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Susceptibility of two maize grain flour to infestation by the rust- red flour beetle (*Tribolium castaneum* Herbst)

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ABSTRACT

The susceptibility of white and yellow maize grain flour to *Tribolium castaneum* was evaluated at ambient temperature and relative humidity in the laboratory were 33.6±0.21 0C and 35.8±0.13% RH. Different quantities of the two varieties of maize grain flour was infested with 5 adults *T. castaneum* in the ratio of 3:2. The result showed that at 20 days after infestation, there were significant differences in the number of *T. castaneum* larvae in the different quantities of the yellow maize. Moreover, the number of *T. castaneum* pupae in the yellow and while maize grain flour was statistically different from each other at 66 days after infestation. However, the results at 66 days after infestation showed that there were significantly differences in the mean number of *T. castaneum* adults emerged from the different quantities of yellow and white maize grain flour.

Keywords: *Tribolium castaneum*, Susceptibility, Infestation, Grain.

INTRODUCTION

Tribolium castaneum Herbst (ColeopteraTenebrionidae) is one of the most widespread and destructive pests of stored products, feeding on different stored-grain and grain products [1]. *T castaneum* infestation could directly result in weight loss and the beetle indirectly imparts a brownish tinge and pungent smell to infested flour by secretion of benzequinones [2].

It is a major pest of stored products and can be a major pest in anthropogenic structures used for the processing and storage of grains based products such as flour mills, biscuit industry warehouses and retail stores. This species has had a long association with human stored food and has been found in association with a wide range of commodities including grain, flour, peas, beans, cacao, nuts, dried fruits, and spices, but milled grain products such as flour appear to be their preferred food [3].

Tribolium castaneum may have originally occurred primarily in rotting logs and under tree bark feeding on plant and animal detritus, and on insect eggs and pupae [4]. These natural and anthropogenic landscapes are characterized by spatially and temporally patchy resources. The ability of this species to find and colonize patches of food and to persist on small amounts of food that accumulate *in refugia* contributes to its pest status [5]. It is found throughout the tropics and is regarded as an important pest of processed cereal products [6] and biscuits [7]. Adult *T. castaneum* are 2-3.4mm in length and red brown to dark brown in colour. The life cycle takes about 28 days under optimum conditions of 35^0C and75% relative humidity. Female copulates many times, lay sticky eggs in the commodity and the number depends on the temperature. Eggs laid could be up to 500. Adults can live for about six months [8].

Maize (*Zea mays* L.) is a member of the grass family (gramineae). It originated from South and Central America. It was introduced to West Africa by the Portuguese in the 10th century. Maize is one of the most important grains in Nigeria, not only on the basis of the number of farmers that engaged in its cultivation, but also in its economic value. Maize is a major important cereal being cultivated in the rainforest and the derived savannah zones of Nigeria. Maize has been in the diet of Nigerians for centuries. It started as a subsistence crop and has gradually become a more important crop. Maize has now risen to a commercial crop on which many Agra-based industries depend for raw materials [7].

Maize is a multipurpose crop because every part of its plant has economic value. The grain, leaves, stalk, tassel and cob can all be used to produce a large variety of food and non-food products. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products, while in low-income countries, it is mainly used for human consumption [8]. Milled flour constitutes the major form in which maize are consumed in Nigeria. However, insect pest courses considerable losses in quantity and quality. Notably among the storage pest is the red-rust flour beetle *T. castaneum* which infest a vast range of common maize products and occur abundantly in milled product and broken grains. The proliferation of the flour mills in the country has stepped-up the quantity of milled products which

could immensity the pest activity of *T. castaneum.* Annual post-harvest damage is estimated to be in order of 25-40% and about 10% loss in stored grains of maize in Nigeria. The present study investigates the performance of *T. castaneum* on yellow and white maize grain flour.

MATERIALS AND METHODS

Culture Methods

Maize grains infested *T. Castaneum* was obtained from the Monday market in Maiduguri, Borno State, Nigeria which served as stock culture. The stock culture was maintained in the department of Biological sciences, University of Maiduguri. A thermo hydrography was used to monitor temperature and relative humidity in the laboratory. Ambient temperature and relative humidity in the laboratory were 33.6±0.21 °C and 35.8±0.13% RH. Culture method described by Buahin and Turaki [9] was employed in which maize grains with adults ready to emerge were sorted into a kilner jar.

Experimental Design and Infestation Procedure

Randomized Complete Block Design was employed in the experiment, in which the first factor treatment comprises of two varieties of maize and different quantities formed the other factor treatment. Yellow and white maize varieties using different quantities of 20, 60 and 100g was used. Five (5) adult *T. castaneum* (3 female and 2 males) were used for the infestation. They were transferred into the center of each Kilnar jar, containing maize flour specified for each treatment. Each of the different quantity were replicated three times. The kilnar jars were covered with fine mesh, to prevent escape of the insects and allow for aeration.

Data Collection and Analysis

Data was collected on the number of larvae, pupae and adults that emerged from different quantities of the two varieties of maize flour used. Analysis of the data was done using Minitab statistical software. The results were expressed as mean ± standard error of mean (SEM). The statistical significance of difference among treatments was done using one-way analysis of variance (ANOVA) followed by Tukey's tests to separate the means and obtain the specific significant differences among the different groups. The values of $P \leq 0.05$ were considered to be significant.

RESULTS

Mean Number of *T. castaneum* larvae in the two varieties of Maize grain flour

The mean number of *T. castaneum* larvae in different quantities of two varieties of maize grain flour at 20, 40, and 60 days after infestation is shown in table 1. The results showed that at 20 days after infestation, there were significant differences in the number of *T. castaneum* larvae in the different quantities of the yellow maize. However, no significant differences observed in the number of *T. castaneum* larvae for the different quantities of the white maize (P<0.05; Table 1).

Table 1: Mean Number of *T. castaneum* larvae in the two varieties of Maize grain flour

	20 DAI		40 DAI		60 DAI	
Treatment	YM	WM	YM	WM	YM	WM
20g	5.3 ± 0.3^a	6.0 ± 0.6^a	19.6 ± 0.3^a	7.7 ± 0.3^a	18.0 ± 0.5^a	9.7 ± 0.3^a
60g	5.7 ± 0.3^a	2.7 ± 0.3^a	8.7 ± 0.3^b	6.7 ± 0.3^a	10.0 ± 0.0^b	28.3 ± 0.3^b
100g	8.7 ± 0.3^b	4.3 ± 0.3^a	6.0 ± 0.0^c	4.3 ± 0.3^b	18.3 ± 0.3^a	8.7 ± 0.3^a

All values are expressed as mean ± SEM. Values followed by the same superscript within the same column are not significantly different (P>0.05 analysed by ANOVA and Tukey's post hoc test). YM = Yellow maize, WM = White maize, DAI = Days after infestation.

However, the results showed that the mean number of *T. castaneum* larvae was statistically different in the different quantities of yellow and white maize after 40 days of infection. At 60 days after infestation, the number of T. castaneum larvae was statistically different from each other in the different concentration of the yellow and white maize (P<0.05; Table 1)

Mean Number of *T. castaneum* pupae in the two varieties of Maize grain flour

The mean number of *T. casteaneum* pupae in the different quantities of the two varieties of maize grain flour are shown in table 2. The mean number of *T. castaneum* pupae in the yellow and while maize grain flour was statistically different from each other at 66 days after infestation (P<0.05; Table 2). However, there were no significant differences in the mean number of *T. castaneum* pupae in the yellow maize at 72 days after infestation. But the mean number of *T. castaneum* pupae were significantly different in the different quantities of white maize grain flour at 72 days after infestation (P<0.05; Table 2). Further, at 75 days after infestation, the number of T. castaneum pupae were significant difference in the different quantities of the two varieties of maize grain flour (P<0.05; Table 2).

Table 2: Mean Number of *T. castaneum* pupae in the two varieties of Maize grain flour

	66 DAI		72 DAI		75 DAI	
Treatment	YM	WM	YM	WM	YM	WM
20g	3.0± 0.0^a	2.6± 0.3^a	0.7± 0.1^a	2.0± 0.0^a	0.0 ± 0.0^a	0.7± 0.0^a
60g	3.0± 0.0^a	0.3± 0.3^b	0.0± 0.0^a	0.0± 0.0^b	0.0± 0.0^b	0.0± 0.0^b
100g	5.2± 0.1^b	2.0± 0.0^a	1.0 ± 1.0^a	1.3 ± 0.3^a	0.3 ± 0.3^a	0.7± 0.0^a

All values are expressed as mean ± SEM. Values followed by the same superscript within the same column are not significantly different (P>0.05 analysed by ANOVA and Tukey's post hoc test). YM = Yellow maize, WM = White maize, DAI = Days after infestation.

Mean Number of *T. castaneum* adults in the two varieties of Maize grain flour

The mean number of *T. castaneum* adults emerged from the different quantities of the two varieties of maize grain flour is presented in table 3. The results at 66 days after infestation showed that there were significantly differences in the mean number of *T. castaneum* adults emerged from the different quantities of yellow and white maize grain flour. Furthermore, there were significant difference in the number of adults *T. castaneum* emerged from the different quantities of yellow and white maize grain flour at 73 days after infestation ($P<0.05$; Table 3). At 75 days after infestation, there were significant differences in the mean number of adults *T. castaneum* emerged from the different quantities of yellow and white maize grain flour.

Table 3: Mean Number of *T. castaneum* adults in the two varieties of Maize grain flour

	66 DAI		72 DAI		75 DAI	
Treatment	YM	WM	YM	WM	YM	WM
20g	18.3 ± 0.3^{a}	7.7 ± 0.7^{a}	17.3 ± 0.3^{a}	7.7 ± 0.7^{a}	17.7 ± 0.9^{a}	8.7 ± 0.3^{a}
60g	8.3 ± 0.3^{b}	24.0 ± 2.0^{b}	13.7 ± 0.9^{b}	24.3 ± 1.7^{b}	13.7 ± 0.9^{b}	24.3 ± 1.2^{b}
100g	12.0 ± 0.5^{c}	7.0 ± 0.5^{a}	17.0 ± 0.5^{a}	7.7 ± 0.7^{a}	17.3 ± 0.3^{a}	0.6 ± 0.6^{a}

All values are expressed as mean ± SEM. Values followed by the same superscript within the same column are not significantly different ($P>0.05$ analysed by ANOVA and Tukey's post hoc test). YM = Yellow maize, WM = White maize, DAI = Days after infestation.

DISCUSSION

The present study demonstrated the susceptibility of *Tribolium castaneum* on the two varieties of maize grain flour. The results showed that the number of *T. castaneum* larvae in the yellow maize outnumbered that of white maize in the different treatment tested at 20, 40 and 60 days after infestation. This clearly showed that the yellow maize is highly susceptible to infestation by *T. castaneum* larvae than the white maize.

T. castaneum have been reported to be very prolific and has the ability to produce millions of progeny within a life span [10]. A major factor influencing the susceptibility and development of *T. castaneum* is the quality of the diet [11]. According to Booth et al. [12] development of *Tribolium* sp. takes about 20 days on a good qualitative diet with other factors being optimal. However, when the diet presented for development is of less quality, developmental period takes longer time and it can be as long as 45 days or more [10]. In the present study, a period of 75 days recorded for *T. castaneum* on the white and yellow maize grain flour.

The moisture content of any food is an index of its water activity and is used as a measure of stability and the susceptibility to microbial contamination (Okaraonye and Ikewuchi, 2009). Makanjuola *et al*.[13] reported that the low moisture content of rice was a likely factor that conferred susceptibility to rice cultivars in storage. Carbohydrates also serve as a source of energy and may be converted to fat for storage and two amino acids (Chapman, 1980). The number of adults reduced as the development period progressed because there was no replenishment of the food media. Chapman [14] also reported that *Tribolium*uses starch, alcohol, trisaccharides, disaccharides and monosaccharides.

Much of the work that has been reported on the rearing of *T. castaneum* in the laboratory has been a mixture of diet and oaths resulting in a shorter developmental period [10]. It is also possible that these substrates presented very good qualitative nutrients for the development of *T. castaneum*. In the present study, *T. castaneum* developed in maize grain flour and hence a lot of adults were recorded suggesting very high susceptibility. The quality of the food presented in this case maize grain flour is a factor in the development in *T. castaneum* and ultimately their susceptibility to the store pest.

CONCLUSION

Purchasing of processed maize grain flour does not stop the product from being infested by the storage pest. Cross infestation of products have been reported in *T. castaneum* [15]. *T. castaneum* is a colonizing species with a long life span and long reproductive period [16]. Therefore, the preparation and storage of ready-made maize grain flour should not be emphasized among household especially in the countries where the storage facilities of *T. castaneum* are not readily available.

Conflict of interest: NIL

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