THE EFFECT OF CHANGES IN TEMPERATURE ON AMINO ACIDS OF SMOKED TILAPIA (*Orechromis niloticus*) USING THE IMPROVED TRADITIONAL (STEEL DRUM) SMOKING KILN

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ABSTRACT

This study investigated the effect of changes in temperature(60 ^{0}C- 90^{0}C, 90^{0}C- 120^{0}C and 120^{0}C-150^{0}C respectively) in amino acids profile using both the traditional and improved traditional smoking kilns, the aim of the experiment was determine and compare the highest percentage occurrence between the two smoking method in relation to time of smoking (6hrs, 9hrs and 12hrs respectively) Technicon sequential Multi Amino Acid Analyzer (TSM) was the material and method used carry out this experiment, it was observed that improved traditional kilns has the highest compositions of amino acids. The improved smoking kilns were labelled, and the smoking was done for 6 hours at varying temperature by the use of a clock and thermometer. 40 pieces of fresh Oreochromis niloticus (Tilapia) was purchased from Gwagwalada market after which the fishes were transported in polythene bags to the University Research Farm at the permanent site (Along Airport Road). On getting to the farm, these fishes were washed, descaled and gutted and sun dried in order to reduce its moisture content, 12 pieces of fish was arranged in each of the three improved traditional smoking drums used (making a total of 36 pieces, the balance of the remaining 4 pieces serve as the control experiment I.e. traditional smoking kiln) . Each drum was then designated as T1, T2, T3. Drum T1, for instance contained three set of tray carrying 4 pieces of fish whereby each of the tray was marked R1, R2, R3. Furthermore, Drum T_1 was smoked for 6hours with a temperature between 60^{0C} – 90^{0C}. Drum T_2 was smoked for 6hours with a temperature between 90^{0C} – 120^{0C}. Drum T_3 was smoked for 6hours with a temperature between 120^{0C}- 150^{0C}. The smoking was done once a week for one month. The best smoking temperature using the improved traditional smoking kilns is 60-90^{0}c which has a total value of 84.54%. Followed by improved traditional kiln of 90-120^{0}c which has a total value of 80.35%. Furthermore, the improved traditional kiln with a temperature between 120-150^{0}c has a total value of 74.44% amino acids. The least total value obtained is 68.55% in traditional kiln. From the outcome of this experiment, Glutamic acid has the highest value at 60 – 90^{0C}, and Cystine has the lowest values at 120 – 150^0. Therefore it can be concluded that improved traditional smoking perform better than traditional smoking kiln. It is recommended that efforts should geared in promoting improved traditional smoking kilns especially at the rural areas

Key words: Amino acid, Improved Traditional Smoking Kiln (ITSK), *Oreochromis niloticus* and Temperature,

INTRODUCTION

Throughout history, Fish has been an important sustainer of human life, second only to cereals in that respect. It ranks first as source of complete protein, edging out meat because of the latest relative scarcity and consequent higher price (Sesugh *et al*.,2012)

The nutritive importance of fish can be categorized into two: , that is, the nutritive value of fish and its medicinal value. For its nutritive value, (Oyero 2006) and Tobor (1985) reported that fish is a source of lysine and sulphur amino acids and is therefore suitable for complementing high carbohydrate diet. In comparison, Afolabi *et al.,* (2009) stated that the mammalian protein only contains L- stereoisomer (a part of lysine) when compared to fish, and in cereals, lysine is also very poor in cereals too . Fish is a good source of

thiamine, riboflavin, vitamins A and D, phosphorus, calcium and iron It is high in polyunsaturated fatty acids (i.e. omega-3 and omega-6 Polyunsaturated Fatty Acids- PUFA), (Oyero 2006).On the medicinal value of fish, fish contain oil (PUFA)which cannot be readily synthesized by the human body, when consumed has a positive effect on cardiovascular problems by reducing the serum cholesterol thus preventing heart related diseases and cancer (Falayi and Amatosero 2014). The preservation of fish is essential to prolong the shelf – life and minimize losses from spoilage. Preservation of fishes is a very important part of commercial fisheries, (Pandey and Shukla, 2005). Currently smoking is the main method of fish preservation in the artisanal sector according to FAO (1988), smoke curing includes all the process starting from the raw material stage to the final smoking which results in changes in colour, flavor and texture of the fish. It is a method of preservation effected by combination of drying and decomposition of naturally produce chemical resulting from thermal breakdown of woods (Tobor, 2004).

Smoking activities are carried out using locally constructed ovens such as the traditional (open fire banda), improved traditional (Altona), traditional fish smoking kilns are poorly constructed and lack mechanism for the control of smoke and heat production, the improved traditional fish smoking kilns are a little bit better constructed and have mechanism for the control of smoke and heat production. Both the traditional and improved traditional smoking kilns affect the efficiency of smoking and the quality of the final product.

Tilapias is known to have around 100 species, and are of east Africa origin and spread in many parts of the world (Celikkale, 1994). Tilapias species are preferred for farming due to several reasons including the fact that they can benefit from various nutrients matters that cannot be used by other fish species, and also due to their short food chain, their adaptation ability to crowded and dense pond condition, their fertility, their resistant to parasites and diseases in general, and their delicious fish meat and their endurance against environmental effects with the exception of low temperatures (Beckcan,1999).

Protein is one of the most important components of muscle tissue that is the edible part of animals in terms of nutrition. Muscle tissue of fishes contains 11-24% of crude protein in general (Shorskize, et *al*., 1990) total amount and quality of protein are very similar in fishes farmed or caught from nature(Nettleton 1990).furthermore, protein content is reported to change seasonally in some species (Hirano,1980) as known, Amino acids are the building structures of proteins. Food and tissue proteins contain 20 different amino acids which have dietary importance. Among them, Threonine, Valine, Methionine, Isoleucine, Phenylalanine, Lysine, and Histidine cannot be synthesized by humans. These amino acids have to be taken with foods. However, these amino acids are as important as essential amino acids for normal cells and organs to function properly (Kucukgulmez, *et al.,* 2008). Other amino acids including aspartic acid, Arginine, Serine, Glutamic acid, Glycine, Alanine, Tyrosine, Proline, Taurine, etc are taken with daily diet and can be synthesized by body. Proteins accounting for 65-70% of total dry body weight in fishes have high nutritional value due to their essential amino acid contents (Wilson, 1989) many amino acids in body are in the form of protein components. It is very useful to know amino acid compositions of smoked fish for many reasons. In addition to determination of nutritional value, aromatics properties of fish are partly depended on the amino acid distribution (Hall, 1992).

According to Ahmed *et al*.,(2009). Amino acids are a type of organic acid that contain both a carboxyl group (COOH) and an amino group (NH_2). Although the neutrally-charged structure is commonly written, it is inaccurate because the acidic COOH and basic NH_2 groups react with one another to form an internal salt called a zwitterion. The zwitterion has no net charge; there is one negative (COO^-) and one positive (NH_3^+) charge.

MATERIALAND METHODS

The Study Area

The study was conducted in the University of Abuja Training and Research Farm. Gwagwalada. Gwagwalada is one of the six area councils of the Federal Capital Territory of Nigeria, it is located 55km from Abuja city. It lies at latitude (85.5^0 N) and longitude (90^0 E), It's land mass is $655km^2$ with a maximum temperature between 30 – 37^{0C} and the rainfall ranges between 1100 – 1650mm (Abuja Area Council Information Office, (GAIO, 2011).

Materials

The materials used include the following items;

- 3 Improved traditional smoking kilns,1 traditional smoking kiln,60 pieces of fire wood,40 pieces of *Oreochromis niloticus* was purchased from Gwagwalada market,Thermometer.

Procedures for carrying out the experiment

The improved smoking kilns were labelled, and the smoking was done for 6 hours at varying temperature by the use of a clock and thermometer. 40 pieces of fresh *Oreochromis niloticus* (Tilapia) was purchased from Gwagwalada market after which the fishes were transported in polythene bags to the University Research Farm at the permanent site (Along Airport Road). On getting to the farm, these fishes were washed, descaled and gutted and sun dried in order to reduce its moisture content, 12 pieces of fish was arranged in each of the three improved traditional smoking drums used (making a total of 36 pieces, the balance of the remaining 4 pieces serve as the control experiment I.e. traditional smoking kiln) . Each drum was then designated as T1, T2, T3. Drum T1,for instance contained three set of tray carrying 4 pieces of fish whereby each of the tray was marked R1, R2, R3.

Furthermore, Drum T_1 was smoked for 6hours with a temperature between 60^{0C} – 90^{0C}. Drum T_2 was smoked for 6hours with a temperature between 90^{0C} – 120^{0C}. Drum T_3 was smoked for 6hours with a temperature between 120^{0C}- 150^{0C}. The smoking was done once a week for one month.

Statistical Analysis

Experimental Design used – Completely Randomized Design (CRD)

The statistical analysis used is SPSS version 16 (2007) by one way analysis of variance. And DMRT (Duncan's Multiple Range Test) was used to separate the means.

Determination of Amino Acid Profile

The Amino Acid profile in the known sample was determined using methods described by Benitez (1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon sequential Multi-Sample Amino Acid Analyzer (TSM).

De-fatting Sample

The sample was defatted using chloroform/methanol mixture of ratio 2:1. About 4g of the sample was put in extraction thimble and extracted for 15 hours in soxhlet extraction apparatus (AOAC, 2006).

Nitrogen Determination

A small amount (200mg) of ground sample was weighed, wrapped in whatman filter paper (No.1) and put in the Kjeldhal digestion flask. Concentrated sulphuric acid (10ml) was added. Catalyst mixture (0.5g) containing sodium sulphate (Na_2SO_4), copper sulphate ($CuSO_4$) and selenium oxide (SeO_2) in the ratio of 10:5:1 was added into the flask to facilitate digestion. Four pieces of anti-bumping granules were added.

The flask was then put in Kjeldhal digestion apparatus for 3 hours until the liquid turned light green. The digested sample was cooled and diluted with distilled water to 100ml in standard volumetric flask. Aliquot (10m1) of the diluted solution with 10ml of 45% sodium hydroxide was put into the Markham distillation apparatus and distilled into 10ml of 2% boric acid containing 4 drops of bromocresol green/methyl red indicator until about 70ml of distillate was collected. The distillate was then titrated with standardize 0.01 N hydrochloric acid to grey coloured.

$$\textit{Percentage Nitrogen} \quad \frac{(a-b)\ x\ 0.01\ x\ 14\ x\ V\ x\ 100}{W\ x\ C}$$

Where:

a = Titre value of the digested sample
b = Titre value of blank sample
v = Volume after dilution (100ml)
w = Weight of dried sample (mg)
c = Aliquot of the sample used (10ml)
14 = Nitrogen constant in mg.

Hydrolysis of the Sample

A known weight of the deffated sample was weighed into glass ampoule. 7ml of 6NHCL was added and oxygen was expelled by passing nitrogen into the ampoule (This is to avoid possible oxidation of some amino acids during hydrolysis. e.g Methionine and Cystine). The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at $105^0C \pm 5^0C$ for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humus. It should be noted that tryptophan is destroyed by 6N HCL during hydrolysis.

The filtrate was then evaporated to dryness at 40^0C under vacuum in a rotary evaporator. The residue was dissolved with 5ml to acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer.

Loading of the hydrolysate into TSM analyzer

The amount loaded was between 5 to 10 microlitre. This was dispended into the cartridge of the analyzer. The TSM analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydrolysate. The period of an Analysis lasted for 76 minutes.

Method of calculating amino acid values from the chromatogram peaks

An integrator attached to the Analyzer calculates the peak area proportional to the concentration of each of the amino acids. Alternatively, the net height of each peak produced by the chart recorder of TSM (each representing and Amino) was measured. The half-height of the peak on the chart was found and width of the peak on the half height was accurately measured and recorded. Approximately area of each peak was then obtained by multiplying the height with the width at half-height.

The norcleucine equivalent (NE) for each amino acid in the standard mixture was calculated using the formula.

$$NE = \frac{Area\ of\ Norceucine\ Peak}{Area\ of\ each\ amino\ acid}$$

A constant S was calculated for each amino acid in the standard mixture:

Where,

$S_{std} = NE_{std}$ x Molecular weight x μMAA_{std}

Finally, the amount of each amino acid present in the sample was calculated in g/16gN or g/100g protein using the following formula:

Concentration (g/100g protein) = NH x W@NH/2 x S_{std} x C

Where $C = \frac{\text{Dilution x 16} \div \text{NH x W (nleu)}}{\text{Sample Wt (g) x N\% x 10 x Vol. loaded.}}$

Where: NH = Net height

W = Width @ half height

nleu = Norleucine

RESULTS

Table 1: Amino acid content of *O.niloticus* smoked using the traditionalsmoking kiln Amino acids g/100g protein

Types of Smoking kiln: Traditional kiln **Time of smoking: 6 hours**		
Amino acids	**MEAN**	**SEM**
Lysine	4.71^{c}	0.25
Histidine	1.92^{a}	0.25
Arginine	5.31^{a}	0.25
Aspartic acid	7.50^{b}	0.27
Threonine	2.89^{b}	0.26
Serine	2.97^{a}	0.25
Glutamine acid	9.60^{c}	0.26
Proline	3.77^{a}	0.25
Glycine	3.93^{c}	0.28
Alanine	3.81^{c}	0.26
Cystine	0.77^{bc}	0.03
Valine	3.51^{a}	0.26
Methionine	2.11^{a}	0.03
Isoleucine	2.93^{d}	0.03
Leucine	6.35^{a}	0.46
Tyrosine	2.84^{a}	0.25
Phenylalanine	3.63^{a}	0.26
TOTAL A.A	68.55	± 3.90

Table 1. Show the Amino acid of traditional smoking kiln. There are seventeen (17) amino acid analysed with values ranging from the least value for cystine with value of 0.07to the highest value for Glutamic acid with a value of 9.60 and a total of 68.55 ± 3.90 values of amino acid.

Table.2: Amino acid content of *O.niloticus* smoked using traditional improved smoking kiln.

Amino acids g/100g protein

Types of Smoking kiln: Improved kiln **Time of smoking: 6 hours**			
Temperature	60 – 90^{0C}	90 – 120^{0C}	120 – 150^{0C}
Amino Acids	SEM	SEM	SEM
Lysine	6.96^{a}	6.25^{ab}	5.48^{bc}
	0.26	0.33	0.25
Histidine	2.59^{a}	2.27^{a}	2.00
	0.25	0.27	0.25
Arginine	5.57^{a}	5.79^{a}	5.77^{a}
	0.25	0.37	0.26
Aspartic acid	9.24^{a}	9.05^{a}	9.08^{a}
	0.26	0.25	0.39
Threonine	3.75^{a}	3.69^{ab}	3.40^{ab}
	0.25	0.25	0.26
Serine	3.52^{a}	3.41^{a}	3.13^{a}
	0.26	0.25	0.26
Glutamine acid	12.93^{a}	12.47^{a}	11.55^{b}
	0.28	0.26	0.28
Proline	3.31^{ab}	3.10^{ab}	2.87^{b}
	0.28	0.25	0.25
Glycine	6.35^{a}	5.94^{a}	5.04^{b}
	0.27	0.26	0.28
Alanine	5.63^{a}	5.18^{ab}	4.37^{bc}
	0.26	0.29	0.28
Cystine	0.95^{a}	0.85^{b}	0.74^{c}
	0.03	0.04	0.03
Valine	3.78^{a}	3.68^{a}	3.38^{a}
	0.26	0.25	0.28
Methionine	2.09^{a}	2.03^{a}	2.04^{a}
	0.04	0.03	0.07
Isoleucine	3.81^{a}	3.56^{b}	3.17^{b}
	0.07	0.04	0.04
Leucine	7.15^{a}	6.58^{a}	6.21^{a}
	0.21	0.33	0.31
Tyrosine	2.92^{a}	2.68^{a}	2.52^{a}
	0.28	0.25	0.48
Phenylalanine	4.03^{a}	3.86^{a}	3.69^{a}
	0.32	0.25	0.26
TOTAL A.A	**84.54 ± 3.83**	**80.55 ± 3.99**	**74.44 ± 4.23**

Mean values on the row having different super scripts are significantly different (P<0.05).

Table 2: Show the values of the improved traditional kiln at different temperature and the jour of smoking. The different temperatures are 60 – 90^{0c}, 90 – 120^{0c}, and 120 – 150^{0c}. The smoking temperature of 60 – 90^{0c} has the highest total value of amino acids which is 84.54 ± 3.83 and the least total value of amino acids is gotten in a smoking temperature of 120 – 150^{0c} which is 74.44 ± 4.23.

Table 3: The Amino acid content of *O.niloticus* smoked using both the traditional and improved smoking kilns

Amino acids g/100g protein

	Types of Smoking kiln:	**Traditional kiln**	**Improved kiln**	**Improved kiln**	**Improved kiln**
	Time of smoking: Temp.	**6 hours 60-90^{0}C**	**6 hours 60-90^{0}C**	**6 hours 90-120^{0}C**	**6 hours 120-150^{0}C**
Amino acids		**SEM**			**SEM**
Lysine		4.71^{c} 0.25	6.96^{a} 0.26	6.25^{ab} 0.33	5.48^{bc} 0.25
Histidine		1.92^{a} 0.25	2.59^{a} 0.25	2.27a 0.27	2.00^{a} 0.25
Arginine		5.31^{a} 0.25	5.57^{a} 0.25	5.79^{a} 0.27	5.77^{a} 0.26
Aspartic acid		7.50b 0.27	9.24^{a} 0.26	9.05^{a} 0.37	9.08^{a} 0.39
Threonine		2.89^{b} 0.26	3.75^{a} 0.25	3.69^{ab} 0.25	3.40^{ab} 0.26
Serine		2.97^{a} 0.25	3.52^{a} 0.26	3.41^{a} 0.25	3.13^{a} 0.26
Glutamine acid		9.60^{c} 0.26	12.93^{c} 0.28	12.47^{a} 0.26	11.55^{b} 0.28
Proline		3.77^{a} 0.25	3.31^{ab} 0.28	3.10^{ab} 0.25	2.87^{b} 0.25
Glycine		3.93^{c} 0.28	6.35^{a} 0.27	5.94^{a} 0.26	5.04^{b} 0.28
Alanine		3.81^{c} 0.26	5.63^{a} 0.26	5.18^{ab} 0.29	4.37^{bc} 0.28
Cystine		0.77^{bc} 0.03	0.95^{a} 0.03	0.85^{b} 0.04	0.74^{c} 0.03
Valine		3.51^{a} 0.26	3.78^{a} 0.26	3.68^{a} 0.25	3.38^{a} 0.28
Methionine		2.11^{a} 0.03	2.09^{a} 0.04	2.03^{a} 0.03	2.04^{a} 0.07
Isoleucine		2.93^{d} 0.03	3.81^{a} 0.07	3.56^{b} 0.04	3.17^{b} 0.04
Leucine		6.35^{a} 0.46	7.15^{a} 0.21	6.58^{a} 0.33	6.21^{a} 0.31
Tyrosine		2.84^{a} 0.25	2.92^{a} 0.28	2.68^{a} 0.25	2.52^{a} 0.48
Phenylalanine		3.63^{a} 0.26	4.03^{a} 0.32	3.86^{a} 0.25	3.69^{a} 0.26
TOTAL A.A		68.55 ±3.9	84.54 ±3.8	80.55 ±3.9	74.44 ±4.23

Mean values on the row having different super scripts are significantly different (P<0.05).

In terms of lysine improved Kilns has the highest values of 6.96 at smoking temperature of 60-90 which is higher compared to improved Kiln of temperature between 90-120c that has a value of 6.25 and lower at 5.48 of improved Kiln of temperature between 120-150c^0, the traditional Kiln has the least value of amino acids at 4.71, while Histidine, has the highest value obtained for improved Kiln at temperature of 60-90c^0 with the highest value of 2.59 in terms of amino acid analysis which is followed by improved Kiln of temperature between 90-120c^0 at a value of 2.27 followed by improved. Kiln of 120-150c^0 with a value of 2.00, and the least at traditional kiln which has a value of 1.92, which means all the values are significantly different (P< 0.05). Arginine has the highest value of 5.79 at improved kiln temperature of 90-120c^0 followed by improved Kiln of temperature of 120-150^{0C} with a value of 5.77 and is comparable to the value obtained at improved Kiln of 60-90c^0 which has a value of 5.57 and the lower value obtained at traditional kiln with a value of 5.31, which means that improved kiln of temperature between 90-120c^0 has the best value of Arginine in terms of amino acid contents. Aspartic acid, for the improved kiln of temperature between 60-90c^0 has the highest value of 9.24 followed by improved kiln of temperature 120-150^0 with a value of 9.08 followed by improved kiln of temperature between 90-120c^0 with a value of 9.05 which means that values obtained at improved kiln of temperature between 90-120c^0 is comparable to the value obtained at improved kiln of 120-150c^0, the least value obtained is at traditional kiln with a value of 7.50. Threonine, has the highest value of amino acid analysis obtained at improved kiln of 60-90c^0 with a value of 3.75, an improved kiln obtained at a temperature of 120-15c^0 has the lowest value of 3.40, but the least value obtained at traditional kiln of 2.89. Serine, obtained at improved kiln of temperature 60-90c^0 has the highest value of 3.52 which is comparable to improved kiln of between 90-120c^0 with a value of 3.41, and the lowest obtained at traditional kiln of 2.97.

Glutamic acid, in terms of amino acid analysis when using both the traditional and improved kilns, Glutamic acid has highest values. Improved kiln of temperature between 60-90c^0 has the highest value of 12.93 followed by improved kiln of temperature between 90-120c^0 with a value of 12.47 and lower at improved kiln of temperature between 120-150c^0 with a value of 11.55 and the least value is obtained at traditional kiln with a value of 9.60. Proline, the traditional kiln has the highest value of 3.77 and the value obtained at improved kiln of temperature between 60-90c^0 is comparable to the value obtained at improved kiln of between 90-12c^0. The least value is obtained at improved kiln of temperature between 120-150 with a valu of 2.87. Glycine, the im[proved kiln of between 60-90^{0}c has the highest value of 6.35 which is a little bit comparable to the value obtained at improved kiln of between 90-120^{0}C with a value of 5.94, and the least value is obtained on traditional kiln with a value 3.93. Alamine, Improved kiln between 60-90^{0}c has the highest value of 5.63 followed by improved kiln of 90-120^{0}c with a value of 5.18, and the least value is obtained at traditional kiln with a value of 3.81.

Cystine, has the lowest value in terms of amino acid analysis using both Traditional and improved Traditional smoking kiln. Improved kiln of 60-9^{0}c has the highest value of 0.95 and the least value obtained at improved kiln at 120-150^{0}c with a value of 0.74. Valine, improved kiln of 90-120^{0}c has the highest value of 3.68, which is comparable to the value obtained at improved kiln of 60-90^{0}c with a value of 3.74 and the lowest value obtained at 120-150^{0}c with a value of 3.38. In terms of Methionine, the traditional kiln has the highest value of 2.11, which is comparable to improved kiln of 60-90^{0}c with a value of (2.09), and the lowest value obtained at improved kiln of 90-120^{0}c with a value of (2.03). Isoleucine, the improved kiln of 60-90^{0}c has the highest value of 3.81, which is comparable to the value obtained at 90-120^{0}c with a value of 3.56 and the least value obtained at traditional kiln of 2.93. Lecine, the improved kiln of to 60-90^{0}c has the highest value of 7.15 which is comparable to improved kiln of 90-120^{0}c with a value of 6.54 and the least value is obtained at improved kiln of 120-150^{90}c with a value of 6.21.

Tyrosine, the improved kiln of 60-90^{0}c has the highest value of (2.92) followed by the traditional kiln with a value of 2.84, and the least value is obtained at improved kiln of 120-150^{0}c with a value of 2.52. Phenylalanine, improved kiln of temperature between 60-90^{0}c has the highest value of 4.03 followed by improved kiln of 90-120^{0}c with a value of 3.86 which is comparable of 90-120^{0}c with a value of 3.69, and the least value is obtained at traditional kiln with a value of 3.63 which means that all the value are significantly different.

Table 4: Essential amino acids content of *O.niloticus* smoked using both the traditional and improved smoking kilns

Amino acids g/100g of protein

	Types of Smoking kiln:	**Traditional kiln**	**Improved kiln**	**Improved kiln**	**Improved kiln**
	Time of smoking:	**6 hours**	**6 hours**	**6 hours**	**6 hours**
	Temperature:	**60-90^{0}C**	**60 – 90^{0C}**	**90 – 120^{0C}**	**120 –150^{0C}**
Amino acids					
Lysine		4.71^{c}	6.96^{a}	6.25^{ab}	5.48^{bc}
		0.25	0.26	0.33	0.25
Methionine		2.11^{a}	2.09^{a}	2.03^{a}	2.04^{a}
		0.03	0.04	0.33	0.07
Threonine		2.89^{b}	3.75^{a}	3.69^{ab}	3.40^{ab}
		0.26	0.25	0.25	0.26
Tryptophan		ND	ND	ND	ND
Arginine		5.31^{a}	5.57^{a}	5.79^{a}	5.77^{a}
		0.25	0.25	0.27	0.26
Phenylalanine		3.63^{a}	4.03^{a}	3.86^{a}	3.69^{a}
		0.26	0.32	0.25	0.26
Histidine		1.92^{a}	2.59^{a}	2.27^{a}	2.00^{a}
		0.25	0.25	0.27	0.25
Isoleucine		2.93^{d}	3.81^{a}	3.56^{b}	3.17^{b}
		0.03	0.07	0.04	0.04
Leucine		6.35^{a}	7.15^{a}	6.58^{a}	6.21^{a}
		0.46	0.21	0.33	0.31
Valine		3.51^{a}	3.78^{a}	3.68^{a}	3.38^{a}
		0.26	0.26	0.25	0.28
TOTAL EAA		**33.36**	**39.69**	**37.67**	**35.14**
		±2.05	**±1.91 ±**	**±2.05**	**±1.98**

Mean values on the row having different super scripts are significantly different (P<0.05).

EAA: Essential Amino Acids

ND: Not Detected

Table 4 shows the values of essential amino acids content of *O.niloticus* smoked using both the traditional and improved traditional smoking kiln. Ten (10) essential amino acid were analyzed but tryptohan is not detected. The amino acid with the least value is histidine with a value of 1.92 and the one with the highest value is leucine with a value of 7.15 at a smoking temperature of 60 – 90^{0C}. The highest total value of essential amino acids is obtained at a smoking temperature of 60 – 90^{0C} with a value of 39.69 ± 1.91.

Table 5: Non-essential amino acids content of *O.niloticus* smoked using both the traditional and improved smoking kilns

	Amino acids g/100g protein			
	Types of Smoking kiln:	**Traditional kiln**	**Improved kiln**	**Improved kiln**	**Improved kiln**
	Time of smoking:	**6 hours**	**6 hours**	**6 hours**	**6 hours**
	Temperature:	**60-90^{0}C**	**60 – 90^{0C}**	**90 – 120^{0C}**	**120 –150^{0C}**
Amino acids					
Alanine		3.81^{c}	5.63^{a}	5.18^{ab}	4.37^{bc}
		0.26	0.26	0.29	0.28
Aspartic		7.50^{b}	9.24^{a}	9.05^{a}	9.08^{a}
acid		0.27	0.26	0.37	0.39
Cystine		0.77^{bc}	0.95^{a}	0.85^{b}	0.74^{c}
		0.03	0.03	0.04	0.03
Glycine		3.93c	6.35^{a}	5.94^{a} 0.26	5.04^{b}
		0.28	0.27		0.28
Glutamine		9.60^{c}	12.93^{a}	12.47^{a} 0.26	11.55^{b}
acid		0.26	0.28		0.28
Proline		3.77^{a}	3.31^{ab}	3.10^{ab}	2.87^{b}
		0.25	0.28	0.25	0.25
Serine		2.97^{a}	3.52^{a}	3.41^{a}	3.13^{a}
		0.25	0.26	0.25	0.26
Tyrosine		2.84^{a}	2.92^{a}	2.68^{a}	2.52^{a}
		0.25	0.28	0.25	0.48
TOTAL NEAA		**35.19**	**±44.85**	**± 42.68**	**39.30**
		1.85	**1.92**	**±1.97**	**±2.25**

Mean values on the row having different super scripts are significantly different (P<0.05).
NEAA: Non Essential Amino Acid

Table 5 shows the value of non-essential amino acids content of *O.niloticus* smoked using both the traditional and improved traditional smoking kilns. The least value of amino acid is obtained on Cystine with 0.74 and the highest is obtained on Glutamic acid with a value of 12.93 at a smoking temperature of 60 – 90^{0C}. The highest total value of non- essential amino acid is obtained at a smoking temperature of 60 – 90^{0C} with a value of 44.85 ± 1.92.

DISCUSSION

The result of this experiment revealed close values with the work of Tosbozan *et al.,* (2013). Also, the values for Histidine, Arginine, Serine, Proline, Valine, and Isoleucine disagree with the findings of Oyero (2006), but the values of Lysine, Aspartic acid, Threonine, Glutamic acid, Glycine, Alaninie, Cystine, Methionine, and Leucine are comparable with the findings of Oyero (2006).

Analysis of amino acids using both the traditional and improved traditional smoking kilns, it was observed that improved traditional kilns has the highest compositions of amino acids. The best smoking temperature using the improved traditional smoking kilns is 60-90^{0}c which has a total value of 84.54. Followed by improved traditional kiln of 90-120^{0}c which has a total value of 80.35. Furthermore, the improved traditional kiln with a temperature

between 120-150^{0}c has a total value of 74.44 amino acids. The least total value obtained is 68.55 in traditional kiln. From the outcome of this experiment, Glutamic acid has the highest value at 60 – 90^{0C}, and Cystine has the lowest values at 120 – 150^{0C}.

Fish protein contains all the essential amino acids. Although, essential amino acids (Leucine, Isoleucine, Lysine, Valine, Methonine, Phenylaline, Threonine and Tryptophane) are very essential and have many important functions in human body, food sources with these amino acids increase the essential protein quality of diets because these molecules cannot be synthesized in the body (Brown , 2000). One of the most important reasons why aqua-products are biologically important food sources is the essential amino acids they contain.

Plant protein sources contain very limited amount of essential amino acids like lysine and methiomine; therefore, animal proteins are essential for a healthy nutrition (Turanc *et al*, 2006).

CONCLUSION

The study showed there was significant different between Tilapia fish smoked with Traditional and Improved Traditional smoking Kilns. There was however, reduction in amino acid levels after smoking indicating that the amino acid levels of food in terms of amino acids analysis in Tilapia fish smoked with improved traditional smoking kilns was found to be efficient when compared to the traditional smoking kilns which reduces the availability of amino acids. Therefore, Tilapia fish smoked with improved Traditional kiln is found to be better than the Traditional smoking kiln.

RECOMMENDATION

The result from this experiment have shown better amino acid performance for improved traditional kiln than the popular traditional kiln, therefore massive awareness should be carried out to encourage the use of improved traditional smoking kilns and the smoking temperature between 60 – 90^{0C} to maintain a balance in amino acids profile.

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