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Comparative Organoleptic Assessment of Smoke-dried *Oreochromis niloticus* and *Clarias gariepinus* treated with *Anacardium occidentale* Nut oil

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Abstract

The seeds of *Anacardium occidentale* were collected, dried, roasted, de-husked and pulverized. The seed oil was extracted with the aid of a Soxhlet apparatus using n-hexane as solvent. Physicochemical analysis of the seed oil was conducted using standard procedures. The extracted oil had a relative density of 0.93 g/cm^3, refractive index at 25˚C (1.39), iodine value (41.13 g/100g), saponification value (165mg KOH/g), peroxide value (4.29meq/kg) and acid value (6.90mg KOH/g). The Phytate (3.26mg/100g), tannin (0.5mg/100g) and oxalate (0.003mg/100g) contents of the oil fell within acceptable levels. Sensory quality test indicated that treated fishes retained good appearance, odour, taste, texture and good consumer acceptance. The implication of these findings to the protection and consumption of smoke-dried *Oreochromis niloticus* and *Clarias gariepinus* are discussed.

Key words: Phytochemicals, Cashew nut oil, Antinutrients, smoked fish

INTRODUCTION

Freshly harvested fish is a highly perishable commodity, but it can be processed to lengthen its shelf-life thereby making it available and relevant to consumers in an acceptable state. Temperatures in the tropics contribute to the high percentage post-harvest losses and quality deterioration of fishes with consequent reduction in value and economic returns. The high ambient temperature hastens spoilage of fish by accelerating the activities of bacteria, enzymes and chemical oxidation of lipids in fish flesh (FAO, 2010). Unwholesome fish may be discarded

by fisherfolk at different stages of handling and processing leading to economic and nutritional loss in the fishing industry (Eyo, 1997; Mgawe, 2008; Kumolu-Johnson and Ndimele, 2011).

Spoilage of fish during processing, transportation and storage is a serious problem in fish processing establishments especially in Africa. Moisture content in poorly smoke-dried fishes give room for moulds and spoilage bacteria to grow and develop. The actions of these microorganisms alongside the oxidation of nutrients (lipids, proteins, and vitamins) gives rise to the development of off-flavour, loss of nutrients and the formation of potentially toxic compounds and finally make the fish unfit for consumption (Shahidi and Shong, 2010; Sriket, 2014). In addition, oxidation of nutrients causes defective nutrition due to the formation of reactive oxygen species and consequently may exhibit deleterious effects on consumers (Esterbauer *et al*., 1991). In recent times, food producers use synthetic antioxidants such as Butylated hydroxyanisole (BHA) and Butylated hydroxytoluene (BHT) to prevent food spoilage and to extend the shelf life of processed foods. Nonetheless, such synthetic compounds have been identified as toxic in the long run and are reported to cause various chronic diseases in humans (Branen, 1975). Therefore, there is need to identify alternative, safe and natural food preservatives. Of late, consumer preferences for plant-based natural preservatives have resulted in an increased interest towards the use of phytochemicals as antioxidants or antimicrobials in the food system (Vadivel *et al*., 2013) and plants could be exploited as a natural source of phytochemicals for fish preservation (Vadivel *et al*., 2014). Essential oils from land and sea sources rich in terpenes, terpenoids and aliphatic compounds have significantly shown antioxidant and antimicrobial activities thereby extending the shelf-life of fish (Moosavi-Nasab *et al*., 2019). Among the tropical nuts, cashew nut (*Anacardium occidentale* L.) plays a vital role as an edible nut (FAOSTAT, 2012). The nut has high oil content exploitable as a preservative in the food processing and preservation industry. The nut oil is rich in mineral nutrients and vitamins particularly vitamins E, making it an important ingredient in the formulation of anti-aging products and in the treatment of fungal infections of the skin (Sitaranikhil, 2020). According to Prakash *et al*. (2018) methanolic extract of cashew nut could be utilized as natural food preservative due to its impressive antioxidant and antibacterial activities in the inhibition of the growth of both Gram-positive and Gram-negative bacteria. Therefore, this study was designed to assess the palatability and acceptability of smoke-dried *Oreochromis niloticus* and *Clarias gariepinus* treated with cashew nut oil.

MATERIALS AND METHODS

Source and Processing of Cashew nuts

The nut oil of Cashew (*Anacardium occidentale* L.) used for this study was obtained from nuts collected from fruiting trees within Ahmadu Bello University, Main Campus, Samaru, Zaria. The Cashew plant was properly identified and authenticated at the Herbarium unit, Department of Botany, Ahmadu Bello University, Zaria, prior to processing.

Cashew nuts were removed from its respective shell then sun-dried for 10 days after which it was pulverized using a mortar and pestle. The pulverized seeds were then stored in new pre – labeled cellophane bags.

Extraction of Oil by Soxhlet Technique

40g of the seed powder was weighed into separate muslin cloth and introduced separately into the Soxhlet chamber for the oil extraction. In the round bottom flask, 350ml of n – hexane was introduced as extraction solvent. The extraction was done at 60 - 80^{0}C until the solvent in the Soxhlet chamber became transparent. The Soxhlet apparatus was then dismantled and the content of the round bottom flask was transferred to a rotary evaporator to evaporate excess solvent from the oil. The 76ml solvent-free oil obtained from 200g of the nut powder was then stored in a labeled bottle in a cool dry place until used for bioassay.

Extraction of the Aqueous Crude Extract

Dried lightly roasted cashew seeds (150g) were weighed and ground using a clean mortar and pistle. Then 400 ml of distilled water was added to the ground seeds. The mixture was allowed to stand for 6 h in distilled water, stirred regularly with a stirrer and then filtered using cheese cloth. The filtrate was then placed in a water bath at 60°C for 6 h to allow for evaporation of the water in the extract. The phytochemicals in the extract was then evaluated.

Quantification of the Phytochemicals

The phytochemicals of the raw and aqueous crude extract of *A. occidentale* were quantified using standard methods adopted from those reported by Ezeonu and Ejikeme (2016); Roghini and Vijayalakshmi (2018).

Determination of Trypsin Inhibitor activity

Trypsin inhibitor activators of the samples were determined as described by Liener (1979). 0.2 g of each sample was weighed into a screw-cap centrifuge tube. 10 ml of 0.1 M phosphate buffer was added and the contents were shaken at room temperature for 1 h on a UDY shaker. The suspension obtained was centrifuged at 5000 rpm for 5 minutes and filtered through Whatman No.42 filter paper. The volume of each was adjusted to 2 ml with phosphate buffer. The test tubes were placed in water bath, maintained at 37±2°C and 6 ml of 5% tricarboxylic acid (TCA) solution was added to one of the tubes to serve as a blank. 2 ml of casein solution was added to all the tubes previously kept at 37±2°C and were incubated for 20 minutes. The reaction was stopped after 20 minutes by adding 6 ml of TCA solution to the experimental tubes and then shaken for 10-15 seconds. The reaction was allowed to proceed for 1 h at room temperature. The mixture was filtered through Whatman No.42 filter paper and the absorbance of filtrate from sample and trypsin standard solutions were read at 280 nm.

Determination of Haemagglutinin Level

Haemagglutinin level of the sample was determined as described by Jaffe (1979). 2 g of each sample was weighed and 50 ml of solvent of mixture of isobutyalcohol and trichloroacetic acid were added and allowed to shake on a UDY shaker for 6 h to extract the haemagglutinin. The mixture was filtered through a double layer filter paper and maintained in a water bath for 2 h at 80±2°C and the filtrate was allowed to cool. A set of standard solutions of haemagglutinin ranging from 0 to 10 ppm were prepared from the haemagglutinin stock solution. The absorbances of the standard solution as well as that of the filtrate were read at 220 nm on a digital spectrophotometer 21D.

Determination of Hydrocyanic acid

The hydrocyanic acids (HCN) of the samples were determined by adopting the procedure of Bradbury *et al*. (1999). 5g of each sample was weighed and each sample was incubated for another 16h at a temperature of 38±2°C. After the extraction, the filtration was done using a double layer of hardened filter paper. The distillation was done with Markham distillation apparatus. Each sample extracted was transferred into a two-necked 500ml flask connected with a steam generator. This was steam-distilled with saturated sodium bicarbonate solution contained in a 50ml conical flask for 60 minutes. 1ml of starch indicator was added to 20ml of each distillate and was titrated with 0.2N of iodine solution.

Determination of Oxalate

The total oxalates were determined as described by Fasset (1996). The extraction was done by weighing 1g of each sample and soaked with 100ml of distilled water. These were allowed to stand for 3h and each was filtered through a double layer of filter paper. 10, 20, 30, 40 and 50ppm standard solution of oxalic acid were prepared and read on the spectrophotometer at 420nm for the absorbance. The absorbances of filtrate from each sample were also read on the spectronic 20.

Determination of Cyanogenic glycoside

Cyanogenic glycoside was determined using alkaline picrate method described by Onwuka and Olopade (2005). Ground sample (5.0 g) was weighed and dissolved in 50 cm3 distilled water. The cyanide extraction was allowed to stay overnight and then filtered (Inuwa *et al*., 2011).

Preparation of Cyanide standard curve

Different concentrations of KCN solution containing 0.1 to 1.0 mg/mL cyanide were prepared. To 1 mL of the sample filtrate and standard cyanide solution in test tubes, 4 mL of alkaline picrate solution (1 g of picrate and 5 g of Na2CO3 in 200 cm3 distilled water) was added andincubated in water bath for 15 min. After color development, the absorbance was read at 490 nm against a blank containing only 1mL distilled water and 4 cm3 alkaline picrate solution. The cyanide content was extrapolated from the cyanide standard curve.

Calculation:

Cyanogenic glycoside (mg/100 g) = (C (mg)/Weight of sample) × 10

where, C (mg) = Concentration of cyanide content read off the graph.

Determination of Phytic acid

Phytic acid was determined by the procedure described by Lucas and Markakas (1975). 2.0 g of the sample was weighed into a 250 mL conical flask. 100mL 2% concentrated HCl was used to soak sample for 3 h and then filtered with a Whatman No. 1 filter paper. 50cm^3 of the filtrate and 10cm^3 of distilled water were added in each case to give proper acidity. 10mL 0.3% ammonium thiocyanate solution was added into the solution and titrated with standard Iron II Chloride solution containing 0.00195g Iron/mL, end point observed to be yellow which persisted for 5 minutes. The percentage phytic acid was calculated thus:

% Phytic acid = y × 1.19 × 100

where, y = titre value × 0.00195 g

Organoleptic Study

Different quantities of the oil were thoroughly rubbed onto the body of smoked fishes weighing 17g each. The treated fishes were placed in kilner jars, covered with muslin cloth and left on the shelf for 30 days. Fishes without oil treatment served as the control. Treated fish at each application level were examined for palatability and physical attractiveness by a panel of eighteen (18) fish assessors within the ages of 24-30 years both at 24 hours of exposure to the nut oil and also at 30 days post-treatment using the modified criteria (Akinwumi, 2007; Okonkwo and Okoye, 2001 and Clucas, 1982). Test was in triplicate for each treatment.

The percentage acceptability was calculated as follows:

$$\text{Acceptance}(\%) = \frac{\text{Scoreobtained}}{\text{Scoreobtainable}} \times 100$$

Statistical Analysis

Data generated were subjected to Multivariate Analysis of Variance (ANOVA) at $p< 0.05$ to determine significant difference between treatments. Tukey's Test was employed for mean separation.

RESULTS

The extracted cashew nut oil is pale yellow in colour with a mild odour. Its relative density, refractive index, peroxide value and acid value fell within the range of 0.93 to 6.90; the acid value had the highest and refractive index the least. The iodine value and the saponification value were 41.13 and 165 respectively (Table 1). The phytochemical screening revealed that carbohydrate, glycosides, steroids, triterpenes and alkaloids are present in the nut oil while saponins, tannins, flavonoids and anthraquinines were not detected (Table 2). Antinutrients detected were oxalate, tannin, phytate, alkaloid and trypsin inhibitor with 0.003mg, 0.5mg, 3.26mg, 1.13mg and 0.31mg respectively (Table 3).

Table 1: Physical Properties of *A. occidentale* nut oil

Properties	**Outcome**
Colour	Pale yellow
Odour	Mild
State at room temperature	Liquid
Relative density (g/cm3)	0.93
Refractive index	1.39
Acid value	6.90
Iodine value	41.13
Peroxide value	4.29
Saponification value	165

Table 2: Phytochemical Constituents of *A. occidentale* nut oil

Constituents	**Test**	**Inference**
Carbohydrates	Molisch test	+
Anthraquinones	Bontragers test	_
Glycosides	Fehling test	_
Cardiac glycosides	Kelle killiam test	_
Saponins	Frothing test	_
Steroids and Triterpenes	Lieberman Burchard test	+
Tannins	Feric chloride test	+
Flavonoids	Shenoda test	_
Alkaloids	Dragendorff test	+

Table 3: Antinutrients present in the nut oil of *A. occidentale*

Antinutrients	**Oxalate (mg)**	**Tannins (mg)**	**Phytate (mg)**	**Alkaloids (mg)**	**Trypsin (mg)**
Replication1	0.0026	0.50	3.16	1.18	0.31
Replication 2	0.0026	0.50	3.37	1.18	0.32
Replication 3	0.0029	0.49	3.26	1.04	0.30
Mean value	**0.003±0.00**	**0.5±0.003**	**3.26±0.06**	**1.13±0.05**	**0.31±0.006**
FAO Standard	**<3.00**	**<3.00**	**>15.00**	**<3.00**	**<5.00**

Mean ± SEM along columns are not significantly different at $P < 0.05$

Table 4: Fatty acids and Metabolite profile of *A. occidentale* nut oil

Fatty Acids/Metabolites	**Percentage (%)**
9-Octadecenoic acid(Oleic acid)	(86.88)
Hexadecanoic acid, ethyl ester (Palmitic acid ester)	(1.60)
Decanoic acid(Capric acid)	(0.27)
Azetidine	(0.08)
Ethylbenzene	(0.12)
Phosphoryl fluoride	(0.04)
Propargylamine	(0.04)
Aminoacetonitrile	(0.12)
2-Aminoethylethyl sulfide	(0.02)
2,1-Benzisoxazole	(0.10)
Benzene, 4-ethyl-1,2-dimethyl-	(0.06)
Methylacrylonitrile	(0.02)
Ethanone, 1-(4-methylphenyl)-	(0.14)
2-Propenamide	(0.02)
Dispiro[2.2.2.2]deca-4,9-diene	(0.14)
Timonacic	(0.04)
Azulene	(0.15)
Benzene, (1-methyl-1-butenyl)-	(0.10)
Arsine, cyanodimethyl-	(0.16)
1-Decanol	(0.18)
9-Thiabicyclo[6.1.0]nonane	(0.06)
2-Propen-1-amine	(0.01)
3-Pentenenitrile	(0.02)
Chloromethyl cyanide	(0.07)
Aminoguanidine	(0.02)
Acetyl cyanide	(0.01)
2-Butanamine, (S)-	(0.05)
Cyclohexanemethanol	(1.00)
Phenol, 2-methyl-	(1.92)
9,17-Octadecadienal, (Z)- (an unsaturated aldehyde)	(6.39)

Sensory quality of Smoke-dried fish treated with cashew nut oil

The appearance of all the treated smoke-dried *O. niloticus* including the control were all appealing to the assessors. 0.003ml/g, 0.009ml/g, 0.027ml/g and 0.081ml/g treated fish samples were most appealing in comparison to the rest of the fish samples (Fig. 1). There was no significant difference ($p<0.05$) in the appearance of all the fish samples at week one; the fishes treated with 0.162ml/g had a better appeal than the control fish that had moderate appeal.

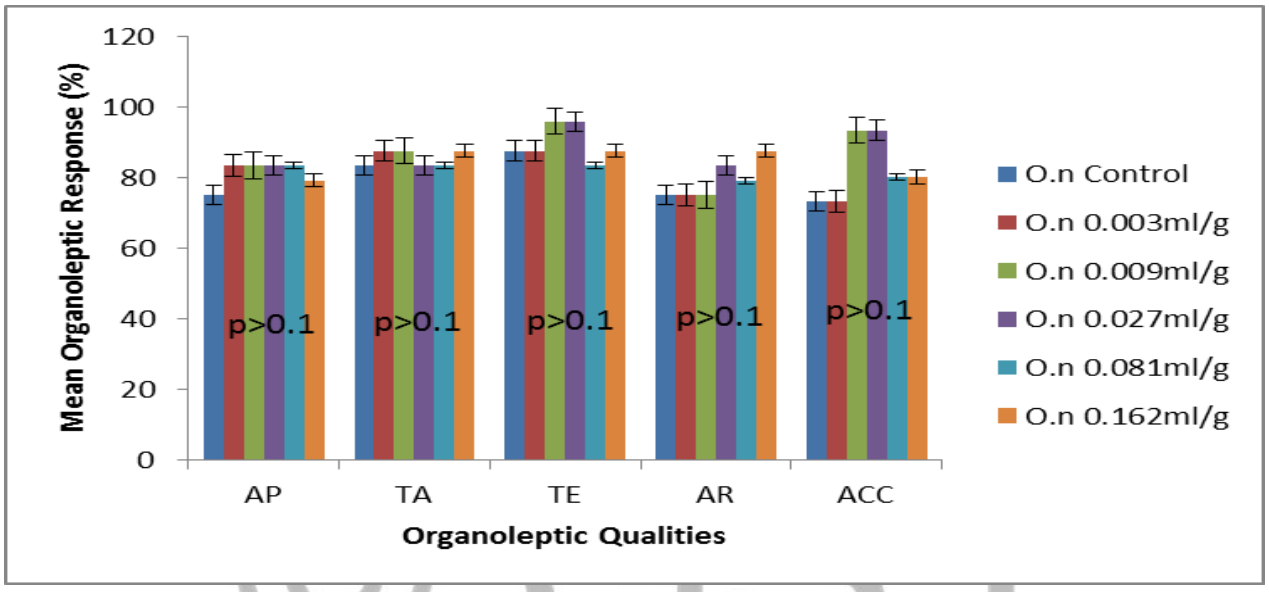

Figure 1: Organoleptic Quality of *O. niloticus* at Week One (Day 7)
*****The 8-point Hedonic scale are 1(12.5%)= Extremely unappealing, 2(25%)= Very much unappealing, 3(37.5%)= Moderately unappealing, 4(50%)= Slightly unappealing, 5(62.5%)= Slightly appealing, 6(75%)= Moderately appealing, 7(87.5%)= Very much appealing, 8(100%)= Extremely appealing*****

The report of the assessors on the appearance of the oil-treated smoke-dried *C. gariepinus* (Fig. 2) was considered as appealing, except for 0.003ml/g treatment which appealed only moderately, yet this did not differ significantly ($p<0.05$) from all the other fish samples.

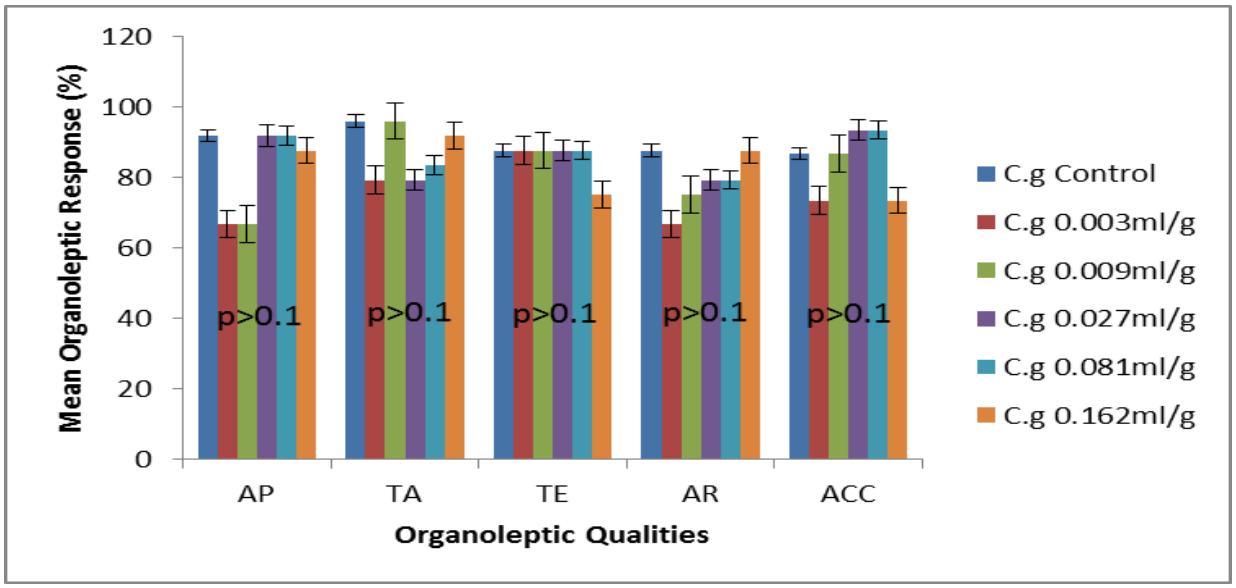

Figure 2: Organoleptic Quality of *C. gariepinus* at Week One (Day 7)
*****The 8-point Hedonic scale are 1(12.5%)= Extremely unappealing, 2(25%)= Very much unappealing, 3(37.5%)= Moderately unappealing, 4(50%)= Slightly unappealing, 5(62.5%)= Slightly appealing, 6(75%)= Moderately appealing, 7(87.5%)= Very much appealing, 8(100%)= Extremely appealing*****

The assessors liked the taste of all fish samples both *C. gariepinus* and *O. niloticus* including those treated with 0.003ml/g, 0.009ml/g and 0.162ml/g of cashew nut oil, there was no significant difference ($p<0.05$) between all the treated fish samples and the control. The textures of both fish types were considered to be very tender with fibrous mouth feel.

There was no significant difference ($p\leq0.05$) in the texture of the treated and control fish samples. Fishes treated with 0.009ml/g and 0.027ml/g of the nut oil were considered to be extremely tender and fibrous in the mouth while the other treatments were very tender with fibrous mouth feel.

The aroma of all the fish samples (*C. gariepinus* and *O. niloticus*) were appealing, especially in samples treated with 0.027ml/g and 0.162ml/g cashew nut oil and adjudged as having a very good aroma, but not statistically different ($p<0.05$) for all treatments including the control. The overall acceptance rating by the assessors was considered as good to excellent for all the fish samples, particularly the treated ones in the first week of treatment with the cashew nut oil.

At the end of the fourth week (30 days), *O. niloticus* treated with 0.009ml/g, 0.027ml/g and 0.081ml/g cashew nut oil retained a moderate to very good appeal in terms of appearance to the assessors, while 0.003ml/g and 0.162ml/g treatment appealed slightly (Fig 3).

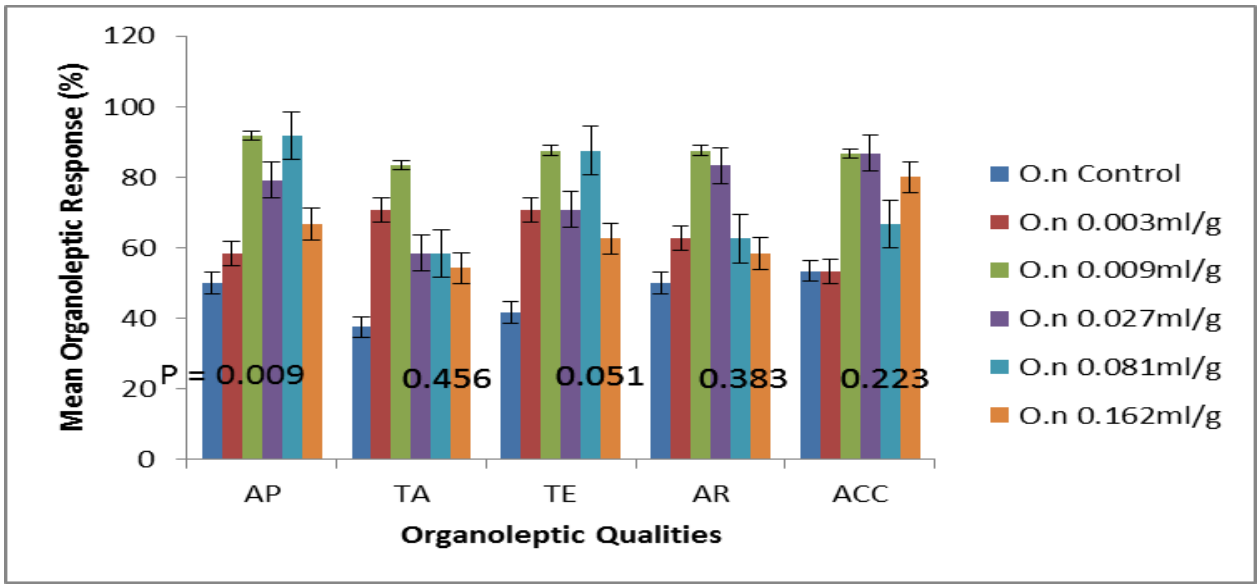

Figure 3: Organoleptic Quality of *O. niloticus* at Week Four (Day 28)
*****The 8-point Hedonic scale are 1(12.5%)= Extremely unappealing, 2(25%)= Very much unappealing, 3(37.5%)= Moderately unappealing, 4(50%)= Slightly unappealing, 5(62.5%)= Slightly appealing, 6(75%)= Moderately appealing, 7(87.5%)= Very much appealing, 8(100%)= Extremely appealing*****

A similar appeal rating for appearance was also allotted to *C. gariepinus* treated with 0.027ml/g, 0.081ml/g and 0.162ml/g of the cashew nut oil. Fish treated with 0.081ml/g and 0.162ml/g had a much greater appeal in comparison to 0.027ml/g which was reported to be slight however, the control fish was reported to be slightly unappealing in both fish type (Fig. 4)

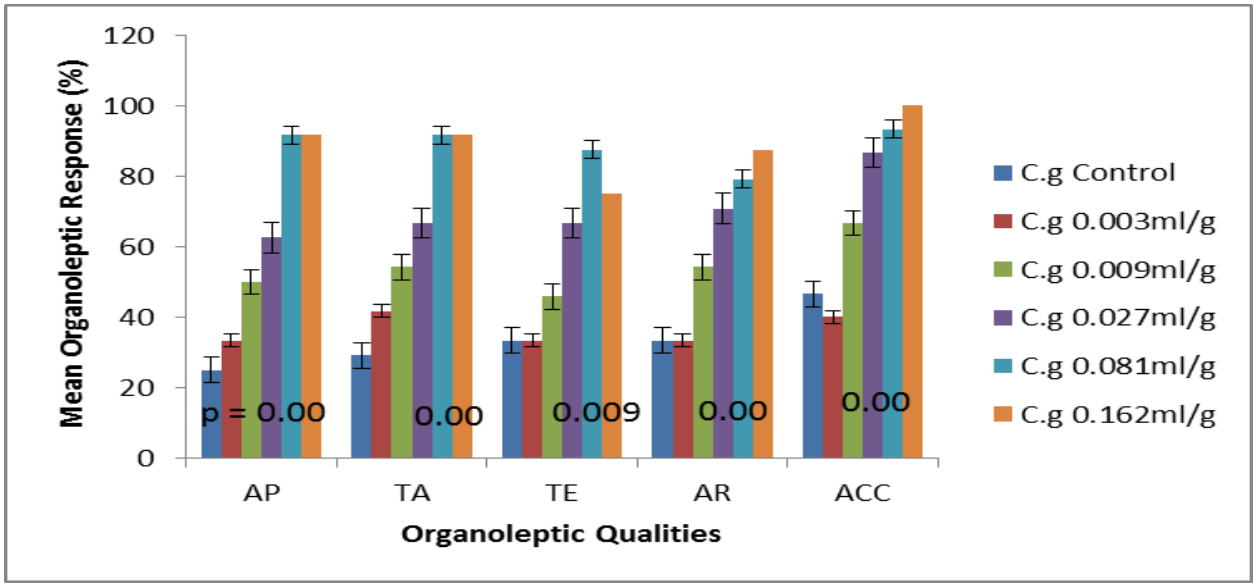

Figure 4: Organoleptic Quality of *C. gariepinus* at Week Four (Day 28)

*****The 8-point Hedonic scale are 1(12.5%)= Extremely unappealing, 2(25%)= Very much unappealing, 3(37.5%)= Moderately unappealing, 4(50%)= Slightly unappealing, 5(62.5%)= Slightly appealing, 6(75%)= Moderately appealing, 7(87.5%)= Very much appealing, 8(100%)= Extremely appealing*****

The taste of the control fish and those treated with 0.003ml/g and 0.009ml/g were relatively poor and unappealing; but fish samples treated with 0.027ml/g, 0.081ml/g and 0.162ml/g cashew nut oil were appealing, and 0.081ml/g and 0.162ml/g had better appeal in comparison to 0.027ml/g treated fish. The taste of the treated fish samples were liked by the assessors but the control fish had awful taste (Fig. 1). In terms of texture, the treated fishes were still tender and fibrous in the mouth. The control fish was moderately tough and flaky in the mouth. Fish samples treated with 0.003ml/g, 0.081ml/g and 0.162ml/g of the cashew nut oil appealed only slightly to the panelists. Fishes treated with 0.009ml/g and 0.027ml/g were considered as very appealing, unlike the control fish. Fish treated with 0.003ml/g, 0.009ml/g and the control were tough with flaky mouth feel however, 0.027ml/g, 0.081ml/g and 0.162ml/g oil-treated fishes still retained tender fibrous mouth feel with 0.081ml/g and 0.162ml/g oil-treated fishes having a much better texture than 0.027ml/g treated fish samples.

The aroma of *C. gariepinus* (Fig. 4) and *O. niloticus* (Fig. 3) treated with 0.003ml/g, 0.009ml/g and the control did not appeal to the assessors at the end of the study period, while those treated with 0.027ml/g, 0.081ml/g and 0.162ml/g cashew nut oil appeal led to the panelists, and the last two higher treatments had the best appeal compared to 0.027ml/g that was considered as having moderate appeal. With respect to overall acceptance of the fish samples, 0.003ml/g oil treated fish and the control fish samples were rated as fair while the other treatments were rated as good to excellent. Fish treated with 0.009ml/g cashew nut oil was rated as satisfactory.

The overall acceptance of the treated *C. gariepinus* and *O. niloticus* was good to excellent but, fish treated with 0.003ml/g of the nut oil and the control fish were ranked as satisfactory by the assessors. At the end of the fourth week (30 days), the appearance, taste, texture, aroma and overall acceptance of treated *C. gariepinus* and *O. niloticus* positively correlated with treatment but negatively correlated with duration (storage period) (Fig. 5).

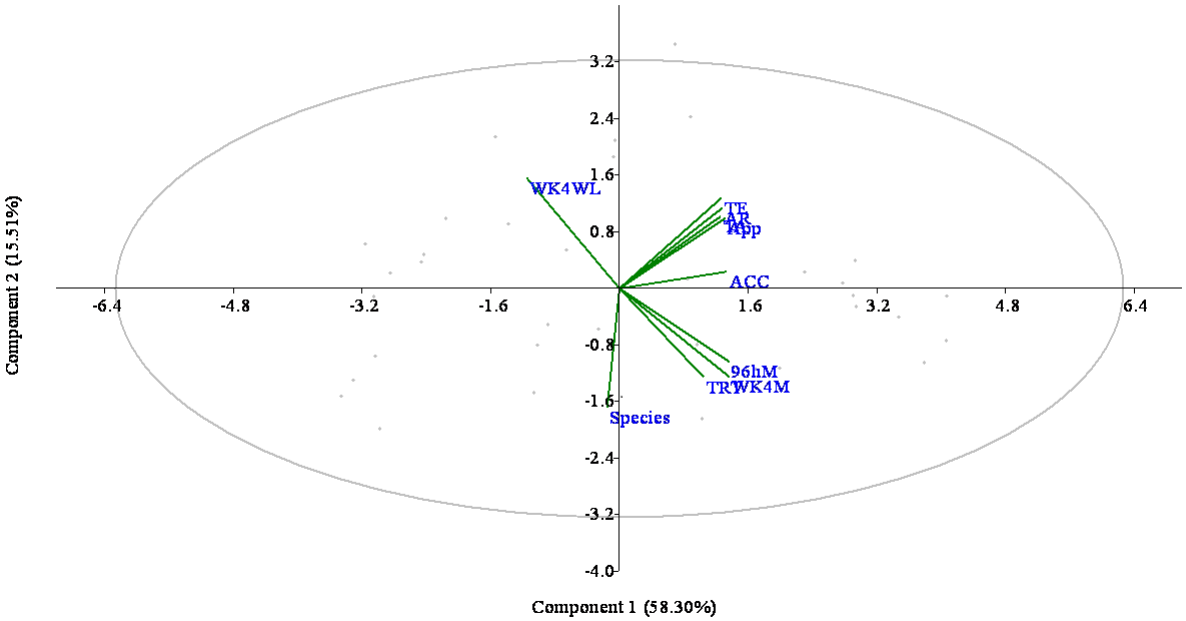

Figure 5a: PCA biplot of Fish samples treated with Cashew nut oil and their Organoleptic Qualities

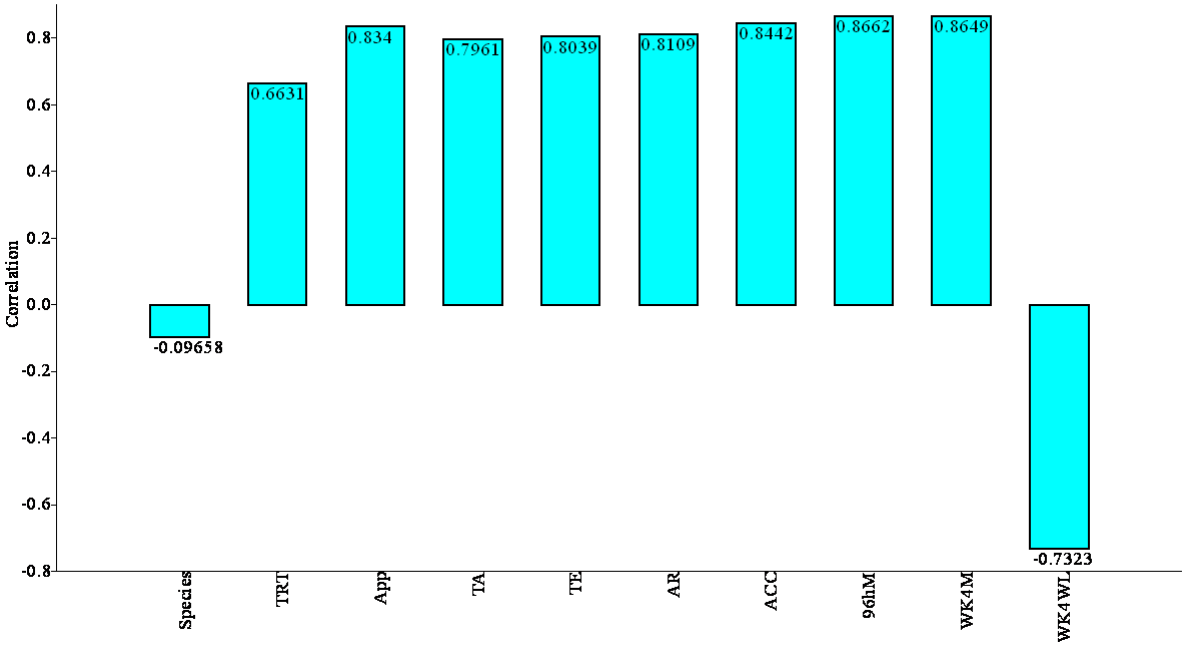

Figure 5b: PCA Loading of Fish samples treated with Cashew nut oil and their Organoleptic Qualities

Table 5 showed that the appearance of *O. niloticus* appealed more to the assessors at week one (6.50) than at week four (5.83). The taste of the fish samples at week one (6.83) were liked more than at week four (4.83). The texture was much better at week one (7.17) in comparison to week four (5.61). Similarly, the aroma appealed more at week one (6.33) compared to week four (5.39). Although there was significant difference between the weeks for all the sensory qualities considered, the fish samples at the end of the experiment were rated to be in good state.

The appearance of *C. gariepinus* (Table 6) reduced in appeal with time. At week one, the fishes had very good appeal, but were reported by the assessors to have reduced slightly at week four. The assessors liked the taste of the fish very much at week one however, at week four, the fishes were liked slightly. The texture of the fish samples at week one was very tender with fibrous feel in the mouth. At week four, the texture of the fishes had reduced tenderness.

The aroma of the fish samples had a very good appeal at the onset of treatment (week one) but reduced slightly by week four. The overall acceptance of the fishes differed significantly ($p<0.05$) yet the fishes at the onset and the end of the experimental period were in good state.

The appearance of *O. niloticus* was more appealing than *C. gariepinus* at the end of the experimental period. The assessors liked the taste of *C. gariepinus* a little more than *O. niloticus*. The texture and aroma of *O. niloticus* was preferred to that of *C. gariepinus*, though both fish species were significantly different ($p<0.05$) in their sensory qualities, but were in good state (Table 7).

Table 5: Week One versus Week Four Sensory attributes of oil-treated smoke-dried *Oreochromis niloticus*

Sensory Quality	Week 1	Week 4	P-Value
Appearance	6.50 ± 0.23^{a}	5.83 ± 0.23^{b}	**0.042**
Taste	6.83 ± 0.32^{a}	4.83 ± 0.32^{b}	**0.000**

Texture	7.17±0.29[a]	5.61±0.29[b]	**0.000**
Aroma/Flavour	6.33±0.33[a]	5.39±0.33[b]	**0.046**
Overall Acceptance	4.11±0.19[a]	3.56±0.19[b]	**0.042**

The 8-point Hedonic scale are 1= Extremely unappealing, 2= Very much unappealing, 3= Moderately unappealing, 4= Slightly unappealing, 5= Slightly appealing, 6= Moderately appealing, 7= Very much appealing, 8= Extremely appealing. Means along a column with the same superscript are not significantly different

Table 6: Week One versus Week Four Sensory attributes of oil-treated smoke-dried *Clarias gariepinus*

Sensory Quality	**Week 1**	**Week 4**	**P-Value**
Appearance	6.94±0.23[a]	4.72±0.23[b]	**0.000**
Taste	7.11±0.32[a]	5.00±0.32[b]	**0.000**
Texture	6.83±0.29[a]	4.56±0.29[b]	**0.000**
Aroma/Flavour	6.33±0.33[a]	4.78±0.33[b]	**0.001**
Overall Acceptance	4.22±0.19[a]	3.61±0.19[b]	**0.026**

The 8-point Hedonic scale are 1= Extremely unappealing, 2= Very much unappealing, 3= Moderately unappealing, 4= Slightly unappealing, 5= Slightly appealing, 6= Moderately appealing, 7= Very much appealing, 8= Extremely appealing. Means along a column with the same superscript are not significantly different

Table 7: Comparative Sensory Attributes of Oil-treated *C. gariepinus* and *O. niloticus* at the end of Week four (Wk 4)

Fish Species	Appearance (%)	Taste (%)	Texture (%)	Aroma (%)	Overall Acceptance (%)
Oreochromis niloticus	72.92±0.20^{b}	60.42±0.32	70.14±0.25^{b}	67.36±0.27	71.11±0.16
Clarias gariepinus	59.03±0.36^{a}	62.50±0.32	56.94±0.34^{a}	59.72±0.30	72.22±0.18
P-Value	**0.001**	**0.764**	**0.029**	**0.236**	**0.849**

The 8-point Hedonic scale are 1(12.5%)= Extremely unappealing, 2(25%)= Very much unappealing, 3(37.5%)= Moderately unappealing, 4(50%)= Slightly unappealing, 5(62.5%)= Slightly appealing, 6(75%)= Moderately appealing, 7(87.5%)= Very much appealing, 8(100%)= Extremely appealing. Means along a column with the same superscript are not significantly different. Means with the same superscript along a column are not significantly different at $P<0.05$.

DISCUSSIONS

The shelf-life of oil treated fish showed that no significant difference exists between the weights of these fishes treated with the cashew nut oil in four (4) weeks storage period. This implies that the oil was effective in preserving the fishes and prolonging its shelf-life. The nut oil's refractive index of 1.39 is an indication that the oil was lighter than most drying oil and may persist longer on surfaces (Rossell, 1991). The relative density (0.93) of the oil indicated that the oil is light and can float on water, thereby suggesting that it has great capacity to spread easily over the smoke-dried fish surfaces (Ogale *et al*., 2018). The iodine value of the oil also indicates that there will be little oxidation and the onset of rancidity may be prolonged, thereby conferring protection on the fish before utilization (Eromosele and Eromosele, 1993; Ajayi and Aghanu, 2011). The acid value for Cashew nut oil in this study is within the FAO/WHO recommended value. However, the low peroxide value obtained (<5) implies that in the process of time, oxidative rancity may set in, giving the oil an off-flavour eventually. Odoom *et al*. (2014) reported that high acid value are undesirable in edible oils because they can result in off-flavours and shorten the shelf life of the oil.

Oxidative rancidity of oil-treated fishes in this present study was minimal as this did not have deleterious effect on the quality of the fishes. Adeyemi *et al*. (2014) reported an increment in

oxidative spoilage as storage time progressed and that *Chrysichthys nigrodigitatus* deteriorated faster in odour and flavor than *Tilapia zilli*, concluding that the optimum storage period for the processed fish species is 4-5 weeks. Peroxidation of lipids can instigate loss of nutritional and quality attributes of foods (Adeyemi *et al*., 2012) and could predispose consumers to various diseases such as cancer and atherosclerosis (Rafieian-Kopaei *et al*., 2014).

The differences observed in the palatability of the fish samples in the present study could have arisen from the high amount of oleic acid present in the oil that may have been subjected to oxidative splitting at the double bonds resulting in the formation of ketones and aldehydes which are largely responsible for flavour, odour and taste of the fish samples. A similar report by Farzana *et al*. (2014) stated that free fatty acid (FFA), calculated as oleic acid, is a tertiary product of rancidity and that it increased during storage.

The cashew nut oil in this study is low in oxalate, tannins, trypsin, phytate and alkaloids all of which were lower than the recommended WHO standard. But some types of alkaloids may be very dangerous to foetal development in sheep leading to death of foetus and also caused haemolysis and infertility in humans (Olayemi, 2007). The low values of anti-nutritional compounds in the current study gives an idea of the suitability of the oil for consumption and utilization in preservation of smoke-dried *O. niloticus* and *C. gariepinus*.

The quality of the smoke-dried *O. niloticus* and *C. gariepinus* treated with the oil of cashew nut did not significantly deteriorate with time, indicating that as time progresses the quality of the smoke-dried fishes diminishes, depending on the concentration of the oil applied to the fish. The appearance, taste, texture, aroma and overall acceptability scores were higher in the first week which diminished in the fourth week indicating that over time the protective quality of the oil reduced. Though, slight differences existed between the appearance, taste, texture and aroma of the fishes, however this was insignificant.

The acceptability of smoke-dried *O. niloticus* and *C. gariepinus* protected with cashew nut oil when freshly applied (at the 7^{th} day) and at the 30^{th} day post-treatment were rated as satisfactory to excellent. Babarinde *et al.* (2016) also reported satisfactory colour and odour of smoke-dried fish treated with neem seed oil. Fish treated with plant extract were accepted by consumers as they had no taint, smell or change in taste, texture or flavor (Akinwunmi *et al*., 2007). It is hereby opined that cashew nut oil may offer safer culinary interest for consumers than synthetic chemicals.

The result of organoleptic test in this study revealed that there was significant difference between the oil treated and the control fishes. Fishes treated with higher concentrations of the oil had the

best acceptance and appeal to consumers. Iheagwara (2013) reported that samples treated with 5% ginger extract had the best acceptance, and were different when compared to the control after 10 days of storage. However, in the current study, the control fish became unfit at the end of the study period. Akinwumi *et al*. (2006) similarly stated that unprotected fish (control) became unhygienic and therefore unfit for human consumption.

Conclusion

The cashew nut oil in this study is low in Oxalate (0.003mg), Tannins (0.5mg), Trypsin (0.31mg), Phytate (3.26mg) and Alkaloids (1.13mg) and are lower than the recommended FAO/WHO standard indicating that oil is safe for consumption. The shelf-life of the cashew nut oil-treated smoke-dried *Oreochromis niloticus* and *Clarias gariepinus* were lengthened due to the non-drying nature of the oil which did not alter the taste, texture, appearance and odour of these fishes, due to little or no oxidation, thereby delaying the onset of rancidity, unlike in the control which was unsuitable for human consumption.

The efficacy of the oil was attributed to the presence of active ingredients in the oil, particularly oleic acid which had the highest percentage (86.88%) of the cashew nut constituents, jointly conferred insecticidal properties on the oil. The oil-treated fish were palatable and generally accepted by consumers both at the seventh and twenty eight day post treatment.

Cashew nut oil is therefore recommended for use as a preservative of smoke-dried *C. gariepinus* and *O. niloticus* for four (4) weeks before consumption by humans as this will not negatively impact on the aroma, taste and textural quality of the treated fishes.

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