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Effect of Extraction Methods on the Quality Characteristics of Catfish (*Clarias gariepinus*) Oil

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Abstract The effect of kiln smoking and manual extraction of oil from catfish was investigated. Oil from African Catfish, *Clarias gariepinus*was extracted by smoking with a WAAPP-NIOMR 50kg capacity Kiln and by manual extraction from the fish abdominal walls and around the organs was rinsed under running water and boiled over medium heat with a Salad master titanium T316pot. Smoking was done for the purpose of preserving, imparting colour and increasing the palatability of fish. The oils obtained through these methods were evaluated physically and chemically. Physical examination showed two clear oils (supernatants) and two sludge obtained through the above methods, respectively. The smoked extracted oil and sludge were associated with darker colour than those obtained by manual method. Manually extracted oil and sludge showed a significant difference ($p \leq 0.05$) and an increase in peroxide value (PV) of 6.90±0.34 and 6.54±0.36meq/kg and a decrease with significant difference ($p \leq 0.05$) in per-cent free fatty acid (%FFA) of 0.54%±0.03 and 0.39%±0.08 respectively when compared with the oil and sludge of kiln smoking with peroxide values of 4.56±0.12 and 3.11±0.14meq/kg and per-cent free fatty acid of 7.27%±0.06 and 6.30%±0.02, respectively. The kiln smoked oil and sludge showed an average per-cent Moisture, Impurity and Volatiles (%MIV) of 1.085±0.13 and 0.743±0.06%, respectively which was insignificant ($p \geq 0.05$) with the manually obtained oil and sludge 0.084±0.01 and 0.1385±0.02%, respectively. Fatty acid profile of the oils showed the existence of twelve fatty acids in the kiln smoked oil and sludge with lignoceric acid (15.08% and 16.70%,respectively) as the predominant saturated fatty acid and linolenic acid (33.26% and 37.05%,respectively) as the major polyunsaturated fatty acid, while the manually extracted oil and sludge were found with fifteen fatty acids with myristic acid (18.89% and 8.61%) as the predominant saturated fatty acid and linolenic acid (43.03% and 48.14%,respectively) as the total unsaturated omega-3 fatty acid.

Keywords: *Extraction methods, catfish, oil, quality characteristic*

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1. Introduction

Fish farming has been found to be the fastest-growing animal based food production sector worldwide [1]. Africa produces about 1% of the world aquaculture with Nigeria as the major producer followed by Egypt, Uganda and Kenya [2].

In Nigeria, the consumption of a considerable amount of fish has been on the increase because of its nutritional values such as proteins, vitamins and minerals [3] as well as the increase in consumer awareness towards the role of essential fatty acids in human health and disease prevention has been unremittingly increasing among people. The consumption of typical wild small bony and oily fish such as sand eel, capelin, pilchard, mackerel etc. can be unappetizing for direct human consumption; based on this, aquaculture farming has been found to be growing rapidly between 4-6% annually [5]. Also in 2008, aquaculture fish output was noted to reach 60% of the overall fish consumption worldwide [5].

Catfish belongs to the family "*Clarias*", comprising of different species with different oil content. Catfish farming has been the most improved aspect in aquaculture. Recently, catfish have high demand in marketplaces since catfish contribute a lot of nutritional value to human and other industries. A considerable amount of total fish catch is discarded annually as wastes such as viscera, head, skin, trimmings etc. and these wastes have high content of nutritive compounds majorly the oil, composed of unsaturated essential fatty acids [6] especially those of the omega-3 family, mainly eicosapentaenoic acid (EPA; C20:5n-3) and docosahexaenoic acid (DHA; C22:6n-3).

One of the major ways of adding values to fish in the tropics is by smoking and drying as they help to remove moisture and reduce considerably the reaction that brings about perishability. Smoking is one of the oldest food preservation methods that is particularly used for fish for the purpose of preserving them and increasing their

palatability by adding flavour and imparting a rich brown colour.

Fish oil is the lipid extraction from fish and fish by-products. The production of fish oil is on the increase due to its high demand as consumable oil as well as pharmaceuticals and Industrial oils [7] and the numerous health benefits of taking fish oil.

Research has proven that the high demand of fish oil majorly catfish oil is due to the presence of the omega-3 fatty acids which helps in the maintenance of cardiovascular health in normal adults, reducing incidence of recurrence of the problem in those suffering from cardiovascular health diseases as well as ameliorating inflammatory disorders amongst others [4].

Fish oil can be extracted from fish using different techniques. Some studies have shown that catfish oil can be extracted using methods such as kiln smoking method, manual method as well as soxhlet extraction method and green extraction methods e.g. microwave assisted, supercritical and Enzymatic hydrolysis etc [7,8,9]. The quality of catfish oils extracted can be affected by the specie of catfish used as well as the extraction method adopted.

There is little or no information on the comparison of the different methods used in catfish oil extraction; therefore the objective of this study is:

- To investigate the effect of extraction methods on the lipid profile and storage parameters of catfish oil.

2. Materials and Methods

2.1. Materials

The catfish samples were harvested from a pond in Bayelsa State, Nigeria.

2.2. Reagents and Chemicals

Chemicals used for these analyses were of analytical grade and were all obtained from the Biochemistry laboratory, Department of Food Science and Technology, Rivers State University.

2.3. Extraction Methods of Fish Oils

2.3.1. Kiln Smoking Extraction Method

The fish samples were placed in a WAAP-NIOMR 50kg capacity fish kiln. The temperature was set at 120°C for 3hours. Subsequently, it was dropped at 60°C for the next 72hours. Oil collection commenced after 12 hours of continuous heating in the kiln. Clear oil (supernatant) was collected from the kiln oil collector as sample A1 while the sludge (sediment) was labeled sample A2. The sample oils appeared to be darker in colour.

2.4. Manual Extraction Method

This extraction is carried out by opening up the abdomen of the catfish using sterile blade. The fat was manually pulled out from the walls of the abdominal cavity and around organs; then rinsed under running water, boiled in salad master titanium T316 pot over medium heat. Clear oil (supernatant) was obtained as sample B1, while sludge (sediment) as sample B2. The samples obtained were lighter in colour when compared with the samples from the kiln smoking method.

2.5. Quality Parameters of Oil Samples

The peroxide value (PV), % free fatty acids (FFA) and % Moisture, Impurities and Volatiles (MIV) were analysed by the methods of the American Oil Chemist Society Official method [10] while the Fatty acid profile of the oil samples were analysed using a Gas Chromatograph (GC) Agilent 7890A coupled with Flame-ionization detector (FID), syringe size 10µl, carrier gas He (helium), injection temperature 250°C at pressure of 7.8696psi and detector temperature 290°C.

2.6. Statistical Analysis

Results were statistically analyzed by using analysis of variance technique. Level of significance within means was calculated using the Least Significant Difference and Standard deviation.

3. Results and Discussion

3.1. Peroxide Values of the Oil Samples

Figure 1 shows the peroxide values of the oil samples obtained from the extraction methods. The oil samples ranged from 3.11 ± 0.14 - 6.90 ± 0.34meq/kg with the sludge from kiln smoking (sample A2) as the least and the supernatant from manual extraction (sample B1) as the highest. Peroxide value is a recommended chemical means for determination of the oxidative status for crude and refined fish oils (European Food Safety Authority). Result showed that the peroxide values of the manually extracted oil samples are higher with a significant difference ($p \leq 0.05$) when compared to the oil samples from kiln smoking. This increase may be due to the degree of temperature involved in the boiling of the oil in manual extraction as elevated temperatures form free radicals or peroxides [8]. The values obtained in this study falls within the acceptable limit of 10meq/kg maximum declared by Nigerian Industrial Standards [11] but higher than the limit of ≤2.5meq/kg of the US FDA, GRAS [12]. Kirks and Sawyer [13] reported an onset of rancid taste in oily foods with a peroxide value up to 20-40meq/kg.

3.2. Free Fatty Acids of the Oil Samples

Figure 2 shows the free fatty acid content of the oil samples obtained from the extraction methods. In nature fats and oils exist as a mixture of fatty acids, esters and glycerol which under bad storage conditions hydrolyses partially to free fatty acids which is an important parameter in evaluating oil quality in terms of oxidation and rancidity. The percentage free fatty acids of the oil samples ranged from 0.39 ± 0.08% - 7.27 ± 0.06%, with the sludge from manual extraction (sample B2) as the least and the supernatant from kiln smoking (sample A1) as the

highest. Result showed a significant difference ($p \leq 0.05$) and an increase in the % free fatty acid of oil samples obtained through kiln smoking from those obtained manually. This increase may be due to simultaneous lipid oxidation alongside heat treatment due to smoking duration (3-72 hours), reduction in smoking temperature (120°C - 60°C) and long extraction time (after 12 hours) associated with kiln smoking in contrast with the quick extraction and short period of boiling in the manual extraction method. The free fatty acid values of this study are higher than the acceptable limit of ≤0.25% for edible fats given by Codex-Stan [14] and IS 8323 (2014). The findings of this work appear higher than the findings of Thitiphan and Waranya [8] who carried out their extraction using microwave. The lower the free fatty acid content, the better the oil.

3.3. % Moisture, Impurities and Volatile Matters

The water activity of many foods depend on the moisture content of the food and act as a means of testing food quality [15]. The values of the % moisture, impurity and volatiles (MIV) of the present study are as shown in Figure 3. The result ranged from 0.084 ± 0.01 - 1.085 ± 0.13% with the supernatant from manual extraction (sample B2) as the least and the supernatant from kiln smoking (sample A1) as the highest. The oil samples showed no significant difference from one another. Result showed that the % moisture impurity and volatiles of these oil samples are higher than the acceptable limit of 0.2% for fats and oil at 105°C declared by Codex Alimentarius /FAO/WHO [16], except for the manually extracted supernatant (sample B1) with % MIV of 0.084±0.01% which could be due to short extraction duration, lesser heating time as well as the layer which the sample oil occupied in the extraction container (supernatant).

3.4. Fatty Acid Profile of Oil Samples (%)

The term essential fatty acids (EFA) refer to those polyunsaturated fatty acids (PUFA) that must be provided in the food and necessary for health. There are two families of EFA, omega-3 (ω-3) and omega-6 (ω-6). Table 1 shows the fatty acid profile of the oil samples from the extraction methods. Result showed that the kiln smoked supernatant and sludge had a predominant saturated fatty acid as lignoceric acid (15.08 and 16.70%, respectively) with total polyunsaturated fatty acid as linolenic acid (33.26 and 37.05%, respectively) while the manually extracted supernatant and sludge had myristic acid (18.89 and 8.61%, respectively) as the predominant saturated acid and linolenic (43.03 and 48.14%) as the polyunsaturated acid. The oil samples from the two extraction methods consist of the omega-3 and omega-6 polyunsaturated fatty acids namely: linoleic (ω-6), linolenic (ω-3) and Arachidonic (ω-6) fatty acids. The poly unsaturated fatty acids (linoleic and linolenic) from fish oils are rich sources of Eicosapentaenoic (EPA), Decopentaenoic (DPA) and Decosahexaenoic (DHA) [17]. Fish and fish oil are the richest sources of this fatty acid with contents ranging from 39 % to 50 % for both fresh and salt water fish [18].

Studies have shown that the omega-3 (ω-3) and omega-6 (ω-6) fatty acids have benefits on human health such as prevention of coronary heart diseases by reducing the plasma lipids, reducing cancer risk as well as prevention of toxic shock syndrome and cardiomyopathy [19]. Also the Decosahexaenoic (DHA) of omega-3 (ω-3) fatty acid is involved in cognitive functions and necessary for pregnant women, children and elderly [17]. Research has further shown that the consumption of Eicosapentaenoic (EPA) and Decosahexaenoic (DHA) above 250mgday^{-1} results to fatal cardiac death and so a reduction in the omega-6 (ω-6) and omega-3 (ω-3) fatty acid ratio of 2.5% linoleic and 0.5% linolenic fatty acids of daily intake is recommended to avoid formation of pro-inflammatory eicosanoids from omega-6 (ω-6) polyunsaturated acid and to increase the production of anti-inflammatory mediators from omega-3 (ω-3) fatty acids [17]. From the result, the sludge of both the kiln smoking and manual extraction methods showed to be higher in total unsaturation (70.1% and 75.16%, respectively) compared with the supernatants (64.25% and 66.88%, respectively) of the extraction methods.

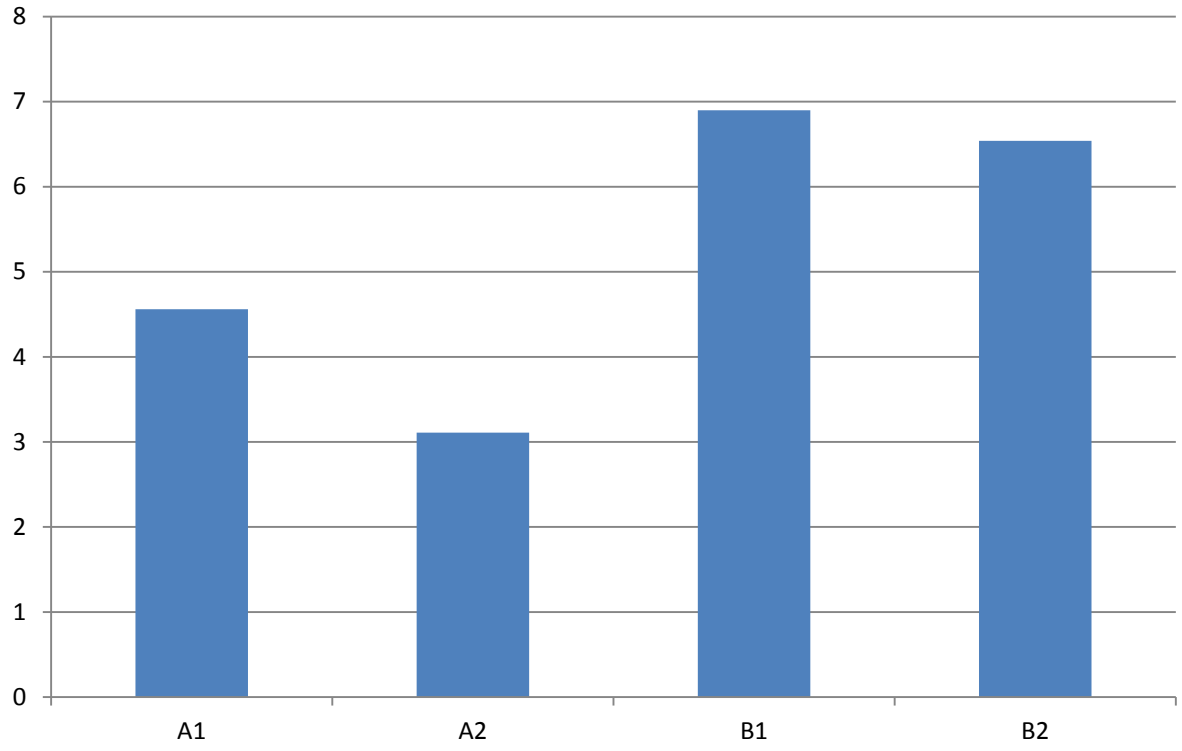
4. Conclusion

Result has shown that the two extraction methods produced oil samples with high unsaturation and rich in omega-3 (ω-3) and omega-6 (ω-6) polyunsaturated fatty acids beneficial to human health. Also, the oil samples obtained from manual extraction method have shown to be better than the kiln smoking in terms of % free fatty acid values, % Moisture impurities as well as high level of total unsaturation.

Table 1. FATTY ACID PROFILE OF THE EXTRACTED OIL SAMPLES

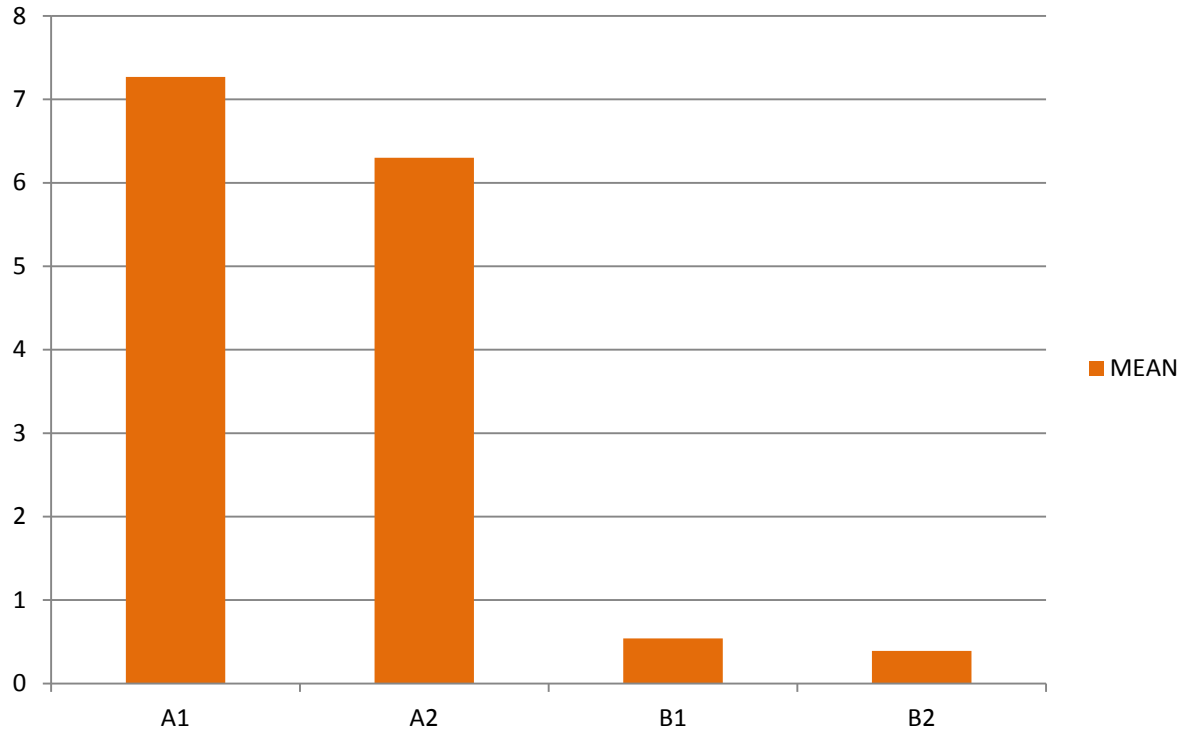
FATTY ACIDS		SAMPLES			
		A1	A2	B1	B2
Myristic	(C14:0)	10.50	3.05	18.89	8.61
Myristoleic	(C14:1)	4.19	0.58	4.27	4.86
Palmitic	(C16:0)	-	-	1.37	1.56
Palmitoleic	(C16:1)	9.43	10.50	2.92	3.32
Stearic	(C18:0)	-	-	6.84	7.78
Oleic	(C18:1)	2.16	2.11	13.83	15.61
Linoleic(∞-6)	(C18:2)	3.83	7.18	0.81	0.92
Linolenic (∞-3)	(C18:3)	33.26	37.05	43.03	48.14
Eicosenoic	(C20:1)	-	-	0.07	0.08
Eicosadienoic	(C20:2)	-	-	1.87	2.13
Eicosatrienoic	(C20:3)	6.23	6.94	0.06	0.07
Arachidonic(∞6)	(C20:4)	5.15	5.74	0.02	0.03
Behenic	(C22:0)	5.61	6.25	2.81	3.20
Erucic	(C22:1)	3.51	3.91	0.25	0.29
	(C22:6)	0.95	1.06	-	-
Lignoceric	(C24:0)	15.08	16.70	-	-
Arachidonic	(C20:0)	-	-	0.02	0.03

Key:
A1= Supernatant from kiln extraction
A2= Sludge from kiln extraction
B1= Supernatant from manual extraction
B2= Supernatant from manual extraction



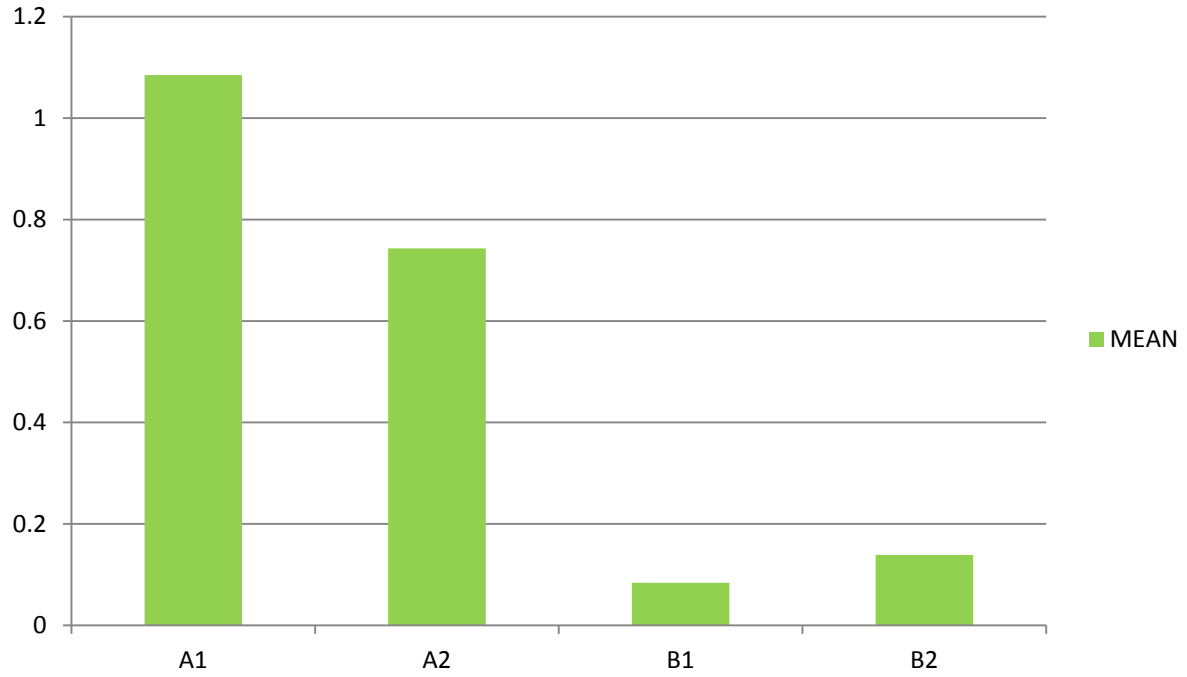
Key:
A1= Supernatant from kiln extraction
A2= Sludge from kiln extraction
B1= Supernatant from manual extraction
B2= Supernatant from manual extraction

Figure 1. PEROVIDE VALUES OF CATFISH OILS(meq/kg)



Key:
A1= Supernatant from kiln extraction
A2= Sludge from kiln extraction
B1= Supernatant from manual extraction
B2= Supernatant from manual extraction

Figure 2. FREE FATTY ACID OF CATFISH OILS (%)



Key:
A1= Supernatant from kiln extraction
A2= Sludge from kiln extraction
B1= Supernatant from manual extraction
B2= Supernatant from manual extraction

Figure 3. MOISTURE, IMPURITIES AND VOLATILES of CATFISH OIL (%)

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