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Evaluation of Indigenous *Okpeye (Prosopis africana)* Processing Conditions in Nsukka L.G.A, Enugu, Nigeria and Its Effect on the Quality of the Fermented Seasoning

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Abstract
This study focused on the indigenous processing conditions of *okpeye* (*Prosopis africana*) seasoning in Nsukka L.G.A, Enugu State, Nigeria and the effect on its quality. *Okpeye* seasonings were produced by nine processors from different villages who were grouped into three according to similarity of their processing conditions. The seeds were sorted, cooked, dehulled, washed and parboiled, fermented, pounded and sun dried. Parameters such as cooking time and temperature, parboiling time and temperature as well as fermentation time and temperature were noted. Proximate, antinutrient properties and volatile compounds of the seasonings were assessed. Cooking temperature and time ranged from 124-133°C and 540-720 min, parboiling temperature and time ranged from 100-105°C and 10-20mins, while, fermentation and drying temperatures rranged from 34.25-35.13°C and 36.94-37.63°C respectively. The processing conditions significantly affected the proximate composition of the seasonings, while, the antinutrients were significantly reduced. Organic acids, esters, alcohols and hydrocarbons, were the major volatile compounds in the *okpeye* seasoning. The study demonstrated that the processing conditions affected the quality of the *okpeye* seasonings. Therefore, provides quantitative data on the indigenous processing conditions of *okpeye* seasoning and how these conditions affect the chemical composition of the end product. This could serve as a baseline for standardization of the *okpeye* seasoning production process.

Keywords: ***Processing conditions, Okpeye, seasoning, volatile compounds, cooking, fermentation***

Introduction

Traditional fermented seasonings are vital components of West African dishes because of their sensory and nutritional properties (Achi 2005; Ogunshe, *et al.,* 2007; Ouoba *et al*., 2005; Parkouda *et al*., 2009), they include; O*giri* (fermented castor oil, melon or oil bean paste), *Dawadawa* (Fermented African locust bean), and *okpeye* (fermented *Prosopis africana*). Fermented *okpeye* condiment has a very strong aroma and is used as a flavour enhancer in soups (Achi, 2005). *Okpeye* belongs to the family leguminosae also known as African mesquite or iron tree which is very popular for its seed that is used to produce food seasoning, rich in protein, fatty acids and other vital nutrients and minerals such as phosphorus, potassium and calcium (Ayanwuyi *et al*., 2010; Amusa *et al*., 2010). The raw seeds are inedible; hence need some thorough processing before they can be safe for human consumption. Processing method varies from one location to the other. The major effects of processing are detoxification, flavour improvement and bioavailability of nutrients. The processing of *okpeye* seeds into its seasoning is largely manual making it tedious and taking a long time to get the end product. Difficulties in its processing include the dehulling process which can be laborious and time consuming and also the hard-to-cook phenomenon which has led to long cooking times and utilization of more fuel during preparation. The *okpeye* seasonings are usually produced at a small-scale level using indigenous knowledge under highly variable conditions, with most processing parameters, such as pH, time, and temperature often poorly controlled, which affects product quality and safety (Odunfa 1981; Owusu-Kwarteng *et al*., 2020). These indigenous methods need to be standardized to assure quality and safety of the end products. Standardization of the production method will be impossible if the indigenous methods are not studied and documented. The objective of this work therefore is to evaluate some indigenous *okpeye* processing methods and their effect on the quality of the seasoning. The outcome of this study will be beneficial to Engineers in developing machines that will be used for *okpeye* processing, nutritionist, Food standardization agencies and the general public.

Materials and methods

Source of raw materials

The *okpeye* seeds for production were purchased from *Ibagwa* market in *Igbo-eze* South Local Government Area (LGA) of Enugu State, Nigeria. The *okpeye* seeds were sorted to remove extraneous materials and the chemical reagents used were of analytical grade.

Preparation of okpeye seasoning

A multi-stage sampling procedure was used to select *okpeye* producers. In the first stage, three communities in Nsukka LGA were selected based on their *okpeye* production intensity and consumption level, and Obukpa community selected based high level of production of *okpeye* seasoning. Three villages were selected from Obukpa community also based on level of processing and consumption of the *okpeye* seasoning. Finally three processors each from the three villages in Obukpa community were selected making nine participants. They were grouped into three according to similarity of the indigenous processing conditions. Exactly 2kg of *okpeye* seeds from the same batch was given to each of the processors for processing into the seasoning using their indigenous methods. The entire production process was closely monitored. Parameters such as cooking time and temperature, parboiling time and temperature as well as fermentation time and temperature were noted. The seeds were sorted and cooked using fire wood and the time and average temperature recorded. The seeds were dehulled manually by pressing in-between fingers to separate the cotyledons from the hulls after which some samples were collected for analysis. The dehulled cotyledons were washed and parboiled in water (1:2 w/v) and the time and average temperatures noted. The parboiled cotyledons were poured to a depth of 2cm into separate baskets woven with raffia palm leaves and lined with avocado leaves after which they were covered with avocado leaves weighted with pebbles and left to ferment. The fermentation time and average temperatures were noted for each group. The fermented seeds were pounded using wooden mortar and pestle to form a dark paste which was moulded, sun dried and stored in airtight containers for further use.

Chemical composition analysis

Analysis of moisture, ash, crude protein, fat and fibre contents of the raw, parboiled and fermented *okpeye* samples were carried out using the AOAC (2010) method. The pH of the samples was measured using calibrated pH meter (PHS-3C model, UK) on 10g of sample homogenized with 20ml of deionized water. The total titratable acidity as lactic acid was determined using the method described by Bainbridge *et al*. (1996).

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Antinutritional factors

Determination of Alkaloid content

One (1) gram of sample was weighed into a 250ml beaker and 30ml of 20% acetic acid in ethanol was added corked and allowed to stand for 4 hours at 25°C. It was then filtered and the filtrate was concentrated using water-bath to one quarter of the original volume. Concentrated ammonium hydroxide was added drop-wise to the extract until the precipitation was completed. The whole solution was allowed to settle and the precipitate was collected and washed with dilute ammonium hydroxide (NH OH) solution. It was then filtered using a pre-weighed filter paper. The residue on the filter paper which is the alkaloid was dried in the oven at 80°C. The alkaloid content was collected and expressed in mg/100g (Qayyum, 2012).

Determination of Saponin

The method adopted was that described by Obadoni and Ochuko (2001). Twenty grams of each sample was dispersed in 200ml of 20% ethanol. The suspension was heated over a hot water bath for 4 hours with continuous stirring at about 55°C. The mixture was filtered and the residue re-extracted with another 200ml of 20% ethanol. The combined extracts were reduced to 40ml over water bath at about 90°C. The concentrate was transferred into a 250ml separating funnel and 20ml of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. Sixty (60) mL of n-butanol extract was washed twice with 10ml of 5% aqueous Sodium Chloride. The remaining solution was heated in a water bath. After evaporation the samples were dried in the oven (SLS 450) to a constant weight. The saponin content was calculated as follows:
(Saponin content = weight of sample before extraction – loss in weight after extraction).

$$\% \text{ saponin} = \frac{\text{saponin content x } 100}{\text{Weight of sample}}$$

Determination of Tannins

The Follins Dennis titration method as described by Pearson (1976) was adopted. Thirty (30) ml of petroleum ether was added to 5.0g of the already crushed sample in a conical flask and corked for 24 hours. It was then filtered and allowed to stand for 15 minutes to evaporate the petroleum ether. It was re-extracted by soaking in 50ml of 10% acetic acid in ethanol for 4 hours. The sample was then filtered and the filtrate collected. Twenty five (25) ml of ammonium hydroxide (NHOH) was added to the filtrate to precipitate the alkaloid. It was then heated to remove some ammonium hydroxide (NHOH) still in solution. The remaining volume of the solution after heating was noted and 5ml of this solution was taken and 20ml of ethanol was added to it and then titrated with 0.1M sodium hydroxide (NaOH) using phenolphthalein as an indicator until the pink endpoint was reached. Tannins content was then calculated and expressed in mg/100g (Aremu *et al*., 2006).

V*olatile compounds analysis*

The method of Ezhilan and Neelamegam (2011) was used in the identification of compounds present in the raw *okpeye* cotyledons and *okpeye* condiments. Compounds present in the ethanol extract were identified by GC-MS analysis (GC-MS-QP2010 PLUS Shimadzu, Japan) on Elite 5 MS Column 20m long and

0.18µ internal diameter. The temperature was programmed from 200°C to 300°C at a rate of 4°C min^{-1} with 10 minutes hold. Injection was at 200°C. The carrier gas was Helium with a constant flow at 1ml/min. Mass method used was Electron Ionization with ionization voltage of (EI+) 70 eV for m/z value 50 to 300 at a scan time of 0.3 sec and interscan delay of 0.1 sec. The operation conditions were: coven temperature – 80°C, Injection temperature – 250°C, Injection mode – Split, Injection Port Dwell Time – 0.3sec, Pressure – 108.0kPa, Linear velocity – 46.3cm/sec. Interpretation on mass-spectrum GC-MS was conducted using the database of National Institute Standard and Technology (NIST). The spectrum of the unknown components was compared with the that of known components stored in the NIST library. The name, molecular weight and structure of the components of the test materials were ascertained.

Statistical analysis

Part of the data obtained were subjected to analysis of variance (ANOVA) using a statistical software (SPSS version 20). Significant difference was accepted at 5% probability level.

Results and Discussion

Evaluation of the Weight of the okpeye samples

Table 1 shows the weight of the *okpeye* samples during processing. Two (2) kilograms of *okpeye* seeds were processed by each of the nine women. The result revealed that after dehulling, an average of 60% of the total whole seed weight was lost in group A samples, 35% in group B, and 25% in group C. This observation implies that dehulling as one of the unit operations in *okpeye* processing reduced the weight of the product. The high percentage weight loss observed could be because some seeds were not soft enough for dehulling after cooking, and hence were discarded alongside the hulls. The variation in percentage weight loss could be due to variation in cooking time and temperature (Since group A with the highest parentage loss has the least cooking time and temperature when compared with other groups) and dehulling efficiency of the women who carried out the process. The result further revealed that the weight of the samples also reduced after fermentation. The average percentage weight loss ranged from 22.2% (in group C samples) to 12.5% (in group B samples). The weight losses observed could be attributed to loss of dry matter during fermentation as microbes degrade carbohydrates and protein (Day and Morawicki, 2018).

Evaluation of the okpeye seasoning production process

The evaluation of the indigenous *okpeye* seasoning processing methods of the three groups is presented in Table 2. It was observed that the unit operations involved in the *okpeye* seasoning production were the same for the three groups, however, the cooking, parboiling, fermenting and drying time and temperatures varied. Group C samples had the highest average cooking temperature (133°C) followed by group B (130.67°C), while group A had the lowest cooking temperature (124°C) and time (540 mins). This justifies the weight loss observed after dehulling group A samples as most of the samples were not yet soft due to the lower cooking temperature and time, so could not be dehulled and were discarded with the hull leading to the high weight loss observed. Group A samples had the highest parboiling temperature (105°C) and time (20 mins), while group B had the lowest (100°C) and (10 mins). The fermentation and drying time was the same for three groups (96hrs each), however, fermentation and drying temperatures were highest (35.13°C and 37.63°C respectively) for group A samples and similar for group B and C. The processing conditions observed for the three groups were similar to what was reported by Okpara (2018).

Chemical Composition of okpeye seeds and seasoning

The proximate composition of the cooked *okpeye* seeds and fermented seasonings are presented in Table 3. There were significant differences ($p<0.05$) on the proximate composition of cooked *okpeye* seeds. The results revealed that cooking conditions of group A and C caused a significant increase in the moisture content of the seeds, however, there was no significant difference in the moisture content of group B's seeds and the raw samples. The moisture content observed in this study was lower than 10.65% earlier reported by Olorunmaiye *et al*. (2019). The moisture content of the fermented *okpeye* seasonings ranged from 4.83% (in *okpeye* seasoning produced by group A) to 9.25% (in *okpeye* seasoning produced by group B). The low moisture content observed in *okpeye* seasoning produced by group A could be due to higher drying temperature (37.63°C) since the drying time was the same for the three groups (Table 2). The moisture values observed in the seasonings fall below the safe moisture level (≤10 g/100 g) for prolonged storage and compares well with those of Balogun *et al*. (2014) who reported moisture range of 6.78 to 10.70%.

The average protein content of the boiled *okpeye* seeds ranged from 19.98% (group C) to 24.32% (group A), while that of the *okpeye* seasonings ranged from 26.00% (group C) to 28.48% (group A). There was no significant difference ($p>0.05$) between the protein content of the raw seeds (24.93%) and the seeds boiled by group A (24.32%) and group B (21.49%), however, the protein content of the seeds boiled by group C was significantly lower than the rest of the samples (Table 2). The protein content in *okpeye* seasonings increased after fermentation with the seasoning produced by group A having the highest protein content (28.48%), a similar observation was made in the fermentation of chickpea (Balasubramanian *et al*., 2015). This increase could be due to the increase in proteinase activity, leading to an increase in total nitrogen and soluble proteins (Balasubramanian *et al*., 2015). The high protein content of *okpeye* seeds and seasonings suggest that their consumption could increase the protein intake of the consumer and help reduce the problem of protein malnutrition among the vulnerable group.

The fiber content of the cooked *okpeye* seeds ranged from 1.91 (group A) to 2.26% (group B) and they are lower than 6.76% reported by Musbau and Asiru (2020). There was no significant difference ($p>0.05$) in the fiber content of the cooked *okpeye* seeds. This suggests that cooking although carried out at different temperatures and times did not alter the fiber content of the *okpeye* seeds. The fiber content of the *okpeye* seasonings ranged from 1.62 (group A) to 2.14% (group B). The fibre content of the raw *okpeye* seeds (2.18%) was not significantly different ($p>0.05$) from that of *okpeye* seasonings from groups B and C which have fiber contents of 2.14 and 2.12% rrespectively, however the fibre content of Group A's seasonings was significantly lower. The fiber content is associated with benefits in lipid metabolism; the fiber traps fatty acids and bile salts while passing through the small intestine without digestion, thus inhibiting fat absorption in the small intestine.

The fat content of the cooked *okpeye* seeds ranged from 4.14 (group B) to 7.61% (group A). Significant differences ($p<0.05$) exist on the fat content of the *okpeye* seeds, this variation could be due to the different cooking time and temperature used by the different groups. The fat content of the *okpeye* seasonings ranged from 6.06% (raw) to 13.49% (group B) and is in agreement with the report of Ugwuarua (2010) but was however, found to be slightly lower than 13.76 to 23.19 reported by Okwunodulu *et al*. (2020) on *ogiri* from castor oil and melon seeds blend. The fat content of the *okpeye* seasonings were higher than those of the *okpeye* seeds. This observation is contrary to that made by Adebiyi *et al*. (2019) on fermented Bambara groundnut.

The ash content of the *okpeye* seeds ranged from 4.12 (group C) to 8.18% (raw seeds). The ash content is an indication of the levels of minerals or inorganic component of the sample. These minerals act as inorganic co-factors in metabolic processes, absence of which could lead to impaired metabolism (Iheaanacho and Udebuani, 2009). Cooking significantly reduced the ash content of the various *okpeye* samples. This could be due to the leaching of the minerals into water (Franziska, 2019). Ash content of the *okpeye* seasonings increased after fermentation as the ash content was found to be lower in the boiled samples before fermentation. This could be attributed to the reduction in anti-nutrients in the condiments by fermentation (Adebiyi *et al*., 2019; Olukomaiya *et al*., 2020; Chinma *et al*., 2020).

The carbohydrate content of the *okpeye* seeds ranged from 54.00% (raw seeds) to 62.09% (group B's cooked seeds). The carbohydrate content of group A's cooked seeds did not significantly differ ($p>0.05$) from that of the raw seeds. This could be due to the relatively lower cooking time and temperature. The carbohydrate contents of the *okpeye* seasonings were observed to be lower than those of the boiled seeds which imply that fermentation process decreased the carbohydrate content of the samples. This could be because during fermentation, the fermenting microorganisms convert carbohydrates to glucose and use them as source of energy (Maji and Adegoke, 2019). The carbohydrate content of the seasonings was similar to that reported by Okwunodulu *et al*. (2020) on *ogiri* from castor oil and melon seeds blend. There were significant differences ($p<0.05$) in the total titratable acidity (TTA) of the fermented *Okpeye* samples**.** The results revealed that fermentation process decreased the TTA level of the *okpeye* samples. Decrease in TTA was accompanied by an increase in pH from 6.21 (in raw *okpeye*) to 8.28 (group C's seasoning). This could be due to the proteinaceous nature of the *okpeye* seeds, the natural fermentation of which could have led to hydrolysis of the proteins into peptides, amino acids and ammonia, resulting to increase in pH of the end product (Aderibigbe and Odunfa, 1990; Leejeerajumnean *et al*. 2001; Odunfa 1985; Omafuvbe *et al*. 2003).

Antinutrient factors of okpeye seeds and seasoning

Table 4 shows the anti-nutrients composition of o*kpeye seeds and seasoning.* Cooking significantly reduced ($P<0.05$) the phenolic contents of the seeds. The variations may be attributed to the difference in cooking temperature and time. This is in agreement with the result by Omoruyi *et al*. (2007) that parboiling and cooking were effective in lowering the levels of anti-nutrient factors in oil seed plants. Phenols are plant secondary metabolites, primarily produced as a defense mechanism, but having numerous health benefits. The saponin content of the cooked *okpeye* seeds ranged from 0.11% (group A) to 0.24% (raw seeds). There was a significant difference ($P<0.05$) in the saponin content of the raw and cooked samples. This variation could be as a result of the different cooking conditions. Fermentation also significantly reduced the saponin content of the seasonings which is in line with the study by Omoruyi *et al*. (2007) which reported that fermentation is ideal in the reduction of saponin. The tannin content of the *okpeye* seeds were significantly reduced by cooking at the different temperatures and time. This could be as a result of leaching loss during cooking. A similar observation was made by Ogbonna *et al*. (2012). The tannin content of the fermented seasonings was further reduced after fermentation. This could be as a result of microbial activity. A similar observation was made by Grewal (1992) and Schons *et al*. (2012) in fermented sorghum flour. Tannins form complexes with digestive enzymes and other nutrients, reducing their bioavailability.

Volatile compounds

The volatile composition of the raw seeds and fermented *okpeye* condiments are presented in Table 5. Volatile compounds have been shown to be partly responsible for the aroma of fermented foods (Kabuo *et al*., 2007; Lee and Ahn, 2009; Ogueke *et al*., 2010; Zhao *et al*., 2011). A total of 39 volatile compounds were identified in both the raw *okpeye* seeds and fermented seasoning with 33 and 15 compounds identified in each respectively. The result showed that organic acids, esters, alcohols and hydrocarbons, are the major volatile compounds in the seasoning. Production of unsaturated

fatty acid such as oleic acid may be due to fermentation (Suomalainen and Lehtonen, 1978). Hexadecanoic acid is a common saturated fatty acid found in plants. Aroma compounds such as esters and alcohol were observed more in the fermented samples than in the raw samples. Aroma is a very important quality parameter of any flavoring agent. Esters which are major volatile compounds in African fermented seasonings are likely to be the product of reactions between microbial acidic and alcoholic metabolites and is associated with nice flavour (Leejeerajumnean *et al*., 2001) and have been reported to be responsible for quality sensory properties of various fermented foods (Perestrelo *et al*., 2006). Alcohols also contributed to the flavour of the condiment (Onyenekwe *et al*., 2014). Raw *okpeye* seeds were dominated by hydrocarbons which do not play a significant role as flavour compounds as they possess a relatively weak aroma (Nwokeleme and Ugwuanyi, 2015). The major volatile compound in raw seeds is gamma.-Tocopherol, (with peak area of (41.35%), whereas, the fermented *okpeye* seasoning was dominated by 9,12-Octadecadienoic acid (with peak area of 45.89%). Quantitatively, the most abundant volatile compounds were the fatty acids (with total peak area of 86.26%), followed by the alcohols (with total peak area of 7.43%) and then the esters (with total peak area of 1.56%). Volatile compounds present in both the raw *okpeye* seeds and the fermented seasoning include; Bis(2-ethylhexyl) phthalate, gamma.-Tocopherol, Squalene, and Vitamin E. The variation in the volatile compounds in both samples could be attributed to the fermentation process which the *okpeye* seasoning had undergone which could have resulted to the breakdown of plant compounds as well as formation of microbial metabolites (Nwokeleme and Ugwuanyi, 2015). This is in line with Costa *et al.* (2008) who reported that volatile compounds of legumes can be improved by the process of fermentation. The amides identified could be precursors of pyrazines which has been related to sensory attributes of legumes (Lee and Ahn, 2009).

Conclusion

The effects of indigenous processing conditions of *okpeye* in Nsukka LGA, Enugu state on the quality of *okpeye* seasoning were studied. The study has demonstrated that the different processing conditions affected the proximate and antinutrient composition of the *okpeye* seeds and seasonings. The volatile compounds identified in the *okpeye* seasoning (33) were more than those identified in the raw seeds (15) with the seasoning mainly composed of Organic acids, esters, alcohols and hydrocarbons, while raw *okpeye* seeds were dominated by hydrocarbons. The cooking conditions and manual dehulling method resulted to a lot of losses, hence the cooking temperature (133^0C) and time (600 min) adopted by group C before dehulling is therefore recommended. However, future studies are still needed on ways to upgrade these indigenous processing methods and develop a dehulling machine for *okpeye* seeds to reduce drudgery and minimize waste.

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Table 1: Variation in weight of *okpeye* samples during processing

Weights	Group A	Group B	Group C
Weight of whole sample (g)	2000±0.00	2000±0.00	2000±0.00
Weight after dehulling (g)	800±35.65	1300±34.03	1500±25.19
Percentage weight loss after dehulling (%)	60±7.94	35±7.00	25±5.57
Weight before fermentation (g)	500±21.59	800±23.27	900±20.15
Weight after fermentation (g)	400±24.81	700±21.59	700±23.13
Percentage weight loss after fermentation (%)	20±7.95	12.5±6.33	22.5±7.23

Values are means ± standard deviation

Table 2: Evaluation of the process variables in *okpeye* production

Process variables	Group A	Group B	Group C
Cooking time (mins)	540±15.54	720±9.02	600± 14.36
Cooking temperature (^{0}C)	124.00±10.49	130.67±8.86	133.00±5.24
Parboiling time (mins)	20±1.53	10±1.15	14±1.53
Parboiling temperature (^{0}C)	105±7.64	100±3.61	102±3.06
Fermentation time (h)	96±0.00	96±.00	96±0.00
Fermentation temperature (^{0}C)	35.13±7.86	34.25±8.23	34.92±8.58
Drying time (h)	96±0.00	96±0.00	96±0.00
Drying temperature (^{0}C)	37.63±8.65	36.94±9.19	36.94±9.18

Values are means ± standard deviation

Table 3: Physicochemical properties of the cooked *okpeye* seeds and fermented seasonings

Sample	Moisture (%)	Protein (%)	Fiber (%)	Fat (%)	Ash (%)	CHO (%)	TTA (%)	pH
***Okpeye* seeds**								
OSCGA	$6.21^{a}\pm0.05$	$24.32^{a}\pm0.27$	$1.91^{a}\pm0.47$	$7.61^{a}\pm0.62$	$5.55^{b}\pm0.06$	$54.42^{c}\pm0.70$	$0.036^{b}\pm0.00$	$6.22^{a}\pm0.61$
OSCGB	$4.56^{b}\pm0.01$	$21.49^{a}\pm2.47$	$2.26^{a}\pm0.12$	$4.14^{c}\pm0.54$	$5.48^{b}\pm0.14$	$62.09^{b}\pm2.18$	$0.018^{c}\pm0.00$	$6.61^{a}\pm0.00$
OSCGC	$6.08^{a}\pm0.64$	$19.98^{b}\pm0.50$	$1.97^{a}\pm0.13$	$7.13^{ab}\pm0.62$	$4.12^{c}\pm0.93$	$60.73^{a}\pm0.05$	$0.027^{c}\pm0.06$	$6.48^{a}\pm0.06$
ROS	$4.67^{b}\pm0.15$	$24.93^{a}\pm0.09$	$2.18^{a}\pm0.04$	$6.06^{b}\pm0.23$	$8.18^{a}\pm0.04$	$54.00^{c}\pm0.16$	$0.045^{a}\pm0.00$	$6.21^{a}\pm0.15$
***Okpeye* Seasoning**								
OSGA	$4.83^{bc}\pm0.16$	$28.48^{a}\pm1.21$	$1.62^{b}\pm0.15$	$12.57^{a}\pm1.71$	$5.93^{b}\pm0.52$	$46.59^{b}\pm2.10$	$0.041^{ab}\pm0.006$	$8.25^{a}\pm0.01$
OSGB	$9.25^{a}\pm0.86$	$27.73^{b}\pm0.41$	$2.14^{a}\pm0.20$	$13.49^{a}\pm1.68$	$5.91^{b}\pm0.01$	$55.03^{a}\pm2.74$	$0.036^{ab}\pm0.000$	$7.99^{b}\pm0.04$
OSGC	$6.29^{b}\pm0.71$	$26.00^{c}\pm1.75$	$2.12^{a}\pm0.23$	$13.27^{a}\pm1.56$	$5.16^{b}\pm0.47$	$51.44^{a}\pm0.21$	$0.032^{b}\pm0.006$	$8.28^{a}\pm0.01$
ROS	$4.67^{c}\pm0.15$	$24.93^{d}\pm0.09$	$2.18^{a}\pm0.04$	$6.06^{b}\pm0.23$	$8.18^{a}\pm0.04$	$54.00^{a}\pm0.16$	$0.045^{a}\pm0.000$	$6.21^{c}\pm0.15$

Means with different superscripts within the same column are significantly different (p<0.05)
OSCGA= Okpeye seeds cooked by group A , OSBWB = Okpeye seeds cooked by group B, OSBWC= Okpeye seeds cooked by group C, ROS= Raw Okpeye seeds (control)
OSGA= Okpeye seasoning produced by group A, OSGB= Okpeye seasoning produced by group B, OSGC= Okpeye seasoning produced by group C

Table 4: Anti-nutrient composition of *okpeye* seeds and seasonings

Sample	Phenol (%)	Saponin (%)	Alkaloid (%)	Tannin(%)
Cooked seeds				
OSCGA	$0.17^{b}\pm0.15$	$0.11^{c}\pm0.14$	$1.72^{a}\pm0.63$	$0.72^{a}\pm0.64$
OSCGB	$0.17^{b}\pm0.12$	$0.20^{b}\pm0.03$	$1.74^{a}\pm0.71$	$0.60^{b}\pm1.22$
OSCGC	$0.16^{b}\pm0.08$	$0.21^{b}\pm0.01$	$1.78^{a}\pm0.11$	$0.56^{b}\pm0.33$
ROS	$0.84^{a}\pm0.14$	$0.24^{a}\pm0.01$	$1.90^{a}\pm1.23$	$0.86^{a}\pm0.53$
Fermented seasoning				
OSGA	$1.74^{a}\pm0.15$	$0.08^{d}\pm0.03$	$1.66^{b}\pm0.23$	$0.23^{b}\pm0.64$
OSGB	$0.79^{d}\pm0.13$	$0.16^{c}\pm0.00$	$1.64^{b}\pm1.58$	$0.17^{c}\pm0.00$
OSGC	$1.10^{b}\pm0.11$	$0.22^{b}\pm0.03$	$1.63^{b}\pm0.18$	$0.11^{c}\pm1.30$
ROS	$0.84^{c}\pm0.18$	$0.24^{a}\pm0.02$	$1.90^{a}\pm1.23$	$0.86^{a}\pm0.05$

Values are mean ±standard deviation for triplicate determinations. Values with different superscripts in the same column are significantly different (P<0.05). OSCGA= Okpeye seeds cooked by group A, OSBWB = Okpeye seeds cooked by group B, OSBWC= Okpeye seeds cooked by group C , ROS= Raw Okpeye seeds (control). OSGA= Okpeye seasoning produced by group A, OSGB= Okpeye seasoning produced by group B, OSGC= Okpeye seasoning produced by group

Table 5: Volatile compounds of raw and fermented *Okpeye* seeds and their peak area (%)

Compounds	*Okpeye* Seasoning(%)	Raw seeds (%)
Fatty acids		
Pentadecanoic acid	0.12	-
Oleic acid	1.98	-
n-Hexadecanoic acid	17.54	-
Octadecanoic acid	8.11	-
9-Octadecanoic acid, (E)-	12.62	-
9,12-Octadecadienoic acid (Z,Z)-	45.89	-
Esters		
9,12-Octadecadienoic acid (Z,Z)- methyl ester	0.13	-
9- Octadecenoic, methyl ester, E	0.18	-
Pentadecanoic acid, -methylbutyl ester	0.11	-
Linoleic acid ethyl ester	0.69	-
Heptatonic acid, octyl ester	0.26	-
Isoamyl laurate	0.12	-
Bis(2-ethylhexyl)phthalate	0.07	2.28
Alcohol		
phytol	1.19	-
[1.1',-Biphenyl]-3-3'-diol	1.68	-
Gamma-sitosterol	1.49	-
Stigmasterol	0.28	-
Gamma.-Tocopherol	1.60	41.35
Vitamin E	0.59	10.82
Aldehydes		
9-Tetradecenal, (Z)-	0.27	-
Amides		
9-Octadecenamide, (Z)	1.27	-
Hexadecanamide	2.04	-
Hydrocarbons		
Gamma.-Elemene	-	0.98
Cis-beta.-farnesene	-	2.30
Humulene	-	1.63
Copaene	-	7.05
.alpha.-Guaiene	-	1.59
Germacrene D	-	3.91
Beta.-Bisabolene	-	3.61
Cyclohexene,3-(1,5-dimethyl-4-hexenyl	-	0.88
Cetene	-	1.24
Squalene	0.35	3.02
Cholest-5-ene,3-methoxy-, (3.beat.)-	0.08	-
Bis(2-(Dimethylamino)ethyl)ether	0.09	-
1-hexyl-1H-indole	0.12	-
1H-indene, 1-hexadecyl-2,3-dihydro	0.06	-
2-propenoic acid, 2-phenyl-,1,7,7-trimethyl	0.15	-
Benzene, (1-methylnonadecyl)-	0.09	-
Naphthalene,1,2,4a,5,6,8a-hexahydro-4,7-dimethyl(1-methylethyl)	-	4.83
Bicyclo(7.2.)jundec-4-ene,4,11,11-trimrthyl	-	14.51