Physico, Microbiological and Nutritional Quality of Vacuum Smoked Nile Tilapia (Oreochromis Niloticus) in Different Moisture Content at Various Storage Time and Temperature

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***Abstract*—** The microbial safety and quality of Vacuum Packed (VP) hot-processed filleted smoke flavored Nile Tilapia (Oreochromis niloticus) in different moisture content at various time and temperature were examined during eight (8) weeks at room (320C) and refrigerated (40C) temperature. Moisture content was determined according to the method of AOAC (2002a). In this study, no significant differences ($P > 0.05$) were found between any of the samples of the color, aroma and saltiness attributes while flavor and texture and aroma were significantly different ($P<0.05$). The sensory evaluation panel also indicated that the most favorable smoked tilapia was the product stored at refrigerated temperature (40C) with 20% moisture content and the most acceptable products for panelists. The yeast and molds using the parameters of Yeast & Molds in food associated with the vacuum-packed smoked flavored Nile Tilapia stored room and refrigerated temperature, the yeast and mold count was less than 150 cfu/g. Thus, proper packaging, storage and hygienic processing improves the quality and safety of smoked fish. Level of proximate minerals content obtained in this study is within the standard provided by FAO (2007) for both STAP AND STVP. Hence, packaging is one of the most important technologies to be considered in any fish processed products.

***Keywords*—** Nutritional Quality Smoked Tilapia.

INTRODUCTION

On a global basis, tilapia (*Oreochromis niloticus*) is one of the most important species in aquaculture because of its genetic, reproductive, and marketing characteristics. Tilapia is a popular freshwater fish due to their nutritional benefits and wide availability. Intensive tilapia farming in Asia has increased steadily and become an important source of fish within the last few years (Murthy et al., 2011) [1]. Another important global trend has been the continued spread of tilapia products into the food service and restaurant sectors. Tilapia are now served in virtually all multinational casual dining chains along with cruise ships, most dedicated seafood restaurants and increasingly at schools and hospitals (Fitzsimmons,2008) [2].

Fish have soft tissues and high amounts of water and this enhances its susceptibility to microbial contamination (Olayemi et al., 2012) [3]. Many researchers had evaluated the spoilage of seafood in general and fish in particular.

The spoilage activity of food samples depends on several factors such intrinsic (nutrient content, pH and buffering capacity, redox potential, water activity and antimicrobial barriers and constituents), extrinsic (relative humidity, temperature and gaseous atmosphere), implicit and microbial factors (Adams and Moss, 2008) [4].

Fish smoking is one of the most common methods of fish processing known as “tinapa”. Smoked processing aims to reserve fish by lowering moisture content, enhance smoke flavor as well improve its appearance, Bigiueja et.al, 2010) [5]

Smoking is a traditional method used to preserve fish in the world, although today, its acceptance in developed countries is primarily based upon the sensory characteristics it imparts on the product. Furthermore, smoking increases the shelf life of fish as a result of the combined effect of dehydration, antimicrobial and antioxidant activities of several smoke constituents mainly: formaldehyde, carboxylic acids and phenols (Doe, 1998) [6]. An additional preservative effect is owed to salting which comprises the first step of the fish smoking process. However, smoking is not an absolute preservation method. For this reason, the quality of raw material, the concentration of salt, water activity of the fish, heat through the smoking process, the quantity of smoke, the way of packaging, hygienic circumstances and heat of storage have the most important effects to reduce the risk of deterioration (Serkan et.al., 2009) [7].

In the Philippines, in contrast, smoking serves primarily as a tool to enhance the flavor and texture of fish, often

producing value-added products whose preservation is achieved by other means. In smoking, wood smoke is good to use, other agro-waste material can be used like rice hull and bagasse that can enhance flavor and improve the quality of smoked product (Bigueja, et. al, 2010) [8]. "Tinapa" is soft and easily damaged and it is still subject to many forms of spoilage unless it is properly packaged and air is eliminated during packing. Bigueja, et.al, 2012[9]. Observed that vacuum packaging method not only prevented the smoked products from post contamination but also protected from damage during transport of the products.

Vacuum Packaging (VP) is exclusion of the air from the package and thus creating a vacuum also is, in effect a certain type of modification of the atmosphere (Hall, 1994) [10]. In the study of Dondero et al., (2004) [11] changes in the quality of vacuum packed cold smoked salmon (Salmo salar) were evaluated through a systematic study of biochemical, microbiological and sensory analyses during storage at different temperatures.

Consumers are rediscovering the good taste, flavor and appearance of smoked fish and to satisfy the consumer demand, it is necessary to produce good quality and safe smoked fish products. The aim of this study was to investigate the microbiological and nutritional quality of smoked tilapia using flavor enhancers.

II. METHODOLOGY

2.1 Raw Materials.

50 kilos of tilapia were bought directly to fisherman this is to ensure that the product is still fresh. The fish were packed in a cooler with a chilling temperature. Immediately after reaching the fish processing laboratory of PSU Sagnay Campus the weight of the tilapia fish was determined. Remove the fins and entrails and wash thoroughly. The washed fish were weighed again to ease the determination of the moisture content of the fish during smoking.

2.2 Smoking process.

The tilapia fish were smoked until the moisture content reached to 20%, 15%, and 10%. The smoking was done in a conventional smoking facility with temperature control. The smoke was produced from the saw dust. The temperature was maintained at 100^0C.

2.3 Packaging process.

After smoking, smoked tilapia in different levels of moisture was divided into two parts. Then separately Air Packing (AP) in PPE bag, the first part was sealed in impulse sealed while the 2nd part was Vacuum Packed (VP) using vacuum pouch bag. The products were stored at room and refrigerated temperature for 8 weeks.

2.4 Microbiological Evaluation.

After storing at the given period of time the product was subjected to microbiological analysis. Products were submitted to the DOST V for microbiological analysis.

2.5 Sensory Evaluation.

Preference testing and just about right: The preference test of three products was subjected to a preference test by 30 untrained panels consisting of Faculty and Fishery students. Each sample was served with fresh water for rinse after testing. The product characteristics such as flavor, texture, color, aroma and saltines. The overall liking was also determined using the 9-point hedonic scale (1-dislike extremely.

2.6 Chemical Analysis.

Proximate and mineral composition was carried out for the best treatment of smoked tilapia to determine the moisture, crude protein, crude lipid and ash using the method of Association of Official Analytical Chemistry (AOAC, 2016) [12] and using Microwave Plasma-Atomic Emission Spectroscopy (MP-AES) and USFDA- NLR and DOST-FNRI-PDRI, 2015, respectively. Nutritional was computed based on the result of Proximate and mineral composition.

III. RESULTS AND FINDINGS

3.1 Sensory Assessment of Smoked Tilapia

According to the Institute of Food Technologists (IFT), sensory evaluation is a scientific method used to evoke, measure, analyses and interpret those responses to products as perceived through the senses of sight, hearing, touch, smell and taste (Stone and Sidel 1993; IFT 2007) [13].

Table 1: *Sensory Analysis of Experimental of Smoked Tilapia in Air Packed (STAP)*

Physical Characteristics	**Level of Preference**					
	Room temperature (32^0C) 8 weeks			**Refrigerated temperature (4^0C) 8 weeks**		
	20% Moisture Content (Sample 1)	15% Moisture Content (Sample 2)	10% Moisture Content (Sample 3)	20% Moisture Content (Sample 1)	15% Moisture Content (Sample 2)	10% Moisture Content (Sample 3)
Flavor	4.12 ± 1.29^a	4.80 ± 1.61^b	4.15 ± 2.03^c	6.23 ± 1.22^a	6.41 ± 1.98^a	5.12 ± 2.03^b

Texture	4.13±1.30[a]	3.41±2.98[b]	2.15±2.79[c]	6.23±2.22[a]	5.80±1.61[b]	5.12±2.03[b]
Color	4.15±1.31[a]	4.90±1.73[a]	5.15±1.31[a]	6.20±1.61[a]	6.40±1.55[a]	6.15±1.31[a]
Aroma	4.23±2.22[a]	3.17±1.98[a]	5.15±2.03[b]	6.43±2.11[a]	5.63±2.14[a]	5.77±2.26[a]
Saltiness	4.43±2.11[a]	4.63±2.14[a]	5.77±2.26[a]	6.80±1.79[a]	5.90±1.73[a]	6.15±1.31[a]

**Different letters in the same row show significant differences among samples (P < 0.05). Values are shown as mean ± SD of triplicate measurements*

Sensory attributes of Sample 1, were found dislike slightly for the stored at room temperature and like slightly for the product stored in refrigerated temperature. On the other hand, samples 2 and 3 were found to decrease the scores. The results implied that the panelist did not like the air packing (AP) smoked tilapia after 8 weeks of storage. Hence, air packing is not best in controlling spoilage of smoked products. Moreover, the texture of sample 3 was rated disliked very much. The results indicate, the lower the moisture content changes the palatability of the smoked products. Generally, the AP smoked fish consumer acceptability is shorter than VP smoked products.

Further, no significant differences (P > 0.05) were found between any of the samples of the color, aroma and saltiness attributes while flavor and texture and aroma were significantly different (P<0.05) (Table 2). The sensory evaluation panel also indicated that AP is not favorable and acceptable to the panel for longer storage. This implied that the AP cannot guarantee the quality and food safety of the smoked products.

3.2 The effect of vacuum packaging on keeping quality of hot-processed smoked Tilapia

Table 2: *Sensory Analysis of Experimental Vacuum Smoked Tilapia (STVP)*

Physical Characteristics	**Level of Preference**					
	Room temperature (32^0C) 8 weeks			**Refrigerated temperature (4^0C) 8 weeks**		
	20% Moisture Content (Sample 1)	**15% Moisture Content (Sample 2)**	**10% Moisture Content (Sample 3)**	**20% Moisture Content (Sample 1)**	**15% Moisture Content (Sample 2)**	**10% Moisture Content (Sample 3)**
Flavor	4.12±1.29[a]	4.80±1.61[b]	4.15±2.03[c]	6.23±1.22[a]	6.41±1.98[a]	5.12±2.03[b]
Texture	4.13±1.30[a]	3.41±2.98[b]	2.15±2.79[c]	6.23±2.22[a]	5.80±1.61[b]	5.12±2.03[b]
Color	4.15±1.31[a]	4.90±1.73[a]	5.15±1.31[a]	6.20±1.61[a]	6.40±1.55[a]	6.15±1.31[a]
Aroma	4.23±2.22[a]	3.17±1.98[a]	5.15±2.03[b]	6.43±2.11[a]	5.63±2.14[a]	5.77±2.26[a]
Saltiness	4.43±2.11[a]	4.63±2.14[a]	5.77±2.26[a]	6.80±1.79[a]	5.90±1.73[a]	6.15±1.31[a]

**Different letters in the same row show significant differences among samples (P < 0.05). Values are shown as mean ± SD of triplicate measurements*

Table 2 indicates that both products stored in the room and refrigerated all attributes were rated moderately. This result indicates that the best moisture content of the smoked tilapia in vacuum packed is 20%. On the other hand, the texture of 15% and 10% moisture content under room temperature was rated either like or dislike (5.41) and dislike slightly (4.15) while the texture and flavor 10% moisture content stored in refrigerated temperature was rated like slightly (6.12).

Generally, the rates of 20% moisture content stored in room and refrigerated temperature in all attributes were rated liked moderately. This result indicates that the most favorable moisture content was 20%. Interestingly, the results noted that the vacuum packed smoked tilapia stored either at room and refrigerated temperature were acceptable to the panelist.

Hence when the product is vacuum packed it can prolong the shelf life of the smoked products. Similarly, Ochieng, O., et.al.(2015) [14] stated that vacuum packaging in combination with chilling was found to be the best in delaying spoilage and Thereby significantly extending dried fish products shelf life in tropical environments.

No significant differences (P > 0.05) were found between any of the samples of the color, aroma and saltiness attributes while flavor and texture and aroma were significantly different (P<0.05) (Table 1).

The sensory evaluation panel also indicated that the most favorable smoked tilapia was the product stored at refrigerated temperature (40C) with 20% moisture content and the most acceptable products for panelists.

3.3 Microbiological Analysis of Smokes Tilapia

Table 3: *Yeast & Molds Content of the Smoked Nile Tilapia in Vacuum Packed*

Samples	Room Storage (8 weeks)		Cold Storage (8 weeks)	
	Results	**Method Used**	**Results**	**Method Used**
20% Moisture Content	<150 cfu*/g	AOAC BAM	<150 cfu*/g	AOAC BAM
15% Moisture Content	<120 cfu*/g	AOAC BAM	<80 cfu*/g	AOAC BAM
10% Moisture Content	<120 cfu*/g	AOAC BAM	<80 cfu*/g	AOAC BAM

*colony forming unit, 3m St. Paul, Minn. USA

The present study also investigated the yeast and molds using the parameters of Yeast & Molds in food (DRBC, 250C, 5 Days) (Table 2) associated with the vacuum-packed smoked flavored Nile Tilapia stored room and refrigerated temperature, the yeast and mold count was less than 150 cfu/g for 20% moisture content. This result placed the fish samples in class B (microbiological status of the food is less than satisfactory but is still acceptable for consumption. For 15% and 10% moisture content, it is less than 20% moisture content. These results showed that the lesser moisture content the least content of yeast and molds.

This result is in agreement with the works Microbial load of smoked fish from the local fish processor was higher experimental samples (Adeosun, O. et. Al. (2015) [16] further explains this due to strict compliance with good manufacturing practices and also the use of packaging material. This led to improved quality of the experimental fish and longer storage life than fish samples obtained from local fish processors. The packaging materials used to package the experimental samples also prevented the samples from insect infestation. Therefore, similar to the previous studies proper packaging, storage and hygienic processing improves the quality and safety of smoked fish.

3.4 Proximate Composition of Vacuum Smoked Tilapia

After determining the best sample for Vacuumed Smoked Nile Tilapia (Oreochromis niloticus) the process repeated for proximate and nutritional analysis were determined.

The bio-chemical composition (proximate composition and pH value) of fish is an important aspect in fish processing as it influences both the keeping quality and the technological characteristics of the fish (Farzana Binte Farid et al., 2014) [16]. Similarly, Mphande and Chama (2015) [17], observed that processing and storage significantly affected the proximate composition of fresh water fish species and their effect varied from species to species.

Nutritional value of fish may sometimes be altered or rather compromised depending on the way it is brought on the market. In most cases, the available and most common types of Tilapia species on the market are either, fresh, sundried, and smoke dried fish. The nutritive value and how consumers respond differs with each one, and in some cases most fish dealers have ended up having a commodity which is undervalued on the market thereby losing out on profit (Musuka, C. and Kanyembo, H, 2017) [18]. Holma and Maalekuu, (2013) [19] observed that different processing methods have different effects on the nutritional compositions of fish and some traditional processes in food preservation may also destroy or remove some essential nutrients or decrease their digestibility.

Table 4: *Proximate and Mineral Composition of the Air Packed and Vacuum Packed Smoked Tilapia*

Parameters	Smoked Tilapia in Air Packed (STAP)	Smoked Tilapia in Vacuum Packed (STVP)
Ash	4.57	4.95
Fat	4.00	1.64
Protein	29.04	38.49
Moisture	52.06	42.0
Carbohydrates	.33	2.91
Potassium, mg/100g	441	453
Calcium, mg/100g	51	49
Iron, mg/100g	.74	3.43
Zinc, mg/100g	1.01	1.04

In this study proximate chemical analysis was carried out by the AOAC methods. The Results of STAP moisture, protein, crude fat, ash, and carbohydrates were 52.06, 29.0, 4.0, 4.57 0.33 respectively. These average values fall within the range given by various authors in earlier studies (Oparaku and Mgbenka, 2012[20], Olayemi et al., 2011[21.]; Mohammed and Karrar, 2012[22]; Akhter et al., 2009) [23]

Results for proximate analyses of *Oreochromis mossambicus* fish samples for the two samples (STP and STVP are presented in Table 1. STVP had the highest protein, ash and carbohydrates (38.49, 4.95 and 2. 91) and lower fat (1.64). Highest fat (4.00) and Moisture (42.06) was observed in STAP. These average value for STVP and STAP fall within the range given by various authors in earlier studies (Oparaku and Mgbenka, 2012[20], Olayemi et al., 2011[21]; Mohammed and Karrar, 2012[22]; Akhter et al., 2009) [23].

3.4.1Moisture

Moisture is one of the factors that increases muscle spoilage in fresh fish. Moisture (Idah, P. and Peter Nwankwo, I, 2013) [24] In this experimental study the moisture for vacuumed smoked tilapia was within the limit to prevent microbial spoilage (Immaculate *et al.*, 2012) [25] suggesting a product with a longer storage (shelf) life.

3.4.2 Protein

Protein is the most important nutrient component that fish supplies to the human body. According to Ravichandran et al. [26], protein forms the largest component of dry matter in fish. Farzana *et al.* (2014[])[27], fish supplies protein of high class quality compared to protein of other animal sources. With reference to Table 5, protein composition was recorded for STAP is (29.04%) and 38.49 for STVP This result is lower than from result of study of (Musuka, C. and Kanyembo, H, 2017) [28] on smoked dried tilapia which is 63.2% protein. Reduction in protein content during smoking in this study, has been reported by several authors [29, 30, and 31]. The decrease has been widely attributed to the loss in available lysine which according to Arannilewa (2005) [32] may vary from 6-33% at 25ºC to 53-56% at 40oC during hot smoking. Furthermore, Akande (1998) [33] made an observation that lysine reduction was directly proportional to the temperature and duration of smoking. It is also observed (Akhter et al., 2009) [34] that wood smoke contains pyroligenous acid which may have an added preservative effect on smoked dried meat. It is observed that protein contents increased with decrease in moisture content (Aliyaet al., 2012) [35]. Generally, the values obtained where within the standard provided by FAO (2007) [36].

3.4.3 Fat

Fat was found to be high in STAP samples with composition of about 4% compared to STVP. The finding is a good indication that oxidation in STVP may be avoided. Furthermore, (Idah, 2013) [37] stated that variation in fat content can be attributed to the different behavior of smoke dried tilapia species in terms of fat composition when subjected to different temperature treatments and therefore, the results can be said to be dependent on the smoking temperature associated with the samples. Many other studies have indicated a reduction in fat composition in smoke dried fish especially when smoking is done at high temperatures, according to Ahmed *et al.*, (2011) [38] higher temperatures during smoking contributes to the loss of fat in fish. However, another factor can also be attributed to how this is culture, tilapia can culture in ponds and on the lakes. In this study, tilapia are raised in hapa at Lake Buhi.

3.4.4 Ash and Mineral

Ash is a measure of the mineral content in the food item. Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food. Analytical techniques for providing information about the total mineral content are based on the fact that the minerals (the "analyte") can be distinguished from all the other components (the "matrix") within a food in some measurable way (Holma and Maalekuu, 2013) [39]. In this study, the ash and mineral content has a significant difference. This can be attributed to the fact that method packing has no effect on the ash and mineral content. However, in this study both fish samples show good percentage of ash content and minerals. Generally, the amount of ash in the fish is influenced by the size and the bone to flesh ratio, this is why smaller sized fish species tends to have more ash because of the higher bone to flesh ratio (Daramola *et al.*, 2007) [40]. Iron is an essential component in the transfer of oxygen in the body and a deficiency of iron in the body may lead to anemia while magnesium is an activator of many enzymes systems and maintains the electrical potential in nerves, calcium is involved in bone formation (Aremu *et al.*, 2013)[41],potassium is an essential nutrient needed for maintenance of total body fluid volume, acid and electrolyte balance, and normal cell function(Young DB ,2001)[42] and Zinc plays in growth and development (Neumann CG, etal,, 2003)[43] . Level of minerals recorded in this study agrees with Aremu *et al.* (2013)

[41] that high ash content in fish is indicative of high levels of minerals.

34.5 Carbohydrates

Interestingly, the samples containt carbohydrates although it is minimal. Carbohydrate is the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake (FAO/WHO, 1998) [44].

IV. CONCLUSION

The smoking process content reduced the microbial load on the fresh fish and the reduction in moisture content of the experimental samples made the smoked samples shell stable. Vacuum packaging also plays an important role in safeguarding the health of consumers by protecting and preserving the food product during its anticipated shelf life. The vacuum packaging of fish products should ensure attractive presentation among other food products without contaminating them. The vacuum packaging also prevented re-contamination and reduced breakage. It should however be emphasized that chilled vacuum-packing success is completely dependent on the initial state of the processed fish and on adequate temperature control throughout the storage temperature. Level of moisture, protein, fats, carbohydrates, ash and minerals obtained in this study is within the standard provided by FAO (2007).

ACKNOWLEDGMENT

The authors wish to thank the management and staff of the Department of Science and Technology, Region V (DOST V) for making available their Laboratory facilities for the successful completion of this study.

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