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Physico-Chemical Characteristics and Microbiological Contamination Smoked Skipjack Tuna (*Katsuwonus pelamis*) Using Canary and Candlenut Shell Smoking Materials

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Abstract: Fish is one of the export commodities from marine products that need to be developed for processing methods. One method of preserving fish that is widely used is smoking. The aims of this study were: to determine the physicochemical properties and the content of microbiological contamination in smoked skipjack tuna using canary shells and candlenut shells as fumigants. The quality of smoked skipjack tuna tested were aw, moisture content, protein content, fat content, ash content and microbiological contamination test (*Salmonella*, *Escherichia coli*, *Staphylococus aureus*). Of the two types of smoked fish smoked using canary shells and candlenut shells, the best chemical parameter values for smoked fish using candlenut shells were smoked where the Aw value was 0.95%, the water content was 56.23%, the protein content was 37.76. %, fat content was 2.21%, ash content was 2.41%, and carbohydrate content was 0.99%. Overall, the smoked fish analyzed had quality standards that were in accordance with Indonesian National Standard. Total plate number analysis on smoked fish using canary shell smoked materials were 2.19 x 103 colonies/g, while smoked fish using candlenut shell smoked materials was 2.09 x 101 colonies/g. For the lowest total plate number, smoked fish uses candlenut shell fuel and the highest is smoked fish using canary shell smoker. *E. coli* analysis results for both types of smoked fish are the same, namely < 3 APM/g. Also *S.aureus* has the same value as well as *Salmonella* analysis results for both types of smoked fish are negative.
Keywords : skipjack tuna-smoking, canary, candlenut.

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1. Introduction

Fish smoking is one of the oldest processing technologies that have been traditionally practiced for many years. North Sulawesi has one of the famous products that are processed by smoking, namely smoked skipjack tuna. Skipjack tuna (*Katsuwonus pelamis*) is a type of pelagic fish that belongs to the Scombridae family and is widely distributed in Indonesian waters. North Sulawesi is one of the areas with the largest skipjack tuna potential in Indonesia, thus making skipjack tuna an important non-oil and gas export commodity for North Sulawesi Province (Department of Marine and Fisheries of North Sulawesi Province, 2015). Smoking is a process of penetrating volatile compounds in fish produced from burning wood which has been recorded to produce products with specific tastes and aromas[1]. The content of several phenols, formaldehyde and other compounds originating from smoke seeps into fish meat and functions as a preservative to extend the shelf life of the final product and provides its own delicious, savory taste with a distinctive aroma caused by the smoking process[2,3,4].

Seeing the potential of smoked skipjack tuna as a mainstay local product of North Sulawesi, it is necessary to improve the quality so that it is more desirable and consumers still get security guarantees in consuming these products, and also increase the storage time of smoked skipjack tuna in order to extend the sales distribution chain. For this reason, in this study, canary shells (*Canarium indicum* L.) and candlenut shells (*Aleurites moluccana* L.) will be used as fumigants derived from the waste of ripe and dried canaries and candlenuts.

Canary shells are a waste generated in the production of canary seeds, and in North Sulawesi it is available in large quantities. Canary shell has higher lignin content when compared to wood in general. The lignin content contained in the material will determine the aroma of the smoked products, because the pyrolysis process of lignin will produce phenolic compounds and phenolic ethers such as guaiacol and syringol which affect the aroma of smoke[5].

Candlenut shells in Indonesia are a by-product of processing candlenut seeds. This food waste has not been used optimally. It is estimated that candlenut shells can be used as raw materials for making activated charcoal and smoking materials. It is suspected that candlenut shells contain high levels of wood materials such as lignin, cellulose and hemicellulose.

The area of candlenut forest managed is 9,299 ha with a production of ± 3,675.40 tons/year. Candlenut shell waste in general has not been widely used or managed to increase its selling value in the market. 70% of the shell content in candlenut so far has only been waste that has not been fully utilized. Innovation is needed in the management of candlenut shell waste. In order to maximize the increase in the economic value of the candlenut plant, it is necessary to verify it into a product with a high economic value by utilizing the candlenut shell as the main ingredient for making briquettes. Candlenut shell contains 49.22% holocellulose and 54.46% lignin. The high lignin content has the potential to make charcoal which produces a high calorific value.

2. Experimental

The research was conducted based on the following procedures:

a. The raw materials for fresh skipjack tuna are purchased from a group of fishermen on the Island of Manado Tua

b. Skipjack tuna used weighs an average of 2 kg/head.

c. The fish are washed and removed from the gills and entrails then cut in half and clamped with bamboo.

d. A total of 10 clean skipjack tuna, each smoked using smoking materials for canary shells and candlenut shells, with each smoking time 3 hours each.

e. The smoking process is carried out on a fumigation furnace measuring 4 m long, 2 m wide and height 70 cm.

f. Each smoking treatment requires 100 kg of smoking material for one process to produce smoked fish products.

g. The smoking process lasts for 180 minutes until the fish is cooked and colored golden silver to golden yellow.

h. Smoked skipjack tuna products are then tested in the laboratory for knowing the physicochemical properties and the content of microbiological contamination.

Observational data have been analyzed using ANOVA with completely randomized design method with two replications. Observations of physicochemical parameters which include aw analysis followed the method of[6], analysis of water content, protein content, fat content, ash content, microbiological contamination following method of[7]. The data were displayed in the form of tables and histograms after which they are discussed using the latest theory and research results.

3. Results and Discussion

The results of the analysis of the physicochemical characteristics of skipjack tuna smoked with smoked canary shells and candlenut shells with a smoking time of three hours were presented in Table 1.

Table 1. Chemical content of smoked skipjack tuna with smoked canary shells and candlenut shells

Smoker	Aw	Water content (%)	Protein content (%)	Lipid content (%)	Ash content (%)	Carbohydrate (%)
Cannary shells	0,97 ±0,02	57,26 ± 0,09	35,04 ± 0,23	2,53 ± 0,04	2,42 ± 0,18	2,42 ± 0,18
Candlenut shells	0,95±0,07	56,23 ± 0,03	37,76 ± 0,02	2,21 ± 0,03	2,41 ± 0,33	0,99 ± 0,02

a. Test Value Aw

The test results of the Aw value of skipjack tuna smoked with smoked canary shells for a smoking period of 3 hours was 0.97% and those smoked with candlenut shell smoked ingredients were 0.95%. The results of the analysis showed that the Aw value of the candlenut shell was lower than the Aw value of the canary shell. This is because different smoke materials contain different chemical components and will produce different temperatures. According to[8] the difference in temperature of the smoking process is thought to be due to the different levels of cellulose and pentosan components in canary shells and candlenut shells and these differences can further cause the burning speed of these materials to be different, resulting in different heat.

b. Water Content

Based on the results of the analysis, it can be seen that the water content of smoked skipjack tuna smoked using canary shells is higher, ranging from 57.26%, where the smoked skipjack tuna using candlenut shell fuel is 56.23%, the lowest water content is in smoking using candlenut shells and the highest water content in smoked skipjack tuna using canary shells as fuel. The low water content will have an impact on the longevity of smoked skipjack tuna during storage. The drier the product, the longer it will last. Moisture content also affects the texture of the final product. If the water content is too high, the texture of the smoked fish becomes soft and not compact so that it affects consumer acceptance of the product. Drying, including smoking, can remove water contained in foodstuffs. As stated by[9] that the longer the drying time, the lower the water content in a food item. According to[10] that the greater the difference between the temperature of the heating medium and the smoked material, the greater the speed of heat transfer into the product material, so that the evaporation of water from the product will be more. Research results of[11] show similar results, in this case in the smoking process of fish meat, water loss in the initial phase which can be compared to the cooking period (3 hours, temperature of

800^{o}C), followed by the formation of a protective layer caused by the formation of carbonization and other components by wood smoke.

c. Protein Level

The highest protein content was found in smoked fish using candlenut shell fuel, which was 37.76%, while the lowest was found in smoked fish using canary shell fuel, which was 35.04%. Smoked fish is a product that contains high protein, like other fishery products. Protein is a food substance that is very important for the body because it functions as a source of energy, building blocks and regulators. Protein in fish has complete amino acids, both essential amino acids and non-essential amino acids. Smoking is one of the protein hydrolysis methods, the protein can be converted into value-added products through enzymatic hydrolysis, which is widely used to improve and enhance the nutritional properties of proteins. The data in Table 3 shows that there is no difference in protein content between the fumes, which is because the moisture content of smoked skipjack tuna products is relatively uniform, so the protein content produced also does not show a difference. This is also because protein content is often associated with water content, where if the water content of smoked skipjack tuna products is relatively high, the protein content will decrease due to the amount of protein that is still bound to water and vice versa with low water content will increase protein content. As reported by[6] that the protein content of smoked tuna in Spain were 15.4% - 34.5%. In this study, the protein content of smoked skipjack tuna from both smoking materials was higher than previously reported. According to[12] that with reduced water, protein levels increase. As mentioned by[13] the ability to absorb and convert protein is an important nutrient from the species, diet and local environment in which the fish live.

d. Fat level

The lowest fat content of smoked skipjack tuna was obtained from samples that were smoked using candlenut shell smoker, which was 2.21% and the highest was smoked fish smoked using canary shell smoker, which was 2.53% and not significantly different ($P > 0.05$). This shows that the use of canary shells and candlenut shells reduces the fat content due to the heat generated by the smoking materials. This is also because the length of time the smoking process was carried out is relatively the same, the closer the smoke source is to the product, the longer the smoking process time and the higher the smoking room temperature is expected to reduce levels of smoke. As reported by[6] that the average fat content of skipjack tuna smoked using beech wood were in Spain ranged from 1.4% to 3.8%. As stated by[14] that variations in fat content are influenced by place of life, season, food source, activity and growth phase.

e. Ash Level

Based on the results of the analysis, the lowest ash content was found in samples of smoked skipjack tuna using candlenut shell fuel, which was 2.41%. The highest ash content was found in samples of smoked skipjack tuna using canary shell smoker, which was 2.42%. Ash content is a mixture of inorganic or mineral components contained in a food ingredient. The results of this study indicate that the ash content is within the average range reported by[15], namely the ash content of smoked skipjack tuna ranging from 1.36% - 5.66%. Variations in composition can occur between species, between individuals within a species and body parts [16] and these variations can also be caused by several factors, including season, size, stage of maturity, ambient temperature and food availability[17]. The ash content gives an indication that smoked fish can be a good source of minerals such as calcium, potassium, zinc, iron and magnesium. As reported by[11] that the association between smoked fish products, protein content, fat content and ash content increased, due to reduced water content during the smoking process, specifically the ash content was generally due to increased salt content during the smoking process. Ash content is a parameter of the nutritional value of a product material produced by the components of inorganic substances contained in fish. According to[18] that in the smoke contained compounds that can prevent oxidation of fats. The results of the research by[19] that smoked tilapia have an ash content of 9.14%. Foodstuffs consist of 96% inorganic materials and water, while the rest are mineral elements. The ash content can show the total minerals in a food ingredient. Organic materials in the combustion process will burn but the inorganic components will not, because that is called the ash content[20]. The ash content is influenced by the length of smoking and the temperature used. The longer the smoking and the higher the temperature used, the higher the ash content of the smoked skipjack tuna products produced. In addition, the number of smoke particles attached to the surface of the fish can increase the ash content of smoked fish[21].

f. Carbohydrate Level.

Based on the results of the analysis of carbohydrates, the lowest was found in smoked fish that used smoked canary shells, which was 0.97%, while the highest was found in smoked fish using candlenut shells, which was 0.99%. The difference in proximate composition was caused by various factors such as the species of fish used, smoking method either hot smoking or cold smoking, smoking time, salting method either dry or wet method, and the concentration of added salt. Differences in the proximate composition of smoked fish and smoking conditions will affect the sensory quality, shelf life and product integrity[22].

g. Microbiological Contamination

The results of the analysis of the microbiological contamination of smoked skipjack tuna using smoking materials canary shells and candlenut shells were presented in Table 7.

Table 7. Microbiological contamination analysis of smoked skipjack tuna using materials smoker of canary shells and candlenut shells

Parameters	Analysis Results		Unit	Analysis method
	Canary shells	Candlenut shells		
Total plate number	2,19 x 10^3	2,09 x 10^1	CFU/g	SNI 2897:2008 item 4.1
Escherichia coli	< 3	< 3	APM/g	SNI 2897:2008 item 4.3
Staphylococcus aureus	0	0	Colony/g	SNI 2897:2008 item 4.4
Salmonella	Negative	Negative	Nrg/25g	SNI 2897:2008 item 4.5

The results of ALT analysis on smoked skipjack tuna using smoked canary shells were 2.19 x 103 CFU/g, while smoked skipjack tuna using smoked candlenut shells was 2.09 x 101 CFU/g. The lowest total plate number is for smoked skipjack tuna which uses candlenut shells as a smoker and the highest in smoked skipjack tuna using canary shells smoker. *E. coli* analysis results for both types of smoking materials were the same, namely <3 APM/gr. Also *S. aureus* was the same value as well as salmonella analysis results for both types of fuel were negative. The total plate number ALT is the entire colony that grows on foodstuffs or on finished products (BPOM, 2003). The ALT limit for foodstuffs is 106cfu/gram. According to[23] the growing colonies showed the total number of microorganisms present in the sample such as bacteria, molds and yeasts. For ALT analysis of smoked skipjack tuna using smoked candlenut shells was low, this was due to a good and hygienic smoking process. This is confirmed by the number of samples detected by *E. coli* and *Salmonella* indicating that there was no contamination of smoked skipjack tuna. *E. coli* is a strain of coliform which is a gram-negative that does not have aerobic spores to facultative aerobic rods and can ferment lactose by producing acid and gas at 350C for 48 hours. Contamination of foodstuffs can occur if sanitation and hygiene during processing are not carried out with hygiene[24]. Efforts to prevent transmission can be carried out by instilling understanding and awareness in workers about the importance of sanitation. *S. aureus* is a gram-positive that has a higher tolerance than other pathogenic bacteria. *S. aureus* bacteria live on the surface of the skin, nails and human respiratory tract. Processed products that undergo a heating process are easily contaminated by these bacteria through the hands of the processor, besides that, storage at temperatures that are in accordance with the optimum tolerance can cause the growth of these bacteria. *Salmonella* is a facultative aerobic gram-negative bacterium that is not spore and rod-shaped, mostly motile. Animal food and waste water are known to be good media for the growth of these bacteria. Salmonella can live in the intestines of humans and animals and develop into colonies in the excretion, salmonella transmission can occur during the transportation of raw materials or in the processing process.

4. Conclusions

1. Candlenut shells produces the best chemical parameter values in smoked fish using candlenut shells smoker where the Aw value 0.95%, water content 56.23%, protein content 37.76 %, fat content 2.21%, ash content 2.41 %, and 0.99% carbohydrate content. Overall, the smoked fish analyzed had quality standards that were in accordance with Indonesian National Standard.

2. The results of ALT analysis on smoked fish using canary shells smoked materials were 2.19 x 103 colonies/gr while smoked fish using candlenut shells smoked materials was 2.09 x 101 colonies/g. For the lowest total plate number, smoked fish uses candlenut shells fuel and the highest is smoked fish using canary shell smoker. *E. coli* analysis results for both types of smoked fish are the same, namely <3 APM/gr. Also *S. aureus* has the same value as well as *Salmonella* analysis results for both types of smoked fish are negative.

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