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Susceptibility of Three Groundnut Products to Infestation by *Tribolium castaneum*

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Abstract The susceptibility of groundnut products to *Tribolium castaneum* was evaluated at ambient temperature of 28± 2℃ and 78+2% relative humidity in the laboratory for 5 weeks. 50g of each sample was infested with 5 newly emerged. *T. castaneum*. The highest mortality of 46.6% was recorded in burger sample 40% was recorded in groundnut cake while the lowest mortality of 6.6% of *T. castaneum* was recorded in cookies after two weeks of infestation. The percentage of moisture, ash, fibre, fat, carbohydrate and protein increased in both groundnut cake and burger while it decreased in cookies sample after five weeks of infestation. The result of mortality obtained in burger and groundnut cake samples significantly differs from the result obtained in cookies sample. These shows that cookies is the most susceptible of the three groundnut products to infestation by *T. castaneum*, followed by groundnut cake, while burger being the least susceptible.

Keywords Susceptibility, *Tribolium castaneum*, Mortality, Infestation, Moisture, Ambient

1. Introduction

Insects attack various products when stored as a result of poor method of production, packaging and storage. There are several cases of insect infestation in stored products such as biscuit infested with *Tribolium castaneum*, Spaghetti infested with *Sitophilus sp*, Semovita and Wheat flour infested with *Tribolium castaneum* on the removal of the polythene wrapper used for storing it. The infestation of these products in storage is as a result of inadequate processing resulting from improper sterilization of equipment used for production and packaging of materials which supports development of eggs to adults. Also there are several cases in which the infested products are consumed by the consumer unknowingly which have led to serious health problems.

The red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenbebrionidae) is a major pest of groundnut and its products and can be a major pest in anthropogenic structures used for the processing and storage of groundnut products (e.g flour mills, biscuit industry warehouses and retail stores). *Tribolium castaneum* is found throughout the topics and is regarded as a major pest of shelled groundnut (Odeyemi and Daramola, 2000), an important pest of processed cereal products (Odeyemi *et al*. 2001) and biscuits (Odeyemi *et al*. 2005). Adult *T. castaneum* are 2-3.4mm in length and red brown to dark brown in colour. Life cycle takes about 28 days under optimum conditions of 35^0C and 75% 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.

The role of the red-flour beetle in the deterioration of shelled groundnuts has been assessed in terms of loss in weight which is about 4.5% and loss in germination, about 73%, the free fatty acid content of the groundnut oil increases, resulting in additional deterioration of quality (Apert, 1987). *T. castaneum* is fond of wheat flour in which it digs tunnels, imparts a brownish tinge and pungent smell to the flour.

Groundnut *Arachis hypogea* belongs to the division papilionaceae of the family leguminosae. The raw nuts can be used as roasted groundnut, baked groundnut, groundnut butter paste, fried groundnut balls and groundnut stew (Susan and Anne, 1988). The groundnut cake (Kulikuli) is usually fried in oil and is used as delicious snacks or as food supplement in Nigeria. Groundnut is almost invariably stored in form of unshelled nuts. Drying and damage by pest like rodents are the principal causes of losses during storage of groundnuts (Salunkhe and Desai, 1986). In Nigeria, groundnut of 7% moisture contents are stored in jute bags pending transportation to market. The nuts can be stored in the shell or after being shelled. As food, groundnut is nutrient dense since it is very high in energy due to its high fat and protein content. The nutritive value of groundnut seems to be limited only by its low content of lysine and methionine and it is marginal in tryptophan and theonine contents (Oyenuga, 1967). The nut as well as the oil contains appreciable quantities of tocopherols. The proximate

composition of raw groundnut, boiled groundnut, groundnut cracker and groundnut spread chocolate flavoured has been investigated (Anonymous, 1968).

This study was designed to investigate the level of susceptibility of groundnut products to red-rust beetle, *Tribolium castaneum*, assess the effect of three different groundnut products on Adult *T. castaneum* mortality and evaluate the change in nutrient composition of the groundnut products during infestation with *T castaneum*.

2. Materials and Methods

2.1. Preparation of Materials

2.1.1. Insect culture

A survey was conducted in different retail shops in Akure market for infested raw groundnut. The major insect pest found in groundnut was *Tribolium castaneum*. The stock culture of *T. castaneum* used for experiment was prepared using Kilner Jar in which 200 of whole, uninfected heat sterilized wheat flour was placed. Adult castaneum were introduced an covered with muslin cloth held in place with perforated cover to prevent the exit of beetles and a low ventilation under open laboratory conditions of 28±2%RH. Insect culture was maintained by continuously replenishing the devoured and infested flour with uninfected ones. The jar was placed inside a wire mesh cage and the newly-emerged insects were used for subsequent experiment.

2.1.2. Groundnut Products

Groundnut products including groundnut cake, cookies and burger processed from raw groundnuts were obtained from Oba market in Akure, Ondo State. The products were disinfected in the freezer for 72 hours in polyethylene wraps and then air-dried after removal. The moisture content of the different products was determined before and after the experiment with the aid of moisture analyser. The products were used for experimental tests.

2.2. Experimental Tests

Fifty grammes of each of groundnut cake, cookies and burgher were weighed into a plastic transparent cup (200ml) covered with muslin cloth held tightly in a place with perforated cloth to prevent exit of the insects each sample was replicated three times and the control was set up for each sample. Five adults of newly emerged insects were introduced into each cup and placed inside a wire net cage. The set up was left under ambient conditions of 28±2℃ and 78±2% relative humidity in the laboratory for five weeks.

2.2.1. Susceptibility Test

Larva emergence was monitored and Susceptibility Index was calculated for groundnut cake, cookies and burger using the method of Howe (1971).

Index of susceptibility $\frac{Log\frac{n}{N}x\ 100}{D}$

Where n = number of F1 adults

N = number of adults introduced

D = Time from oviposition to emergence

Index of Susceptibility was recorded and compared among the different groundnut products.

2.2.2. Assessment of Adult Mortality

Five adults of newly emerged *T. castaneum* adults were introduced into each cup containing samples in three replicates. Observations were made at ambient conditions of 28±2^{0}C and 78±2% relative humidity in the laboratory for five weeks. Insects counted were presumed to be dead if they did not respond when probed at the abdomen with a pin. Mortality was recorded in percentage based on number of dead insects out of five adults introduced multiplied by 100. The percentage mean value for each three replicates was recorded as mortality percentage. The mortality of the insects introduced was monitored on the 2nd, 3rd, 4th and 5th weeks of infestation.

2.2.3. Evaluation of Proximate Composition of Test Samples

The proximate composition of the groundnut products was evaluated before and after they were infested with *T. castaneum*. This was to determine to observe the effect of infestation on the percentage moisture, proteins, ash, fibre, fat content and carbohydrates in the products. Proximate analysis was carried out using the methods of Association of Official Analytical Chemist (Anonymous, 1990). Determination of proximate compositions of groundnut cake, burger and cookies were carried out in the laboratories of Food Science and Technology of the Federal University of Technology, Akure. The various products were ground into fine powder and packed in an air-tight polythene bags labeled for analysis. The moisture content, ash, crude fibre and crude protein were determine using official methods(AOAC,1990). Each sample of 100g was weighed in hot air oven at 105^{o}C to a constant weight. The difference in weight was recorded as the moisture content. 3g of each sample was placed in a pre-weighed porcelain crucible and ignited in an ash furnace maintained at 600^{o}C. The ash content was determined as soon as white ash was obtained and a constant weight was maintained. The nitrogen content was determined by Micro-Kjeldahl method and multiplied by 6.25 to estimate the crude protein content. Carbohydrate content was determined by difference between 100 and the summation of other values as described by AOAC, 1990.

3. Results

3.1. Assessment of Product Susceptibility

After 5 weeks of infestation, the groundnut cake was observed to have few holes tunneled by *T. castaneum*, the burger sample had more holes tunneled by the insects while the cookies was degraded into small particles. Observation showed that only the Cookies had larval stages and all died by the 4th and 5th week. Thus no insect emerged as adult from the products throughout the experimental period. The Susceptibility Index was Zero for each product (Table 1).

Table 1. Larva emergence and Susceptibility Index of Three Groundnut Products

Groundnut Product Samples	Number of Larvae (%)				
	2weeks	3weeks	4weeks	5weeks	Susceptibility
Cookies	0	0	2	3	0
Cake	0	0	0	0	0
Burger	0	0	0	0	0

3.2. Adult Mortality of *Tribolium castaneum*

The percentage mortality of *T. castaneum* varied with groundnut products is shown in Table 2. At two weeks of infestation 40% adult mortality was recorded in cookies, 33.40% in cakes while 46.60% was recorded in Burger. At the end of the third week, adult mortality was 20% in cookies, 40% in cake and 33.40% in Burger. Adult mortality in the fourth and fifth weeks showed that there was no significant difference in mortality recorded from cookies and cakes but significant difference occurred in adult mortality from burgers.

Table 2. Mortality of Adult *T. castaneum* in three Groundnut Products at 28± 2^{0}C and 78± 2^{0}C

Groundnut Product Samples	% Adult mortality (Weeks) +S.E			
	2weeks	3weeks	4weeks	5weeks
Cookies	40.00±0ab	20.00±2.94c	6.60±1.6c	13.40±2.68b
Cake	33.40±1.67b	40.00±2.32a	13.40±2.16b	13.40±0.62b
Burger	46.60±1.82a	33.40±2.46b	20.00±2.07a	0.00±0a

3.3. Change in moisture Content

Observations showed that the groundnut products absorbed moisture from the environment which resulted in moisture gain (Table 3). The percentage moisture content gained was 4.49 in groundnut cake, 6.53 in cookies and 4.55 in Burger.

Table 3. Moisture Content of Groundnut Product Samples used in experiment.

Groundnut Product Samples	% Moisture Content		
	Initial	Final	Gain
Cookies	1.30	7.83	6.53
Cake	1.18	5.67	4.49
Burger	1.26	5.81	4.55

3.4. Proximate Composition of Groundnut Products

Results derived from the evaluation of Cookies, Cake and Burger from initial to the final evaluation showed that there was increase in the percentage fibre and fat composition of the Cookies with decrease in the fibre, fat, protein and carbohydrate contents after infestation. The Cake and Burger samples had an increase in the moisture, ash, fibre, fat and protein composition with decrease in the carbohydrate composition after infestation. Figures 1, 2 & 3 revealed the differences in the proximate composition of the groundnut products.

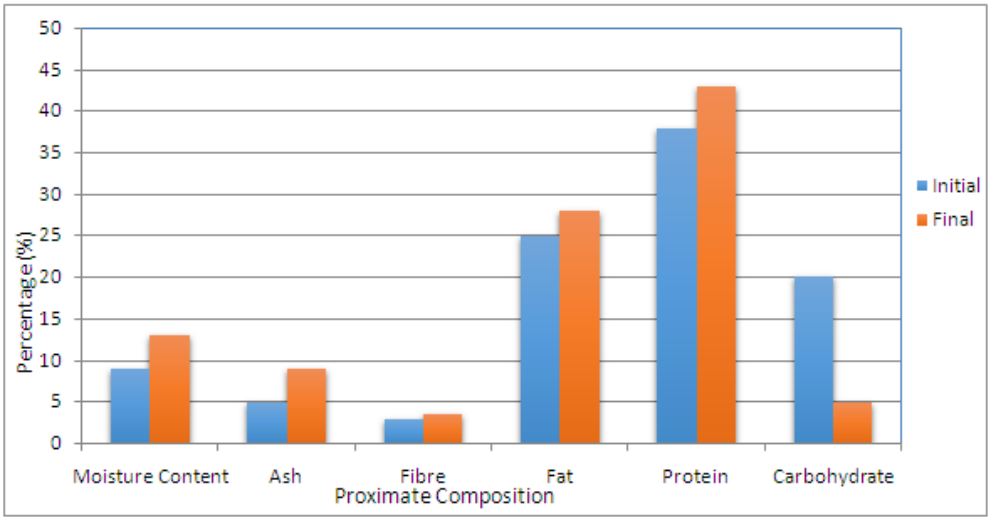

Figure 1. Change in proximate composition of Groundnut cake after infestation by *Tribolium castaneum*

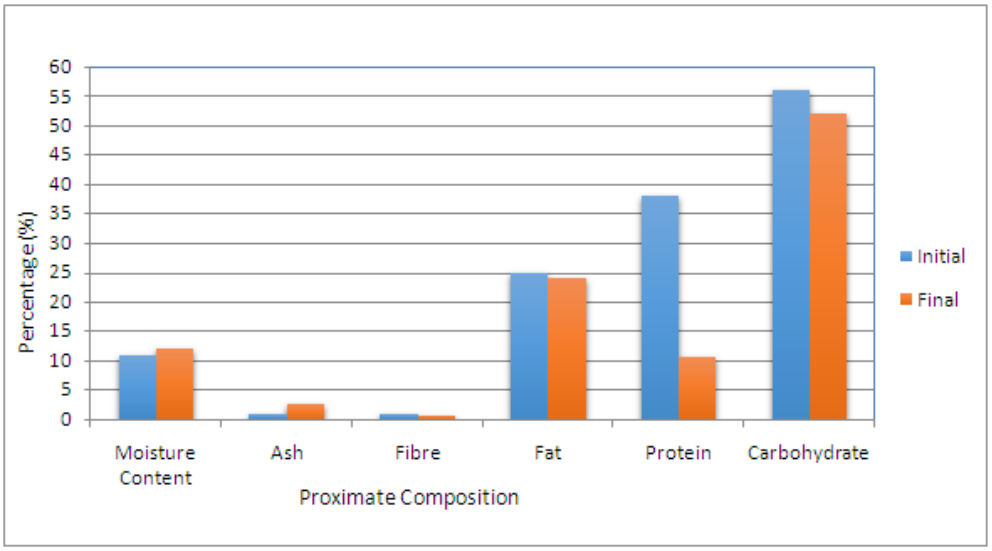

Figure 2. Change in proximate composition of Cookies after infestation by *Tribolium castaneum*

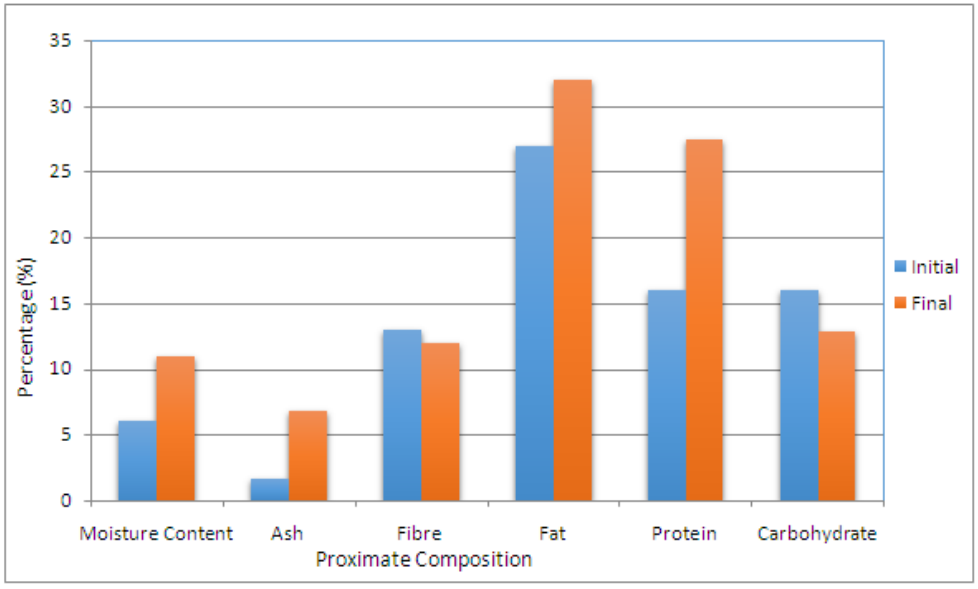

Figure 3. Change in proximate composition of Burger after infestation by *Tribolium castaneum*

4. Discussion

Findings from the study showed that in the groundnut products tested, the differences in mortality of *T. castaneum* in each of the infested products revealed the level of susceptibility of the products infestation by the beetles. There was no adult emergence in the Burger, Cake and Cookies throughout the test period while only larval activity was observed in the Cookies in the fourth and fifth week after which they died. This lack of adult emergence was as a result of the inability to invade and feed on the products (Ogundipe, 2004). Since the beetles cannot survive without food, they die due to starvation. The penetration of Burger and Cakes was more difficult than Cookies for *T. castaneum* and all the products did not support development of the insects and thus the Susceptibility Index was zero for each of the products.

The groundnut product samples used in this study are made with inorganic salts such as sodium chloride and sodium bicarbonate. These chemicals have inhibitory effect on the development of *T. castaneum* even at low concentration of 0.01% (Majunder, 1970). The groundnut products are processed with vegetable oil into hard dry products. According to Odeyemi (1991), Odeyemi and Daramola (2000), oil has inhibitory effects on pests of stored products. This probably accounts for the high resistance of the products to insect attack and high mortality of *T. castaneum* adults after two weeks of infestation.

The moisture content of all the samples increased due to the absorption of moisture from the environment. The products are processed from milled groundnut mixed with either salt or sugar which are hydroscopic in nature. The Cookies absorbed more moisture than Burger and Cake. This makes it softer than others and therefore prone to insect attack than other products. The insects were able to penetrate easily, degrade it to particles and feed on it but could not develop in it.

From the results of analysis of the proximate composition of the products, the decrease in the percentage of fibre, fat, carbohydrates and proteins of Cookies is as a result of the feeding activities of the insects on the samples while the increase in percentage composition of ash content could be as a result of presence of dead insect parts which constitute the inorganic residue that added to percentage increase. In the Burger and Cake samples, the percentages of fibre, fat, carbohydrates, proteins and ash were not affected which is evidence that *T. castaneum* does not thrive or feed on the samples. Figures 1 and 3 were plotted using the raw data. However statistical analysis showed that there was no significant difference at $P > 0.05$ in the percentages of fibres, fat, carbohydrates, proteins and ash. This further explains the inability of *T. castaneum* to thrive or feed on the samples.

Groundnut cake, burger and cookies are sold without packaging materials to consumers. The research work focused on susceptibility of the three groundnut products to infestation by *T. castaneum*. The study revealed that susceptibility was more in Cookies as shown: Cookies> Burger > Groundnut cake. The ingredients used for local products have inhibitory effect on the development of insects even at low concentration of 0.01% (Majunder, 1970). The groundnut products are processed with vegetable oil into hard dry products. According to Odeyemi (1991), Odeyemi and Daramola (2000), oil has inhibitory effects on most pests of stored products. This probably accounts for the resistance of the products to insect attack and mortality of *T. castaneum* adults after two weeks of infestation.)

The environmental temperature throughout the experiment was kept at $28 \pm 2^{o}C$ which was still normal for the activity of insect pest. At temperatures below $20^{o}C$, development of the individual organism is very slow, mortality is relatively high and the activity of individual organism is also slow (Odeyemi and Daramola, 2000). The study focused on infestation at temperature range of $28 \pm 2^{o}C$ and $78 \pm 2\%$ relative humidity in the laboratory.

In summary, data from the mortality of adult *T. castaneum* revealed that the three groundnut products were susceptible to attack by the beetle although none developed to adult stage. Also the proximate composition of the Burger and Cake products after infestation for five weeks were affected in terms of increase in ash content. To an average consumer, the presence of any insect parts in the product renders it unfit for human consumption. Thus it is important that groundnut products should be kept using adequate packaging and low environmental temperatures so as to prevent infestation.

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