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MOISTURE CONTENT AND pH MEASUREMENTS OF SMOKED TILAPIA (*Oreochromis niloticus*)

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Summary

With commercial aquaculture venturing into smoked tilapia for increased marketability and revenue generation, storage plays a key role in ensuring that spoilage does not set throughout the chain of distribution. In view of this, the study aimed at assessing the susceptibility of smoked Tilapia to spoilage basing on pH and moisture content as key indicators. Two kinds of Tilapia, *Oreochromis niloticus* were used including fresh Tilapia (preserved on ice) and Aged Tilapia (aged implies fish kept for six days without ice). Both samples were subjected to the same processing procedure though aged Tilapia was washed in brine solution. Moisture content of aged smoked Tilapia was significantly lower than that for smoked fresh Tilapia due to the action of the salt. However, both samples of Tilapia recorded moisture content greater than 13%, making it vulnerable to spoilage, especially in the absence of appropriate storage conditions. Furthermore, pH value of smoked fresh Tilapia was significantly lower than recorded for aged smoked Tilapia, indicating that quality of smoked fresh Tilapia was better than aged smoked Tilapia due to rapid decay. Nonetheless, pH values were within the range for quality fish, indicating the both aged and fresh smoked Tilapia were fresh product. From the study, it is recommended that brining should be done during smoking. This will reduce the moisture content of smoked fish and subsequently increase its storage duration, regardless of the chain of distribution.

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 such as 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 advantages of fish are limited by its rapidly perishable nature and vulnerability to spoilage (FAO 2016; Modibbo *et al*., 2014).

Spoilage set in because fish is susceptible to microbial and enzymatic deterioration and quality reduction occur, especially in the absence of proper steps for processing fish. In view of fish susceptibly to spoilage, there are several ways of accessing quality of fish product (Fapohunda *et al.,* 2006). The study of chemical composition of fish is important since it influences keeping quality characteristics of the fish. Measurement of fish quality parameters including moisture content and pH are often necessary, as they ensure that the requirements of food regulations and commercial specifications are satisfied (Olatunde *et al*., 2013). On the other hand, deterioration in fish quality parameters such as moisture content and pH through oxidation damage, microbial

activity, rodent and insect infestation influences postharvest processing and the shelf-life of the fish and fish products (Salaudeen, 2013). In view of this, the study focused on estimating moisture content and pH of smoked Nile tilapia (*Oreochromis niloticus*) in assessing its susceptibility to spoilage.

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 lake in Ghana, particularly the Lake Volta. It has enjoyed wide acceptability in most parts of the Ghana because of its unique taste, smell, color, social status and nutritional value (Darko, 2011). However, farmed fish marketers in the aquaculture industry, Ghana 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.

In view of above mentioned changes in farmed fish marketing, this study was aimed at assessing the susceptibility of smoked Nile Tilapia to microbial spoilage.

CHAPTER TWO

METHODOLOGY

2.1 Sample collection

One hundred (100) kg of Nile Tilapia (*Oreochromis niloticus*) were obtained from the fish farm on the Volta lake, Ghana. However, two categories of samples were used for the study, namely fresh and aged *Oreochromis niloticus* (i.e. aged tilapia samples were samples kept for 6 days prior to processing). These samples (both fresh and aged) 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 stove includes the fuelwood entrances, combustion chamber, and an oil 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. An oil 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 and at the end and a chimney hood placed after 2-3 hours of smoking. In all, six wooden trays were placed on each stove. The temperature of the smoke generated was monitored in the

smoking chamber until the required temperature was obtained using a thermometer. The fish samples were then placed on the mesh in the wooden trays. To ensure that the required temperature in the chamber during the smoking period is maintained, burning fuelwood was adjusted. In this study, temperatures of 50, 60 and 70° were used during smoking of the fish samples.

2.2.2 Tilapia

Generally, the method of smoking was essentially the same for both type of tilapia. The fresh and aged tilapia were washed, descaled, arranged on a smoker trays and smoked for 2-3 hours for a wet hot smoking and ≥ 5 hour for dry hot-smoked product. However, aged tilapia was washed in brine solution due to its off ‘smell’. Figure 1 shows the flow chart detailing the various processes leading to the production of smoked fresh and aged tilapia.

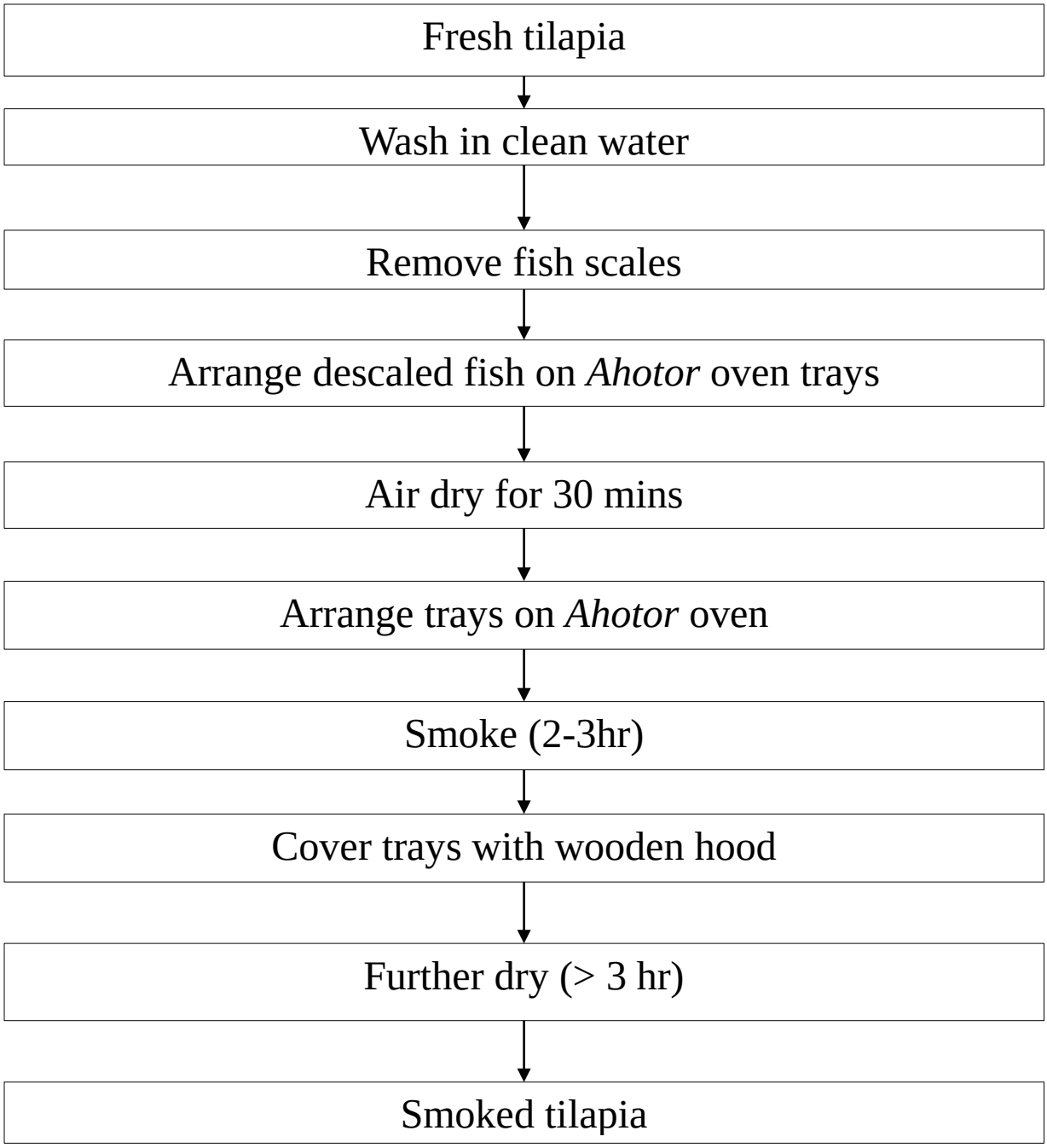

Figure 1: Process flow diagram for hot-smoked fresh tilapia

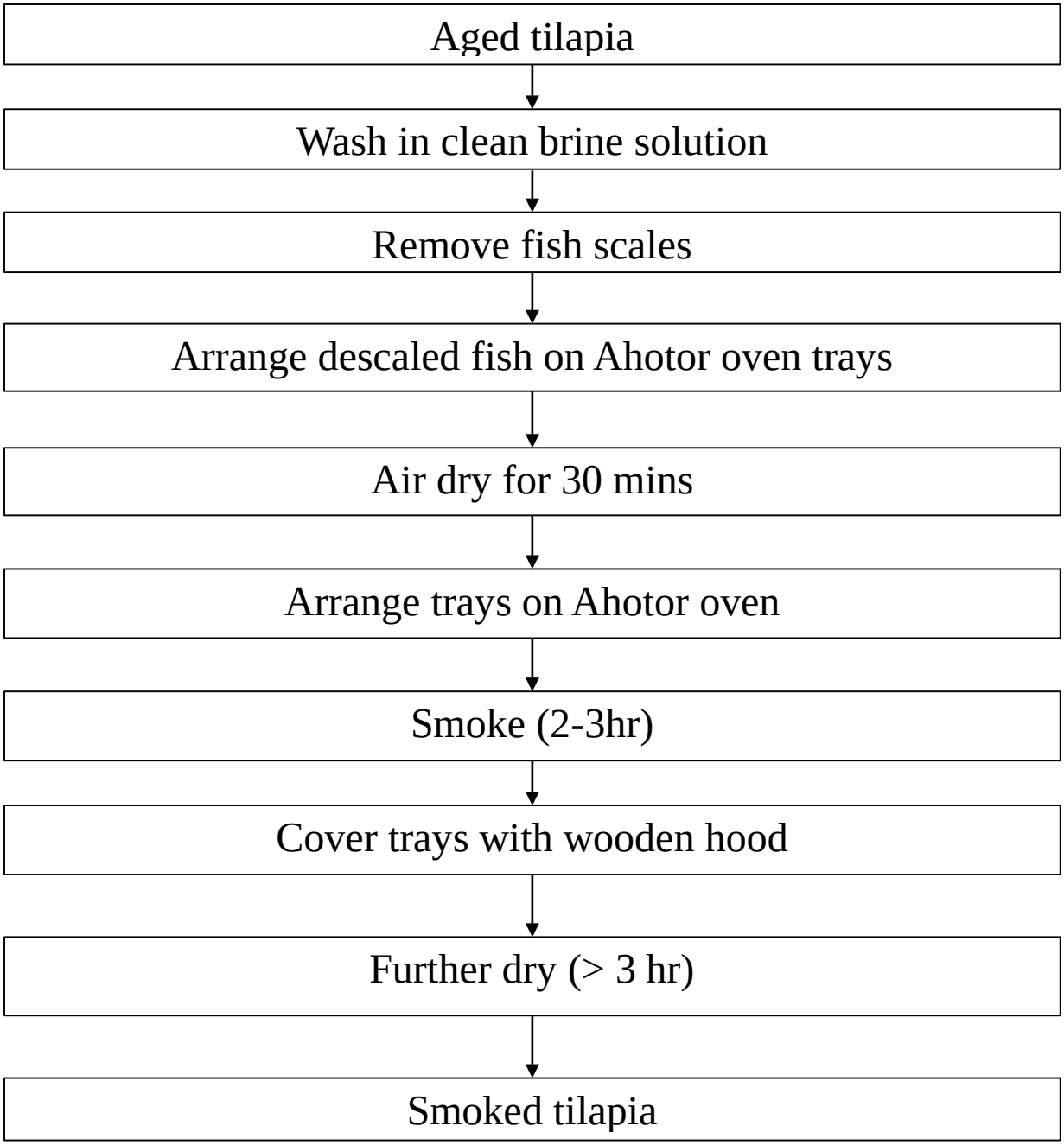

Figure 2: Process flow diagram for hot-smoked aged tilapia

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 (AOAC, 1995).

2.5 pH Determination

pH value was estimated according to Goulas and Kontominas (2005) as follows. Ten grams of sample was homogenized in 100 ml of distilled water and the mixture was filtered. The pH of filtrate was measured using Hanna pH meter (H14222) at ambient temperature.

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 reported.

CHAPTER THREE

RESULTS AND DISCUSSIONS

3.1 Moisture content

The estimated moisture content of smoked aged tilapia ranged from 14.01% - 15.07% (Table 1). However, the estimated moisture content of smoked fresh tilapia ranged from 18.15% - 20.84% (Table 1). Averagely, the moisture content of both smoked aged and fresh tilapia was 14.59 % ± 0.54 and 19.54% ± 1.35 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 of both fresh and aged smoked tilapia fish

Category of tilapia samples	Mean moisture content ± SD	Mean pH ± SD
Aged samples	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 fresh smoked tilapia in comparison to the aged smoked tilapia could be attributed to the difference in moisture of the fish prior to the smoking process. Furthermore, the presence of salt (brine) for washing the aged smoked tilapia contributed to the observed lower moisture content than in fresh smoked tilapia. This observation 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 salting may have contributed to the significant difference in moisture content recorded from the two samples of tilapia.

FAO/APHCA (1989) documented that fish products begin to grow moulds after few days if not properly stored 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 after few days of poor storage. 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) stated that moisture level of 15% and above in smoked fish facilitates proteolytic and lipolytic deterioration as well as microbial infestations. Hence from the study, smoked fresh tilapia will be more vulnerable to proteolytic and lipolytic deterioration and microbial infestations than the aged smoked tilapia. Phalar *et al.*, (1996) recommended that initial smoked fish should have moisture content of 13% before storage since satisfying this condition would not favor the development of aflatoxin moulds. From the present study, none of the samples satisfied this condition hence the need to re-smoke and further dry before storage.

3.2 pH

The estimated pH level of smoked aged tilapia ranged from 6.40 – 6.43 (Table 1). However, the estimated pH level of smoked fresh tilapia ranged from 6.29 – 6.32 (Table 1). Averagely, the pH

level of both smoked aged and fresh tilapia was 6.41 ± 0.01 and 6.31 ± 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 nitrogen by fish spoilage bacteria (Jeyasanta *et al.,* 2015). Similarly, Farid *et al*., (2013) 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 in the 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) reported that with the isoelectric point of protein in fish muscle at pH 5, a pH above 5 will improve the water holding capacity and water absorption of the muscle. Therefore, the shelf life of smoked aged fish will be relatively higher than smoked fresh fish due to improved water holding capacity and absorption ability of its muscle.

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) reported that the freshness of fish pH oscillates between 6.0 and 6.5, hence indicating the freshness of the smoked fish samples from the study. Nevertheless, increase in pH indicates the loss of quality, hence from the study, smoked fresh tilapia was slightly of a better quality than the smoked aged tilapia.

CHAPTER FOUR

CONCLUSION

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

However, smoked aged fish has a higher shelf-life due to higher pH value and lower moisture content than the fresh smoked fish.

Furthermore, cleaning fish in brine solution has positive impacts on the quality and shelf life of smoked fish products.

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