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Seasonal and Temperature Dependent Variations in Amino Acid Profiles of Smoke-dried Catfish (*Clarias gariepinus*, Burchell, 1822) using Traditional and Eco-Friendly Kilns in Lagos, Nigeria

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Abstract

Smoke-dried *Clarias gariepinus* (catfish) is a major source of animal protein and livelihood for many people in Lagos State. The subjectivity of the smoke-drying process using Traditional Drum Kiln (TDK) and epileptic power supply experienced in Lagos Nigeria and its effects on amino acids profile of smoke-dried catfish was ascertained in this study. TDK was constructed as used in fishing villages in Lagos State and a new Eco-Friendly Kiln (EFK) was constructed to have flame, drying and electronic components. The smoke-drying was done in both wet and dry seasons and stored at ambient and refrigerated temperatures of 28 and 4 ^{0}C respectively. The amino acid profiles were determined according to standard procedures. The smoke-drying temperature was standardized at 60 - 80 ^{0}C with the aid of electronic components and smoke-drying carried out for 24 ± 3 hours. The highest and lowest essential amino acids were found to be Lysine at 10.11 using EFK and Methionine at 2.23 using TDK when both were stored at ambient temperature in dry season. The highest and lowest non-essential amino acids were found to be Glutamate at 15.13 using EFK in dry season and Cystine at 1.00 using TDK in wet season when both were stored at ambient temperature. Recorded values were significantly different using both kilns with generally higher values using EFK and also showed that epileptic power supply denatures amino acids.

Keywords: Amino acids, African Catfish, Smoke-drying kilns and Lagos State.

1. Introduction

Fish supply from capture and aquaculture is significant for global food security, providing about 15% of all animal protein world-wide. It is also the most important source of animal protein and accounts for about 50% of the total animal intake of the average Nigerian [9, 7, 14, 22].

African mud catfish *Clarias gariepinus* (Burchell, 1822), of the family Clariidae is one of the most highly valued freshwater fishes in Africa and presently the most successfully cultured fish in Nigeria because of its resilient nature, ability to thrive under low oxygen concentration and high feed to muscle conversion ratio [3, 2]. *Clarias gariepinus* is also known to have higher nutrient components such as amino acids and a greater ratio of polyunsaturated fatty acids to saturated fatty acids over other fishes such as *Tilapia zilli*, *Pseudotolithus typus* and *Pentanemus quinquarius* [24].

Up to 35% of freshly harvested fish in Nigeria goes to waste because once fish dies, irreversible spoilage sets in within a few hours due to enzymatic and microbial processes which lead to a degradation in the sensory and biochemical characteristics of the harvested fish [4, 16]. Since fresh fish cannot always be consumed within a few hours, there is the need to delay the inevitable spoilage all year round. This is most commonly done during both wet and dry seasons via smoke-drying using Traditional Drum Kiln (TDK) [19]. TDK is used to apply heat of temperatures averaging 60^0 to 120 ^{0}C in a hot smoke-drying process and combines cooking, drying and smoke application [8]. The smoke-dried catfish usually has a moisture content of less than 25% to ensure freshness for at least a day before being re-dried again or refrigerated before consumption [20].

This processing method is favoured over preservation methods such as freezing due to epileptic power

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supply, high costs of maintaining generators, ready availability of the raw materials required for smoke-drying and the unique flavour smoke-dried fish has which makes it a delicacy in Nigeria [21, 26].

The use of TDK however poses a number of health challenges such as the direct exposure of both the processors and the processed fish to smoke and heat leading to excessive inhalation of smoke, stinging eyes as well as excess coating of the fish with smoke particles [6]. The smoke-drying process is also fully subjective to the skill of the processor, thereby leading to inconsistencies in the quality of smoke-dried fish product thus presenting the need for new kiln which would address these challenges.

There is presently no documentation on the changes which occur to the biochemical constituent of catfish namely amino acids when the smoke-dried catfish samples are refrigerated at 4 ± 2 ^{0}C as is obtainable in Nigeria because of epileptic power supply and also in different seasons. This work is therefore aimed at constructing an Eco-Friendly Kiln and assessing the changes in the amino acids profiles of catfish smoke-dried in wet and dry seasons using both Traditional Drum Kiln and Eco-Friendly Kiln when the smoke-dried catfish samples are stored at ambient and refrigerated temperatures of 28 and 4 ^{0}C respectively.

2. Materials and Methods

2.1 Construction of Smoke-drying Kilns

The Traditional Drum Kiln (TDK) was built according to specifications as used in fishing villages in Lagos State and comprised of a cylindrical metal drum with dimensions 72 cm height, 187 cm circumference and 55 cm diameter. The aperture through which wood fuel was placed was of diameter 36 cm. A circular rack of diameter 76.5 cm was placed on the open end for smoke-drying the catfish samples (Plate 1).

Eco-Friendly Kiln was built to comprise of three chambers namely the flame, drying and electronic. The flame chamber was constructed with dimensions 93.1 X 77.5 X 85.2 cm using interlocking bricks coated with lagging material composed of clay, sawdust and silicon carbide in the ratio 4 : 2 : 0.5. The wood fuel used for smoke-drying were arranged in it via an aperture with dimensions 29.6 X 16.8 cm. The drying chamber was separated from flame chamber at the back with the use of smoke filters size 0.3 cm, was built from a metal drum with same dimensions as TDK and was coated with same lagging material as the flame chamber. A drying rack composed of three layers with dimensions 44.3 X 44.2 cm on lowest layer, 40 and 49.5 cm diameters in middle and topmost layers respectively was then placed in the drying chamber. The electronic components comprised of a temperature sensor built as a nub that was placed in smoke-drying catfish sample mouth. The nub transmitted heat message to visual light emitting diode and also an audio alarm which made no sound when the smoke-drying temperature was less than 60 ^{0}C, made a beeping sound with a second interval at optimum drying temperatures of 60 - 85 ^{0}C [25] and a loud blaring sound when the drying temperature rose above 85 ^{0}C (Plate 2).

Plate 1

Figure 1: Constructed Traditional Drum Kiln

Plate 2

Figure 2: Constructed Eco-Friendly Kiln

2.2 Sample Collection, Preparation and Analyses

Catfish samples were obtained live from the Aquaculture Unit of the Department of Marine Sciences, University of Lagos and were of average weight of 350 ± 100 g. They were stunned with a wooden club, degutted, thoroughly washed with clean pipe borne water and then bent into horse shoe shapes. The catfish samples were not seasoned with salt or any other condiment, allowed to drain and were arranged in both kilns and smoke-dried at a stretch at a temperature range of 60 - 80 ^{0}C till the weight of the fish samples were almost constant. The smoke-drying process during both wet and dry seasons lasted 24 ± 3 hours using both kilns.

The amino acid profile of the smoke-dried catfish samples was determined by extracting with 30ml of Dichloromethane three times before concentrating to 1.0ml. The concentrated extract was then derivatized for gas chromatography analysis according to [5]. All analytical procedures were performed in triplicates.

2.3 Statistical Analysis

All data for the amino and fatty acids of the smoke-dried catfish were presented as means ± standard error (SE). Analysis of variance (ANOVA) set at 0.05 level of significance, Duncan multiple-range test (DMRT) and T-test were carried out using Excel, PAST 3 and SPSS 20.0 software.

3. RESULTS AND DISCUSSION

3.1Traditional and Eco-Friendly Kilns Smoke-drying Process

Smoke-dried catfish is an important source of income and animal protein for many Nigerians especially around water bodies in Lagos State [4] . The construction of Eco-Friendly Kiln with flame and drying chambers to separate the burning fuel from smoke-drying catfish samples ensured that the smoke-dried catfish samples and the processors were not directly exposed to smoke generated by the fuel. This did not agree with the works of [12] and [6] who built improvements on Traditional Drum Kiln but without distinct compartmentalization.

Studies show that over 90% of processors in Lagos State are women with young children [1, 18]. These children are exposed to excessive heat given off by TDK which rises to well over 100^0 C when in use. The effective lagging/refractory material of clay, sawdust and silicon carbide with the sealing with cement of the newly constructed Eco-Friendly Kiln (EFK) ensured that even when the flame temperature within the kiln was as high as 650 ^{0}C, most of the generated heat was contained within Eco-Friendly Kiln and the temperature of the kiln when touched on the outside did not exceed 65 ^{0}C thus making it safe to use around little children, agreeing with the work of [6] who also obtained similar safe results on the kiln temperature with his lagged kiln.

3.2 Essential Amino Acids

Amino acids form the building blocks of proteins and carry out different purposes in the human body [27]. The results from this study found 18 amino acids in the smoke-dried catfish samples using both Traditional and Eco-Friendly Kilns and differed from the work of [13] who found 17 amino acids from their work on smoke-dried catfish. This shows that the smoke-drying process using both kilns better did not denature any of the amino acids and is thus better for human consumption. Amino acids are divided into two namely essential and non-essential amino acids. Essential amino acids cannot be synthesized de novo and thus must be supplied in the diet in order for promote body functions. Isoleucine is essential for hemoglobin formation, stabilizing and regulating blood sugar and energy [23]. Deficiency in these amino acids is known to cause a hindrance in quick recovery process in humans [15]. This study found seven essential amino acids namely Leucine, Isoleucine, Threonine, Lysine, Histidine, Methionine and Phenylalanine. The highest recorded essential amino acid in dry season was found to be Lysine at 10.11 and 8.84 both using EFK stored at ambient and controlled temperatures respectively while the lowest was found to be Methionine at 2.23 when stored at ambient temperature and Histidine at 2.46 when stored at controlled temperature both using TDK. Highest recorded values in wet season were found to be Lysine at 10.08 at ambient temperature and 9.37 at controlled temperature using TDK and EFK respectively. All values found were within range of findings of [11] and [23] who also found similar values in their studies of traditionally smoke-dried Indonesian Catfish and fresh Catfish respectively.

Smoke-drying catfish using Traditional Drum Kiln and Eco-Friendly Kiln showed significantly different results when the processing was carried out in both wet and dry seasons and when stored at ambient and refrigerated temperatures except for Leucine in dry season at controlled temperature, Threonine in wet

season at ambient temperature and Phenylalanine in wet season at ambient temperature.

The essential amino acids were also observed to be generally higher when the catfish samples smoke-dried using both kilns were stored at ambient temperature as against refrigerated temperature and shows that epileptic power supply reduces the nutritive quality of smoke-dried catfish.

Table 1: Seasonal variations in essential amino acid compositions of smoke-dried *clarias gariepinus* using traditional and eco-friendly kilns and stored at ambient and refrigerated temperatures

Essential Amino Acids		Ambient Temperature		Controlled Temperature	
		DRY SEASON	WET SEASON	DRY SEASON	WET SEASON
Leucine	TDK	8.45 ± 0.04^{abc}	9.10 ± 0.04^{b}	7.18 ± 0.13^{ab}	7.99 ± 0.12^{bc}
	EFK	8.05 ± 0.15^{b}	8.96 ± 0.15^{ab}	7.32 ± 0.09^{ab}	8.71 ± 0.06^{c}
Isoleucine	TDK	3.59 ± 0.08^{ab}	3.68 ± 0.06^{ab}	3.44 ± 0.045^{b}	3.45 ± 0.05^{b}
	EFK	4.09 ± 0.03^{c}	3.80 ± 0.09^{bc}	3.93 ± 0.03^{ab}	3.77 ± 0.03^{d}
Threonine	TDK	3.50 ± 0.04^{b}	3.79 ± 0.10^{c}	3.59 ± 0.019^{c}	3.62 ± 0.05^{ab}
	EFK	3.93 ± 0.05^{ab}	3.80 ± 0.02^{c}	3.59 ± 0.04^{bc}	3.67 ± 0.03^{e}
Lysine	TDK	8.61 ± 0.20^{c}	10.08 ± 0.08^{bc}	8.56 ± 0.15^{bc}	8.38 ± 0.14^{d}
	EFK	10.11 ± 0.05^{ab}	9.89 ± 0.05^{c}	8.84 ± 0.07^{a}	9.37 ± 0.06^{b}
Histidine	TDK	2.33 ± 0.05^{d}	2.84 ± 0.05^{b}	2.46 ± 0.01^{ab}	2.73 ± 0.03^{bcd}
	EFK	2.89 ± 0.04^{bc}	2.76 ± 0.07^{abc}	2.84 ± 0.04^{a}	2.73 ± 0.03^{c}
Methionine	TDK	2.23 ± 0.07^{bc}	2.61 ± 0.02^{ab}	2.47 ± 0.01^{b}	2.29 ± 0.03^{de}
	EFK	2.67 ± 0.03^{ab}	2.54 ± 0.06^{e}	2.84 ± 0.02^{a}	2.39 ± 0.03^{b}
Phenylanine	TDK	4.09 ± 0.06^{cd}	3.88 ± 0.09^{bc}	3.22 ± 0.06^{bc}	3.27 ± 0.06^{e}
	EFK	3.73 ± 0.01^{c}	3.76 ± 0.02^{bc}	3.27 ± 0.03^{bcd}	3.49 ± 0.03^{ab}

Mean ± S.E (standard errors) of each Essential Amino Acid using TDK and EFK with the same alphabet(s) in the same column are not significantly different ($p > 0.05$), TDK: Traditional Drum Kiln, EFK: Eco-Friendly Kiln

3.3 Non-Essential Amino Acids

Non-essential amino acids are produced by the human body but can also be supplied in diet. They perform a variety of functions. Arginine helps in keeping the liver, skin, joints and muscles healthy, glutamate helps in building and maintaining muscles and maintaining a healthy central nervous system and Glycine is a major component of human skin collagen binds together with alanine to form a polypeptide that promotes re-growth and tissue healing [10, 23].

This study found all known eleven non-essential amino acids namely Glycine, Alanine, Serine, Proline, Valine, Aspartate, Glutamate, Arginine, Tyrosine, Tryptophan and Cystine thus showing that the smoke-drying process was properly done and did not denature the protein in the smoke-dried fish product. The highest percentage was found to be Glutamate at 15.13 when the catfish samples were smoke-dried using EFK in dry season and stored at ambient temperature while the lowest was Cystine at 1.00 when the catfish samples were smoke-dried using TDK in wet season and stored at ambient temperature.

The amino acid profiles of the catfish samples smoke dried using both kilns showed significant difference when the smoke-drying was done in wet and dry seasons and stored at both ambient and controlled temperatures except for Glycine, Serine and Tryptophan in dry season stored at ambient temperature, Glutamate in dry season at controlled temperature and Tyrosine and Cystine in wet season at controlled temperature.

The average values of Histidine, Leucine, Arginine and Glutamate of smoke-dried fish using Eco-Friendly Kiln and stored across the weeks at ambient and controlled temperatures in wet and dry seasons were also generally higher than those in catfish samples smoke-dried using Traditional Drum Kiln. This could because the drying chamber in EFK was built separate from TDK and so assisted in better maintaining the levels of amino acids in the smoke-dried fish.

Table 2: Seasonal variations in non-essential amino acid compositions of smoke-dried *clarias gariepinus* using traditional and eco-friendly kilns and stored at ambient and refrigerated temperature

Non-Essential Amino Acids		Ambient Temperature		Controlled Temperature	
		DRY SEASON	WET SEASON	DRY SEASON	WET SEASON
Glycine	TDK	3.37 ± 0.07^{bc}	3.87 ± 0.07^{ab}	3.16 ± 0.05^{abc}	3.24 ± 0.06^{ab}
	EFK	3.33 ± 0.06^{bc}	3.67 ± 0.06^{b}	3.39 ± 0.03^{ab}	3.65 ± 0.04^{bc}
Alanine	TDK	4.45 ± 0.14^{b}	5.86 ± 0.11^{bc}	4.49 ± 0.09^{ab}	4.72 ± 0.10^{ab}
	EFK	4.48 ± 0.10^{bc}	5.83 ± 0.07^{c}	4.73 ± 0.05^{bc}	4.93 ± 0.07^{b}
Serine	TDK	3.58 ± 0.10^{a}	3.74 ± 0.07^{a}	3.43 ± 0.07^{a}	3.19 ± 0.07^{a}
	EFK	4.10 ± 0.02^{a}	3.64 ± 0.06^{bc}	3.57 ± 0.03^{bc}	3.57 ± 0.03^{c}
Proline	TDK	3.30 ± 0.05^{bc}	3.09 ± 0.03^{ab}	3.25 ± 0.04^{bc}	2.79 ± 0.03^{bc}
	EFK	3.03 ± 0.03^{a}	3.16 ± 0.04^{b}	2.98 ± 0.03^{ab}	2.82 ± 0.03^{ab}
Valine	TDK	3.95 ± 0.08^{b}	3.83 ± 0.09^{abc}	3.45 ± 0.05^{ab}	3.70 ± 0.04^{ab}
	EFK	3.91 ± 0.05^{a}	4.12 ± 0.09^{c}	3.78 ± 0.02^{bcd}	4.17 ± 0.03^{b}
Aspartate	TDK	9.16 ± 0.06^{bc}	9.68 ± 0.10^{cd}	7.58 ± 0.12^{ab}	8.75 ± 0.12^{abc}
	EFK	10.25 ± 0.09^{a}	10.47 ± 0.05^{ab}	9.39 ± 0.09^{bc}	9.36 ± 0.09^{cd}
Glutamate	TDK	13.24 ± 0.08^{b}	13.53 ± 0.15^{abc}	12.55 ± 0.08^{ab}	13.60 ± 0.06^{ab}
	EFK	15.13 ± 0.03	14.93 ± 0.10^{ab}	14.49 ± 0.05^{ab}	14.92 ± 0.04^{ab}
Arginine	TDK	5.06 ± 0.12^{ab}	5.22 ± 0.14^{a}	5.22 ± 0.04^{bc}	5.12 ± 0.06^{bc}
	EFK	6.06 ± 0.06^{a}	6.43 ± 0.04^{ab}	5.24 ± 0.06^{b}	5.91 ± 0.05^{bcd}
Tyrosine	TDK	2.59 ± 0.04^{b}	2.61 ± 0.07^{ab}	2.27 ± 0.03^{ab}	2.50 ± 0.04^{ab}
	EFK	3.07 ± 0.03^{a}	3.05 ± 0.05^{bc}	3.05 ± 0.03^{c}	2.96 ± 0.03^{ab}
Tryptophan	TDK	1.09 ± 0.03^{a}	1.07 ± 0.06^{a}	1.08 ± 0.02^{a}	1.19 ± 0.02^{a}
	EFK	1.21 ± 0.02^{a}	1.16 ± 0.04^{ab}	1.02 ± 0.02^{cd}	1.13 ± 0.02^{bc}
Cystine	TDK	1.33 ± 0.03^{c}	1.00 ± 0.09^{a}	1.14 ± 0.02^{a}	1.17 ± 0.02^{a}
	EFK	1.36 ± 0.02^{a}	1.13 ± 0.05^{bc}	1.21 ± 0.02^{b}	1.28 ± 0.02^{b}

Mean ± S.E (standard errors) of each Non-Essential Amino Acid using TDK and EFK with the same alphabet(s) in the same column are not significantly different ($p > 0.05$), TDK: Traditional Drum Kiln, EFK: Eco-Friendly Kiln.

4. Conclusion

The construction of Eco-Friendly Kiln has been able to solve some of the challenges of Traditional Drum Kiln such as direct exposure of fish and processors to smoke and subjectivity of the smoke-drying process. This study has also been able to establish that smoke-drying catfish at temperatures between 60 - 80 ^{0}C ensures that good quality smoke-dried fish is produced and that epileptic power supply reduces the quality of smoke-dried catfish.

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