PRODUCTION AND QUALITY ASSESSMENT OF ENRICHED COOKIES FROM PLANTAIN FLOUR AND BAMBARA GROUNDNUT PROTEIN CONCENTRATE

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ABSTRACT: *Plantain flour was prepared from matured-unripe fruits of Agbagba cultivar, protein concentrate was prepared from bambara groundnut seeds using the alkaline extraction method, plantain cookies were produced using different levels of plantain flour substituted with bambara groundnut protein concentrate ranging from 0 – 25% and using 100% wheat flour as control. Physical characteristics, proximate composition and sensory properties of the cookies samples were determined, cookies prepared from 15% bambara groundnut protein concentrate and 85% plantain flour (sample D) compared favourably in physical characteristics (weight, height, diameter and hardness) with the control (100% wheat flour). Addition of bambara groundnut protein concentrate significantly improved the crude protein content (17.8%), ash content (2.8%), crude fibre (9.2%) and energy (434.0 kcal/100g) of the cookies compared to values obtained from 100% wheat flour. Sensory evaluation showed that sample D was preferred in terms of colour, flavor and general acceptability with mean scores of 8.1, 8.3 and 7.8, respectively and showed no significant difference (P > 0.05) with the control with mean scores of 8.6, 8.5 and 8.0, respectively.*

KEYWORDS: Protein Concentrate, Enriched Cookies, Sensory Properties, Physical Properties.

INTRODUCTION

Cookies are consumed all over the world as a snack food by children and adult alike. Cookies are a form of confectionary product dried to a low moisture content (Okaka, 2009), soften when compared to biscuits. Cookies had been suggested as a better form of composite flour than bread because of its ready to eat nature, wide consumption by different categories of people and relatively long shelf-life (Tsen *et al.,* 1973). These characteristics make protein-rich cookies attractive in countries where protein energy malnutrition is prevalent (Chinma and Gernah, 2007), and also in areas such as child feeding programmes, low income and disaster relief operations (Young *et al*., 1985). Cookies with high sensory ratings have been produced from blends of wheat/cowpea flours (Okaka and Isieh 1990), wheat/soybean (McWalters *et al*., 2003), wheat and full fat soya (Ndiefe *et al*., 2014). Several studies have reported the use of wheat-based composite flour in cookies production (Kamaljit *et al.*, 2010); Onoja *et al.*, 2010; Ajankau *et al.,* 2011). All these efforts were aimed at improving the nutritional content of the cookies and also to enhance crop utilization. Recently, attempts had been made to produce cookies from non-wheat based composite flours with high nutritional and sensory properties from unripe plantain and defatted sesame flour blends (Chinma et al., 2012), cassava groundnut – corn starch blends (Agriga and Iwe, 2009) and pigeon pea, cocoyam and sorghum flour blends (Okpala and Okoli, 2011). A current trend in nutrition is the consumption of functional foods – (Foods that not only supply basic nutrients but also help to prevent disease) advocated

by world nutrition bodies due to different health problem related with wheat consumption such as celiac disease (life-long intolerance to wheat gluten, characterized by inflamination of the proximal small intestine), diabetes and coronary heat diseases (WHO/FAO, 2003). This situation has created the need for the consumption of low-carbohydrate diets, slowly digested starchy foods as well as an increased intake of functional foods (Hurs and Martin, 2005). Therefore, this study is aimed at producing plantain cookies enriched with bambara groundnut protein concentrate in order to improve the nutritional quality of the cookies and increase the utilization of bambara groundnut flour.

MATERIALS AND METHODS

A local cultivar (agbagba) of plantain (*Musa paradisiaca*) was harvested from the International Institute for Tropical Agriculture (IITA), high Rainfall Station, Onne, near Port Harcourt, Nigeria. Bambara groundnut (Vignu Subterrenea (L) verdc) seeds – (The cream coloured variety) were purchased from markets in Enugu, Nigeria.

Preparation of plantain and bambara groundnut flours. The methods of Adeniji *et al*., (2007) and Barimalaa *et al.*, (1994) were used in the production of plantain flour and bambara groundnut flour, respectively.

Plantain Flour

Plantain fruits (agbagba cultivar) obtained from hand number 2, from the proximal end of the bunch, as recommended by Baiyeri and Ortiz (1996) were peeled manually with the aid of stainless steel kitchen knives and the pulp was cut into uniform slices with thickness of about 1.5mm, socked in 1.25% sodium metabisulphide solution for 5 min, drained and then dried in air circulating oven (Gallemtanp S/No 90/20/190, U.K) at 65°C for 20h. The dried samples were milled to pass a 0.25mm sieve.

Bambara Groundnut Flour

Bambara groundnut seeds were sorted and the bean soaked for 24h in tab water and dehulled manually. The seeds were further boiled for 10 min (1:4 bean to water ratio); in a stainless steel pot, drained and dried at 50°C in an air circulating oven for 19h. The dried samples were milled (Foss, Cyclotec 1093, Sweden) and sieved into flour using 0.25mm sieves.

Preparation of Bambara Groundnut Protein Concentrates

The protein concentrates from bambara groundnut flour were prepared using the alkaline wet extraction process described by Giami and Isichei (1999), for fluted pumpkin seed as shown in Figure 1. About 50gm flour sample was weighed and suspended in 300ml of 0.04m NaoH and the mixture was stirred at room temperature ($28 \pm 1^{\circ}$C) for 1hr, using a mechanical shaker. The pH of the slurry was adjusted to 10.8 using 1.0m NaoH and centrifuged at 3500 rev. min^{-1} for 25 min to obtain a residue and a supernatant. The residue was re-suspended in alkaline solution and the extraction procedure repeated to increase the yield of protein. The pH of the combined extract was adjusted to 4.5 using 1m Hcl to precipitate more proteins. The mixture was centrifuged for 15 min to yield protein concentrate which was washed twice and adjusted to pH, then air-dried for 48 hr and stored at 4°C.
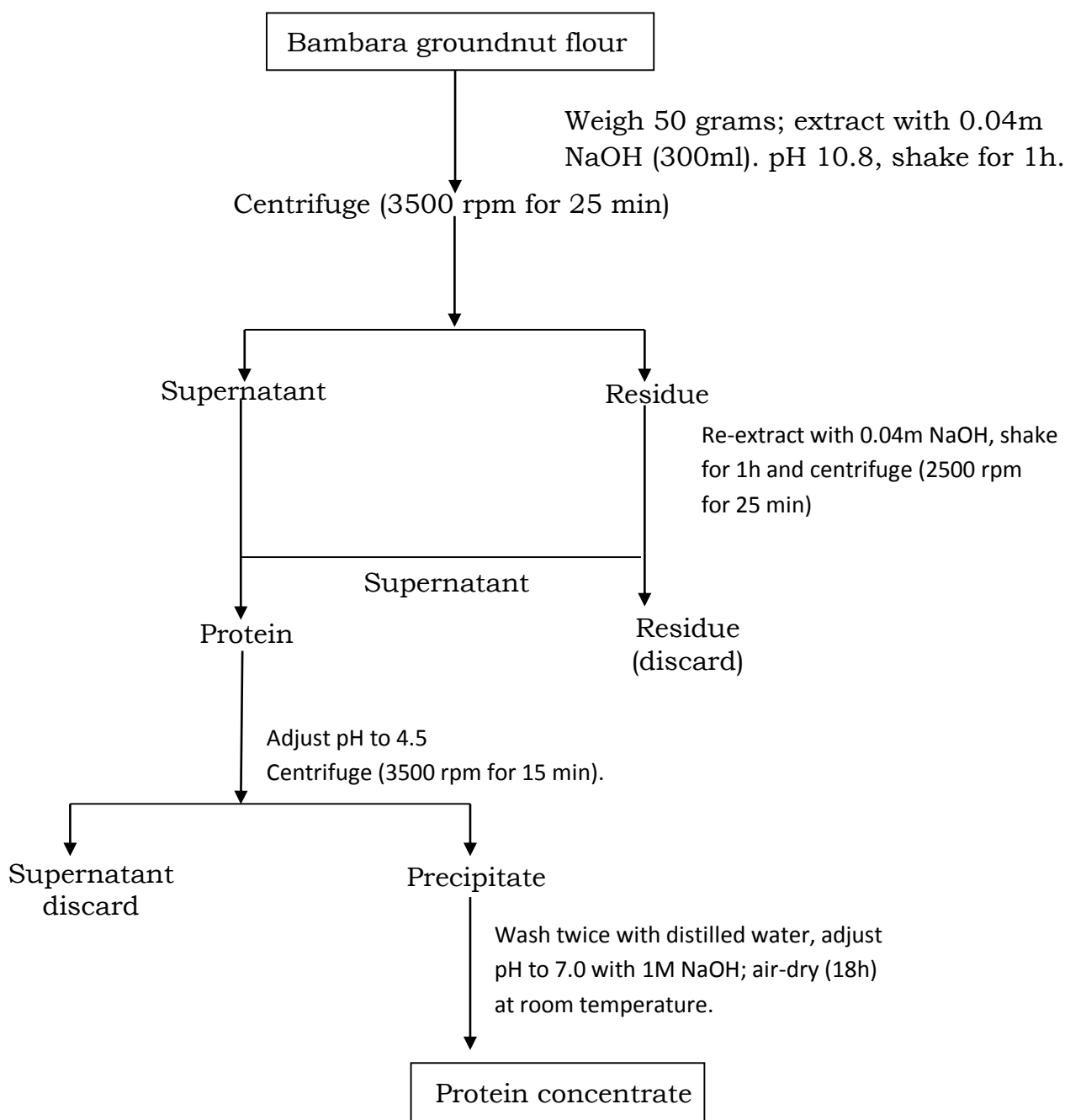
Bambara groundnut flour

Weigh 50 grams; extract with 0.04m
NaOH (300ml). pH 10.8, shake for 1h.

Centrifuge (3500 rpm for 25 min)

Supernatant   Residue

Re-extract with 0.04m NaOH, shake
for 1h and centrifuge (2500 rpm
for 25 min)

Supernatant

Protein   Residue
(discard)

Adjust pH to 4.5
Centrifuge (3500 rpm for 15 min).

Supernatant   Precipitate
discard

Wash twice with distilled water, adjust
pH to 7.0 with 1M NaOH; air-dry (18h)
at room temperature.

Protein concentrate

Fig. 1: Flow diagram for the production of protein concentrate from bambara groundnut flour.

Preparation of Flour Blends

Graded levels of bambara groundnut protein concentrate (BGPC) ranging from 0 – 25% level of enrichment of plantain flour were prepared. Also, 100% wheat flour was prepared as control. The recipe is presented in Table 1.

Table 1:   Recipe for the production of plantain cookies

Ingredient	Samples						
	A	**B**	**C**	**D**	**E**	**F**	**G**
Plantain flour (g)	200	190	180	170	160	150	-
BGPC (g)	-	10	20	30	40	50	-
Wheat flour (g)	-	-	-	-	-	-	200
Sugar (g)	75	75	75	75	75	75	75
Margarine (g)	125	125	125	125	125	125	125
Vanilla flavour (ml)	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Milk (powder, peak) (g)	105	105	105	105	105	105	105
Baking powder (g)	5	5	5	5	5	5	5
Egg (whole)	1	1	1	1	1	1	1

Key:

Sample A: 100% PF
Sample B: 95% PF; 5% BGPC
Sample C: 90% PF; 10% BGPC
Sample D: 85% PF; 15% BGPC
Sample E: 80% PF; 20% BGPC
Sample F: 70% PF; 25% BGPC
Sample G: 100% WF:

Where   PF   =   Plantain flour

        WF   =   Wheat flour

    BGPC   =   Bambara groundnut protein concentrate

Production of Plantain Cookies

The method described by Arisa *et al.*, (2013) was used in the production of plantain cookies. Sugar (75g) was added to 125g of margarine in a Kenwood mixer and mixed at medium speed until fluffy. Whole egg and milk powder were added while mixing and then mixing continued for about 30 min. Sifted plantain flour, baking powder and flavor were slowly added to the mixture; and treaded to form a dough. It was then rolled on a flat rolling board sprinkled with flour to a uniform thickness of about 0.4cm, circular cookies of 5.8 – 6.0cm diameter were cut, placed in oiled baking trays and baked in the oven at 160°C for 15 min. Other samples with graded levels of protein concentrates and the control with 100% wheat flour were baked in the same manner.

Physico-chemical Analysis of Plantain Cookies

The physical properties of enriched cookies were measured using the method of Zoulias *et al.*, (2002) and reported by Giami and Barber (2004) for fluted pumpkin cookies. Physical characteristics such as weight, height, hardness, diameter and the spread ratio were calculated. The determination of the chemical composition of the cookie samples viz; moisture content, ash, protein, fat and crude fibre were determined with the method of AOAC (2012), while

carbohydrate was done using the clegg an throne method as described by Osborne and Voogt (1978) and energy was calculated using the Atwater factors.

Sensory Evaluation of Enriched Cookies

Sensory evaluation of plantain cookies were carried out after baking using the method described by Giami and Barber (2004) for fluted pumpkin cookies. The sensory attribute included colour, texture, taste and general acceptability were evaluated using a 9 – point hedonic scale with 1 representing the least score (dislike extremely) and 9, the highest score (like extremely) as described by Iwe, (2010).

Statistical Analysis

The data obtained were analysed using the analysis of variance (ANOVA) and where means were significant, were separated using the Duncan multiple range test at the level of $P \leq 0.05$ (Wahwua 1999).

RESULT AND DISCUSSION

Table 2: Physical characteristics of enriched cookies with bambara groundnut protein concentrate.

Samples	Hardness (N)	Weight (g)	Diameter D(cm)	Height H(cm)	Spread Ratio (D/H)
A	59.1 ± 0.2^a	14.7 ± 0.3^a	7.6 ± 1.2^c	1.3 ± 0.01^b	5.9 ± 0.5^a
B	58.4 ± 0.6^a	12.8 ± 1.0^b	7.8 ± 0.9^c	1.4 ± 0.03^b	5.8 ± 0.4^a
C	58.6 ± 0.2^a	12.4 ± 0.6^b	8.4 ± 0.7^b	1.6 ± 0.04^a	5.3 ± 0.4^b
D	57.9 ± 0.3^a	12.9 ± 0.4^b	9.8 ± 1.1^a	1.6 ± 0.03^a	6.1 ± 0.2^a
E	50.4 ± 0.2^b	13.4 ± 1.1^a	9.2 ± 0.9^a	1.4 ± 0.02^b	6.6 ± 0.6^a
F	47.5 ± 0.5^b	14.7 ± 0.3^a	8.4 ± 0.5^b	1.4 ± 0.05^b	6.0 ± 0.5^a
G	57.8 ± 0.3^a	12.6 ± 0.7^b	10.6 ± 1.2^a	1.7 ± 0.5^a	6.2 ± 0.5^a

[a,b,c] Means bearing the same superscript within the same column do not

 differ significantly.   (P > 0.05)

$\pm$ = mean $\pm$ standard deviations of triplicate determinations.

Sample A = 100% PF
      B =   95% PF; 5% BGPC
      C =   90% PF; 10% BGPC
      D =   85% PF; 15% BGPC
      E =   80% PF; 20% BGPC
      F =   75% PF; 25% BGPC
      G =   100% WF

Where PF = plantain flour

   WF = wheat flour

BGPC = Bambara groundnut protein concentrate

Table 3: Proximate composition of cookies enriched with bambara groundnut protein concentrates

Samples	Crude protein (%)	Carbohy-drate (%)	Moisture content (%)	Fat (%)	Ash (%)	Crude fibre (%)	Energy (Kcal/ 100g)
A	2.0^c	60.6^a	5.8^a	25.2^a	1.2^c	5.2^a	469.8^a
B	4.8^c	58.2^a	5.8^a	22.6^b	2.2^b	6.4^c	448.1^b
C	10.7^b	53.6^b	5.4^b	21.4^b	2.4^b	6.5^c	443.8^{ab}
D	14.6^b	48.3^c	6.1^a	23.4^b	2.2^b	5.4^d	458.6^a
E	16.2^a	44.5^c	6.2^a	22.7^b	2.6^a	7.8^b	444.4^b
F	17.8^a	42.7^c	5.9^a	21.6^b	2.8^a	9.2^a	434.0^c
G (control)	11.2^b	47.4^c	6.8^a	18.4^c	1.3^c	7.4^b	386.4^d

Means bearing the same superscript within the same column are not significantly different.

A   =   100% PF,
B   =   95%   PF; 5% BGPC
C   =   90%   PF; 10% BGPC
D   =   85%   PF; 15% BGPC
E   =   80%   PF; 20% BGPC
F   =   75%   PF; 25% BGPC
G   =   100% WF; (Control).

Where   WF = Wheat flour

        PF = Plantain flour

     BGPC   = Bambara groundnut protein concentrate

Table 4: Sensory scores for cookies enriched with bambara   groundnut protein concentrate

Samples	Colour	Texture	Flavour	Overall Acceptability
A	7.4^b	6.5^c	7.6^b	7.3^c
B	7.6^b	7.0^b	7.8^b	7.4^c
C	8.4^a	7.7^a	8.1^a	7.7^a
D	8.1^{ab}	7.2^b	8.3^a	7.8^a
E	7.5^b	6.4^c	7.8^b	7.5^b
F	7.2^b	6.1^c	8.1^a	7.2^c
G	8.6^a	8.1^a	8.5^a	8.0^a

[a,b,c] Means bearing the same superscripts within the same column do not differ significantly. ($P > 0.05$)

Sample

A   =   100% Plantain flour
B   =   95% plantain flour + 5% BGPC

C   =   90% plantain flour + 10% BGPC
D   =   85% plantain flour + 15% BGPC
E   =   80% plantain flour + 20% BGPC
F   =   75% plantain flour + 25% BGPC
G   =   100% wheat flour (control).

Where   BGPC = Bambara groundnut protein concentrate

The physical characteristics of cookie samples prepared from plantain flour enriched with bamabara groundnut protein concentrates are presented in Table 2. The weight of cookie samples ranged from 14.7g (sample A) to 12.6g (sample G). There was no significant difference (P > 0.05) between sample G (100% wheat flour) and sample D. However, a significant difference (P > 0.05) was observed in samples E, and F, when compared to others. The height and diameter of plantain cookies were also observed to increase gradually with increase in the level of bambara groundnut protein concentrates, up to sample D. Therefore, cookies prepared from 15% bambara groundnut protein concentrate and 85% plantain flour compared favourably in height diameter, hardness with the control (100% wheat flour). 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 work of Chinma *et al*., (2012), who reported that addition of defatted sesame flour to unripe plantain flour in the production of composite cookies.

Crude protein in the enriched cookie samples increased from 2.01% obtained in sample A (100% plantain flour) to 17.8% in sample F with 25% bambara groundnut protein concentrate. The results showed that protein concentrates improved the crude protein of cookies prepared from plantain flour. This is in agreement with the work of Arisa *et al.*, (2013), they reported a crude protein of 4.31% for blended plantain flour and 12.5% wheat flour cookies.

It therefore followed that only 10% bambara groundnut protein concentrate would be needed to produce cookies with a crude protein content of 10.7% which compared favourably with the control (11.2%). There was no significant difference (P > 0.05) in moisture content of all samples prepared (5.4% to 6.2%). The ash and crude fibre of the enriched cookies increased from 1.21% (100% plantain flour) to 2.8% (sample F) and 5.2% to 9.2%, respectively.

The energy content of the samples ranged from 386.25kcal/100g (control) to 469.78kcal/100g in 100%, plantain flour. Moisture content, crude fibre and ash values of 7.24%, 5.73% and 2.95%, respectively had been reported by Ndife *et al.,* (2014) for cookies prepared from 50% soy flour supplemented with wheat flour.

Cookies prepared using 15% bambara groundnut protein concentrate and 85% plantain flour (sample D) was acceptable with reference to colour and general acceptability which showed no significant difference (P > 0.05) when compared to the control (100% wheat flour) as shown in Table 4. This may be due to better processing control which include temperature and time regulation and efficient heat transfer in the oven which helped to prevent colour darkening that is attributed to caramelization and millard reactions as reported by Alobo (2001). There was no significant difference (P > 0.05) in flavor between samples D, C and F when compared to sample G (100% wheat flour). This may be due to the incorporation of protein concentrates which eliminated the beany flavor associated with bambara groundnut (Barimalaa *et al.*, 2005) and other food legumes (Okoye and Okaka, 2009). However, this observation was contrary to the work of Arisa *et al.,* (2013) who reported a significant difference in flavour of plantain

biscuits compared with 100% wheat biscuit. The texture (hardness) of the enriched cookies decreased from a mean sensory score of 8.1 (sample G) to 6.1 (sample F). Cookies prepared from 10% bambara groundnut protein concentrate and 90% plantain flour (sample C) was not significantly different (P > 0.05) when compared with 100% wheat flour (sample G). Ndife *et al*., (2014) had also reported a score of 8.10 for texture for cookie samples with 30% soy flour substitution with wheat flour.

CONCLUSION

Addition of bambara groundnut protein concentrate significantly improved the protein content, ash, crude. Fibre and energy of cookies better than cookie samples with 100% wheat flour. Cookies prepared from 15% bambara groundnut protein concentrate and 85% plantain flour (sample D) compared favourably in physical characteristics with the control. Sensory scores showed that sample D was preferred with reference to colour, flavor and general acceptability.

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