discussion

Insect pests are controlled by the plant extract and their essential oils are considered to be alternative sources (Tripathi, 2009). Their secondary active chemical components may be used for pest prevention, early pest detection or pest control (Lopez, 2008). In previous literature reports denoting the biological activities of medicinal plant extracts and chemical compound against bacteria, fungi viruses and pests (Unicini Manganeli et al., 2005). Here, in the current study confirms the leaf extract of *S. trilobatum* has varied biological applications with consideration to the insecticidal activity against the adults of *S. oryzae* and *T. castaneum.* The *S. trilobatum* extract activities were observed to be increasing in a dose dependent manner and that these significantly protected the grains from insect damage. Moreover, previous researchers Rajashekar et al. (2010; 2012b) had reported that dose dependent activity of organic powder *Decalepis hamiltonii* extracts and its bioactive compounds showed the capability of grain protectant action against pests. Similarly, the methanol extracts of *L. camara* was also observed for the significant dose dependent management of stored grain pest (Rajashekar et al., 2013).

Based on the LC_{50} and LC_{90} values and their respective confidence intervals,*S. trilobatum* extract was shown in the current study to possess fumigant toxicity to both *S. oryzae* and *T. castaneum* adults. However, these extracts were less toxic to *T. castaneum* when fumigant toxicity was evaluated and this may be attributed to the accruing thickness of the cuticle or its structure or different weights among insects (Gillott, 2005). This was demonstrated by previous authors that exposure variations are due to the change in cuticular components in stored produced insect species (Stefanazzi et al., 2010).Similarly, bioactive chemical compounds of plants such as *Ocimum selloi* Benth.. *Ruta graveolens* L..*Leonotis nepetifolia* L., *Datura stramonium* L., *Cordia verbenacea* L., *Mentha piperita* L., *Mormodica charantia* L. and *Ageratum conyzoides* L. was formerly screened with insecticidal activity against Coleopteran pests of stored products (Moreia et al., 2007).In addition, the plants of *Cassia tora* and *Clerodendrum inerme* extracts with ethanol (5%) extract had insecticidal activity against *S. oryzae* and show significant level of grain was protectant (Yankanchi and Gadache, 2010).

Ovipositions deterrency activity of the leaf extracts of *S. trilobatum* at different concentrations was compared and these extract caused laying eggs to a significant extent dose level at 0.200 mg L^{-1}. The ovipositor activity thus amassed as the doses increased subsequently and it had allowed *S. oryzae* to lay 10 eggs and *T. castaneum* to lay 12 eggs as compared to the untreated grains with 302 eggs and 310 eggs with 97% and 94 % ovipositions deterrency respectively. During ovipositor inhibition, the females were observed to die before laying eggs or the females failed to lay many eggs in optimum conditions. From the obtained results, it was clearly evident that the ovipositor deterrency activity was also in a dose dependent manner. Similarly, dose dependent ovipositor activity had been observed (Shukla et al. 2011), the ornamental plant essential oil of *Callistemon lanceolatus* against *C.chinensis* which achieved 96% deterrency result in0.1 µl mL^{-1} concentrations. Moreover, adult female insect juvenile hormones are produced depending on the protein content and this hormone is essential for the functional development and maturation of ovarian eggs(Genc, 2006). Plant extracts contain steroid chemical compounds and these compound blocks the sterol carrier protein of the insect (Kumar et al., 2012). A lack in this protein is said to have abnormalities in insect egg morphology. Similarly, morphologically abnormal eggs were found in *S. oryzae* and *T. castaneum* insects treated with *S. trilobatum* leaf extracts.

The repellency activity of the leaf extracts of *S. trilobatum* showed consistent responses from both adult insect pests. Strong repellent action observed against *S. oryzae*(96%)at a concentration of 200 mg g^{-1} after 24 h of exposure and a moderate repellent action against *T. castaneum* (95%) was observed for the same concentration. According to Liang et al. (2013) who reported, fourteen Chinese medicinal herbs extracts from *Curcuma longa*, *Epimedium pubescens*, *Lindera aggregate*, *Nardostachys chinensis*, *Schizonepeta tenuifolia*, *Zanthoxy-lum schinifolium*, and *Zanthoxylum officinale* was observed to exhibit strong repellency against *T. castaneum* pest (PR 37–94%). Similarly, Chebet et al. (2013) observed the extracts of *Tephrosiavogelii*and *Azadrachta indica* were most repellent (88-90%)against Coleopteran beetle *Prostephantus truncates*. Also, the crude methanol extract of *Asimina parviflora* and *Trichilia connaroides* leaves revealed a significant repellent activity against *T. castaneum*, *R. dominica* adults (Guruprasad and Pasha, 2014). Padin et al. (2013) suggested that *Bactris campestris*, *Jacaranda mimosifolia*, *Matricaria chamomilla* and *Veronica arvensis* extracts exhibited a good capability as a potential repellent and toxicant agent to adults of *T. castaneum*.

Plant extracts consist of metabolic compounds that explore repellent, antifeedant, sterilization and toxic effects of insects (Liu et al., 2006). Exploration of the plant product and their chemical compounds against insect antifeedant activity is conclusively successful in agriculture (Isman, 2002). Antifeedant activity was observed as dose dependent and their effectiveness was increased with increasing concentration gradients in which, adult *S. oryzae* had negligible variations on feeding activity. According to Pungitore et al. (2005) observed, the essential oil of *Junellia aspera* and Moldenke oil (Verbenaceae) against grain insect pests was evaluated taste receptor. Herein, the plant chemical compounds suppress the insect feeding activity on the central nervous system following its ingestion and absorption. Pervious literatures also reported that plant triterpenoid compounds affected insect feeding deterrent ability, such as triterpenoids based on a 30- carbon structure, glycoside substances occurring conjugated with sugars and highly oxygenated derivatives such ascardenolides are found to be potent antifeedants (Isman, 2002). This expresses the functional role of oxygenated glycosides providing the effective toxicity which prohibit insects feeding activity.

Conclusion

Thus, the study demonstrates that the leaf extracts of *S. trilobatum* had posed biological characteristics such as fumigant toxicity, oviposition deterrent activity, repellent activity and antifeedant activity against *T. castaneum* and *S. oryzae*. With constructive safety limits, we can therefore recommend the potential exploitation of *S. trilobatum* leaf extracts as a favorable fumigant in insect management strategies for grains/pulses. Hence, the application of *S. trilobatum* extracts as fumigants in management of pulse beetles and other storage insect pests would be economical. However, further studies are needed to increase our understanding on the effective use of these technologies on a wide range of pests in commercial stores.

Acknowledgments

This work was supported in part by a funding grant from Council of Scientific and Industrial Research (CSIR), New Delhi.

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How to cite this article:
Vallavan Rajkumar, Chinappan Gunasekaran, Jayaraman Dharmaraj, Panneerselvam Chinnaraj, Cheruvathur Amita Paul, Inbaraj Kanitha Christy. (2018). Insecticidal property of *Solanum trilobatum* L. Extract against stored-grain pests. Int. J. Adv. Res. Biol. Sci. 5(9): 145-155.
DOI: http://dx.doi.org/10.22192/ijarbs.2018.05.09.015