International Journal of Agriculture and Plant Science
Online ISSN: 2664-7664; Print ISSN: 2664-7656
Received: 05-05-2019; Accepted: 07-06-2019; Published: 14-06-2019
www.agriculturejournal.in
Volume 1; Issue 3; 2019; Page No. 25-30

Quality evaluation of biscuit from wheat-tiger nut composite flour

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Abstract
The quality evaluation of biscuit from wheat-tiger nut composite flour was carried out. Biscuit was prepared from varying proportion of 100%, 90%, 80%, 70%, and 60% wheat flour substituted with 0%, 10%, 20%, 30% and 40% tiger nut flour respectively. The biscuit samples were analyzed for the chemical composition, physical, sensory and functional properties on the blends. The tiger nut flour addition increased ($p<0.05$) significantly the moisture content (4.64 – 5.16). Sensory evaluation showed that although there was significant ($p<0.05$) increase in the nutritional content of the biscuit, the overall acceptability of all biscuit samples decreased with increasing level of tiger nut flour.

Keywords: wheat, biscuit, tigernut, composite flour

Introduction

Wheat is a cereal plant grown all over the world which is very useful and nutritious. It is second only to rice as the main human food crop [1]. The first cultivation of wheat occurred about 10, 000 years ago, as part of the 'Neolithic Revolution', which saw a transition from hunting and gathering of food to settled agriculture. The kernel of wheat consists of the wheat germ and the endosperm, which is full of starch and protein [2]. Usually the whole grain is milled to leave just the endosperm for white flour, while the by-products of bran and germ are discarded. It has been shown that the whole grain is a concentrated source of essential nutritional components such as vitamins, minerals, protein, fat and fiber while the refined grain is mostly starch [3, 4]. Wheat, is perhaps the most popular energy grain for the production of confectionary products, because of the unique properties of its protein (gluten) which combines strength and elasticity required to produce bread, biscuits, cakes and pastries such as spaghetti, macaroni and noodles of desirable texture and flavour [3, 5].

The Cyperaceae specie are monocotyledonous plants which include up to 4000 species worldwide [6]. The Cyperaceae family is of very little economic value with the exception of *Cyperus papyrus* which is used in the manufacture of paper and *Cyperus esculentus* (tiger nut) which is edible [7]. Tiger nut is a weed plant of tropical and Mediterranean regions. It is mainly consumed after being soaked in water for tenderization or blanched as a traditional snack food or roasted and grinded in powder form as a drink. Tiger nut (*Cyperus esculentus*) also known as Aya in Hausa and Shoho in Tiv language is an under-utilized crop which has a sweet and nutty taste. The tubers are edible; they can be eaten raw, dried, roasted, prepared as tiger nut milk or oil, used as a composite in the production of biscuits, bread and other bakery products used in making jams, beer and as a flavouring agent in ice cream. According to Anderson *et al.* [8], tiger nut has been reported to be high in dietary fiber and is effective in the prevention and treatment of a lot of diseases, not excluding colon cancer, coronary heart diseases, gastro intestinal disorders, obesity and diabetics. Tiger nut oil is a rich source of quality oil and has moderate amounts of protein. It is also a rich source of some useful minerals such as iron and calcium which are essential to body growth and development [9]. Furthermore, tiger nut contains more essential amino acids than those proposed in the protein standard by the [10] for satisfying adult needs [11].

Biscuit is a small hard, sweet, flat baked food made from flour, water, fat and sugar. It is a healthy snack made from palatable dough that is transformed into delicious product through the application of heat in an oven [12]. Biscuits are a nutritive source of fat and carbohydrates hence, are energy giving foods and a good source of protein [12]. Biscuits are one of the low cost processed foods, which are most widely consumed. It, amongst many snacks, has certain advantages, such as being cheaper than the conventional snack items, easy to use at home or even during travel, easily being available in massive variety of shapes, sizes, tastes, and packs, and appeals to all age groups. They have good shelf life at ambient temperature [13]. The consumption of biscuit and bread appears in the list of top ten daily consumed foods, and they are easily available and convenient to be enjoyed as snack [14]. Attempts were being made in recent days to improve the nutritional qualities and functionalities of biscuits, due to competition in the market for healthy, natural and functional products [15]. Biscuit requires a balanced nutritional value which can be enhanced by fortification and supplementation with a wide variety of protein rich cereal and pulses [16]. Flour is a powder which is gotten by grinding grains such as wheat, corn, rye, sorghum etc. or roots like cassava. Wheat flour is the most common flour used in baking food products. Composite flours found themselves at the center of attention in the European and International Cereal Research in the 1960s and 1970s. Most of the studies in this field were supported by the FAO (Food and Agricultural Organisation of the United Nations). These were three main reasons responsible for this and they include a steadily growing population, changes in eating habits and an overall increase in income. Because the climatic conditions and soil did not favour the growth of wheat locally, the wheat flour needed for making biscuit, bread, rolls and pastry foods most times had to be imported. Due to this reason, the FAO and these developing countries were interested in the possibility of replacing the wheat needed for making baked foods and also pasta wholly or partly with flour obtained from home grown products. Some of the sources available were tuberous plants rich in starch such as sweet potatoes, cassava, yams, protein rich flours such as soy and peanuts and other cereals including Maize, rice, millet and sorghum. The use of composite flours had the following advantages in developing countries; saved money, promoted high yielding native plant species, better supply of protein for human nutrition a more appropriate overall use of domestic agriculture [17, 18].

Milligan *et al.* [19] defined composite flour as a mixture of flours, starches and other ingredients intended to replace wheat flour totally or partially in bakery and pastry products. Therefore, the addition of tiger nut to wheat flour to produce biscuit will enhance the nutritional and sensory properties of the biscuit. The broad objective of the study was to evaluate the quality of biscuit produced from wheat and Tiger nut composite flour

Materials and Methods

Wheat flour, tiger nut and other baking ingredients such as fat, sugar, baking powder, eggs and salt were obtained from North bank market, Makurdi, Nigeria.

Preparation of composite flour

The composite flour were formulated in different ratios with wheat being the highest. The table 1 below shows the composite flour and their ratios.

Table 1: Blend Formulation

Samples	Wheat flour	Tiger nut Flour
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40

Production of Tiger nut flour

The production flow chart for tiger nut flour is presented in figure 1.

Tiger nut seed
↓
Sorting
↓
Cleaning by washing with water
↓
Oven drying (at 60ºC for 24 hours)
↓
Milling (Hammer milling)
↓
Sieving (600um aperture size)
↓
Packaging in polyethene bags until analysed
↓
Flow chart for the production of tiger nut flour.

Biscuit Preparation

Biscuit was prepared according to the method of (20) with some modifications in the recipes; flour 100g, sugar 100g, baking powder 10g, salt 5g, composite flour 100g. The dry ingredients (flour, sugar, salt and baking powder) were thoroughly mixed in a bowl by hand for about 3 minutes. Vegetable shortening was added and mixed until uniform. Egg was then added and the mixture kneaded. The batter was rolled and cut with a 50mm diameter biscuit cutter. The biscuit was placed on baking trays, leaving 25mm spaces in between and was baked at 180ºC for 10 minutes in the baking oven. Following baking, the biscuits were cooled at ambient temperature, packed and stored at 23ºC prior to subsequent analysis and sensory evaluation

Materials
↓
Mixing
↓
Kneading
↓
Rolling and cutting
↓
Baking (at 350ºF for 15 minutes)
↓
Biscuits
↓
Cooling
↓
Packaging
↓
Storage
↓
Biscuit

***Source*:** [21].

Flowchart for the production of biscuits

Analyses

Functional Properties of wheat and tiger nut composite flour

The water absorption capacity of the different flours was determined as described by [21]. 1g of each sample was weighed into a conical graduated centrifuge tube. Using a whining mixer, the samples were mixed thoroughly with 10ml of distilled water in a centrifuge for 30 minutes. The volume of the free water or oil (supernatant) was read directly from the gradual centrifuge tube. The bulk density of samples was determined as described by Onwuka [22], by weighing 3g of each sample into 10ml graduated cylinder on the laboratory bench several times until there was no further diminution of the sample's level after filling to the 10ml mark.

$$\text{Bulk density (ml)} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample (ml)}} \qquad (1)$$

The swelling capacity was determined using the method as described by [22], 10g of the sample was weighed into a 100ml graduated cylinder with the dry bulk volume noted. 100ml of hot water at 70ºC was then mixed. The volume after 10 minutes was recorded and the swelling capacity calculated thus;

$$\text{Swelling capacity} = \frac{\text{Change in volume of sample (ml)..}}{\text{Original weight of sample (g)}} \qquad (2)$$

Oil absorption capacity was done according to the method described by Giami *et al* [23]. 1g of each flour sample was weighed out with the aid of an analytical balance and mixed with 10ml of refined palm kernel oil with known density in a weighed 20ml centrifuge tube for each sample. The resulted slurries was agitated on a vortex mixer for 2 minutes, and allowed to stand at a temperature of 280ºC for 30 minutes and then centrifuged supernatants were decanted and discarded. The adhering drops of the oil was removed and the tubes weighed in each case. The weight of oil absorbed by 1g of each of the flour samples was calculated and expressed as oil absorption capacity of the samples.

Proximate Composition (%) of wheat and tiger nut biscuit

Moisture content was determined by [24]. Clean crucible was dried in the oven at 100ºC for 1 hour to obtain a constant weight and then cooled in a dessicator. 2g of the samples was weighed into the crucibles and dried at 100ºC until a constant weight is obtained.

$$\%\text{ moisture content} = \frac{\text{Weight loss}}{\text{Weight sample}} \times 100 \qquad (3)$$

The soxhlet extraction method of AOAC [24] was used to determine the fat content of the biscuit. A soxhlet extractor with a reflux condenser and a 500ml round bottom flask will be fixed. 2g of sample weighed into a thimble- petroleum ether (300ml) was filled into the round bottom flask. The extractor thimble was then sealed with a cotton wool. A soxhlet apparatus was allowed to reflux for 6 hours, the thimble was removed with care and the petroleum ether collected at the top and drained into a container for reuse. When the flask was free of ether, it was removed and dried at 105ºC in an oven, cooled in a dessicator and weighed.

$$\text{Fat (\%)} = \frac{\text{Weight loss}}{\text{Weight of sample}} \times 100. \qquad (4)$$

Protein content of the biscuit was determined according to standard method of AOAC (24) using the kjeldahl method described below;

Digestion sample: 2g of samples was weighed in a kjeldahl flask. About 5g anhydrous sodium sulphate or 2 tablets of kjeldahl catalyst was added. 25ml of concentrated H_2SO_4 was added with a few boiling chips (antibumps). It was heated in a fume chamber until the solution became clear. The solution was then cooled to room temperature, after which it was transferred into a 250ml volumetric flask and made up to level with distilled water.

Distillation: A 100ml conical flask, containing 5ml of 2% buric acid was placed under the condenser with addition of drops of methyl red indicator. 5ml of the digest was pipetted into the apparatus through the small funnel washed down with distilled water and titrated with 0.049 H_2SO_4 to get a pink colour.

The ash content was done following the method described by AOAC [24]. 2g of sample was weighed into a preheated cooled crucible. This sample was charred on a Bunsen flame inside a fume cupboard. Samples were transferred into a preheated muffle furnace at 550ºC for 3-5 hours until a white or light grey ash was obtained.

$$\%\text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100 \qquad (5)$$

Carbohydrate content of the samples was determined by the difference method described by AOAC [24] using the equation;

% Carbohydrate = 100- (% moisture + % ash + % protein + % crude fibre + % crude fat)…….. (6)

Determination of Mineral content of the Biscuit

Iron was determined following the phenanthroline method of Iwe, [25]. Five milliliters of digested sample was placed in a 50ml volumetric flask. Then 3ml of phenanthroline solution, 2ml of hydrochloric acid and 1ml of hydroxylamine solution were added to the sample in sequence. The sample solution was added to the solution. The absorbance was determined at 510nm wavelength. Iron standard solution was prepared in order to plot a calibration curve to determine the concentration of the sample. Standard solution containing 100mg/ml of fermic irons was prepared from 1g pure iron wires. The wires were dissolved in 100ml concentrated nitric acid, boiled in a water bath and diluted to 100ml with distilled water after cooling.

Standards solutions of known concentrations were prepared by pipetting 2,4,6,8 and 10ml standard iron solution into 100ml volumetric flasks and made up to volume.

Calcium was determined using the method described by [25]. Twenty- five milliliter of digested sample was pipetted into 250ml conical flask and a pinch of Eriochrome Black- T-Indicator (EBT) was added. Thereafter, 2ml of 0.1N NaOH solution was added and the mixture titrated with standard EDTA (0.01M EDTA) solution.

$$\text{Ca (mg/1)} = \frac{\text{T X M X E}}{\text{Volume of sample used}} \times 1000 \qquad (7)$$

Where T = Titre value

M = Morality of EDTA

E = Equivalent weight of calcium used.

Phosphorus and samples was determined according to (22) by molybdate method using hydroquinone as a reducing agent.

Five milliliters (5ml) of the test solution was pipetted into 50ml graduated flask. Then 10ml of molybdate mixture was added and diluted to mark with water. It was allowed to stand for 30minutes for colour development. The absorbance was measured at 660mm against a blank. A curve relating absorbance to mg phosphorus present was constructed. Using the phosphorus standard solution, and following the same procedure for the test sample, a standard curve was plotted to determine the concentration of phosphorus in the sample.

Potassium was determined by a procedure described by Iwe, [24] using a flame photometer. Potassium standard was prepared. The standard solution was used to calibrate the instrument read out. The meter reading was at 100% E (Emission) to aspire the top concentration of the standards. The %E of all the intermediate standard curves was plotted on linear graph paper with these readings. The sample solution was aspired on the instrument and the readings (%E) was recorded. The concentration of the element in the sample solution was read from the standard curve.

Calculation

$$\%\text{Potassium} = \frac{\text{DF X 100}}{\text{1 million}} \text{ X ppm} \quad (8)$$

Where

Ppm = parts per million

Sensory Evaluation of Biscuits

The organoleptic properties of the biscuit including taste, texture, colour and overall acceptability was accessed by 15 member panelists who are familiar with the product at 9-point Hedonic scale with 1 representing the least score (dislikes extremely) and the highest score (like extremely).

Statistical Analysis

Analysis of variance (ANOVA) was performed on the data to determine differences, while the Duncan multiple range test was used to separate means where significant difference exist.

Results and Discussion

Functional Properties

Table 2 present the functional properties of the composite wheat-tigernut flour. The functional properties are those parameters that determine the application and end use of food materials for various food products.

The bulk density is a reflection of the load the sample can carry if allowed to rest directly on one another. The bulk density of foods is affected by the particle size and the starch content. It is important in determining the packaging requirement, raw materials handling and application in wet processing in the food industry. The samples A and B had no significant difference on the bulk density, but the inclusion of tiger nut flour made samples C, D and E to be significantly different from each other,. The bulk density ranged from 0.76 – 0.67g/ml.

Oil absorption capacity is important since oil acts as flavor retainer and increases mouth feel of foods. In oil absorption capacity, the samples A was significantly different from samples B, C, D and E. This implies that tigernut addition improved the oil absorption capacity

In the water absorption capacity, sample A was significantly different from other samples but the remaining samples were not significantly different from each other. This implies that wheat flour had higher water absorption but the tiger nut level of substitution was not affected. The ability of flour to absorb water was reported to have a significant correlation with its starch content. There was decrease in the swelling capacity as the ratio of tigernut flour increased. The values recorded for the sample ranged between 300-9.403.

For the Foam capacity, showed no significant increase in sample B but there was a significant decrease in samples C, D and E respectively.

Table 2: Functional Properties of the Wheat- Tiger nut Composite Flour

Parameters	A	B	Samples C	D	E	LSD
BD (g/ml)	$0.76^{a}\pm0.02$	$0.67^{c}\pm0.01$	$0.69^{bc}\pm0.01$	$0.71^{b}\pm0.01$	$0.70^{bc}\pm0.01$	0.036
OAC (ml/g)	$0.27^{e}\pm0.01$	$0.73^{b}\pm0.01$	$0.82^{a}\pm0.02$	$0.46^{d}\pm0.01$	$0.55^{c}\pm0.00$	0.04
WAC (ml/g)	$1.10^{a}\pm0.00$	$1.00^{b}\pm0.00$	$0.91^{c}\pm0.01$	$1.00^{b}\pm0.00$	$0.90^{c}\pm0.00$	0.01
SI	$9.40^{a}\pm0.00$	$8.00^{b}\pm0.00$	$5.76^{c}\pm0.01$	$4.19^{d}\pm0.01$	$3.00^{e}\pm0.00$	0.01
FC	$7.85^{b}\pm0.01$	$8.00^{a}\pm0.00$	$3.93^{c}\pm0.01$	$3.92^{c}\pm0.00$	$2.94^{d}\pm0.00$	0.01

Values are means ± SD duplicate determinations. Values with different superscript within the same row are significantly different ($P < 0.05$)

Physical properties

The physical properties of the wheat – tiger nut flour are shown in table 9 below.

The weights of the biscuits were not significantly different from each other ($P>0.05$). This implies that tiger nut addition on wheat flour does not affect the weight.

Samples E, D, B and A were significantly different from each other but not same for sample C which was not significantly different from each other in the thickness.

In the diameter, samples B and E were significantly different from each other but not significantly different from other samples. This means that tiger nut addition to wheat flour has no significant different

The spread ratio also did not have great difference on the physical properties of the product.

Table 3: Physical Properties of Biscuit Produced from Wheat- Tiger nut Composite Flour.

Parameters	A	B	Samples C	D	E	LSD
Weight (g)	$15.43^{bc}\pm1.44$	$16.30^{b}\pm2.38$	$13.73^{c}\pm1.02$	$19.03^{a}\pm0.50$	$17.40^{ab}\pm0.30$	2.46
Thickness (mm)	$1.17^{a}\pm0.23$	$1.23^{a}\pm0.12$	$1.20^{a}\pm0.00$	$1.23^{a}\pm0.15$	$1.20^{a}\pm0.17$	0.28
Diameter (mm)	$8.50^{a}\pm0.10$	$5.67^{b}\pm0.32$	$5.70^{b}\pm0.61$	$5.87^{b}\pm0.12$	$6.07^{b}\pm0.80$	0.87
Spread Ratio	$7.50^{a}\pm1.59$	$4.63^{b}\pm0.60$	$4.75^{b}\pm0.50$	$4.80^{b}\pm0.59$	$5.17^{b}\pm1.26$	1.83

Values are means ± SD triplicate determinations. Values with different superscript within the same row are significantly different ($P < 0.05$)

Table 4 shows the proximate composition of biscuit produced from wheat and tiger nut flour blends. The moisture content of the samples ranged from 4.64- 5.16%. The low moisture content could reduce the growth of microorganisms thereby increasing the shelf life of the product.

The protein content of the biscuit samples increased as the ratio of tigernut flour increased in the mixture, the values ranged from 8.61 to 9.88%. Significant differences ($p < 0.05$) were observed amongst the samples when compared.

The fat content of the biscuit increased as the tiger nut addition progressed. The increase in fat ranged from 16.65 – 17.85.

The crude fiber also was significantly different from each other. The mean value increased as tiger nut flour was blended across the samples. The high content of fiber in tiger nut has a good effect on digestion. This is because fibre stimulates digestive juices, contributes to a longer feeling of fullness and speeds up transit in the intestinal tract and so prevents constipation.

The ash content (%) of the sample increased with decrease in the ratio of wheat flour in the samples. Sample A was not significantly different from samples B, C, D and E. The ash content is also a rough estimate of the mineral contents of the samples.

The carbohydrate content was significantly different from each other, across the rows. The addition of tiger nut flour in the samples resulted to a reduced carbohydrate level in the samples. The carbohydrate content of the composite flours ranged from 64.53 to 60.85.

Table 4: Proximate Composition of Biscuit Produced from Wheat- Tigernut Composite Flour

Parameters	A	B	Samples C	D	E	LSD
Ash (%)	$3.48^{a}\pm0.01$	$3.51^{a}\pm0.01$	$3.51^{a}\pm0.08$	$3.60^{a}\pm0.05$	$3.57^{a}\pm0.05$	0.13
Crude protein (%)	$8.61^{d}\pm0.01$	$8.89^{cd}\pm0.01$	$9.23^{bc}\pm0.01$	$9.52^{ab}\pm0.12$	$9.88^{a}\pm0.46$	0.55
Crude fibre (%)	$2.11^{d}\pm0.01$	$2.23^{cd}\pm0.01$	$2.33^{bc}\pm0.02$	$2.43^{b}\pm0.10$	$2.71^{a}\pm0.07$	0.14
fat (%)	$16.65^{c}\pm0.21$	$16.88^{bc}\pm0.03$	$16.90^{bc}\pm0.57$	$17.40^{ab}\pm0.14$	$17.85^{a}\pm0.06$	0.72
Moisture (%)	$4.64^{b}\pm0.01$	$4.79^{ab}\pm0.01$	$5.01^{ab}\pm0.15$	$5.08^{a}\pm0.31$	$5.16^{a}\pm0.01$	0.40
CHO (%)	$64.53^{a}\pm0.23$	$63.71^{ab}\pm0.04$	$63.04^{b}\pm0.31$	$61.98^{c}\pm0.10$	$60.85^{d}\pm0.65$	0.88
Ca (mg/100g)	$120.50^{b}\pm0.71$	$118.50^{c}\pm0.71$	$120.50^{b}\pm0.71$	$130.50^{a}\pm0.71$	$117.50^{c}\pm0.71$	1.82
Fe (mg/100g)	$1.12^{c}\pm0.00$	$1.10^{c}\pm0.00$	$1.22^{b}\pm0.02$	$1.44^{a}\pm0.01$	$1.05^{d}\pm0.01$	0.04
P (mg/100g)	$321.50^{c}\pm0.71$	$218.50^{e}\pm0.71$	$332.00^{b}\pm2.83$	$343.00^{a}\pm0.00$	$317.00^{d}\pm1.41$	3.81
K (ml/100g)	$114.50^{d}\pm0.71$	$119.50^{c}\pm0.71$	$124.50^{b}\pm0.71$	$126.50^{a}\pm0.71$	$118.50^{c}\pm0.71$	1.82

Values are means ± SD duplicate determinations. Values with different superscript within the same row are significantly different ($P < 0.05$)

Table 5: Sensory scores of biscuit from wheat and tiger nut flours

Parameters	A	B	Samples C	D	E	LSD
Appearance	6.87^{b}	7.27^{ab}	7.33^{ab}	7.80^{a}	8.00^{a}	0.87
Texture	7.53^{a}	7.40^{a}	7.33^{a}	7.27^{a}	7.33^{a}	0.72
Aroma	7.80^{a}	7.73^{a}	7.27^{ab}	7.60^{ab}	7.00^{b}	0.73
Taste	7.93^{a}	7.67^{ab}	7.13^{b}	7.53^{ab}	7.33^{ab}	0.70
General acceptability	7.93^{a}	7.93^{a}	7.27^{a}	7.60^{a}	7.40^{a}	0.75

Means with different superscript within the same row are significantly different

Conclusion and Recommendation

Conclusively, the study has shown that the biscuit can be adequately produced using tiger nut in the range of 10-40%.

The proximate analysis indicated that the nutritional value of the biscuit increased as the tiger nut flour level increased.

The sensory result showed that biscuit made from wheat with 10% tiger nut flour was more acceptable.

The use of tiger nut wheat composite flour is recommended so as to reduce the cost of biscuit production and improve the nutritional value of biscuits.

Thus, sample B with 90% wheat flour and 10% tiger nut flour is recommended for consumption and will increase fiber and protein intake in children, help to prevent diseases associated with gluten and protein- energy malnutrition among children and increase the utilization of tiger nut in developing countries including Nigeria.

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