Effect of Fermentation on Nutritional Composition of African Oil Bean Seed

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ABSTRACT

African oil bean seed (*Pentaclethra macrophylla*), when locally fermented as "ugba", is used to prepare different types of food items especially in Igbo land and in Nigeria in general. The local fermentation process involves boiling the seed for four hours, de-hulling, slicing into different sizes, boiling again for another two hours, and soaking in water for two hours. At the end of the soaking stage, it is allowed to ferment for between 12 to 24 hours. This work studied the effect of this fermentation on the nutritional composition of African oil bean seed.

Standard procedures of investigation were applied in the proximate analysis of the seed from raw to 96 hours of fermentation and at 12 hours interval. The Kjeldhal method for protein analysis, described by AOAC (1997) with slight modification by Opara C.C. et al (2013), was used to measure nitrogen content of the seed during the fermentation processes, at different temperatures of 28°C, 32°C, and 35°C, and for different sizes of slicing to throw light on the rate of fermentation.

The mineral content of the oil was analyzed using Atomic Absorption Spectroscopic method (AAS). The extracted oil was subjected to both physical and chemical analyses as way of throwing more light on its further domestic and industrial applications. The study revealed that fermentation brought about change in nutritional content of the seed with the fermentation reaching its peak at about seventy two hours due to the amount of nitrogen released during the period of fermentation. Results also showed that temperature greatly affects fermentation because fermentation did not occur at 35°C. Nitrogen content increased as fermentation was going on except on the third day when nitrogen was not seen but was observed on the fourth day.

The data, which were analyzed by ANOVA, showed that the highest rate of fermentation occurred at 28°C and on a sliced size of 5.0cm long x 1.0cm wide The regression equation is given as $Y = 0.004t + 0.168$, with $R^2 = 0.979$. In conclusion, the study shows that fermentation increases the nutritive value of 'Ugba'. It also shows that the nutritional composition of African oil bean seed varies with length of time of fermentation.

(Keywords: oil bean seed, fermentation, nutritive values, physico-chemical properites)

INTRODUCTION

African oil bean seed (*Pentaclethra macrophylla*) is one of the many tropical under-utilized crops that are recently attracting worldwide attention because of its high nutrient potential (Enujiugha, 2003). The Ibo's in the Eastern Nigeria use the name 'Ugba' for the fermented African oil bean seed. It is a traditional food condiment generally produced by (local) fermentation in homes as a small family business (Ogueke et al, 2010). African oil bean seed is a cheap source of protein and minerals for feeding pregnant and lactating mothers, malnourished children and animals (Enujiugha, 2008).

Fermentation is a reaction wherein a raw organic feed is converted into products by the action of microbes or by the action of enzymes. Fermentation takes place mostly in absence of oxygen (lactic acid fermentation) but it can also occur in abundant presence of oxygen as in the case of yeast cells which are used in baking.

Fermented foods, found in many parts of the world, include: wine, yogurt, bread, cheese, alcohol, vinegar, etc. In Africa, fermented food such as garri, fermented millet porridge, Ogi, Ugba, Iru, Ogili, etc. exist (Dirar, 1993).

Fermented foods are produced in different ways. For instance Ogili, Iru, Ugba, etc., are subjected to heat treatment by boiling for several hours, dehulling, slicing and subsequent wrapping in fresh leaves where the fermentation will then take place. Garri on the other hand is dehulled, ground and the water drained. It is allowed to ferment for about 48 hours after which it is sieved and fried. In production of alcoholic beverages such as wine, beer, etc., sugars in fruits, cereals, etc., are converted into ethanol. In baking and some other food processing, fermentation is used to convert carbohydrates to alcohols and carbon dioxide or organic acids using yeast, bacteria or a combination thereof (Dirar, 1993). In this study, microbial fermentation is involved.

The nutritive and calorific value of African oil bean seed (Ugba) makes it a good source of protein, edible oils, and fats. It contains all essential amino acids (Enujiugha and Akanbi, 2005).

The 'Ugba' is prepared locally by boiling the African oil bean seed for several hours after which the water is drained. The cooked seed is dehulled, and sliced. The sliced 'Ugba' is cooked again for some hours and the water is drained. At this point the 'Ugba' is soaked in water for hours, washed several times after which the water is drained thoroughly using a basket. Another basket is lined with fresh leaves and the 'Ugba' poured inside it, well covered and is allowed to ferment for about three days or more.

The method of preparation of 'Ugba' varies from community to community. This affects its fermentation process and consequently its nutrients. The wrapped 'Ugba' is sold to consumers at various stages of fermentation and they are often told the length of fermentation as this affects the nutritional composition of such food. On the other hand, allowing foods to ferment for an extended period of time before being consumed can cause some health problems (Wikipedia, 2017). African oil bean seed is fermented and consumed either alone or in combination with other food ingredients or as a condiment in soup and salads (Achinewhu, 1986). Unfermented seeds are bitter to taste and contain toxic alkaloid, paucine and growth depressant, cafeoyl-putescine (Mbadiwe, 1979). Fermentation renders the seed nutritious and non-toxic (Uzogara et al, 1990).

Fermentation food serves various purposes such as elimination of anti-nutrients, enrichment of the diet through development of a diversity of flavors, aromas, and texture in food substrates, preservation of substantial amounts of nutrients, biological enrichment of food substrates with protein, vitamins, fat and oil, etc. Fermented foods reduce cooking time and fuel requirement. The sale of fermented and unfermented African oil bean seed is a common business among the Ibos, thereby serving as a source of income and subsequently creating employment.

This study aims at determining the nutritional composition of the Africa oil bean seed (i.e. proximate analysis of the oil bean seed) at the various stages of fermentation. This will help to give the consumers insight on the nutritional composition of the seed at the time of purchase based on stage of fermentation of the seed. The study is also aimed at providing parameter data for local batch processing method and information on the effect of fermentation on the oil content of the seed, as well as the Nitrogen content of the seed during fermentation.

EXPERIMENTAL WORK

Fresh and uninjured oil bean seeds were purchased from Afor Opi, Nsukka Local Government Area of Enugu State in Nigeria.

Proximate Analyses

The African oil bean seed was boiled for four hours, dehulled, sliced and boiled for another two hours. Then, it was soaked in water for two hours and afterwards thoroughly washed and packed in different water bottles that provide warmth for fermentation. Proximate analysis of the seed was carried out at twelve hours interval of fermentation for four days. The temperatures of the fermenting samples were also measured. The percentage moisture, the crude fiber, the crude protein, the crude fat and the carbohydrate content were determined using the standard methods of Proximate analyses which include: Protein by Kjeldhal method described by AOAC (1997), Ash by gravimetric method as outlined by Pearson (1976) with slight modification by Odo and Ishiwu (1999), Crude fat and moisture content by method described by Pearson (1976) and outlined by Odo and Ishiwu (1999) and carbohydrate by subtracting the sum total of all other parameters from 100.

Oil Extraction/Characterization

The oil extraction from the flour was done by leaching method. The extraction and oil characterization were done on the raw seed and after fermentation at fourth day. The physicochemical properties determinations also followed standard methods. The specific gravity by Onwuka, (2005), the refractive index by Kyari, (2008), the viscosity by AOACD, (1997), the iodine value by Wij's method described by Pearson, (1976) and modified by Odo and Ishiwu, (1999), the saponification value by Pearson, (1981), the free fatty acid and the peroxide by AOAC, (1997).

Nitrogen Content of Oil Seed

The method used is according to Kyeldhal method for protein analysis described by AOAC, (1997) with slight modification by Opara et al., (2013) the ammonia generated during fermentation is collected in an excess of boric acid $2NH_3 + 2H_3BO_3 \rightarrow 2NH_4 \; H_2BO_3$. Subsequently the nitrogen is estimated by titration of the ammonium borate produced with standard H_2SO_4 or HCl.

RESULTS AND DISCUSSION

Table 1: Proximate Analysis of the African Oil Bean Seed during Fermentation.

Parameters (%)	Raw	12hrs	24hrs	36hrs	48hrs	60hrs	72hrs	84hrs	96hrs
Protein	17.37	18.01	20. 00	20.98	22.21	22.98	23.56	23.98	24.00
Fat	21.7	23.57	25.28	26.57	27.87	28.12	29.21	30.00	30.1
Crude fiber	5.2	4.59	3.27	3.05	2.10	1.90	1.20	0.82	0.71
Moisture	30.31	34.00	37.01	39.18	40.25	41.02	42.10	42.51	42.89
Ash	0.51	0.42	0.31	0.29	0.23	0.20	0.19	0.16	0.15
Carbohydrate	24.19	19.41	14.13	9.93	7.34	5.78	3.74	2.53	2.15

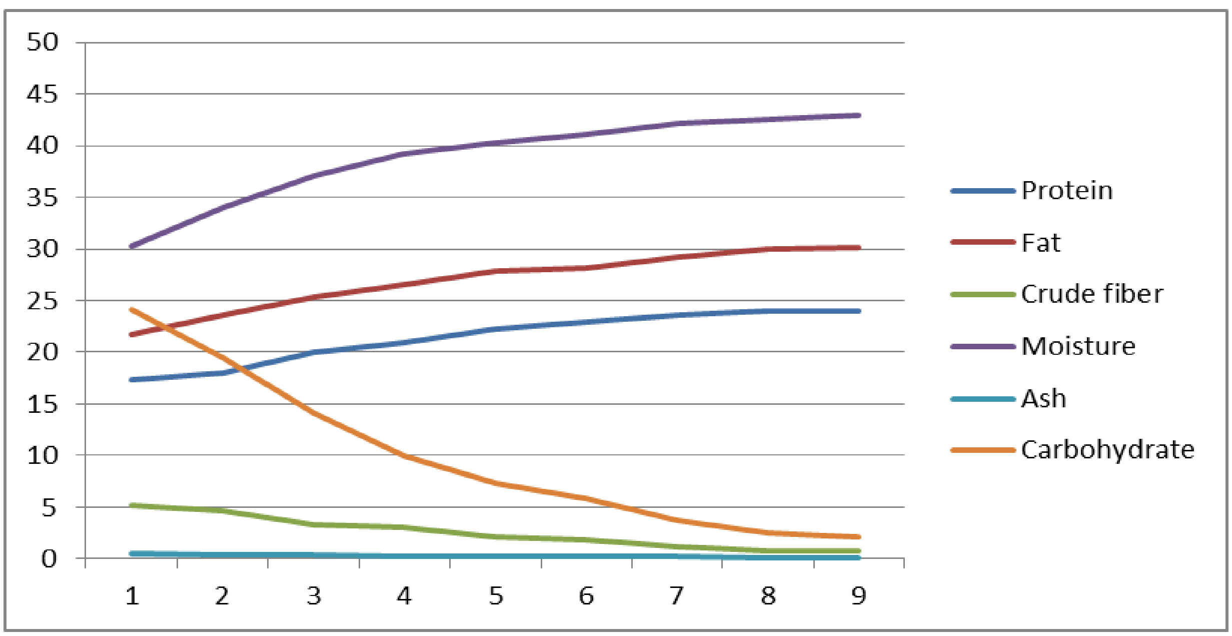

Figure 1: Plot of Nutritive Values with Time of Fermentation.

Fermentation brought about changes in the nutrient composition of "Ugba". The protein content rose from 17.37% in raw seed to 24.00% at the 96th hour of fermentation as can be seen from Table1 and Figure1 (above). The value of 17.37% is close to 22.32 obtained by Enujiugha and Akanbi, (2005) for raw seed. The optimum period of protein content enhancement was about three days. The increase in crude protein content of "Ugba" was as a result of protein synthesis during the period. This agrees with the finding by Okechukwu, et al. (2012) on changes in nutrients of the African oil bean meal under natural fermentation. According to Pearson, (1976) plant food that provides more than 12% of its calorific value from protein is considered good source of protein.

The crude fiber reduced during the fermentation process. It decreased from 5.2% in raw seed to 0.71% at the 96th hour. This is close to 7.57% in raw seed obtained by Eze, et al. (2014) and 0.17% in fermented seed is close the value obtained by Enujiugha and Akanbi (2005). The reduction observed in crude fiber content was due to action of cellulolytic micro-organism present in the fermenting substrate. Isu and Ofuya (1990) reported an over 35% loss of cellulose during the solid state fermentation of cassava peel.

The moisture content increased from 30.31% in raw seed to 42.89% at 96th hour. This shows that the fermented seed is liable to deterioration. However, the high moisture level has been suggested to predispose the product to rapid spoilage (Odunfa and Oyeyiola, 1985; Ogueke and Aririatu, 2004). This is because a number of biochemical reactions and physiological changes in food depend very much on the moisture content (Onwuka, 2005). Eze, (2013) reported in kinetic analysis of the thermos-stability of peroxidase from African oil bean seed that a major problem in the storage and marketing of processed oil bean seed is its high deterioration rate due to activity of peroxidase.

The fat content increased from 21.7% in raw seed to 30.1% at 96th hour. The value 21.7% in raw seed agrees with the value 20.80% obtained by Akubugwo, et al. (2008) and 19.72% obtained Eze, et al. (2014). Enujiugha and Akanbi, (2014) obtained 53.98±0.99% in raw seed and 61.35±1.21% in fermented seed. Kar and Okechukwu, (1978) reported that the oil content could be as low as 38% which is close to 30.1% obtained from this study. However this study and that by Enujiugha and Akanbi showed that fermentation increases the fat content of the African oil bean seed. This means more calories for man and animals. It also shows that it is a source of edible fats and oil for which when ingested metabolizes to give energy and other fat soluble vitamins.

The carbohydrate decreased from 24.19% in raw seed to 2.15% in fermented seed. This is in agreement with Monago, et al. (2004) which states that carbohydrate decreased significantly as fermentation time increases. A value of 24.19% is close to 27.72% obtained by Okechukwu, et al. (2012) and 19.16±0.76% obtained by Enujiugha and Akanbi (2005) in raw seed, respectively. The value 2.15% obtained in the fermented seed differs significantly from 17. 48% obtained by Enujiugha and Akanbi (2005) in fermented seed.

Ash is the measure of mineral content. Though fermentation reduced the ash content especially zinc and sodium composition, magnesium, phosphorus, manganese and iron contents were found to increase as shown in table above. The ash content decreased from 0.51mg/g to 0.15mg/g. The 0.15mg/g obtained in fermented seed from study is very close to 0.17mg/g obtained by Okechukwu, et al. (2012) at the fifth day of fermentation. Animals need elements for body function such as formation of egg shell, heart and muscle activities, nervous coordination and blood coagulation (Okechukwu, et al., 2012). This will ensure better mineral supply for production of healthy animal.

Table 2: Characterization of Oil.

Parameters	Raw	Fermented
S.G	0.87	0.921
Saponification (mg/g)	218.3	200.5
Acid value(mg/g)	3.0	15.4
FFA(mg/g)	1.5	7.7
Peroxide(mg/g)	2.61	22.7
Iodine value(mg/g)	20.8	23.0
Refractive index	1.4641	1.4635
Viscosity(mg/g)	0.0024	0.0092

Table 2 shows the physiochemical composition of the African oil bean seed. The FFA for the raw seed 1.5% conforms with 1.4% obtained by Akubugwo, et al. (2008). The free fatty acid increased from 1.5% before fermentation to 7.7% after fermentation.

The saponification value decreased from 218.3% in raw seed to 200.5 after fermentation. This is close to 209.40% obtained by Akubugwo, et al. (2008). The peroxide value increased from 2.61% in raw seed to 22.7% in fermented seed. This conforms to the value 2.35 ± 10.41 in raw seed as obtained by Akubugwo, et al. (2008). Peroxides values are used as indicators of deterioration of oils. Fresh oil has peroxides values less than 10meq/kg while values above 20 indicate a rancid taste and disagreeable odor (Pearson, 1976).

The lower peroxide value of this oil is indicative of low level of oxidative rancidity of the oil and also suggests the presence or high level of antioxidant. A relative high saponification value of oil indicates that the oil has potentials for use in the industries especially in soap manufacturing industries (Kyari, 2008 and Amo, et al., 2004). Acid value is used as an indicator for edibility of oil and stability for use in the paint industries. The acid value of the raw seed studied, 3.0 fell within allowable limits for edible oil (Codex Alimentarius Commission, 1982). The oil from fermented seeds has high acid value from 3.0 to 15.4.

Refractive index remained unchanged. The iodine value remains slightly unchanged from 20.8 raw to 23.0 after fermentation. This shows difference from the value 74.9 got by Akindahunsi (2004) but close to 20.50 ± 2.0 obtained by Akubugwo, et al. (2008) for the raw seed.

Table 3 below shows the mineral composition of raw seed and fermented seed of various particle sizes. Results from the present investigation show that the seed is of high nutritional values. The mineral composition being the ash content shows high values in calcium, magnesium, phosphorus, sodium, zinc, manganese and iron.

Table 3: Minerals.

Parameters (mg/g)	Raw	Fermented
Calcium (mg)	0.2	4.53
Magnesium (mg)	0.21	1.07
Phosphorus (mg)	60.01	69.91
Sodium (mg)	65.27	42.21
Zinc (mg)	12.19	10.13
Manganese (mg)	16.23	17.73
Iron (mg)	10.02	11.23

Calcium increased from 0.2 in raw seed to 4.53 after fermentation. Phosphorus increased from 60.01 in raw seed to 69.91 after fermentation. This is close to 60.40 obtained by Okechukwu, et al. (2013). Sodium decreased from 65.27 to 42.21 after fermentation. Iron increased from 10.02 to 11.23 after fermentation. This agrees with the result 11.40 obtained by Okechukwu, et al. (2013).

Table 4: Nitrogen Content of the Fermented Seed.

Temperature		212 (Paste Microns)µm	3cm x 1cm	5cm x 1cm
28°C	Day1	0.616%	0.448%	0.280%
	Day2	0.700%	0.504%	0.336%
	Day4	0.784%	0.616%	0.560%
32°C	Day1	0.252%	0.168%	0.112%
	Day2	0.588%	0.336%	0.224%
	Day4	0.616%	0.504%	0.252%
35°C	Day1	Nil	Nil	Nil
	Day2	Nil	Nil	Nil
	Day4	Nil	Nil	Nil

The amount of nitrogen given out by the different sizes of the sample increased from 24 hours to 48 hours. This can be seen in Tables 4a and 4b. No nitrogen was discovered at the 72nd hour but at the 96th hour nitrogen was given out as can be seen in Table, Days 3 and 4. This can be attributed to the fact that pH decreased at 72hrs Obeta (1983). The drop in pH at 72 hrs could be attributed to the fact that B. *subtilis* and B. *licheniformis* use ammonia as nitrogen source Odunfa (1986). Fermentation took place only at 28ºC and 32ºC but not at 35ºC as no ammonia was found at 35ºC, suggesting little or no fermentation at all at this temperature. The amount of nitrogen given out decreased with increase in temperature and size. The results of Table 4 were plotted as shown in Figures 4a and 4b

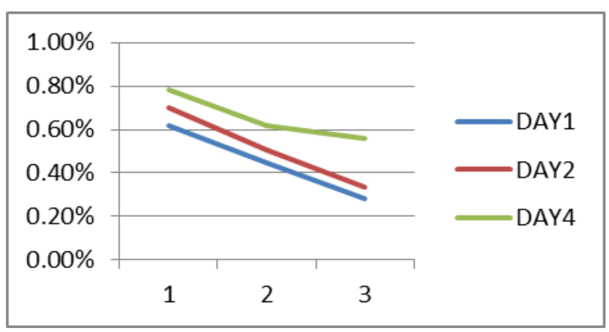

Figure 4a: Plot of %Wt of Nitrogen versus Time at 28^{O}C.

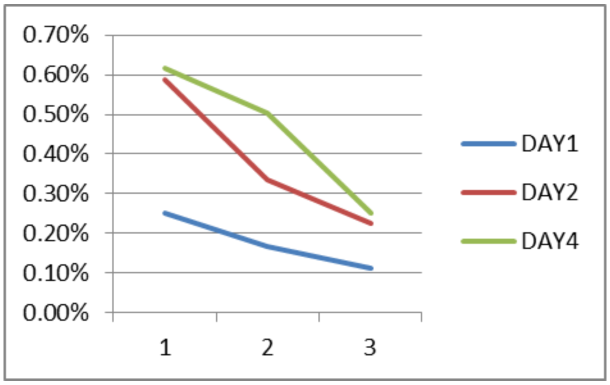

Figure 4b: Plot of %Wt of Nitrogen versus Time at 28^{O}C.

CONCLUSION

From the results discussed above, it is seen that the length of time of fermentation of African oil bean seed has significant effect on its nutritional composition. The study suggests that African oil bean seed is an alternative protein and other nutrient sources as can be seen in the experimental result. The results also show that fermentation increases key nutritional values like protein, fats and oil etc. The seed could be a good source of protein and food supplement for human nutrition and animal feed. The seed also contains high level of good quality of oil in terms of its iodine value, peroxide value, saponification value, etc. Time of fermentation also affects the mineral content of the oil.

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