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Comparative Quality Evaluation of Biscuit supplemented with Bambara Groundnut Protein Isolate and defatted Flour

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Abstract

Biscuits were produced from composite flour (wheat flour, defatted bambara groundnut flour, bambara groundnut protein isolate). Five samples of the cookies were produced from the composite flour formulation. Bambara groundnut flour was obtained by soaking, dehulling, drying and milling the bambara groundnut. Sample EMO (100 % wheat flour), served as the control. Others were sample DMO (80 % wheat flour and 20 % bambara groundnut defatted flour) formulation, sample CMO (70 % wheat flour and 30 % bambara groundnut defatted flour) formulation, sample BMO (80 % wheat flour and 20 % bambara groundnut protein isolate) formulation and sample AMO (70 % wheat flour and 30 % Bambara groundnut protein isolate) formulation. Wheat flour, defatted bambara flour, bambara isolate flour and cookies were evaluated for the composition. Proximate composition, anti-nutritional factors, functional properties of the flours were evaluated. Cookies developed from the composite flours were also evaluated for proximate composition, physical attributes and consumer acceptability. Results showed that substitution of wheat flour with bambara groundnut defatted flour and protein isolate contributed to a progressive in the protein content (up to 100 % increment). Also it was noted that with increase in bambara groundnut flour in the two blends of varying proportions there was significant increase ($p < 0.05$) in the protein (12.37 – 26.20). The addition of bambara groundnut flour decreased the water absorption capacity of composite flour from the two blends. With respect to the sensory analysis, there was no significant difference in terms of colour, taste, flavour, appearance and overall acceptability between samples with defatted flour and isolate.

Keywords: Bambara Groundnut Composite Flour, Protein Isolate, Biscuit

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Introduction

Increasing urbanization in African countries is changing the food habit and preference of the population towards convenience foods. Change in consumption pattern towards biscuit and similar foods made from wheat flour has become very popular in Nigeria. This has led to nutritional disorders and socio-economic implications such as high cost of wheat importation as it cannot be grown here in Nigeria (Alozie et al., 2009). Research efforts in developing countries have been focused on the improvement of protein quality of cereal products and other tuber crops (Kiin-kabari and Banigo, 2016). Enrichment of cereal-based products (biscuits) with other protein sources such as oil seeds and legumes (Bambara groundnut) has received considerable attention to fight malnutrition (O'Sullivan and Sheffrin 2003)

Bambara groundnut is a type of legume Fabacea. The leguminous crop (Vigna subterrenea) is an indigenous, underutilized secondary food crop in semi – arid Africa (Adjetey and Sey, 1998), and is widely produced in Nigeria, in Borno, Taraba, Anambra, Sokoto, Bauchi, Benue, Yobe, Adamawa, and Gombe states (Atiku, 2000). They can be eaten fresh or boiled after drying and have potential in Agriculture as cover crops, green manure and mulch as they improve soil fertility by fixing Nitrogen. Bambara groundnut (Vigna subterrenea) has been found to contain carbohydrate (54.5-69.3 %), proteins (17-24.6 %), fat (5.3- 7.8 %) and calories (367- 414 Kcal) per 100 g. It is a good source of fibre, calcium, iron, and potassium. It is unusually high in methionine, an essential sulphur –containing amino acid. The beans have a potential for acting as a substitute and providing a balanced diet in areas where animal protein is expensive and cultivation of other legumes is risky because levels are unfavourable. Bambara groundnut (Vigna subterranean) is an important legume consumed in many parts of Nigeria. Despite its nutritional potentials, Bambara groundnut, like common food legume, has not attained full utilization in the local diet due partly to its hard to cook phenomenon, pronounced beany and often offensive flavour and high degree of anti-nutritional factors (Akinjayeju and Bisiriju, 2004). Adegbanke et al., (2019) produced cookies from wheat flour which was enriched with bambara groundnut flour at different levels of substitution.

In recent years, the need for less expensive proteins and the growing demand for alternatives to meat have increased interest in the potential of legume as a source of edible vegetable protein such as defatted bambara groundnut flour. Hence, the research is aimed at producing Bambara groundnut flour isolate to supplement wheat flour at different ratios in order to formulate a healthy and more nutritionally beneficial alternative to conventional biscuits.

Materials And Methods

Materials: The Bambara groundnut seeds were purchased at Owena market along Akure Ilesha road in Osun State, Nigeria. The equipment and chemicals used were obtained from the Department of Food Science and Technology, Federal University of Technology, (FUTA) Akure, Ondo State, Nigeria. The chemicals and reagents used were of analytical grade.

Methods

Preparation of the Bambara groundnut flour

The flour was processed with slight modification according to Mune et al., 2011. Bambara groundnut seeds were sorted to remove extraneous materials and damaged seeds. The seeds were then soaked in tap water at a ratio of 1:2 for 24 h at room temperature. It was mechanically dehulled using the attrition mill and dried in the moisture extraction oven at 60 oC for 24 h. The dried seeds were finely ground using the hammer mill to obtain the flour.

Preparation of defatted flour

The dehulled seeds were equilibrated at 20 % moisture and passed through a flaking machine to obtain flakes of 0.3 mm thickness and dried to 5 % moisture level. Defatted flakes were obtained by repeated extraction with n-hexane until the fat content was less than 1%. The defatted flakes was then dried at 50 °C and passed through a quadrumat mill having standard sieves with sizes below 100 um and finally sieved. This was carried out according to Aremu et al., (2007)

Preparation of protein isolate

The protein isolate was carried out according to Aremu et al., (2007). The Bambara groundnut defatted flour was dispersed in distilled water, the pH was increased to pH 10 with the aid of 1N NaOH and stirred for 3 hours at room temperature using a mechanical stirrer. Following centrifugation at 3000 X g., the supernatant was collected and the pH adjusted to 4.5. The precipitated protein was then recovered by centrifugation at 3000 X g, and the pH adjusted to 7.0 and dried by an oven at a low temperature (40-50 °C).

Formulation of composite flour

The flour used for biscuit production was obtained from blends of Bambara groundnut protein isolate, defatted flour and wheat flour. The composite flour was obtained by blending in the ratio of 70:30; 80:20; for wheat flour: Bambara groundnut flour protein isolate, 70:30; 80:20; wheat flour: Bambara groundnut defatted flour. The 100 % wheat flour cookie was used as the control sample.

Product	Wheat Flour %	Bambara Flour Isolate%
AMO	70	30
BMO	80	20
Product Code	**Wheat Flour%**	**Bambara Flour Defatted%**
CMO	70	30
DMO	80	20
EMO	100	0

Table 1: Formulation of composite flour

Production of biscuit

The method used for the preparation of dough was the creaming method where fat and sugar were creamed together using a mixer at medium speed for 2 min. After creaming, flour, baking powder and milk were added and mixed until the dough was well mixed and the dough was manually kneaded to ensure uniformity. The dough was then transferred to a clean tray and gently rolled using a roller. The dough sheath was then cut into round shapes using a cutter.

Biscuit was produced according to the method of by Okaka (1997). The fat and sugar were mixed until fluffy. Egg and milk were added while mixing continued for about 40 min appropriate amounts of flour, baking powder, and nutmeg, vanilla flavouring and salt were slowly added into the mixture. The dough was rolled and cut into circular shapes of 5 cm diameter. Shaped dough pieces were placed into a greased pan and baked in the oven at 160 oC for 25 min. The baked biscuits were then placed on a cooling rack for 30 min to cool before packaging.

Analyses

Proximate Analysis: The proximate composition: moisture content, crude protein, crude fat, crude fiber and ash content were determined according to AOAC (2005). The carbohydrate content was calculated by difference.

Anti-nutritional Factors: Anti-nutritional factors which include tannin, phytate and oxalate were determined according to AOAC (2001) method.

Functional Properties: Water absorption capacity, Oil absorption capacity were determined according to the method of Adebowale et al. (2005). Bulk density was determined according to the method of Asoegwu et al. (2006).

Determination of Physical Properties: Weight according to Ayo et al. (2007), Diameter according to (AACC, 2000), Height according to Giami and Barber (2004) and Spread ratio according to Gomez et al. (1997).

Sensory Evaluation: Coded samples of the biscuits were presented to twenty untrained panellists to check for the following attributes: colour, flavour, taste, appearance, crispness and overall acceptability of the products using a 9-point hedonic scale. 100 % wheat flour biscuit was used as control.

Statistical Analysis: All analysis were carried out in triplicates and they were analysed using Analysis of Variance. Data obtained were subjected to statistical analysis (ANOVA) using Statistical Package for the Social Sciences, SPSS (version 16). Mean values were separated using Duncan's New Multiple Range (DNMR) test and significance difference was accepted at 5 % confidence level.

Results And Discussion

Chemical Composition of Bambara Groundnut and Wheat Flour

The proximate composition of both bambara groundnut flour and wheat flour were determined and presented in Table 1. It was observed that the protein content, 22.75 ± 0.00 %, of bambara flour was higher than that of wheat flour, 11.15 ± 1.10. However the fat content of the wheat flour, 14.89 ± 0.29, was higher than bambara flour, 12.48 ± 0.04. The moisture content of wheat flour, 8.94 ± 0.35, was less than that of bambara flour, 11.24 ± 0.23. The protein content of the proximate composition is in accordance with the report of Adeleke et al., (2018) wherein the bambara flour had higher protein content.

Samples	Moisture(%)	Fat(%)	Ash(%)	Fibre(%)	Protein(%)	Carbohydrate(%)
BF	9.24±0.23	8.48±0.04	0.99±0.00	0.42±0.02	22.75±0.00	58.12±0.26
wF	8.94±0.35	6.89±0.29	2.85±0.05	0.45±0.00	0.45±0.00	70.31±1.56

Table 2: Chemical composition of Bambara groundnut and Wheat flour
BF – Bambara flour, WF- Wheat flour

Anti-nutritional Factors of Bambara Groundnut Flour

The anti-nutritional factors of bambara groundnut flour is presented in Table 3. The phytate content of the flour is 3.29 %, tannin; 0.07 mg/g, oxalate; 4.51- 4.53 mg/g. This is similar to the report of Okafor et al., (2014) who reported the tannin content of bambara groundnut flour was 0.62 mg/g. This is of significant importance because high tannin content in food could have harmful effects such as stomach damage, nausea, vomiting, and liver damage

Sample	Phytate	Oxalate	Tannin
BF	3.29±0.00	4.51±0.02	0.07±0.0

Table 3: Anti-nutritional Analysis of Bambara groundnut flour (mg /100g)
BF- Bambara flour

Proximate Composition of Biscuits from Wheat-Bambara Defatted Flour and Protein Isolate Composite Flours

The moisture value ranged from 3.03 % to 8.40 % for all the samples with sample DMO the largest at 8.40 % and sample AMO been the least with a value of 3.03 %, while for ash the value ranged from 1.58 % to 2.51 % with sample BMO the highest at 2.51 %, and the lowest being sample EMO with a value of 1.58 %. The reason for this value might be due to processing conditions that the sample was subjected to. The fat content ranged from 16.22 % to 12.69 %. The values of fibre ranged from 3.11 % to 2.19 %. The protein content was highest in sample AMO with a value of 26.20 % while the lowest in sample EMO with a value of 12.37 %. Protein in the supplemented biscuit samples increased from 17.41 % to 21.22 % in sample DMO and 22.72 % in sample CMO and BMO, and 26.20 % in sample AMO. This is in agreement with the study of Arisa et al., (2013) which recorded an increase in the protein content in the production of cookies with composite flour.

Samples	M.C(%)	Ash(%)	Fat(%)	Fber(%)	Protein(%)	CHO(%)
AMO	$3.03±0.04^d$	$1.94±0.03^b$	$12.69±0.00^e$	$2.82±0.00^a$	$26.20±0.03^a$	$53.3±0.03^b$
BMO	$5.73±0.12^b$	$2.51±0.20^a$	$13.54±0.05^d$	$2.26±0.03^c$	$22.72±0.01^b$	$53.24±0.04^b$
CMO	$5.39±0.01^c$	$1.71±0.02^c$	$14.56±0.04^c$	$2.19±0.02^d$	$21.22±0.13^c$	$58.27±3.44^{ab}$
DMO	$8.40±0.44^a$	$1.94±0.09^b$	$15.63±0.02^b$	$2.54±0.01^b$	$17.41±0.08^b$	$54.07±0.11^b$
EMO	$5.69±0.02^b$	$1.58±0.03^d$	$16.22±0.02^a$	$3.11±0.01^e$	$12.37±0.07^e$	$61.05±0.12^a$

Table 4: Proximate composition of the biscuits
AMO-70%WF&30%BI, BMO-80%WF&20%BI, CMO-70%WF&30%BDF, DMO- 80%WF&20%BDF and EMO- 100%WF

Functional Properties Analysis of the Composite Flours

As presented in Table 5, the oil absorption capacity of sample AMO was the highest with a value of 2.47 % followed by sample EMO with 2.30 % and DMO with 2.03 %. Samples CMO and BMO had the least oil absorption capacity with 1.93 % and 1.80 % respectively. For the water absorption capacity, the highest was sample EMO with a value of 4.03 % followed by samples DMO, CMO, BMO and AMO respectively with values 3.93 %, 3.80 %, 3.63 % and 3.33 %. Thus the 100 % wheat flour cookie had the highest affinity for water. This is significantly indicative of the fact that wheat flour confers high water binding capacity than Bambara groundnut defatted flour and protein isolate, which causes the reconstitution ability and textural properties of dough obtainable from wheat composite flour to be better than that of the composite flours. This is in accordance with the observation of Onabanjo and Dickson (2014). Sample DMO had the highest bulk density of 0.72 %, EMO had a value of 0.67 %, while AMO and CMO had the same bulk density of 0.64 %. BMO had the least bulk density posing a value of 0.58 %.

Samples	M.C(%)	Ash(%)	Fat(%)	Fber(%)	Protein(%)	CHO(%)
AMO	3.03±0.04^{d}	1.94±0.03^{b}	12.69±0.00^{e}	2.82±0.00^{a}	26.20±0.03^{a}	53.3±0.03^{b}
BMO	5.73±0.12^{b}	2.51±0.20^{a}	13.54±0.05^{d}	2.26±0.03^{c}	22.72±0.01^{b}	53.24±0.04^{b}
CMO	5.39±0.01^{c}	1.71±0.02^{c}	14.56±0.04^{c}	2.19±0.02^{d}	21.22±0.13^{c}	58.27±3.44^{ab}
DMO	8.40±0.44^{a}	1.94±0.09^{b}	15.63±0.02^{b}	2.54±0.01^{b}	17.41±0.08^{b}	54.07±0.11^{b}
EMO	5.69±0.02^{b}	1.58±0.03^{d}	16.22±0.02^{a}	3.11±0.01^{e}	12.37±0.07^{e}	61.05±0.12^{a}

Table 5: Functional properties of the Composite Flour
AMO-70%WF&30%BI, BMO-80%WF&20%BI, CMO-70%WF&30%BDF, DMO- 80%WF&20%BDF and EMO- 100%WF

Physical Characteristics of Biscuits from Wheat-Bambara Defatted Flour and Protein Isolate Composite Flours

The weight of the biscuit ranged from 12.6 g (sample DMO) to 14.7 g (sample AMO). There was significant difference (P < 0.05) between sample EMO (100 % wheat flour) and other samples AMO, BMO, CMO, and DMO when compared to others in terms of weight, height and diameter. The height and diameter of biscuit were also observed to increase gradually with increase in the level of Bambara groundnut flour for both defatted flour and protein isolate. Therefore, cookies prepared from 70 % wheat flour and 30 % Bambara groundnut protein isolate compared favourably in height, diameter and spread ratio with the control EMO. This can therefore be attributed to the reduced level of wheat flour in the blends which allowed for a wider spread ratio.
This observation is similar to the report of Giami and Barber (2004) for cookies made from a blend of wheat flour and fluted pumpkin seed protein concentrates. Also these findings are in agreement with the study of Chinma et al. (2012), who reported the addition of defatted sesame flour to unripe plantain flour in the production of composite cookies. It's in agreement with the study of Kabari et al. (2015), who also reported the production and quality assessment of enriched cookies from plantain flour and Bambara protein concentrate.

Samples	Weight	Height	Diameter	Spread Ratio
AMO	14.7±0.3^{a}	1.3±0.01^{b}	7.6±1.2^{c}	5.9±0.5^{a}
BMO	13.4±1.1^{a}	1.4±0.02^{b}	9.2±0.9^{a}	6.6±0.6^{a}
CMO	12.9±0.4^{b}	1.6±0.03^{a}	9.8±1.1^{a}	6.1±0.2^{a}
DMO	12.6±0.7^{b}	1.7±0.5^{a}	10.6±1.2^{a}	6.2±0.5^{a}
EMO	12.8±1.0^{b}	1.4±0.03^{b}	7.8±0.9^{c}	5.8±0.4^{e}

Table 6: Physical characteristics of Biscuits
AMO-70%WF&30%BI, BMO-80%WF&20%BI, CMO-70%WF&30%BDF, DMO- 80%WF&20%BDF and EMO- 100%WF

Sensory Evaluation of Biscuit from Wheat-Bambara Defatted Flour and Protein Isolate Composite Flours

With reference to general acceptability, sample AMO, BMO, CMO and DMO showed significant difference (P < 0.05) when compared to the control, EMO (100 % wheat flour) as shown in Table 7. This may be due to varying levels of constituent composite flours and their processing which led to colour darkening attributable to caramelization and Maillard reactions as reported by (Alobo, 2001). There was no significant difference (P < 0.05) in flavour between samples AMO, BMO, CMO and DMO, with varying levels of different composite flour, from the control EMO. This may be due to the bambara groundnut flour which made the beany flavour detecteable, associated with bambara groundnut (Barimalaa et al., 2005) and other food legumes (Okoye and Okaka, 2009).

Samples	Flavour	Appearance	Crunchiness	Overall Acceptability
AMO	6.60 ± 0.26^{cd}	6.75 ± 0.18^{b}	6.50 ± 0.18^{c}	6.70 ± 0.23^{c}
BMO	7.70 ± 0.21^{ab}	7.05 ± 0.18^{b}	7.40 ± 0.20^{b}	7.60 ± 0.22^{b}
CMO	6.20 ± 0.25^{d}	6.85 ± 0.15^{b}	7.25 ± 1.17^{b}	6.85 ± 0.15^{c}
DMO	7.20 ± 0.21^{bc}	7.85 ± 0.17^{a}	8.05 ± 1.20^{a}	7.75 ± 0.19^{b}
EMO	8.25 ± 0.18^{a}	7.85 ± 0.24^{a}	7.75 ± 0.22^{b}	8.40 ± 0.17^{a}

Table 7: Sensory evaluation of biscuit enriched with bambara groundnut flours
AMO-70%WF&30%BI, BMO-80%WF&20%BI, CMO-70%WF&30%BDF, DMO- 80%WF&20%BDF and EMO- 100%WF.

Conclusion

The addition of Bambara groundnut flour significantly improved the protein content, ash and crude fibre of biscuits better than biscuit from 100 % wheat flour. Bambara groundnut flour can be used to substitute wheat flour up to 30 % in the production of biscuit as the sensory characteristics were acceptable up to the level of inclusion.

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