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Proximate Composition of Ten Types of Biscuits and their Susceptibility to *Tribolium castaneum* Herbst (Tenebrionidae: Bostrichidae) in Nigeria

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Abstract
Ten biscuit types namely Tea, Digestive, Butter Scotch, Cream Cracker, Coaster, Fibre Plus, Shapes, Gin-Gin, Cabin and Crunchy were examined for their proximate composition and susceptibility to *Tribolium castaneum* Herbst. The biscuit samples had proximate composition ranging from 4.9 - 5.5% moisture content, 8.6 - 12.0% crude protein, 3.4 – 4.8% ash, 15.4 – 24.0% fat, and 55.4 – 64.0% carbohydrate and 2.09 - 2.81% crude fibre. Assessment of the biscuit types for susceptibility test was based on percentage adult mortality, mean number of adult emergence and percentage weight loss. Results showed that there were significant differences ($P<0.05$) in the parameters studied. Fibre Plus biscuit had significantly ($p<0.05$) lower mortality of *T. castaneum* adults, higher level of adult emergence and the most weight loss of 53.0% as a result of insect infestation within 120 days after infestation. Results showed that the biscuits were susceptible to *T. castaneum* infestation particularly if not properly packaged or preserved. Apart from proper preservation, biscuits should be supplemented with protein-rich diets to meet the nutritional needs of consumers.
Keywords: Composition, emergence, mortality, susceptibility, weight loss, *T. castaneum*

1. Introduction

In Nigeria, biscuits constitute a popular cereal food consumed by the young and the old. Some of the reasons for such wide popularity are low cost compared with other processed foods, good nutritional quality and availability in different forms, varied taste and longer shelf-life (Hussein *et al.,* 2011).They are ready to eat, convenient and inexpensive food products, containing digestive and dietary principles of vital importance (Kulkarni, 1997). Biscuits are made from wheat flour with the addition of other ingredients such as salt, fat, sugar, baking powder, milk, and flavouring agents. Neil (2002) reported that wheat (*Triticum* spp.) grain is a staple food used to make flour for leavened, flat and steamed breads, biscuits, cookies, cakes, breakfast cereal, pasta, noodles, couscous and for fermentation to make beer, other alcoholic beverages. Biscuits are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in the oven (Olaoye *et al*., 2007).

Changes in the feeding habits of Nigerians have been quite dynamic over the years, and trend in economic growth, education, affluence and urbanization are some of the factors which influence what Nigerians eat (Edwards, 1984). There is general increase in consumption of processed and convenience foods (bread, rice, semovita, biscuits, cakes and pastries) and the need to save time and conserve fuel has become an important factor in the decline in the use of foods which cannot be consumed with minimal processing, especially roots and tubers (Oti, 2007).

Pest infestation seriously affects the cereals and cereal products preservation and storage. For example, biscuits which are processed products of wheat flour are damaged by the biscuit beetle, *Stegobium paniceum* L. and rust red flour beetle, *Tribolium castaneum* Herbst. These insects can enter any food package attacking milled products and causing economic losses. Odeyemi (2001) reported that processed cereals and pulses are attacked mainly by secondary insect pests. There have been little published scientific researches into the susceptibility of biscuits to stored product insects, particularly *T. castaneum*, leaving the problem poorly understood and consumers or grocers disadvantaged on necessary information. The objectives of this study were therefore, to determine the proximate composition of some selected biscuit types being consumed by Nigerians and evaluate their relative susceptibility to rust red flour beetle, *T. castaneum*.

2. Materials and Methods

2.1 Insect culture

Initial stock of adults of *T. castaneum* was obtained from the laboratory colony in the insectary of Nigerian Stored Products Research Institute (NSPRI), Ilorin, Nigeria. The insects were maintained in fresh ground biscuits kept in a 500 ml Kilner jar covered with a light textured material to allow aeration and prevent escape of the insects. Newly emerged adults were picked with the aid of a pooter for use in the course of the experiment.

2.2 Collection and preparation of biscuits

Good quality of ten different biscuits viz: Tea, Digestive, Butter Scotch, Cream Cracker, Coaster, Fibre Plus, Shapes, Gin-Gin, Cabin and Crunchy without any damage to the package were purchased from a supermarket in Ilorin, Nigeria.

2.3 Experimental procedure

Each biscuit sample weighing 100 g was sterilized at 40^0 C for 30 min, cooled to room temperature and placed in a sterilized transparent container. The containers were arranged on a laboratory desk and 3 freshly emerged adults of *T. castaneum* were introduced into each container. The flat surface of the cover to the transparent plastic containers was removed leaving the round edges to hold the light textured material firmly to the plastic. This prevented escape of the insects and allowed aeration. All the 30 units were arranged in completely randomized design (CRD) replicated three times and kept in a constructed box so as to ward off rodents.

2.4 Data collection

Each biscuit sample was examined for *T. castaneum* adult mortality, adult emergence and biscuit weight loss. Counts of adult mortality were taken and recorded at 2, 4, 6 and 8 days after infestation (DAI). At 10 DAI, live and dead beetles were removed from the experimental set up and disposed to avoid overlap with new emergence of beetles. The emerged adults were sieved from each biscuit sample using a sieve of 0.1 mm mesh and counted and recorded at 36, 38, 40, 42 and 44 DAI. Thereafter, the biscuit samples were reweighed 50, 90 and 120 DAI and weight loss expressed as a percentage of initial weight.

Percentage weight loss of the biscuits to *T. castaneum* was assessed by the amount of biscuit powder consumed by the beetle. The quantity consumed was determined as the difference between the weight of biscuit before and after infestation and percent weight loss was computed as:

$$\frac{\text{Weight of biscuit powder consumed}}{\text{Weight of biscuit powder supplied}} \times 100$$

2.5 Chemical analysis: Determination of the proximate composition of the biscuits was carried out in the laboratories of Chemistry Department, University of Ilorin, Nigeria. The various biscuits were ground into fine powder and packaged in air-tight polythene bags labeled for analysis. The moisture content, ash, crude fire, and crude protein contents of the biscuits were determined using official methods (AOAC, 1990). Biscuit samples of 100 g were weighed in hot air oven at 105^0 C to a constant weight. The difference in weight was recorded as the moisture content. Three gram of the biscuit samples was placed in a pre-weighed porcelain crucible and ignited in an ashing furnace maintained at 600^0 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 also determined by difference as described by AOAC, 1990.

2.6 Data analysis

Data were statistically analyzed using one-way analysis of variance (ANOVA) and Duncan`s new multiple range test at p=0.05 was used to separate the values of the proximate

composition. Tukey test at p=0.05 was used to separate the means of other parameters that examined the susceptibility of the biscuits to the beetle.

3.0 Results and Discussion

The mean numbers of adult mortality and emergence of *T. castaneum* in the biscuits tested for susceptibility are presented in Table 1. There was no mortality in Butter Scotch, Coaster, Shapes, Gin-Gin and Crunchy biscuits which was significantly ($p<0.05$) different from the percentage mortality recorded in Cream Cracker biscuit at 6 days after infestation (DAI). During the same period of exposure of *T. castaneum* adults to fresh ground biscuits, maximum adult mortality of 33.3% was recorded on Cream Cracker biscuit powder. Digestive biscuit had 100% mortality of *T. castaneum* adults which differed significantly from the other biscuits at 8 DAI. Cream Cracker biscuit which had the 2nd highest percentage mortality (77.7%) was significantly ($p<0.05$) different from the mortality recorded in Coaster, Shapes and Gin-Gin biscuits at 8 DAI. Therefore, adult insect mortality was significantly higher in the Digestive and Cream Cracker biscuits than other biscuits at 8 DAI. Significant differences in adult mortality showed varying degrees of susceptibility of the biscuits to *T. castaneum* and this may be attributed to differences in the chemical composition of the biscuits.

Analysis of variance showed significant ($p<0.05$) differences among the stored biscuits with respect to *T. castaneum* adult emergence. In 38 DAI, Fibre Plus biscuit had the highest level of the beetle infestation following mean emergence of 6.3 and it differed significantly from other biscuits. In 40 DAI, Fibre Plus biscuit had the highest mean emergence of 16.3 which differed significantly from other biscuits excluding Crunchy biscuit with 7.3. Fibre Plus biscuit had significantly higher level of infestation following mean emergence of 67.3 compared to all other biscuits in 44 DAI. The number of beetles that emerged from the most susceptible biscuit (Fibre Plus) was significantly ($p<0.05$) higher than those of the other biscuits. Fibre Plus biscuit was observed to have consistently sustained *T. castaneum* emergence and infestation. It showed significant increase in the mean numbers of emerged adults with increase in period of exposure. It has long been known that rust red flour beetle is a secondary insect pest attracted to wheat flour and other stored products previously damaged by primary insect pests.

The biscuit powders significantly increased the rate of *T. castaneum* adult survival as evidenced by increased adult emergence. The high proportion of the beetle was probably influenced by large emergence in Fibre Plus biscuit. However, emergence of adults in all the biscuits tested showed that they favoured the development of *T. castaneum* probably because the nutritional components associated with the biscuits provide sufficient nutrients for feeding and place for oviposition for sustained infestation to take place. It is therefore revealing that *T. castaneum* causes damage to biscuits in storage particularly if the processed food is exposed to infestation.

The results in this study showed significantly greater impact of the beetle on the Fibre Plus biscuit powders than other biscuits.

Table 2 shows the percentage weight loss of the biscuits. Significant differences ($p<0.05$) in weight loss were observed sequel to *T. castaneum* feeding in the ten types of biscuits in 50 and 90 DAI. Digestive biscuit recorded the least weight loss ranging from 29.33 to 31.67% in three months storage period. The percentage weight loss of the biscuits ranged from 29.33 to 50.33%; 29.67 to 51.33%; 31.67 to 53% in 50, 90 and 120 DAI respectively. Significant differences occurred among the biscuit weight losses recorded suggestive of the feeding impact of the insect on the different biscuits. There was however, no significant difference ($P>0.05$) in the weight losses recorded in 120 DAI. Fibre Plus biscuit was the most susceptible being the most consumed by the insect with 53% weight loss in 120 DAI. Anene (2001) reported that some nutritional and related factors may influence feeding behaviour of insects. It was observed that the insect build up on the preferred biscuit type, and the degree of loss was dictated by the population of the insect.

Table 3 shows the results of the proximate composition of ten different biscuits popularly consumed in Nigeria. The moisture content of the biscuits ranged between 4.9 and 5.5% with Digestive biscuit having the highest value and Crunch biscuit the lowest. Analysis of variance shows that there was significant difference ($P<0.05$) between the ten biscuit samples. Obasi *et al.* (2012) associated the slight difference in moisture content to the level of environmental factors, experimental methods of analysis and the types of biscuit. The low moisture content of

the biscuits renders them less perishable thus increasing their shelf-life and makes their transportation inexpensive. Biscuits differ from other baked cereal products such as bread and cakes by having low moisture content. Bread typically has 35-45% moisture, cake, 15-30% and biscuits, 1-5% moisture (unpublished data). The low moisture content ensures that biscuits are generally free from microbiological spoilage and have a long shelf life if they are protected from absorbing moisture from damp surroundings or atmosphere. The implication of reduced moisture content is that there is reduction in water activity, thereby inhibiting the continuous activity of the fermenting organisms (Platt, 1983).

The crude protein content of the biscuits ranged between 8.6 g and 12.0 g with Tea biscuit having the highest value and Cabin biscuit the lowest. Ogunlakin *et al*., 2012 had reported that losses of protein depend on the intensity of heat and temperature. The low protein content of these conventional biscuits shows that their consumption alone could cause protein-deficiency condition such as kwashiorkor.

The ash content of the biscuits which is the total mineral content, present in the samples ranged between 3.4 g and 4.8 g with Tea biscuit having the highest value and Fibre Plus biscuit having the lowest value. The mineral content of these confectionery biscuits is generally low suggesting the need for supplementary diets. Since the ash content is to some extent indicative of mineral content (Jossylyn, 1973), it is expected that Tea biscuit with higher ash content would have higher mineral content. The Tea biscuit had high protein and ash contents while Cabin biscuit and Fibre Plus biscuit had low protein and ash content respectively. Significant difference was observed in the chemical composition of cookies (Chinma and Gernah, 2007). Most of these foods are however poor sources of protein and such contribute to poor nutritional quality (Akpapunam and Darbe, 1994; Aloba, 2001). This informs the suggestion that biscuits should be fortified with vitamins and minerals (Elizabeth *et al*., 1999) and enriched with other protein sources such as oil seeds and legumes (Obasi *et al.,* 2012).

The fat content of the biscuits was within the range of 15.4 g and 24.0 g with Butter Scotch biscuit having the highest value and Gin-Gin biscuit the lowest value. Ogunlakin *et al.,* 2012 observed that low content of fat enhanced the storage life of biscuits due to the lowered chance of rancid flour development. On the whole, the crude fat content of the biscuits is high, creating problem of rancidity in storage. Of the main classes of foodstuff, lipids are probably the most important source of derived flavours because they play significant role as precursors of volatile flavours (Omololu, 1986).

Analysis of variance showed significant ($p<0.05$) differences in acidity (pH) of the biscuits with Fibre Plus and Cream Cracker biscuits being less acidic (Table 3). The pH value of the different biscuits ranged between 6.3 and 6.6 with Fibre Plus and Cream cracker biscuits having the highest value and Digestive and Gin-Gin biscuits having the lowest value. Digestive and Gin-Gin biscuits had highest acidity. The lowest biscuit acidity (highest pH) was obtained from Fibre Plus and Cream Cracker biscuits. Their value was significantly lower than those of other biscuits.

The carbohydrate content of the biscuits ranged between 55.4 g and 64.0 g with Coaster biscuit having the highest value and Cream cracker biscuit the lowest. Analysis of variance shows that there was significant difference ($P<0.05$) between the ten biscuit samples. The high carbohydrate content may have explained the high sugar content in the biscuits which could be responsible for browning reactions leading to intense colour during baking.

The crude fibre content of the biscuits was within the range of 2.1 g and 2.8 g with Fibre Plus biscuit having the highest value and Shapes biscuit the lowest value. Crude fibre shows the cellulose, hemicelluloses and lignin contents of the biscuits. This study shows that biscuits are nutrient-deficient sources of protein, poor sources of essential minerals and dietary fibre.

Table 1. Survival of *Tribolium castaneum* in some selected biscuits consumed in Nigeria

	%	Adult	Mortality	(DAI)	Mean	No.	Adult	Emergence	(DAI)
Types of biscuit	**2**	**4**	**6**	**8**	**36**	**38**	**40**	**42**	**44**
Tea	0.0[a]	11.1[a]	11.1[ab]	22.2[b]	0.0[a]	0.0[b]	1.3[b]	5.0[a]	0.0[c]
Digestive	11.1[a]	11.1[a]	22.2[ab]	100.0[a]	0.3[a]	0.0[b]	2.0[b]	10.0[a]	7.0[c]
ButterScotch	0.0[a]	0.0[a]	0.0[b]	33.3[b]	0.3[a]	0.0[b]	1.7[b]	5.0[a]	0.0[c]
C/cracker	22.2[a]	22.2[a]	33.3[a]	77.7[ab]	0.0[a]	0.0[b]	0.0[b]	0.3[b]	0.0[c]
Coaster	0.0[a]	0.0[a]	0.0[b]	11.1[c]	0.0[a]	0.0[b]	0.7[b]	0.7[b]	0.0[c]
Fibre Plus	0.0[a]	11.1[a]	11.1[ab]	22.2[b]	0.0[a]	6.3[a]	16.3[a]	23.0[a]	67.3[a]
Shapes	0.0[a]	0.0[a]	0.0[b]	11.1[c]	0.0[a]	0.0[b]	0.3[b]	0.3[b]	0.0[c]
Gin-Gin	0.0[a]	0.0[a]	0.0[b]	11.1[c]	0.0[a]	1.0[b]	1.7[b]	27.0[a]	19.6[b]
Cabin	11.1[a]	22.2[a]	22.2[ab]	33.3[bc]	0.0[a]	0.0[b]	0.3[b]	0.3[b]	0.0[c]
Crunchy	0.0[a]	0.0[a]	0.0[b]	22.2[bc]	0.0[a]	0.0[b]	7.3[ab]	7.7[a]	0.0[c]
SE±	**0.22**	**0.24**	**0.19**	**0.37**	**0.15**	**1.00**	**2.35**	**5.24**	**11.27**

Values in the same column with the same superscript(s) are not significantly different at p=0.05 using Tukey test

DAI=Days after infestation

Table 2. Percentage weight loss of selected biscuit samples due to *Tribolium castaneum* infestation

Types of biscuit	**Weight loss 50 DAI**	**Weight loss 90 DAI**	**Weight loss 120 DAI**
Shapes	32.33^{bc}	34.00^{bc}	35.00^{a}
Tea	33.67^{bc}	39.67^{abc}	47.67^{a}
Digestive	29.33^{b}	29.67^{b}	31.67^{a}
Gin Gin	30.33^{b}	33.00^{b}	44.67^{a}
Crunchy	45.67^{ac}	47.67^{ac}	50.33^{a}
Butter Scotch	38.00^{abc}	39.67^{abc}	41.67^{a}
Fibre Plus	50.33^{a}	51.33^{a}	53.00^{a}
Cabin	49.67^{a}	50.67^{a}	52.67^{a}
Coaster	46.00^{a}	47.33^{ac}	48.33^{a}
Cream Cracker	46.47^{a}	47.67^{abc}	47.67^{a}
S.E±	**2.26**	**2.88**	**5.43**

Values in the same column with the same superscript(s) are not significantly different at p=0.05 using Tukey test

WAI=Weeks after infestation

Table 3. Proximate composition of different selected types of biscuits consumed in Nigeria

Biscuit type	MC	CP	ASH	FAT	pH	CHO	CF
Shapes	5.3±0.64	9.8±0.38	4.7±0.15	15.6±0.78	6.4±0.06	62.5±1.51	2.1±0.05
Tea	5.1±9.75	12.0±1.45	4.8±0.10	17.2±1.65	6.5±0.10	58.5±1.22	2.4±0.33
Digestive	5.5±0.36	11.6±0.40	4.4±0.36	17.4±0.73	6.3±0.15	58.7±0.49	2.3±0.51
Gin Gin	5.4±0.20	9.3±0.86	4.7±0.05	15.4±1.21	6.3±0.10	62.7±1.69	2.5±0.24
Crunchy	4.9±0.72	11.0±0.47	3.9±0.31	18.2±1.11	6.5±0.10	56.4±4.85	2.6±0.14
Butter Scotch	5.0±0.71	10.9±0.79	4.8±0.15	24.0±2.43	6.5±0.26	52.8±2.29	2.2±0.18
Fibre Plus	5.2±0.20	10.6±0.37	3.4±0.05	19.2±1.07	6.6±0.26	58.9±1.08	2.8±0.53
Cabin	5.4±0.40	8.6±0.54	4.5±0.25	16.2±0.63	6.5±0.12	63.1±0.42	2.2±0.15
Coaster	5.0±0.87	8.9±0.45	4.3±0.30	15.6±1.04	6.5±0.35	64.0±1.46	2.4±0.24
Cream Cracker	5.3±0.30	10.3±0.90	3.6±0.06	22.5±2.00	6.6±0.15	55.4±1.1	2.7±0.49
Significance	**0.059**	**0.326**	**0.097**	**0.419**	**0.105**	**0.030**	**0.008**

MC=Moisture content; CP=Crude protein; CHO=Carbohydrate; CF= Crude fibre

Values are expressed in g/100g samples and are mean±SD of triplicate determinations

4.0 Conclusion

From this work, it is established that biscuits contain high quality carbohydrate which does not vary remarkably with different biscuits. Biscuits should however, be supplemented with protein and mineral-rich diets to reduce nutritional ailments. It will also lead to diversification of food use of such diets/crops in the confectionery industry. It is therefore recommended for human consumption after proper preservation. Precaution has to be taken to avoid exposing the package to insect infestation. This recommendation is useful in reducing biscuit damage in storage.

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