



EFFECT OF SOFTENING AGENTS ON THE CHEMICAL AND ANTI-NUTRIENT COMPOSITIONS OF FERMENTED *PROSOPIS AFRICANA* SEEDS

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ABSTRACT

The fermentation of *Prosopis africana* leads to the production of a local condiment in Nigeria called *Okpehe*. In this study, *Okpehe* was processed from *Prosopis africana* seeds using two chemical softening agents (wood ash and potash) at different concentrations (1%, 5%, 10%, 15% and 20%). Sample A was *Okpehe* processed with wood ash while potash was used for processing sample B. The effect of these softening agents on chemical and anti-nutritional (tannin, phytate and oxalate) composition of *Okpehe* was investigated every 24 hours for 72 hours. Different concentrations (1%, 5%, 10%, 15% and 20%) of the antinutrients were used for the study. There was a significant increase ($p < 0.05$) in pH (6.00 – 8.50), crude protein (32.00 – 39.50%) and crude fibre (4.10 - 6.00%) while the amounts of crude fat (12.02 – 7.20%) and carbohydrate (38.30 – 31.30%) decreased significantly ($p < 0.05$) till the end of fermentation for all the samples. There was reduction in the anti-nutritional content of *Okpehe* processed with the two softening agents as fermentation progressed. *Okpehe* processed with wood ash at 15% and that processed with potash at 20% had better chemical composition and lower anti-nutritional values. Results obtained from this study showed that wood ash is a better softening agent that can be used in the processing of *Okpehe* with an accompanying reduction in time and energy used in its production.

1. Introduction

Legumes are important sources of dietary protein in developing nations. They are traditionally available but most of their values are not well appreciated (Igwe et al., 2012). Some of these legumes like bambara groundnut, African oil bean, *Prosopis africana* seeds are underutilized. They also contain anti-nutritional factors which has contributed to their under utilization. These anti-nutrients, however, can be reduced by fermentation. Fermented plant seeds are used as food in some

rural parts of Nigeria. For example *ugba* is made from African oil bean (*Pentaclethra macrophylla*) (Achi, 2005), *iru* from African locust bean (*Parkia biglobosa*), *ogiri* from castor bean (*Ricinus communis*) and *Okpehe* from *Prosopis africana* seeds (Omafuvbe et al., 2003). *Okpehe* is a traditionally fermented soup condiment produced from *Prosopis africana* seeds. The seeds are inedible in the raw form. They can only be consumed when processed and fermented using the metabolic apparatus of microorganisms. This process enhances

digestibility of proteins and oligosaccharides through hydrolysis (Oguntoyibo, et al. 2007). The processed seeds have an increased shelf life and a reduction in the anti-nutritional factors (Odunfa, 1985a). Fermentation improves digestibility, nutritive value and flavour of the raw material. *Okpehe* may serve as a substitute for meat for the low income earners (Oguntoyinbo et al. 2010), as a flavour intensifier for soups and stews and also improve the protein content of poor protein diet (Balogun et al., 2013; Oguntoyinbo et al., 2010). It also contribute to the intake of essential fatty acids (Ezenwa and Ikenebomeh, 2008), vitamins particularly B vitamins, riboflavin and vitamin A.

Prosopis africana seeds like other legumes contain anti-nutrients which are concentrated in the seed coat and dehulling becomes a critical operation in their processing. The seeds are difficult to dehull and can thus be classified as a hard to dehull legume. Several methods have been reported for the softening of the seeds. Traditionally, *Okpehe* seeds are boiled overnight to soften the seeds. Achi and Okereke (1999) reported the use of 0.1M Na_2CO_3 to boil *Prosopis africana* seeds which reduces the normal cooking time of about 5-6 hours and increased the dehulling efficiency to 89%. The addition of potash (potassium carbonate) in the softening of African oil bean seed has also been reported (Odunfa 1985b). Literature abounds on the processing of *Prosopis africana* seeds into fermented product using different methods; however, there is little or no information on the effect of softeners on the chemical composition of the fermented seeds. This study therefore, was designed to determine the effect of softening agents (wood ash and potassium carbonate) on the chemical and anti-nutrients composition of fermented *Prosopis africana* seeds.

2. Materials and methods

2.1. Vegetal samples

Prosopis africana fruits were picked from the main campus of the University of Ilorin,

Ilorin, Nigeria and *Okpehe* was produced in the Department of Home Economics and Food Science Laboratory using the hot plate method described by Balogun and Oyeyiola, (2011). Ash was produced in the Department of Home Economics and Food Science Laboratory while food grade potash was obtained from a chemical score in Ilorin, Nigeria.

2.2. Preparation of *Okpehe* using hot plate

The hot plate method described by Balogun and Oyeyiola, (2011) was used with some modifications. *Prosopis africana* seeds were removed by beating the fruits with a club on a concrete surface to break the tough fruit coats. 150g of the seeds were heated at 60°C for 2 hours 15mins using wood ash and potash at varying concentrations (1%, 5%, 10%, 15% and 20%) separately. The seeds of the samples were allowed to cool and the seed coats were removed by rubbing soften seeds between palms. The seed coats were washed with distilled water and decanted along, leaving the clean cotyledons. Clean cotyledons were rinsed with sterile water and cooked on the hotplate set at 60°C for 30 minutes. Cooked seeds were drained with a sterile sieve and inoculated with starter cultures of *Bacillus subtilis* and *Bacillus licheniformis* (1:1) (Balogun et al., 2014). The resulting mash after inoculation was first wrapped with pawpaw leaves and then in three layers of sterile aluminium foil. The pawpaw leaves used had been cleaned and surface sterilized with 70% alcohol and rinsed with sterile water prior to their usage. The wrapped cotyledons were left at $30 \pm 2^\circ\text{C}$ for 72 hours in an incubating unit to ferment. Wrapping time was regarded as zero hour and subsequently after every 24hours till the end of fermentation, samples were taken for analysis.

2.3. Chemical Composition Determination

Standard methods of Association of Official Analytical Chemists (AOAC, 2000) were used to determine the moisture content, crude protein, crude fat, crude fibre, ash, carbohydrate and pH of the samples, while anti-nutrient composition

of the samples was done using the method described by Amadi et al. (2004).

2.4. Statistical Analysis

All analysis except otherwise stated were in triplicates. Data generated were subjected to analysis of variance (ANOVA) and the means separated by Duncan multiple range test using statistical package for social science (SPSS) software (Version 17).

3. Results and discussions

The chemical composition of *Okpehe* fermented at 0, 24, 48 and 72 h as affected by the softening agents are presented in Tables 1, 2, 3 and 4 respectively. Generally, the chemical composition of *Okpehe* varied with softening agent and fermentation period. There were significant differences ($p \leq 0.05$) in the proximate compositions and pH values of *Okpehe* produced from seeds softened with wood ash and potash at all concentrations. At 0 h, a range of 7.58 - 11.00%, 32.00- 32.70%, 9.60-12.02%, 3.00-4.86%, 3.16-5.20%, 38.30-39.40% and 6.00-6.40 was observed for moisture, crude protein, crude fat, ash, crude fibre, carbohydrate and pH respectively for the two softeners (Table 1). A range of 10.50 - 11.70%, 35.30 - 35.90%, 10.01-11.80%, 3.20-4.85%, 3.30-6.00%, 32.70- 35.60% and 6.20 - 6.80 was observed for moisture, crude protein, crude fat, ash, crude fibre, carbohydrate and pH respectively (Table 2). A similar pattern in the physicochemical content was observed for *Okpehe* fermented for 48 (Table 3) and 72 h (Table 4). The percentage crude protein contents of *Okpehe* produced from wood ash softened seeds were higher than those produced from potash softened seeds. However, there was a reduction in the crude protein content of *Okpehe* produced from wood ash and potash softened seeds when compared to the control (*Okpehe* produced without softening agent) throughout the period of fermentation. The reduction observed in the protein content of the samples when compared to the control may be attributed to the addition of the softening agents. However there was an increase in the

protein content as fermentation progressed for all the samples. This is consistent with the work of Balogun and Oyeyiola, (2011) although the values obtained in this study were lower than those reported previously for *Okpehe* by these authors. The increase in crude protein during fermentation may probably be due to the presence of enzymes in the fermenting organisms. Carbohydrate values reduced as fermentation progressed for all the samples (Tables 1, 2, 3 and 4). Reduction in the carbohydrate content of *Okpehe* may be attributed to their utilization for metabolism by the fermenting organisms. Ogunshe *et al.*, (2007), reported that *Bacillus* spp. are important sources of amylase and therefore may have been involved in the degradation and subsequent utilization of this fraction in the fermented samples.

The crude fibers increased with fermentation period but no significant changes were observed when the softener concentration was varied. The percentage increase observed may be attributed to the reduction in carbohydrate fractions which may have influenced the crude fibre content. Balogun *et al.*, (2013) attributed a similar increase in fermented *okpehe* to the fact that crude fibre consist largely of cellulose and hemicelluloses, which most fermenting microorganisms cannot breakdown.

The pH values observed in this study were lower than those reported by Balogun and Oyeyiola, (2011). This may be because of the addition of the softening agents. The pH values increased from 6.00 – 6.40 at 0 h to 6.60 – 8.50 at the end of 72 h fermentation period for all the samples. The increase in pH is mainly due to ammonia production, which is characterized by the pungent smell of fermented condiments (Ogunshe et al., 2007; Balogun et al., 2014).

The anti-nutrients composition of *Okpehe* as affected by the wood ash and potash are presented in figures 1 - 4. Reductions in all the anti-nutrients of the fermented samples were observed throughout the fermentation period.

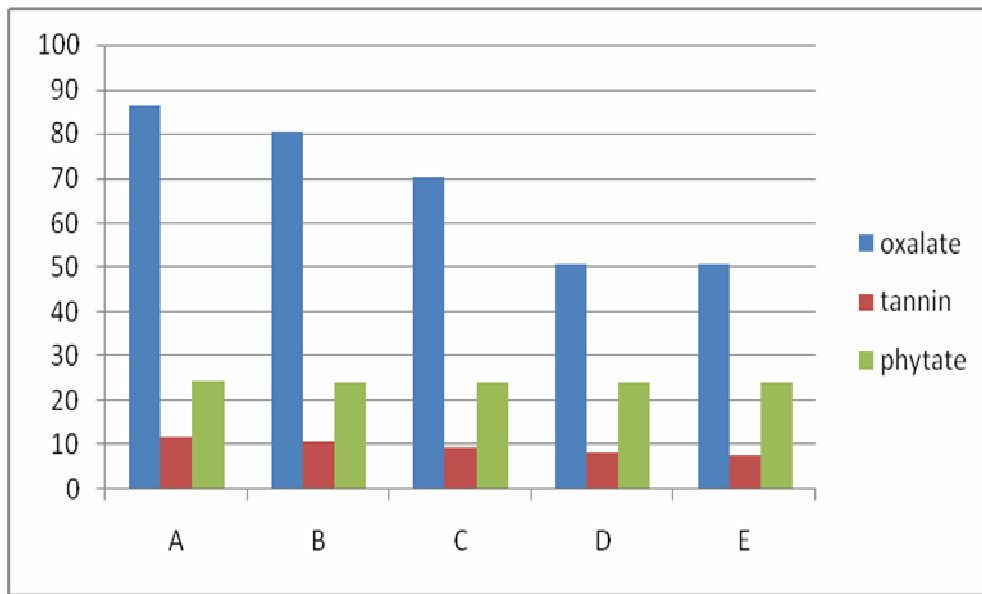


Figure 1. Anti-nutrients composition of *Okpehe* processed with wood ash at various concentrations after 0 hour of fermentation
A -1%, B -5%, C -10%, D -15%, E-20%

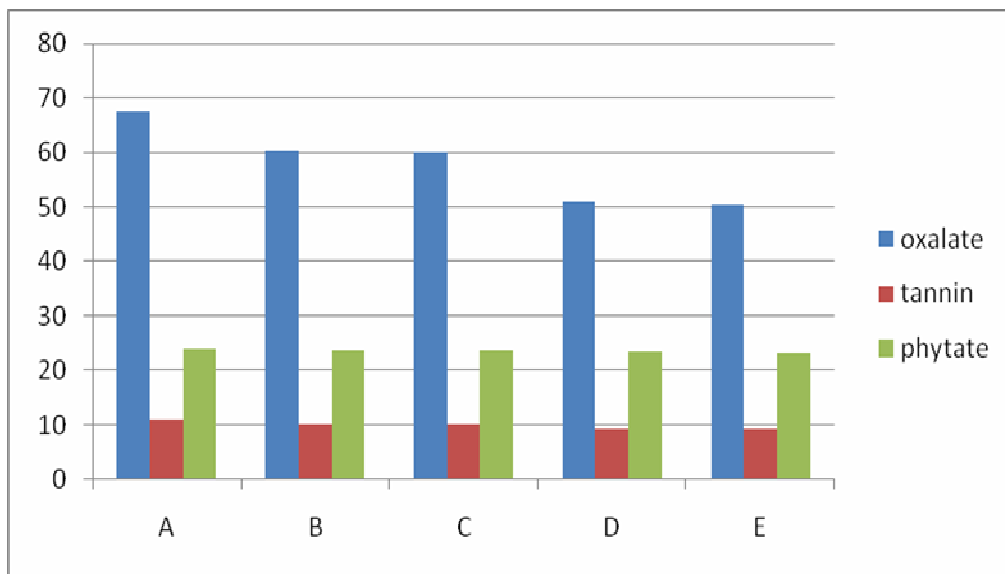


Figure 2. Anti-nutrients composition of *Okpehe* processed with wood ash at various concentrations after 72 hours of fermentation

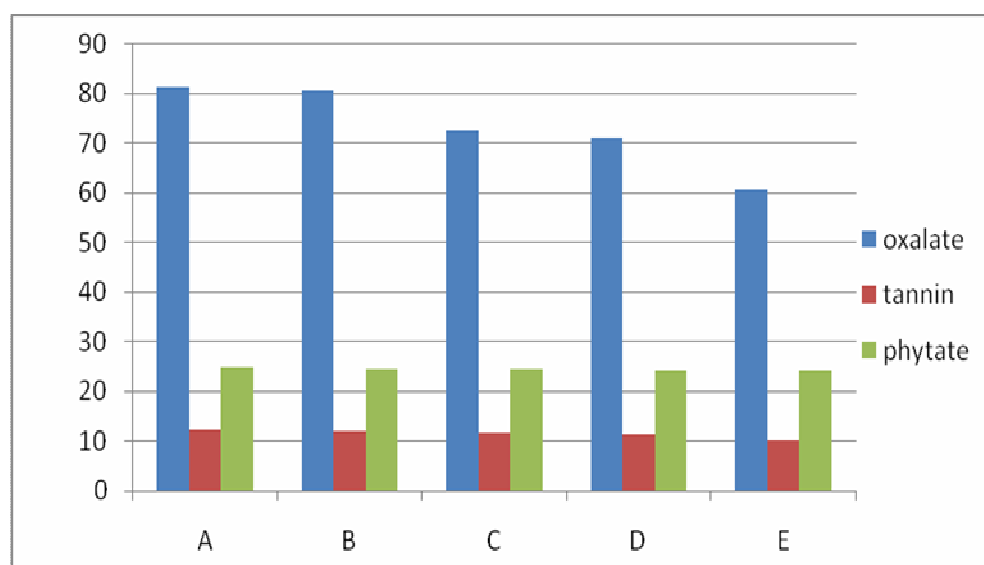


Figure 3. Anti-nutrients composition of *Okpehe* processed with potash at various Concentrations after 0 hour of fermentation

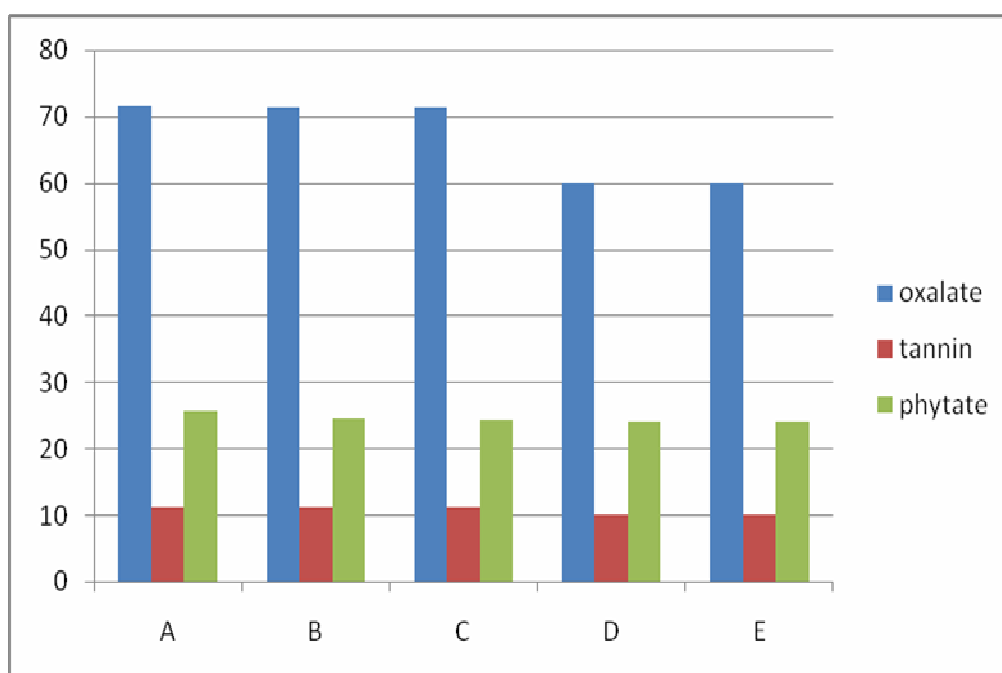


Figure 4. Anti-nutrients composition of *Okpehe* processed with potash at various concentration after 72 hours of fermentation

Table 1. Effect of softening agent on chemical composition of *Okpehe* at 0 hour

Concentration of softening agent (%)	Softening agent	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)	pH
0	-	7.58±0.01 ^e	34.54±0.01 ^a	11.49±0.01 ^b	4.86±0.01 ^a	3.16±0.10 ^c	45.95±0.01 ^a	6.40±0.00 ^a
5	Wood ash	11.00±0.05 ^a	32.50±0.02 ^b	11.60±0.10 ^b	3.10±0.01 ^b	4.10±0.10 ^b	38.30±0.05 ^c	6.20±0.02 ^b
10	Wood ash	11.00±0.02 ^a	32.60±0.02 ^b	11.80±0.01 ^a	3.00±0.01 ^b	4.10±0.10 ^b	38.40±0.08 ^c	6.20±0.02 ^b
15	Wood ash	9.60±0.02 ^c	32.70±0.02 ^b	11.90±0.10 ^a	3.10±0.10 ^b	4.10±0.10 ^b	38.60±0.05 ^c	6.40±0.05 ^a
20	Wood ash	8.70±0.10 ^d	32.20±0.10 ^c	12.02±0.02 ^a	3.00±0.01 ^b	4.20±0.01 ^b	38.90±0.01 ^c	6.40±0.05 ^a
5	Potash	11.00±0.01 ^a	32.00±0.10 ^c	9.60±0.05 ^c	3.00±0.03 ^b	5.20±0.01 ^a	39.20±0.05 ^b	6.00±0.09 ^c
10	Potash	10.80±0.02 ^a	32.10±0.02 ^c	9.70±0.05 ^c	3.10±0.10 ^b	5.00±0.04 ^a	39.30±0.01 ^b	6.00±0.09 ^c
15	Potash	10.50±0.07 ^a	32.10±0.02 ^c	9.80±0.02 ^c	3.20±0.20 ^b	5.10±0.10 ^a	39.30±0.01 ^b	6.10±0.10 ^c
20	Potash	10.30±0.05 ^b	32.20±0.05 ^c	9.90±0.01 ^c	3.30±0.03 ^b	5.20±0.01 ^a	39.40±0.01 ^b	6.10±0.10 ^c

Values are triplicate determination; means within a column having different superscripts differ significantly ($p \leq 0.05$)

Table 2. Effect of softening agent on chemical composition of *Okpehe* at 24 hours

Concentration of softening agent (%)	Softening agent	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)	pH
0	-	7.83±0.01 ^a	35.98±0.01 ^a	11.12±0.01 ^b	4.85±0.00 ^a	3.30±0.00 ^d	44.75±0.01 ^a	6.80±0.01 ^a
5	Wood ash	11.70±0.02 ^b	35.70±0.10 ^b	11.40±0.02 ^{ab}	3.30±0.05 ^b	4.20±0.01 ^c	32.70±0.05 ^c	6.50±0.01 ^b
10	Wood ash	11.30±0.02 ^b	35.80±0.02 ^b	11.60±0.02 ^a	3.30±0.05 ^b	4.30±0.05 ^c	33.70±0.05 ^c	6.50±0.01 ^b
15	Wood ash	11.10±0.01 ^b	35.90±0.04 ^b	11.50±0.01 ^a	3.40±0.10 ^b	4.30±0.05 ^c	33.80±0.01 ^c	6.50±0.01 ^b
20	Wood ash	11.40±0.02 ^b	35.30±0.10 ^b	11.80±0.10 ^a	3.30±0.05 ^b	4.50±0.01 ^c	33.70±0.05 ^c	6.50±0.01 ^b
5	Potash	11.50±0.10 ^a	35.10±0.01 ^b	10.01±0.10 ^b	3.20±0.10 ^b	5.80±0.01 ^b	34.20±0.10 ^c	6.20±0.05 ^c
10	Potash	11.40±0.09 ^a	35.30±0.01 ^b	10.01±0.10 ^b	3.20±0.10 ^b	5.90±0.10 ^b	35.10±0.10 ^c	6.20±0.05 ^c
15	Potash	10.60±0.05 ^b	35.30±0.01 ^b	10.02±0.10 ^b	3.30±0.05 ^b	6.00±0.02 ^a	35.60±0.05 ^b	6.30±0.01 ^c
20	Potash	10.50±0.01 ^b	35.50±0.01 ^b	10.03±0.10 ^b	3.20±0.10 ^b	6.00±0.02 ^a	35.50±0.10 ^b	6.30±0.01 ^c

Values are triplicate determination; means within a column having different superscripts differ significantly ($p \leq 0.05$)

Table 3. Effect of softening agent on chemical composition of *Okpehe* at 48 hours

Concentration of softening agent (%)	Softening agent	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)	pH
0	-	8.36±0.01 ^a	38.01±0.01 ^a	10.81±0.10 ^e	4.84±0.01 ^a	3.52±0.00 ^d	42.82±0.01 ^b	7.40±0.02 ^a
5	Wood ash	12.40±0.05 ^b	35.40±0.10 ^b	10.40±0.01 ^d	3.40±0.05 ^b	5.10±0.1 ^c	30.40±0.05 ^b	6.60±0.02 ^c
10	Wood ash	11.00±0.01 ^d	36.40±0.10 ^b	10.60±0.01 ^c	3.30±0.10 ^b	5.30±0.1 ^b	30.60±0.02 ^b	6.60±0.02 ^c
15	Wood ash	10.70±0.01 ^e	36.30±0.10 ^b	10.70±0.10 ^b	3.40±0.03 ^b	5.40±0.10 ^b	30.80±0.02 ^b	6.60±0.10 ^c
20	Wood ash	10.20±0.1 ^e	36.40±0.10 ^b	10.90±0.03 ^a	3.30±0.10 ^b	5.60±0.10 ^a	30.90±0.02 ^a	6.70±0.10 ^b
5	Potash	12.40±0.05 ^b	35.40±0.10 ^b	10.40±0.10 ^d	3.40±0.05 ^b	5.10±0.10 ^c	31.30±0.01 ^a	6.60±0.02 ^c
10	Potash	11.30±0.01 ^c	36.30±0.10 ^b	10.60±0.10 ^c	3.30±0.10 ^b	5.30±0.01 ^b	31.40±0.05 ^a	6.60±0.02 ^c
15	Potash	11.20±0.01 ^c	36.40±0.10 ^b	10.70±0.10 ^b	3.40±0.05 ^b	5.40±0.10 ^b	31.50±0.10 ^a	6.60±0.10 ^c
20	Potash	11.00±0.01 ^c	36.40±0.10 ^b	10.90±0.03 ^a	3.30±0.10 ^b	5.60±0.10 ^a	31.60±0.10 ^a	6.70±0.10 ^b

Values are triplicate determination; means within a column having different superscripts differ significantly ($p \leq 0.05$)

Table 4. Effect of softening agent on chemical composition of *Okpehe* at 72 hours

Concentration of softening agent (%)	Softening agent	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)	pH
0	-	9.46±0.00 ^a	40.05±0.00 ^a	10.04±0.00 ^c	4.84±0.00 ^a	3.63±0.00 ^c	41.44±0.01 ^a	8.00±0.00 ^a
5	Wood ash	13.50±0.01 ^c	39.20±0.01 ^b	10.40±0.01 ^a	3.50±0.10 ^b	5.60±0.05 ^b	31.30±0.01 ^c	7.00±0.03 ^b
10	Wood ash	13.50±0.01 ^c	39.20±0.01 ^b	10.30±0.05 ^a	3.50±0.10 ^b	5.60±0.05 ^b	31.40±0.01 ^c	7.00±0.03 ^b
15	Wood ash	13.50±0.02 ^c	39.50±0.10 ^b	10.40±0.01 ^a	3.50±0.10 ^b	5.70±0.02 ^b	31.50±0.10 ^c	7.20±0.08 ^b
20	Wood ash	13.40±0.10 ^c	39.40±0.50 ^b	10.40±0.01 ^a	3.60±0.01 ^b	5.70±0.02 ^b	31.60±0.10 ^b	7.20±0.08 ^b
5	Potash	15.60±0.02 ^b	38.30±0.10 ^c	7.20±0.01 ^b	3.40±0.80 ^b	5.90±0.01 ^{ab}	31.90±0.01 ^b	6.60±0.01 ^c
10	Potash	15.60±0.02 ^b	38.30±0.10 ^c	7.30±0.02 ^b	3.30±0.10 ^b	5.90±0.01 ^{ab}	31.80±0.01 ^b	6.70±0.01 ^c
15	Potash	15.70±0.01 ^b	38.40±0.01 ^c	7.30±0.02 ^b	3.40±0.80 ^b	6.00±0.02 ^a	31.70±0.10 ^b	6.80±0.10 ^c
20	Potash	15.40±0.01 ^b	38.60±0.05 ^c	7.50±0.01 ^b	3.40±0.80 ^b	6.00±0.02 ^a	31.80±0.01 ^b	8.50±0.01 ^a

Values are triplicate determination; means within a column having different superscripts differ significantly ($p \leq 0.05$)

Phytate content of the *Okpehe* however, did not change significantly at 24 and 48 h of fermentation with both softening agents. Similarly, reductions in the anti-nutrients were also observed as the concentration of the softening agent increased. The oxalate content of *Okpehe* was relatively higher than the tannin and phytate contents of all the samples. Fermentation at 72 h showed the highest reduction in the anti-nutrients composition of *Okpehe*, with both softening agents. The reduction observed in the anti-nutrients is consistent with the work of Achi, (2005), Okwu and Ndu, (2006,) and Parkouda *et al.*, (2009) where it was reported that fermentation helps in the reduction of anti-nutritional factors in foods.

4. Conclusions

This study showed that the processing of *Okpehe* could be improved upon with the utilization of potash and wood ash as softeners so as to reduce time and energy usually wasted before the end product is obtained by the local producers. *Okpehe* can therefore be produced with ease and minimal loss of nutrients as shown by the proximate composition of the samples. Furthermore, the antinutrient content of the samples reduced considerably after fermentation. More investigation should however, be done on the components of these softeners so as to ensure their safety for human consumption.

5. References

- Achi O.K (2005). The upgrading of traditional fermented foods through biotechnology. *African Journal of Biotechnology*, 4, 375-380.
- Achi O.K. and Okereka E.G (1999). Proximate composition and functional properties of *Prosopis africana* seed flour. *Journal of Management Technology*, 1, 7-13.
- Amadi, B.A., Agomuo, E.N. and Ibegbulem, C.O. (2004). Research methods in Biochemistry. Supreme 31.Publishers, Owerri, Nigeria. pp.50-59
- AOAC (2000) Association of Official Analytical chemist. Official method of analysis (17th ed), Washington Dc.
- Balogun. M.A. and Oyeyiola , G.P.(2011). Microbiological and chemical changes During the production of *Okpehe* from *Prosopis africana* seeds. *Journal of Asian Scientific Research*, 1, 390-398
- Balogun. M.A. Kolawole, F.L, Oyeyinka, S.A., Joseph, J.K and Adiamoh, H.O. (2013). Studies on chemical composition and storage stability of cubed *Okpehe*. *Journal of Science, Technology, Mathematics and Education (JOSTMED)*, 10(1), 28 – 33.
- Balogun. M.A., Oyeyiola, G.P. and Kolawole, F.L. (2014). Physicochemical and Sensory Characteristics of Fermented Seeds of *Prosopis africana*. *Ethiopia Journal of Environmental Studies and Management*, 7 (4), 411 – 422.
- Ezenwah, C. N. and Ikenebomeh, M. J. (2008). Processing effects on the nutritional and anti-nutritional contents of African locust bean (*Parkia biglobosa* Benth.) seed. *Pakistan Journal of Nutrition*, 7(2), 214-217.
- Igwe, C. U., Ojiako, O.A., Anugweje, K.C., Nwaogu, L.A. and Ujowundu, C.O. (2012) Amino acid profile of raw and locally processed seeds of *Prosopis africana* and *Ricinus communis*: potential antidotes to protein malnutrition. *Functional Foods in Health and Disease*, 2(4),107-119
- Odunfa S.A (1985a). African Fermented Foods. In: Microbiology of Fermented Foods vol 2 ed. BJB Wood. Elsevier Applied Science. pp. 155-191.
- Odunfa S.A (1985b) Microbiological and toxicological aspect of fermentation of castor oil seeds for ogiri production. *Journal of Food Science*, 50, 1758-1759.
- Ogunshe, A.A.O., Omotosho, M.O. and Ayanshina, A. D.V. (2007) “Microbial Studies and Biochemical Characteristics of

- Controlled Fermented Afiyo- a Nigerian Fermented Food Condiment from *Prosopis africana* (Guill and Perr.) Taub". *Pakistan Journal of Nutrition*, 6(6), 620-627.
- Oguntoyinbo, F. A., Sanni, A. I., Franz, C.M.A.P., Holzapfel (2007). In vitro fermentation studies for selection and evaluation of *Bacillus* strains as starter cultures for the production of *Okpehe*, a traditional African fermented condiment. *International Journal of Food Microbiology*, 113, 208-218.
- Oguntoyinbo F.A, Schillinger U, Holzapfel W.H, Sanni A.I and Franz C.M (2010) Diversity of *bacillus* species isolated from *Okpehe*, a traditional fermented soup condiment from Nigeria. *Journal of Food Protection*, 73(5), 870-878
- Okwu, D. E and Ndu, C.U (2006) : evaluation of phyto nutrients, minerals and vitamin content of some varieties of yam (*Dioscorea spp*). *International Molecular Medicine and Advance Science* 2(2), 199-203.
- Omafuvbe, B. O., Falade, O. S. Oshuntogun, B. A. and Adewusi, S. R. A. (2003). Chemical and Biochemical Changes in African Locust Bean (*Parkia biglobosa*) and Melon (*Citrullus vulgaris*) Seeds During Fermentation to Condiments. *Pakistan Journal of Nutrition*, 3, 140-145.
- Parkouda, C., Nielsen, D. S., Azokpata, P., Ouoba, L. I. I., Amoa-Awua, W. K., Thorsen, L., Hounhouigan, J. D., Jensen, J. S., Tano-Debrah, K., Diawara, B. and Jakobsen, M. (2009). The microbiology of alkaline-fermentation of indigenous seeds used as food condiments in Africa and Asia. *Critical Reviews in Microbiology*, 35 (2), 139-156.

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