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Development of Gluten-free Cookies from Fonio and Coconut Flour Blends

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Abstract
The overdependence on refined wheat flour in food processing has called for a critical need to search for alternatives in snack production. Fonio is a nutritious, gluten free cereal with a low glycaemic index. Defatted coconut flour is low in calorie and rich in fibre. This work therefore, evaluated the quality of cookies produced from blend of fonio and coconut flour. Coconut meat was cut into smaller chunk, wet milled and sieved. The chaff obtained was oven dried and milled into flour. Cookies were produced from blend of fonio and coconut flour at different ratio (100:0, 90:10, 80:20, 20:80, 0:100%) and was analysed for proximate, physical, and sensory attributes. The data obtained was subjected to statistical analysis. The results showed that the proximate composition of flour samples ranged from 4.71 to 8.91%, 5.98 to 7.51%, 2.13 to 43.08%, 2.67 to 8.10, 0.30 to 0.37 and 29.05 to 78.30.54% for moisture, protein, fat, crude fibre, ash and carbohydrate, respectively. The physical properties of cookies for weight, thickness and spread ratio of the cookies ranged from 5.50 to 6.40 g, 0.70 to 0.77 cm, and 5.91 to 6.64, respectively. The judges rated cookies from 100% coconut as most preferred in terms of overall acceptability. Cookies of acceptable quality were produced from 80:20 composite flours of fonio and coconut flour. Fonio and coconut flour blends can be used in the production of cookies with improved nutritional and sensory qualities.

Keywords: Coconut, Fonio, Cookie, Proximate Analysis, Flour

Introduction
The attention of nutritionist has recently focused on the ways to solve the problem of protein malnutrition by improving the protein quality of foods especially diet of young children. The increasing demand of nutritious and affordable foods and increasing number of people with celiac diseases has called for alternative use of gluten-free flour in production of baked and complementary foods (Babarinde *et al.*, 2020a; Babarinde *et al.*, 2020b).

Cookie is an age long snack with an appealing appearance and a delicious taste. It is different from other baked products like bread and cakes because of its low moisture content which extends the shelf life of the product (Hussain, 2017). In many developing countries, the growing number of working mothers have contributed greatly to the popularity and increased consumption of snack food like cookies; hence the need for production of nutritious and health friendly snack foods.

Fonio is a pseudo cereal that is attracting the interest of researched due to its nutritional content and peculiar taste. It is known as *acha* in Nigeria and it is an annual cereal crop indigenous to West Africa origin belonging to the family Graminae where it is cultivated as straw and edible grains (Jideani, 1999). It can be used in several ways which makes it play a vital role in food security to millions of African farmers. Wheat, has been used as a major ingredient and main source of nutrients to a large world population (Jisha *et al.*, 2008). However, most developing countries including Nigeria rely on its importation to get the needed supply for most baked products. Therefore, there is keen interest to wholly or partly replace wheat flour with home-grown cereals. This can be achieved by using under exploited cereals that are nutrient-dense. Fonio is an underutilized cereal that does not contain gluten and which represents an important source of nutrients, in particular fibres and proteins. It contains no *trans* fatty acids and has a low glycaemic index (Jideani 2011).

Fonio is used for nutrition and health purposes because of its high fibre and low glycaemic content (Agu *et al.*, 2015). It also serves as food security in times of scarcity. Across Africa, several indigenous foods and drinks are made from flour, meal and malts of acha (Ayo and Gidado, 2017). It can be processed into drinks with high level of nutrient. Foods or meals produced from acha are high energy and nutritious foods recommended for the health and wellbeing of infants, lactating mothers, elderly and convalescents; it will therefore make a

good choice for composite flour. Acha has been used as ingredient in complementary and breakfast foods and its nutritional composition such as vitamins and minerals have been investigated (Abioye and Babarinde, 2009; Babarinde *et al.*, 2020a).

Coconut chaff that is obtained as by-product from oil production can also be used in bakery products. Considering the availability of coconut and fonio in Nigeria, production of cookie from the aforementioned crops will increase their utilization and enhance the nutritional value of the snack. This research work investigated the physical, proximate, physico-chemical and sensory properties of cookies made from fonio and coconut flour blends.

Materials and Method

Procurement of Materials

Fonio was obtained from Jos, Plateau Nigeria and coconut was obtained from a local market in Ogbomoso. Other ingredients used were margarine, sugar and egg which were also purchased from local market in Ogbomoso.

Sample Preparation

Fonio grains were sorted to remove tiny stones and foreign materials. They were washed severally with water according to the method described by Abioye and Babarinde (2009) clean tap water. Fonio grains were drained, dried at 60 ºC for 8 h in the cabinet dryer and milled. After drying, the grain was milled to flour. The whole meal flour was packaged in ziplock bags and stored. Coconut flour was processed from the local variety of matured coconuts, which were free from damage.

The coconut was split and water was drained. The kernel (meat) was cut into slices, wet milled, mixed with adequate water and sieved to separate milk from chaff. The chaff obtained after thorough washing was dried at 60 ºC for 8 h, milled into flour, packed in high density polyethylene, sealed and stored.

Cookies formulation from the blend of fonio and coconut flour

The flours were prepared by mixing the blends in the ratios 100:0, 90:10, 80:20, 20:80, 0:100 of fonio to coconut flour. The cookies were prepared using the method described by (Joel *et al.*, 2014) with slight modifications. The composite flours were blended with other baking ingredients in a mixer. Sugar (60 g) and margarine (100 g) were mixed with Kenwood mixer at a medium speed until fluffy (for 12 min). Coconut milk was added while mixing sugar and margarine and then mixed for a total of approximately 30 min. Sifted flour (200 g), baking powder (2 g), vanilla flavour (0.2 g), psylium husk were slowly added into the mixture. The mixture was kneaded for 12 min until a consistent dough was formed. The formed dough was rolled on a flat rolling board sprinkled with flour to a uniform thickness of about 0.4 cm using wooden rolling pin. Circular cookies of 5.8 cm - 6 cm diameter was cut, then placed on oiled baking trays. The stamped dough were baked in the oven for 45 min at 260 °C, the products were allowed to cool and were subsequently packaged with a cellophane wrapper.

Analyses

Physical Attributes of Cookies

The weight, thickness and spread ratio were determined according to the method described by AACC (2000).

Proximate Analysis of Flour

Moisture, protein, fat, crude fibre, ash and carbohydrate were determined using AOAC (2005) method while physico chemical properties were determined using AACC (2000).

Functional Properties of the Flour Blends

Bulk Density: The bulk density of the flour samples was determined by weighing 50 g of the sample into 100 ml graduated cylinder, then, the bottom was tapped gently several times on a laboratory bench, until no further diminution of the sample level. After this, the final volume was expressed as g/ml (Nwosu, 2011).

$$Bulk\ Density\ (g/ml) = \frac{Weight\ of\ sample(g)}{volume\ of\ sample\ (ml)}$$

pH Measurement: The pH values of the samples was determined by suspending 10 g of each sample in 100 ml of distilled water in 250 ml beaker. The sample was thoroughly mixed, stirred and the pH was read on a Jenway pH meter (AACC, 2000).

Water absorption capacity: Twenty millimeter of water was added to 10 g of the samples and poured into a blender at high speed for 30 s. The sample was allowed to stand at 30 °C for 30 min, centrifuged at 10,000 rpm for 30 min. The volume of the supernatant in a cylinder was noted, the density of water was determined (AACC, 2000).

Free Fatty Acid Determination

Ten grams (10 g) of the sample was accurately measured into a 250 ml Stopper flask. Ethanol (50 ml) was measured into another flask and allowed to boil at its boiling point, when over 70 ºC, it was neutralised with 0.1N NaOH using phenolphthalein as indicator. The neutralised ethanol was poured on the sample in the first flask and the content was mixed. They were boiled, while still hot, was titrated using 0.1N NaOH. The end point was reached when the addition of a drop produced pink colour which persisted for 15 s. The acid value was calculated.

Sensory attributes

A panel of 40 semi trained male and female individuals, aged 18–40 years, assessed the colour, flavour, taste, crispiness and overall acceptability of the cookies using a 9-point hedonic scale.

Statistical Analysis

Data was statistically analysed using analysis of variance techniques and means were separated by new Duncan multiple range test.

Results and Discussion

Physical properties of cookies

The physical properties of cookies are shown in Table 1. The weight, thickness and spread ratio of the cookies ranged from 5.50 to 6.79 g, 0.70 to 0.84 cm and 5.36 to 6.61, respectively. Their weights decreased with increased substitution of coconut flours. The thickness of the cookies prepared from the composite flour did not vary significantly among the treatments. The trend obtained in this study was similar to findings of Bornare and Khan (2015) who observed decrease in weight and thickness of cookies as level of rolled oat increased in wheat rolled oat blend. The spread ratio increased (5.36 to 6.61) with increasing supplementation of coconut flour. Cookies from 100% wheat sample had the lowest spread ratio and the highest thickness. Cookies having high spread ratio are considered most desirable. Dhankhar (2013) reported spread ratio as an important attribute of cookies. The higher the spread ratio the higher will the product yield be.

Table 1. Physiochemical properties of flour and physical attributes of cookies from fonio coconut blend

Sample	pH	Bulk density	WAC	Weight (g)	Thickness (cm)	Spread ratio	Free fatty acid
A	6.26±0.0^{b}	0.81±0.0^{e}	124.96±0.3^{a}	6.79±0.0^{c}	0.84±0.0^{b}	5.36±0.0^{a}	1.97±0.0^{e}
B	6.08±0.0^{a}	0.66±0.0^{d}	139.74±0.1^{b}	6.40±1.1^{b}	0.77±0.0^{a}	5.89±0.3^{a}	1.86±0.1^{d}
C	6.06±0.0^{a}	0.61±0.0^{c}	159.48±0.1^{c}	6.00±1.0^{ab}	0.72±0.2^{a}	6.39±0.4^{b}	1.70±0.3^{c}
D	6.06±0.0^{a}	0.33±0.0^{b}	461.22±1.3^{d}	5.80±0.8^{a}	0.70±0.1^{a}	6.61±0.1^{b}	1.28±0.2^{b}
E	6.29±0.0^{c}	0.27±0.0^{a}	573.70±0.6^{e}	5.70±0.8^{a}	0.70±0.1^{a}	6.6±0.5^{b}	0.73±0.0^{a}

Proximate Composition of Flour Samples

Moisture content of the samples ranged from 4.71 - 8.91% for all the samples which are used to produce cookies. Flour produced from 100% fonio had the highest value of moisture content (8.91%) while sample with 20: 80% coconut to fonio flour had the lowest value (4.71%). The fonio and coconut flours are low in moisture content because they were dried before prior to cookie production, and this will increase their storage stability.

The protein content of the samples ranged from 5.98% to 7.51%. Sample with 100% fonio had the highest protein content of 7.51%. It was observed that the protein content increased with increase in fonio, this shows that fonio is rich in protein.

The protein content of fonio flour as reported by Olapade *et al.* (2011) was 7.41% which is a bit lower than the one obtained for fonio mixes in this study. Protein is needed as building blocks for the body, necessary for the growth and the repair of damaged tissues (Wardlaw, 2004). Alternative use of fonio and coconut flour in cookie production shows that protein can also be obtained from other cereal products. The fat content of the samples ranged from 2.13 to 43.08%. Sample with 100% coconut had the highest value for fat content 43.08%. Fat is a rich source of energy and is essential as carrier of fat soluble vitamins: A, D, E and K. The highest value of crude fibre (8.1%) was obtained from 100% coconut while the lowest value (2.67%) was obtained from 100% fonio (Table 2). Coconut is a rich source of crude fibre. Proper use of fibre in diet is an essential requirement for maintaining good health. It helps in reduction of blood insulin and postprandial glucose. Lack of its intake in diet can lead to constipation, diverticulation, cardiovascular diseases and cancer (Chen *et al.,* 1988). Generally dietary fibre acts as non-caloric bulking agents, increase water holding and retaining capacities and also enhances oxidation stability. Dietary fibres positively affect structural and physical properties of food, sensory characteristics, texture and shelf-life of product (Elleuch *et al.,* 2011).

The ash content of the five samples ranged from 0.30 to 0.49% with 100% fonio having the highest

value. The high ash content indicates high level of minerals in the cookie produced. The ash content of the samples increased with increase in fonio flour. Carbohydrate content of the samples ranged from 29.05% to 78.30%. Flour produced from 100% coconut had the lowest carbohydrate content of 29.05% while 100% fonio had the highest value of 78.30%. The increase in the value of carbohydrate is as a result of the increase in the fonio content. It was observed from the result in Table 2 that as level of coconut in the mixes increased, the carbohydrate content decreased, and the crude fibre content increased. The low carbohydrate content and increased fibre content have several health benefits, as it aids digestion in the colon and reduce constipation often associated with products from refined grain flours (Elleuch *et al.,* 2011). The 100% whole fonio flour had the highest percentage carbohydrate content of 78.30.

Table 2. Proximate composition of flour from fonio and coconut

Sample	Moisture (%)	Protein (%)	Fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
A	8.91±0.0^{d}	7.51±0.0^{d}	2.13±0.0^{a}	2.67±0.1^{a}	0.49±0.00^{d}	78.30±0.01^{e}
B	6.93±0.0^{b}	7.21±0.0^{c}	4.92±0.0^{b}	3.76±0.3^{b}	0.45±0.00^{c}	76.74±0.3^{d}
C	7.68±0.3^{c}	6.19±0.0^{b}	8.38±0.0^{c}	4.23±0.1^{c}	0.42±0.00^{c}	73.11±0.4^{c}
D	4.71±0.3^{a}	6.11±0.0^{ab}	51.57±0.1^{e}	6.35±0.0^{d}	0.37±0.0^{b}	39.39±0.3^{b}
E	5.00±0.1^{a}	5.98±0.1^{a}	43.08±0.0^{d}	8.10±0.0^{e}	0.30±0.00^{a}	29.05±0.3^{a}

Values are mean ± standard deviation of triplicate determinations. Means with different superscripts are significantly different ($P < 0.05$).

Sample A – 100% Fonio flour, Sample B – 90% Fonio, 10% Coconut; Sample C –20% Coconut, 80% Fonio; Sample D –20% Fonio, 80% Coconut; Sample E – 100% Coconut

Table 3. Sensory evaluation of cookies from blend of fonio and coconut flour

Sample	Colour	Flavour	Taste	Crispness	Texture	Overall acceptability
A	6.76±0.1^{ab}	6.76±0.9^{bc}	6.68±1.2^{c}	6.84±1.0^{a}	7.06±1.3^{b}	7.36±1.2^{c}
B	7.02±1.6^{b}	6.82±1.6^{bc}	6.67±1.5^{c}	6.92±1.10^{a}	7.04±1.0^{b}	7.25±1.6^{bc}
C	7.00±1.2^{b}	6.96±1.3^{c}	7.48±0.9^{d}	7.08±0.9^{a}	7.16±0.9^{b}	7.40±1.1^{c}
D	6.28±0.9^{a}	6.16±1.3^{a}	5.52±1.6^{a}	5.24±1.2^{a}	5.56±1.6^{a}	6.04±1.2^{a}
E	6.65±1.2^{ab}	6.37±1.4^{ab}	6.14±1.4^{b}	6.71±1.5^{a}	6.22±1.3^{b}	6.80±1.4^{b}

Values are mean ± Standard deviation of triplicate determinations. Means with different superscripts are significantly different ($P < 0.05$).

Sample A – 100% Fonio flour; Sample B – 90% Fonio, 10% Coconut;
Sample C –20% Coconut, 80% fonio; Sample D – 20% Fonio, 80% Coconut;
Sample E – 100% Coconut



a



b



c

Plate 1: (a) Fonio grains (b) Fonio flour (c) Pictorial view of coconut flour

Physicochemical properties of the samples

The results of the functional properties of the flours are presented in Table 2. Water absorption capacity ranged from 124.96 to 573.70 g/ml. The water absorption capacity increased from 124.96 g/ml in 100% fonio to 573.7 g/ml in 100% coconut flour. Water absorption capacity increased with increase in coconut flour. Water absorption capacity is also the ability of a product to link or connect with water under a condition where water is limiting (Otegbayo et al., 2013). Madu (2007) stated that water absorption capacity enables bakers to add more water to dough and so improve handling characteristics and maintain freshness of the baked products.

Bulk density of the samples had the highest value (0.81g/ml) in sample with 100% fonio and the lowest value (0.27 g/ml) in sample with 100% coconut. It was observed that the bulk density increased as fonio increased in the mix. There was significant difference ($P < 0.05$) in the bulk densities of all the samples.

The higher the bulk density, the denser the packaging material required. It indicates the porosity of a product which influences the package design and could be used in determining the type of packaging material returned (Iwe and Onadipe, 2001). Low bulk density of flours has been reported to be useful for food formulation and such products have less retrogradation (Oladele and Aina, 2009). The pH of the samples ranged from 6.06 to 6.29. Acidic products are more shelf stable than non-acidic counter parts (Ikpeme *et al.,* 2010) and all the samples in this study were slightly acidic.

Free fatty acid ranged from 0.73 to 1.97%. Sample with 100% fonio had the highest value (1.79%) while sample with 100% coconut had the least free fatty acid (0.73%). The values for the free fatty acid were significantly different ($p < 0.05$). The value for free fatty acid increased as fonio increased in the mixes. Kechkin *et al.* (2020) reported that the higher the fatty acid value of the food grain the "older" the grain is. Higher value of FFA could be due to the longer storage of the grain before utilization.

Sensory attributes of the cookies produced from fonio/coconut flours

The result of the sensory evaluation is shown in Table 3. The cookies made with 80% fonio and 20% coconut flour were rated best for colour, flavour, taste, crispiness and overall acceptability among the treatments. In terms of overall acceptability, cookies made from 80% fonio and 20% coconut flour and 90% fonio and 10 % coconut flour, did not differ significantly ($p<0.05$) from the control. The flavour of coconut flour possibly enhanced the taste and aroma of the cookies. All the samples attributes scores above 5 which indicates like moderately.

Conclusion

The cookies produced, have relatively high protein, crude fibre, ash and carbohydrate which are all desirable for good health and wellbeing. They also possess good physical and physicochemical attributes suitable for cookies production. The use of fonio and coconut in cookies will go a long way in enhancing food and nutrition security, health and wellbeing of the consumers. It will also reduce over dependence on wheat flour, thereby saving the huge foreign exchange used in importing wheat, for other projects. Incorporation of fonio and coconut flour into the production of snacks especially cookies should be encouraged.

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