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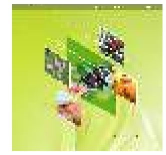

TOXICITY AND REPELLENCE OF PLANT OILS AGAINST *TRIBOLIUM CASTANEUM* (HERBST), *RHYZOPERTHA DOMINICA* (F.) AND *TROGODERMA GRANARIUM* (E.)

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ABSTRACT

Toxicity and repellency of *Conocarpus erectus, Rosa indica* and *Cassia fistula* oils extracted by Soxhlet apparatus in two solvents (petroleum ether and ethanol) were evaluated against *Tribolium castaneum, Rhyzopertha dominica* and *Trogoderma granarium* . The oils were applied on wheat grains at three concentrations (10, 20 and 30%). The treated grains were offered to targeted insects. The toxicity results revealed that the ethanolic extracts were more effective against *T. castaneum* than petroleum-ether extracts. Ethanolic extracts of *C. erectus* proved more effective against *T. castaneum* followed by ethanolic extracts of *C. fistula* and *R. indica*. Petroleum ether extracts proved more effective against *R. dominica* and *T. granarium* because petroleum-ether extracts of *C. erectus* proved more effective followed by *R. indica* and *C. fistula* than their ethanolic extracts. The repellency data revealed that petroleum extracts proved more effective than ethanolic extracts against *T. castaneum* and *R. dominica*. *Conocarpus erectus* extracts were more repellent followed by *C. fistula* and *R. indica* However, *C. erectus* proved more effective repellent against *T. granarium* followed by *R. indica* and *C. fistula*. All the leaf-extracts investigated in present study can be better alternatives to synthetic grain protectants and should be further studied for characterization of the active molecules present in these extracts.

Keywords: Laboratory study, Plant extracts, Repellency, Stored insect pests, Toxicity

INTRODUCTION

Wheat is the world's third largest cereal crop after maize and rice. There has been considerable increase in its consumption due to intensive population increase (Belderok *et al*., 2000). Almost 60-80% of all grains produced are stored at the farm level for food and seed purpose (Golob *et al.,* 1999). During storage the wheat grains are highly susceptible to insect attack. It has been estimated that 5–7% of food grain losses occur due to poor storage conditions (Jilani and Ahmad, 1982). The most important and premier requirement, therefore, is to check insects and reduce grain losses during storage in the season. Insect pests which cause serious damage to stored grains are beetles (Coleoptera) and moths (Lepidoptera). They not only cause large damage to food grains but also create noxious smell and debris. The worldwide damage is estimated to be 10-40% annually. Therefore, there is an urgent need to maintain stored quality and its proper management (Cauvain and Cauvain, 2003).

Economically important insect pest of stored wheat include *Tribolium castaneum, Rhyzopertha dominica* and *Trogoderma granarium*. *Tribolium castaneum*, causes 15-20% losses in various stored commodities of worth of millions of rupees every year in a developing country like Pakistan (Perveen and Khan, 2014). These three pests are most common, notorious and distructive pests of wheat as both larval and adult stages caused damage.

Now-a-days, chemical insecticides are discouraged because repeated use of synthetic chemical insecticides for several decades has disrupted biological control system by natural enemies, led to outbreaks of insect pests, widespread development of resistance, undesirable effects on non-target organisms environmental and human health concerns (White and Leesch, 1995; Ileke, 2013). Plant derived insecticides are more readily biodegradable, less likely to contaminate the environment and not toxic or may be less toxic to mammals. Plants based oils/insecticides may provide potential alternatives to currently used insecticides because they

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constitute a rich source of bioactive chemicals (Wink, 1993). Natural products can be used by small-scale farmers to protect stored grains from insect infestation (Liu and Ho, 1999; Tapondjoua *et al.*, 2005). Present study was carried out to assess the repellency and toxicity of petroleum ether and ethanol oil extracts of *Conocarpus erectus, Rosa indica* and *Cassia fistula* leaves against *T. castaneum, R. dominica* and *T. granarium* under laboratory conditions.

MATERIALS AND METHODS

Collection and rearing of insects

Insects including *T. castaneum, R. dominica* and *T. granarium* were collected from different storage structures. The adults of *T. castaneum* and *R. dominica* were reared on broken and whole wheat grains, respectively at 25±5°C and 65±5% RH. While *T. granarium* adults were reared on a mixture of milk powder, yeast and flour (1:1:1) at 28-30°C and 70±5% RH.

Collection, drying and grinding of plant parts

Leaves of Rose, *Rosa indica* (Rosales: Rosaceae), Amaltas, *Cassia fistula* (Fabale: Fabaceae) and Buttonwood, *Conocarpus erectus* (Myrtales: Combretaceae) were collected from GC University, University of Agriculture, Ayub Agriculture Research Institute, Faisalabad._ The collected leaves were washed with water, dried and finally grind to fine powder by using an electric blender.

Oil extraction

The oil extraction from fine powder of leaves was undertaken by using microwave-assisted hydro-distillation procedure. The extraction was done through Soxhlet's Extraction Apparatus by using petroleum ether and ethanol as carrier substances as described by Ahmad *et al.*. (2006). Twenty five grams powder of each plant with 250 ml of solvent (petroleum ether and ethanol separately) were used for oil extraction through soxhlet apparatus. The powder of each plant was processed through soxhlet apparatus for 8 hours and then are processed through rotary evaporator to evaporate the solvent from oil. The samples were stored in the refrigerator at 4ºC before use. Six types of oils extracts i.e., *C. erectus* petroleum ether extract, *R. indica* petroleum ether extract, *C. fistula* petroleum ether extract, *C. erectus* ethaonolic extract, *R. indica* ethaonolic extract*, C. fistula* ethaonolic extract) were prepared for evaluation against *T. castaneum, R. domonica* and *T. granarium*.

Preparation of solutions

From the extracted essential oils 10, 20 and 30% concentration solutions were prepared by dissolving 0.1, 0.2 and 0.3 ml of each extracted oil in 0.9, 0.8 and 0.7 ml of solvent (petroleum ether and ethanol) respectively.

Bioassays procedure

Repellent activity test for oils

Area preference method was used to evaluate the repellent effect of test plant oil (Tapondjoua *et al.*, 2005). A Whatman No.1 filter paper of 9 cm diameter was cut into half and used as test area. Each concentration of each of oils (extract in petroleum ether and ethanol) was applied to a half filter paper disc while the other half of the paper was treated with petroleum ether or ethanol. The treated and control half discs were then air dried for 5 minutes to evaporate the solvent. Both halves were attached to their opposites using adhesive tape and then placed in petri dishes. Then ten individuals of each of male and female *T. castaneum, R. dominica* and *T. granarium* were released in the center of each filter paper disc (for each solvent in separate petri dishes). Wheat substrate (Broken-grains, sound grains and mixed) treated with respective oil and concentration were also scattered on the respective treated half filter paper disc. While, untreated half were scattered with untreated wheat substrate. This experiment consisted of eighteen treatments designed in completely randomized design and repeated three times. The number of insects present on the treated and untreated portions of the experimental papers halves were counted after 2, 4 and 24 hours of exposure and percentage repellency (PR) was calculated by the following formula:

$$P_R = [(Nc - Nt / Nc + Nt)] * 100$$

Nc: Number of insects on the untreated area after the exposure interval

Nt: Number of insects on the treated area after the exposure interval

Each treatment was repeated for three times.

Toxicity evaluation of plant oils

Grain treatment method was used to evaluate the toxicity of each botanical/plant extract against experimental pests. Five grams of wheat grains were treated with plant oil @ 0.5 ml of each concentration solution, thoroughly mixed and allowed to dry on plastic sheets for 5-10 minutes. The treated wheat grains were taken into test tube. Insect adults of each insect species were released into the test tubes containing treated wheat (20 in each test tube i.e. 10 male and 10 female individuals). The test tubes were covered by muslin cloth and kept in incubator at controlled conditions (at 25±5°C and 65±5% RH). Data of adult mortality was collected after 1, 7 and 14 days of exposure. Whole of the experiment consisted of eighteen treatments and was carried out in completely randomized design. Each treatment was replicated three times. This Percentage mortality was corrected by Abbott's formula (1925):

$$Pr = \frac{Po - Pc}{100 - Pc} \times 100$$

Where, Po = Observed mortality, Pc = Control mortality

Data were analyzed through One-way Analysis of variance (ANOVA).

Statistical analysis

The percentage repellency and mortality data were analysed thriugh Analysis of Variance (ANOVA) techniques. The means of significant treatments were compared using Tuckey- Kramer (HSD) test at 5% level of significance (Sokal and Rohlf, 1995).

RESULTS

Toxicity of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* against *T. castaneum* at different time interval

Results revealed that ethanolic extracts of each plant species were found more effective than their petroleum ether extracts against *T. castaneum*. *C. erectus* ethanolic extract proved highly toxic causing the maximum mortality of 91.44% at 14 days of post-treatment exposure interval. Ethanolic extract of *C. fistula* and petroleum ether extracts of *C. erectus*, *R. indica* and *C. fistula* demonstrated 85, 83.33, 67.22 and 76.67% mortality, respectively. Mortality increased with increase in post-treatment exposure interval (Table 1). Mortality of *T. castaneum* increased with increasing concentration at each exposure interval. After maximum exposure interval (14 days), higher mortality of *T. castaneum* (87.78%) was recorded at concentration of 30%, irrespective of the oil extract; followed by that recorded at 20% and 10% concentrations (Table 2).

Toxicity of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* against *R. domonica* at different time interval

The results reveal that petroleum-ether extract of *C. erectus* explained higher mortality in *R. dominica* at all post-treatment intervals followed by that demonstrated by ethanolic extract of *C. erectus* (10.56, 43.89 and 84.44% at 1, 7 and 14 days PTEI, respectively) and petroleum-ether extract of *C. fistula* (8.89, 42.22 and 82.78% at 1 day, 7 days and 14 days PTEI, respectively) which explained statistically similar mortalities in *R. dominica* at all post-treatment intervals. Ethanolic extract of *C. fistula*, petroleum-ether extract of *R. indica* and ethanolic extract of *R. indica* caused 7.78, 36.67 and 77.22%; 6.67, 36.67 and 72.78% and 5.56, 32.22 and

Table 1

Percent mortality of *T. castaneum* exposed to ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* at different post-treatment intervals.

Treatments	Mortality (%)		
	1 day PTEI	7 day PTEI	14 day PTEI
C. erectus petroleum ether extract	6.11 IJ	30.00 FGH	83.33 B
R. indica petroleum ether extract	2.78 J	24.44 H	67.22 D
C. fistula petroleum ether extract	3.89 IJ	26.67 GH	76.67 C
C. erectus ethanolic extract	8.88 I	39.44 E	91.44 A
R. indica ethanolic extract	4.44 IJ	31.11 FG	73.89 C
C. fistula ethanolic extract	6.11 IJ	34.44 EF	85.00 B
Means	5.37 c	31.02 b	79.59 a

LSD value @ 5% = 5.6798; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

Table 2

Percent mortality of *T. castaneum* exposed to different concentrations irrespective of the oil extracts of *C. erectus, R. indica* and *C. fistula* at different post-treatment intervals.

Concentrations (%)	Mortality (%)		
	1 day PTEI	7 day PTEI	14 day PTEI
10	5.28 I	35.56 F	72.22 C
20	8.33 H	39.72 E	79.72 B
30	12.78 G	44.72 D	87.78 A
Means	8.80 c	40.00 b	79.91 a

LSD value @ 5% = 7.23; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

69.44% mortality in *R. dominica* at 1, 7 and 14 days post-treatment intervals, respectively. For all extract, mortality of *R. dominica* increased with increasing exposure interval, being significantly higher at longer exposure interval and lower at shorter exposure intervals (Table 3). Mortality of *R. dominica* increased with increasing concentration at each exposure interval. After maximum exposure interval (14 days), higher mortality of *R. dominica* (89.45%) was recorded at concentration of 30%, irrespective of the oil extract; followed by that recorded at 20 and 10% concentrations (Table 4).

Toxicity of plant oils against *T. granarium* at different time interval

The maximum mortalities of *T. granarium* (14.44, 51.11 and 89.44% at 1, 7 and 14 days PTEI, respectively), was observed when *T. granarium* adults were exposed to petroleum-ether extract of *C. erectus*. i.e., Ethanolic extract of *C. erectus*, and petroleum-ether extract *R. indica* both explained statistically similar mortalities at 1 day and 14 days PTEI but statistically different mortality at 7 days PTEI Similarly, ethanolic extract of *R. indica* and petroleum-ether extract *C. fistula* both demonstrated statistically similar mortalities at 1 and 14 days PTEI; but statistically different mortality at 7 days PTEI The minimum mortality of *R. dominica* was explained in case of ethanolic extract of *C. fistula* at all post treatment interval (4.44, 33.88 and 72.78% at 1, 7 and 14 days PTEI, respectively) (Table 5). A concentration and exposure interval dependent mortality in *T. granarium* was demonstrated by all extracts. Maximum mortality was observed at maximum exposure interval (80.09%). Likewise, higher concentration (30%) demonstrated comparatively higher mortalities at 1, 7 and 14 days post-treatment intervals (Table 6).

Repellency of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* towards *T. castaneum* at different post-treatment intervals

The repellency decreased with increase in exposure time for all extracts, being significantly higher at 2 hours PTEI and

Table 3

Percent mortality of *R. dominica* exposed to ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* at different post-treatment intervals.

Treatments	Mortality (%)		
	1 day PTEI	7 day PTEI	14 day PTEI
C. erectus petroleum ether extract	13.33 J	48.33 F	92.78 A
R. indica petroleum ether extract	6.67 LM	36.67 H	72.78 D
C. fistula petroleum ether extract	8.89 KL	42.22 G	82.78 B
C. erectus ethanolic extract	10.56 K	43.89 G	84.44 B
R. indica ethanolic extract	5.56 M	32.22 I	69.44 E
C. fistula ethanolic extract	7.78 LM	36.67 H	77.22 C
Means	8.80 c	40.00 b	79.91 a

LSD value @ 5% = 2.7025; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

Table 4

Percent mortality of *R. dominica* exposed to different concentrations irrespective of the oil extracts of *C. erectus, R. indica* and *C. fistula* at different post-treatment intervals.

Concentrations (%)	Mortality (%)		
	1 day PTEI	ي ŕ ĂŦ t Ç9L	14 day PTEI
10	6.30 I	36.65 F	73.41 C
20	9.35 H	40.88 E	81.23 B
30	13.81 G	45.86 D	89.45 A
Means	9.82 c	41.43 b	81.36 a

LSD value @ 5% = 3.54; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

Table 5

Percent mortality of *T. granarium* exposed to ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* at different post-treatment intervals.

Treatments	Mortality (%)		
	1 day PTEI	7 day PTEI	14 day PTEI
C. erectus petroleum ether extract	14.44 K	51.11 E	89.44 A
R. indica petroleum ether extract	11.11 L	43.33 G	83.33 B
C. fistula petroleum ether extract	8.33 MN	37.22 I	76.67 C
C. erectus ethanolic extract	10.56 LM	46.67 F	81.66 B
R. indica ethanolic extract	6.67 NO	40.56 H	76.67 C
C. fistula ethanolic extract	4.44 O	33.88 J	72.78 D
Means	9.26 c	42.13 b	80.09 a

LSD value @ 5% = 2.71; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

Table 6

Percent mortality of *T. granarium* exposed to different concentrations irrespective of the oil extracts of *C. erectus, R. indica* and *C. fistula* at different post-treatment intervals.

Concentrations (%)	Mortality (%)		
	1 day PTEI	ٻ ŕ ĂǇ t Ç9L	14 day PTEI
10	6.11 H	36.67 F	73.06 C
20	7.78 H	41.66 E	78.05 B
30	13.89 G	48.06 D	89.17 A
Means	9.26 c	42.13 b	80.09 a

LSD value @ 5% = 1.91; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

lower at 24 hours PTEI. The maximum repellency was recorded at 2 hours post treatment interval (93.33%) and minimum repellency was observed at 24 hours post-treatment intervals (43.33%). Ethanolic extract of *C. erectus* demonstrated higher repellency of *T. castaneum* at all post-treatment intervals than other extracts followed by Petroleum-ether extract of *C. erectus*, Ethanolic extracts of *C. fistula* and *R. indica* and petroleum-ether extracts of *C. fistula* and *R. indica* (Table 7).

Repellency of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* towards *R. dominica* at different post-treatment intervals

A decrease in repellency of all tested extracts towards *R. dominica* was observed with increase in exposure time, being significantly higher at 2 hours PTEI and lower at 24 hours PTEI. Petroleum-ether extract of *C. erectus* demonstrated higher repellency of *R. dominica* at all post-treatment intervals (55.33-95.0%) than other extracts. Petroleum-ether extracts of *C. fistula* and *R. indica* demonstrated 50-86.67% and 43.33-78.33% repellency, while ethanolic extracts of *C. erectus, C. fistula* and *R. indica* explained 46.67-83.33%, 45-81.66% and 38.33-73.33% repellency towards *R. dominica* at different post-treatment intervals. The minimum repellency towards *R. dominica* was demonstrated by ethanolic extract of *R. indica* (Table 8).

Repellency of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* towards *T. granarium* at different post-treatment intervals

A decrease trend in repellency of all tested extracts towards *T. granarium* was observed with increase in exposure time, being significantly higher at 2 hours PTEI and lower at 24 hours PTEI. Petroleum-ether extract of *C. erectus* demonstrated higher repellency of *T. granarium* at all post-treatment intervals (53.33-93.33%) than other extracts. Petroleum-ether extracts of *C. fistula* and *R. indica* demonstrated 41.67-78.33% and 48.33-86.67% repellency, while ethanolic extracts of *C. erectus, C. fistula* and *R. indica* explained 43.33-83.33%, 31.67-66.67% and 36.67-73.33% repellency towards *T. granarium* at different post-treatment intervals. The minimum repellency towards *T. granarium* was demonstrated by ethanolic extract of *C. fistula* (Table 9).

Table 7

Percentage repellency of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* towards *T. castaneum* at different post-treatment intervals.

Treatments	Repellency (%)		
	2 hours PTEI	4 hours PTEI	24 hours PTEI
C. erectus petroleum ether extract	88.33 B	71.67 F	56.67 I
R. indica petroleum ether extract	76.67 E	58.33 I	43.33 L
C. fistula petroleum ether extract	80.00 DE	63.33 H	48.33 JK
C. erectus ethanolic extract	93.33 A	78.33 E	63.33 H
R. indica ethanolic extract	83.33 CD	65.00 GH	46.67 KL
C. fistula ethanolic extract	85.00 BC	68.33 FG	51.66 J
Means	84.44 a	67.50 b	51.67 c

LSD value @ 5% = 4.73; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

Table 8

Percentage repellency of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* towards *R. dominica* at different post-treatment intervals.

Treatments	Repellency (%)		
	2 hours PTEI	4 hours PTEI	24 hours PTEI
C. erectus petroleum ether extract	95.00 A	76.67 DE	58.33 IJ
R. indica petroleum ether extract	78.33 CDE	61.67 HIJ	43.33 LM
C. fistula petroleum ether extract	86.67 B	68.33 FG	50.00 K
C. erectus ethanolic extract	83.33 BC	65.00 GH	46.67 KL
R. indica ethanolic extract	73.33 EF	56.67 J	38.33 M
C. fistula ethanolic extract	81.66 BCD	63.33 GHI	45.00 KL
Means	83.06 a	65.28 b	46.94 c

LSD value @ 5% = 5.25; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

DISCUSSION

The present study was carried out to assess the mortality and repellency of *C. erectus, R. indica* and *C. fistula* oils extracted by Soxhlet apparatus in two solvents (petroleum ether and ethanol) against *T. castaneum, R. dominica* and *T. granarium* Our finding would be useful to control the insect pests of stored grains with plant derived materials as reported by Patil *et al.* (2014), perveen *et al.* (2012), Subaramanian and Kaushik (2014), Arya and Tiwari (2013) and Baris *et al.* (2006). Mortality increased while repellency decreased with increasing post-treatment exposure intervals. Grain treatment method to check the toxicity and area preference method for repellency are consider as effective methods to control the most notorious pests of stored products (*T. castaneum, R. domonica. T. granarium*) (Mukherjee *et al.,* 2000; Athanassiou *et al.,* 2005; Haq *et al.,* 2005; Kestenholz *et al,.* 2007; Sagheer *et al.,* 2011; Padin, 2013; Khaliq *et al*., 2014; Mansoor-ul-Hasan *et al*., 2014; Mobki *et al*., 2014; Sagheer *et al*., 2014; Walliullah *et al*., 2014; Chebet *et al*., 2014; Liu *et al*., 2014). Results revealed that selected plants have insecticidal potential against the pests selected for present study as all targeted insect pests showed mortality after ingesting the treated grains. The mortality induced by these extracts may be attributed to physiological changes triggered by the chemical constituents of used plant's oil extracts. We used two solvents to investigate their efficacy as carrier substance towards the insecticidal performance of oils as used by Hamouda *et al*. (2014), Guruprasad and Pasha (2014), Perveen *et al*. (2014) and Rehman *et al*. (2014) in their experiment. In our finding the ethanolic extract were found more toxic to *T. castaneum*, than petroleum-ether extracts.

Table 9

Percentage repellency of ethanolic and petroleum-ether extracts of *C. erectus, R. indica* and *C. fistula* towards *T. granarium* at different post-treatment intervals.

Treatments	Repellency (%)		
	2 hours PTEI	4 hours PTEI	24 hours PTEI
C. erectus petroleum ether extract	93.33 A	75.00 D	53.33 IJ
R. indica petroleum ether extract	86.67 B	68.33 EF	48.33 JK
C. fistula petroleum ether extract	78.33 CD	60.00 GH	41.67 LM
C. erectus ethanolic extract	83.33 BC	65.00 FG	43.33 KL
R. indica ethanolic extract	73.33 DE	55.00 HI	36.67 MN
C. fistula ethanolic extract	66.67 F	48.33 JK	31.67 N
Means	80.28 a	61.94 b	42.50 c

LSD value @ 5% = 5.52; PTEI = Post-treatment exposure interval; Means sharing different alphabets are not similar statistically at probability level of 5%

These finding are in consistent with the results of Manzoor *et al*. (2011), Hamouda *et al*. (2014), Srivivasan *et al*. (2014) and Walliullah *et al*. (2014). Unlikely, petroleum-ether extract proved more toxic to *R. domonica* and *T. granarium* than ethanolic extracts of the same plant. These results are found in confirmation to the resukts of Wakil *et al.* (2012) and Upadhyay *et al.* (2012). According to our results, *C. erectus* extracts proved more effective against three target insect pests. This higher mortality may be attributed to the fact that this plant has antioxidant, anticancer and antimicrobial components as documented by Touqeer *et al*. (2014) who reported that the *C. erectus* possessed active compound to control unwanted organisms than other two plants (*C. fistula* and *R. indica*). *Conocarpus erectus* caused greater mortality followed by *C. fistula* and *R. indica* in case of *T. castaneum* and *R. dominica* while, in case of *T. granarium, C. erectus* proved more effective followed by *R. indica* and *C. fistula*. The proformance of *C. fistula* may be attributed to active antioxidant compounds (polyphenolic, Proanthocyanidin, and Flavonoid Components) present in its leaf extract, as reported by Upadhyay *et al*. (2012) and Wakil *et al*. (2012). The antioxidant compounds in these plant extracts inhibit oxidation by removing radicals in the cell which in turn caused death of cell. Mortality in the present study increased with increase in the concentration and exposure time as toxicity and mortality of plant/botanical extracts were dose and time dependent that affect pests activities to kill or repel them. Similar results were also reported by Nadeem *et al.* (2012), Wakil *et al.* (2012), Ali *et al*. (2014), Khaliq *et al*. (2014), Mobki *et al*. (2014), Nana *et al*. (2014), Walliullah *et al*. (2014), Elamin and Satti (2013) and Arif and Valizadegan (2015), and . Application of these oils would be very useful to reduce the adults of *T. castaneum, R. dominica* and *T. granarium* in wide variety of containers as plant oils were effective as reported by Upadhyay *et al*. (2007), Liu *et al*. (2012), Khani *et al*. (2012), Tayoub *et al*. (2012), Kemabonta *et al*. (2013), Kumawat *et al*. (2013), Mahmooavand *et al*. (2014), Nana *et al*., (2014) and Wu *et al*., (2014), and. Use of extracts investigated in present study would offer an eco-friendly and less expensive way to reduce the problem of stored grain pests in post harvest storage condition as reported by Duke *et al*. (2000), Khaliq *et al*. (2014) and Khan *et al*. (2014), and All of the examined plants are commonly available and are used in Pakistan for various purposes. All the leaf-extracts investigated in present study can be better alternatives to synthetic grain protectants and should be further studies for characterization of the active molecules present in these extracts.

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REFERENCES

Ahmad, U.A.M., S. Zuha, H.H. Nabil, H.H. Bashier, K. Muafi, H. Zhongping and G. Youling. 2006. Evaluation of Insecticidal Potentialities of Aqueous Extracts from *Calotropis procera* Ait. against *Henosepilachna elaterii* Rossi. J. Appl. Sci., 6: 2466-2470.

Ali, S., M. Sagheer, M. Hassan, M. Abbas, F. Hafeez, M. Farooq, D. Hussain, M. Saleem and A. Ghaffar, 2014. Insecticidal activity of turmeric (*Curcuma longa*) and garlic (*Allium sativum*) extracts against red flour beetle, *Tribolium castaneum*: A safe alternative to insecticides in stored commodities. J. Entomol. Zool. Studies, 2 (3): 201-205.

Arif, S.F. and O. Valizadegan, 2015. *Eucalyptus kruseana* Muel essential oil; chemical composition and insecticidal effects against the lesser grain borer, *Rhyzopertha dominica* F. (Coleoptera: Bostrichidae). Biharean Biol. J., 9: 141138.

Arya, M. and R, Tiwari, 2013. Efficacy of plant and animal origin bioproducts against lesser grain borer, *Rhyzopertha dominica* (Fab.) in stored wheat. Int. J. Recent Sci. Res., 4(5): 649-653.

Athanassiou, C.G., D.C. Kontodimas, N.G. Kavallieratos and M.A. Veroniki, 2005. Insecticidal effects on neem azal against three stored- product beetle species on rye and oats. J. Econ. Entomol., 98(5): 1733-1738.

Baris, O., M. Gulluce, F. Sahin, H. Ozer, Kilic, H. Ozkan, M. Sokmen and T. Ozbek, 2006. Biological activities of the essential oil and methanol extract of *Achillea biebersteinii* Afan. (Asteraceae). Turkish J. Biol., 30: 65-73.

Belderok B., H. Mesdag and D.A. Donner, 2000. Bread-making quality of wheat. Springer, New York

Cauvain, S.P. and P.C. Cauvain, 2003. Bread making. CRC Press. pp.540.

Chebet, F., A.L. Deng, J.O. Ogendo, A.W. Kamau and P.K. Bett, 2013. Bioactivity of selected plant powders against *Prostephanus truncatus* (Coleoptera: Bostrichidae) in stored maize grains. J. Plant Prot. Sci., 49(1): 34–43.

Duke, S.O., F.R. Dayan, J.G. Romaine, and A.M. Rimando, 2000. Natural products as sources of herbicides: status and future trends. Pak. J. Weed Sci., 40: 99-111.

Elamin, M.M. and A.A. Satti, 2013. Insecticidal potentialities of *Balanites aegyptiaca* extracts against the khapra beetle (*Trogoderma granarium*). Global Adv. Res. J. Envir. Sci. Toxicol., 2(1): 5-10.

Golob, P., M. Dales, A. Fidgen, J. Evans, I. Gudrups, 1999. The Use of spices and medicinals as bioactive protectants for grains. FAO, Rome, Italy.

Guruprasad, B.R. and A. Pasha, 2014. Assessment of repellency and insecticidal activity of *Ajuga parviflora* (Benth) and *Trichilia connaroides* (W&A) leaf extracts against stored product insects**.** J. Entomol. Zool. Studies. 2 (4): 221-226.

Haq, T., N.F. Usmani, and T. Abbas, 2005. Screening of plant leaves as grain protectants against *T. castaneum* during storage. Pak. J. Bot., 37(1): 149-153.

Hamouda, A.B., A. Mechi, K. Zarred, I. Chaieb, and A. Laarif, 2014. Insecticidal activities of fruit peel extracts of pomegranate (*Punica granatum*) against the red flour beetle *Tribolium castaneum*. Tunisian J. Pl. Prot., 9: 91-100**.**

Ileke, K.D., 2013. Insecticidal activity of four medicinal plant powders and extracts against angoumois grain moth, *Sitotroga cerealella* (Olivier) [Lepidoptera: Gelechidae]. Egyptian J. Biol., 15: 21-27.

Jilani, G. and H. Ahmad, 1982. Safe storage of wheat at farm level. Progress. Farming, 2: 11-15.

Kemabonta, K.A. and B.B. Falodu, 2014. Bioeffecacy of three plant products as post-harvest grain protectants against *Sitophilus oryzae* Linnaeus (Coleptera: Curculionidae) on stored wheat (*Triticum aestivum*). Int. J. Sci. Nat., 4(2): 259-264.

Kestenholz, C., P.C. Stevenson, and S.R. Belmain, 2007. Comparative study of field and laboratory evaluations of the ethnobotanical *Cassia sophera* L. (Leguminosae) for bioactivity against the storage pests *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) and *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). J. Stored Prod. Res., 43: 79–86.

Khaliq, A., A. Nawaz, M.H. Ahmad, M. Sagheer, 2014. Assessment of insecticidal potential of medicinal plant extracts for control of maize weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). Basic Res. J. Agric. Sci. Rev., 3(11): 100-104.

Khan, F., M. Mazid, T.A. Khan, H.K. Patel, and R. Roychowdhury, 2014. Plant derived pesticides in control of Lepidopteran insects: Dictum and directions. Res. J. Biol., 2: 01-10.

Khani, A. and J. Asghari, 2012. Insecticide activity of essential oils of *Mentha longifolia*, *Pulicaria gnaphalodes* and *Achillea wilhelmsii* against two stored product pests, the flour beetle, *Tribolium castaneum,* and the cowpea weevil, *Callosobruchus maculatus.* J. Insect Sci., 12(73): 1-10.

Kumawat, K.C. and B.L. Naga, 2013. Effect of plant oils on the infestation of *Rhyzopertha dominica* (Fab.) in wheat, *Triticum aestivum* Linn. J. Pl. Prot. Res., 53(3): 301-304.

Liu, X.C., Y.P. Li, H.Q. Li, Z.W. Deng, L. Zhou, Z.L. Liu, and S.S. Du, 2014. Identification of repellent and insecticidal constituents of the essential oil of *Artemisia rupestris* L. aerial parts against *Liposcelis bostrychophila* Badonnel. Open Access Article Molecules. 18: 10733-10746.

Liu, Z.L. and S.H. Ho, 1999. Bioactivity of the essential oil extracted from *Evodia rutaecarpa* Hook f. et Thomas against the grain storage insects, *Sitophilus zeamais* Motsch. and *Tribolium castaneum* (Herbst). J. Stored Prod. Res. 35: 317-328.

Mansoor-ul-Hasan, M. Sagheer, M. Farhan, M. Najam-ul-Hassan, S.R. Haidri, M. Bukhari, H.T. Gul, and F.Z.A. Khan, 2014. Repellent potential of *Azadirachta indica*, A Juss. and *Glycyrrhiza glabra* L. against cowpea bruchid, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae). J. Biodiv. Envir. Sci., 5(1): 405-409.

Manzoor, F., G. Nasim, S. Saif, and S.A. Malik, 2011. Effect of ethanolic plant extracts on three storage grain pests of economic importance. Pak. J. Bot., 43(6): 2941-2946.

Mobkia, M., S.A. Safavia, M.H. Safaralizadeha and O. Panahib, 2014. Toxicity and repellency of garlic (*Allium sativum* L.) extract grown in Iran against *Tribolium castaneum* (Herbst) larvae and adults. Arch. Phytopathol. Plant Prot., 47(1): 59–68.

Nadeem, M., J. Iqbal, M.K. Khattak, and M.A. Shahzad, 2012. Management of *Tribolium castaneum* (Hbst.) (Coleoptera: Tenebrionidae) using neem (*Azadirachta indica* A. Juss) and tumha (*Citrullus colocynthis* (L.)). Pak. J. Zool., 44(5): 1325-1331.

Nana, P., F. Nchu, R.M. Bikomo, and H.L. Kutima, 2014. Efficacy of vegetable oils against dry bean beetles *Acanthoscelides obtectus.* Afr. Crop Sci. J., 22(3): 175-180.

Padin, S.B., C. Fuse, M.I. Urrutia, and G.M.D. Bello, 2013. Toxicity and repellency of nine medicinal plants against *Tribolium castaneum* in stored wheat. Bull. Insectol., 66 (1): 45-49.

Patil, P.V., D.K. Kulkarni, and S.P. Taware, 2014. Evaluation of traditional knowledge of plant resources to control stored food grain pest *Callosobruchus maculates* F. Indian J. Fundamental Appl. Life Sci., 4 (2): 1-5.

Perveen, F. and A. Khan, 2014. Toxicity and effects of the hill toon, *Cedrela serrata* methanolic leaves extract and its fractions against 5th instar of the red flour beetle, *Tribolium castaneum*. Int. J. Agric. Res., 1: 18-26.

Rehman, A.U., A. Rehman and I. Ahmad, 2014. Antibacterial, antifungal, and insecticidal potentials of *Oxalis corniculata* and its isolated compounds. Int. J. Analyt.

Chem., *open access article.* Article ID 241412.

Sagheer, M., Mansoor-ul-Hasan, M.A. Latif and J. Iqbal, 2011. Evaluation of some indigenous medicinal plants as a source of toxicant, repellent and growth inhibitors against *Tribolium castaneum* (Coleoptera: Tenebrionidae). J. Pak. Entomol., 33(2): 87-91.

Sagheer, M., Mansoor-ul-Hasan, M. Najam-ul-Hassan, M. Farhan, F.Z.A. Khan, and A. Rahman, 2014. Repellent effects of selected medicinal plant extracts against rust-red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). J. Entomol. Zool. Studies, 2 (3): 107-110.

Srivastava, S., K.C. Gupta, and A. Agrawal, 1988. Effect of plant product on *C. chinensis* infestation on red gram. Seed Res., 16(1): 98–101.

Subramaniam, S. and S. Kaushik, 2014. t Some potential insecticidal plants of India. J. Medic. Pl. Studies, 2(3): 44-50.

Tayoub, G., A.A. Alnaser, and I. Ghanem, 2012. Toxicity of two essential oils from *Eucalyptus globulus* Labail and *Origanum syriacum* L. on larvae of khapra beetle. J. Medic. Aromatic Plants. 2(2): 240-245.

Tapondjoua A.L., C. Adlerb, D.A. Fontemc, H. Boudaa and C. Reichmuth, 2005. Bioactivity of cymol and essential oils of *Cupressus sempervirens* and *Eucalyptus saligna* against *Sitophilus zeamais* Motschulsky and *Tribolium confusum* du Val. J. Stored Prod. Res. 41: 91-102.

Upadhyay, R.K., G. Jaiswal, and N. Yadav, 2007. Toxicity, repellency and oviposition inhibition activity of some essential oils against *Callosobruchus chinensis*. J. Appl. Biosci., 33(1): 21-26.

Upadhyay, R.K. and S. Ahmad, 2011. Management strategies for control of stored grain insect pests in farmer stores and public ware houses. World J. Agric. Sci., 7 (5): 527-549.

Wakil, W., T. Riasat, N. Saeed, M. Ashraf, and M. Yasin, .2012. Fumigant activity of some essential oils against four major insect pests of stored grains. ARBER Professional Congress Services, Turkey. 9: 389-395

Waliullah, T.M., A.M. Yeasmin, I.M. Wahedul, and H. Pervez, 2014. Insecticidal and repellent activity of *Clerodendrum viscosum* Vent. (Verbenaceae) against *Tribolium castaneum* (Herbst) (Coleoptera: tenebrionoidea). Acad. J. Entomol., 7 (2): 63-69.

Wink, M., 1993. Production and application of phytochemicals from an agricultural perspective. In: van Beek T.A. and H. Breteler (eds.), Phytochemistry and agriculture Oxford, United Kingdom: Clarendon Press. pp. 171-213.

White, N.D.G. and J.G. Leesch, 1995. Chemical control. In:Subramanyam, B., D.W. Hagstrum, (Eds.), Integrated management of insects in stored products. Marcel Dekker, Inc., New York, pp. 287-330.

Wu, Y., Y. Wang, L. Zhi-Hua, C.F. Wang, J.Y. Wei, L. Xiao-Lan, P.J. Wang, Z.F. Zhou, S.S. Du, D.Y. Huang, and Z.W. Deng, 2014. Composition of the essential oil from *Alpinia galangal* rhizomes and its bioactivity on *Lasioderma serricorne.* Bull. Insectol., 67 (2): 247-254.