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# STORABILITY CHARACTERISTICS OF SMOKED NILE TILAPIA (*Oreochromis niloticus*)

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# Summary

Currently smoked Tilapia in Ghana enjoys high consumer acceptability and marketability with immense profit margin for both wholesalers and retailers. However, considering the long and complex market channels in the distribution of smoked Tilapia, the study aimed at assessing the storability of smoked Tilapia based on pH and moisture content measurements. Two treated (fresh and aged) samples of Nile Tilapia, *Oreochromis niloticus* from the Volta Lake, Ghana were used. Both samples were subjected to the same processing procedure though aged Nile Tilapia (i.e. samples kept for 6 days without preservation) was cleaned in brine solution. Moisture content of smoked aged Tilapia (14.59 %, SE = 1.35) was significantly lower than that of smoked fresh Tilapia (19.54 %, SE = 0.54). The pH value of smoked fresh Tilapia (6.31, SE = 0.01) was significantly lower than recorded for smoked aged Tilapia (6.41, SE = 0.01), portraying lower water holding capacity and higher water absorption of the muscle in the smoked fresh Tilapia. From the results, storability of smoked aged Tilapia was relatively better, largely due to the presence of salt. Furthermore, pH values were within the range for quality fish (pH = 6.0 - 6.5), an indication that both smoked Tilapia samples are fresh products. Based on the outcome of the study, it is recommended that fish samples should be cleaned in salt water before smoking in order to reduce the moisture content of smoked fish and consequently increase its storability.

# CHAPTER ONE

## INTRODUCTION

Fish is the cheapest source of animal protein for some communities including those who do not consume red meat, the malnourished, immunocompromised, pregnant women, and nursing mothers (Amponsah *et al*., 2016; FAO, 2014). Several species of fish have been part of the diet of some ethnic groups in all continents for a long time, including Ghana (Kraan, 2009). Nutritionally, fish is considered an important and rich source of affordable protein which is characterized by a desirable composition of amino acids (Pasqualino *et al*., 2016). Fish is also a rich source of vitamins A, B and D as well as minerals like calcium, iodine, selenium, zinc and iron (FAO, 2012). Besides its acceptance as a balanced source of animal protein and vitamins, fish also provides polyunsaturated fatty acids (PUFAs) and minerals necessary for optimal health (Allision, 2011). However, nutritional benefits from fish and fish products are limited by its rapidly perishable nature and vulnerability to spoilage (FAO 2016; Modibbo *et al*., 2014).

Spoilage in fish occurs because it is susceptible to microbial and enzymatic deterioration which results in quality reduction, especially in the absence of proper processing and storage techniques. In view of its susceptibility to spoilage, there are several ways of accessing the quality of fish products (Fapohunda *et al.,* 2006). Evaluating the chemical composition of fish and fish products is essential because it influences its keeping quality characteristics. Measurement of fish keeping quality parameters (such as moisture content and pH) are often necessary as they ensure that the requirements of food regulations and commercial specifications are satisfied. On the other hand, deterioration in fish quality parameters such as moisture content and pH through oxidation

processes as well as microbial activity, rodent and insect infestation influences postharvest processing and storability of fish and fish products (Salaudeen *et al*., 2010). In view of this, the study focused on estimating the moisture content and pH of smoked Nile Tilapia (*Oreochromis niloticus*).

*Oreochromis niloticus,* commonly known as Nile Tilapia is a very important freshwater fish in Ghana (whether farmed or wild). It is widely distributed, extensively cultivated in ponds, rivers and lakes in Ghana, particularly the Lake Volta. It enjoys wide acceptability in most parts of Ghana because of its unique taste, smell, color, social status and nutritional value (Darko, 2011). However, farmed fish marketers operating in the Ghanaian aquaculture industry have ventured into smoking of farmed fish species for a number of reasons including attracting better price from local markets, reducing postharvest loss and increasing market channels.

Nonetheless, to meet the complex and long chain of distribution as well as food security (fish), moisture content and pH prior to storage play a key role in ensuring that spoilage does not occur. Again, knowledge in moisture content and pH of smoked fish and fish products ensures that smoked fish and fish products get to the secondary markets and eventually its consumers.

The study aimed at assessing storability (i.e. capable of being stored for considerable time without loss of freshness or usability) of smoked Nile Tilapia using pH and moisture content measurements.

# CHAPTER TWO

# METHODOLOGY

## 2.1 Sample collection

One hundred (100) kg of Nile Tilapia (*Oreochromis niloticus*) were obtained from fish farm located around the Volta lake, Ghana. Two categories of samples were used for the study, namely fresh and aged (i.e. samples kept for 6 days prior to processing without preservation) *Oreochromis niloticus*. These samples (both fresh and aged Tilapia) were then taken to the fish smoking shed at the CSIR-Food Research Institute, Ghana, where smoking was carried out.

## 2.2 Smoking process

### 2.2.1 Ahotor oven

The modified *Ahotor* oven was used for the smoke-drying process. The oven includes the fuelwood entrances, combustion chamber, and a drip collector (Kwarteng *et al*., 2016). The combustion chamber is made with burnt bricks and the stove wall constructed with solid/hollow blocks. Primary and secondary air inlets were fitted into the stove.

The fuelwood in the combustion chamber was placed in a criss-cross pattern on a grate to ensure better combustion of the fuelwood. A drip collector made of galvanized metal sheet with holes and mushroom heads was placed on the top of the combustion chamber. This was to prevent the fats and water from the fish from falling into the fire generated. The trays were stacked one on top of the other. In all, six wooden trays were placed on each stove. A chimney hood was placed after 2-3 hours of smoking. The temperature of the smoke generated in the smoking chamber was

monitored using a Voltcraft K204 Type K Digital thermometer until the required temperature (50 °C – 100 °C) was obtained. The fish samples were then placed on the mesh in the wooden trays. Burning fuelwood was adjusted to ensure that the required temperature in the chamber during the smoking period is maintained.

### 2.2.2 Tilapia

Generally, the method of smoking was essentially the same for both type of Tilapia samples. The fresh and aged Tilapia were washed, descaled, arranged on a smoker trays and smoked for 2-3 hours for wet hot smoked product and ≥ 3 hours for dry hot-smoked product. However, aged Tilapia samples were cleaned in brine solution because the samples were malodorous. Figures 1 and 2 show the flow chart detailing the various processes leading to the production of smoked fresh and aged Tilapia.

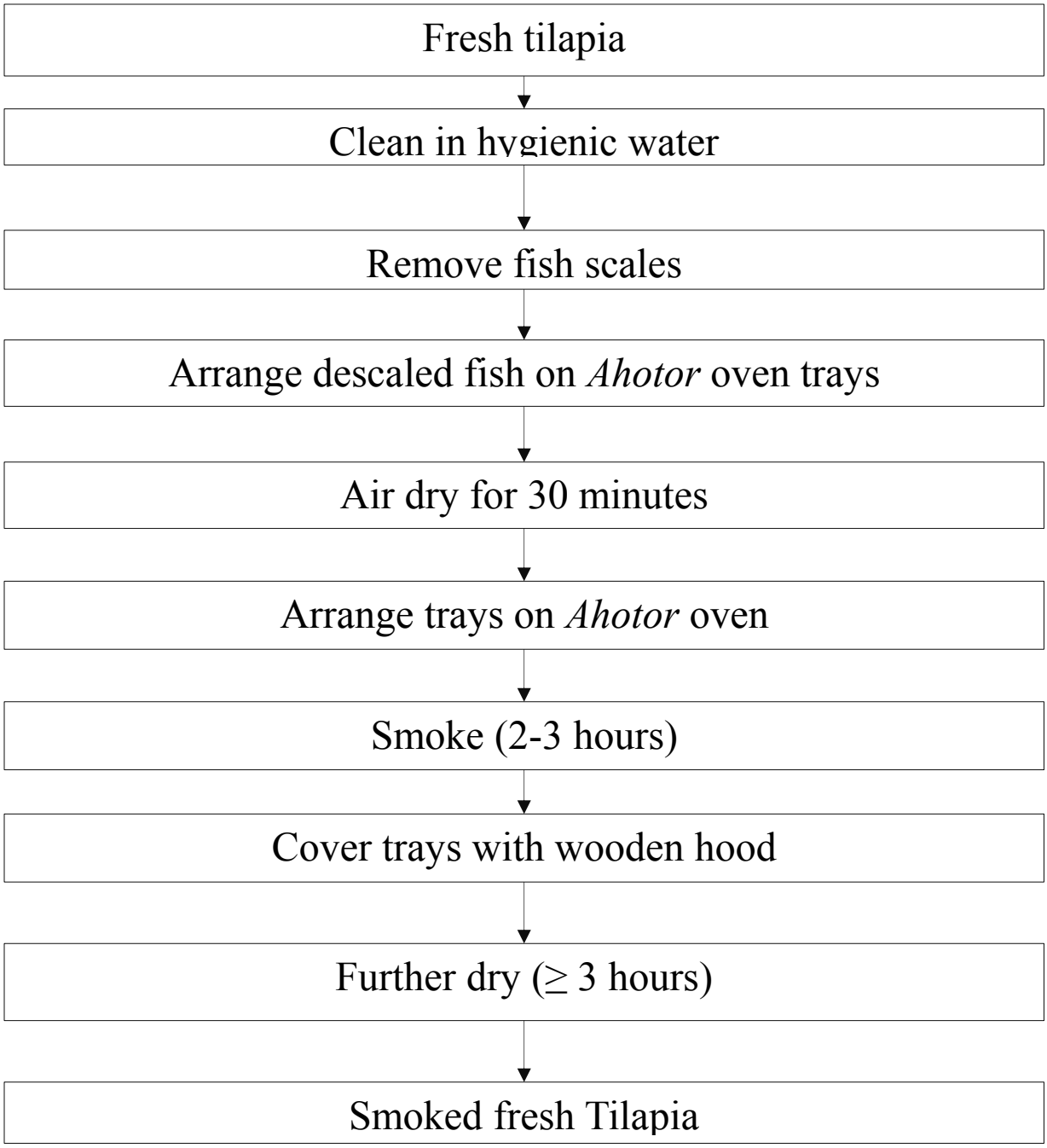


**Figure 1: Process flow diagram for hot-smoked fresh Tilapia**

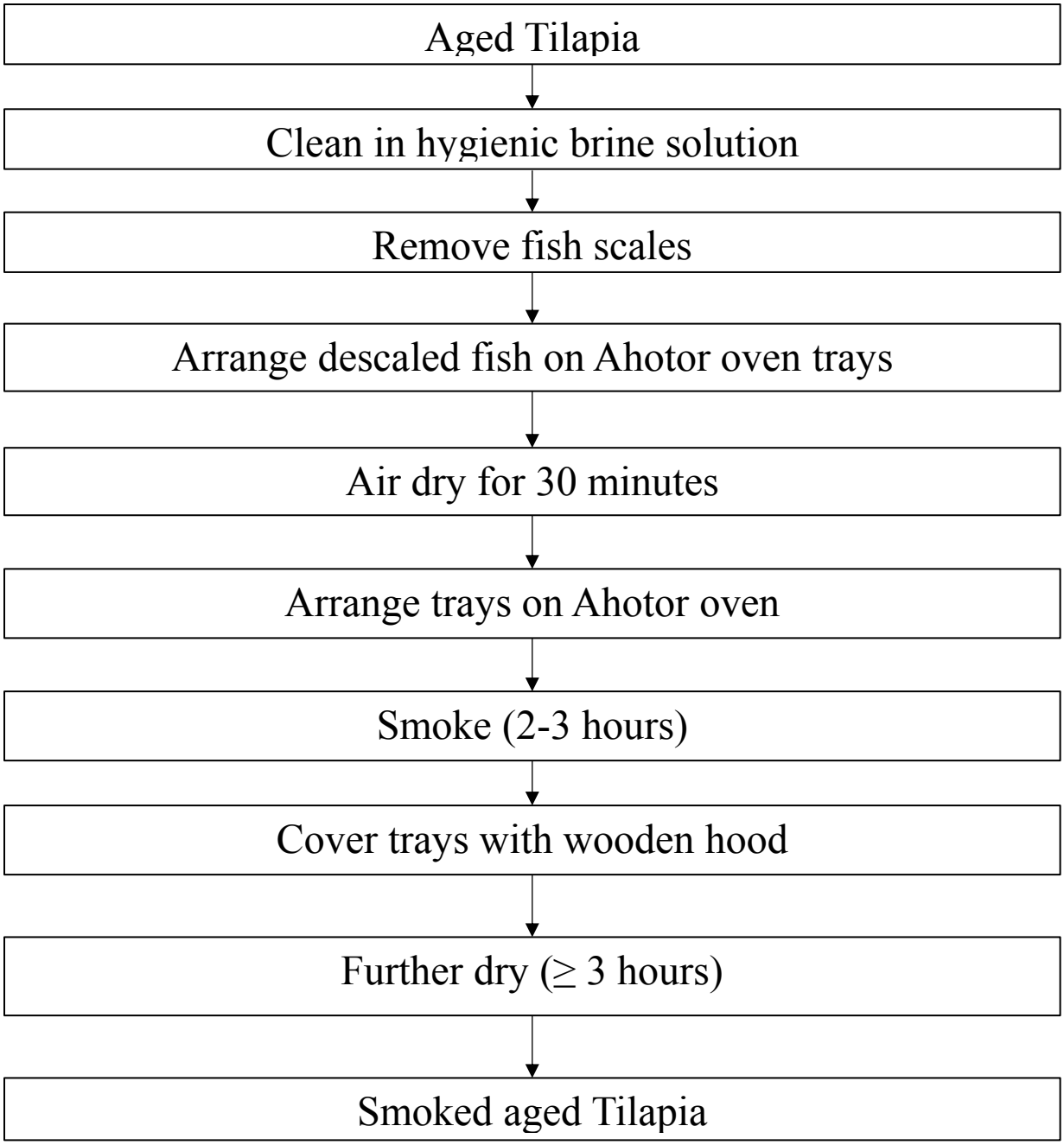


**Figure 2: Process flow diagram for hot-smoked aged Tilapia**

### 2.3 Sample Preparation

Smoked Tilapia samples were carefully washed with distilled water to eliminate any adhering contaminants. The samples were then dissected with a knife and the intestines, guts, head and bones removed. Dissected samples were then homogenized into a fine mesh prior to analysis.

### 2.4 Moisture Determination

Moisture content was determined by using of 5 g of minced smoked fish in a convection oven at 105 °C until constant weight obtained after 3 – 4 hours (AOAC, 1995).

### 2.5 pH Determination

The pH value of both samples of the assessed fish species was estimated according to Goulas and Kontominas (2005) where 10 g of each sample was homogenized in 100 ml of distilled water and the resultant mixture filtered. The pH of filtrate was measured using Hanna pH meter (H14222).

### 2.6 Data Analysis

Data collected were entered into and analyzed using the Microsoft Excel Statistical Tool Pac. Treatment means for both fresh and aged Tilapia samples were compared using one sample t-test at 5% level of significance assuming unequal variances.

# CHAPTER THREE

## RESULTS AND DISCUSSIONS

### 3.1 Moisture content

The estimated moisture content of smoked aged and fresh Tilapia ranged from 14.01 % - 15.07 % and 18.15 % - 20.84 % respectively. Averagely, the moisture content of both smoked aged and fresh Tilapia was 14.59 % (*SE* = 1.35) and 19.54 % (*SE* = 0.54) respectively (Table 1). The difference in moisture content for both assessed processed fish samples was significant (p (0.0097) < 0.05, df = 3).

**Table 1: Moisture content and pH of both fresh and aged smoked Tilapia**

| Category of Tilapia samples | Mean moisture content (SE) | Mean pH (SE) |
|---|---|---|
| Aged samples[1] | 14.59 (1.35) | 6.41 (0.01) |
| Fresh samples | 19.54 (0.54) | 6.31 (0.01) |

The relatively significant high moisture content in the smoked fresh Tilapia in comparison to the smoked aged Tilapia could be attributed to the difference in moisture of the fish prior to the smoking process. Furthermore, cleaning the smoked aged Tilapia with brine may have contributed

[1] **Stored for six days without preservation prior to processing (smoking)**

to the observed lower moisture content than in smoked fresh Tilapia. This finding has been subscribed to by numerous researchers (e.g. Jittinandana *et al*., 2002; Yanar *et al*., 2006; Jeyasanta *et al.,* 2015; Rana and Chakraborty, 2016; Swastawati *et al.,* 2016;). Thus, the presence of salt may have contributed to the significant difference in moisture content recorded from both samples of Tilapia.

FAO/APHCA (1989) documented that fish products begin to grow moulds after few days if not properly stored and when the moisture content is beyond 12%. The average moisture content of both samples (fresh and aged) under study was beyond 12%, indicating their vulnerability to moulds generation after few days, especially during poor storage conditions. This is because fish muscle is normally hygroscopic, which in conjunction with high humidity plays a key role in increasing moisture thus generating an environment suitable for moulds outbreak.

Kaneko (1998) submitted that moisture level of 15% and above in smoked fish facilitates proteolytic and lipolytic deterioration as well as microbial infestations. From the study, smoked fresh Tilapia will be more vulnerable to proteolytic and lipolytic deterioration and microbial infestations than smoked aged Tilapia. Plahar *et al.,* (1999) also recommended that initial smoked fish products should have moisture content of 13% before storage since satisfying this condition will not favour the development of aflatoxin related moulds. It can be seen from the present study that none of the fish samples satisfied this condition. Hence the need to re-smoke and further dry smoked fish and fish products in order to meet the condition suggested by Plahar *et al.* (1999) before storage.

### 3.2 pH

The estimated pH level of smoked aged Tilapia ranged from 6.40 – 6.43 while that recorded for smoked fresh Tilapia ranged from 6.29 – 6.32. Averagely, the pH level of both smoked aged and fresh Tilapia was 6.41 (*SE* = 0.01) and 6.31 (*SE* = 0.01) respectively (Table 1). The difference in pH values for both assessed processed fish samples was significant ($p (0.001) < 0.05$, $df = 4$).

Comparatively, increase in pH of the smoked aged Tilapia may be attributed to production of volatile basic components such as ammonia, trimethylamine and total volatile based nitrogen (TVB-N) by fish spoilage bacteria (Jeyasanta *et al.*, 2015). Similarly, Farid *et al*., (2014) attributed increase in fish pH to the rising presence of alkaline compounds such as ammonia and others. In the post-mortem period, decomposition of nitrogenous compounds leads to an increase in pH of fish flesh (Shenderyuk and Bykowsku, 1989). Nevertheless, the amount of TVB-N of a particular fish species depends on the fish non-protein nitrogen content and other environmental factors such as mode of storage after harvesting (Goulas and Kontominas, 2007).

Dzudie and Scher (2005) also recorded higher pH in salted smoked fish than in unsalted smoked fish and attributed this occurrence to the action of salt on the fish muscle. In furtherance to the action of salt on fish muscle, Hamm (1994) submitted that an isoelectric point of protein in fish muscle above pH 5 will improve the water holding capacity and water absorption of the muscle. Eventually, this improvement will increase storability of smoked fish and fish products. Regarding result from the study, the storability of smoked aged Tilapia product will be relatively better than smoked fresh Tilapia.

Fish products are acceptable up to a pH of 6.8 but are considered to be spoiled above a pH of 7.0 (Huss, 1988). Fennema (2000) also documented that the freshness of fish pH oscillates between 6.0 and 6.5 - indicating the freshness of the both smoked Tilapia (aged and fresh) samples from the study.

# CHAPTER FOUR

## CONCLUSION

From the study, both smoked fish samples are highly vulnerable to spoilage due to the relatively higher moisture content (> 12 %).

Comparatively, storability of smoked aged Tilapia is relatively better than smoked fresh Tilapia (especially in the presence of proper storage conditions) largely due to the presence of salt.

Therefore, it is recommended that:

- fish samples prior to smoking should be cleaned in brine solution to reduce the moisture content and consequently increase its storability.
- moisture content and pH measurements of smoked fish products destined for secondary markets should be within the safe limits to enhance its storability. This can be achieved through further drying and proper storage conditions.

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