

Effects of Varying Fermentation Periods on the Chemical Composition of African Yam Bean (*Sphenostylis stenocarpa*) and Acha (*Digitaria exilis*) Flour Blends and Sensory Properties of Their Products

P. N. Okeke, J. N. Chikwendu

Abstract—The study evaluated the effects of varying fermentation periods on the nutrients and anti-nutrients composition of African yam bean (*Sphenostylis stenocarpa*) and acha (*Digitaria exilis*) flour blends and sensory properties of their products. The African yam bean seeds and acha grains were fermented for 24 hrs, 48 and 72 hrs, dried (sun drying) and milled into fine flour. The fermented flours were used in a ratio of 70:30 (Protein basis) to formulate composite flour for meat pie and biscuits production. Both the fermented and unfermented flours and products were analyzed for chemical composition using the standard method. The data were statistically analyzed using SPSS version 15 to determine the mean and standard deviation. The 24, 48, and 72 hrs fermentation periods increased protein (22.81, 26.15 and 24.00% respectively). The carbohydrate, ash and moisture contents of the flours were also increased as a result of fermentation (68.01-76.83, 2.26-4.88, and 8.36-13.00% respectively). The 48 hrs fermented flour blends had the highest increase in ash relative to the control (4.88%). Fermentation increased zinc, iron, magnesium and phosphorus content of the flours. Treatment drastically reduced the anti-nutrient (oxalate, saponin, tannin, phytate, and hemagglutinin) levels of the flours. Both meat pie and biscuits had increased protein relative to the control (27.36-34.28% and 23.66-25.09%). However, the protein content of the meat pie increased more than that of the biscuits. Zinc, Iron, Magnesium and phosphorus levels increased in both meat pie and biscuits. Organoleptic attributes of the products (meat pie and biscuits) were slightly lower than the control except those of the 72 hrs fermented flours.

Keywords—Fermentation, African yam bean, Acha, biscuits, meat-pie.

I. INTRODUCTION

IN developing countries, especially in Nigeria, widespread food shortage, hunger, and malnutrition have persisted, particularly among the low-income groups. A lot of under-exploited food crops with high nutritional potentials abound. African yam bean is one of the traditional staples that are being neglected in the recent decades. They are not widely cultivated, as such, they are not very common, and their utilization is limited. Research has shown that there is a need for the diversification of some of these indigenous foods and their products to bridge the malnutrition. From studies, it is

seen that legumes and cereals provide the greatest level of cheap proteins and other nutrients [1].

Cereals are known to be rich in methionine and cysteine which are inadequate in legumes, while legumes are rich in lysine and tryptophan, which are limiting amino acids in cereals. Legumes are known to be richer in protein than cereals. Therefore, cereal-Legume supplementation helps in providing the necessary nutrients needed, unlike the synthetic important ingredient [2].

There are several varieties of legumes in Nigeria, but cowpea and groundnut are the commonly used legumes. African yam bean is one of the underutilized legumes in Nigeria, because it is locally cultivated, and takes a longer time to cook but, fermentation has been employed to assist in the processing of African yam bean seed to flour making it less difficult to cook [3].

Acha (hungry rice) is among the cereal that is underutilized in the eastern part of Nigeria, but it is cultivated in the northern part of Nigeria, but its knowledge is not widely exposed. As said earlier, acha as cereal possesses a high level of methionine and cysteine, which makes it a good supplement for legumes [4].

Plant crops contain anti-nutritional factors that limit the bio-availability of nutrients, prevent protein digestibility and mineral absorption. However, some processing methods have been suggested, which can significantly reduce the level of its anti-nutrients (phytate, tannin, polyphenols, etc.). Fermentation is one of the processing methods that help in reduction of anti-nutrients both in cereals and legumes hence, improving the bioavailability of nutrients [4]-[7].

Since snacks consumption is common among children and adolescents, the efforts should be geared towards the use of locally available food crops such as African yam bean and acha in the production of nutritious snacks to help fight malnutrition. There is a need for promotion of local food crops with high nutritional importance.

Malnutrition can only be curbed through improvement in diversification and variation of diet, indigenous food production capacity, and knowledge of their nutrition value. So to reduce the prevalence of energy, protein and micronutrient deficiency in Nigeria, strategies such as dietary diversification, fortification are needed [2], [6], [7].

The objectives of the study were to:

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1. Produce flours from African yam bean and acha, and compare the products from the composite flours, with the same products based on wheat flour.
2. Determine the effects of varying fermentation periods on the nutrient and anti-nutrient content of African yam bean and acha composite flours.
3. Produce snack (meat pie and biscuits) based on African yam bean and acha flour blends and evaluate their nutrient composition.
4. Assess the organoleptic attributes of the products (meat pie and biscuit)

The result of this study will enlighten people and food industries on the nutritional and product potentials of under-exploited cereals and legumes such as acha and African yam bean. It will create awareness on the consumption of acha and African yam bean flour as a substitute for wheat flour in the preparation of nutritious snacks. The study will also help to diversify the food use of African yam bean and acha flours.

II. MATERIALS AND METHODS

A. Sample Processing

African yam bean (*Sphenostylis stenocarpa*) seeds, acha grains (*Digitaria exilis*) and wheat flour used in this study was purchased from Ekeonunwa market in Owerri, Imo State, Nigeria. The materials purchased were subjected to the following processing procedures, this includes:

B. Processing of Fermented African Yam Bean Flours

Three kilograms (3kg) of African yam bean seeds were cleaned and divided into four portions; one portion served as the control. It was washed, dried, distilled and milled into fine flour. The flour was kept in an air tight container until analyzed. The remaining three portions were subjected to different fermentation periods. The seeds were soaked separately in tap water in a ratio of 1:3 (w/v) and allowed to ferment by the microflora inherent in them for 24, 48, and 72 hrs at a temperature of $28 \pm 2^\circ\text{C}$ (Fig. 1). The fermented seeds were separately dehulled, dried (sun drying) and milled into fine flours (70mm mesh screen) and stored in polythene bags for analysis (Fig. 1).

C. Processing of Fermented Acha Flours

Three Kilograms (3kg) of acha grains were cleaned and divided into four portions, with one serving as the control, which was washed, dried and milled into fine flour. The flour was kept in an air tight container until analyzed. The remaining three portions were subjected to different fermentation periods. The grains were soaked separately in tap water in a ratio of 1:3 (w/v) and allowed to ferment by the microflora inherent in them for 24, 48, and 72 hours at a temperature of $28 \pm 2^\circ\text{C}$ (Fig. 2). The fermented grains were separately dried (sun drying) and milled into fine flours (70mm mesh screen) and stored in polythene bags for analysis (Fig. 2).

D. Formulation of Composite Flours

The composite flours were formulated in the ratio 70:30 of unfermented and fermented African yam bean and acha flours respectively on a protein basis. Since there were three fermentation periods, four composite flours were formulated as follows:

- Unfermented African yam bean and acha flour blends
- Fermented African yam bean and acha flour blends for 24 hrs.
- Fermented African yam bean and acha flour blends for 48 hrs.
- Fermented African yam bean and acha flour blends for 72 hrs.

Each was used for the preparation of biscuits and meat pie, which were later subjected to laboratory analysis.

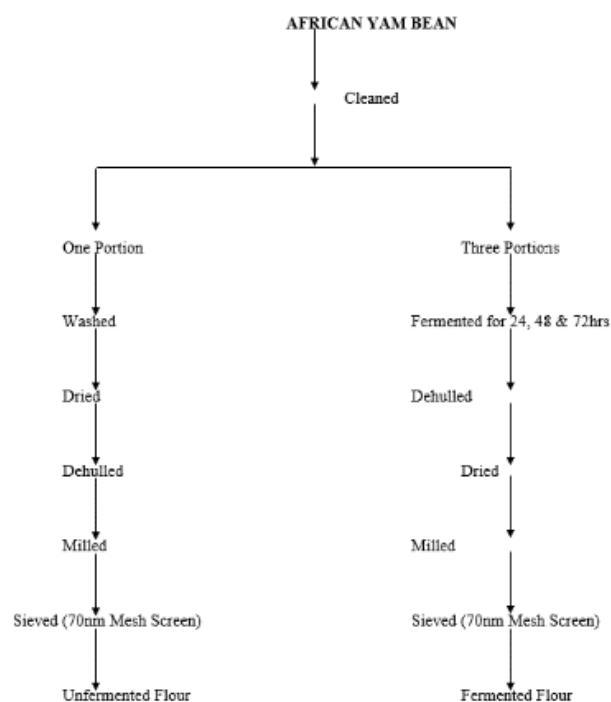


Fig. 1 Processing of Fermented African Yam Bean Flours

E. Preparation of Baked Products

Meat pie and biscuits were prepared from the fermented flours and wheat flour, using similar recipes.

III. MEAT PIE

In the preparation of meat pie, 200g of the composite flours were mixed with one level teaspoonful of baking powder, 0.6ml of salt, 150g of Margarine. All the ingredients were mixed together thoroughly; 200ml of water was added to the mixture, which was stirred thoroughly until the homogeneous dough was achieved.

The dough was rolled on a pastry board using a rolling pin and was cut into shape with a stainless steel knife, the meat sauce was placed on each dough portion that was cut out and folded into a semi-circular shape, and sealed with a fork.

They were placed on a slightly greased aluminum baking pan and allowed to bake in an oven at 200°C for 25mins, then allowed to cool before being analyzed. The same procedure was applied to that of wheat flour.

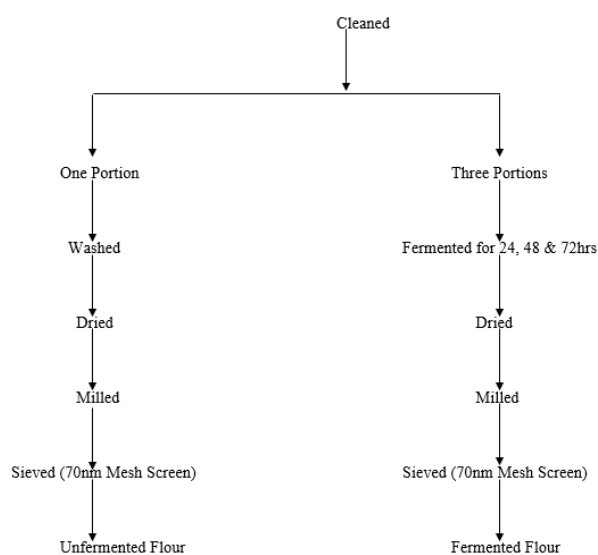


Fig. 2 Processing of Fermented Acha Flours

IV. BISCUITS

In the preparation of biscuits 200g of the composite flours were mixed with one level teaspoonful of baking powder, 100g of sugar thoroughly, then 150g of margarine was added to the mixture and thoroughly mixed with one already beaten egg. Until the consistency of bread crumbs was achieved, 300ml of water was added to the mixture and mixed thoroughly until the homogeneous dough was gotten. The dough was rolled on a pastry board using a rolling pin to 3mm thickness. The flat dough was then cut into shapes using a biscuit cutter, then placed on the slightly greased aluminum baking pan and put in an oven to bake at 150°C for 15 minutes, after which it was allowed to cool before being analyzed. The procedure also applies to that made of wheat flour.

V. SENSORY EVALUATION

This is a scientific discipline that applies principles of experimental design and statistical analysis to the use of human senses (sight, smell, taste, touch, and hearing), for the purpose of evaluating consumers' products. A nine-point hedonic scale was used to test for flavor, texture, color, and general acceptability of both baked products. The degree to which a product was liked was expressed; like extremely (9 points), like much (8 points), like moderately (7 points), like slightly (6 points), Neither like nor dislike (5 points), Dislike slightly (4 points), Dislike moderately (3 points), dislike very much (2 points), Dislike extremely (1 point). Twenty students were selected from Imo State University (IMSU), Owerri for the sensory evaluation in the Nutrition and Dietetics Laboratory, IMSU, Owerri. Each panelist was seated in an

individual compartment to avoid distraction and bias and was given a glass of water to rinse their mouth before testing each product [6].

VI. CHEMICAL ANALYSIS

The proximate analysis (moisture, protein, fat, carbohydrates, ash and crude fiber) was done using the method of AOAC [8].

VII. MINERAL DETERMINATION

The mineral contents of the flour blends and products were estimated by the method of Ranjham and Gopal [9]. The samples were wet-digested with concentrated nitrate and Perchlorate. Iron (Fe), Zinc (Zn) and magnesium (mg) were determined by polarized Zeeman atomic absorption Spectrophotometer, except phosphorus (p) which was determined spectrophotometrically as yellow phosphor-vanado-molybdate complex.

VIII. DETERMINATION OF ANTI-NUTRIENTS

They involve the tannin, phytate, hemagglutinin, oxalate, and saponin content of the flour samples.

A. Tannin

Tannin was determined by the spectrophotometric method as described by Price and Buttler [10]. About 0.5g of each sample was extracted with 3ml methanol. The titrate was mixed with 50ml water. Another 3ml of FeCl_2 , 0.1m HCl and 0.8m $\text{K}_2\text{Fe}(\text{CN})_6$ were added to 0.1ml of the solution. The extracts were read at 720nm on a spectrophotometer.

B. Phytate

This was determined using the method of Pomeranz and Meloan [11]. About 5g of each sample were extracted with 2.0m HCl, 0.1m NaOH and 0.7m NaCl were added and passed through a resin (200-400 mesh) to elude inorganic phosphorous and other interfering compounds. Modified wade reagents 0.03% $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and reading taken at 500nm.

C. Saponin

This was determined using the method of Odo and Ishiwu [12]. About 0.1g of the sample was boiled with 50ml distilled water for 15 mins and filtered with Watman No.1, 5ml of the filtrate was pipetted into a test tube and 2ml of olive oil was added. The solution was shaken vigorously for 30 seconds and read 620nm against a blank.

$$\text{Saponin} = \frac{\text{Reading from curve} \times \text{dilution factor} \times 100(\text{mg } 1000\text{g})}{\text{Weight of sample} \times 10^b}$$

D. Hemagglutinin

This was determined by the method of Pomeranz and Meloan [11]. Weigh 29mg of each sample into a test tube, with 10-20ml H_2O , shake vigorously and filter. Store the extract in the refrigerator at 4°C. In another four test tubes, 4ml of fresh blood of mice was added together with 4ml of normal saline solution, centrifuged at 780g for 60 minutes. The supernatant was decanted and kept for haemoglobin activity estimation.

About 0.1ml of the blood sample was pipetted into the sample test tube, added 4ml of saline solution and two drops of extract and kept for 16hrs at a temperature of 4°C. The turbidity formed was read at 600nm. The turbidity of the extract plus 4ml of saline solution were equally measured at the same wavelength as the control.

E. Oxalate

The oxalate content of the samples was determined by the method described by Odo and Ishiwu [12]. Weigh 0.5g of the sample into a test tube, add 10ml of ethyl acetate and place in a water bath and boil for 3 minutes. Filter; shake 3ml of the filtrate with 0.1ml of diluted ammonia in a test tube. The presence of a yellow colouration in the lower layer indicates the presence of oxalate.

IX.RESULTS

A. Flour Blends

TABLE I

PROXIMATE COMPOSITION OF UNFERMENTED AND FERMENTED AFRICAN YAM, BEAN, AND ACHA FLOUR BLENDS

Sample	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
UAA	8.36±0.04	21.37±0.09	2.49±0.10	2.26±0.06	2.37±0.10	68.01±0.11
AAF ₂₄	9.70±0.03	22.81±0.11	2.54±0.10	3.42±0.07	1.88±0.10	70.44±0.21
AAF ₄₈	10.50±0.04	26.15±0.10	2.86±0.11	4.88±0.02	1.43±0.01	72.95±0.12
AAF ₇₂	13.00±0.06	24.00±0.09	2.96±0.07	3.00±0.01	1.20±0.01	76.83±0.12

Mean ± Standard Deviation of three replications: UAA=Unfermented African yam bean and acha flours; AAF₂₄=African yam bean and acha flours fermented for 24 hrs; AAF₄₈=African yam bean and acha flours fermented for 48hrs; AAF₇₂=African yam bean and acha flours fermented for 72 hrs.

1. Moisture

The moisture content of the flour blends are varied; it ranged from 8.36-13.00%. The 72hrs fermented flour blends had the highest moisture value (13.00%); followed by 48 hrs fermented sample (10.50%), and the 24 hrs fermented sample had the least moisture value (9.70%) among all the fermented samples.

2. Protein

There were variations in the protein level of the flour samples. The 48hrs fermented flour composite had the highest protein (26.15%). When compared to the control and other fermented flours (26.15 vs. 22.81, 24.00, and 21.37% respectively). There was a slight increase in the protein content of the 24hrs fermented flour, relative to the control (22.81 vs. 22.37%). As fermentation period increased, the protein content also increased. However, the 48 hrs fermentation period caused the highest increase in the protein value.

3. Fat

The fat value for the flour samples was comparable. However, it was observed that as fermented period increased the fat value increased ($P>0.05$). The 72 hrs and 48hrs fermentation periods had the highest fat values (2.96% and 2.86% respectively).

4. Ash

The differences in the ash values of the flour samples were a function of treatment. Fermentation caused an increase in the ash level of the flour blends. The 48 hrs fermented flour blend had the highest value (4.88%) as against the control (2.26%). The 24 hrs and 72 hrs fermented period had increased ash values (3.42% and 3.00% respectively).

5. Fibre

The fiber values of the flour samples varied, it ranged from 1.20-2.37%. Fermentation decreased the fiber content of the flours. It was observed that as fermentation period progressed, the fiber value decreased 1.88 to 1.20%. The 72hrs period had the least fiber value (1.20%).

6. CHO

There was an increase in the CHO content of the flour samples as the fermentation period increased. The 72 hrs period had the highest CHO value (76.83%), followed by the 48 hrs period (72.95%).

TABLE II

MINERAL COMPOSITION OF UNFERMENTED AND FERMENTED AFRICAN YAM BEAN AND ACHA FLOUR BLENDS

Sample	Zinc	Iron	Magnesium	Phosphorus
UAA	4.38 ± 0.01	6.25 ± 0.02	20.79 ± 0.12	53.84 ± 0.20
AAF ₂₄	5.75 ± 0.01	6.88 ± 0.02	23.82 ± 0.12	54.08 ± 0.20
AAF ₄₈	7.98 ± 0.02	7.76 ± 0.00	35.93 ± 0.19	56.68 ± 0.18
AAF ₇₂	6.63 ± 0.00	7.25 ± 0.00	31.69 ± 0.17	61.87 ± 0.10

Mean ± Standard Deviation of three replications: UAA=Unfermented African yam bean and acha flours; AAF₂₄=African yam bean and acha flours fermented for 24 hrs; AAF₄₈=African yam bean and acha flours fermented for 48hrs; AAF₇₂=African yam bean and acha flours fermented for 72 hrs.

7. Zinc

The increases in the zinc content of the fermented flours were a function of treatment. The values ranged from 4.38 to 7.89mg. The fermented flour samples had higher zinc relative to the control (5.75, 7.9-8, and 6.63mg vs. 4.38 mg respectively).

8. Iron

The iron content of the flour samples differed. It ranged from 6.88 to 7.76mg. The 24 hrs fermented flour had the least iron value when compared with 48hrs and 72hrs fermented flours. However, the 48 hrs fermented flour blends had the highest iron value (7.76mg) against the control (6.25mg).

9. Magnesium

The Magnesium content of the fermented composite flour was higher than that of the control (23.87, 35.93 and 31.69 vs 20.79 mg respectively). There was almost a double increment in the magnesium content of the 48hrs fermented flour sample when compared with the control (35.93mg vs. 20.79mg).

10. Phosphorus

There were variations in the phosphorus level of the flour samples. The 24 hrs fermented flour had comparable phosphorus value with the control (54.08 vs. 53.84). It was

observed that as the fermentation period increased, the phosphorus level also increased simultaneously.

TABLE III

ANTI-NUTRIENT COMPOSITION OF UNFERMENTED AND FERMENTED AFRICAN YAM BEAN AND ACHA FLOUR BLENDS

Sample	Tannin	Phytate	Haemagglutinin	Saponin	Oxalate
UAA	0.16 ±0.03	0.37 ±0.09	0.39±0.06	0.37 ±0.06	0.13±0.02
AAF ₂₄	0.15 ±0.03	0.35 ±0.02	0.19 ±0.02	0.10 ±0.02	0.11 ±0.01
AAF ₄₈	0.11 ±0.02	0.16 ±0.00	0.11 ±0.00	0.07 ±0.00	0.09 ±0.00
AAF ₇₂	0.08 ±0.00	0.04 ±0.00	0.06 ±0.00	0.02 ±0.00	0.06 ±0.00

Mean ± Standard Deviation of three replications: UAA=Unfermented African yam bean and acha flours; AAF₂₄=African yam bean and acha flours fermented for 24 hrs; AAF₄₈=African yam bean and acha flours fermented for 48hrs; AAF₇₂=African yam bean and acha flours fermented for 72 hrs.

11. Tannin

The tannin levels of the fermented flour blends differed. The 72 hrs fermented flour the lowest tannin value (0.08mg), whereas the 24hrs fermented caused a slight decrease in tannin value when compared with the control (0.15 vs. 0.16mg).

12. Phytate

Fermentation influenced the phytate values. It drastically lowered the phytate content of the flour blends at 72 hrs (0.04mg) as against the control (0.37mg). The 24 hrs fermentation period caused the least decrease in the phytate level when compared with the control (0.35 vs. 0.37).

13. Haemagglutinin

Relative to the control, fermentation significantly reduced the haemagglutinin level. The values ranged from 0.19 to 0.06mg. The highest decrease occurred during the 72 hrs fermentation period.

TABLE IV

PROXIMATE COMPOSITION OF BISCUITS AND MEAT PIE MADE FROM FERMENTED AFRICAN YAM BEAN AND ACHA FLOUR BLENDS AND WHEAT FLOUR

Sample	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
BWF	7.67±0.14	23.66±0.106	30±0.023	0.020	0.00±0.03	67.14±0.50
BFAA ₂₄	9.14±0.12	24.58±0.274	31±0.032	93±0.191	32±0.01	61.29±0.06
BFAA ₄₈	8.08±0.12	25.09±0.224	78±0.063	62±0.161	66±0.00	65.69±0.36
BFAA ₇₂	10.52±0.11	24.69±0.275	00±0.062	91±0.131	42±0.00	64.86±0.20
MPWF	10.76±0.08	27.36±0.295	39±0.093	36±0.112	56±0.02	60.09±0.11
MPAAF ₂₄	11.66±0.15	28.09±0.365	40±0.093	31±0.111	78±0.03	57.41±0.81
MPAAF ₄₈	12.67±0.09	34.28±0.316	00±0.034	52±0.061	89±0.03	53.42±0.81
MPAAF ₇₂	14.00±0.01	31.00±0.315	21±0.062	87±0.031	46±0.02	56.23±0.11

Mean ± Standard Deviation of three replications: BWF=Biscuits made from wheat flour; BFAA₂₄=Biscuits made from 24 hrs fermented African yam bean and acha flour blends; BFAA₄₈=Biscuit made from 48 hrs fermented African yam bean and acha flours blends; BFAA₇₂=Biscuits made from 72 hrs fermented African yam bean and acha flours blends; MPWF=Meat pie made from wheat flour; MPAAF₂₄=Meat pie made from 24 hrs fermented African yam bean and acha flour blends; MPAAF₄₈=Meat pie made from 48 hrs fermented African yam bean and acha flour blends; MPAAF₇₂=Meat pie from 72 hrs fermented African yam bean and acha flour blends.

14. Saponin

The drastic reduction in the saponin level from 0.37 to 0.02 mg was due to fermentation. The saponin level decreased as fermentation period increased. The 72hrs fermented flours had the least saponin value followed by the 48 hrs and 24 hrs as

against the control (0.02, 0.07, and 0.10 vs. 0.37 mg respectively).

15. Oxalate

All the processed flour samples had decreased oxalate levels in relation to the control. The levels ranged from 0.06 to 0.11mg as against the control (0.13mg). The highest decrease occurred in 72hrs fermentation (0.06mg).

B. Biscuits and Meat Pie

1. Moisture

The moisture content of the biscuits and meat pie varied. It ranged from 7.67 to 14.00%. The meat pie had higher moisture content than that of biscuits. However, both the biscuits and meat pie from fermented African yam bean and acha composite flours had higher moisture than those from wheat flour alone (8.08, 9.14 and 10.52 vs. 7.67%) and (11.66, 12.67, and 14.00 vs. 10.76%) respectively.

2. Protein

The protein content of the biscuits and meat pie based on the fermented African yam bean and acha flour blends had higher protein than their controls (24.58-25.09% vs. 23.66 and 27.36-31.00% vs. 24.69%). The protein content of the meat pie was much higher than that of the biscuits (Table IV).

3. Fat

There were variations in the fat content of the biscuits. The biscuits made from the fermented flour blends had decreased fat value (4.31-5.00%) relative to the control (6.30%). The biscuits made from 24hrs and 48hrs fermented flour blends had lower and comparable fat value (4.31% and 4.78%). The meat pie had an increase in protein level compared with the biscuits. The biscuits based on the 48hrs fermented flour blends had the highest protein content relative to the control and other fermented samples (6.00 vs. 5.39, 5.40, and 5.21).

4. Ash

The variability in the ash content of the products was a function of treatment. The meat pie based on 48 hrs fermented flour blends had the highest Ash value (4.52%). Apart from biscuit based on 24 hrs and 72 hrs fermented flour blends and meat pie based on 72 hrs fermented flour blends all other products had comparable ash value (3.00 to 3.36%).

5. Fibre

The fiber content of the products (biscuits and meat pie) based on fermented flour blend samples had decreased fiber values when compared with their control (1.32 to 1.66% vs. 2.00% and 1.46 to 1.89% vs. 2.56%). However, the fiber values for all the products from the fermented flour were relatively comparable.

6. CHO

There were variations in the carbohydrate content of the products. Relative to the control, all the biscuits and meat pie produced from the fermented flour blends had lower carbohydrate values. The carbohydrate values of the biscuits

where higher than that of the meat (61.29 to 67.14% and 53.09 to 60.09%).

TABLE V

MINERAL COMPOSITION OF BISCUITS AND MEAT PIE BASED ON FERMENTED AFRICAN YAM BEAN AND ACHA FLOUR BLENDS AND WHEAT FLOURS

Sample	Zinc	Iron	Magnesium	Phosphorus
BWF	22.73 ± 0.09	11.81 ± 0.01	35.95 ± 0.10	43.58 ± 0.14
BFAA ₂₄	26.00 ± 0.09	14.92 ± 0.02	43.00 ± 0.09	54.27 ± 0.12
BFAA ₄₈	30.65 ± 0.06	15.00 ± 0.02	43.21 ± 0.09	54.27 ± 0.12
BFAA ₇₂	32.24 ± 0.01	16.16 ± 0.03	47.27 ± 0.08	52.63 ± 0.16
MPWF	34.63 ± 0.01	16.27 ± 0.03	13.62 ± 0.16	56.68 ± 0.12
MPAAF ₂₄	40.77 ± 0.16	18.88 ± 0.09	13.62 ± 0.16	61.87 ± 0.10
MPAAF ₄₈	56.00 ± 0.12	17.87 ± 0.11	19.44 ± 0.18	94.96 ± 0.16
MPAAF ₇₂	47.63 ± 0.11	15.06 ± 0.01	16.16 ± 0.15	80.63 ± 0.16

Mean ± Standard Deviation of three replications: BWF=Biscuits made from wheat flour; BFAA₂₄=Biscuits made from 24 hrs fermented African yam bean and acha flour blends; BFAA₄₈=Biscuit made from 48 hrs fermented African yam bean and acha flours blends; BFAA₇₂=Biscuits made from 72 hrs fermented African yam bean and acha flours blends; MPWF=Meat pie made from wheat flour; MPAAF₂₄=Meat pie made from 24 hrs fermented African yam bean and acha flour blends; MPAAF₄₈=Meat pie made from 48 hrs fermented African yam bean and acha flour blends; MPAAF₇₂=Meat pie from 72 hrs fermented African yam bean and acha flour blends.

7. Zinc

The variations in the zinc values for all the products were a function of treatment. Relative to the control, fermentation increased the zinc content of the products. The meat pie had much more increase in zinc than the biscuits 34:63 to 56.00mg vs. 22.73 to 32.24mg respectively.

8. Iron

The iron level of the products increased due to fermentation. The values ranged from 11.81 to 18.88mg. The meat pie and biscuits made from fermented flour blends had higher iron when compared with their control (14.92 to 16.16 vs. 11.81mg and 15.06 to 18.88mg) except the meat pie produced from 72hrs fermented flour blend that had lower iron value than the control (15.06 vs. 16.27mg).

9. Magnesium

The magnesium content of the products varied. The biscuits from 48hrs fermented flour blends had the highest value for magnesium (19.44mg). The biscuits made from 24 hrs fermented flour blends had comparable magnesium value with the control (13.62mg). There was an increase in the magnesium level of the meat pie made from the fermented flour blends when compared with the control (43.00 and 47.27mg vs. 35.93mg). The meat pie from 24 and 48 hrs fermented flour blends had comparable magnesium value (43.00 and 43.21mg), respectively.

10. Phosphorus

The increases in the phosphorus content for products from fermented flour blends had a similar trend. It was observed that as fermentation period increases, the phosphorus content increased for both products. The highest increase occurred at 48 hrs fermented products, followed by those of the 72 hrs.

11. Colour

The colour scores of the products differed. The biscuits and meat pie made from 72 hrs fermented flour blends had the least score for colour (5.70 and 5.25) as against the control and other products (6.20 to 7.10).

TABLE VI

SENSORY PROPERTIES OF BISCUITS AND MEAT PIE MADE FROM FERMENTED AND UNFERMENTED AFRICAN YAM BEAN AND ACHA FLOUR BLENDS AND WHEAT FLOURS

Sample	Colour	Texture	Flavour	General Acceptability
BWF	7.10 ^a ± 1.30	7.15 ^a ± 1.85	7.35 ^a ± 2.23	8.20 ^a ± 0.18
BFAA ₂₄	6.60 ^a ± 2.20	6.60 ^a ± 1.59	4.10 ^c ± 1.34	6.16 ^a ± 0.12
BFAA ₄₈	6.70 ^a ± 1.62	6.70 ^a ± 1.65	5.10 ^b ± 1.26	5.88 ^a ± 0.12
BFAA ₇₂	5.70 ^{ab} ± 2.15	5.45 ^a ± 2.44	3.85 ^{cd} ± 1.62	4.32 ^a ± 0.16
MPWF	6.30 ^a ± 2.49	7.30 ^a ± 1.73	7.60 ^a ± 1.11	8.00 ^a ± 0.09
MPAAF ₂₄	6.20 ^a ± 1.47	6.45 ^a ± 1.91	4.10 ^c ± 1.64	5.48 ^a ± 0.12
MPAAF ₄₈	6.35 ^a ± 1.42	6.15 ^a ± 1.91	4.30 ^c ± 1.62	4.52 ^a ± 0.18
MPAAF ₇₂	5.25 ^a ± 2.19	5.50 ^a ± 2.33	4.30 ^c ± 1.98	3.96 ^a ± 0.24

Mean ± Standard Deviation of twenty replications means within the same column with similar superscript are not significantly different (P>0.05): BWF=Biscuits made from wheat flour; BFAA₂₄=Biscuits made from 24 hrs fermented African yam bean and acha flour blends; BFAA₄₈=Biscuit made from 48 hrs fermented African yam bean and acha flours blends; BFAA₇₂=Biscuits made from 72 hrs fermented African yam bean and acha flours blends; MPWF=Meat pie made from wheat flour; MPAAF₂₄=Meat pie made from 24 hrs fermented African yam bean and acha flour blends; MPAAF₄₈=Meat pie made from 48 hrs fermented African yam bean and acha flour blends; MPAAF₇₂=Meat pie from 72 hrs fermented African yam bean and acha flour Blends

12. Texture

There were variations in the texture scores of the products. The meat pie and biscuits made from 24 and 48 hrs fermented flour blends had comparable texture scores (6.60 and 6.70, 6.45 and 6.15 respectively). The products from 72 hrs fermented flour blends had the lowest scores for texture (5.45 and 5.50), when compared with the control and others.

13. Flavour

The flavor of the products was influenced by treatment. Fermentation decreased the flavor of the products as observed from the ratings. The biscuits made from 72hrs fermented flour blends had the least score for flavor (3.85).

14. General Acceptability

The general acceptability scores of the products varied. It ranged from 3.96 to 6.16 for both meat pie and biscuits. It was observed that as fermentation period increased the general acceptability of the products decreased, hence increased the general acceptability of the products decreased, hence the least acceptability scores for the products from 72 hrs fermented flour blends (Table VI). Relative to the control, fermentation decreased the general acceptability scores of the products.

X.DISCUSSION

A. Proximate Composition of Fermented and Unfermented African Yam Bean and Acha Flours

The higher moisture content of the 48 and 72hrs fermented flours indicated that the flour would have a low keeping

quality and shelf life. It is known that the higher the moisture content of food, the lower is the keeping quality and vice versa. Microorganisms that cause food spoilage thrive well in the presence of adequate moisture [13].

The higher protein for the 48 hrs fermented flours might be that the 48 hrs fermentation is the optimum period for the release of more free amino acid and reduced use of protein for microflora metabolism. This finding accords the report of previous works on fermented cereals and legumes [7], [14]-[18].

It was observed that during fermentation, some of the dormant proteolytic enzymes were activated, which hydrolyzed protein to release more free amino acids. The increase in protein for the fermented samples might also be attributed to the breakdown of protein-tannin, tannin-enzyme complex by the microflora enzymes and released free amino acids.

The slight increase in fat content of the flours at 48 and 72 hrs fermentation periods might be attributed to the activity of the lipolytic enzymes during fermentation. The lipases hydrolyze fat to fatty acid and glycerol [19]. The fatty acids could be used in the synthesis of new lipids. These flours with high fat will have more chance of oxidative rancidity. However, it is known that the higher the fat content of given flour, the higher is the flavor and improved texture of its baked products.

The increase in the ash values of the fermented flours relative to the control was due to fermentation. Fermentation results in an improvement of the nutritive value of food by an increase in the level of essential nutrient or reduction in the level of anti-nutrients and toxicants in the food [15], [18]. The much more increase in the 48 hrs fermented flour indicated that it is the optimum fermentation period for increased ash value in the flours.

The decrease in the fiber level was due to the loss of dry matter. The decrease observed in the flours was in line with the report of [16], [20].

The increase in carbohydrate levels of the fermented flours was contrary to some reports in the literature. It is known that during fermentation, complex carbohydrates are hydrolyzed to simple sugars, these sugars are used for metabolic processes, and this caused a decrease in carbohydrate values.

B. Mineral Composition of Fermented and Unfermented African Yam Bean and Acha Flours

The increase in the mineral (Zn, Fe, Mg, and P) content of the fermented flour composites, relative to the control was not a surprise. Minerals are known to be more available after fermentation [18], [19]. Fermentation improves the bioavailability of minerals such as iron, zinc, magnesium and phosphorus as a result of phytic acid hydrolysis [18], [19]. The highest increase in the zinc, iron, magnesium and phosphorus level of the fermented flour at the 48 hrs fermentation period suggested that it is the optimum period for availability of these minerals.

C. Anti-Nutritional Composition of Fermented and Unfermented African Yam Bean and Acha Flours

The drastic reduction in the level of the anti-nutrients of the flours as fermentation period increased was in agreement with the findings of many researchers on fermented legumes and cereals flours. Osagie [1] revealed that simple food processing techniques such as fermentation factors in plant food. It was observed that the highest decrease occurred at a longer period of fermentation (72hrs), indicating that prolonged fermentation is essential in order to reduce the anti-nutrients to a safe level. [1], [18]-[20]

D. Proximate Composition of Biscuits and Meat Pie Based on Fermented African Yam Bean and Acha Flour Blends and Wheat Flour

The increases in the moisture content of the products (biscuits and meat pie) were a function of treatment. The higher moisture for the meat pie than the biscuit was not a surprise; biscuits are usually dry and have a longer shelf life due to low moisture content [15]. The little quantity of water is added to the biscuit mixture. The meat pie fillings (meat and other ingredients in the meat pie) also attributed to the high moisture content of the meat pie. The higher moisture content for the 72 hrs fermented products lowers their keeping quality and shelf life.

The increase in the protein content of the meat pie than the biscuits was due to the addition of meat or sausage and other ingredients used in the meat pie fillings. The higher protein from the products from 48 hrs and 72 hrs fermented flour blends was attributed to long fermentation period. Fermentation improves the nutritional values or quality of plant foods [1]. This observation was in line with the findings of many researchers [20], [21].

The high-fat content of all the products was of interest. This is because fat acts as flavor retainer and increases the mouth feels of foods. Evidence have shown that the higher the lipid level of a given food, the better the flavor, and aroma.

The ash levels of the products from the fermented flour blends were influenced by fermentation. The meat pie had higher ash than the biscuits. This may be attributed to the ingredients in the meat pie fillings. The highest ash value for the meat pie made from 48 hrs fermented flour blends indicated that 48 hrs fermentation is the optimum period for increased ash availability.

The decrease in fiber level of the products from fermented flour blends was ascribed to treatment and mixture prior to baking.

E. Mineral Composition of Biscuit and Meat Pie Based on Fermented African Yam Bean and Acha Flour Blends and Wheat Flour

The increase in the products from fermented flour blends was not a surprise. Fermentation improves the bioavailability of minerals such as iron, zinc, and phosphorus. Research has shown that acid or alcoholic fermentation can be used for cereals, legumes or vegetables to increase their nutritional value and improve their physical characteristics [20], [22].

F. Sensory Evaluation of Biscuits and Meat Pie Based on Fermented African Yam Bean and Acha Flour Blends and Wheat Flour

The low score for color, flavor, and texture of the products from the fermented flour blends influenced their acceptability. The higher acceptability for the control was that people prefer wheat products because they are used to the taste. Wheat flour is popularly used for baking. However, the fermented products were acceptable especially those of the 24 and 48 hrs fermented flour blends. This suggested that the 24 and 48 hrs were the optimal periods for fermentation of legumes and cereals to impact desirable attributes to their flours and products. Nnam [22] reported better acceptability of cakes and bread produced from fermented flours.

XI.CONCLUSION

This work has provided baseline information on the chemical composition of African yam bean and acha flour blends, as well as the nutrients and sensory properties of snacks produced from the flours. Fermentation increased the nutrient contents of both the composite flours and the products. The protein, ash, and mineral were much more increased. Fermentation effectively reduced the levels of the anti-nutrients (tannin, oxalate, phytate, saponin, and hemagglutinin) of the flours. The snacks (meat pie and biscuits) from 24 and 48 hrs fermented composite flours were acceptable. The use of African yam bean and acha flours in baking offer new food uses of the staples. However, the acceptability of the snacks requires more advertising since many people are not used to snacks made from the legume. As judged by the results, the snacks from the legume and cereal flour blends have more nutrient than the control, although the poor acceptability of the snacks is due to the beany flavor of the African yam bean.

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