Acta Scientific Nutritional Health

Volume 2 Issue 1 January 2018

Research Article

Production and Evaluation of the Physico-Chemical and Sensory Properties of Biscuit from Wheat and Cricket Flours

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Received: September 28, 2017; **Published:** December 07, 2017

Abstract

Cricket was processed into flour and used to supplement wheat flour, at levels of 0g, 5g, 10g, 15g, 20g and 25g, for biscuit production. The proximate composition, physical, properties, and sensory attributes, were evaluated. Results obtained for proximate composition ranged from 9.89 - 15.70% protein, 3.25 - 4.73% moisture content, 1.07 - 1.42% Ash, 0.54 - 0.86% crude fibre, 10.31 - 24.96% fat, 55.09 - 74.11% carbohydrate. Physical properties of the biscuits ranged from 6.60 - 7.70 cm diameter, 5.70 - 6.90 cm height, 11.50 - 15.00 cm break strength, 0.25 - 0.35 cm thickness, 11.00 - 12.00 yields, 18.90 - 27.70 cm spread factor, 30.00 - 53.00 ml volume, 24.05 - 48.07 g/cm^3 density. Sensory results obtain from the analysis of biscuits using 10 untrained panelists on a 9 point hedonic scale showed that no significant difference ($p \leq 0.05$) existed in aroma and texture of the biscuits. Sample 502 with 0g of cricket flour was mostly accepted in terms of appearance, taste, texture. However, sample 511 containing 15g of cricket was most generally preferred in terms of acceptability.

Keywords: Biscuit; Cricket; Wheat; Flours; Proximate Composition; Sensory Properties; Physical Properties

Introduction

Biscuits is a term used for a variety of baked, commonly flour based food product. Biscuit may be defined as a small baked product that would be called either a "cookie" or "cracker". They are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an Oven [1]. Biscuit and other baked food products are important items belonging to the class of food that are sold in ready to serve [2]. They have become post weaning food as mothers feed their children with it at day cares, schools, offices, churches etc.

Biscuit are a rich source of protein and fat, carbohydrate, mineral, energy giving foods [1]. All biscuits are nutritionals, contributing valuable quantities of iron, calcium, protein, calorie, fibre and some B-vitamins to our diet and daily food requirements. The principal ingredient are flour, fat, sugar, milk, salt, flavoring agent, egg, butter [3]. It could be baked in the primitive or modern oven, but the fundamental ingredient is the wheat flour which had the unique ability to form a cohesive gluten network when worked with water. This is used for many yeast breads, biscuits, pastries, cakes, cookies and other baked product that are so popular today [4].

Wheat is an important crop whose grain is a germ covered with starchy guilt. The germ is a good source of vitamins, fat and protein. The germ and starchy cover is packaged in a bran or husk which is also a good source of protein and vitamin (Sumati., *et al.* 2006). Its flour is a critical and principal raw material in biscuit production. Its superiority over other cereals is due to the presence of gluten which inherently imparts all the essential qualities to their products [5]. Wheat is a temperate crop; the flour which has high gluten content classified as a strong or hard flour, and therefore produces strong dough and thus a strong biscuit is produced, while flour with small gluten content produces a soft weak biscuit (Digestive) [6].

Crickets (*Brachytrypes membranacous*) are insects related to grasshoppers. They are small to medium sized insects with cylindrical, somewhat vertically flattened bodies. The head is spherical with long slender antennae arising from cone shaped scapes (first segments) and just behind these are two large compound eyes. On the forehead are three Ocelli (simple eyes) the wings lie flat on the body and are very variable in size (Otte., *et al.* 2007).

Crickets are a great source of nutrition, providing a great source of protein, iron, calcium, B_{12} and more. They are commonly eaten as a snack, prepare by deep frying the soaked and cleared insects (Bray., *et al.* 2010). Cricket had been reported to be five times higher than beef cattle in protein, and if their fecundity is taken into account, fifteen to twenty times higher defoliant [7]. Other edible insect include mealworms, silk worm pupae, Mexican, Mopane worm, palm weevil larvae, termites, cicadas, dragonflies jumiles, June bug, louse Nsenene, sago grubs, scorpion wasp, water bug wax worm, grasshoppers, horn worm, earthworm, dung beetle, fly pupae bee, agave worm (http://www.Fao.org/Forestry/edibleinsects/84627/en).

This work would improve on the utilization of cricket and provide nutritious biscuit for the growing children.

The objectives of this study therefore were to produce biscuit from blends of wheat and cricket flours and to evaluate the chemical, physical and sensory properties of the biscuit.

Materials and Methods

Sources of Materials

The cricket (*Brachytrypes membranacous*) was obtained from Emabu in Ankpa Local Government Area of Kogi State. Wheat grain, salt, butter, and sugar, were purchased from the central market of Anyigba Kogi State Nigeria. The equipment including oven, weighing scale, baking pan, mixing bowl, spoon, rolling pin, pastry board, and dough cutter used for this work were obtained from the Department of Food Nutrition and Home Sciences Laboratory, Kogi State University, Anyigba Nigeria.

Samples Preparation

Cricket was picked manually, de-winged, eviscerated and washed to remove dirt. The cleaned cricket was laid on drying pans in single layer and dried in a solar dryer for one week. The dried cricket was milled, packaged and kept in the refrigerator (Figure 1).

Cricket
↓
De-winging
↓
Eviscerating
↓
Washing
↓
Drying
↓
Milling
↓
Packaging

Figure 1: Flow chart for the production of cricket flour.

Whole wheat was cleaned by winnowing to remove dirt and then milled. The flour was sieve through standard sieve (BSS 20), and packaged as shown in figure 2.

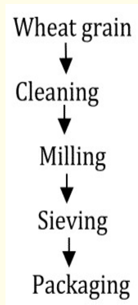

Figure 2: Flow sheet for the processing of wheat flour.

Biscuit Production

The fat was creamed with sugar until fluffy. The dry ingredients were added, followed by 15 ml of water to form the dough which was kneaded properly, cut, and arranged on oiled baking pan and baked at 130oC for 30 minutes. The hot baked biscuit was allowed to cool and packaged in high density polyethylene containers

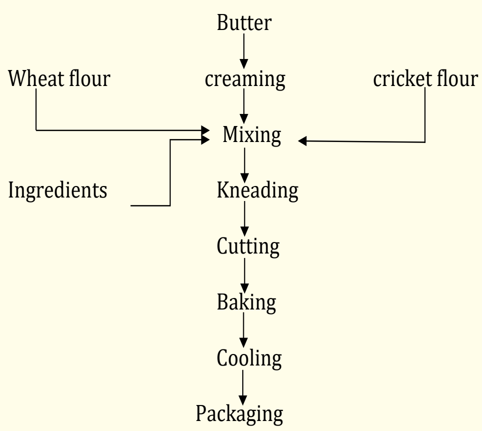

Figure 3: Flow chart for the production of biscuits from wheat and cricket flours

	Sample Codes					
Ingredients	**502**	**507**	**503**	**509**	**511**	**504**
Wheat flour (g)	100	95	90	85	80	75
Cricket flour (g)	0	5	10	15	20	25
Sugar (g)	30	30	30	30	30	30
Salt (g)	0.90	0.90	0.90	0.90	0.90	0.90
Butter (g)	20	20	20	20	20	20
Water (ml)	15	15	15	15	15	15

Table 1: Blend formulations for the Biscuit Samples.

502= 100g Wheat flour and 0g cricket flour; 507 = 95g Wheat flour and 5g cricket flour; 503= 90g Wheat flour and 10g cricket flour; 509= 85g Wheat flour and 15g cricket flour; 511 = 80g Wheat flour and 20g cricket flour; 504=75g Wheat flour and 25g cricket flour

Determination of physical Properties of the Biscuits

The height and width of biscuit samples were determined using a venire caliper, while the weights of the samples were determined with a top loading balance. The volume of the biscuits was determined by seed displacement. In this method measuring cylinder was filled with some rice grains. The grains were removed and a biscuit sample was put into the cylinder. The grains were now poured over the biscuit in the cylinder and leveled. The remaining grains were poured into a measuring cylinder and volume was obtained. Using the mass and volume measured, density of sample was calculated as shown below.

$$\text{Density } (g/cm^3) = \text{mass/volume} \qquad (1)$$

This was repeated twice for each of the samples and the means were calculated.

The spread factor was determined by dividing the average diameter of five well-formed biscuits by average height of the same biscuit. The break strength was determined by placing biscuit of known height between two metal bars. Known weights were added on the bar until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuits.

Determination of Moisture Content

Two grams of the sample was measured into a metal crucible of known weight previously dried at 1000C. The sample was dried in a hot air oven at 1050C to a fairly constant weight. The sample moisture content was calculated as

$$\text{Moisture } (\%) = \frac{\textit{loss in weight}}{\textit{original weight of sample}} \text{X} \frac{100}{1} \qquad (2)$$

Determination of Ash Content

The ash crucible was thoroughly washed dried in an oven and weighed. Two grams of the sample [8] were weighed into the crucible and incinerated. The sample was then transferred into a muffle furnace and heated at 5500C for 6 hours. The ash was cooled in desiccators and weighed using a mettler top loading balance. The ash content was calculated as

$$\%\text{ Ash} = \frac{\textit{weight of ash}}{\textit{weight of sample}} \text{X} \frac{100}{1} \qquad (3)$$

Determination of Fat

Two grams of sample were weighed into extraction thimble [8] and covered with cotton wool. The recovering flask was weighed. About 50 ml of petroleum spirit (40 - 600C) was poured into the flask connected to the thimble and sample. The extractor was connected to a heating mantle. The fat was extracted for 18 hours. The extract obtained was dried in a hot air oven and held in desiccators for cooling after which it was weighed.

The fat content was calculated as:

$$\text{Fat}\ (\%) = \frac{\textit{weight of fat}}{\textit{original weight of sample}}\ \text{X}\ \frac{100}{1}$$

Determination of Protein

The protein content of the biscuit samples was determined according to AOAC [8]. In this method, 0.15g of sample was put into Kjhedal flask and 8g of selenium catalyst mixture (0.5% SeO_2, 3.5% $CUSO_4$ and 96% Na_2SO_4) was added, followed by 25 ml concentrated H_2SO_4. The flask was heated on a heating mantle until frothing ceased, the solution became clear. The digest was then transferred into 100 ml volumetric flask and made up to mark. 10 ml of 40% NaOH was added and boiled in the distillation apparatus to liberate ammonia into a collection flask containing 10 ml of 2% boric acid. This was titrated against 0.05 ml H_2SO_4. The protein content was calculated thus

$$\%\ \text{Nitrogen} = \frac{\textit{titre X } 0.0014 \textit{ X dilution factor}}{\textit{weight of sample}}\ \text{X}\ \frac{100}{1}$$

% Protein = % Nitrogen x factor (6.25).

Determination of Carbohydrate

The total carbohydrate content was determined by difference; as

Total Carbohydrate (%) = 100 – (% Ash + % Fat + % moisture + % protein).

Sensory Properties

The evaluation was carried out on a 9- point hedonic scale where 9= like extremely and 1= dislike extremely. The coded biscuit samples were presented to the judges composed of mothers of children of pre nursery and nursery schools age, in similar containers and in randomized order.

Statistical Analysis

Data generated was subjected to one way analysis of variance (ANOVA) while treated means were calculated and comparable by the list significant difference as described by Ihekoronye and Ngoddy [9].

Results and Discussion

Proximate Composition of the Biscuit Samples

The values of moisture, ash, crude fibre, fat, protein and carbohydrates contents of the biscuits are shown in table 2 below. Moisture values of the samples ranged from 3.25% to 4.73% showing significant difference ($P \leq 0.05$) in moisture content between all the samples. The lower the initial moisture contents of a product to be stored, the better the storage stability of the product (Adebowale., *et al.* 2008). This indicates that sample 504 with the least moisture content might have longer shelf life. However, the moisture value across the biscuit samples was minimal and according to Kure., *et al.* [1] may not have adverse effects on the quality of the biscuits.

Sample	Moisture	Ash	Crude Fibre	Fat	Protein	Carbohydrates
502	4.07 ± 0.09^{b}	1.07 ± 0.03^{c}	0.54 ± 0.02^{d}	10.31 ± 0.15^{d}	9.89 ± 0.12^{d}	74.11 ± 0.12^{a}
507	4.73 ± 0.09^{a}	1.32 ± 0.03^{ab}	0.72 ± 0.02^{b}	19.36 ± 0.22^{c}	10.17 ± 0.15^{c}	63.69 ± 0.02^{b}
503	4.25 ± 0.07^{a}	1.22 ± 0.03^{b}	0.59 ± 0.1^{c}	21.15 ± 0.07^{b}	14.15 ± 0.21^{ab}	58.63 ± 0.19^{c}
509	3.42 ± 0.0^{c}	1.4 ± 0.00^{a}	0.83 ± 0.01^{a}	24.11 ± 0.09^{ab}	10.63 ± 0.12^{c}	59.19 ± 0.60^{ab}
511	4.4 ± 0.22^{ab}	1.42 ± 0.03^{a}	0.86 ± 0.02^{a}	24.96 ± 0.05^{a}	13.45 ± 0.15^{b}	55.09 ± 0.48^{c}
504	3.25 ± 0.21^{d}	1.27 ± 0.03^{b}	0.68 ± 0.00^{ab}	22.15 ± 0.21^{b}	15.70 ± 0.24^{a}	56.94 ± 0.21^{f}

Table 2: Proximate Composition of the Biscuit Samples (%).

Values represent triplicate determination ± SD. Means in a column with the same superscript are not significantly different ($P \leq 0.05$). 502= 100g Wheat flour and 0g cricket flour; 507=95g Wheat flour and 5g cricket flour; 503= 90g Wheat flour and 10g cricket flour; 509= 85g Wheat flour and 15g cricket flour; 511 = 80g Wheat flour and 20g cricket flour; 504=75g Wheat flour and 25g cricket flour.

The crude fibre content of the biscuits ranged from 0.54% to 0.86% with sample 511 containing 80:20 wheat/cricket (0.86%) while sample 502 (control) had the lowest value (0.68%). Fibre is an indigestible component of plant material that helps in bowel elimination and bulk as well as contributes to healthy condition of intestine and has been kwon to reduce cholesterol in the body [12]. The increase in the crude fibre could be due to addition of the cricket. There was no significant difference between sample 509 and 511.

The fat content of the biscuit samples ranged from 10.31% to 24.96%. There was no significant difference ($P \leq 0.05$) in fat content between sample 509 and 511 and sample 503 and 504. There was significant difference between sample 502 and 507. The fat content of the biscuits increased with increased addition of cricket. Similar report had been given by Agu., *et al.* [11] for wheat/African bread fruit biscuit.

The protein content of the biscuits ranged from 9.89% to 15.70%. There was a general increase in the protein content of the biscuit with increase in the addition of cricket flour. The result implied that the biscuit samples were high in protein content from 5% cricket flour substitution and could be used as alternative source of protein in protein deficiency.

The carbohydrate content of the biscuits ranged from 55.09% to 74.11%. The carbohydrate content of the biscuits generally decreased with increasing amount of cricket flour. For instance, while the control contained 74.11% carbohydrate, addition of 5g, 10g and 15g reduced the carbohydrate to 63.69%, 63.59% and 59. 19%. However, as much of the cricket flour was added, there was a slight increment. The reduction in carbohydrate could be of help in addressing the risk of sugar intake. The reduction in carbohydrates might be due to high protein, ash and fat content of the biscuit. This observation agreed with earlier reports by Messiaen [13].

Sensory Properties of the Biscuit Samples

Table 3 shows the sensory properties of the biscuit. It was observed that the colour of the samples 502, 507, 503 were significantly difference (P ≤ 0.05) from samples 509, 511, and 504. The colour of the biscuits became duller with increased addition of the cricket flour. The taste of samples 502, 507, 503, 511 and sample 509, were not significantly different (P ≤ 0.05) but were significantly different from samples 509 containing 15g of cricket flour and 504 containing 25g of cricket flour. Sample 504 had the least value (6.75 ± 0.21). This could be due to production error.

Sample	Colour	Taste	Aroma	Texture	General Acceptability
502	7.75 ± 0.26^a	7.90 ± 0.12^a	7.55 ± 0.19^a	7.80 ± 0.21^a	7.55 ± 0.25^a
507	7.40 ± 0.21^a	7.30 ± 0.12^a	7.35 ± 0.16^a	7.50 ± 0.21^a	8.00 ± 0.17^a
503	7.25 ± 0.23^a	7.00 ± 0.19^a	7.60 ± 0.15^a	7.00 ± 0.20^a	7.85 ± 0.19^a
509	6.30 ± 0.26^b	6.80 ± 0.18^b	7.30 ± 0.19^a	7.05 ± 0.18^a	8.05 ± 0.18^a
511	6.70 ± 0.26^b	7.30 ± 0.17^a	7.15 ± 0.20^a	7.10 ± 0.21^a	7.90 ± 0.19^a
504	6.35 ± 0.32^b	6.75 ± 0.21^b	7.15 ± 0.18^a	6.85 ± 0.15^b	7.30 ± 0.19^b

Table 3: Sensory properties of the Biscuit Samples.

Values represent triplicate determination ± SD. Means in a column with the same superscript letters are not significantly different (P ≤ 0.05).

502= 100g Wheat flour and 0g cricket flour; 507 = 95g Wheat flour and 5g cricket flour; 503= 90g Wheat flour and 10g cricket flour; 509= 85g Wheat flour and 15g cricket flour; 511 = 80g Wheat flour and 20g cricket flour; 504=75g Wheat flour and 25g cricket flour

All the samples showed no significant difference (P ≤ 0.05) in aroma. All samples also showed no significant difference (P ≤ 0.05) in texture except sample 504 (6.85 ± 0.15) which had the least value. This observation agreed with earlier reports by Olaoye., *et al* [14].

The general acceptability scores of samples showed that samples 502, 507, 503, 509 and 511 were not significantly different; (P ≤ 0.05) but were significantly differences from sample 504 containing 25g cricket flour having acceptability Score of 7.30 ± 0.19 was highly unaccepted. The unacceptability of the sample might be due to unappealing colour, taste and texture of the sample.

Physical properties of the biscuits

The table 4 shows the physical properties of the biscuit samples. It was observed that the volume of the samples increased with addition of cricket flour, while the density of the samples reduced with addition of cricket flour.

Sample code	Diameter (cm)	Height (cm)	Thickness (cm)	Yield	Volume (cm^3)	Mass (g)	Density (g/cm^3)	Break strength	Spread factor
502	6.90^a	6.20^a	0.35a	12^{ab}	3.00^c	12.75^a	0.43^b	12.00^c	19.70^d
507	6.60^a	6.50^a	0.35^a	11^{ab}	3.00^c	14.42^a	0.48^a	14.01^{ab}	18.90^d
503	7.40^a	6.60^a	0.30^b	13^a	4.00^b	14.58^a	0.36^c	15.00^a	24.70^b
509	6.90^a	5.70^a	0.35^a	12^{ab}	4.09^b	14.03^a	0.35^c	11.50^c	19.70^d
511	6.80^a	6.00^a	0.25^c	12^{ab}	5.30^a	12.75^a	0.24^c	12.10^c	27.70^a
504	7.70^a	6.90^a	0.30^b	12^{ab}	5.30^a	13.94^a	0.36^c	13.02^{bc}	22.00^c

Table 4: Physical properties of the biscuit samples.

Values represent triplicate determinations. Means in a column with the same superscript are not significantly different (P ≤ 0.05).

502= 100g Wheat flour and 0g cricket flour; 507 = 95g Wheat flour and 5g cricket flour; 503= 90g Wheat flour and 10g cricket flour; 509 = 85g Wheat flour and 15g cricket flour; 511 = 80g Wheat flour and 20g cricket flour; 504 =75g Wheat flour and 25g cricket flour.

The decrease in the density of the biscuits following the addition of cricket flour could be of help in the choice of packaging material.

There was a general increase in the spread factor of the biscuit samples. However, sample 507 complaining 5g of cricket had the lowest value which however was not significantly different from the control. The low spread ratio [11] was an indication that starch polymer molecules are highly bound with the granules hence swelling was limited when heated. Increased spread factor might be due to difference in particle size between the wheat and the cricket flours.

Significant differences existed between the 100g wheat biscuit and these containing 5g, 10g, and 25g of cricket flours that had higher values of break strength. On the other hand, there were no significant differences between the 100% wheat biscuit and the samples containing 15g and 20g cricket flours respectively. Agu., *et al.* [11] had reported similar observation for biscuit produced from wheat and African bread fruit.

The yield of the biscuits ranged from 11 to 13 showing no significant differences (P ≤ 0.05) [15-21].

Conclusions

This study showed that the nutritional and sensory qualities of biscuit were improved with supplementation of cricket flour; showing that wheat flour and cricket flour mixes had higher protein, carbohydrate, ash, crude fibre contents than the whole wheat flour. Sensory analysis showed high acceptability for the biscuits up to 20% substitution. The use of cricket flour this way would improve on the utilization of cricket as well as the quality of biscuit for growing children.

Recommendation

The use of cricket in the production of biscuit should be encouraged for the enhancement of the nutritional requirements of growing children. However studies on the microbiological status of the product could be carried out to help in improvement on the product's stability.

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Volume 2 Issue 1 January 2018