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THE EFFECT OF STRAIGHT CHAIN FATTY ACIDS ON GROWTH OF *CALANDR A ORYZAE.* *

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A B S T R A C T

The effect of straight chain fatty acids (C5 to C19) on growth and development of *Calandra oryzae* L. was studied. It was found that certain acids at a concentration of 3 kg per ton, were lethal to the adult beetles and prevented infestation of this pest.

A close correlation between the chain length of the acids and the biological activity was observed. Quantitative data of the active compounds needed to prevent infestation of grain is presented.

INTRODUCTION

The massive application of insecticides in recent years has resulted in the emergence of resistant individuals, and the necessity to use the ever increasing doses has led to cumulation of toxic residues of these compounds in food (Brown and Pal, 1971), thus directly or indirectly endangering human health and the environment as well. Due to the increasing restrictions concerning the tolerance of insecticidal residues in food, the development of new chemicals for the control of stored products and quarantine insects has slowed down.

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Patent Pending.

Searching for alternative ways for insect control not involving insecticides, we found that fatty acids (C_8 to C_{11}) are rather active for controlling stored-product pests.

In this paper we would like to report the results obtained with *Calandra oryzae* L., a serious pest which attacks grain rice and corn in storage.

MATERIALS AND METHODS

a. *Insect culture.*

Calandra oryzae was cultured on soft wheat No. 2152, at 28°C and 65% relative humidity. The female lays its eggs into holes she drills in the seeds. The insect spends all developmental stages (from the egg to the adult) inside the seed. The mature adult lives about three months. We have determined that the adult consumes 0.4 mg of wheat per day which is about 36 mg of food during its life cycle. The larva consumes 9.5 mg of food during its whole life. Thus, during the life cycle the food consumption of the adult beetle is three times higher than that of the larva. The adults survive 3 to 5 days without food.

b. *Bioassay.*

Ice cold 10μl of diethyl ether containing the desired amount of the tested acid was evenly distributed on a wheat seed with a micro-pipette. The treated seeds were dried in a stream of cold air for two hours before they were transferred to small dishes which were placed in a 0.5 liter glass jars separately. Control seeds were treated with 10μl ether only. Each jar was infested with 15 beetles aged 9–11 days for a period of 10 days.. Following this period the insects were removed. The changes in the moisture content of the seeds during the test were recorded. Three repetative tests were done for each experiment. The fact that *Calandra* female lays its eggs in holes she drills in the seeds, makes it practically impossible to count the number of eggs layed in each seed, without damaging the eggs. Therefore, we have worked out a bioassay for *Calandra* which is based on the following criteria:

1. Percentage of adult mortality during 10 days of exposure to the treated seeds.

2. Food consumption of the adults in 10 days expressed as mg/15 adults/10 days.

3. The number of new beetles emerged in the first generation.

4. Food consumption by the larvae expressed as mg/emerged adult.

RESULTS

The data obtained by testing the activity of C_5 to C_{19} acids at concentrations of 20 and 8 kg per ton of wheat seeds is shown in Figures 1 and 2. These figures indicate that the middle chain-size acids are the most active. Thus, C_7 to C_{11} acids at the above concentration and C_6-acid at the higher concentration are lethal to adults, who died without consuming any food (Figures 1a, 2a). Moreover, neither new generation of beetels emerged, nor any larva developed, and no change in the weight of the seeds was observed (Figures 1b, 2b). Reducing the concentration of C_7 to C_{11} acids to 4 kg per ton of seeds had no effect on their activity (Figure 3a,b). The same results were obtained at 3 kg per ton seeds. Seeds treated with a concentration of 3 kg/ton of C_{11} (undecanoic) acid and control after infestation are presented in Figure 4. Further reduction in the acid concentration make them only partially effective. For example, the adult mortality following a 10 day exposure to treated seeds at a concentration of 2 kg per ton was as follows: C_8 - 33%; C_9 - 60%; C_{10} - 27%; C_{11} - 25%; control - 0% and the number of adult emerged were 30, 18, 33 and 72, respectively.

These results were confirmed by performing a larger scale laboratory test in which 1 kg of wheat seeds was mixed with 3 kg/ton seeds using undecanoic acid and infested with 500 adult beetles for a period of 10 days. In the control, 2200 beetles emerged in the first generation, and no adults emerged in the treated seeds. Moreover, the treated seeds were undamaged since we could not detect any larvae inside the seeds.

Examination of Figures 1a, 2a, 3a indicate that C_8 to C_{11} acids are very active adulticides, and also prevent infestation (Figure 1b, 2b, 2c). As no larvae in the treated seeds were developed, it is likely that these compounds might also have ovicidal effect.

We observed that adult *Calandra* which were introduced to seeds treated with the active acids hardly could be spotted on the seeds and had minimal contact with the food. In order to get inside the mode of action of the active acids on adult mortality and oviposition, the following experiment was designed. Five groups of adult

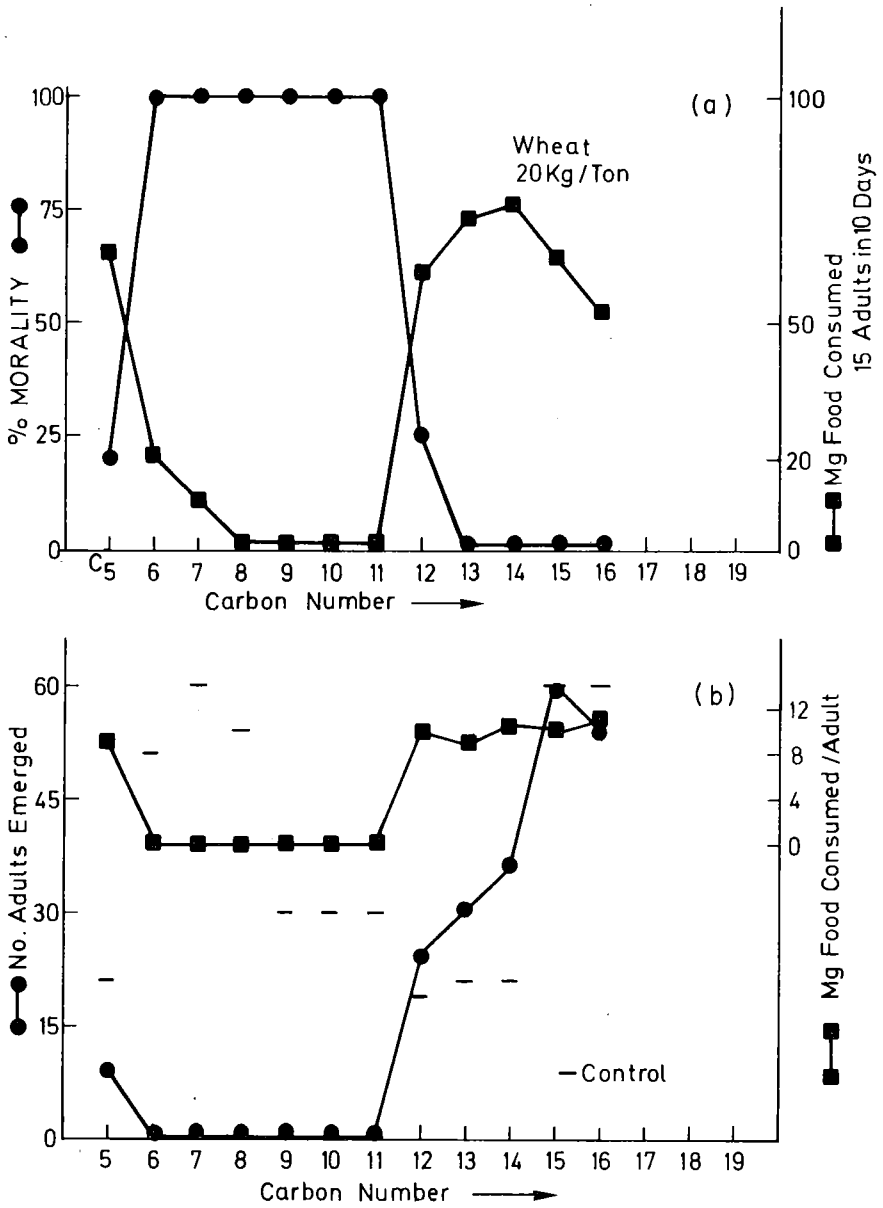


Figure 1: The influence of C_5 to C_{16} fatty acids (20 kg/ton): a. on adult mortality and mg of food consumed by the adults. b. on the number of newly emerged adults and mg of food consumed by larva, expressed mg/adult. The data are the average of triplicate tests. In the control tests adult beetles consumed 0.4 mg/day and 9.5 mg of food was consumed per emerged adult. Adult mortality 0-5% in the control.

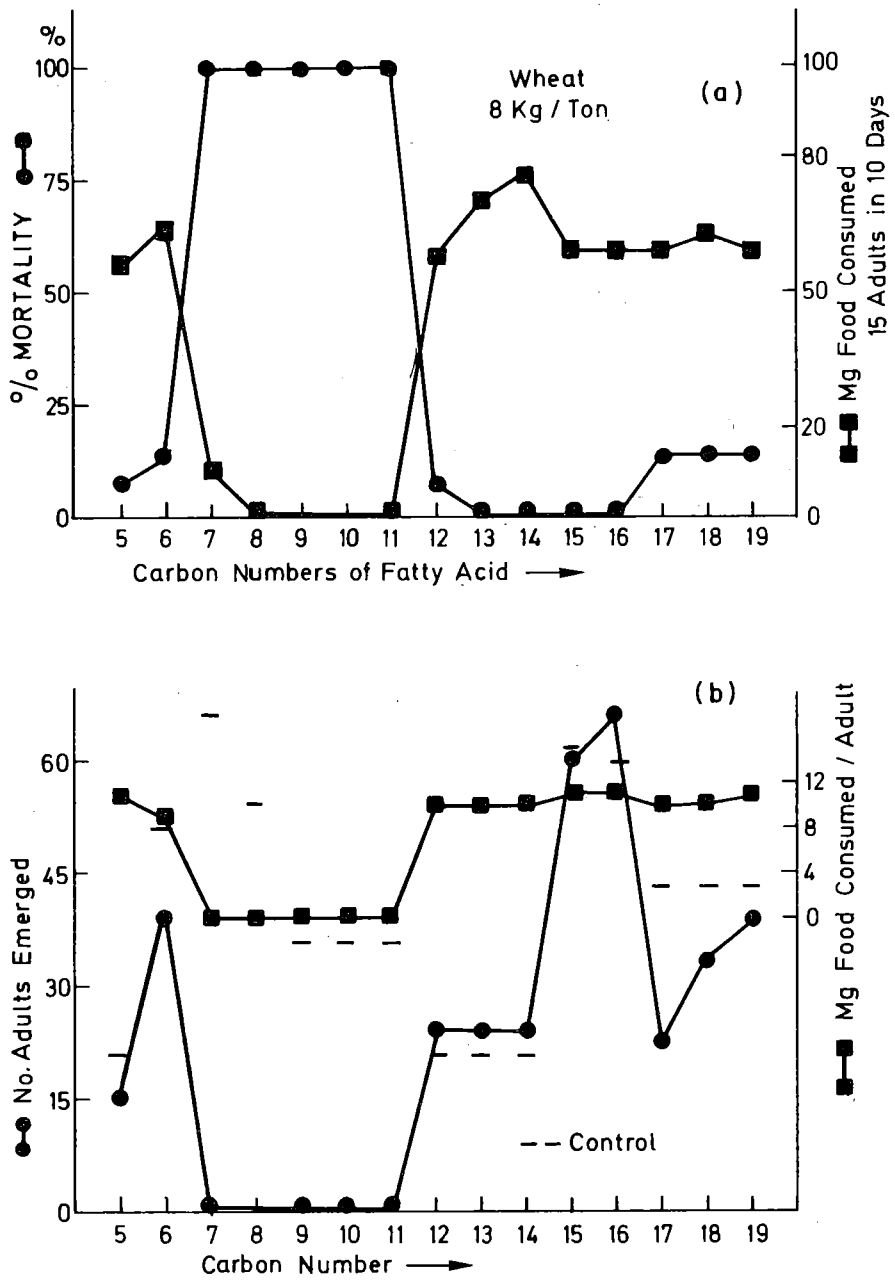


Figure 2: The influence of C_5 to C_{19} acids (8 kg/ton), other details as in Fig. 1.

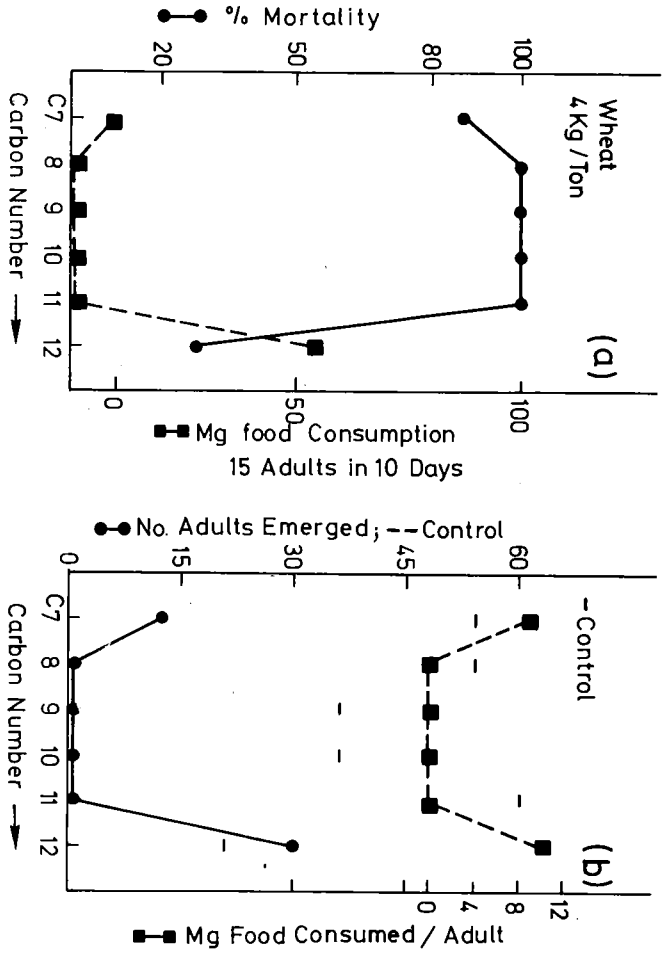
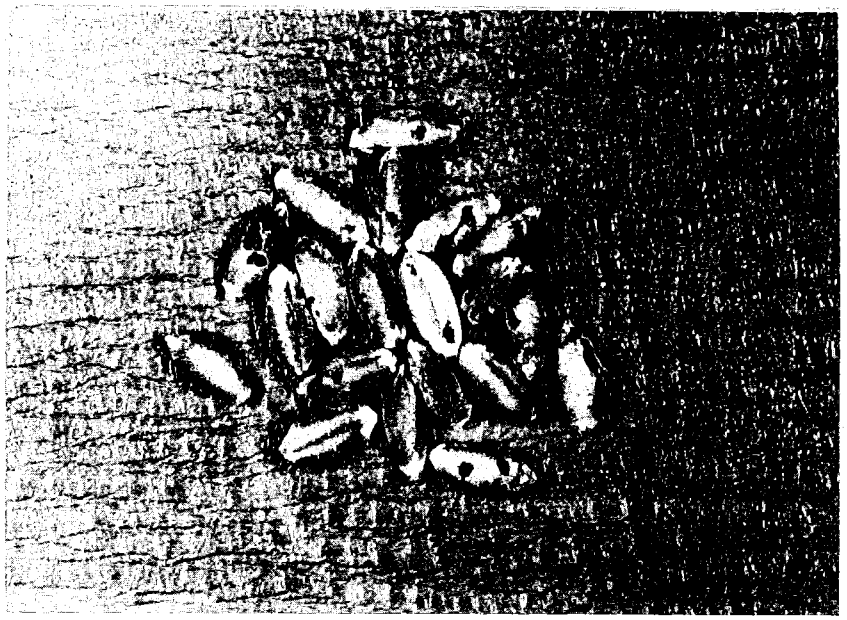


Figure 3: The influence of C_7 to C_{12} acids (4 kg/ton), other details as in Fig. 1. Similar results were obtained with 3 kg/ton. The adults introduced to treated seeds died within a period of 3 to 5 days.



Wheat control

Wheat treated with 3 kg/ton of
undecanoic acid

Fig. 4

insects were used. Group 1 was kept in contact with seeds treated only with diethyl ether. Groups 2 and 3 were kept in contact with seeds treated with 4 kg/ton of C_{10} and group 4 was kept without food. This part of the experiment was done in small vials designed for this purpose. Group 5 was kept in jars with treated acids throughout the experiment, as described in Materials and Methods.

After a period of 24 hours, the first two groups together with their seeds were transferred into jars (½ liter), group three was supplied with untreated seeds and group four was again left without food. Adult mortality and the number of beetles in the first generation were recorded for 10 days.

The results summarized in Table 1 show that the 24 hour contact with the treated seeds did not result in changes in the mortality rate of the adults, see Table 1, group 2 and 5. This suggests that physical contact with the acids is not prerequisite for its action. Furthermore, the similarity in the mortality rate obtained with group 4, which was kept without food with that of groups 2 and 5, make it likely that these acids act mainly as repellents. The data of group 3, indicate that the effect of these acids is highly reversible.

DISCUSSION

The finding that C_8 to C_{11} fatty acids at a concentration of 3 kg acid/ton wheat are lethal to adults of *Calandra oryzae*, and prevent its infestation, is consistent with similar studies conducted with *Callosobruchus chinensis* L., a major pest of legumous seeds (Shaaya, Grossman and Ikan, 1976).

The facts that no adult Calandra were seen in or around the treated seeds and that physical contact of the beetles with treated seeds had no effect on the mortality rate (Table 1), make it unlikely that these compounds act as contact toxicants. We postulate, therefore, that the fatty acids act as repellents and the beetles die of starvation. This is supported by the finding that the adults died within 3 to 6 days, either by keeping them without food or by supplying them with treated seeds only. This is also apparent from our studies with *Callosobruchus chinensis*, where the active acids prevent the females from laying eggs on treated seeds and have no lethal effect on adults (Shaaya, Grossman and Ikan, 1976). This could be due to the fact that the adults consume no food.

Group Number*	% Adult Mortality Days after treatment 2	3	5	6	10	Number of emerged adults
1	0	0	0	0	0	72
2	0	18	90	100	–	0
3	0	13	18	24	24	59
4	0	15	82	100	–	0
5	0	26	100	–	–	–

For each test 20 seeds infested with 15 adult beetles (age 9-11 days). Infestation lasted for 10 days. The data are of triplicate tests.

*Group 1: The insects were kept for 24 hours with seeds treated with diethyl ether. Then transfered to jars with the same seeds.

Group 2: As above, however, the seeds were treated with 4 kg/ton C_{10} acid.

Group 3: As in group 2, then transfered to jars with untreated seeds.

Group 4: No seeds supplied.

Group 5: The insects kept with seeds treated with C_{10} acids, in jars (½ liter) throughout the experiment.

Table 1: Effect of continuous contact of C_{10} acid on the mortality and oviposition of *Calandra oryzae.*

The correlation between the molecular structure and the biological activity of the acids in both, ***Calandra*** and ***Callosobruchus*** indicate a specific characteristic effect rather than a non-specific pharmacological one.

It should be pointed out however, that middle chain fatty acids were found to act as larvicides of the housefly (Quraishi and Thorsteinson, 1965) and of ***Psadosarcophaga affinis*** F. (House, 1967). C_{10} acid acts as a larvicide of ***Tribolium confusum*** Duv. (House and Graham 1967) and mosquito (Maw.1970; Maw and House,1971).C_5-C_{10} fatty acids suppress the fertility of ***Dermestes maculatus*** Deg. (Cohen and Levinson, 1972).

The active fatty acids are stable compounds (Gunstone, 1967), and seem to be harmless to warm blooded animals and man (House and Graham, 1967). The C_{10} and C_{11} acids possess a very mild odor. It is interesting to note that woman's milk contains 0.5 to 2.7% of capric C_{10} acid (Hilditch,1956; Lang, 1961).

It seems, therefore, that using active natural acids, their derivative or synergistic compounds might open new avenues for eradication of insects.

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