Effect of fermentation periods on the nutrient quality and sensory acceptability of Africa Yam Beans (*Sphenostylis sternocarpa*) porridge

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**Abstract**

This study evaluated the effect of fermentation periods (24, 48 and 72 h) on the nutrient quality and sensory acceptability of African yam bean (AYB) porridge. The result shows significant (p<0.05) effect on the nutrient composition and sensory scores of AYB porridge due to fermentation periods. The unfermented (control) AYB porridge had higher values of fat (7.78%), fibre (4.31%) and ash (2.94%) than the 24 h, 48 h, and 72 h fermented porridge. The reverse was the case as 24 h, 48 h and 72 h fermented porridge had higher values of protein (27.87%, 28.90%, 30.80%) than the unfermented porridge (26.35%). The range of the mineral values for Ca (22.74 - 28.06 mg/100g), Mg(10.88 - 26.13 mg/100g), K (115.25 - 140.86 mg/100g) and anti-nutrients for phytate (0.02 – 0.15 mg/100g), oxalate (0.25 – 4.82 mg/100g), tannin (0.93 – 8.46 mg/100g) showed a decreasing trend from unfermented porridge > 24h > 48 > 72 h fermented porridge, respectively. Fermented porridge especially at 24 h, and at 48 h had better sensory acceptability scores than the unfermented and 72 h porridge. The total microbial population in the fermented liquor indicates that Total Viable and Lactobacillus counts increased with increasing fermentation period, that is, from 24 to 72 h, while total Fungal count decreased from 24 to 72 h fermentation period. This study shows that fermentation periods have significant effect in increasing the nutrient quality of AYB porridge for improved human nutrition and in amelioration of hidden hunger.

**Keywords:** African yam bean porridge, Fermentation periods, Nutrient quality, Sensory acceptability, improved nutrition

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AYB is believed to have strong potential for the management of malnutrition, some degenerative and chronic non-communicable diseases because of its dietary fibre content (Abioye et al., 2015). Proximate analysis of AYB seed by Abioye et al. (2015) showed that it contains 8.73-9.37% moisture, 28.63-30.43% protein, 2.40-3.33% fat, 3.23-3.70% ash, 2.40-3.05% crude fiber, and 50.80-53.57% carbohydrates. However, AYB contains some anti-nutritional factors (trypsin inhibitors, haemagglutins, phytate, tannin, oxalate and alkaloids) that hinder the availability of the nutrients and cause reduced growth (Nwokolo, 1987; Ajibade et al., 2005; Fasoyiro et al., 2006).

One other limitation of AYB meal is the flatulence factor due to high content of oligosaccharide (stachyose and raffinose) (Nwinuka et al., 1997; Oboh et al., 1998), which freedom can be achieved through fermentation and other processing methods. AYB is also hard to cook but can be substantially reduced by pre-cooking treatment.

In Southeast region, AYB is processed and eaten by roasting in pan, the seed coat de-hulled by bruising with hands or bottle on a flat surface and then winnowed to obtain clean and roasted seeds. The roasted seeds are packaged and retailed in cellophane or corked bottles. It is also sorted and washed in water and then cooked over-night, and made into porridge. As porridge, it can be mixed with yam, cocoyam or trifoliate yam in addition with such ingredients like crayfish, salt, pepper, onion, oil and vegetables. This is regarded as a family delicacy in some Communities of Southeastern Nigeria, especially Abia State. AYB seed are used for different food preparations in Nigeria and other West African Countries. Ogbonna and Sokari (1996) had reported on the fermentation of AYB seed for Owoh production. Jeff-Agboola (2007) also reported on the production of Otiru from AYB seeds through natural fermentation. The nutritional and anti-nutritional composition of AYB seed have been reported by several authors (Ajibade et al., 2005; Ajayi, 2011; Adelekan et al., 2012; Onuoha et al., 2017), unlike the fermented and cooked porridge made from AYB seeds. Studies on fermented and cooked AYB seed is important because the bioavailability of nutrients should best be considered based on processed conditions in which the food is consumed.

Fermentation is an important food processing method. It is a less expensive traditional processing method used to improve digestibility, nutritional quality of foods and at the same time, reduce the anti-nutritional factors and toxic substances like phytic acid, polyphenols, oxalic acid, hydrogen cyanide, raffinose and stachyose (Aburime, 2012). Fermentation modifies natural products and makes it a more acceptable nutrition with characteristic taste and aroma. Odunfa (1988) isolated some microorganisms like Lactobacillus and Bacillus spp in the fermentation of AYB. Ajayi (2011) also reported on the isolation of Aerococcus viridians and Pediococcus cerevisiae from AYB during fermentation. It is reported that undesirable anti-nutrient compounds are degraded by fermenting micro flora (Adanne et al., 2013), resulting in the enhancement of sensory and nutritional values of fermented products when compared to unfermented foods and substrates. Bearing in mind the importance of fermentation in food processing, this study was designed to understand the effect of fermentation periods on quality characteristics of Africa yam bean (Sphenostilis sternocarpa) porridge. The effect of fermentation periods (24, 48 and 72 h) at ambient temperature on the nutrient quality of Africa yam bean (Sphenostylis sternocarpa) porridge, the sensory acceptability and the microbial population involved in the natural fermentation were the major aims of this study.

Materials and Methods

Raw material

African yam bean (AYB) (Sphenostylis Stenocarpa) was purchased from Ubani market in Umuahia metropolis of Abia State, Nigeria. The chemicals and equipment were from Central Laboratory Service Unit of National Roots Crops Research Institute (NRCRI) Umudike, Umuahia, Nigeria.

Sample preparations and natural fermentation

Five (5) kg of cream colored AYB seeds were sorted, weighed and divided into three portions of 1.5kg each. These portions were labeled 24h fermentation, 48h fermentation and 72 h fermentation. Each portion was washed and soaked in tap water in the ratio of 1:3 for 24h natural fermentation at room temperature (30 °C ± 2). The same procedure was used for 48 h and 72 h fermentation.

Preparation of African yam bean porridge

The AYB porridge was prepared according to the method in Figure I. After the fermentation process (24, 48 and 72 h), the beans were rinsed thoroughly with clean water. Each of the 1.5kilograms of the fermented and unfermented beans (control) was boiled with 2.5 liters of water for 90 minutes. The same amount and types of ingredients were added, mixed with wooden spatula and boiled further for 15 minutes and the porridge was made ready for analysis.
Results and Discussion

Proximate composition of Africa yam bean porridge

The proximate composition of the fermented and unfermented AYB porridge is shown in Table 1. There were significant (p<0.05) variations in the results obtained. The moisture content of the fermented porridge was higher than the unfermented one. The same trend was observed in the protein content of the fermented porridge which were not statistically (p>0.05) different, but showed slight progressive increase from unfermented < 24 h < 48 h < 72 h fermented porridge (26.35 - 30.80%). The results shows the protein increased as the fermentation time increased.

The fibre content shows that the values of the unfermented, 24 and 48 h AYB porridge were significantly (p<0.05) higher (4.0 - 4.31%) than that of 78 h value which showed the least value.

Data analysis

Mean and standard deviation were calculated for duplicate determinations using the Statistical Package for Social Sciences (SPSS) version 10 Statistic Software Package. Data were expressed as mean ± standard deviation (SD). Comparisons between groups were performed with analysis of non-parametric test. A value of P< 0.05 was considered statistically significant.

Proximate Analysis

Moisture, crude protein, crude fat, crude fibre, ash contents were determined according to the standard methods of Association of Official Analytical Chemists (AOAC), (2010). Carbohydrate was determined by difference as follows: %Carbohydrates = 100 – (%moisture + %fat +%ash + %protein + %crude fibre).

Determination of Mineral contents

Calcium was determined using the method described by Pearson (1976). Flame photometry was used to determine the concentration of potassium and magnesium as described by James (2005).

Determination of Anti-nutrients content

Tannin was determined by the method of Harbone (1993), phytate was determined using the Biphyrimididine colorimeter method described by Onwuka (2005), while oxalate content was determined by the titration method described by Day and Underwood (1986).

Determination of microbial population of AYB fermented liquor

The method described by Ezeama (2007) was adopted. One (1) mL of the sample dilution from 24h, 48h and 72h fermented liquor was inoculated by spread plates in Nutrient Agar, Potato Dextrose Agar, MRS and MacConkey Agar and were incubated at 37°C while the PDA plates were incubated at room temperature (28°C). At the end of incubation, colonies were counted with a colony counter.

Fig. 1: Preparation of AYB porridge
The fat content of unfermented porridge (7.78%) was higher than their fermented counterpart. The result shows that the fat content progressively decreased as fermentation time increased from 24 h (4.86%), 48 h (2.91%) and 72 h (2.69%), respectively. The same trend was observed in the ash content of the porridge. There was a progressive decrease in the ash content from unfermented porridge > 24 h > 48 h > 72 h, respectively. Fat (7.78%), fibre (4.31%) and ash (2.94%) contents of unfermented AYB porridge were higher than those of the 24 h, 48 h and 72 h fermented porridge. The reverse was the case in the moisture and protein contents of the porridge which indicated significant increases in the fermented porridge than the unfermented porridge. The carbohydrate values were not statistically different irrespective of the fermentation time.

Table 1: Proximate composition of African yam bean porridge (%)

| Samples          | 500                | 501                | 502                | 503                |
|------------------|--------------------|--------------------|--------------------|--------------------|
| Moisture         | 27.56±0.01         | 30.56±0.01         | 31.74±0.01         | 31.80±0.01         |
| Protein          | 26.39±0.01         | 27.87±0.01         | 28.90±0.01         | 30.80±0.01         |
| Fibre            | 4.31±0.01          | 4.25±0.01          | 4.00±0.01          | 2.98±0.01          |
| Fat              | 7.79±0.01          | 4.86±0.01          | 2.91±0.01          | 2.69±0.01          |
| Ash              | 2.94±0.01          | 2.06±0.01          | 1.76±0.01          | 1.68±0.01          |
| Carbohydrate     | 31.06±0.01         | 30.46±0.01         | 30.69±0.01         | 30.05±0.01         |
| Energy Kcal      | 268.43±0.13        | 271.57±0.13        | 274.36±0.13        | 270.22±0.01        |

Values are means± standard deviation of duplicate determinations. Means with the same superscripts within the same rows are not significant differences at 0.05 confidence level (p<0.05).

Mineral composition of Africa Yam Bean porridge

Significant (p<0.05) variation was observed in the mineral content of AYB porridge (Table 2). The result shows progressive decrease in the minerals during fermentation time. The calcium content of the porridge ranged from 22.74 (72 h fermented porridge) to 28.06 mg/100g (unfermented porridge). Magnesium content ranged from 10.88 (72 h fermented porridge) to 26.13 mg/100g (unfermented porridge). Potassium ranged from 115.25 (72 h fermented porridge) to 140.86 mg/100g (unfermented porridge). This study reveals that unfermented porridge had higher values of Ca, Mg and K > 24 h > 48 h > 72 h fermentation, respectively. As fermentation time increased, the mineral contents decreased. The relative loss of minerals in the fermented porridge may be due to mineral utilization by microorganisms during the fermentation period. Adane et al. (2013) and Ukom and Okerue (2018) had reported similar loss of mineral elements during fermentation of cocoyam Colocasia esculenta and Xanthosoma sagittifolium. The result of mineral contents obtained in this study shows that AYB porridge can support active mineral nutrition for humans.
The anti-nutrient composition of AYB porridge is shown in Table 3. The result shows progressive reduction of the anti-nutrient phytate from unfermented (0.15 mg/100g) > 24 h (0.11 mg/100g) > 48 h (0.05 mg/100g) > 72 h (0.02 mg/100g) fermented porridge. It shows that the phytate content at 72 h fermentation had the lowest value (0.02 mg/100g), while the unfermented porridge had the highest value (0.15mg/100g). This result indicates the effect of fermentation time on phytate metabolism by fermenting microorganism. Phytate is mainly found in tubers and roots, cereals, vegetables, most legumes such as soya bean, palm kernel seed and cotton seed meal. It forms insoluble salts with divalent metal ions (calcium, magnesium, iron and zinc), and hence interferes with mineral availability since it renders the minerals unavailable for absorption into the body. Phytate also affects protein digestibility by binding with proteolytic enzyme (Onyeike, 2012).

For oxalate content, the unfermented AYB porridge had the highest value (4.82 mg/100g), followed by 24 h fermentation (3.01 mg/100g), and 48 h fermentation (2.66 mg/100g), while the 72 h fermented AYB porridge had the least value (0.25/mg/100g). The result shows that oxalate content reduced considerably during fermentation. Ingestion of foods containing oxalates has been reported to cause caustic effects and irritation to the throat and intestinal tract (Adane et al., 2013). Soaking, fermentation and boiling were found to reduce the oxalate content of the fermented AYB possibly due to the effect of leaching and enzyme hydrolysis of starch during fermentation that resulted in oxalate reduction from 4.71 to 0.25 mg/100g in fermented AYB porridge.

Likewise, the tannin content of 72 h fermented AYB porridge had the lowest value (0.93/mg/100g), while the unfermented had the highest value (8.46mg/100g)  This indicates high significant (p<0.05) decrease from 8.46 mg/100g to 0.93 mg/100g during 24 to 72 h fermentation period. The browning of AYB porridge (not shown) can be attributed to the high tannin content, which resulted into mild astringency. Fermentation of AYB seed for 24 h by Pediococcus cerevisiae (Ajayi, 2011) showed considerable reduction of phytic acid from 17.4 to 10.92 mg/100g, while tannic acid and oxalic acid increased from 0.24 to 1.49 mg/100g and from 0.04 to 1.22 mg/100g during fermentation process. These values are in disagreement with the results in this study (Table 3), probably on the basis of their variety, geographical location and fermentation time.

### Table 2: Anti-nutrient composition of Africa yam bean porridge (mg/100g)

| Samples  | 500 | 501 | 502 | 503 |
|----------|-----|-----|-----|-----|
| Phytate  | 0.15\(^a\) ± 0.01 | 0.11\(^b\) ± 0.01 | 0.05\(^c\) ± 0.01 | 0.02\(^d\) ± 0.00 |
| Oxalate  | 4.82\(^a\) ± 0.01 | 3.01\(^b\) ± 0.01 | 2.66\(^c\) ± 0.01 | 0.25\(^d\) ± 0.01 |
| Tannin   | 8.46\(^a\) ± 0.01 | 5.55\(^b\) ± 0.01 | 2.37\(^c\) ± 0.01 | 0.93\(^d\) ± 0.01 |

Values are Means ± standard deviation of duplicate determinations \(^a-d\) Means with the same superscripts within the same rows are not significantly different (P=<0.05)

**Keys:** 500 = unfermented AYB porridge, 501 = 24 h fermented AYB porridge, 502 = 48 h fermented AYB porridge, 503 = 72 h fermented AYB porridge.
Sensory Acceptability of AYB porridge

The results of the sensory acceptability score is presented in Table 4. The results show significant (p<0.05) differences. Sensory scores were carried out by 45 panelists on a 9 scale hedonic scale for attributes of aroma, texture, taste, appearance, and general acceptability. Result shows that 24 and 48h fermented porridge had higher values in all the parameters tested and were preferred to other samples, showing higher general acceptability.

Unfermented AYB porridge was the least accepted followed by the 72h fermented porridge. The general acceptability of 24 and 48 h fermented porridge was due to its moderate taste and texture. The results suggest that fermentation for at least 24h, but not exceeding 48h, will greatly enhance the sensory acceptability of AYB porridge.

Fermentation degrades anti-nutrients, extends shelf life, enhance nutritional value and sensory properties of some food products including AYB porridge. With this result, AYB porridge can serve as food substitute for the vulnerable people and diabetics.

Table 4: Sensory acceptability score of African yam bean porridge

| Attributes | 500 (unfermented AYB porridge) | 501 (24h fermented AYB porridge) | 502 (48h fermented AYB porridge) | 503 (72h fermented AYB porridge) |
|------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Aroma      | 3.08 ± 0.03                   | 6.60 ± 0.85                   | 6.12 ± 1.40                   | 4.36 ± 0.59                   |
| Texture    | 3.12 ± 0.04                   | 6.68 ± 0.92                   | 6.20 ± 0.89                   | 4.56 ± 0.67                   |
| Taste      | 2.98 ± 0.06                   | 7.08 ± 0.24                   | 5.40 ± 0.70                   | 4.80 ± 0.33                   |
| Sour       | 3.03 ± 0.66                   | 6.20 ± 0.44                   | 6.04 ± 0.93                   | 4.44 ± 0.69                   |
| Appearance | 2.30 ± 0.06                   | 5.96 ± 0.08                   | 6.50 ± 1.00                   | 4.12 ± 0.25                   |
| After taste| 2.40 ± 0.47                   | 6.49 ± 0.62                   | 6.16 ± 0.48                   | 4.88 ± 0.61                   |
| Overall    | 3.10 ± 0.08                   | 7.00 ± 0.66                   | 6.90 ± 0.61                   | 5.48 ± 0.75                   |

Values are Means ± standard deviation of duplicate determinations. Means with the same superscripts within the same rows are not significantly different (P<0.05)

Keys: 500 = unfermented AYB porridge, 501 = 24h fermented AYB porridge, 502 = 48h fermented AYB porridge, 503 = 72h fermented AYB porridge

Microbial population of AYB fermented liquor evaluated at 10^n dilution factor

Table 5 describes the microbial population on the nutrient agar plates. There was no microbial report in the cooked porridge since the microorganisms would have been killed during the cooking process. Only the fermented liquor at 24, 48 and 72h were evaluated for microbial growth. The PDA and MRS plate shows significant growth of microbes on the fermented liquor while the MacConkey agar plates had no presence of Coliform. The result shows that at 24 h fermentation, the total viable count was 1.42x10^8 cfu/g, it increased to 2.00x10^8 cfu/g at 48 h and to 2.48x10^8 cfu/g at 72 h. Fungal growth in PDA at 24 h fermentation gave a load of 4.00x10^7 cfu/g, while in 48 and 72h fermentation, they reduced to 1.40x10^8 and 1.48x10^8 cfu/g, respectively. Lactobacillus growth in MRS had a load of 2.00x10^7 cfu/g in 24 h fermentation, it increased to 6.00x10^7 cfu/g and 6.80x10^7 cfu/g during 48 and 72 h fermentation, respectively. The clear observation was a progressive microbial population increase as fermentation time increased for Total viable count and Lactobacillus count which agreed with the observation of Jeff-Agboola (2007) on the fermentation of AYB seed in 24 to 72h. The high Total viable and Lactobacillus count may be due to high protein content of AYB and increased temperature generated during the fermentation process. In all the fermentation time carried out, there was no identification of the presence of Coliform organism.

Isolation of microorganisms involved in AYB seed fermentation was reported by Ajayi (2011) to include Pediococcus cerevisiae and Aerococcus viridians. Jeff-Agboola (2007) also isolated the following bacteria, Lactobacillus jensenii, Bacillus coagulans, Aerococcus viridians, Pediococcus cerevisiae and yeast, Saccharomyces cerevisiae and Candida mycorderm from natural fermented AYB at 30 °C for 72, 96 and 120 h, respectively. We did not attempt to isolate the microorganisms involved in the sample fermentation periods because earlier researchers have identified some which constituted the fermenting micro flora of AYB seeds for porridge production.
**Conclusion**

The effect of fermentation periods (24, 48 and 72 h) on the quality characteristics of African yam bean (*Sphenostylis stenocarpa*) porridge showed that protein increased as fermentation time increased, while fibre, fat, ash, minerals and anti-nutritional contents showed varying levels of reduction as fermentation time increased probably as a result their microbial utilization and lixiviation. The results also showed that AYB porridge produced at 24 h fermentation, but not exceeding 48 h fermentation will have better sensory acceptability. The microbial population for Total viable and Lactobacillus counts showed increases as fermentation time increased from 24 to 72 h, while Fungal growth reduced as fermentation time increased from 24 to 72 h. Coliform (pathogenic) organism was not noticed throughout the duration of fermentation. From this study, the production of porridge from AYB seed and its nutritional qualities at different fermentation periods have been highlighted. The high nutritional value and reduced anti-nutritional factors in AYB porridge makes it a valuable nutrient dense food source for all groups of people.

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