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Biocidal effects of powder and methanolic extracts of *Capsicum frutescens* L. (Solanaceae) on *Tribolium castaneum* (Herbst) (Coleoptera : Tenebrionidae)

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Abstract: The biocidal / repellent activity of the powder and methanolic extract of *Capsicum frutescens* L. fruits on adults of *Tribolium castaneum* (Herbst) infesting wheat seeds was studied under controlled conditions. The powder at 0, 0.025, 0.05, 0.075 and 0.1 g / g of wheat grain and the methanolic extract at 0, 10, 20, 25 and 30 $g.l^{-1}$ were applied. Compared to the control, the powder causes a low adult mortality (5%) but significantly higher than that obtained with adults released on untreated seeds (1.67%). For the methanolic extracts, the concentration 30 $g.l^{-1}$ causes a significantly higher mortality (37%) than that obtained with adults released on seeds treated with 0 $g.l^{-1}$ (5%). With regard to the repellency, the test indicates that the average number of *T. castaenum* present on the half-discs containing powder ranges from 20 to 26% and is significantly lower than that of the control which is 73%. at 85%. As for the methanolic extract, the insect repellent activity shows that the average number of *Tribolium* present on the semi-disk impregnated with the extract is 8 to 28% and is significantly different from the control whose average number varies from 71 to 91%.

Keywords: Plant extracts, biopesticides, repellent activities, toxic effects, grain pests.

1. Introduction

The red beetle *Tribolium castaneum* (Herbst) is considered one of the most serious pests of stored grain and processed grain products worldwide [1]. In addition to weight loss, the insect causes deterioration in the quality of stored products and decreases in market value [2]. The larvae sink into the seeds and eat in the shelter. They produce lumpy feces and dust-like flour. Excretion gives a strong smell to cereals.

Effective control of these stored cereal pests has long been the goal of entomologists around the world [3]. The use of synthetic insecticides has gained momentum and has become the fastest and most effective weapon in the fight against this beetle. Thus, the fight against *T. castaneum* is mainly based on the use of synthetic fumigants.

However, poorly conducted applications of these chemicals cause serious drawbacks, including the appearance of resistant strains [4], [5], chronic consumer intoxication and a negative impact on the environment [6], [7].

Faced with these problems, it is interesting to develop new methods, as alternatives, for phytosanitary protection [8].

In this context, the use of plant extracts with insecticidal activities offers some potential. Among these plants, the hot pepper, *Capsicum frutescens*, has been the subject of many works. Thus, the powder and extracts of *C. frutescens* showed a repellency against *Callosobruchus maculatus* F. and *Rhyzopertha dominica* L. [9], [10], [11]. The toxicity of chili fruit extracts was also noted in *C. maculatus*, *R. dominica*, *Sitophilus oryzae* L. and *Tribolium confusum* J. [12]. The insecticidal power of the methanolic extract of *Capsicum frutescens* (L.) var. longum on larvae of the fly Aedes aegypti has been shown [13].

Based on the above, our study investigated the effects of *C. frutescens* powder and methanolic extract on *T. Castaneum* adults.

2. Materials and Methods

2.1 *Tribolium castaneum*

The *Tribolium castaneum* species comes from a local market cereal storage warehouse. It is maintained by mass rearing at a temperature of 28 ° C, a relative humidity of 70 ± 5% and a photoperiod of 16: 8 hours (light: dark). To obtain a large

population of *T. castaneum*, insects of the same sex are reared on 100 g of soft wheat in 1-liter borosilicate glass jars. These jars are covered with mosquito net so that the insects can breathe. A week after having ensured the laying, the adults are eliminated. The laid eggs evolved and gave first generation adults 40-45 days after the infestation. In order to avoid the phenomenon of overcrowding, we have regularly transferred adults to new jars, thus ensuring new generations. We used in our trials adults of known age, between 10 and 14 days old.

2.2 Preparation of the powder

The dried fruits of *Capsicum frutescence* were bought at the local Meknes market and dried in an oven set at 40 ° C to constant weight. They were then crushed. The powder is passed through a 0.5 mm mesh sieve and then stored in glass vials in a cool place away from light and air.

2.3 Extraction of the compounds from the fruits of *Capsicum frutescens*

50 g of powdered fruit from *C. frutescens* was extracted with a soxhlet using 250 ml of absolute methanol for analysis (LABOSI) for five hours. The methanolic extract was then evaporated to dryness and under vacuum at 40 ° C. by a Bruchi-type rotavapor at speed 4. The dry residue was taken up in 1% methanol for biological tests.

2.4 Biological tests

2.4.1 Evaluation of the contact effect of *Capsicum frutescence*

a. Effect of powder on *Tribolium castaneum*

Twenty (20) individuals of *T. castaneum* aged 10 to 14 days are introduced into petri dishes (Ø 90 mm) containing 20 g of wheat seeds treated with different doses of powders of the fruits of *C. frutescence*. The doses used are 2.5%, 5%, 7.5% and 10% of the weight of the powder per weight of seeds, i.e. a powder weight of 0.5 g, 1 g, 1.5 g, and 2 g respectively. Control batches (0%) are carried out in parallel with untreated seeds. The tests are repeated 3 times for each dose and for the control. The number of dead insects is calculated every 24 hours for 6 days after treatment. The petri dishes are kept under the same culture conditions as *T. castaneum*.

b. Effect of the methanolic extract on *T. castaneum*

Twenty (20) individuals of *T. castaneum* aged 10 to 14 days are placed in petri dishes containing 20 g. of wheat placed on filter paper immersed beforehand in the methanolic extract at concentrations of 10 g, 20 g, 25 g, and 30 g of extract per liter of 1% methanol for 20 seconds then air-dried free for two hours to evaporate the methanol. The tests are repeated 3 times for each dose and for the control (0 g.l-1). The number of dead insects is calculated every 24 hours for 6 days after treatment. The petri dishes are maintained under the same conditions described above.

2.4.2 Evaluation of the repellent effect of *Capsicum frutescence*

This test is used to calculate the percentage of repulsion of the powder and methanolic extract of the fruit of *C. frutescence* with respect to *T. castaneum* by the preferential zone method on filter paper described by [14]).

In this test, 90 mm diameter petri dishes were used containing two half-discs of filter paper separated by a space of 1 cm. One half-disc is treated with the powder or extract and the other untreated control half-disc in the case of the powder, or treated with 1% methanol in the case of the methanolic extract. Twenty (20) individuals of T. castaneum aged 10 to 14 days are placed in the center of each box. The number T. castaneum in contact with each half-disc is counted every 5 minutes for 35 minutes (n = 7 counts). Three repetitions are performed for each dose. The petri dishes are kept under the same farming conditions.

a. Effect of the powder

Discs of filter paper, 9O mm in diameter, are cut into two equal parts and placed at the bottom of the Petri dishes. Doses of 0 g, 0.5 g, 1 g, 1.5 g and 2 g are evenly spread on one half of a filter paper disc and the other half does not receive powder.

b. Effect of the methanolic extract

90 mm diameter filter paper discs are cut into two equal parts. Half of the paper is immersed in the methanolic extract at concentrations of 10 g, 20 g, 25 g, and 30 g of extract per liter of 1% methanol. The other half is immersed in 1% methanol only (0 g / l). The two half discs of filter paper are dried in the open air for two hours (to evaporate the methanol) and then put in a Petri dish.

2.5 Data analysis

The results of the various tests were subjected to statistical analysis with the Fisher test. This method makes it possible to compare the means two by two, for the different doses of powder and methanolic extracts, with the Statview V5.0 software. If the adjusted probability is less than 0.05, the difference is significant. If the adjusted probability is greater than 0.05, the difference is considered not significant. Mortalities have been corrected according to the method of [15].

3. Results

3.1 Effects of Capsicum frutescens powder on the viability of adults of Tribolium castaenum

The daily observations of adults of Tribolium castaenum, in direct contact with the powder of Capsicum frutescens, enabled us to record variable responses depending on the concentration considered and the exposure time. As shown in Figure 1, after 72 hours, the powder causes low adult mortality. The death toll is around 1.67% for the 0.025, 0.05, and 0.075 g / g doses. It then drops to 3.33% after 120 hours of exposure. This rate remains invariable and not significant compared to the control lots. It then goes to 5% for the dose 0.1 g / g which is significantly higher than that obtained with adults released on untreated seeds.

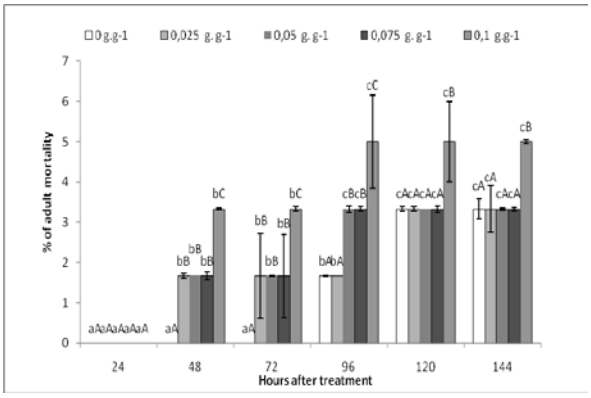

Figure 1: Cumulative mean (± SD) of adult mortality of Tribolium castaenum due to powder from Capsicum frutescens fruits.

[a, b, c] Within the same concentration, the means affected by the same lowercase letter do not differ statistically between them according to the Fisher test at the probability threshold (5%); [A, B, C] Within the same period, the means affected by the same capital letter do not differ statistically between them according to the Fisher test at the probability threshold (5%).

3.2 Effects of methanolic extracts on the viability of adults of Tribolium castaenum.

The adults of *Tribolium castaenum*, brought into contact with wheat seeds treated with methanolic extracts of the fruit of *C. frutescens* have a response which varies according to the concentration tested.

As shown in Figure 2, the concentration 30 g.l^{-1} causes a significantly higher mortality than those obtained with adults released on seeds treated with 0, 10, 20 and 25 g.l^{-1}. These vary from approximately 0 to 5% with 0 gl^{-1}, from 0 to 8% with 10 gl-1, from 2 to 10% with 20 gl^{-1}, from 7 to 13% with 25 gl^{-1} and from 13 to 37% with 30 gl^{-1}.

On the other hand, the mortality of adults of the insect is chronologically less dependent compared to the mortality due to methanolic extracts.

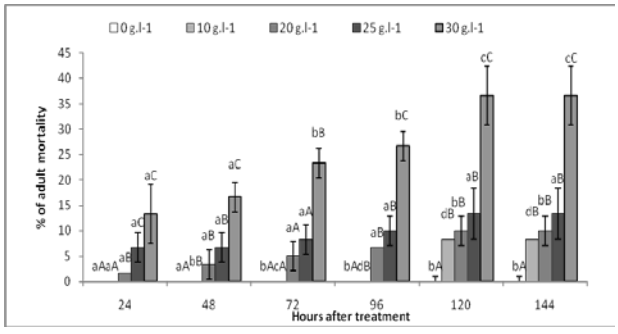

Figure 2: Cumulative means (±SD) of adult mortality of Tribolium castaenum due to methanolic extract from Capsicum frutescens fruits.

[a, b, c] Within the same concentration, the means affected by the same lowercase letter do not differ statistically between them according to the Fisher test at the probability threshold (5%); [A, B, C] Within the same period, the means affected by the same capital letter do not differ statistically between them according to the Fisher test at the probability threshold (5%).

3.3 Repellent effects of *Capsicum frutescens* fruit powder on adults of *Tribolium castaenum.*

Table 1 illustrates the evolution of the percentage of adults of *T. castaenum* present per half-disc as a function of time and of the concentration for the insecticidal activity test of the powder of the fruit of *Capsicum frutescens*. It indicates that the majority of insects choose the control side compared to the side of the half-disc containing the powder. Thus, the test shows that the average number of *T. castaenum* present on the half-discs containing the powder is 20 to 26%. It is significantly lower than that of the control, which is 73 to 85% with (DDL = 3), (F = 13.343) and (p <0.0001). In addition, the duration of the exposure and the concentrations tested have no significant effect on the repellency of the powder.

Table 1: Percentage of adults of Tribolium castaenum present per half-disc for the insecticidal activity test of the fruit powder of Capsicum frutescens.

Powder (g / half disc)	Exposure time (minutes)					
	5	10	15	20	25	30
0	73,33^{aA} ± 2,89	75,00^{aA} ± 0,00	73,33^{aA} ± 2,89	75,00^{aA} ± 0,00	73,33^{aA} ± 2,89	75,00^{aA} ± 0,00
0,5	26,67^{bA} ± 2,89	25,00^{bA} ± 0,00	26,67^{bA} ± 2,89	25,00^{bA} ± 0,00	26,67^{bA} ± 2,89	25,00^{bA} ± 0,00
0	76,67^{aA} ± 2,89	76,67^{aA} ± 2,89	78,33^{aA} ± 2,89	80,00^{aA} ± 5,00	81,67^{aA} ± 5,77	81,67^{aA} ± 5,77
1	23,33^{bA} ± 2,89	23,33^{bA} ± 2,89	21,67^{bA} ± 2,89	20,00^{bA} ± 5,00	18,33^{bA} ± 5,77	18,33^{bA} ± 5,77
0	78,33^{aA} ± 2,89	78,33^{aA} ± 2,89	80,00^{aA} ± 5,00	78,33^{aA} ± 2,89	81,67^{aA} ± 5,77	80,00^{aA} ± 5,00
1,5	21,67^{bA}± 2,89	21,67^{bA} ± 2,89	20,00^{bA} ± 5,00	21,67^{bA} ± 2,89	18,33^{bA} ± 5,77	20,00^{bA} ± 5,00
0	76,67^{aA} ± 2,89	75,00^{aA} ± 5,00	76,67^{aA} ± 2,89	75,00^{aA} ± 5,00	78,33^{aA} ± 2,89	80,00^{aA} ± 0,00
2	23,33^{bA} ± 2,89	25,00^{bA} ± 5,00	23,33^{bA} ± 2,89	25,00^{bA} ± 5,00	21,67^{bA} ± 2,89	20,00^{bA} ± 0,00

3.4 Repellent effects of methanolic extracts of *Capsicum frutescens* on adults *Tribolium castaenum.*

As can be seen from Table 2, the evolution of the percentage of *Tribolium castaenum* present per half-disc, for the test of insect repellency activity of methanolic extracts of the fruit of *Capsicum frutescens*, indicates that 71 to 91% of Tribolium on average, choose the witness side; while 8 to 28% choose the side of the half-disc impregnated with methanolic extracts. The test indicates that the average number of *T. castaenum*, present on the half-discs impregnated with the methanolic extract, is significantly different from that of the control with a (DDL = 3), (F = 48.520) and (p <0 , 0001).

Table 2: Percentage of adults of Tribolium castaenum present per half-disc for the insect repellent activity test of the methanolic extract of the fruit of Capsicum frutescens.

[C]	Exposure time (minutes)

(g.l^{-1})	5	10	15	20	25	30
0	76,67^{aA} ±5,77	75,00^{aA} ±5,00	71,67^{aA} ± 2,89	75,00^{aA} ± 5,77	71,67^{aA} ± 2,89	73,33^{aA} ± 2,89
10	23,33^{bA} ± 5,77	25,00^{bA} ± 5,00	28,33^{bA} ± 2,89	26,67^{bA} ± 5,77	28,33^{bA} ± 2,89	26,67^{bA} ± 2,89
0	76,67^{aA} ± 2,89	76,67^{aA} ± 2,89	78,33^{aA} ± 2,89	80,00^{aA} ± 5,00	83,33^{aA} ± 5,77	81,67^{aA} ± 5,77
20	23,33^{bA} ± 2,89	23,33^{bA} ± 2,89	21,67^{bA} ± 2,89	20,00^{bA} ± 5,00	16,67^{bA} ± 5,77	18,33^{bA} ± 5,77
0	80,00^{aA} ±5,00	78,33^{aA} ± 2,89	81,67^{aA} ± 5,77	80,00^{aA} ± 5,00	78,33^{aA} ± 2,89	85,00^{aA} ± 5,00
25	20,00^{bA} ± 5,00	21,67^{bA} ± 2,89	18,33^{bA} ± 5,77	20,00^{bA} ± 5,00	21,67^{bA} ± 2,89	15,00^{bA} ± 5,00
0	88,67^{cA} ±2,89	90,00^{cA} ± 5,00	88,33^{cA} ± 2,89	90,00^{cA} ± 5,00	88,33^{cA} ± 2,89	91,67^{aA} ± 2,89
30	11,33^{dA} ±2,89	10,00^{dA} ± 5,00	11,67^{dA} ± 2,89	10,00^{dA} ± 5,00	11,67^{dA} ± 2,89	8,33^{cB} ± 2,89

$^{a, b, c, d}$ ***Within the same concentration, the means affected by the same lowercase letter do not differ statistically between them according to the Fisher test at the probability threshold (5%);*** $^{A, B, C}$ ***Within the same period, the means affected by the same capital letter do not differ statistically between them according to the Fisher test at the probability threshold (5%).***

4. Discussion

At the end of these experiments, the powder and methanolic extracts of the fruit of *C. frutescens* have insecticidal and repellent effects on the red beetle of *T. castaenum* flour. This has also been observed in *Sitophilus Zeamais* [16] and *Aedes aegypti* [13]. [17], showed that the powders of *Peper nigrum*, *Capsicum. annuum* and *Cinnamomum zeylanicum* Blume had a repellent effect on *S. zeamais*. [18] have reported an average mortality of S. zeamais at 28 days post-treatment at three rates (0.2, 0.4 and 0.6/20g of Capsicum frutescens/ maize seeds). It is unequivocal that seeds powders of Capsicum annum (5.0g/50g) seeds and Capsicum frutescens at 5.0g/50g and 7.5g/50g seeds manifested contact insecticidal action against C.maculatus and S.zeamais in this study

Similar results were obtained by [19] [20]. They found that *C. frutescens* significantly reduced all stages of *C. maculatus*. These observed insecticide and repellant activities can be attributed to the presence of capsaicin [21]. The toxicity of capsaicin dilutions has been previously verified on potato beetle larvae (*Leptinotarsa decemlineata*) [22] and on *Tenebrio molitor* [11]. The capsaicin extracted from *Capsicum annum* caused the mortality of approximately 97% of *Aphis myzus* [23].

The fruits of *C. frutescens* therefore appear to be potentially usable in integrated pest management.

5. Conclusion

The results obtained show that the powder and methanolic extracts of *C. frutescens* have a toxic and repellent power on *T. castaenum*, with a more pronounced activity of methanolic extracts. In the short and medium term, the powder with 0.1 g.g^{-1} of sheaths and the methanolic extracts at 30 g.l^{-1}, can be integrated into a management program for T. castaenum, a pest of cereals stored especially in a situation at risk of resistance. to other products.

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