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Chemical and Mineral Analysis of Biscuits and Cakes Produced from Acha, Soybean and Groundnut Flour Blends

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Abstract

Composite flour blends (acha, defatted soybean and groundnut flour) in the ratio of 100:0, 90:10, 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25 respectively were produced and analyzed for chemical properties. Biscuits and cakes were produced from the flour blends and the mineral contents investigated using standard methods. The chemical properties of the blends showed that sugar ranged from 1.53% to 3.66%, starch from 51.78-74.31%, amylose from 18.59 to 38.47%, while amylopectin by difference ranged from 30.52 to 45.43%. Moisture content ranged from 9.69 to 12.92%, ash from 0.40 to 1.79%, fat from 0.60 to 9.79%, crude protein ranged from 7.48 to 29.38%, crude fiber from 3.76 to 8.55%, while total carbohydrate ranged from 41.26 to 74.44%. Sugar, amylopectin, ash, fat, protein and fiber contents increased while starch, amylase, moisture, and total available carbohydrate decreased with an increase in substitution of acha flour, indicating a significant ($p<0.05$) difference. The mineral analysis result of the biscuit produced ranged from 20.55 to 65.53 mg/kg, 16.17 to 46.20 mg/kg, 7.49 to 13.23 mg/kg, 5.43 to 11.12 mg/kg and 19.59 to 68.59 mg/kg respectively for iron, calcium, potassium, zinc and magnesium. While the mineral content of the cake produced ranged from 13.15 to 44.52 mg/kg, 12.51 to 24.90 mg/kg, 7.42 to 15-21 mg/kg, 6.70 to 14.92 mg/kg and 6.77 to 56.99 mg/kg for iron, calcium, potassium, zinc and magnesium respectively.

Keywords: Chemical; Mineral; Biscuits; Cakes; Acha; Soybean; Groundnut

Introduction

Baked products provide an excellent opportunity to incorporate food-grade fractions from grains, legumes or other indigenous food sources. Cake is one the relished and palatable baked product prepared from flour, sugar, shortening, baking powder, egg and essence as principal ingredients [1]. Biscuits are variety of quick breads popular in different forms. This simple dough is generally rolled out, cut into small rounds, baked and served hot according to Wheat food council [2]. They are made from a combination of flour, shortening, leavening and milk or water. Acha (*Digitaria exilis*) commonly referred to as fonio, hungry rice Jideani & Akingbala [3] is probably one of the oldest of African cereals [4]. The grains are widely produced in Northern Nigeria and used for human nutrition. They are processed and consumed as 'tuwo', 'kunu', 'gote'and whole grains in soup and porridge [5].

Acha is reported to have a high pentosan (3.3%), hence high water absorption capacity that could be utilized in baked goods Lasekan [6] and relatively evokes low sugar on consumption Ayo, et al. [7], an advantage for diabetes. Consumption of various bakery and confectionary products is in high demand of time due to change in food habit of people. Supplementing cereal flour with inexpensive stable legumes/pulses such as soybean and groundnut would help to improve the nutritional quality of cereal based products. Hence the aim of this study is to improve the quality of acha based biscuit and cake.

Materials and Methods

Acha *Digitaria exilis* (white) was bought from Kasuwon Monday Gurmin Gwari Kaduna, soybean Glycine max and groundnut Arachis hypogeal, wheat flour, sugar, baking fat, eggs, milk, salt and baking powder were bought from Mile 3 market Diobu, Port Harcourt.

Preparation of Acha Flour

Acha was manually cleaned by washing in clean tap water using local calabash to wash and de-stoned by sedimentation. Drained and dried in cabinet drier at 50°C for 6 hrs. The resultant dried acha was milled into flour using hammer mill (2014, hot model PC 180), according to Olapade, et al. [8].

Preparation of Defatted Soybean Flour

Soybean was sorted and thoroughly washed in clean water running water and then sundried for 3-4 hours (tempering). The tempered seeds were cracked in an attrition type mill. Soybean hulls were removed by manual winnowing and then soaked in water for 24hours. It was then washed in clean running water and the grit boiled for 5mins at 100°C, decanted and dried in an electric oven at 60°C for 12hours and thereafter dried soybean grit was milled to flour. The flour was mixed with food grade hexane and allowed to stand for 1hour before it was desolventized, pouring into a muslin cloth and pressed using screw press and the residue oven dried at 70°C for 6hours to obtain defatted soybean flour, according to the method of Clyde [9].

Preparation of Defatted Groundnut Flour

Groundnut seeds were sorted to remove extraneous materials. Sorted seeds were subjected to roasting in aluminium pot over charcoal fire and stirred at intervals to ensure proper roasting for 20-25mins. Roasted seeds were allowed to cool and dehulled manually by rubbing and winnowing. The roasted seeds were milled in laboratory attrition mill. The milled flour was diluted with food grade hexane at a ratio of 500g: 200ml of hexane and allowed to stand for 1hour. It was then desolventized by pouring into a muslin cloth and pressed with a screw press. The residue was oven dried at 70°C for 6hours to obtain defatted groundnut flour, according to Fekria, et al. [10].

Preparation of Flour Blends

Acha, defatted soybean and groundnut flour were properly mixed in different ratios. 100% acha flour was used as control and substitution up to 50% for both defatted soybean and groundnut flour respectively (Table 1).

S/No	Sample Codes	Ratio of Components
1	A	100:00:00
2	AS	90:10:00
3	AG	90:10:00
4	ASG	90:05:05
5	ASG	80:10:10
6	ASG	70:15:15
7	ASG	60:20:20
8	ASG	50:25:25

Table 1: Blend Formulation.
Keys: A = Acha flour, AS= Acha/defatted Soybean flour, AG= Acha/defatted Groundnut flour, ASG= Acha/defatted Soybean/defatted Groundnut flour.

Preparation of Biscuit

Biscuits were prepared from the blends and 100% wheat flour used as control according to Olapade, et al. [8]. The sugar and baking fat were creamed together until light and fluffy. Egg and flour were added to the mixture followed by milk, salt and baking powder. The mixture was thoroughly mixed into consistent dough. The dough was rolled on flat surface and cut into predetermined size and shape using a biscuit cutter. The dough was arranged in pre-oiled trays and baked in a preheated laboratory oven at 180°C for 12min. The biscuits were allowed to cool to room temperature before packaging in air tight Ziploc and stored for sensory evaluation (Table 2).

Ingredient	Amount (g)
Flour	200
Sugar	100
Baking fat	100
Eggs	1 (Large)
Milk	30
Salt	1
Baking powder	1

Table 2: Recipe for the production of Biscuit.

Preparation of Cake

The method of Ceserani, et al. [11] was adapted with slight modification for the preparation of cake. The margarine and sugar were creamed manually for 10min in a stainless steel bowl until light and fluffy. The egg was beaten for 3mins and added to the creamed mixture gradually while beating continuously. Flour samples from various composite blends and baking powder were separately weighed and properly mixed and folded and gradually folded into the mixture until batter was formed. The batter was transferred into a cup cake pan and baked in a pre-heated oven at 150°C for 45mins. Baked cake was allowed to cool and packed in airtight Ziploc bags for sensory evaluation (Table 3).

Ingredient	Amount (g)
Flour	200
Sugar	120
Margarine	120
Egg	200
Baking powder	1

Table 3: Recipe for the production of Cake.

Chemical Properties

The moisture content, ash, protein, crude fibre, fat and carbohydrate were determined according to a procedure described by AOAC [12]. Amylose content of samples was determined by the method described by Williams, et al. [13], while amylopectin was calculated by difference as reported by Eke- Ejiofor & Deedam [14]. Starch and sugar was determined by the method described by Eke [15].

Mineral Analysis

The Mineral content of the samples was determined using the wet method as described by Onwuka [16]. Calcium, iron, zinc, potassium and magnesium element content was determined by atomic absorption spectrophotometer.

Statistical Analysis

Data obtained for all the analysis carried out was subjected to statistical analysis using the software SPSS for windows version 21.0 statistical package (SPSS Inc.) and the significant differences between the means were analyzed using Duncan Multiple Range Test. All statistical tests were performed at 5% significant level.

Results and Discussion

Table 4 shows the chemical analyses result of blends. Sugar, ash, fat, and fiber content showed a significant increase ($p<0.05$) with increase in substitution of defatted soybean and groundnut flour which ranged from 1.53 to 3.66%, 0.40 to 1.79%, 0.60 to 9.79% and 3.76 to 8.55% respectively, with a corresponding decrease in starch, amylose, amylopectin, moisture and carbohydrate contents with values ranging from 74.31 to 51.78%, 38.47 to 18.59%, 45.43 to 33.19%, 12.92 to 9.69% and 74.44 to 41.26% respectively, as the level of substitution of defatted soybean and groundnut flour increased. The results obtained were within the findings of Andrew [17] who reported that 68% of carbohydrate in acha consists of starch with 75% of that coming from amylopectin and 25% from amylose. The high level of carbohydrate is desirable in the presence of water for baked products because it forms a gel which is important for the characteristic texture and structures of baked goods [18]. There was a significant decrease ($p<0.05$) in carbohydrate content from 74.44 to 41.26% with a corresponding significant increase ($p>0.05$) in energy as the substitution of defatted soybean and groundnut flour increased. This decrease in carbohydrate was expected with increase in protein and fat content which resulted in dilution effect [19]. Like most grains, acha has little soluble sugars of about 1%. The result also indicated that acha flour contained low amount of protein and fat 7.48% and 0.60% respectively, which increased significantly ($p<0.05$) with increase in defatted soybean and groundnut flour substitution to 29.38% and 9.79(%) for protein and fat respectively. There was a significant increase in ($p<0.05$) in ash content and crude fibre as the substitution of defatted soybean and groundnut flour increased. Crowford [20] reported that majority of the carbohydrate in soybean can be classified as dietary fiber (Table 4).

Samples	Sugar	Starch	Amylose	Amylopectin	MC	Ash	Fat	Crude Protein	Crude Fibre	TAC
A	1.92^{f}	74.31^{a}	28.90^{d}	45.43^{a}	12.68^{ab}	0.40^{de}	0.60^{h}	7.48^{f}	4.16^{c}	74.44^{a}
AS	2.08^{d}	64.76^{ab}	25.75^{e}	39.01^{abc}	12.46^{ab}	1.79^{a}	1.79^{g}	12.24^{e}	7.11^{b}	66.26^{b}
AG	1.53^{g}	68.99^{ab}	38.47^{a}	30.52^{c}	12.92^{ab}	0.25^{e}	3.19^{e}	11.83^{e}	3.97^{c}	67.85^{b}
ASG	1.97^{ef}	63.61^{ab}	29.92^{b}	37.33^{abc}	13.09^{a}	0.65^{cd}	2.59^{f}	11.83^{e}	4.69^{c}	67.20^{b}

ASG	2.05^{de}	68.78^{ab}	29.29^{c}	34.32^{abc}	11.36^{abc}	0.89^{c}	3.77^{d}	17.48^{d}	3.76^{c}	62.73^{c}
ASG	2.53^{b}	59.71^{ab}	24.21^{f}	44.57^{ab}	11.14^{bc}	1.35^{b}	5.77^{c}	21.44^{c}	4.49^{c}	55.82^{d}
ASG	2.28^{c}	51.78^{cd}	19.37^{g}	40.34^{abc}	10.47^{c}	1.60^{ab}	6.84^{b}	26.45^{b}	7.15^{b}	47.20^{e}
ASG	3.66^{a}	64.90^{d}	18.59^{h}	33.19^{bc}	9.69^{c}	1.60^{ab}	9.79^{a}	29.38^{a}	8.53^{a}	41.26^{f}

Table 4: Chemical analysis (%) result of Acha, defatted Soybean and Groundnut flour blends.
Means with same superscripts in the same column are not significantly differently DMRT (p≥0.05)

KEYS

A = Acha flour
AS =Acha flour/defatted soybean flour
AG =Acha flour/defatted groundnut flour
ASG =Acha flour/defatted soybean/groundnut flour
A (100:0) = Acha flour 100%
AS (90:10) = Acha flour 90%, Soybean flour 10%
AG (90:10) = Acha flour 90% Groundnut flour 10%
ASG (80:10:10) = Acha flour 80%, Soybean flour 10%, Groundnut flour 10%
ASG (70:15:15) = Acha flour 70%, Soybean flour 15%, Groundnut flour 15%
ASG (60:20:20) = Acha flour 60%, Soybean flour 20%, Groundnut flour 20%
ASG (50:25:25) = Acha flour 50%, Soybean flour 25%, Groundnut flour 25%
MC= Moisture Content
TAC=Total Available Carbohydrate

Table 5 shows the mineral analysis result of the biscuit samples produced from blends of acha, defatted soybean and groundnut flour. Results shows that iron ranged from 20.55 to 65.53 (mg/kg), with sample has the least and sample F as the highest, indicating that the inclusion of soybean and groundnut impacted on the iron (Fe) content depending on the blend. Dabels, et al. [21] reported a range of 6.98 to 39.82 (mg/100 g) irons for cookies produced from blends of wheat, acha and mung beans.

Samples	Fe	Ca	K	Z	Mg
A (A)	55.99±0.05^{c}	46.20±0.08^{b}	12.50±0.03^{b}	11.12±0.02^{a}	68.59±0.01^{a}
B (AS)	29.65±0.01^{g}	16.17±0.08^{h}	8.94±0.03^{e}	8.69±0.01^{b}	27.76±0.07^{e}
C (AG)	46.81±0.09^{d}	39.41±0.00^{c}	11.34±0.03^{d}	4.91±0.00^{f}	20.09±0.01^{g}
D (ASG)	58.46±0.17^{b}	20.14±0.09^{g}	11.80±0.09^{c}	8.73±0.01^{b}	56.62±0.01^{b}
E (ASG)	33.05±0.05^{f}	25.55±0.23^{d}	9.00±0.03^{e}	6.17±0.02^{d}	43.17±0.02^{c}
F (ASG)	65.53±0.06^{a}	44.48±0.11^{a}	13.23±0.07^{a}	10.99±0.01^{a}	38.91±0.01^{d}
G (ASG)	35.32±0.08^{e}	22.69±0.15^{f}	7.66±0.00^{f}	6.53±0.30^{c}	21.59±0.03^{f}
H (ASG)	20.55±0.05^{h}	23.02±0.08^{e}	7.49±0.00^{g}	5.43±0.01^{e}	19.59±0.01^{h}

Table 5: Mineral analyses (mg/kg) result for Biscuit produced from blends of Acha, defatted Soybean and Groundnut flour.
Means with the same subscript in the same column are not significantly different (p≥0.05)

Keys

A= Acha flour
AS= Acha flour/defatted soybean flour
AG= Acha flour/defatted groundnut flour
ASG= Acha flour/defatted soybean/defatted groundnut flour
A (100:0)= Acha flour 100%
AS (90:10)= Acha flour 90%, Soybean flour 10%
AG (90:10) = Acha flour 90% Groundnut flour 10%
ASG (80:10:10) = Acha flour 80%, Soybean flour 10%, Groundnut flour 10%
ASG (70:15:15) = Acha flour 70%, Soybean flour 15%, Groundnut flour 15%
ASG (60:20:20) = Acha flour 60%, Soybean flour 20%, Groundnut flour 20%
ASG (50:25:25) = Acha flour 50%, Soybean flour 25%, Groundnut flour 25

Calcium and potassium content ranged from 16.17 to 46.20 (mg/kg) and 7.49 to 13.23 (mg/kg) respectively, showing a significant decrease ($p \leq 0.05$) with increase in the level of substitution of defatted soybean and groundnut flour with the exception of sample ASG (70:15:15) which indicated an increase for both calcium and potassium. The values for calcium and potassium are lower than values reported by Ndife, et al. [22] which ranged from 30.48 to 65.26 (mg/100g) and 412.47 to 460.82 (mg/100g) respectively, for cookies produced from blends of whole-wheat and soybean flour. The observed variations could be as a result of the different cereals used for the flour blends.

Zinc content ranged from 5.43 to 11.12 (mg/kg) showing a significant decrease ($p<0.05$) with increase in level of substitution of defatted soybean and groundnut flour with the exception of sample ASG (70:15:15) with 15% substitution each of both defatted soybean and groundnut flour which was not significantly different ($p \geq 0.05$) from (100% acha). The value obtained were slightly higher than values reported by Dabels, et al. [21] which ranged from 2.71 to 6.00 (mg/100g) for cookies produced from blends of wheat, acha and mung beans. Inadequate intakes of micronutrients (iron and zinc) have been associated with severe malnutrition [23].

Magnesium content, ranging from 19.59 to 68.59 (mg/kg) showed a significant decrease ($p<0.05$) with increase in substitution of defatted soybean and groundnut flour with (100% acha) flour having the highest value. This is expected as acha has been reported to be high in magnesium with a value of 849.0(mg/kg) according to Victor, et al. [24]. Biscuit from sample ASG (70:15:15) stood out in all the mineral analysis with the exception of magnesium.

Samples	Fe	Ca	K	Z	Mg
A (A)	44.52 ± 0.04^{a}	21.62 ± 0.00^{d}	10.09 ± 0.03^{d}	10.06 ± 0.01^{d}	56.99 ± 0.01^{a}
B (AS)	13.15 ± 0.07^{h}	12.51 ± 0.58^{g}	15.21 ± 0.06^{a}	14.92 ± 0.02^{a}	25.59 ± 0.07^{d}
C (AG)	19.96 ± 0.08^{g}	24.90 ± 0.16^{a}	13.42 ± 0.11^{b}	10.80 ± 0.02^{b}	20.31 ± 0.02^{f}
D (ASG)	35.33 ± 0.05^{b}	21.10 ± 0.20^{e}	10.84 ± 0.12^{c}	10.31 ± 0.02^{c}	54.89 ± 0.14^{b}
E (ASG)	31.07 ± 0.05^{e}	19.49 ± 0.06^{f}	7.69 ± 0.04^{f}	8.71 ± 0.05^{e}	20.43 ± 0.07^{e}
F (ASG)	33.99 ± 0.09^{c}	21.96 ± 0.16^{cd}	8.50 ± 0.04^{e}	7.83 ± 0.02^{f}	32.46 ± 0.07^{c}
G (ASG)	31.21 ± 0.05^{d}	22.60 ± 0.09^{b}	7.43 ± 0.03^{g}	7.84 ± 0.01^{f}	17.46 ± 0.11^{g}
H (ASG)	24.18 ± 0.09^{f}	22.24 ± 0.35^{bc}	6.89 ± 0.03^{h}	6.70 ± 0.02^{g}	16.77 ± 0.01^{h}

Table 6: Mineral analyses (mg/kg) result of Cakes produced from blends of Acha, defatted Soybean and Groundnut flour. Means with the same subscripts in the same column are not significantly different ($p \geq 0.05$)

Keys

W= Wheat flour (Control)
A= Acha flour
AS= Acha flour/defatted soybean flour
AG= Acha flour/defatted groundnut flour
ASG= Acha flour/defatted soybean/defatted groundnut flour
A (100:0) = Acha flour 100%
AS (90:10) = Acha flour 90%, Soybean flour 10%
AG (90:10) = Acha flour 90% Groundnut flour 10%
ASG (80:10:10) = Acha flour 80%, Soybean flour 10%, Groundnut flour 10%
ASG (70:15:15) = Acha flour 70%, Soybean flour 15%, Groundnut flour 15%
ASG (60:20:20) = Acha flour 60%, Soybean flour 20%, Groundnut flour 20%
ASG (50:25:25) = Acha flour 50%, Soybean flour 25%, Groundnut flour 25%

The mineral analysis for the cake samples in (Table 6) showed that iron and magnesium content varied from 13.15 to 44.52 (mg/kg) and 16.77 to 56.99 (mg/kg) respectively. The result showed a significant decrease ($p<0.05$) with increase in substitution of defatted soybean and groundnut flour for both minerals. This could be attributed to the fact that acha have been reported to be high in iron and magnesium with values as high as 133.6 (mg/kg) and 849.0 (mg/kg) according to Victor, et al. [24]. Magnesium is involved in making proteins and releasing energy and also it helps hold calcium in the enamel of the teeth [25]. Potassium and zinc varied from 7.42 to 15.21 (mg/kg) and 6.70 to 14.92 (mg/kg) respectively indicating a significant increase ($p<0.05$) with increase in the level of substitution of defatted soybean and groundnut flour though a decrease from 20% level of

substitution and below. Sample AS (90:10) recorded the highest value for both potassium and zinc. Soybean is reported to be high in potassium according to Lokuruka [26]. Ibeanu, et al. [27] reported a range of 1012 to 2310 (mg/100g) and 6.02 to 9.97 (mg/100g) for potassium and zinc respectively for cake produced from blends of unripe and ripe plantain flour and wheat. Zinc plays a role in the breakdown of carbohydrate, cell division, cell growth and healing of wound. Calcium ranging from 12.15 to 24.90(mg/kg) showed a significant increase ($p<0.05$) with increase in substitution of defatted soybean and groundnut flour with sample AG (90:10) as the highest value for calcium. Mustapha, et al. [28] reported a value of 90.00 (mg/100g) for calcium in groundnut. Calcium is essential for proper bone and teeth formation [23].

Conclusion

This study showed that the addition of defatted soybean and groundnut flour positively affected the chemical properties of acha flour. The protein, fat and ash content of the composite flour increased from 7.48 to 29.38%, 0.60 to 9.79% and 0.40 to 1.60% respectively. Biscuit made from the flour blend with 30% inclusion of defatted soybean and groundnut flour stood out in all the minerals assessed while cake with 10% inclusion of defatted soybean and groundnut flour stood out. This is as a result of the improved quality of acha flour.

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