NIGERIAN JOURNAL OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY (NJAAT)

Volume 2
Number 2, 2022

Website: www.niae.net.ng; Email: njatat@yahoo.com
ISSN(Online): 2736-0903; ISSN(Print): 2811-0905

A Publication of the Nigerian Institute of Agricultural Engineers Technology
Adamu Fika Secretariat Complex, Ilorin, Nigeria.

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Nigerian Journal of Agriculture and Agricultural Technology (NJAAT)
Volume 2, Number 2, December, 2022
ISSN (Print): 2811-1885; ISSN (Online): 2811-1893

PHYSICAL, CHEMICAL, AND MICROBIOLOGICAL PROPERTIES OF TILAPIA FISH AS AFFECTED BY CHARCOAL, ELECTRIC GRILLER, AND FIREWOOD HEAT SOURCES

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ABSTRACT
The influence of three heat sources on the physicochemical composition and meat quality of Tilapia (*Oreochromis niloticus*) was investigated. The fish farm produced twelve Oreochromis niloticus weighing an average of 65825 grams each. The fish were gutted and washed with distilled water to eliminate filth and blood; the dressed weights were then smoked. Smoking was accomplished using charcoal, wood, and an electric grill. Study examined the product's production, pH, water-holding capacity (WHC), and oxidative rancidity. A sensory analysis and microbiological count were conducted in accordance with standard procedures. The data were analyzed using 0.05-level one-way ANOVA and graph pad prism. Compared to firewood and electricity, cooking Tilapia with charcoal yielded the highest output. Tilapia prepared over a firewood heat source had a pH of 6.62, whereas those prepared over an electric heat source had a pH of 6.56. At 54.44 percent, the Tilapia using an electric heat source had the highest Water holding capacity (WHC). There was a statistically significant difference (P0.05) in the Oxidative Rancidity, with the electric heat source Tilapia fish having the highest level at 0.31 mg/g. In terms of appearance, electric heat source Tilapia fish was preferred to firewood and charcoal heat source Tilapia fish; nevertheless, it was inferior in terms of taste, tenderness, texture, and salinity. Firewood-heated Tilapia fish had the best texture, but the worst flavor. This study found that electric heat sources for smoking Tilapia fish might be used without impacting nutritional content or consumer acceptability.

Keywords: Tilapia fish, Charcoal, Electric griller, Firewood, Heat sources.

INTRODUCTION
Fish is one of the most accessible sources of animal protein in the tropics, and it is widely recognized as a source of high-quality protein and other critical components for body maintenance. Fish is used as an excellent food therapy tool and source of therapeutic elements to treat cardiovascular illnesses, autoimmune diseases, anemia, and protein-energy shortage (Glomset, 1986; WHO, 2017). However, fish is a highly perishable commodity that quickly degrades after being harvested. When a food spoils, its odor/flavor, texture, and Ilusota Happiness Imhamuhi, Nou193135030 Various preservation techniques, including smoking, drying, freezing, salting, and modified atmospheric storage, can be used to prevent the microbiological deterioration of fish (Awan and Okaka, 1985; Gupta and Gupta, 2006). Tilapia (*Oreochromis niloticus*) is a group of fish species that are native to Africa; however, they have been introduced in numerous other nations. They are disease-resistant, easily reproducible, omnivorous, and tolerant of poor water quality and low dissolved oxygen levels. Most will grow in brackish water, while a few will adapt to seawater (Ogbonnaya, 2009). These traits

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make Tilapia well-adapted to the climatic conditions of Africa and the majority of developing nations. However, fish is extremely perishable due to the favorable environment it provides for the growth of bacteria after harvest (Idah and Nwankwo, 2014).

In worldwide markets, including Nigeria. Twenty-five to thirty percent of the world's fish catch is consumed in dried, salted, smoked, or a combination of these forms (Aliya *et al*., 2012). It has been found that different processing and drying procedures have varying effects on the nutritional contents of fish, despite the fact that some of these preservation processes are essential (Oparaku and Mgbenka, 2012). Drying and smoking rank top among the traditional techniques used to preserve fish, with the primary goal of preventing deterioration and ensuring availability. Antioxidant and antibacterial capabilities of phenolic compounds in smoke, as well as the elimination of moisture by drying, contribute to the preservation effect of the two procedures. The processes may affect the chemical, physical, and sensory characteristics of the fish (Kjallstrand and Petersson, 2001). In the traditional method of smoking fish to preserve it, the concentration of phenolic chemicals in the finished product varies on the type of wood employed (Seron *et al.*, 2004). The mode of smoke generation and the smoking procedure can have a significant impact on the sensory qualities of smoked fish items.

Smoking is the technique of flavoring, frying, or preserving food by exposing it to smoke from a burning or smoldering substance, typically wood. Smoking has been utilized for generations to preserve food (Rahman, 2007; Petridis *et al*., 2012; Huong, 2014). Smoking imparts a unique color and flavor to fish and extends its shelf life through the dehydrating, antimicrobial, and antioxidant properties of the smoke components (Pagu *et al.*, 2013). Moreover, smoking alters the texture of a product (Sigurgisladottir *et al.*, 2001). The main objective of this study is to determine the effect of heat sources on the physicochemical, microbiological, and sensory assessment of smoked tilapia fish, taking into consideration the significance of smoked fish products in the culinary practices of customers.

MATERIALS AND METHODS

Experimental Site

This experiment was conducted in the Post-Graduate Laboratory, Department of Chemistry, Faculty of Natural Science and Pharmacy Microbiological Laboratory, Faculty of Pharmaceutical Science, University of Jos, Plateau State, Nigeria. On latitude 9.9181ºN and longitude 8.8804ºE

Methodology

A total of fifteen *Oreochromis niloticus* with mean weight 658±25g were caught from the fish farm. The live weights were taken using digital weighing balance. After gutting and carefully washing the fish with water to remove slime and blood, the dressed weights were recorded. Before smoking, the fish were placed in a basket for proper water drainage. In addition, they were covered with muslin cloth to prevent dust and insects.

Smoking Procedure

In order to ensure homogeneous smoking, one hour was spent using charcoal, firewood, and an electric griller. The fish was wrapped in carton to maintain heat from the smoke and prevent dust and flies from contaminating it. After hot smoking, the smoked items were taken from the kiln and cooled to room temperature before being weighed to estimate the moisture loss.

Smoking process

In order to ensure homogeneous smoking, one hour was spent using charcoal, firewood, and an electric griller. The fish was wrapped in carton to maintain heat from the smoke and

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prevent dust and flies from contaminating it. After hot smoking, the smoked items were taken from the kiln and cooled to room temperature before being weighed to estimate the moisture loss.

Heat sources

The heat sources used for this study are:

1. Charcoal
2. Electric griller
3. Firewood

Fish Quality

Products yield

The weight of fish was recorded before and after cooking and the yield was expressed as percentage

$$\text{product yield} = \frac{\text{weight of cooked fish}}{\text{Weight of raw fish}} \times 100$$

pH

The pH value of raw and cooked meat samples was evaluated by blending 10 grams of sample with 90 milliliters of distilled water until a smooth slurry forms. Before inserting the pH meter into the prepared slurry, the digital pH meter was placed in a buffer solution for two minutes to allow equilibrium. Using the AOAC (2000) described approach, the pH value was determined by averaging three measurements.

Water Holding Capacity (WHC)

According to Wardlaw *et al.* (1973), water Holding Capacity (WHC) was measured 20 grams of minced meat were inserted in a centrifuge tube holding 30 milliliters of 0.6M NaCl and agitated with a glass rod for one minute. The tube was then maintained at 4 1 °C for 15 minutes before being agitated once more and centrifuged at 3000g (R-24, Remi Instruments, India) for 25 minutes. The supernatant was tested, and the WHC concentration was expressed as a percentage.

Oxidative Rancidity

Thiobarbituric acid value (TBA) was estimated using modified Buege and Aust techniques (1978). Three milliliters of glacial acid and one milliliter of a 1 percent TBA solution were put to test tubes labeled as blank and tests. For the blank, 0.6ml of distilled water was supplied, while 0.6ml of the homogenized sample was added to each test tube. These were well combined, incubated for 15 minutes in a boiling water bath, allowed to cool, centrifuged, and their supernatants were collected. The blank's supernatant was used to zero the spectrophotometer (preset at 532nm) prior to measuring the absorbance of the test solutions' supernatant. The amount of TBARS was expressed as milligrams of malondialdehyde per gram of sample.

$$\text{TBA} = \frac{\text{O.D} \times \text{V} \times 1000}{\text{A} \times \text{v} \times \text{I} \times \text{Y}}$$

where;

O.D = Absorbance of test at 532nm.

V = Total volume of the reaction mixture = 6.6mL

A = Molar extinction coefficient of the product, and according Buege and Aust (1978) is equal to 1.56x105

I = Length of light path =1cm.

Y = mg of tissue in the volume of the sample used.

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V = volume of tissue extract used =0.6ml

Sensory evaluation

Twenty (20) semi-trained individuals between the ages of 20 and 40 were used to evaluate two replicates of the prepared sausage. On a nine-point hedonic scale, the samples were rated for color, scent, flavor, tenderness, texture, saltiness, and overall acceptability. The maximum score on the scale was 9, while the lowest possible score was 1 for the worst condition (Mahendraker et al., 1988).

Microbial Analysis

The pour plate water method was used for microbial counting (Harrigan and Macanee, 1976). 1 ml of the 10-3 dilution was measured using a sterile pipette and then pipetted onto sterile Petri dishes, into which 45 °C nutritional agar was placed. It was gently stirred to ensure uniform distribution. At 37 °C, the plate was inverted and incubated in an incubator. After 24 hours, a complete plate count was performed.

Statistical Analysis

The data collected were statistically evaluated using one-way ANOVA and multiple t-tests in graph pad prism version 8, and the findings were expressed as the mean standard deviation. A confidence interval of 95 percent was utilized to determine the statistical difference between the control and treated groups and between groups.

RESULTS AND DISCUSSION

Product Yield of Tilapia Fish Heated with three Heat Sources

Figure 1 depicts the yield of smoked tilapia using three distinct heat sources. The product yield of Tilapia fish varied significantly. Charcoal-heated tilapia fish had the maximum output, while electric-heated tilapia fish produced the lowest yield. The Tilapia fish with the charcoal heat source had the maximum product output at 65.18 percent, whereas the Tilapia fish with the electric heat source had the lowest product yield at 59.08 percent. The higher product yield in the charcoal-heated Tilapia fish used in this investigation may have been the result of a lower ultimate cooking temperature. Bochi *et al.* (2008) tested catfish burger and observed product yield values between 58 to 65%, but Berry (1992) stated that burgers cooked to higher internal temperatures around 80 °C had a lower product yield.

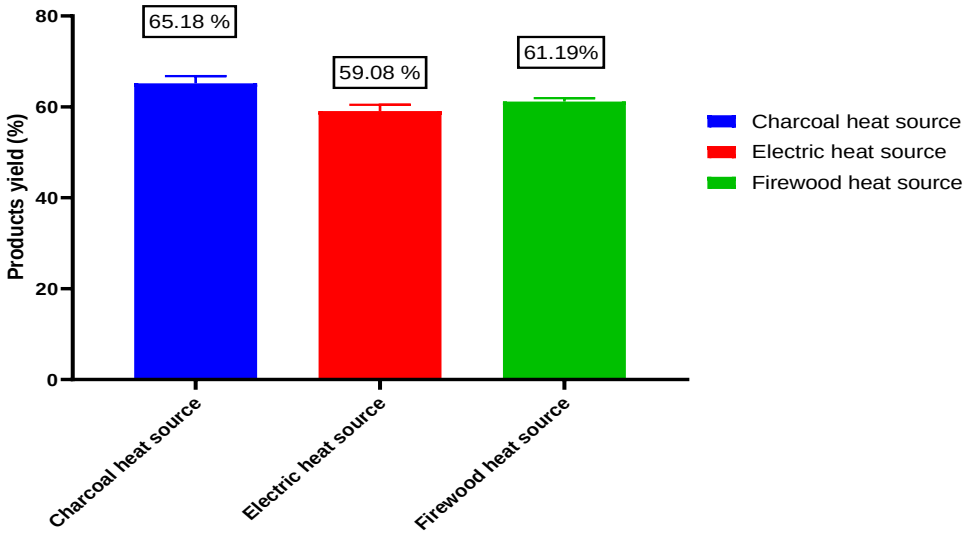


Figure 1: ***Effect of heat sources on product yield of roasted Tilapia fish***

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Effect of Heat Sources on pH Value of Roasted Tilapia Fish

The influence of heat sources on pH value is depicted in Figure 2. Tilapia Fish roasted using hardwood had the highest pH with a value of 6.62, followed by charcoal and electric heat sources with pH values of 6.57 and 6.56, respectively. In this study, a statistically significant difference (P 0.05) was discovered between the pH values of Tilapia fish treated with three different heat sources. Tilapia fish with an electric heat source had the lowest pH (P0.05). Chun *et al*. (2013) came to comparable conclusions (2013). Who observed the effect of cooking with superheated steam on the pH of Tilapia? Vanitha *et al.* (2013) obtained pH values ranging from 6.8 to 6.5 for fish burger made from Catla catla and Taskaya *et al.* (2003) observed pH values ranging from 6.5 to 7.0 for fish burger made from rainbow trout during 21 days of refrigeration storage.

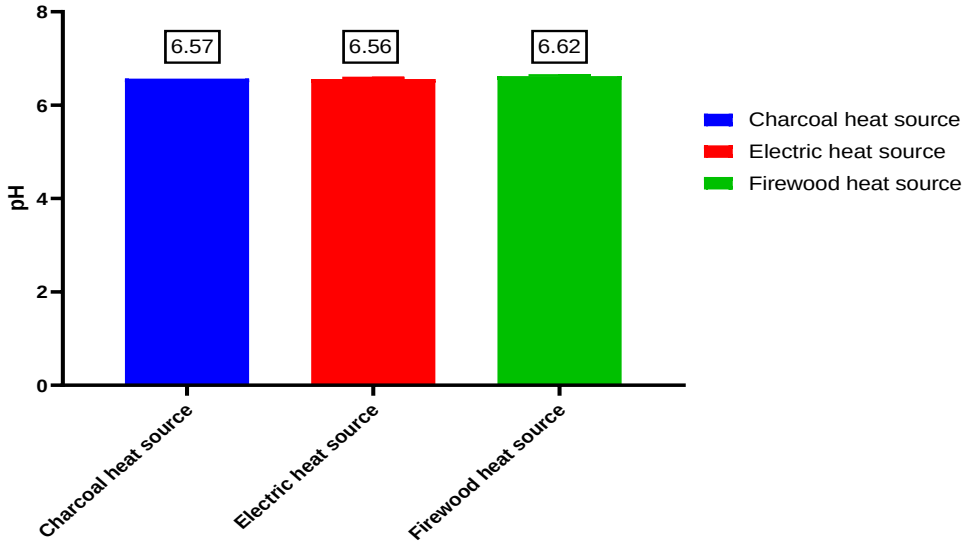


Figure 2: *Effect of heat sources on pH value of roasted Tilapia fish*

Effect of Heat Sources on Water Holding Capacity of Roasted Tilapia Fish

The effect of heat sources on the WHC of roasted Tilapia is depicted in Figure 3. Electric heat source tilapia fish had the greatest WHC at 54.44 percent, followed by firewood heat source tilapia fish at 43.33 percent and charcoal heat source Tilapia Fish at 38.89 percent. This demonstrates that there are substantial differences between the three heat sources. The water holding capacity (WHC) is the ability of a fish to retain water when subjected to external pressure. There was a statistically significant difference (P0.05) in the WHC of Tilapia fish, with electric heat source having the highest WHC at 54.4% and charcoal heat source having the lowest WHC at 38.89%. Similar results were obtained by Smida *et al.* (2014), who reported in their findings that heating affects the Water Holding Capacity (WHC) of frozen fish, resulting in protein degradation, whereas this contradicts the results obtained by Vanitha *et al.* (2013), who investigated various cooking methods for catla fish burgers (Catla catla).

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Volume 2, Number 2, December, 2022
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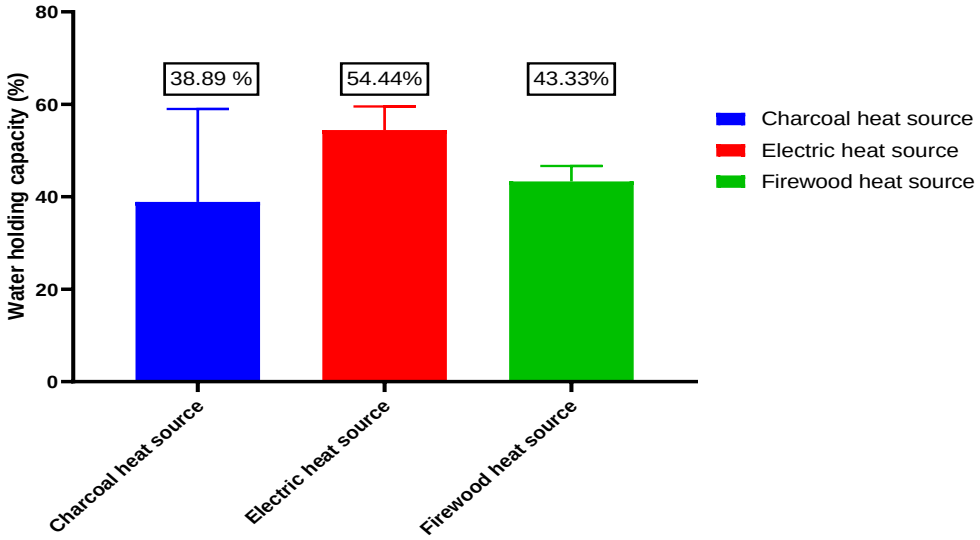


Figure 3: *Effect of heat sources on water holding capacity of roasted Tilapia fish*

Effect of heat sources on oxidative rancidity of roasted Tilapia fish

The influence of heat sources on the oxidative rancidity of roasted Tilapia is depicted in Figure 4. The electric heat source Tilapia Fish had the most oxidative rancidity with 0.31(mg/g), followed by the charcoal heat source Tilapia Fish with 0.29(mg/g), and finally the firewood heat source Tilapia Fish with 0.20(mg/g). The present study indicated significant differences in the oxidative rancidity of Tilapia fish (P 0.05). The electric heat source Tilapia fish had the highest oxidative rancidity (0.31 mg/g), whereas the firewood heat source Tilapia fish had the lowest (0.20 mg/g) oxidative rancidity. The acquired results resemble those of Tokur *et al.* (2004) and Yanar and Fenercioglu (1999) regarding fish burgers manufactured from Tilapia and fish balls created from carps, respectively. Chukwu (2009) obtained similar results and reported that oxidative rancidity is more intense in fish grilled with an electric grill than with charcoal.

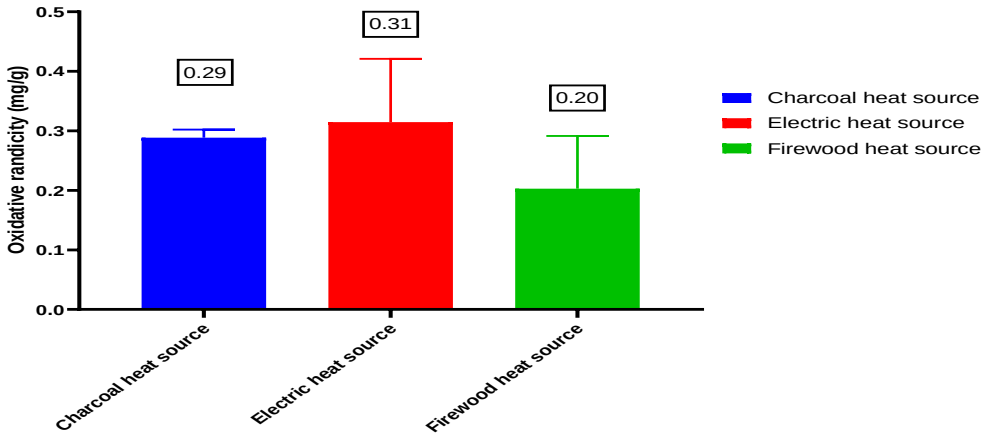
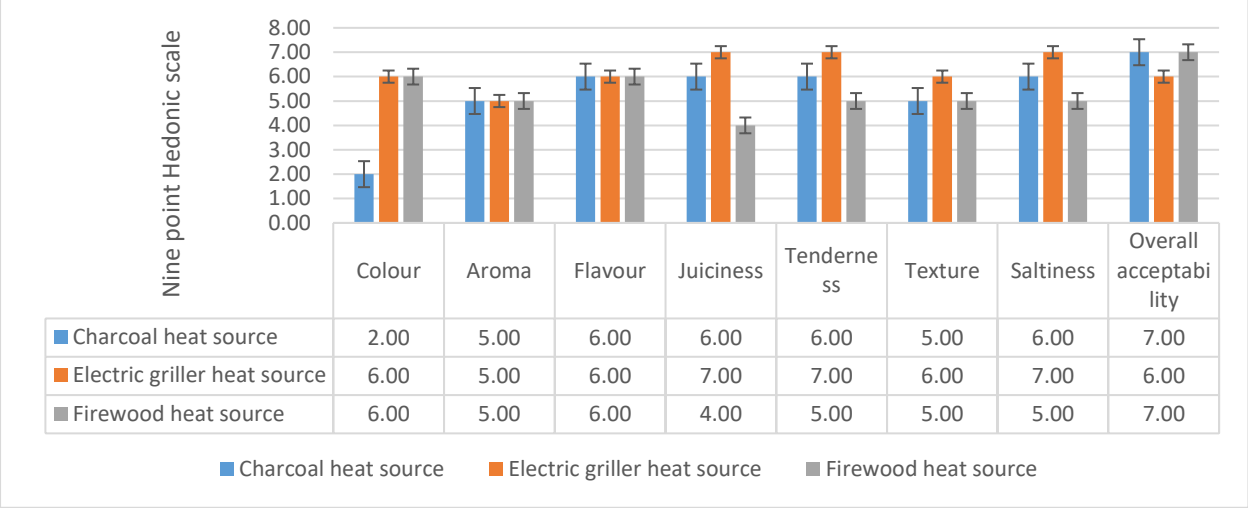


Figure 4: *Effect of heat sources on oxidative rancidity of roasted Tilapia fish*

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Effect of Heat Sources on Sensory Evaluation of Roasted Tilapia Fish

Figure 5 illustrates the effect of heat source on the sensory evaluation of roasted Tilapia. The sensory evaluation of Tilapia fish smoked with three different heat sources reveals that electric heat source Tilapia fish is preferred in terms of color but has the least desirable texture, while firewood heat source Tilapia fish has the most desirable texture. On a nine-point hedonic scale, each of the three heat sources received a score of seven for overall acceptability, indicating that panelists favoured or enjoyed them all. In this experiment, the electric heat source Tilapia fish had the lowest preference for juiciness, tenderness, texture, and salty. The charcoal and firewood heat source Tilapia fish had the highest preference for color. There was a significant variation (P0.05) in the texture of Tilapia fish based on the heat source, with firewood producing the most textural qualities and the least flavor. In contrast to Hassaballa *et al*. (2009), who reported that there was no significant variation in texture scores between baked and grilled Tilapia fish burgers based on sensory evaluation, these data indicate a substantial difference. In contrast to the findings reported by Eduarda *et al.* (2014), who investigated the influence of grilling on the physicochemical and textural qualities of Tilapia, there were no significant variations (P>0.05) in aroma and overall acceptability.



	Colour	Aroma	Flavour	Juiciness	Tenderness	Texture	Saltiness	Overall acceptability
Charcoal heat source	2.00	5.00	6.00	6.00	6.00	5.00	6.00	7.00
Electric griller heat source	6.00	5.00	6.00	7.00	7.00	6.00	7.00	6.00
Firewood heat source	6.00	5.00	6.00	4.00	5.00	5.00	5.00	7.00

Figure 5: *Effect of heat sources on sensory evaluation of roasted Tilapia fish*

Effect of Heat sources on microbial count of roasted Tilapia fish

Figure 6 illustrates the influence of heat sources on the microbiological count of roasted Tilapia fish using the charcoal heat source. Tilapia fish had the greatest microbiological growth/count of 1.33(CFU/g), whereas electric heat source and firewood heat source Tilapia fish had identical microbial growth/counts of 0.67(CFU/g). Some future contamination and microbe growth in the Tilapia fish can account for the observed variations. Microbial plate count values were highest for charcoal-heated Tilapia fish with 1.33(CFU/g), while electric and firewood-heated Tilapia fishes had the same microbial plate count value of 0.67(CFU/g). It has been discovered that microbial load increases as postmortem time progresses. The resulting total plate count result agreed with that of Agnihortri and Pal (2000) and Oshibanjo (2017), however Dharrmaveer (2007) reported higher value. It was noticed that overall plate counts increased as time post-mortem increased. The observed variances can be related to the eventual contamination and microbial development of the Tilapia fish.

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Volume 2, Number 2, December, 2022
ISSN (Print): 2811-1885; ISSN (Online): 2811-1893

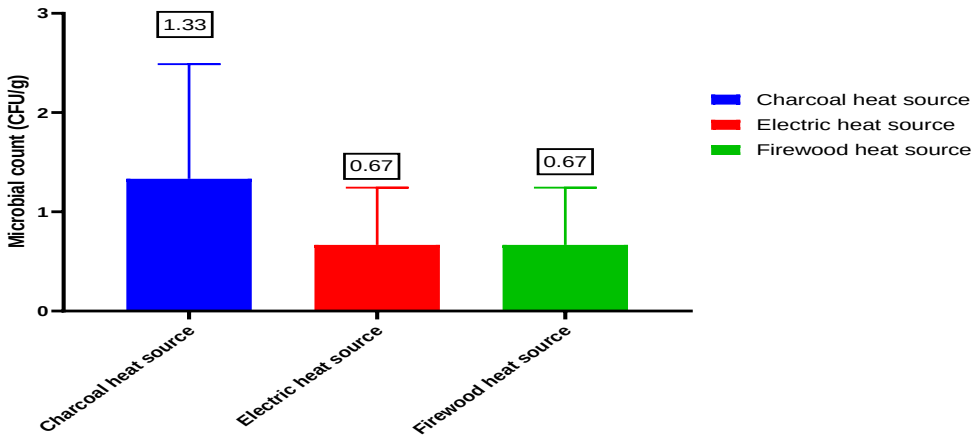


Figure 6: *Effect of heat sources on microbial count of roasted Tilapia fish*

CONCLUSION AND RECEMMENDATIONS

The results of this study indicated that electric heat source Tilapia fish had good potential as a fuel for smoking Tilapia fish because it was the most preferred in terms of color, water holding capacity (WHC), and oxidative rancidity, as well as the lowest in terms of juiciness, tenderness, texture, and aroma, without inhibiting the nutrients and consumer acceptability, because the smoking temperature did not exceed 200 degrees Celsius. This resulted in the retention of the majority of sensory qualities at the conclusion of the smoking process, resulting in highly acceptable and excellent products. Due to the findings of this study, which indicate that electric heat source Tilapia fish possessed good potential as a fuel for smoking Tilapia fish, electric heat source Tilapia fish smoking/processing should be suggested over charcoal and firewood heat sources for fish smoking/processing. Consequently, We also recommend the following:

1. The proximate makeup should be the subject of further research.
2. Additional research is required to determine why firewood-heated Tilapia fish had the lowest color preference.
3. Additional research should also be conducted on oxidative stress utilizing Drosophila Melanogaster (fruit fly).

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