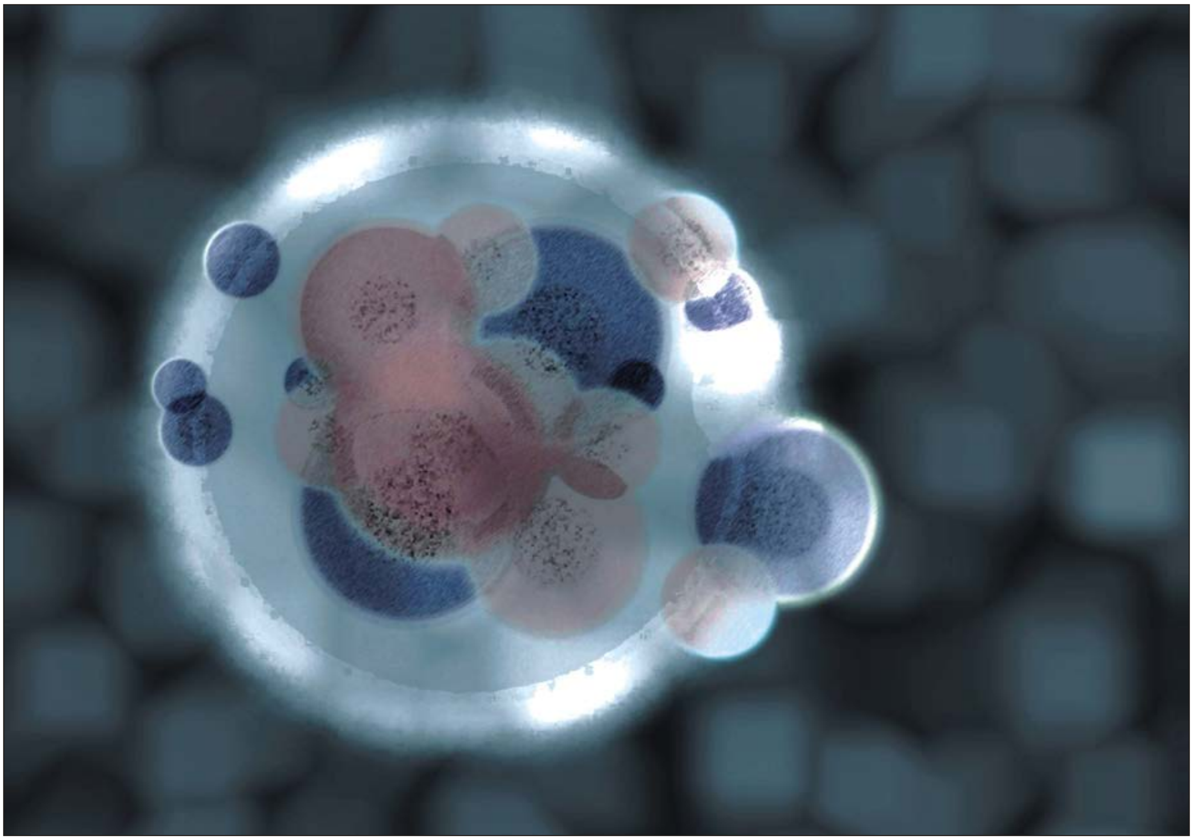

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# Testing Some Various Botanical Powders for Protection of Wheat Grain Against *Trogoderma granarium* Everts

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**Abstract:** Powders prepared from parts of 11 different plant species were tested for their effectiveness on *Trogoderma granarium* adults and larvae reared on wheat grains under laboratory conditions. *Capsicum frutescens* caused highest (77-85%) and significant (F = 54.40) mortality of *T. granarium* adults at all concentrations within 7 days, followed by *Lawsania inermis* at all concentrations (73-78%) (F= 42.65), *Allium ascalonicum* at 2 , 6% concentrations (62-75%) (F=27.56), *Mesua ferrea* at all concentrations (60-65%) (F=17.12) and *Raphanus sativus* at 6% concentration (62%) (F=4.29), while control mortality averaged 42%. The other powders did not consistently differ from the control. The significant reduction in $F_1$ progeny at 6% concentration of plant materials was in the order: *R. sativus* (70.6%) > *Carthamus tinctorius* (67.7%) > *C. frutescens* (58.9%) > *A. ascalonicum* (52.9%) > *L. inermis* (47.1%). On the other hand progeny emergence was significantly higher in *Acacia farnesiana*, *Albizzia lebbeck* and *Delonix regia*. A significant mortality of *T. granarium* larvae was observed at all concentrations (2, 4 and 6%) of *C. tinctorius*, *L. inermis* and *Allium cepa* treatments at 4 and 6% concentrations of *D. regia* and at 6% of *C. frutescens* and *M. ferrea* treatments. No significant effect was observed in *Eruca sativa* on adult mortality, larvae mortality and $F_1$ progeny of treated adults. Thus *C. frutescens* and *L. inermis* had significant effect on mortality of adults and larvae and significantly reduced $F_1$ progeny.

**Key words:** *Trogoderma granarium*, plant protectants, plant powder, grain protectant

## INTRODUCTION

The stored grain insects caused a high rate of post-harvests, losses in continent stored products[1]. At farm level where financial and technical means are limited, post-harvest losses in grain legumes can reach 100% in a few months[2].

Today, the use of synthetic insecticides for the protection of stored grain products has declined significantly mainly to drastic reduction[3]. The statistics of United Nations indicated that there were more than one million poisoning case per year[4]. The need to find materials which protect stored products with less poisonous and less detrimental to environment, has turned the attention to plant materials.

The toxicity of a large number of various plant parts against a number of stored-product insects have been evaluated.

The wheat is considered one of the main crops which kingdom of Saudi Arabia is interested in its cultivation. The production fulfills local consumption and more is exported[5]. The wheat grains are infected by different insects, for example, kapra beetle, *Trogoderma granarium* Everts[6] which is one of the most overspread in the stores of grains in the kingdom of Saudi Arabia[7].

It is also among the most serious and of widest occurrence of insect pests in stored grains in tropical and subtropical regions of Asia and Africa[8,9]. Various indigenous plant products were used in recent past as grain protectants against *T. granarium* in stored grain[10,11].

In this present study, the effectiveness of various parts of 11 plant species on immediate effect on adults and larvae mortality and inhibition of reproduction were evaluated against *T. granarium*.

## MATERIALS AND METHODS

**Source and preparation of plant samples:** The plant used were procured from the local markets. All are planted in Saudi Arabia farms and streets except safflower, *Carthamus tinctorius* and *Mesua ferrea*.

Seeds were washed thoroughly in running tap water then dried at 60°C for 96 h[12]. Leaves of henna,

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Table 1: List of plants used in the study

| Scientific name | Family name | Plant part | English/Common name |
|---|---|---|---|
| *Acacia farnesiana* | Leguminosae | Seeds | Acacia |
| *Albizzia lebbeck* | Mimocaceae | Seeds | Lebbeck |
| *Allium cepa* | Liliaceae | Seeds | Onion |
| *Allium ascalonicum* | Liliaceae | Seeds | Shallot |
| *Capsicum frutescens* | Solanaceae | Seeds | Chilli |
| *Carthamns tinctorins* | Compositae | Fruits | Safflower |
| *Ernca sativa* | Raquette | Seeds | Rocket |
| *Lawsonia inermis* | Lythraceae | Leaves | Henna |
| *Mesua ferrea* | Guttiferae | Seeds | Mesua |
| *Delonix regia* | Caesalbiniaceae | Seeds | Delonix |
| *Raphanns sativus* | Cruciferace | Seeds | Garden radish |

*Lawsonia inermis* collected were dried in a shade for 7 days. All fully dried parts were ground to fine particles separately, which could pass through a 80 mesh screen.

The powders are kept in air-tight jars prior to use. The plants used are listed in Table 1 and the English name of the plant material is used, in case English name was not available, the Latin name is given.

**Rearing of test insect:** This study was conducted in the Department of Zoology, Girls College in 2003. Cultures were maintained in incubator at temperature 30±2°C and humidity 60±5% RH. conditions. All the post-treatment studies were carried out at the same conditions.

After emergence, the new insects were transferred into fresh jars, so that the $F_1$ larvae of uniform size and age were available and collected for the experiments. Males and females were separated in the pupal stage by separating newly formed pupae daily from the cultures to another jars. The new adults >24 h were used for this study.

The relative efficacy of all tested powders on adults and larvae were determined by: a) parent beetle mortality in control and treatments during 14 days, b) the number of emergence in each treatment and control over 35 days and c) larvae mortality during 30 days after treatment.

**Experiment I:** All eleven plant powders were applied separately at 1:100, 2:100, 4:100 and 6:100 parts (wt./wt.) of plant powder: wheat grains on the test insect *T. granarium*. The jars were shaken manually to enable the powders to spread evenly over the grain. Each concentration was replicated three times.

Ten pairs (10 males+10 females) of adults were introduced in each jar. All the jars were then covered with muslin cloths with the help of elastic bands. Mortality counts of the adult beetles was recorded after 3 , 7 and 14 days. Insects were taken as dead if they did not move away when touched or tilted. All adults were discarded after 14 days and the jars incubated. Observations on adult emergence were made from the first day of emergence until adult emergence was complete.

**Experiment II:** The relative toxicity of different plant powders was evaluated against third instar larvae of khapra beetle, *T. granarium* by using the same previous experiment for this test. Except for the untreated control, dry, ground plant products were applied at the rate of 2 , 4 and 6% to each 10 g lot of uninfected wheat grain in glass jars.

The contents of the jars were stirred thoroughly to ensure uniform coverage by the powders. Three replicates were maintained for each treatment including control. Twenty third instar larvae were released in each jar, also untreated jars (control) were similarly infested. The open ends of the jars were covered by muslin cloth. Data on mortality of larvae were taken at intervals of 7,14 and 30 days.

**Data analysis:** The data obtained on mortality experiment were then subjected to analysis of variance (ANOVA)[13] to test the significance of the factors studied and their interaction, using F-test. Standard error of the differences were computed for mean comparisons. Mean difference of each variable was further separated by using least significant difference test at $p<0.05$.

Percentage of reduction in progeny was calculated according to the following equation:

$$\frac{C-T}{C} \times 100$$

where:

C: Number of $F_1$ progeny in control.

T : Number of $F_1$ progeny in treatment.

Data on productivity and larvae mortality were statistically analysed by using Tukey's studentized range test T-test[14]. Standard error of means (±SEM) were recorded.

## RESULTS

Table 2 gives the effects of the different plant powders on mortality of adult *T. granarium* up to 14 days post-treatments. Adult in grain incorporation various concentrations (1, 2, 4 and 6%) of different plant materials did not suffer significant mortality after three days of application except at 6% of *A. ascalonicum* and *R. sativus* treatments, in spite of some mortality was found with the different concentrations of powders ranged from 5 to 25% compared with 5% in untreated treatment.

Additionally, all treatments gave about 38-85% mortality during 7 days of exposure. *C. frutescens* and *L. inermis* offered similar activity and maximum mortality at all concentrations, while *A. farnesiana, A. lebbeck, A. cepa* and *C. tinctorius* offered about the same level of control at most of the tested concentrations after 7 days

Table 2: Percentage mortality of *Trogoderma granarium* adults in wheat grain treated with various plants at different concentrations

| | % Adult mortality after indicated days and concentrations (%) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | | | 7 | | | | 14 | | | |
| Plant materials | 1 | 2 | 4 | 6 | 1 | 2 | 4 | 6 | 1 | 2 | 4 | 6 |
| *A. farnesiana* | 18 | 20 | 17 | 13 | 50 | 50 | 45 | 38 | 100 | 100 | 100 | 100 |
| *A. lebbeck* | 18 | 17 | 25 | 17 | 42 | 45 | 58 | 47 | 93* | 100 | 100 | 100 |
| *A. cepa* | 22 | 10 | 10 | 8 | 50 | 43 | 42 | 37 | 100 | 100 | 100 | 100 |
| *A. ascalonicum* | 8 | 10 | 15 | 23* | 38 | 62* | 58 | 75* | 100 | 100 | 100 | 100 |
| *C. frutescens* | 12 | 10 | 10 | 13 | 80* | 77* | 85* | 85* | 100 | 100 | 100 | 100 |
| *C. tinctorius* | 13 | 10 | 13 | 8 | 47 | 38 | 40 | 40 | 100 | 100 | 87* | 90* |
| *E. sativa* | 18 | 12 | 13 | 6 | 58 | 50 | 55 | 42 | 95* | 98 | 100 | 97 |
| *L. inermis* | 15 | 22 | 17 | 13 | 73* | 78* | 77* | 75* | 100 | 100 | 100 | 100 |
| *M. ferrea* | 5 | 10 | 5 | 12 | 65* | 62* | 60* | 62* | 100 | 100 | 100 | 100 |
| *D. regia* | 33 | 15 | 27 | 22 | 60 | 55 | 62 | 55 | 100 | 100 | 100 | 100 |
| *R. sativus* | 12 | 10 | 12 | 28* | 45 | 43 | 50 | 62* | 100 | 100 | 100 | 100 |
| Un-treated | 5 | | | | 42 | | | | 100 | | | |
| F-value | 2.08 | 1.35 | 1.63 | 4.18 | 16.56 | 7.14 | 7.41 | 17.89 | 2.28 | 1.0 | 16.0 | 2.91 |
| LSD | NS | NS | NS | 0.063 | 0.062 | 0.090 | 0.092 | 0.071 | 0.0273 | NS | 0.017 | 0.031 |

*significantly different, Tabulated F = 2.216, NS = Non- significant

Table 3: Adult population of *T. granarium* observed after 30 days of their first release on wheat treated with various plant products

| | Average population at [a] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1:100 parts (wt./wt.) | | | 2:100 parts (wt./wt.) | | | 4:100 parts (wt./wt.) | | | 6:100 parts (wt./wt.) | | |
| Plant materials | Mean±SE | (95% CI) | Reduction% | Mean±SE | (95% CI) | Reduction% | Mean±SE | (95% CI) | Redution% | Means±SE | (95% CI) | Redution% |
| *A. farnesiana* | 28.0±7.4 | 3.2,52.8 | 17.7 | 30.3±7.8 | 5.5,55.1 | 10.9 | 57.0±2.5* | 46.2,67.8 | -67.7 | 57.3±1.2* | 45.0,75.2 | -686.5 |
| *A. lebbeck* | 27.3±11.0 | -7.7,62.3 | 19.7 | 20.3±8.4 | -6.4,47.0 | 40.3 | 52.3±2.3* | 45.0,59.6 | -53.8 | 56.7±1.2* | 52.9,60.5 | -66.8 |
| *A. cepa* | 34.3±1.2 | 30.5,38.2 | -0.1 | 41.0±9.6 | 10.4,71.6 | -20.6 | 43.3±1.9 | 37.3,49.4 | -27.4 | 30.0±1.8 | 22.7,39.9 | 11.8 |
| *A. ascalonicum* | 40.7±2.4 | -3.6,11.7 | -19.7 | 40.0±2.1 | 33.3,46.7 | -17.7 | 28.0±2.5 | 20.0,36.0 | 17.7 | 15.7±1.9 | 9.6,21.7 | 53.8 |
| *C. frutescens* | 36.7±5.3 | 19.8,53.5 | -7.9 | 35.3±3.2 | 25.1,45.5 | -3.8 | 27.0±4.7 | 12.0.42.0 | 20.6 | 14.3±1.8* | 8.6,20.1 | 57.9 |
| *C. tinctorius* | 30.0±5.7 | 11.9,48.1 | 11.8 | 24.7±6.7 | 3.4+46.0 | 27.4 | 13.0±1.5* | 6.4,19.6 | 61.8 | 11.0±1.2* | 7.2,14.8 | 67.7 |
| *E. sativa* | 38.3±1.5 | 33.6,43.1 | -12.7 | 30.0±7.0 | 7.7,52.3 | 11.8 | 33.7±6.9 | 11.3,52.3 | 2.1 | 37.0±2.3 | 29.7,44.3 | -8.8 |
| *L. inermis* | 39.3±4.1 | 26.3,52.4 | -15.6 | 25.0±6.1 | 5.6,44.4 | 26.5 | 23.7±2.2* | 16.7,30.7 | 30.3 | 18.3±0.9* | 14.5,22.1 | 46.2 |
| *M. ferrea* | 31.7±9.3 | 2.1,61.3 | 6.8 | 32.0±8.1 | 6.2,57.8 | 5.9 | 28.7±8.8 | 0.7,59.7 | 15.6 | 29.3±6.9 | 7.3,15.3 | 13.8 |
| *D. regia* | 50.3±2.2* | 43.3,57.3 | -47.1 | 53.0±2.3* | 43.1,2.9 | -55.9 | 52.7±1.2* | 48.9,56.5 | -55.0 | 46.7±1.5* | 41.9,51.4 | -37.4 |
| *R. sativus* | 32.7±4.3 | 19.0,46.4 | 3.8 | 33.0±3.0 | 23.5,42.5 | 2.9 | 10.7±3.2* | 0.5,20.9 | 68.5 | 10.0±1.2* | 6.2,13.8 | 70.6 |
| Un-treated | 34.0±1.2 | 29.9,37.5 | | | | | | | | | | |

[a]Average of three replicates , 10 pairs each, Each value is the mean number of three replicates, * significantly different determined by T-test

Table 4: Percentage mortality of *Trogoderma granarium* larvae in wheat grain treated with various plants at different concentrations

| | % Larvae mortality after indicated days and concentrations (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7 | | | 14 | | | 30 | | |
| Plant materials | 2 | 4 | 6 | 2 | 4 | 6 | 2 | 4 | 6 |
| *A. farnesiana* | 3 | 8 | 3 | 8 | 12 | 8 | 10 | 15 | 12 |
| *A. lebbeck* | 8 | 8 | 7 | 10 | 10 | 10 | 10 | 10 | 12 |
| *A. cepa* | 10* | 10* | 12* | 10* | 20* | 18* | 10* | 20* | 22* |
| *A. ascalonicum* | 3 | 7 | 10 | 10 | 12 | 13 | 10 | 12 | 13 |
| *C. frutescens* | 8 | 3 | 15* | 10 | 8 | 23* | 10 | 10 | 27* |
| *C. tinctorius* | 8* | 8* | 13* | 12* | 10 | 20* | 12* | 12* | 20* |
| *E. sativa* | 7 | 0 | 5 | 7 | 0 | 7 | 7 | 2 | 7 |
| *L. inermis* | 15* | 12 | 17* | 20* | 15* | 25* | 22* | 18* | 32* |
| *M. ferrea* | 12 | 5 | 13* | 17 | 5 | 18* | 17 | 8 | 23* |
| *D. regia* | 3 | 15* | 13* | 7 | 28* | 23* | 7 | 28* | 23* |
| R. sativus | 3 | 5 | 3 | 5 | 7 | 7 | 7 | 7 | 7 |
| Un-treated | 2 | 3 | 3 | | | | | | |

*significantly different as determined by T-test

of application. *C. frutescens* caused highest (77-85%) and significant (F = 54.4, LSD = 1.5995) mortality of *T. granarium* adults within 7 days at all concentrations, followed by *L. inermis* at also all concentrations (73–78%) (F = 42.65, LSD = 1.4860), *A. ascalonicum* (62 and 75%) at 2 and 6% concentrations, respectively (F = 27.56, LSD = 0.0528), *M. ferrea* at all concentrations (60–65%) (F = 17.12, LSD = 1.0152) and *R. sativus* at 6%

concentration (62%) (F = 4.29, LSD = 0.0732), while control mortality averaged 42%.

The other powders did not consistently differ from the control. Surprisingly, most of the powders gave equal effectiveness at different concentrations (1-6%) except at *A. ascalonicum* and *R. sativus* treatments which mortality increased with increasing of concentration. On the contrary, at *A. farnesiana, A. cepa* and *E. sativa*, mortality decreased with increasing of concentration. After 14 days of exposure, total mortality rate was recorded at most treatments.

Results of the effectiveness of tested botanical materials against the population of *T. granarium* are summarized in Table 3. Among the various plant powders, the mean number of $F_1$ developed in grains treated with powders was found to be significantly higher in *A. farnesiana* (57 and 57.33 progeny), followed by *A. lebbeck* (52.33 and 56.67 progeny) at the highest concentrations (4 and 6%), respectively, while the number of $F_1$ progeny was significantly higher in all concentrations of *D. regia* (46.67-53 progeny) more than the control (34 progeny). On the contrary, similar application of *C. tinctorius, L. inermis* and *R. sativus* powders at the same concentrations (4 and 6%) significantly reduced the progeny with average of 10 to 24 emergence (29.4 to 70% reduction) compared with the control (34 emergence), while powders of *A. ascalonicum* and *C. frutescens* were significantly reduced the progeny at only the highest concentration (6%) with an average of 16 and 14 emergence (52.9 and 58.9% reduction), respectively compared with the control.

The percent reduction in progeny numbers compared with the control was ranged from 2.9% (not significant) to 70.6% (significant), whereas, highest percent reduction was observed in case of *R. sativus* treated grains (68.5 and 70.6%) followed by *C. tinctorius* treated grains (61.8 and 67.7%) and *L. inermis* treated grains (30.3 and 46.2%) at 4 and 6% concentrations, respectively, but *C. frutesens* and *A. ascalonicum* treated grains showed high reduction in $F_1$ progeny (57.9 and 53.8% respectively) at only 6% concentration. Consequently, of the materials tested, *R. sativus* and *C. tinctorius* are significantly the most effective on *T. granarium* progeny at the two highest concentrations.

The effectiveness of the plant powders used against *T. granarium* on $F_1$ reduction at 6% concentration was in the order, *R. sativus* (70.6%) > *C. tinctorius* (67.7%) > *C. frutescens* (58.9%) > *A. ascalonicum* (52.9%) > *L. inermis* (47.1%). Progeny emergence of *E. sativa* and *M. ferrea* treated grains and in the control were not different statistically.

The susceptibility of the larvae to plant powders with concentrations ranging from 2 to 6% has already been noted in Table 4, so grain treatment of *T. granarium* larvae with various plant powders resulted in knockdown of the larvae.

When third instar larvae were fed with a diet of treated grains, some mortality was produced during the first 7 days, but mortality was decreased with duration of exposure. A small number of larvae, however, died on examination 15 day post treatments but a smaller number were died 30 day post treatments.

Significant mortalities of *T. granarium* larvae were observed at the most concentrations of *A. cepa, C. tinctorius* and *L. inermis.* In the case of *D. regia* the significant effect was observed at 4 and 6% concentrations, while in the case of *A. cepa*, the significant effect was observed at all concentrations, whereas, in *C. frutescens* and *M. ferrea*, the significant effect was observed at only the highest concentration (6%).

At other powders (*A. farnesiana, A. lebbeck, A. ascalonicum, E. sativa* and *R. sativus*, mortality was reduced and only 3-15% of the larvae died, but there was no significant difference between the tested concentration and the control.

## DISCUSSION

Considering the above results, the most striking of some of these 11 plants is a reduction in fecundity. Unfortunately, some powders as conducted could not prove high toxic activity. Also most of the powders did not offer similar activity on adults, larvae and population, except at *C. frutescens* and *L. inermis.* At *C. tinctorius* treatment, no significant effect was observed in adult mortality, nevertheless, there was significant effect on either larvae mortality and reduction of progeny, so the toxicity action of the powders was on larvae, especially, first instar larvae, additionally, the weakening of adults by the powder may cause them to lay a few eggs. High concentrations of *A. ascalonicum* and *R. sativus* powders had significant effect against adult mortality, hence, also they did significantly reduce the number of emergence compared with the control, but there was no significant effect of both of them on larvae mortality.

The increase of progeny was in *D. regia* at all concentrations, followed by *A. farnesiana* and *A. lebbeck* at 4 and 6% concentrations indicated its effectiveness against beetle attack. Although *A. cepa, C. tinctorius* and *D. regia* powders were none-toxic to the adults, they had toxic effect to the larvae at most of the concentrations tested.

*C. tinctorius* and *R. sativus* powders seem to have retained their effectiveness against *T. granarium* by significantly suppressing the progeny development as compared to the control.

In addition, no significant difference was observed in susceptibilities of *T. granarium* adults and larvae to the treated grains with *A. farnesiana*, *A. lebbeck* and *E. sativa* but the first two powders caused increasing in progeny.

Don-Pedro[15] observed that the fact action of plant materials appears to be mainly against eggs or early larvae restricts their possible use to prophylactic-rather than curative measures in storage systems.

Poswal and Akpa[16] suggested that the tested plant powders may have no insecticidal properties, but fill the spaces between grains, restricting the movement of adults for egg laying and decreasing infestation levels.

Some of these tested plant materials are known to be insecticidal or repellency to some grain stored insects. The results of chilli effect are in agreement with the results obtained by Ofuya[17] using dry chilli pepper fruits. Also Onu and Aliyu[18] found that *C. frutescens* powders was effective by the significant lower number of oviposition and emergence holes of cowpea seeds by *Callosobruchus maculatus*. They stated pungent, the main component of chilli may contribute to the insecticidal properties. Ho *et al.*[19] reported that the non-polar (hexane) extract of chilli repelled *Sitophilus zeamais* and *Tribolium castaneum*, but the repellent action of some plants on its own would not be very useful for pest control purposes. However, the suggested that the repellent action of spice plants, on their bioactive compounds, could complement as well as reduce the use of organic pesticides in grain storage. Rajapakse *et al.*[20] found that chilli powder caused significant reduction on oviposition and adult emergence of *C. maculatus* in comparison to control.

On the contrary, Ivbigaro and Agbaje[21] observed no appreciable toxicity to *C. maculatus* by using *C. frutescens*. Similarly Shikaan and Uvah,[22] reported that chilli pepper offered no adequate protection to cowpea from infestation by *C. maculatus*.

Comparing our results on chilli powder with those of the literature it can be stated the toxic effect on *T. granarium*. On the other hand Gupta *et al.*[23] found that safflower oil can be used for protection pulses against pulse beetle.

This study has shown that some tested plant materials applied to wheat grains significantly either reduced progeny emergence and killed adults or third instar larvae. On the other hand, many researchers had reported the nontoxicity of most of various plant powders which they had tested on adult mortality[24-27]. Also some researchers had found no significant effect of some plant materials on progeny reduction[28,29].

Many plants are screened in programs to discover new agents in a costly process that can take 10-20 years to product development[30].

Results reported in this study show some insecticidal effect of most plant species on each of adult mortality, larvae mortality and progeny reduction, one, two, or all of them.

Different hypotheses have been suggested to explain the effect of these plants on insects:

- The ovicidal effect on the eggs.
- The toxic effect on early or first instar larvae.
- The toxic effect on all larvae stages.
- The toxic effect on the adults.
- The oviposition repellency to the insects.

Thus more studies are needed on this plant species to establish their potential sources, which might lead to their improvement as protectants in direct application assays.

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