Sensory and Quality Assessment of Smoked Skipjack Tuna (Katsuwonus Pelamis) using Tamarind Leaves (Tamarindus indica) and Pandan Leaves (Pandanus amaryllifolius)

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***Abstract*—** The present study evaluated the sensory, organoleptic of smoked Skipjack Tuna (Katsuwonus Pelamis) using the Tamarind (Tamarindus indica) and Pandan (Pandanus amaryllifolius) leaves extracts. The Effect of these herb extracts and the right concentration of salt was determined on the quality of smoked products in terms of color, aroma, taste, texture and general acceptability. There were 30 Panelists evaluated the product using the 9 hedonic scale ranging from 1 = Dislike extremely and 9 = Like extremely. Results suggested that the used tamarind (Tamarindus indica) and Pandan (Pandanus amaryllifolius) leaves were accepted form the panelists regardless of the salt concentration applied in soaking the fish with the tamarind (Tamarindus indica) and Pandan (Pandanus amaryllifolius) extracts. It was revealed that the use of Pandan (Pandanus amaryllifolius) extracts that the odor is 7.74 or like very much as rated by the panelist. The Mean scores also shows that the flavor of using tamarind (Tamarindus indica) and Pandan (Pandanus amaryllifolius) leaves extracts was rated very much with the rating 7.99 and 7.67 respectively. Therefore, the tamarind (Tamarindus indica) and panda extract is a good flavor enhancer in smoking fish. Further studies on keeping quality and chemical content of the products is recommended.

***Keywords*—** Vacuum Pack Hot-Processed Smoked-Flavored Skipjack Tuna (Katsuwonus Pelamis).

I. INTRODUCTION

Fish consumption plays a key role in the supply of animal protein and micronutrients needs of humans globally. With the rising risk of contracting various diseases associated with meat consumption, the dependency on fish keeps increasing (Asiedu, B. et.al 2015) [1]. World fish consumption and utilisation is growing with corresponding growth in world population. The world population is expected to hit over 9 billion by the year 2050. About 2 billion people worldwide would be experiencing hunger by 2050. The right to food is a universal human right, but currently, over 800 million people suffer from hunger [2]. Demand for fish is expected to grow given escalating animal protein demands in developing countries and the rapidly increasing human population [3]; [4].

Most Filipinos love Skipjack Tuna (Katsuwonus Pelamis locally known as tuna not because it's the national fish but because of the unique flavor, the qualities that cannot be found in other fish and that makes it special. Philippines' main seafood industry product is tuna, which is their main product in volume and in value (Market Intelligence Team, 2020) [5]. According to the latest FAO fishery databases (FAO, 2015), world production of the main commercial tuna species surpassed 4 million tons in 1999 and reached 4.6 million tons in 2011. Wild catches represent 96.7% of total supply. These figures indicate an increase of 1,019.5% since the earliest statistics of 1950, but only 12.5% since 2000 [6].

Lagonoy Gulf which located ni Bicol Region, Philippines is considered the most productive fishing grounds of tuna and tuna like fishes. Fisher folks usually processed the surplus catch of tuna into smoked fish locally known "inagunan". Inagunan a term used that the describe that tuna are processed by cutting the fish into chunk hold tightly by the bamboo stripe and laid on wire mesh trays above the improvised stove, the tuna is usually cooked and flavored by the smoked coming the sawdust which are used for smoking the tuna. The product has a unique taste and became a popular tuna product. However, the products were processed unsanitary. The purpose of this study is to assess the quality of the smoked tuna using fabricated smoke houses where the temperature can be controlled and with the application of flavor enhancers like the tamarind (*Tamarindus indica)* and Pandan (*Pandanus amaryllifolius*) leaves.

Consumers globally are becoming more concerned about the food safety of fish and fishery products. To produce safe and wholesome food for consumption there

is a need that fish processors should practice the good hygienic method of processing fish and products must be free from any recontamination of bacteria that can cause food poisoning. Hence, practices using the standard set government must be applied to the fish processing industry may it small, medium and large industry. There are a number of ways to enhance food safety. These include proper way of handling fish and other fishery products, better education for both processors and consumers, and control of bacteria throughout the food chain by using a suitable packaging method and materials.

Fish preservation is a big challenge in different regions of the world. Among fish preservation methods, smoking is the mostly used method (Berkel et al., 2005; Nout et al., 2003; Toth & Potthast, 1984) [7,8,9]. It extends shelf life and confers special taste and aroma to the end products (Igwegbe et al., 2015; Yusuf et al., 2015) [10,11]. Smoking is one of the oldest food preservation technologies and can be used to achieve the characteristics of taste, colour and aroma for food (Djinovic et al., 2008) [12]. Fish smoking in the Philippines is one of the most popular fish products that not only provide food but also provide employment and provide additional to the fisher folks. However, foods are nowadays smoked for sensory quality rather than for preservative effect [11]. Yanar et al. (2006) [13] reported that the acceptance of smoked fish in developed countries is based primarily on the sensory characteristics it imparts to the products while Akin et al. (2013) confirmed the nutritional qualities and adequacies [14].

In this study, skipjack tuna was smoked using indigenous herbs to assess its effect on the aroma odor and flavor of the tuna smoked products. Pandan *(Pandanus amaryllifolius*) leaves are some plants that mostly grow in southern Asia and usually grow wild in your garden. In some countries such as Indonesia Pandan (*Pandanus amaryllifolius*) is one of the needed ingredients to make traditional or even daily food so that it can taste more delicious. It's fragrant, also smells good and raises your appetite. Health benefits of Pandan (*Pandanus amaryllifolius*) Leaves for some treatment are very potent. Based on many long term studies and observations Pandan (*Pandanus amaryllifolius*) leaves occur to have so many benefits for health. It can be a natural and safe traditional cure. It is also recommended by some doctors to help you boost your health (Team, H., 2022) [15]. The benefits of tamarind (T*amarindus indica*) leaves are versatile. They contribute as much to medicine as they do to cuisines. Its cathartic, astringent and antiseptic properties makes it an important element in Ayurveda while the light tart flavour that its leaves impart makes it a viable ingredient in Indian cuisines (Vasant RA, Narasimhacharya AV. (2012) [16].

II. METHODOLOGY

An experimental and developmental method of research was used in this study. Three (3) treatments and two 3 replicates were applied to determine the best smoke flavor enhancer of the hot smoked tuna.

2.1 Preparation of the Raw Material- 50 kilograms Fresh Skipjack Tuna (Katsuwonus Pelamis) were obtained directly to the fish operator at Lagonoy Gulf, Philippines. The Skipjack Tuna (Katsuwonus Pelamis) were chilled in the icebox. After reaching the laboratory they were immediately washed with tap water. The tuna fish were cut into chunk and soak in 10% brine solution for 30 minutes to leach out the blood.

2.2 Preparation of Enhancers. The tamarind (*Tamarindus indica)* and Pandan *(Pandanus amaryllifolius)* leaves extract as done by boiling the 1 kilogram Pandan *(Pandanus amaryllifolius)* and tamarind *(Tamarindus indica)* leaves were added 5 kilos of water boiled separately for 30 minutes. After boiling the leaves were removed and while the boiled water was still hot, salt was added at the different percentage, 10% (T1), 15%(T2) and 20% (T3) then the tuna chunks were soaked for one hour to absorb the aroma and chemical content extracted from herbs during boiling. This process is applied to both enhancers, the tamarind (*Tamarindus indica*) and Pandan (*Pandanus amaryllifolius*) leaves. The best formulation was repeated for producing the best and quality smoked skipjack tuna and named as Sample 1 (S1) is the control, Sample 2 (S2) is the Tamarind (*Tamarindus indica)* leaves enhancer and Sample 3 (S3) with Pandan (*Pandanus amaryllifolius*) Leaves.

2.3 Smoking. All Treatments were smoked for 1 hour at 100^0C using the fabricated smokehouse. After smoking products were subjected to sensory evaluation.

2.4 Sensory Analysis. All treatments were undergone a consumer preference test. The products were presented to 30 sensory panels consisting of fisher folks, College students and teachers. 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 determined using the 9-point hedonic scale (1-dislike extremely).

2.5 Microbial load/count. The analysis of coliform count, E. coli count, Rapid yeast and molds count and Total plate count was determined using the Official

Analytical Chemists method (AOAC 2021 Ed.). The Analysis was carried out in the DOST V Laboratory. This microbial parameter is the FDA requirements.

2.6 Statistical Analysis. The results are expressed as means and standard deviation and analyzed using two ways Analysis of Variance (ANOVA) using SPSS version 17.0. T-test and Post-hoc analysis were used to determine which the samples are more acceptable.

III. RESULTS AND FINDINGS

3.1 The Most Preferred Salt Solution using Flavor Enhancer on Hot-smoked Skipjack Tuna (Katsuwonus Pelamis)

Smoking of fish products is one of the most ancient processing technologies. It has been used for preservation and is still widely used by several communities in the third world where up to 70% of the catch is smoked for preservation (Begum, M., al., 2013).

Hot smoked flavored tuna is a delicious product and packaging conditions are limited factor to limit shelf life. In this study, the best smoke flavor enhancer was analyzed through consumer preference test. Gatchalian, M. 1985[17] stated that the ultimate fate of manufactured good is in the hands of the end-users.

Considering the power of consumers to select the best products, the result of the analysis on some quality aspect of hot processed smoked flavored Skipjack Tuna (Katsuwonus Pelamis) was shown in Tables presented in the succeeding pages.

Table 1: *Level of preference of Hot- Smoked skipjack tuna (Katsuwonus pelamis) without smoke flavor enhancer at different ratio of salt and enhancer*

Attributes	T1	T2	T3
Color	4.81±2.28 [a]	5.53±1.85 [a]	5.91±2.62 [a]
Flavor	5.66±1.58 [a]	5.66±1.81 [a]	6.75±1.22 [b]
Texture	5.69±1.69 [b]	5.06±1.54 [a]	6.16±2.00 [a]
Odor	4.42±1.89 [a]	5.45±2.17 [a]	5.52±2.55 [a]
Gen. Acceptability	5.84±2.17 [a]	5.50±2.09 [a]	5.97±1.47 [b]

*Different letters in the same row show significant among samples at (P<.05). values are shown as mean = sd of triplicate measurement

Table 1 shows the preference test of smoked skipjack tuna without flavor enhancer used. It was revealed that in terms of flavor and general acceptability the T3 or the 1:5 ratios of salt and water without enhancer are more acceptable than T1 AND T2. In terms of color texture and odor there was no significant difference of using different percentages of salt solution of soaking fish for one hour. It means that the color texture and odor are not affected by the different salt solutions.

Table 2: *Level of preference of Smoked skipjack (Katsuwonus Pelamis) tuna using Tamarind zleaves flavor enhancer at different ratios of salt and enhancer.*

Attributes	T1	T2	T3
Color	7.16±1.46[a]	6.87±1.96 [a]	6.56±2.16 [a]
Flavor	7.25±1.62 [a]	6.53±1.87 [a]	7.19±1.81 [a]
Texture	7.15±1.46 [a]	6.87±1.96 [a]	6.56±2.16 [a]
Odor	6.90±2.19 [a]	6.97±2.16 [a]	6.81±2.24 [a]
Gen. Acceptability	7.94±1.65 [a]	7.28±1.57 [a]	7.56±1.79 [a]

*Different letters in the same row show significant among samples at (P<.05). values are shown as mean = sd of triplicate measurement

The level preference of the sensory panelist on smoked skipjack tuna using tamarind *(Tamarindus indica)* leaves as flavor enhancer is shown in Table 2. It was noted that all physical attributes of smoked were not affected with the different percentage of salt added to the boiled water with tamarind enhancer. However, as noted in the ratings of the sensory panelist it shows that tamarind contributed quality of smoked skipjack tuna in all physical attributes regardless of applying different salt solution concentration. Salan et al. (2006) [18] explained and observed that smoking inhibits microbial growth in stored fish products. The use of salt together yielded the best outcome compared to the salt alone as it retained the more useful nutrient property,

lower moisture, higher fat, ash and protein. Salt removed water from fish bodies and thus helped through smoking, whereas salt not only removed water from fish but also added some nutrients that prevented the growth of molds and bacteria due to the creation of an unfavorable expansion medium retaining the good taste. Although in the present study is using different enhancers it also shows that using salt using flavor enhancer contributed to improve the quality of smoked products.

Table 3: *Level of preference of Smoked skipjack tuna (Katsuwonus Pelamis) using Pandan (Pandanus amaryllifolius) leaves flavor enhancer at different ratios of salt and enhancer.*

Attributes	T1	T2	T3
Color	5.87±1.83 [a]	6.06±2.06[b]	7.15±1.63 [b]
Flavor	5.97±180 [a]	6.21±2.09 [a]	7.84±1.43 [b]
Texture	6.90±2.19 [b]	6.96±2.16 [a]	6.80±2.24 [a]
Odor	7.43±1.50 [a]	5.62±1.66 [a]	5.66±2.55 [a]
Gen. Acceptability	6.63±1.26 [a]	6.31±1.80 [a]	7.88±1.29 [b]

*Different letters in the same row show significant among samples at (P<.05). values are shown as mean = sd of triplicate measurement

The smoked skipjack tuna treated with Pandan (*Pandanus amaryllifolius*) there was no significant difference using different percentages of salt in terms of texture and odor. On the other hand, there was a significant difference in the color, flavor and general acceptability. Hence, the most preferred percentage is 20% salt added to the boiled water with Pandan (*Pandanus amaryllifolius*) leaves. Results also indicate that Pandan (*Pandanus amaryllifolius*) extracts improve the flavor and color of the smoked products. According to Cheetangdee V., and Chaiseri S., (2006) [19] that Pandan (*Pandanus amaryllifolius*) leaves extract contains the free amino acids and reducing sugars such as glutamic acid, proline, glucose, and fructose as possible precursors to ACPY (2-acetyl-1-pyrroline) and might play significant role in the aroma ACPY formation. The major volatile compounds in heated Pandan (*Pandanus amaryllifolius*) and unheated Pandan (*Pandanus amaryllifolius)* are 3-methyl-2(5H)-furanone followed by ACPY and 3-Methyl2(5H)-furanone respectively. They also found that ACPY is the only compound that possessed Pandan (*Pandanus amaryllifolius*) aroma characteristic by using GCO (gas chromatography-olfactometry) analysis.

3.2 Effect of Flavor enhancer on Quality of Hot-Processed Smoked-Flavored Skipjack Tuna (Katsuwonus pelamis)

3.2.1 Descriptive characteristics of smoked Skipjack Tuna (Katsuwonus pelamis)

Flavor is usually more important in determining consumer acceptance of foods than appearance or texture. Generally sweet and salty tastes seem to increase liking and sour and bitter taste decrease (Opeña, A.M., et. al. 2017) [20]. Using herbs in fish smoking are common to improve the aroma, flavor and odor. Lesschaeve and Issanchou (1996)[21] found that odor memory is more related to previous experience of a subject with an odor than with training a subject to recognize an odor. Odorants are small molecules, usually less than 1 kDa.

Table 4: *Summary of Descriptive Characteristics of the Smoked Skipjack Tuna (Katsuwonus Pelamis) with Flavor Enhancers*

Attributes	S1	Description	S2	Description	S3	Description
Color	5.42	Neither like nor dislike	6.86	Like moderately	6.36	Like slightly
Flavor	6.02	Like slightly	7.99	Like very much	7.67	Like very much
Texture	5.54	Like slightly	6.86	Like moderately	6.89	Like moderately
Odor	5.13	Neither like nor dislike	6.89	Like moderately	7.74	Like very much
Gen. Acceptability	5.77	Like slightly	7.59	Like very much	6.94	Like moderately

On this present study as shown Table 4. It was revealed that the use of Pandan (*Pandanus amaryllifolius*) extracts that the odor is 7.74 or like very much as rated by the panelist. The Mean scores also shows that the flavor of using tamarind (*Tamarindus indica*) and Pandan (*Pandanus amaryllifolius*) leaves extracts was rated like very much with the rating 7.99 and 7.67 respectively. Generally, the result showed that the use of tamarind (*Tamarindus indica)* and Pandan (*Pandanus amaryllifolius) leaves extracts is accepted by the sensory panelist as good* smoked enhancers.

Furthermore, at a glance on Table 4 Tamarind (*Tamarindus indica*) extracts are the most acceptable as compared to Pandan (*Pandanus amaryllifolius*) extracts and the control.

3.3 Analysis of Variance (ANOVA) on the Different Sensory Attributes of on Quality of Hot-Processed Smoked-Flavored Skipjack Tuna (Katsuwonus pelamis)

3.3.1 Results of ANOVA on color of smoked products with flavor enhancer

Analysis of variance was used to differentiate the actual sensory attributes of smoked skipjack tuna. T-test and Post-hoc analysis were used to determine which the samples are more acceptable.

Table 5 shows the results of ANOVA to determine the significant difference among treatments. As revealed P< 0.05, hence, there was significant difference in means between three samples. This indicates that the color of the three samples are different. Using the t-test and Post-hoc analysis it revealed that color Sample 1 of smoked skipjack tuna (5.42±1.58) were significantly lower as compared to sample 2 (6.85±1.51) and sample 3 (6.35±1.35). This results indicates that the color of the smoked skipjack tuna with flavor enhancer is the most preferred and moderately acceptable of the panelists. Some of the panelists said that the color of smoked skipjack tuna is light brown to golden brown.

Although the golden color may not be dependent on flavor it is also associated with the kind of wood used. Flick, G. J., (2010)[22] stated that The characteristic golden color of smoked seafood products is due to the interaction of carbonyls with amino components on the flesh surface. It has also been found that as fish spoils, amine compounds become increasingly important in determining the extent of browning. Phenols released from wood also contribute to the formation of brown color on the product being smoked although the intensity is not as big as carbonyl (Leksono, T., 2020) [23].

Table 5: *Results on Analysis Variance (ANOVA) on Color of Smoked Skipjack Tuna (Katsuwonus pelamis) with Flavor Enhancers*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	34.08333	2	17.04167	7.006693	0.001464	3.094337
Within Groups	226.1944	93	2.432198			
Total	260.2778	95				

3.3.2. Results of ANOVA on Flavor of smoked products with flavor enhancer

There is a good deal of evidence that the sensory characteristics of food, in particular the taste and flavour, have a very specific effect on the consumers' food choice. In many ways the sensory attributes could be seen as a key area in which food manufacturers can differentiate their products (Clark, J.E., ,1998)[24]..Individual differences in flavor perception are regarded as noise by some researchers, but are actually very real and can tell us many things about people as instruments.

They can be genetical, for example inherited color-blindness, ability to taste phenylthiocarbamide, etc. They can be physiological, for example saliva production and perhaps differences in brain neurology[20].

Results of ANOVA on the sensory of evaluation on flavor of smoked skipjack tuna with flavor enhancer showed that P<.05 hence there was a significant among three samples of the smoked skipjack tuna. This indicates that smoked skipjack tuna treated with tamarind (Tamarindus indica) extracts is more palatable (7.00±1.33) than treated with Pandan (Pandanus amaryllifolius) extract (6.70±1.29) and the control (6.02±1.01).

The-is result may due the additional compound tamarind (*Tamarindus indica)* extract absorb by the tuna fish during soaking in the extract with salt. Arya, C. (1999); Jauregui, D.M., et.al., (2006) [25-26] said that Tamarind (Tamarindus indica) leaves retain amore empiric use.

As the fruits, tamarind (Tamarindus indica) leaves are also edible and are used to make curries, salads, stews and soups in many countries, but especially in times of scarcity, even when their protein ratios (4,0-5,8%) [27] are not too far from those reported for fruits (2,0-7,1%) [28].

In fact, most of the chemical studies of tamarind (*Tamarindus indica)* leaves are focused in their eatable properties, with flavonoid compounds as the only exception, which have been reported with certain frequenc

Table 6: *Results on Analysis Variance (ANOVA) on Flavor of Smoked Skipjack Tuna (Katsuwonus pelamis) with Flavor Enhancers*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	16.06183	2	8.030914	5.430487	0.005881	3.094337
Within Groups	137.5337	93	1.478857			
Total	153.5955	95				

3.3.3. Results of ANOVA on Texture of smoked products with flavor enhancer

The texture of tuna fish meat is associated with the muscle fiber density and depends on a number of intrinsic biological factors [(29).] Higher values ($p<0.05$) of cohesiveness and resilience probably indicate better textural attributes of ordinary muscle because cohesiveness and resilience are both measures of the elasticity of muscle (Liu, S., et al., 2014) [30]. Table 6 shows the results on ANOVA on texture of the smoked skipjack tuna. It was noted that since P> .05 therefore was no significant differences among samples it means the panelist rated the samples like moderately. This present study was similar to other findings of some other studies that the texture measurements of samples showed a range between 6.17 to 10.10 N and there were no significant differences ($P > 0.05$) between samples from different producers. Although Gómez-Guillén et al. (2009) [31[found that the texture of different smoked fish (dolphinfish, blue whiting, fatty sardine, lean sardine) were in the range of 15 to 27 N at different storage times. Andersen et al. (1997) [32] noted that the possible factor affecting the difference in texture measurement values was fat content, however Mørkøre et al. (2001) [33] reported that smoked Atlantic salmon texture was not related to its fat content. Sigurgisladottir et al. (2000) [34] stated that location and season where fish was harvested and processing steps, gave a more significant effect on the texture of the end product.

Table 6.1: *Results on Analysis Variance (ANOVA) on Texture of Smoked Skipjack Tuna (Katsuwonus Pelamis) with Flavor Enhancers*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	8.017233	2	4.008616	2.252733	0.110818	3.094337
Within Groups	165.4884	93	1.779445			
Total	173.5057	95				

3.3.4. Results of ANOVA on Texture of smoked products with flavor enhancer

The data in Table 7 showed that P<.05 hence there was a significant difference among the sample. Using the t-test and Post-hoc analysis it revealed that odor of Sample 1 of smoked skipjack tuna (5.22±1.52) were significantly lower as compared to sample 2 (6.93±1.80) and sample 3 (6.93±1.80). The differences may be due to the used tamarind (Tamarindus indica) and Pandan (Pandanus amaryllifolius) extract and from the chemical compound from the wood used for smoking. Sayuti, M., et al., 2021[35] said that changes in the smoked fish taste and odor were caused by carbonyl and phenol compounds in the smoke Kostyra & Baryłko-Pikielna (2006) [36] contended that carbonyl and phenol compounds or their derivatives contribute to the typical colors, flavor, and aroma of smoked product

3.3.5. Results of ANOVA on Texture of smoked products with flavor enhancer

As reflected in Table7, the general acceptability indicates that P< .05 therefore there was a significant difference among samples. It also shows that the sample 1 is Sample 1 of smoked skipjack tuna (5.77±1.36) were significantly lower as compared to sample 2 (6.94±1.04) and sample 3 (6.94±1.04). This result implied that smoking skipjack tuna using tamarind (Tamarindus indica) and Pandan (Pandanus amaryllifolius) extracts during the process improves the quality of smoked skipjack tuna. However, further studying on the chemical and microbiological content must be done.

Table 7: *Results on Analysis Variance (ANOVA) on Texture of Smoked Skipjack Tuna (Katsuwonus pelamis) with Flavor Enhancers*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	62.25926	2	31.12963	10.65161	6.835E-05	3.094337
Within Groups	271.7951	93	2.922528			
Total	334.0544	95				

Table 7: *Results on Analysis Variance (ANOVA) on General Acceptability of Smoked Skipjack Tuna (Katsuwonus pelamis) with Flavor Enhancers*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	29.03704	2	14.51852	10.82463	5.94E-05	3.094337
Within Groups	124.7361	93	1.341249			
Total	153.7731	95				

VI. CONCLUSIONS

Smoked Skipjack Tuna (*Katsuwonus pelamis)* using tamarind (*Tamarindus indica*) and Pandan (*Pandanus amaryllifolius*) leaves extract are significantly different in terms of color, flavor odor and to the general acceptability of smoked products. Therefore, the tamarind (*Tamarindus indica)* and panda extract is good flavor enhancer in smoking fish. However further studies on keeping quality and chemical content of the products is recommended

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REFERENCES

[1] Asiedu, B. et.al 2015. The performance of tuna processing fishery sector to sustainable fish trade and food security in Ghana. JENRM, Vol. 2, No. 1, 8-14, 2015 Research Article

[2] FAO.2014. The state of world fisheries and aquaculture 2014. Rome, FAO., 223 p

[3] FAO. 2009.The state of world fisheries and aquaculture 2008. Rome, FAO. 162 p.

[4] Delgado, C. L., Wada, N., Rosegrant M. W., Meijer S. and Ahmed, M.2003. Outlook for fish to 2020: meeting global demand. Food Policy Report. Washington (D. C.): International Food Policy Research Institute. 28 p.

[5] Market Intelligence Team, (2020). 2020 Industry Report: Tuna. https://cdn.tridge.com/market_report_report/1e/6d/f5/1e6df56b91050b8e71746afcefcbf596bcf491c4/Tuna_Market_Report.pdf

[6] FAO, 2015. FishstatJ. Available at: <http://www.fao.org/fishery/statistics/software/fishstat/en>.

Google Scholar

[7] Berkel, B. M. V., Boogaard, B. V. D., & Heijnen, C. (2005). Smoking. In M. Goffau-Markusse (Ed.), Preservation of fish and meat, Agrodokseries 12.86 (3rd edn.). Agromisa Foundation. Retrieved from http:// www.agromisa.org/wp-content/uploads/Agrodok-12-Preservati on-of-fish-and-meat_sample.pdf

[8] Nout, R., Hounhouigan, J. D., & Van Boekel, T. (2003). Les Aliments: Transformation, conservation et qualité [Foods: Processing, conservation and quality]. The Netherlands: Backhuys Publishers.

[9] Toth, L., & Potthast, K. (1984). Chemical aspects of the smoking of meat and meat products. Advances in Food Research, 29, 87–158.

[10] Igwegbe, A. O., Negbenebor, C. A., Chibuzo, E. C., Badau, M. H., & Agbara, G. I. (2015). Effect of season and fish smoking on heavy metal contents of selected fish species from three locations in Borno State of Nigeria. Asian Journal of Science and Technology, 6(2), 110–1019.

[11] Yusuf, K. A., Ezechukwu, L. N., Faykoya, K. A., Akintola, S. L., Agboola, J. I., & Omoleye, T. O. (2015). Influence of fish smoking methods on polycyclic aromatic hydrocarbons content and possible risks to human health. African Journal of Food Science, 9(3), 126–135. https://doi.org/10.5897/AJFS2014.1227

[12] Djinovic J Popovic A, Jira W (2008). Polycyclic aromatic hydrocarbons (PAHs) in different types of smoked meat products from Serbia. Meat Science, 80:449-456.

[13] Yanar Y, Celik M, Akamca E (2006). Effects of brine concentration on shelf-life of hot- smoked tilapia stored at 4oC. Food Chem. 97:244-247

[14] Akintola SL, Brown A, Abdullahi B, Osowo OD, Bello BO (2013). Effects of Hot Smoking and Sun Drying Processes on Nutritional Composition of Giant Tiger Shrimp (Penaeus monodon, Fabricius, 1798) Pol. J. Food and Nutr. Sci. 63(4):227-237

[15] Team, H., (2022). 24 Health Benefits of Pandan (Pandanus amaryllifolius) Leaves (No.1 Surprising You). Dr.HealthBenefit.com

[16] Vasant RA, Narasimhacharya AV. Ameliorative effect of tamarind (Tamarindus indica) leaves on fluoride-induced metabolic alterations. Environmental health and preventive medicine. 2012 Nov;17(6):484. [Cited 27 June 2019]. Available from:https://environhealthprevmed.biomedcentral.com/articles/10.1007/s12199-012-0277-7

[17] Gatchalian, M. (1985). Quality Assesment through Statyisitically- Based Sensory Evbaluation method. https://www.deepdyve.com/lp/emerald-

publishing/quality-assessment-through-statistically-based-sensory-evaluation-N6dydpwGIg

[18] Salan, O.E., Juliana, A.G., Marilia, O., 2006. Use of smoking to add value to salmon trout. Brazilian Archives of Biology and Technology 49(1), 57-62.

[19] Cheetangdee V., and Chaiseri S., (2006). Free Amino Acid and Reducing Sugar Composition of Pandan (Pandanus amaryllifolius) (Pandan (Pandanus amaryllifolius)us amaryllifolius)Leaves. Kasetsart Journal - Natural Science, Vol 40 (Suppl.).. https://www.researchgate.net/publication/228502036

[20] Opeña, A.M.,et. al. 2017. Sensory, organoleptic, and proximate composition of smoked surgeon fish Acanthurus sp. using selected herbs as flavor enhancer. International Journal of Food Science and Nutrition ISSN: 2455-4898, Impact Factor: RJIF 5.14 www.foodsciencejournal.com Volume 2; Issue 1; January 2017; Page No. 174-181.

[21] Lesschaeve I, Issanchou S., (1996). Effects of panel experience on olfactory memory performance: influence of stimuli familiarity and labeling ability of subjects. Chem. Senses.; 21:699-709

[22] Flick, G. J., (2010). Smoked Fish Old Product with New Appeal Offers Enhanced Taste, Shelf Life. global aquaculture advocate. https://ucanr.edu/sites/camasterfoodpreservers/files/335818.pdf

[23] Leksono, T., et al. (2020). The effect of different variety of fire-woods on smoking of selais catfish (Cryptopterus bicirchis). IOP Conf. Series: Earth and Environmental Science 4

[24] (Clark, J.E., ,1998).. Taste and flavour: their importance in food choice and acceptance. Proceedings of the Nutrition Society

[25] Arya, C. (1999) Res J Chem Envirom. 3: 305-17.

[26] Jauregui, D.M., et.al., (2006). Revista de Fitoterapia,6: 79-82.

[27] Duke, JA. Handbook of Legumes of World EconomicImportance. Plenum Press, New York, USA, pp 228-230, (1981)

[28] Ishola MM, Agbaji EB, Agbaji AS.J. Sci. Food Agric., 51:141-143, (1990)

[29] Zhao J, Li JR, Wang JL, Lv WJ (20112). Applying different methods toevaluate the freshness of large yellow croacker (Pseudosciaenacrocea) fillets during chilled storage. J. Agr. Food Chem. 60: 11387-11394

[30] Xiangyang Li, Shulai, et al., (2014). Comparative Study of Basic Characteristics of Ordinary and DarkMuscle in Skipjack Tuna (Katsuwonus pelamis), Food Sci. Biotechnol. 23(5): 1397-1404 (2014)DOI 10.1007/s10068-014-0191-4

[31] Gómez-Guillén MC, Gómez-Estaca J, Giménez B, Montero P (2009). Alternative fish species for cold-smoking process. Int. J. Food Sci. Technol. 44:1525-1535.

[32] Andersen UB, Thomassen MS, Røra AMB (1997). Texture properties of farmed rainbow trout (Onchorhynchus mykiss): effect of diet, muscle fat content and time of storage on ice. J. Sci. Food Agric. 74:347-353.

[33] Mørkøre T, Vallet JL, Cardinal M (2001). Fat content and fillet shape of Atlantic salmon: relevance for processing yield and quality of raw and smoked products. J. Food Sci. 66:1348-1354

[34] Sigurgisladottir S, Sigurdardottir MS, Torrissen O, Vallet JL, Hafsteinsson H (2000). Effect of different salting and smoking processes on the microstructure, the texture and yield of Atlantic salmon (Salmo salar) fillets. Food Res. Int. 33:847-855.

[35] Sayuti, M., et al., (2021). Chemical composition and hedonic test of asar fish (smoked Katsuwonus pelamis) from Sorong, West Papua, Indonesia. AACL Bioflux, 2021, Volume 14, Issue 5. http://www.bioflux.com.ro/aacl

[36] Kostyra E., & Baryłko-Pikielna N., 2006 Volatiles composition and flavour profile identity of smoke flavourings. Food Quality and Preference 17(1–2):85–95. http://doi.org/10.1016/j.foodqual.2005.06.008