Scholar J
Food and Environment

Research Article

Anti-nutrient Composition, Amino Acid Profile and Sensory Attributes from Unripe Plantain and African Yam Bean

[1]Uwaoma, F. K., [2]Akinfolarin. O.A., [3]Saliu-Olaoluwa, A.O. and [4]Owoicho, H.A.

[1]Centre for Food Technology and Research, Benue State University, Makurdi, Nigeria.

[2,3]Department of Home Economics, Federal College of Education Special, Oyo, Nigeria.
[4]Department of Botany and Environmental Science, Joseph Sarwuam Tarka University, Makurdi, Nigeria.

Received 21 February 2024; Acceptance 15 May 2024; Published 1 June 2024.

Abstract

This study investigated anti-nutrient composition, amino acid profile and sensory attributes of cookies produced from unripe plantain and African yam bean. Results of the study showed that the antinutrient composition of the cookies decreased significantly (P<0.05) when compared with the result of antinutrient of the flour samples. The values of the amino acid showed significant increase in all the parameters with increasing addition of African yam bean. The sensory scores showed that cookies produced from 80% plantain and 20 % African yam bean compared favourably with the control and therefore cookies could be successfully produced from the composite flour of plantain and African yam bean. This would enhance the utilization of these underutilized crops and help in alleviating protein energy malnutrition problems in developing countries.

***Keywords**:* Sensory, Attributes, Cookies, Nutritional, Composition.

Introduction

A snack is a portion of foods or caloric beverages often smaller than the regular meal which is generally eaten between regular meals while snacking refers to the act of eating a snack, regardless of whether it is a healthy choice or not [1]. Snack foods are energy-dense, nutrient-poor foods high in sodium, sugar, and/or fat such as cookies, cakes, sugar-sweetened beverages, and chips. Snack foods are sometimes referred to as convenience foods because they are quick and ready-to-be consumed on impulse wherever that impulse strikes [2]. A snack food is seen in western culture as a type of food not meant to be eaten as a main meal of the day- breakfast, lunch or dinner, but one rather intended to assuage a person's hunger between these meals, providing a brief supply of energy for the body. The term may also refer to food item consumed between meals purely for the enjoyment of its taste [3].

Correspondence to: Fortune Kelechi Uwaoma, e-mail: uwaomafortunel@gmail.com

How to Cite: Uwaoma et al. (2024). Anti-nutrient Composition, Amino Acid Profile and Sensory Attributes of Cookies Produced from Unripe Plantain and African Yam Bean, *Scholar J Food and Environment,* **1(6)**. DOI: 10.5281/zenodo.11408850

Traditionally, snacks were prepared from ingredients commonly available in the home, often leftovers, sandwiches made available from cold cuts, fruits, and the like. With the multiplication of convenience stores, packaged snack foods are now a significant business. Snack foods are typically designed to be portable, quick and satisfying. Processed snack foods should be less perishable, more durable, and/or more appealing than prepared foods. They often contain substantial amount of sweeteners, preservatives and appealing ingredients such as chocolates, peanuts and flavours. Stable snacks seen as ready-to-eat savory products are capable of being held at ambient temperature for a reasonable length of time, from 6-12weeks [2].

The snack food industry in market-driven societies such as the United States generates billions of dollars in revenue each year. Snack food industry is emerging in Nigeria and other developing countries. The market for processed snack foods is enormous, and a number of large corporations compete rigorously to capture larger shares of the snack food market [4]. Snack foods which are a significant part of the food industry include candies, cookie-crackers, snack cakes, pies, potato chips, corn/tortilla chips, nut-based snack, popcorn, beverages, milk and dairy products, dried fruits, extruded snacks, meat snack among others [5].

Snack foods are often subjectively classified as junk food. They are said to have little or no nutritional value, and are not seen as contributing towards general health and nutrition. With growing concerns for diet, weight control and general health, government bodies like Health Canada are recommending that people make conscious effort to eat more healthy natural snacks while avoiding high-calorie, low-nutrient, and junk food [3]. This can be achieved by fortification with alternative ingredients such as vitamins, minerals, proteins and dietary fibre. For this reason, this study aims to investigate the anti-nutrient composition, amino acid profile and sensory attributes of cookies produced from unripe plantain and African yam bean.

Materials and Method

The following materials were employed in this study, namely, unripe plantain, African yam bean, vegetable shortening, egg, honey, salt, milk and baking powder all purchased from Wadata market in Makurdi, Benue State, Nigeria.

Preparation of Cookies

The cookies were prepared using the method described by AACC [6] with some modifications in the recipe. The basic formulation was 100 g flour, 50 mL honey, 2.5 g vegetable shortening, one egg, 1 g salt, 1 g baking powder and varying volumes of water. The dry ingredients (flour, salt and baking powder) were thoroughly missed in a bowl by hand for 3 minutes. Vegetable shortening was added and mixed until it become homogenous. Egg was then added and the mixture kneaded. The batter was rolled and cut with a 10 mm diameter cookies cutter. The cookies were placed on baking trays, leaving 25 mm space in between and were baked at 180 ^{o}C for 20 minutes in a baking oven. The cookies were thereafter cooled to ambient temperature, packed in a polyethylene bag.

Determination of Phytate

The phytate determination was as described by Thompson and Erdman [7]. 2 grams of each of the cookie samples was placed in a flask into which 100.0 ml of 1.2 HCl and 10 % Na_2S0_4 was added. The flask was stoppered and shaken for 2 hours on a mechanical shaker. The extract was vacuum filtered through No4 Whatman paper. 10 ml of the filtrate was pipetted into a 50 ml centrifuge tube. l0 ml deionized water was added, followed by 12 ml of $FeCl_3$ solution (2 gm $FeCl_3.6H_2O$) + 16.3 ml conc. HCl per litre). The contents was stirred, heated for 75 minutes in boiling water, cooled and covered for one hour at room temperature. The tube was centrifuged at 1000xg for 15 minutes. The supernatant was decanted and discarded and the pellet was thoroughly washed thrice with a solution of 0.6 % HCl and 2.5 % Na_2SO_4. After each wash, the content was centrifuged at 1000xg for 10 minutes and the supernatant discarded. l0 ml concentrated HNO_3 was added to the resulting pellet and the content transferred quantitatively to a 400 ml beaker with several small portions of deionized water. 4 drops of concentrated H_2SO_4 were added and contents heated approximately 30 minutes in a hot plate until only the H_2SO_4 was left. Approximately 4 – 5 ml of 30 % H_2O_2 was added and the mixture returned to the hot plate at a low heat until bubbling ceases. The residue was dissolved in 15 ml 3M HCl and heated for 10-15 minutes. The resulting solution was made up to 100 ml volume diluted and then analyzed for iron using Franson *et al.* [8] procedure.

Determination of Tannin

The Folin-Denis colorimetric method as described by Kirk and Sawyer [9] was used for the determination of tannin content in the samples as follows: five grams (5 gm) of the samples was dispersed in 50 ml of distilled water and agitated. The mixture was allowed to stand for 30 minutes at room temperature and shaken every 5 minutes. After 30 minutes it was centrifuged and the extract obtained. The extract (2 ml) was taken into a 50 ml volumetric flask. Similarly, 2 ml standard tannin solution (tannic acid) and 2 ml of distilled water was put in separate 50 ml volumetric flask to serve as standard and reagent (1 ml of Folin-Denis) added to each of the flasks, followed by addition of 2.5 ml of saturated sodium carbonate solution. The content of each flask was made up to 50 ml with distilled water and allowed to incubate for 90 minutes at room temperature. Their respective absorbance was measured in a spectrophotometer at 260nm using reagent blank to calibrate the instrument at zero. The tannin content was calculated using equation (1).

$$\%\, Tannin = \frac{An}{As} \times \frac{C}{Va} \times Vf \times \frac{100}{w} \quad (1)$$

Where: An = absorbance of test sample,
AS = absorbance of standard solution,
C = concentration of standard solution,
W = weight of sample used,
Vf = total volume of extract,
Va = volume of extract analyzed.

Determination of Oxalate

The titration method AOAC [6] was used. Two grams of sample was suspended in a mixture of 190 ml of distilled water in a 250 ml volumetric flask. 10 ml of 6M HCl was added and the suspension was heated for 1 hour at 100 ^{o}C in a water bath. The mixture was cooled and made up to 250 ml mark with distilled water before filtration. Duplicate portion of 125 ml of the filtrate was measured into 250 ml beakers. Each extract was made alkaline with concentrated sodium then made acidic by drop wise addition (4 drops) of acetic acid until the test solution was changed from salmon pink to faint yellow (pH 4-4.5) (methyl red indicator used). Each portion was heated to 90 ^{o}C to remove precipitate containing ferrous ions. The filtrate was heated again to 90 ^{o}C on a hot water bath and 10 ml and 5 % calcium chloride solution added while being stirred constantly. After heating, it was centrifuged at full speed (2500 rpm) for 5 minutes. The supernatant was decanted and the precipitate completely dissolved in 10 ml of 20 % (v/v) H_2SO_4 solution and the total filtrate resulting from 2 gm of the sample were made up to 300 ml.

Permaganate titration: Aliqout 125 ml of the filtrate was heated until near boiling and then titrated against 0.05M $KMnO_4$ solution to a faint pink colour which persisted for 30 seconds. Oxalic acid content was calculated using equation (2).

$$\%\, Oxalic\ acid = T \times (Vme)(Df) \times 105\, ME \times Mf \quad (2)$$

T = Titre of $KMNO_4$ (ml),
Vme = volume - mass equivalent (1 ml of 0.05M M_nO_4 solution equivalent to 0.0022gm anhydrous oxalic acid),
Df = the dilution factor (i.e 300 ml) 125ml,
ME = the molar equivalent of $KMnO_4$ in oxalic acid ($KMnO_4$ redox reaction is 5),
Mf = the mass of the sample used.

Amino Acid Profiling

Amino acid profile was determined based on the method described by AOAC. [6], using the Technicon Sequential Multi- Sample Amino Acid Analyzer (TSM - 1TechniconInstrument Basingstoke, UK). The sample (1gm) was transferred into 10 mL distilled water and was dispensed into the cartridge of the analyzer. TSM is an automated instrument designed to detect, separate, and quantitate amino acids. It worked maximally at 35 ^{o}C and humidity of 80%. Due to the sensitivity of some of the amino acids like tryptophan to degradation, propionic acid was used for the hydrolysis of 5 gm of the powdered sample. The hydrolysate was vacuum-dried to remove the buffer solution before loading into the TSM. Compressed nitrogen was passed into the TSM to serve as a segmented stream flow of the amino acid which helped the analyzer to detect any amino acid found and stop mix-up of amino acids. The TSM analyzer separated

the essential amino acids of the hydrolysate and their measure. The analysis lasted for 76 minutes and their values noted.

Sensory Evaluation

Cookies samples prepared from each blend were presented in coded white plastic plate, samples were served to 15 panelists consisting of students of the Benue State University using a 9 point Hedonic scale (1=dislike extremely, 9=like extremely). The orders of presentation of samples were randomized. Sachet water was provided to rinse the mouth between evaluations. The panelists were instructed to evaluate the coded samples for crispiness, colour, taste, texture and overall acceptability [10]. The sensory scores obtained were subjected to Analysis of Variance (ANOVA).

Data Analysis

The experiments were conducted in a completely randomized design (CRD). Data obtained was subjected to analysis of variance (ANOVA) and mean separation were done by Duncan multiple range test (p=0.05), using Statistical Package for Social Sciences (SPSS) version 17.0.

Results and Discussion

Anti-nutrient composition of unripe plantain and African Yam Bean flour blends, 100 % wheat flour, 100 % unripe plantain and 100% African Yam Bean are shown in Table 1.

The tannin content of African Yam Bean flour had a value of 1.59 mg/g, 100 % unripe plantain flour was 0.13 mg/g and the flour blends ranged from 0.57 mg/g in 90:10 unripe plantain-African Yam Bean flour blends to 1.27 mg/g in 50:50 unripe plantain-African Yam Bean flour blends while the value of 100 % wheat was 0.89 mg/g. The samples differed significantly from each other.

The phytate content of the flours were 0.60 mg/g for 100 % wheat flour, 0.16 mg/g in 100 % unripe plantain, 2.57 mg/g in 100 % African Yam Bean and a range of 0.24 mg/g to 2.10 mg/g for samples 90:10 to 50:50 unripe plantain-African Yam Bean respectively.

The oxalate content of value differed significantly from each other. 100% African Yam Bean had the highest value of 0.00225 mg/g while unripe plantain had the least value of 0.00083 mg/g. Whole wheat had a value of 0.00169 mg/g and the flour blends ranged from 0.00173 mg/g to 0.00197 mg/g (90:10 – 50:50 unripe plantain-African Yam Bean) respectively.

Table 1: Anti-nutrient Composition of Flours (mg/g)

Samples	Tannin	Phytate	Oxalate
A	0.89^{e}±0.01	0.60^{b}±0.01	0.00169^{b}±0.01
B	0.13^{a}±0.01	0.16^{a}±0.01	0.00083^{a}±0.01
C	0.57^{b}±0.01	0.24^{a}±0.02	0.00173^{c}±1.01
D	0.71^{c}±0.01	1.13^{c}±0.02	0.00175^{c}±0.01
E	0.83^{e}±0.01	1.63^{d}±0.01	0.00183^{d}±0.01
F	0.95^{d}±0.01	1.75^{d}±0.00	0.00189^{e}±0.01
G	1.27^{g}±0.01	2.10^{e}±0.02	0.00197^{f}±0.00
AYB	1.59^{f}±0.01	2.57^{e}±0.02	0.00225^{g}±0.00
Permissible limit	20 mg/g	2.5 – 5.0 mg/g	0.003–0.005mg/g

Values are mean ± standard deviation of triplicate determination. Columns with the same alphabet are the same while those with different alphabet are different at $p<0.05$ (where a,b,c… are superscript showing the difference in means of the samples)

Key:

Samples A = 100 % Wheat flour (control)
B = 100 % Unripe Plantain flour
C = 90 % Unripe Plantain flour, 10 % African yam bean flour
D = 80 % Unripe Plantain flour, 20 % African yam bean flour
E = 70 % Unripe Plantain flour, 30 % African yam bean flour
F = 60 % Unripe Plantain flour, 40 % African yam bean flour
G= 50 % Unripe Plantain flour, 50 % African yam bean flour
AYB = 100 % African yam bean flour

The anti-nutrient composition of cookies produced from plantain and African Yam Bean flour blends are shown in Table 2.

The tannin content of the test cookie samples ranged from 0.05 mg/g in 100 % unripe plantain to 0.68 mg/g in 50:50 unripe plantain-African Yam Bean. Sample A (100 % wheat) which had a value of 0.32 mg/g did not differ significantly from sample C (90:10) unripe plantain-African Yam Bean.

Sample B (100 % unripe plantain) had the least phytate content of 0.06 mg/g while sample G (50:50 unripe plantain-African Yam Bean) had the highest 1.13 mg/g. The control sample had a value of 0.29 mg/g.

The oxalate content ranged from 0.00038 mg/g in 100 % unripe plantain to 0.00067 mg/g in 50:50 unripe plantain – African Yam Bean. All the test samples differed significantly from the control sample which had a value of 0.0008 mg/g.

Table 2. Anti-nutrient Composition of Cookies Produced from Unripe Plantain and African Yam Bean Flour Blends (mg/g).

Samples	Tannins	Phytates	Oxalates
A	0.32^{b}±0.01	0.29^{b}±0.01	0.00080^{e}±0.01
B	0.05^{a}±0.01	0.06^{a}±0.01	0.00038^{a}±1.01
C	0.34^{b}±0.01	0.09^{a}±0.01	0.00040^{b}±0.01
D	0.39^{c}±0.01	0.32^{b}±0.03	0.00044^{b}±0.01
E	0.43^{d}±0.01	0.81^{c}±0.01	0.00055^{c}±0.00
F	0.52^{e}±0.01	0.99^{d}±0.01	0.00059^{c}±0.01
G	0.68^{f}±0.01	1.13^{e}±0.02	0.00067^{d}±0.00

Values are mean ± standard deviation of triplicate determination. Columns with the same alphabet are the same while those with different alphabet are different at $p<0.05$ (where a,b,c… are superscript showing the difference in means of the samples).

Key: Samples A = 100 % Wheat flour (control)
B = 100 % Unripe Plantain flour
C = 90 % Unripe Plantain flour, 10 % African yam bean flour
D = 80 % Unripe Plantain flour, 20 % African yam bean flour
E = 70 % Unripe Plantain flour, 30 % African yam bean flour
F = 60 % Unripe Plantain flour, 40 % African yam bean flour
G= 50 % Unripe Plantain flour, 50 % African yam bean flour

The result of amino acid profile of cookies produced from a blend of unripe plantain and African Yam Bean is shown in Table 3.

The lysine content ranged from 0.48 g/100g in 100 % unripe plantain to 4.13 g/100g in 50:50 unripe plantain-African Yam Bean. Sample D (80:20) and E (70:30) were the same but differed significantly from other samples.

Methionine had a value of 0.79 g/100g for cookies produced from 100% wheat. Cookies with 100 % unripe plantain had the least value of 0.18 g/100g while 50:50 unripe plantain-African Yam Bean with a value of 2.45 g/100g was the highest.

Threonine ranged from 0.72 g/100g in 100 % unripe plantain to 3.13 g/100g in 50:50 unripe plantain-African Yam Bean. Sample A (100 % wheat cookie) and C (90:10 unripe plantain-African Yam Bean) had the same value of 2.00 g/100g. Iso-leusine ranged from 0.46 g/100g in 100 % unripe plantain to 4.82 g/100g in 50 % substitution of African Yam Bean. Sample C and D (1.58; 1.66 g/100g differed significantly from other samples.

All the samples differed from each other and from the control in leusine and phenylalanine. The values ranged from 0.87 g/100g for 100 % unripe plantain to 8.67 g/100g for 50:50 unripe plantain-African Yam Bean with a value of 5.83 g/100g for whole wheat cookies in leusine. Phenylalanine ranged from 0.51

g/100g (100 % unripe plantain) to 5.16 g/100g (50:50, unripe plantain-African Yam Bean) with a value of 4.11 g/100g for wheat.

Valine, Histidine Arginine and Cystenine ranged from 0.63-5.95 g/100g, 0.37-3.16 g/100g, 0.45-2.86 g/100g and 0.39-0.85 g/100g respectively. Serine and tyrosine sample differed from each other and from the control. The ranged from 0.46 g/100g (100% unripe plantain) – 3.85 g/100g (50:50, unripe plantain-African Yam Bean) for serine and 0.36 g/100g (100 % unripe plantain) – 3.73 g/100g (50:50, unripe plantain-African Yam Bean) for tyrosine.

100 % unripe plantain had the least value in Alanine and Aspartic Acid while the highest value was observed in 50 % African Yam bean substitution (1.85-9.13 g/100g, 0.58-5.41 g/100g and 0.20-4.61 g/100g respectively).

Glutamic acid, glycine and proline ranged from 1.85-9.13 g/100g, 0.58-5.41g/100g and 0.20-4.61g/100g respectively.

Table 3: Amino Acid Profile of Cookies Produced Plantain and African Yam Bean Composite Flour (g/100g)

Samples	A	B	C	D	E	F	G
Lysine	$2.65^{b}\pm0.01$	$0.48^{a}\pm0.01$	$2.98^{b}\pm0.01$	$3.83^{c}\pm0.01$	$3.86^{c}\pm0.01$	$3.96^{d}\pm0.01$	$4.13^{f}\pm0.01$
Methionine	$0.79^{b}\pm0.01$	$0.18^{a}\pm0.00$	$1.26^{c}\pm0.01$	$2.02^{d}\pm0.01$	$2.15^{e}\pm0.01$	$2.22^{f}\pm0.01$	$2.45^{g}\pm0.01$
Threonine	$2.00^{b}\pm0.01$	$0.72^{a}\pm0.01$	$2.00^{b}\pm0.01$	$2.82^{d}\pm0.01$	$2.96^{d}\pm0.01$	$2.67^{c}\pm0.01$	$3.13^{e}\pm0.01$
Iso Leusine	$3.22^{c}\pm0.21$	$0.46^{a}\pm0.01$	$1.58^{b}\pm0.01$	$1.66^{b}\pm0.01$	$3.87^{d}\pm0.01$	$3.52^{c}\pm0.01$	$4.82^{e}\pm0.01$
Leusine	$5.83^{c}\pm0.01$	$0.87^{a}\pm0.01$	$3.93^{b}\pm0.01$	$6.76^{d}\pm0.01$	$7.05^{e}\pm0.00$	$7.52^{f}\pm0.01$	$8.67^{g}\pm0.01$
Pheynalaline	$4.11^{c}\pm0.01$	$0.51^{a}\pm0.01$	$3.26^{b}\pm0.01$	$4.76^{d}\pm0.01$	$4.86^{e}\pm0.01$	$4.97^{f}\pm0.01$	$5.16^{g}\pm0.01$
Valine	$2.86^{b}\pm0.01$	$0.63^{a}\pm0.01$	$2.43^{b}\pm0.01$	$3.89^{c}\pm0.71$	$5.13^{d}\pm0.01$	$5.34^{de}\pm0.02$	$5.95^{e}\pm0.01$
Histidine	$1.35^{b}\pm0.00$	$0.37^{a}\pm0.00$	$1.85^{c}\pm0.00$	$2.16^{cd}\pm0.01$	$2.32^{d}\pm0.01$	$2.46^{e}\pm0.01$	$3.16^{f}\pm0.01$
Arginine	$2.22^{b}\pm0.01$	$0.45^{a}\pm0.00$	$2.49^{c}\pm0.01$	$2.50^{c}\pm0.00$	$2.54^{d}\pm0.01$	$2.78^{e}\pm0.01$	$2.86^{f}\pm0.01$
Cystenine	$0.36^{a}\pm0.00$	$0.39^{a}\pm0.01$	$0.53^{c}\pm0.01$	$0.70^{d}\pm0.01$	$0.79^{e}\pm0.01$	$0.80^{e}\pm0.01$	$0.85^{f}\pm0.00$
Serine	$2.05^{b}\pm0.00$	$0.46^{a}\pm0.01$	$2.28^{c}\pm0.01$	$2.65^{d}\pm0.00$	$3.00^{e}\pm0.00$	$3.36^{f}\pm0.01$	$3.85^{g}\pm0.00$
Tyrosine	$2.30^{b}\pm0.00$	$0.36^{a}\pm0.01$	$2.46^{c}\pm0.01$	$3.13^{d}\pm0.01$	$3.42^{e}\pm0.01$	$3.70^{f}\pm0.01$	$3.73^{g}\pm0.01$
Alanine	$3.00^{c}\pm0.00$	$0.41^{a}\pm0.01$	$2.17^{b}\pm0.02$	$3.35^{c}\pm0.00$	$4.27^{d}\pm0.01$	$4.33^{d}\pm0.01$	$4.49^{e}\pm0.13$
Aspartic acid	$1.63^{b}\pm0.01$	$0.63^{a}\pm0.00$	$1.91^{b}\pm0.02$	$2.32^{c}\pm0.01$	$2.76^{d}\pm0.01$	$2.76^{d}\pm0.01$	$2.86^{e}\pm0.01$
Glutamic acid	$6.53^{b}\pm0.01$	$1.85^{a}\pm0.00$	$6.89^{c}\pm0.01$	$7.85^{d}\pm0.00$	$8.13^{e}\pm0.01$	$8.54^{f}\pm0.02$	$9.13^{g}\pm0.01$
Glycine	$3.76^{b}\pm0.01$	$0.58^{a}\pm0.01$	$3.96^{b}\pm0.01$	$4.50^{c}\pm0.00$	$4.66^{c}\pm0.00$	$4.69^{c}\pm0.01$	$5.41^{d}\pm0.27$
Proline	$1.39^{b}\pm0.33$	$0.20^{a}\pm0.01$	$1.25^{b}\pm0.02$	$2.26^{c}\pm0.01$	$3.18^{d}\pm0.01$	$3.91^{e}\pm0.00$	$4.61^{f}\pm0.02$

Values are mean ± standard deviation of triplicate determination. Columns with the same alphabet are the same while those with different alphabet are different at $p<0.05$ (where a,b,c… are superscript showing the difference in means of the samples).

Key:

Samples A = 100 % Wheat flour (control)

B = 100 % Unripe Plantain flour

C = 90 % Unripe Plantain flour, 10 % African yam bean flour

D = 80 % Unripe Plantain flour, 20 % African yam bean flour

E = 70 % Unripe Plantain flour, 30 % African yam bean flour
F = 60 % Unripe Plantain flour, 40 % African yam bean flour
G= 50 % Unripe Plantain flour, 50 % African yam bean flour

The sensory attributes result of cookies produced from unripe plantain and African yam bean flour blends are presented in Table 4.

The crispiness of all the samples varied but not significantly from each other and from the control.

The value ranged from 7.07 in 50:50 unripe plantain-African Yam Bean to 7.73 in 100 % unripe plantain. 100 % wheat cookies had a value of 7.69. There was no significant difference in all the samples.

The appearance of the control sample with a value of 8.13 differed significantly from all the other cookies samples. Sample B (100 % unripe plantain), C (90:10), D (80:20), and E (70:30) did not differ significantly from each other.

The taste values ranged from 6.67 in 50:50 unripe plantain-African Yam Bean to 8.00 in 100 % unripe plantain with 100 % wheat cookies having a value of 8.13. Sample B (100 % unripe plantain) was the same with sample A (100 % wheat) and did not differ significantly from samples C (90:10) and D (80:20).

Sample A (100 % wheat) with a value of 8.27 did not differ significantly from sample B (100 % unripe plantain) with a value of 7.87 in texture. The values ranged from 7.13 in 50:50; unripe plantain-African Yam Bean to 7.73 in 90:10 unripe plantain-African Yam Bean.

The general acceptability score was 6.60 (50:50 unripe plantain-African Yam Bean), 7.43 (100 % unripe plantain) and a value of 7.90 for cookies from whole wheat.

Table 4: Sensory Attributes of Cookies Produced from Unripe Plantain and African Yam Bean Flour Blends

Samples	Crispiness	Appearance	Taste	Texture	General acceptability
A	7.69±0.49^{a}	8.13±0.64^{d}	8.13±0.84^{c}	8.27±0.80^{c}	7.90±0.85^{b}
B	7.73±0.46^{a}	7.27±0.70^{c}	8.00±1.13^{c}	7.87±0.74^{bc}	7.43±0.88^{ab}
C	7.53±1.10^{a}	7.20±0.77^{c}	7.87±1.13^{bc}	7.73±0.59^{abc}	7.70±1.12^{b}
D	7.33±0.72^{a}	7.07±0.80^{bc}	7.33±0.98^{abc}	7.47±1.06^{ab}	7.87±1.36^{b}
E	7.33±0.72^{a}	7.00±0.93^{bc}	6.93±0.88^{a}	7.40±0.83^{ab}	7.43±1.41^{ab}
F	7.07±0.88^{a}	6.53±0.99^{ab}	7.07±1.33^{ab}	7.33±0.98^{ab}	6.87±0.98^{a}
G	7.07±0.88^{a}	6.20±0.86^{a}	6.67±1.23^{a}	7.13±0.92^{a}	6.60±1.12^{a}

Values are mean ± standard deviation of triplicate determination. Columns with the same alphabet are the same while those with different alphabet are different at $p<0.05$ (where a,b,c… are superscript showing the difference in means of the samples).

Key: Samples A = 100 % Wheat flour (control)
B = 100 % Unripe Plantain flour
C = 90 % Unripe Plantain flour, 10 % African yam bean flour
D = 80 % Unripe Plantain flour, 20 % African yam bean flour
E = 70 % Unripe Plantain flour, 30 % African yam bean flour

F = 60 % Unripe Plantain flour, 40 % African yam bean flour
G= 50 % Unripe Plantain flour, 50 % African yam bean flour

The presence of anti-nutrients in foods could hinder the efficient utilization, absorption or digestion of some nutrients and thus, reduce their bioavailability [11]. The result of selected anti-nutrient (Tannins, Phytates and Oxalates) contents in unripe plantain flour, composites of unripe plantain-African yam bean flour blends as well as 100% African yam bean flour are shown in Table 1. The unripe plantain flour had very low levels of oxalate, tannin and phytate. Similarly, low levels of tannin, oxalate and phytate had been reported by Adeniji *et al* [11] for Agbagba an African plantain landrace. Substitution of unripe plantain flour with different levels of African yam bean flour led to significant ($p<0.05$) increases in the anti-nutrient contents with increased in levels of African yam bean flour substitution. The consistent increase in tannin, phytate and oxalate contents in the blended flours with increasing levels of African yam bean flour substitution could be attributed to the higher content of these anti-nutrients in the African yam bean flour as shown in Table 1 and the report by Inyang and Eyo [12] than in the 100% unripe plantain flour.

Anti-nutritional factors which are generally toxic and may negatively affect the nutrient value of seeds by impairing protein digestibility and mineral availability are heat labile and hence may be inactivated by processing methods involving heat generation [13]. Table 2 shows the anti-nutrition content of cookies produced from wheat flour (control), 100% plantain flour and plantain – African yam bean flour blends. The results showed a decrease in the anti-nutritional content of the flour blends after the cookies were baked. This may be as a result of the denaturation of protein by high temperature during baking. Nwosu [14] reported a significant reduction in phyate and tannins contents following cooking which is in agreement with this research. In the same manner, tannin content of the African yam bean seeds and other legumes such as pigeon pea (*Cajanus cajan*) and cowpea (*Vigna unguiculata*) decreased with processing. Phytic acid reduces the bioavailability of minerals by chelating divalent cations such as calcium, magnesium, zinc and iron forming insoluble complexes (Muahamad *et al* [15]. Processing is therefore necessary to reduce the level of all the anti-nutrients analysed to their permissible levels [13].

The values obtained showed that the samples contained most of the amino acids that are found in plant proteins. It was observed that the amino acid composition of the cookies samples increased significantly ($p<0.05$) as the percentage of African yam bean supplementation increased.

The works from different researches have shown that the amino acid profile of African yam bean is higher than that of plantain [16-17]. The values obtained from Sample B that contain only unripe plantain were lower than those obtained from other samples. Amino acid profile of cookies produce from unripe plantain was generally lower than the result of samples produced from the flour blend. The values were in agreement with the report Sheng *et al* [17] and Awedem *et al* [18] for the plantain flour. The values were significantly different ($p< 0.05$) from those obtained from the composite cookies.

Sample A, (100 % wheat) also had low values. This might be because the protein content of legume-based food is higher than that of cereal based food [19]. The lysine content of Sample A is 2.65, and it is lower than the composite samples. This is expected, as lysine is the first limiting amino acid in cereal-based products [20]. Generally, the amino acid composition was highest in Sample G due to the highest level of African yam bean supplementation in the sample. African yam bean protein had been reported as a better source for infants in preparing weaning foods than soybean because of the higher content of histidine which according to Okaka *et al*. [21] is an essential amino acid to infants. Omeire [16] reported an increase in the amino acid profile of an extruded food from African yam bean and cassava.

Blending plantain with African yam bean flour resulted in the increase amino acid content of the blends. The result showed that blending plantain with African yam bean before baking marginally improved the nutritional value of the cookies.

The wheat flour cookies used as control were rated higher than the test cookie samples plantain 100% and plantain – African yam bean 10 to 50% African yam bean flour substitutions for the attributes of taste,

appearance, texture and general acceptability. The samples showed no significant difference ($p<0.05$) in crispiness.

The cookie samples with 50% African yam bean flour substitution were significantly ($p<0.05$) different from the control and other samples in appearance. This showed that the level of likeness of the cookies reduced gradually with Improvement in appearance as substitution with African yam bean flour increased. This could be as a result of increased tannin content in the sample. Onwuka [22] reported that tannin can cause browning or other pigmentation problems in both fresh foods and processed products.

The significant difference in texture between 100% wheat flour and composite cookies could be attributed to the presence of gluten in wheat flour that resulted in the formation of elastic dough which was hard during handling, resulting to cookies with higher texture after baking than non-wheat composite cookies. Gluten is an important constituent of wheat because it provides strength to dough and texture to baked wheat products [23].

From the overall acceptability scores cookies can be produced from plantain and African yam bean composite flour up to the ratio of 80:20 without affecting the sensory properties of the cookies.

Conclusion

The study has shown that acceptable cookies can be produced from unripe plantain and African yam bean composite flours. From the findings, the processing activity carried out on the flour and baking reduced the anti-nutrients in the cookies. Tannin, phytate and oxalate were higher in the flour but reduced in the cookie samples. However, the anti-nutrient content of the cookies was below the permissive limits.

The inclusion of African yam bean to plantain flour improved the amino acid composition of cookies produced from the composite flour. Additionally, the organoleptic attributes of the cookies produced from 80 % plantain and 20 % African yam bean was the most acceptable composite cookies and it compared favorably with cookies produced from 100 % wheat flour. All the other cookies were of acceptable quality on a 9-point hedonic scale. Based on these findings, the study recommended that cookies should be utilized to help alleviate protein malnutrition problems in developing countries.

References

[1]. Hess J .M, Jonnalagadda S.S, and Slavin J.L (2016). What Is a Snack, Why Do We Snack, and How Can We Choose Better Snacks? A Review of the Definitions of Snacking, Motivations to Snack, Contributions to Dietary Intake, and Recommendations for Improvement. *American Society for Nutrition. Adv Nutr 7:466–475.*

[2]. Okaka, J.C. (1997). Cereals and Legumes: Storage and processing technology. Data and Microsystems publishers Enugu, Nigeria. 5-6, 153-154.

[3]. Wikipedia. (2016). The free Encylopedia. http://www.wikipedia.com. Assessed September 2017.

[4]. Onuh, J.O. (2007). Development and evaluation of extruded snacks from cereals, legumes and ripe-pulpy fruits and vegetables.A Ph.D Proposal of the Department of Food Science and Technology, University of Nigeria Nsukka, 5 – 7.

[5]. Hui, Y.H. (1999). Snack Food Technology. In: Encyclopedia of Food Science and Technology, 4, John Wiley and Sons Inc., New York, 2379.

[6]. AOAC, (2012). Official methods of analysis, Association of official analytical chemist 19th edition, Washington D.C., USA.

[7]. Thompson, D. B. and Erdman, J. W. Jnr. *(1982).* Phytic acid determination in soybean. *J `Food Sci., 47: 513 - 517.*

[8]. Franson, M., R., Franson M. C., Greenberg, A. E. and Taras, M. J. (1975). Iron L Phenanthroline Method. Standard Methods for the Examination of Water and Waste water, 14th Ed. Academic Press, New York, 208 – 211.

[9]. Kirk, H. and Sawyer, R. (1998). Frait Perrson Chemical Analysis of Foods (8th ed). *Longman Scientific and Technical, Edinburgh, pp 211-212*.

[10]. Apotiola Z.O and Fashakinly J.F. (2013). Evaluation O F Cookies from (Wheat, Yam, And Soybean) Blend. *Food Science and Quality Management 14(2)*.

[11]. Adeniji, T.A., Sanni, L.O., Barimalaa, I. S and Hart, A.D. (2007). Nutritional composition of five new Nigerian musa hybrid cultivars. Implication for adoption in human nutrition. *Fruits, 62, 135 – 142.*

[12]. Inyang U. E. and Eyo E. A. (2015). Effect of Soaking African Yam Bean Seeds in Unripe Plantain Peel Ash Solutions on the Nutrients, Anti-nutrients and Functional Properties of the Flour. *Journal of Food and Nutrition Sciences.3(4),147-151.*

[13]. Ndidi, U.S, Ndidi, C.U, Olagunju, A, Muhammad, A, Billy, F.G, and Okpe, .O (2014). Proximate, Antinutrients and Mineral Composition of Raw and Processed (Boiled and Roasted) *Sphenostylis stenocarpa* Seeds from Southern Kaduna, Northwest Nigeria. *http://dx.doi.org/10.1155/2014/280837.*

[14]. Nwosu J. N. (2010). Effects of soaking, blanching and cooking on the antinutritional properties of asparagus bean *(Vigna sesquipedalis)* flour. *Nature and Science. 8(8):163–167.*

[15]. Muahamad N. F., Muhammad A. R., Muhammad A., Moazzam R. K., Shahzad H. and Muhammad S. J. (2010). An overview of anti-nutritional factors in cereal grains with special reference to wheat-A review. *Pakistan Journal of Food Sciences,20, 1-4,: 54-56.*

[16]. Omeire, G. C. (2012). Amino acid profile of raw and extruded blends of African yam bean (*Sphenostylis stenocarpa*) and cassava flour. *American Journal of Food and Nutrition,2:3 (65-68)*.

[17]. Awedem W. F., Achu M. B. L. and Happi E. T. (2015). Nutritive Value of three varieties of banana and plantain blossoms from Cameroon. *Greener Journal of Agricultural Sciences,5 (2), 052-061.*

[18]. Sheng, Z.W, Wei-Hong, M, Jin-He, G, Yang, B, Wei-Min, Z, Hua-Ting, D and Zhi-Qiang, J (2010). Investigation of dietary fiber, protein, vitamin E and other nutritional compounds of banana flower of two cultivars grown in China. *African Journal of Biotechnology, 9: 3888-3895.*

[19]. Oluwamukomi, M.O, Eleyinmi, A.F. and Enujiugha, V.N (2005). Effect of Soy Supplementation and Its Stage of Inclusion on the Quality of Ogi – A Fermented Maize Meal*. Food Chemistry, (91)4, 651 – 657.*

[20]. Uchegbu N. N and Ishiwu C. N, (2016). Nutritional Composition of Crackers Produced from Blend of Sprouted Pigeon Pea *(Cajanus cajan),* Unripe Plantain *(Musa parasidiaca)* and Brewers' Spent Grain Flour and Blood Glucose Level of Diabetic Rats Fed the Biscuit. *World Academy of Science, Engineering and Technology International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering Vol:10,*

[21]. Oluwamukomi, M.O, Eleyinmi, A.F. and Enujiugha, V.N (2005). Effect of Soy Supplementation and Its Stage of Inclusion on the Quality of Ogi – A Fermented Maize Meal*. Food Chemistry, (91)4, 651 – 657.*

[22]. Onwuka G.I 2006. Soaking, boiling and antinutritional factors in pigeon peas *(Cajanus cajan)* and cowpeas *(Vigna unguiculata). Journal of Food Processing and Preservation. 30(5):616–630.*

[23]. Naveen K., Bhupendar S. K. and Ravinder K. (2013). Effect of Reducing Agents on Wheat Gluten and Quality Characteristics of Flour and Cookies. *The Annals of the University Dunarea de Jos of Galati Fascicle VI – Food Technology 37(2), 68-78.*