

Effects of Three Plant Extracts, *Zingiber officinale* (Roscoe), *Allium sativum* L. and *Red Pepper Capsicum annuum* L. Against the Adult of Red Flour Beetle *Tribolium castaneum* (Herbst) (Coleoptera, Tenebrionidae)

Ebtisam M. Bashir

Department of Plant Protection and Environmental Studies, Faculty of Agriculture, Al Zaiem Al Azhari University

-ABSTRACT:

Laboratory studies were conducted in the lab research of faculty of agriculture, University of Al zaeim Al azhari, Sudan, Khartoun North to evaluate the efficacy of water and powder extracts of three plants *Zingiber officinale*, *Allium sativum* and *capcicumannuum* against the adult stage of red flour beetle *Tribolium-castaneum* and estimating the percentage of the insecticidal and antifeedant effect for the following concentrations 5% and 10% for water extracts and 0.5g, 1g and 2.5g for powder extracts. The experiment was carried out in a completely randomized design (CRD) and each treatment was replicated four times within 24, 48 and 72 exposure hours. The results showed no significant insecticidal effects of 5% plants water extract in all treatments after 24 and 48 hours but more efficacious significant differences between treatments and Ginger which cause 26% mortality after 72 hrs. Also result showed moderate effect of Ginger and Garlic at 10 % concentration for mortality with value 45% and 39% respectively. The results indicate that Ginger and Garlic powders at the same concentration (1g) the most toxic plant and Red pepper the least toxic one, which caused adult mortality of 5%, 6% and 1.33% respectively after 72 hrs. Significant difference was observed between all treatments and control in 0.5g concentration after 72 hrs of exposure. Also result showed excellence effect of Ginger powder at concentration 2.5g as antifeedant effect with the flour weight loss value of 4% while the value for Garlic and Red pepper fruit powders at the same concentration were 5% and 8.33% respectively.

Keywords: *Tribolium castaneum*, antifeedant, *Zingiber officinale*, mortality, adult stage

تأثير ثلاثة مستخلصات نباتية الزنجبيل والثوم والفلفل الأحمر على بالغات خنفساء

الدقيق الحمراء

د. إبتسام محمد بشير - كلية الزراعة - جامعة الزعيم الأزهرى

المستخلص:

أجريت الدراسات المعملية في معملابحث كلية الزراعة ، جامعة الزعيم الأزهرى ، السودان، الخرطوم لتقييم فعالية المستخلصات المائية والبدرلة لنباتات الزنجبيل والثوم والفلفل الحار ضد بالغات خنفساء الدقيق الحمراء وتقدير نسبة التأثير كمبيدات حشرية وممانعات للتغذية بتركيز 5% و 10% للمستخلص المائي وتركيز 0.5 جرام و 1 جرام و 2.5 جرام لمستخلص البدرلة. تم إجراء التجربة بالتصميم العشوائى الكامل (CRD) وتم تكرار كل معاملة أربع مرات خلال 24 و 48 و 72 ساعة من التعرض. أظهرت النتائج عدم وجود آثار معنوية كمبيدات حشرية للتركيز 5% من المستخلص المائي في جميع المعاملات بعد 24 و 48 ساعة ولكن هناك فروق معنوية أكثر فاعلية بين المعاملات والزنجبيل الذي سبب نسبة موت 26% بعد 72 ساعة. كما أظهرت النتائج تأثيرا معتدلا للزنجبيل والثوم بتركيز 10% للموت بقيمة 45% و 39% على التوالي. أشارت النتائج إلى أن مسحوق الزنجبيل والثوم بنفس التركيز (1 جم) أكثر النباتات سمية والفلفل الأحمر الأقل سمية مما تسبب في موت الحشرات الكاملة بنسبة 5% و 6% و 1.33% على التوالي بعد 72 ساعة. لوحظ اختلاف كبير بين جميع المعاملات والشاهد في تركيز 0.5 جرام بعد 72 ساعة من التعرض. كما أظهرت النتائج تأثيرا ممتازا لمسحوق الزنجبيل بتركيز 2.5 جم كمضاد للتغذية حيث بلغت نسبة فقدان وزن الدقيق 4% بينما كانت نسبة الفقد لمسحوق الثوم والفلفل الأحمر بنفس التركيز 5% و 8.33% على التوالي.

الكلمات المفتاحية:

INTRODUCTION:

Wheat is a major cereal in Sudan after Sorghum. The grain and its products are exposed during periods of storage to damage and loss of weight and poor quality due to several factors. Wheat flour is subject to the attack and suffers heavy losses during storage due to several storage pests the most important one is the Red flour beetle *Tribolium castaneum* (Herbst) is a cosmopolitan in distribution and consider as one of the key pests of stored grains and stored products throughout the world [1]. Both the adults and grubs cause serious damage to most kinds of grains including flour and dried fruits. In the Sudan considerable damage of flour beetle occur during storage due to the attack by the Red Flour Beetle *Tribolium castaneum*.

Control and protection of stored grains and the products from insect damage is mainly depends on synthetic pesticides,

one of the most prominent methods of control the use of fumigant gases. Synthetic chemicals have numerous negative effects on human health and non-target beneficial organisms[2]. Therefore, specialists in the fight against insect stores to find alternatives to this method, including Botanicals like *Datura*, , *Eucalyptus*, *Neem*, and many other plants belonging to the families of *Annonaceae*, *Asteraceae*, *Apiaceae*, , *Cupressaceae*, *Lauraceae*, *Lamiaceae*, *Meliaceae*, *Myrtaceae*, *Poaceae*, *Piperaceae*, *Rutaceae*, and *Zingiberaceae* were reported as promising sources of botanical insecticides[3] a promising source of pest control and can be grown by farmers with minimum expense and extracted by indigenous methods. These botanical materials can be used as an alternative to chemical pesticides and will be very helpful in minimizing the undesirable side effects of synthetic pesticides.

The present study aims to:

Evaluate the effect of powder and water extract from three plants namely, *Ginger Zingiber officinale* (Roscoe), *Garlic Allium sativum* L. and *Red Pepper Capsicum annum* L on the percentage of adult mortality and antifeedant effect against the red flour beetle *Tribolium castaneum* Herbst.

Materials and Methods

1. Mass Culture of the Insect

The adult individuals of the *Tribolium castaneum* beetle were collected from the infected wheat flour obtained from different stores in Bahri, Khartoum state. The samples were kept in a large glass jar contain clean, undamaged wheat flour for feeding the insect and covered with a muslin cloth and stored at lab temperature (35°C & 70 % relative humidity) at the lab research of Agriculture, University of Alzaeim Alazhari, Khartoum North, Sudan for three months so as to produce a pure culture to the experiments.

2. Preparation of the Plant Materials

Ginger Zingiber officinale, *Garlic Allium sativum* and *Red Pepper Capsicum annum* obtained from Bahri local market were used.

2.1 Preparation of plant powders

The plant samples were washed, shade dried for 3 days and ground to a fine powder with an electric blender and each sample was kept in a tightly closed glass jar using.

2.2 Preparation of Plant water Extracts

The water extracts of Ginger rhizomes, Garlic and Red Pepper fruits were prepared by adding 5 and 10 grams of the powder prepared as above to 95 and 90 ml of tap water in two conical flasks respectively. The mixtures were thoroughly shaken by hand for ten minutes and kept in the laboratory for 24 hours and filtered using filter papers (5 cm). The volumes were completed with water to 100 ml to obtain 5% and 10% (w/v) concentrations. The extracts were kept in cleaned flasks and used for the mortality experiments.

3. The experiment

Three laboratory experiments were conducted from June to November 2021 to study the effects of the water and powder extracts of three plants, *Zingiber officinale*, *Allium sativum* and *Capsicum annum* in mortality and weight loss of wheat flour due to *T. castaneum* feeding. The experimental unit was a plastic cup measuring (20×25×8 cm) and covered by a fine mesh cloth for ventilation (Plate. 1). All experiments were arranged in a completely randomized design (CRD) with four replicates. The control was kept untreated.



Plate. 1 the experimental units

3.1 Testing the effect of plant water extract 5% and 10% on the percentage of adult mortality

32 plastic cups were prepared (16 were used for each experiment).

Four cups sprayed with 5% and another four sprayed by 10% concentrations of plant extracts, and a fourth one was treated with tap water and used as control. The two concentrations (5% and 10%) were evaluated in separate experiments. Treated cups were left to dry for 5 minutes under room conditions. Each cup supplied by 10g of clean wheat flour (measured by an electronic sensitive balance) and newly 10 adult insects were introduced. The adult mortality was recorded after 24, 48 and 72 hours.

5.2 Testing the effect of plant powder extract at 0.5 g and 1g on the percentage of adult mortality Bioassay

32 plastic cups used for this experiment, each containing 10g of wheat flour were treated with two different weights of powder (0.5g and 1g) of each plant and thoroughly shaken to ensure adequate mixing, and a fourth cup was used as untreated control. 10 newly emerged adult released in each cup. The different weights of powder (0.5g and 1g) were evaluated in separate experiments (16 cups were used for each experiment with a set of untreated control). The percentage mortality of adults was taken after 24, 48 and 72 hours.

5.3 Testing the Antifeedants effect of plant powders on the adult

10g of wheat flour free from pest injury was mixed with 2.5g of three plant powder and 10 adult insects were released in three cups and fourth one was used as control. The weight of flour was taken after 24, 48 and 72 hours to determine the weight loss.

Statistical Analysis

Treatments were arranged in a complete randomized design. Each treatment was replicated four times. Data were subjected to analysis of variance (ANOVA) and the means were separated using the least significant difference (LSD) [4]. Gomez (1984).

Result

1. The effect of plant water extracts 5% on the percentage of adult mortality

In figure.1 the results showed no significant insecticidal effects of 5% plants water extract in all treatments after 24 and 48 hours but

more efficacious significant differences between treatments and Ginger which cause 26% mortality after 72 hrs.

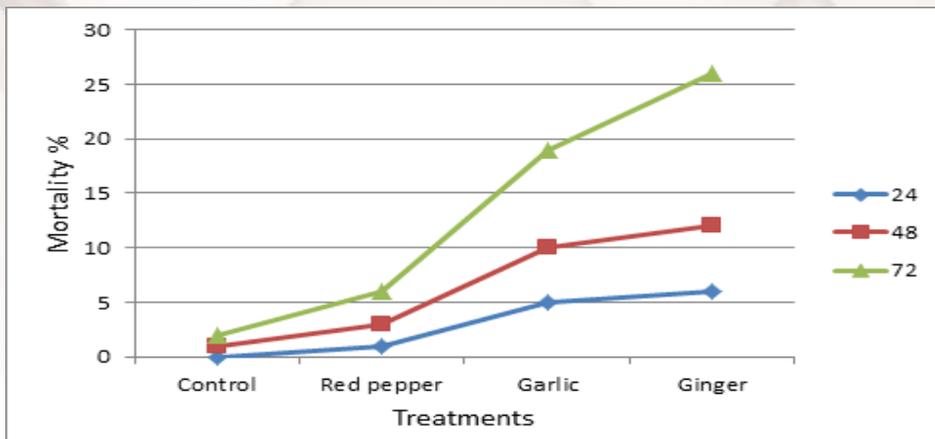


Figure 1. Mean percentage mortality of *Tribolium castaneum* adult after treatment with 5% Ginger, Garlic and Red pepper water extract at 24, 48 and 72 hrs

2. The effect of plant water extracts 10% on the percentage of adult mortality

Data are listed in fig.2 showed moderate effect of Ginger and Garlic at concentration 10% for mortality with value 45% and 39% respectively. The maximum mortality value in the case of Ginger was 45 after 72 hours of exposure compared with red pepper and control which causes 10% and 5% consecutively.

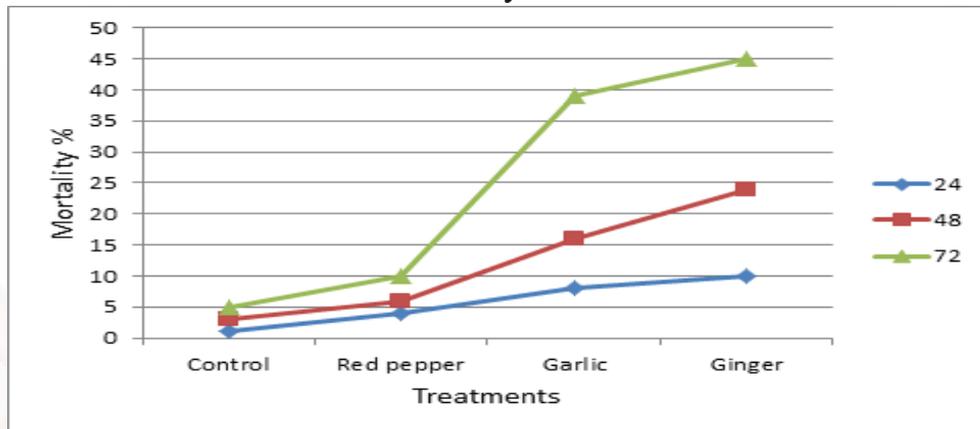


Figure 2. Mean percentage mortality of *Tribolium castaneum* adult after treatment with 10% Ginger, Garlic and Red pepper water extract at 24, 48 and 72 hrs.

3. The effect of plant powder extract at 0.5 g on the percentage of adult mortality

Figure (3) clearly demonstrates various degrees of the lethal effect of the three plant after treatment. The results obtained showed that significant mortality among adult could be observed after application of 0.5 g concentration. Ginger extract was the most potent at the test rate which caused 28% mortality of adult after 72 h of treatment. This followed by garlic that evoked 23% weevil mortality. the least toxic was red pepper that caused 5% mortality of adult.

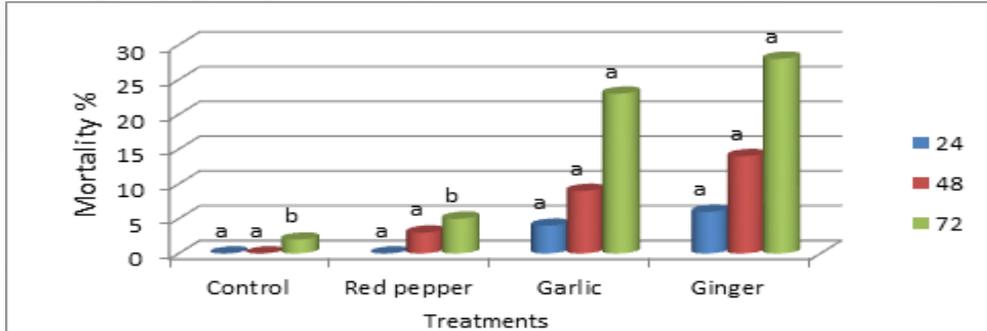


Figure 3. Mean percentage mortality of *Tribolium castaneum* adult after treatment with 0.5g Ginger, Garlic and Red pepper powder at 24, 48 and 72 hrs.

4. The effect of plant powder extract at 1 g on the percentage of adult mortality of

Highest mortality was observed in ginger and Garlic powders at the same concentration (1g) which caused adult mortality of 34% and 30% respectively after 72 hrs. Control and Red pepper showed the least mortality rates (2% and 6%) respectively (Fig.4).

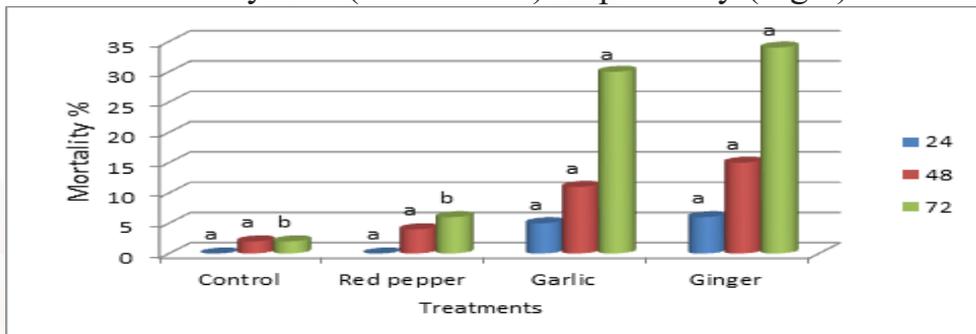


Figure 4. Mean percentage mortality of *Tribolium castaneum* adult after treatment with 1g Ginger, Garlic and Red pepper powder at 24, 48 and 72 hrs

5. the Antifeedants effect of plant powders on the adult

Data illustrated in table.1 displayed the effects of powder extracts in food consumption of *T. castaneum* after treatment. powder extract had a marked antifeeding effect, inhibiting adult feeding completely in all treatments. There was significant difference between the three plant extract on the consumption especially 72 hrs. after treatment where the consumption value average 4.0, 5, 8.33 and 9.01 treated by ginger, garlic, red pepper and control respectively. In most cases some adult were observed crawling away from the treated flour, suggesting the presence of repellent effects.

Table 1: the weight loss of wheat flour by *Tribolium castaneum* after treated by 2.5g powder of ginger, garlic and red pepper at 24, 48 and 72hrs

treatment	Weight loss(g) of wheat flour after treatment		
	24	48	72
Control	0.66a	2.20b	9.01b
Red pepper	0.90a	1.80b	8.33b
Garlic	0.35a	1.90a	5.00a
Ginger	0.50a	1.40a	4.00a
LSD	0.72	0.51	0.54

The means followed by the same letter (s) in the same column are not significantly different at ($P \leq 0.05$) according to LSD

Discussion

The use of synthetic pesticides have caused serious problem in the environment, these problems include contamination of the biosphere, toxicity to man, animals, beneficial insects and other non-target organisms. These problems had drawn the attention of public and policy makers to development of bioinsecticides as a viable pest control strategy in recent years [5], based on soft insecticidal chemicals of low environmental persistence, highly specific, cheap, available and bio-degradable. The promising sources are the natural products such as jatropa, neem, garlic, ginger and gel. Many plant extracts may be used for protection of stored product pests as they constitute a rich source of bioactive chemicals [6].

This experiment was conducted in order to determine the insecticidal activity of three plant *Zingiber officinale* (Roscoe), Garlic *Allium sativum* L. and Red Pepper *Capsicum annum* L. used on *Tribolium castaneum*. In all cases, considerable differences in insect mortality and antifeedant effect were shown with different plant extracts.

Figure 1 and 2 showed the effect of Ginger, Garlic and red pepper water extracts. They indicated that no variation in percentage mortality was noticed between the different treatments in 5% concentration against the adult of *T. castaneum* but more efficacious significant differences between treatments and Ginger which cause 26% mortality after 72 hrs. Similar results were reported by [7] who found that at the highest concentration of (6%) *Z. officinale* was found to be comparatively toxic and killed 9.81% to 22.05% of the *Tribolium confusum* larvae after 24 and 96 hrs. Also result showed moderate effect of Ginger and Garlic at concentration %10 for mortality with value 45% and 39% respectively. These findings consisting with the findings of [8] who found that the concentrations (5%, 10% and 15%) of the aqueous extract of *Pimentad dioica* and *Allium sativum* added to semolina, caused the highest mortality in the saw-toothed grain beetle *Oryzaephilus surinamensis*. These lethal effects of ginger and garlic water and powder extracts on adult of *T. castaneum*, in the present study, may be attributed to the feeding inhibition which usually leads to continuous starvation and subsequently death.

The results have demonstrated that Ginger and garlic have proved to be an effective botanical against the *T. castaneum* when mixed with wheat flour at a rate of 0.5 and 1g, these findings are in accordance with earlier studies by [9] Epi who confirmed that the garlic and ginger have been proved to be insecticidal against *Sitophilus zeamais* Motsch (Coleoptera: Curculionidae) and *T. castaneum* when mixed with seed.

Remarkable differences were found in flour weight among different treatments. It is clearly that there was appreciable reduction

in flour weight treated by ginger, garlic and red pepper compare to control. At the end of 72hrs of experiment, mean weight loss from original weight of 10 g was 9.01g for untreated wheat flour, 8.33g for red pepper, 5g for Garlic and 4g for Ginger. Similar result found by [10] who found that the *T. castaneum* was clearly demonstrated by the significant reduction in weight of the untreated groundnut seeds compared with the treated by the powder extract of *Zingiber officinale* (ginger), *Vitex grandifolia* (Vitex) and *Dracaena arborea* (dragon tree) at 5g, 10g, and 15g/500g seeds. Also result agree with [11] who found that the extracts of Ginger caused the strongest feeding deterrence against the *Callosobruchus maculatus* with percentage feeding index of 48.3%. The order of the anti-feedant potency of the extracts against *C. maculatus* after 5-hour exposure was *Z. officinale* (43.9%), > *X. aethiopicum* (48.3%) > *C. millenii* (59.9%) > *A. sativum* (61.6%) > *M. myristica* (64.9%)

Smaller weight loss may be gain due to not only reduction in food intake, but also to the poor utilization of food resulting from some physiological damage.

Conclusion and recommendations

The outcome of the study revealed that the aqueous and powder extracts of the botanicals might be useful as store insect control agents. All tested plant extracts were effective to some degree in reducing the number of *T. castaneum*. The results of the present study indicated that by considering the mean mortality as a main index, *Zingiber officinale* proved to be the most effective of the three test plants materials against the *T. castaneum*. However, further research experiments should be conducted to evaluate the effects higher concentrations of these plants and effective methods for stored pest management.

References:

- (1) Sinha, R.N. and F.L. Watters Insect pests of flour mills, grain elevators, and feed mills and their control. Agriculture Canada. Publication, Ottawa Canada; 1985 pp. 290.
- (2) Islam, M.S., & Talukdar, F.A. Toxic and residual effects of Azadirachtaindica, Tagetes erecta and Cynadondactylon seed extract and leaf powders towards Tribolium castaneum. Journal of Plant Disease Protection; 2005, 112 (6), 594-601.
- (3) Isman MB. Leads and prospects for the development of new botanical insecticides. In: Roe RM, Kuhr RJ, editors. Reviews in pesticide toxicology. Raleigh: Toxicology Communications Inc; 1995. pp. 1-20.
- (4) Gomez, T.P. and Gomez A.A. Statistical Procedure for Agriculture Research John Willy and Sons Inc. New York, U.S.A. 1984.
- (5) Hashim, M.S. and K.S. Devi. Insecticidal action of the polyphenolic rich fractions from the stem bark of Streblus asper on Dysdercus ingulatus; 2003, 74, Fitoterapia (7-8): 670-676.
- (6) Kim, S. I, Roh J. Y, Kim D. H, Lee H. S and Ahn Y.J. Insecticide activities of aromatic plant extracts and essential oils against Sitophilus oryzae and Callosobruchus chinensis. J. Stored Prod. Res; 2003. 39: 293-303.
- (7) Malgorzata, K. and Anna, P. The mortality of Oryzaephilus surinamensis Linnaeus, (Coleoptera: Silvanidae) induced by powdered plants. Journal of Plant Protection Research; 2015 Vol. 55, No.1: 110-116
- (8) Wand. K.A. and Hena H.M. Toxic Effect of Some Plant Extracts on the Mortality of Flour Beetle Tribolium confusum (Duval) (Coleoptera: Tenebrionidae). Entomology, Ornithology & Herpetology: Current Research. Aliet and oammed Entomol Ornithol Herpetol; 2013. DOI: 10.4172/2161-0983.1000115
- (9) Epedi, T.T., Odili, E.O. Biocidal activity of selected plant powders against Tribolium castaneum Herbst in stored groundnut (Arachis hypogaea L.). Afr. J. Environ. Sci. Technol. 2009. 3, 001-005.

- (10) Timothy T. Epedi and Esther O. Odili. Biocidal activity of selected plant powders against *Tribolium castaneum* Herbst in stored groundnut (*Arachis hypogaea* L.). *African Journal of Environmental Science and Technology*. 2009 Vol. 3 (1), pp. 001-005.
- (11) Egwunyenga O. A. and Ake J. E. Antifeedant Potential of Some Aromatic Plants against Cowpea Weevil, *Callosobruchus maculatus*. *World Journal of Agriculture and Soil Science*. 2019