ORIGINAL RESEARCH PAPER

Environmental Science

ANTIFEEDANT EFFECT OF SOME PLANT EXTRACTS ON *TRIBOLIUM CASTANEUM* (HERBST)

KEY WORDS: Pest, botanicals, environment, antifeedant

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ABSTRACT

Dichloromethane extracts of eight locally available plants *Anona squamosa, Calotropis procera, Jatropha curcas, Datura metel, Lantana camara, Murraya koenigii, Polygonum hydropiper and Vitex negundo* were screened to find their antifeedant effect on a stored grain pest, *Tribolium castaneum,* commonly known as the red rust flour beetle. Results showed that all the plant extracts exhibited significant effects on the tested pest; the aqueous and DCM extracts of A. squamosa showing the highest antifeedant potential.

INTRODUCTION:

Insects are one of the most important causes of food deterioration in storage. They consume grains as well as contaminate the stored products with their cast skins, dead bodies and fecal matter. Some species secrete chemicals that alter the flavor and odor of the products, thus affecting food quality and safety which lead to reduced marketability and consumption by humans and livestock. Heavy infestations also cause heat built-up in storage containers, which stimulates seed deterioration and further attack by microbes. These pests can be controlled by contact insecticides or by fumigation. However, these chemicals are expensive and may alter the odor and taste of grains as well as affect the viability of seeds. They also leave their residues in the foodstuff which may affect other non-target species.

Owing to all these problems, attention has been focused in favor of botanical extracts that possess insecticidal properties like toxicity, repellency, effect on progeny production, ovicidal and antifeedant effects. Plants provide potential alternatives to currently used insect control agents because they contain a rich source of bioactive chemicals. Several plants have insecticidal properties and are traditionally used to control insect pest species, which do not have any adverse effects on the environment and other life forms.

Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae) is a reddish brown coloured stored grain pest, found worldwide and is commonly known as the red flour beetle. It attacks stored grain products such as flour, cereals, crackers, beans, spices, pasta, cake mix, dried pet food, dried flowers, chocolate, nuts, seeds, and even dried museum specimens (Via, 1999; Weston and Rattlingourd, 2000). The egg to adult life cycle takes about 30 days. Red flour beetles can breed throughout the year in warm areas and they are prolific breeders. All forms of the life cycle may be found in infested grain products at the same time which cause significant loss. They infest stored products with their larva layers and excrements and consequently lower the quality of stored products greatly. They can be controlled through use of chemical pesticides which have adverse effects on human health, environment, non-target organisms besides pest resurgence and pesticide resistance. Hence, there is need for effective use of biodegradable pesticides with greater selectivity and efficacy.

It has been reported that essential oils of several spices like anise (*Pimpinella anisum* L.) and peppermint (*Mentha piperita* L.) possess toxicity against four major stored product pests, *R. dominica, T. castaneum*, *S. oryzae* and *Oryzaephilus surinamensis* (L.) (Shaaya *et al.*, 1991). Ho *et al.* (1996) found that essential oil of garlic was insecticidal to *T. castaneum* and *Sitophilus zeamais* (Motschulsky). The essential oil of nutmeg seeds (*Myristica fragrans* Houtt) (Huang *et al.*, 1997) and cinnamon bark (*Cinnamomum aromaticum* Nees) (Huang and Ho, 1998) were also found to be toxic to *T. castaneum* and *Sitophilus zeamais*. The effect of a crude extract of *Melia azedarach* fruits on *T. castaneum* was studied by Tio *et al.* (1996). Leaf extracts of *J. curcas, L. camara, C. procera* and *D. metel* were found to be toxic to *T. castaneum* (Kalita and Bhola, 2014). Penaloza (1995) also reported the biological effects of crude extracts of six plants on *T. castaneum*. Novo *et al.* (1997, 1998) observed the repellent activity of several crude extracts of four native plants against *T. castaneum.* The repellent activity of *L. camara* and *C. procera* was studied by Kalita and Bhola (2013). Both the tested botanical extracts repelled adults of *T. castaneum.*

The present study was undertaken to observe the antifeedant effects of the tested botanicals on *T. castaneum*.

MATERIALS AND METHODS:

Insect rearing and preparation of plant extracts: *T. castaneum* was cultured in the laboratory at ambient conditions of temperature, relative humidity and photoperiod of (30±2°C), (70±5%) and (12:12, L: D conditions) respectively. Leaves of *Anona squamosa, Calotropis procera, Jatropha curcas, Datura metel, Lantana camara, Murraya koenigii, Polygonum hydropiper* and *Vitex negundo* were collected, washed and air dried for three to five days, followed by drying in the oven at 40°C for 24 hours after which they were powdered. The extraction was carried out in Soxhlet apparatus using Dichloromethane. The extract was collected and air-dried to vaporize the solvent, sealed with aluminum foil and stored at 4°C.

Antifeedant test: The antifeedant test was conducted using the wheat wafer disc bioassay with some modifications (Paruch *et al.*, 2001, Morimoto *et al.,* 2006). Wheat wafer discs made of finely ground wheat flour and water were baked at 80˚C for 1h and used as the test food or substrate. The discs were of 2.5 cm diameter and weighed 0.40–0.41g. The test insects were starved for 36 hours before being introduced into the petri dishes containing the wafer discs. Wafer discs were dipped into 15, 30, 60 or 100 mg/ml concentration of the extracts. The discs were air-dried overnight at 30^0C, weighed and provided to *T. castaneum* adults as food. Fifty beetles were placed in petri dishes and were given the treated and weighed wafer discs as food and monitored for 10 days. Control beetles were provided with wafers treated with acetone. The discs were weighed prior to the experiment and again after ten days of feeding by the adults. Each treatment was replicated five times for all the plant extracts.

The percentage of Antifeedant activity or Feed Deterrence Index was calculated using the formula ofJannet *et al.* (2000).

% Feed Deterrence Index (FDI) = C-T/C+T × 100

C is the consumption of control disc and T is the consumption of treated disc.

RESULTS:

Feeding deterrence Index (FDI) of different plant extracts against adults of *Tribolium castaneum* is shown in Table 1. Aqueous extract of all the plants exhibited significantly low FDI compared to DCM extract of the same plant at same concentration. In both the cases FDI was directly related to concentration, except in case of aqueous extract of *P. hydropiper*. In case of aqueous extracts highest FDI was observed in case of *A. squamosa* (80.1%) followed by *M. koenigii* (68.4%), *C. procera* (53.78%), *V. negundo* (45.0%), *J. curcas* (41.66%), *D. metel* (32.7%), *P. hydropiper* (32.46%) and *L. camara* (30.61%) (Fig: 1). In case of DCM extracts, *A. squamosa* exhibited highest FDI (78.6%) followed by *P. hydropiper* (72.61%), *M. koenigii* (70.3%). *L. camara* (70.2%), J. *curcas* (69.64%), *V. negundo* (65.53%), *C. procera* (60.56%) and *D. metel* (59.84%). (Fig: 2).

Table: 1. Antifeedant index of different plant extracts at different concentrations against adults of *Tribolium castaneum*

Treatment	Conc. (mg/ml)	FDI (%) ± S.D	FDI (%) ± S.D
		Aqueous extract	DCM extract
	CONTROL	2.0±0.62	2.16±0.85
J. curcas	15	24.86±1.30^{*a}	32.86±1.93*
	30	30.13±3.68^{*a}	34.02±3.57*
	60	40.38±3.98^{*a}	61.52±2.40*
	100	41.66±4.30^{*a}	69.64±5.42*
C. procera	15	30.44±2.90^{*b}	31.22±2.85*
	30	30.32±3.28^{*b}	32.50±5.44*
	60	40.28±5.23^{*b}	42.31±5.30*
	100	53.78±8.92^{*b}	60.56±3.10*
D. metel	15	26.77±2.30^{*a}	31.82±2.57*
	30	28.70±3.60^{*a}	42.90±3.77*
	60	30.89±3.99^{*a}	49.20±3.80*
	100	32.77±4.02^{*a}	59.84±2.44*
A. squamosa	15	44.38±4.02^{*b}	45.23±6.10*
	30	49.92±2.86^{*b}	50.10±2.45*
	60	59.33±1.96^{*b}	58.23±3.40*
	100	80.10±4.76^{*b}	78.60±5.70*
V. negundo	15	30.67±1.33^{*a}	38.00±3.46*
	30	32.11±4.02^{*a}	44.90±4.10*
	60	39.46±3.98^{*a}	56.70±6.43*
	100	45.00±4.03^{*a}	65.53±3.80*

DISCUSSION:

All the plant extracts, both aqueous and DCM exhibited significant antifeedant effect; although the antifeedant effect of the aqueous extracts were significantly less compared to DCM extract of the same plant at the same concentration. Also, all the plants exhibited different antifeedant effect. Feed Deterrence Index also varied depending upon the concentration of plant extracts. In their study, Rani and Murty (2009) studied the antifeedant activity of flower head extract of *Spilanthes acmella* against the third instar larva of *Spodoptera litura*. The study revealed that the extract possessed strong antifeedant activity against the third instar larva of *Spodoptera litura* and the effect was concentration dependent. This indicated that the active principle(s) present in the plants inhibit feeding behaviour or make the food unpalatable or the substances directly act on the chemosensilla of the insect resulting in feeding deterrence.

In the present investigation DCM extract of *A. squamosa* was found to be the best antifeedant among all the plants against *T. castaneum* followed by *P. hydropiper, M. koenigii, L. camara, J. curcas, V. negundo, C. procera* and *D. metel.* In contrast to the present investigation, hexane, acetone and methanol extracts of *Annona squamosa* leaves exhibited low antifeedant effect against *Helopeltis theivora*. However, in another study, organic solvent extracts exhibited significantly more antifeedant effect compared to aqueous extract at the same concentration (Sarmah, 2010). Further, in the present study, both the aqueous and DCM extract of *Datura metel* were found to have lowest antifeedant effect (Highest FDI =32.77%) compared to *A. squamosa* (Highest FDI=80.10%). Methanolic leaf extract of *Datura metel* was reported to possess a significant antifeedant effect against cotton boll worm (Liyanage *et al*., 2009). In another study, Sudhakar *et al*. (1978) reported that ether extract of *Datura metel*, *Lantana camara*, *Aloe vera*, *Eurphobia royleana* and rhizome of *Acorus calamus* possessed high antifeedant activity against *Athalia lugens*. However, in the present study, *Lantana camara* extract was found to possess low Feeding Deterrence Index.

Several authors have reported plant extracts possessing similar type of antifeedant activity against lepidopteran pests (Morimoto *et al*., 2002; Jeyasankar and Jesudasan, 2005; Abdullah and Subramanian, 2008; Jeyasankar *et al*., 2010, 2011, 2012; Pavunraj *et al*., 2012). Antifeedant and growth inhibitory effect of crude plant extract of *Melia volkensii* and *Origanum vulgare* and pure allelochemicals (digitoxin, cymarin, xanthotoxin, toosandanin, thymol and *trans*-anethole) was investigated by Akhtar and Isman (2004) against four phytophagous insects. Based upon their antifeedant property, it was suggested that these extracts could be used as crop protectant against several pest species. Diaz *et al*. (2009) reported strong antifeedant effect of ethanolic extract of floral aerial parts of *Flourensia oolepis* against *Epilachna paenulata*. Xu *et al*. (2009) reported antifeedant activity of the methanol, petroleum ether, ethyl acetate and n-butanol extracts of *Ajuga nipponensis* against striped leaf beetles. All the extracts exhibited significant antifeedant index.

Haq *et al.* (2005) reported that pulverized leaves of *Eucalyptus spp., Bouganvillea glabra, Azadirachta indica, Saraca indica* and *Ricinus communis* were effective against *T. castaneum.* They were also found to be seed protective to a significant extent. Gandhi *et al.* (2010) concluded that pulverized leaves of *Pudica granatum* and *Murraya koenigii* were responsible for high mortality, delayed development and significant population reduction. Moharrammipour *et al.* (2002) and Shahkarami *et al.* (2004) also demonstrated that *Ferula asafetida* L. extract and the essential oil of *Artemisia aucheri* Boiss exhibited antifeedant effect on *T. castaneum* adults.

Extracts from seeds of *Pongamia pinnata* showed an antifeedant effect on *Diacrisia obliqua* Walker (Chakraborty and Roy 1988; Mohanty *et al*., 1988), *Scelodonata strigicollis* (Durairaj *et al*., 1991), *Spodoptera litura* and *Tribolium castaneum* (Prakash and Rao 1986). Similar results of antifeedant effect on *S. oryzae* and *T. castaneum* were observed by Talukder and Howse (1993,1994) with four different extracts of *Aphanamixis polystachya*, acetone extract being the most effective with a high total deterrence coefficient.

Several active compounds isolated from different plants have been reported to be responsible for antifeedant property. The tested botanical extracts may be used for combating pests of stored food commodities as these have less residual toxicity on organisms including man and is locally available, thereby ushering in ecofriendly management of insect pests.

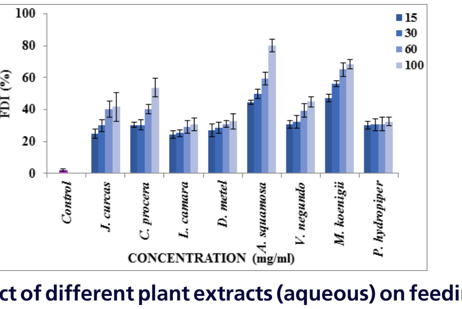

Fig. 1: Effect of different plant extracts (aqueous) on feeding deterrence index(FDI)

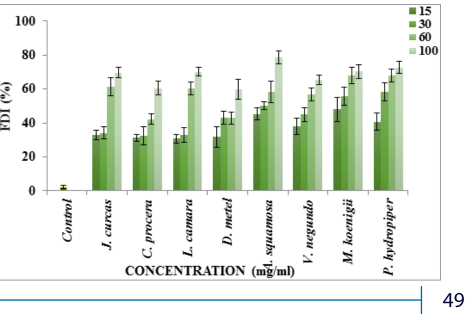

Fig. 2: Effect of different plant extracts (DCM) on feeding deterrence index (FDI)

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