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Physico-Chemical Characteristics and Fatty Acid Profiles of Smoked Skipjack Tuna *(Katsuwonus pelamis)* from Several Producers in Bitung Municipality, North Sulawesi, Indonesia

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Abstract: This study was aimed to analyze the physico-chemical characteristics and fatty acid profiles of the skipjack tuna smoked using smoking material of coconut skin under traditional smoking technique of three producers (A, B, and C), in Bitung Municipality, North Sulawesi. The skipjack tuna smoked produced by Producer A contained the lowest water content anda_w, and the highest protein, fat, and ash contentand no significant difference ($P<0.05$) from those of Producer B and C.The fatty acid profile of the smoked skipjack of Producer Ashowed the lowest total saturated fatty acid (SFA) and the highestmonounsaturated fatty acid (MUFAandpolyunsaturated fatty acid (PUFA) and it was significantly different (P<005) from Producer B and Producer C.
Keywords : skipjack tuna, smoking, fatty acid profile, coconut skin.

Introduction

Fish smoking is one of the oldest fish processing technology traditionally done for many years. Smoking can be defined as volatile compound penetration process into the fish meat generated from wood burning which is known to be able to produce specific taste and aroma. Some phenolic contetn, formaldehyde, and other compoundsabsorbed in the flesh derived from smokes act as preservatives to prolong the storage duration of the end product and give peculiar good flavor with typical aroma produced by the smoking processs[3].

Skipjack tuna (*Katsuwonus pelamis*) is locally called "cakalang" is one of the most popular fish preserved through traditional smoking process in Bitung Municipality, North Sulawesi.Nevertheless, one of the problems faced in smoking process is no standard process implemented yet so that the quality of smoked fish produced can change. Different smoking temperature, different smoking duration, different number of smoking materials, different quality of smoking material, and different water content have caused different quality of smoked fish produced affecting the consumer's demand level[21].

The chemical compounds of smoking wood are generally phenol as antioxidant, organic acids, alcohol, carbonyl, hydrocarbon, and nitrogen compounds, such as nitrooxide[8], aldehyde, ketone, esther, and ether, attached on flesh surface andthen penetrate into the fish flesh[13].

According[2-3,6,21,24,32] fish shape, sampling location, and smoking methodaffect the smoked fish quality.Since information on the characteristic of smoked skipjack tuna in Bitung Municipality has not been available, this study was aimed at providing information on the physico-chemical characteristics and fatty acid profiles of smoked skipjack tuna produced by 3 producers in Bitung Municipality, North Sulawesi, using coconut skin as smoking material.

Materials and Method

Fresh skipjack tuna (*Katsuwonus pelamis*) samples were purchased from the local fish processors, and the coconut skin was collected from farmers in Bitung Municipality.The study used fish with mean weight of 2.5 kg/ind., cleansed, gill and intestine discarded, and the fish were divided by half and clipped within bamboo sticks. One-hundred and fifty individuals were taken and smoked using the coconut skin.The smoking process was carried out in a smoking room of 6 m long, 4 m wide, and 60 cm high. Each tretment needed 60 kg of smoking materials per cycle to have a smoked fish product. The smoking process was done for 180 minutes to have cooked fish and goldenish silver to goldenish yellow color.The smoked skipjacks were then characterized their physico-chemistry and fatty acid profile.The former, a_w, followed the method of[12], in which water content, protein, fat, and ashwere determined using AOAC method[5]. The fatty acid profile was carried out using Chromatography (GC 210A SHIMADZU).

Sample preparation

Ten grams of sample were homogenized in 10 ml of concentrated HCL, heated in a water bath at 70^{o}C until boiling about 30 minutes, cooled, extracted with 25 ml of diethyl ether, then vortex. Add with 25 ml of petroleum benzene(40-60^{0}C), and then vortex.Separate the clear upper part, poured into a 100 ml flask, and evaporate in the water bath at 60^{o}C by flowing nitrogen gas (N_2), then add ± 3 ml of 0.5 N Sodium methanolic, heated in the water bath at 60^o C for about 10 minutes**,** and after cooled, add 3 ml of 20% BF_3-$CH_3$0H solution. Reheat it in the water bath at 60^{o}C for about 10 minutes and cooled.Methyl-esther formed was then extracted with 1 ml of n-Heptane (vortex) and added with 2 ml of saturated NaCl, so that 2 layers were formed**.** One-µl of the upper layer was injected into GC at the running condition of 140^{0}C-260^{0}C**,** column length of 30m, RTX-5-semipolar column, He gas carrier,Flame Ionization Detector (FID).

Statistical Analysis

Data were analyzed using 0ne-Way ANOVA to estimate the effect of physico-chemical composition and fatty acid profile of the smoked fish processed by Producer A, Producer B and Producer C. The statistical analysis used version 20-SPSS Software (Chicago,IL, USA). The value was expressed as mean and standard deviation at P<0.05.

Results and Discussion

Deskripsi rata-rata (mean) dan keragaman SD variabel pada ketiga perlakuan Produsen A, Produsen B dan Produsen C, shown in Table 1.

Table 1. Physico-chemical content of smoked skipjack tuna in 3 producers in Bitung Municipality, North Sulawesi Province.

Treatment	Chemical Parameters				
	a_w	Water Content (%)	Protein (%)	Fat (%)	Ash(%)
Producer A	0.94±0.006a	57.04±0.742a	37.76±1.484a	1.80±0.146a	2.33±0.315a
Producer B	0.96±0.007a	58.48±2.028a	35.96±0.026a	1.22±0.155a	2.20±0.195a
Producer C	0.95±0.008a	57.38±2.335a	37.44±3.457a	1.37±0.542a	2.11±0.116a

Note: similar alphabets in the same column indicate no difference between treatments (P>0.05)

The physico-chemical compositiion data of the smoked skipjack show that $a_w$values of the producers range from 0.94 to 0.96. Statistical analysis found no difference in $a_w$values of the smoked productbetween treatments (P>0.05). It could result from the use of same smoking material and relatively same smoking duration so that water content reduction of the flesh is relatively same as well.The present study found that the smoked fish $a_w$of the three producers was lower than previous report. [12]Fuentes A et al reported that the average $a_w$value of the skipjack tuna smoked using beech in Spain ranged from 0.92 to 0.96

Water content analysis of the smoked skipjack of the studied producers ranged from 57.04 % - 58.48 %. Statistical analysis found no difference in water content of the smoked skipjacks between the producers (P>0.05). The lowest water content ccurred in producer A, 57.04% and the highest in producer B, 58.48%.It could result from relatively same smoking material and number of smoking materials used by the three producers, so that the produced heat degree is relatively the same, in which distance of smoke source and length of smoking duration could result in low water content of the smoked fish. According[11,22] longer the smoking duration and higher smoking room temperature could bring about low water content of the smoked fish.Heat from the burning causes drying process which could reduce the water content of fish tissue through smoking process[17]. Also stated that water content reduction from product evaporation is affected by air temperature and surrounding environmental humidity[29].

The loss of water content of the smoked fish could result from hot smoking process[19], in which the water content of catfish *(Clarias gariepinus)*smoked for 4 hours at 100^0C in Nigeriapossessed mean water content between 10.86% and 26.50%, while [28]Swastawati F. reported that mean water content of milkfish *(Chanos chanos)*smoked for 3 hours at 40^0C to 80^0C was 68.11%. The present study also found lower water content of smoked skipjack tuna than previous reports. Toisuta B.R. et al found that the higher the difference between heating media and smoked materialis, the faster the heat moves into the product material causing water evaporation of the product be higher.

The protein content of the smoked skipjacks from all producers ranged between 35.96% to 37.76%, and there was no significant difference in the product protein level between producers (P>0.05).Since protein level is often related with water content, the protein level is influenced by flesh water content, in which higher water content will result in lower protein level and vice versa[17]. The highest mean protein level was recorded in the smoked skipjack of producer A (37.76 %) andthe lowest in producer B (35.96 %). Fuentes A et al reported that protein level of the smoked tuna in Spain ranged from 15.4% to 34.5%. the present study found higher smoked skipjack protein level than previously reported. Vasiliadou S et al stated that reduction in water content causes increased protein level.

Fat content of the smoked skipjack ranged from 1.22% to 1.80%. There is no significant differencein fat content of the smoked skipjack product (P>0,05). Nevertheless, producer A produced the highest fat content, 1.80 % and producer B produced the lowest fat content, 1.22%. It could result from relatively similar smoking duration among the producers. The closer the smoke source to the product, the longer the smoking duration, and the higher the room temperature, the higher the fat level of the fish will be reduced through axidation. Ahmed E.O et al found that increased protein and fat levels could result from reduction of water content during the smoking process. Also found that fat level variation is affected by habitat, season, food source, aktivita and growth phase[7].

Ash level analysis of the smoked skipjack tuna ranged from 2.11% to 2.33%. there was no significant difference in ash level of the smoked fish between producers in Bitung Municipality (P>0.05).It could result from relatively same processing method, in which there was no salt addition producing low ash level. Ahmed E.O et al reported that increased protein, fat, and ash could result from reduction of water content, particularly ash level due to increased salt content during the smoking process.The ash level is nutritive value parameter of the product material generated from inorganic components of the fish flesh. According to Pokorny J et al[23] smoke contains compounds capable of preventing the oxidation of fat. [10]Daramola J. A et al found that the ash level of Tilapia (*Oreochromis niloticus*) was 9.14 %. Fatty acid profile of the smoked skipjack tuna is presented in Table 2.

Table 2. Fatty acid profile of the smoked skipjack in three producers in Bitung Municipality, North Sulawesi Province.

Fatty Acids	Producer		
	Producer A (%)	Producer B (%)	Producer C (%)
Capricacid(C10:0)	0.035±0.005a	0.057±0.006a	0.058±0.008 a
Lauric acid (C12:0)	0.110±0.064a	0.048±0.018 a	0.299±0.447 a
Miristic acid (C14:0)	2.882±0.24 a	2.232±0.171 a	1.363±0.169 a
Pentadecanoicacid (C15:0)	1.221±0.171b	2.471±0.311 c	1.949±0.011 a
Palmitic acid (C16:0)	31.229±0.106a	30.035±0.926 a	30.171±0.639a
Heptadecanoicacid (C17:0)	1.322±0.073a	1.628±0.070 a	2.525±0.065a
Stearic acid (C18:0)	12.147 ±0.180a	12.556±0.542ab	14.150±0.265b
Arachidic acid (C20:0)	2.131±0.107a	3.445±0.018 b	3.319±0.137ab
Total SFA	51.077±0.304a	52.472±0.235 b	54.723±0.060c

Palmitoleic acid (C16:1n-7)	3.668±0.421a	3.300±0.066 a	3.529±0.074a
Oleic acid (C18:1n-9)	8.103±0.365a	4.025±0.017 b	3.795±0.109b
Elaidic acid (C18:1)	0.305±0.122a	1.406±0.605a	1.595±0.387a
Cis Eicosenoic acid (C20:1)	2.099±0.058a	2.162±0.229 a	2.713±0.206b
Euric acid (C20:1)	24.988±0.423a	26.746±0.113 b	26.444±0.375b
Nervonic acid (C24:1)	0.311±0.229a	0.316±0.446 a	0.421±0.137a
Total MUFA	39.474±0.315a	37.973±0.405 b	38.497±0.309b
Linoleicacid (C18:2n-6)	0.541±0.041a	0.394±0.153 b	0.485±0.188ab
Linolenic acid (C18:3n-3)	0.605±0.771a	0.807±0.370 a	0.387±0.,260a
Gama Linolenic acid (C18:3n-6)	4.485±0.315a	3.505±0.283 a	3.428±0.069a
Eicosatrinoicacid (c20:3)	0.039±0.003	0.876±0.132a	0.894±0.135a
Arachidonic acid (C20:4)	0.431±0.031a	0.105±0.155 a	0.282±0.268a
Eicopentanoicacid(EPA)	0.296±0.446a	0.156±0.869 a	0.677±0.384a
Docosadinoic acid (DHA)	0.126±0.098 a	0.376±0.148 b	0.212±0.037a
Total PUFA	6.523±0.544a	6.019±0.707 b	6.367±0.51a

Note: the same alphabets in the same row indicate no difference between treatments (P>0.05)

Table 2 reveals that the smoked fish of producer A, B and C contain total SFA (*Saturated Fatty Acid*) comprising capric acid (C10:0), lauric acid (C12:0), miristic acid (C14:0), pentadecanoic acid (C15:0), palmitic acid (C16:0), heptaecanoicacid (C17:0), stearic acid (C18:0), and arachidic acid (C20:0).The smoked skipjack tuna of producer A has the lowest total SFA of 51.077% and no difference (P>0,05) from those of producer B with total SFA of 52.472% and producer C with total SFA of 54.723%. It could result from similar smoking makterial used, relatively same smoking durationand distance of smoking source to smoked product which could influence the chemical characteristic of the smoked fish products[16,25,28] reported that total SFA of several smoked marine fish ranged from 24.2% to 28.0%. This study found higher total SFA than the previous finding.

Total MUFA (*Monounsaturated Fatty Acid*), palmitoleic acid (C16:1n-7), oleic acid (C18:1n-9), cis eicosenoic acid (C20:1), euric acid (C20:1) and nervonic acid (C24:1) shows that the smoked skipjack of producer A has the highest total MUFA, 39.474%,and it is significantly different from that of producer B, 37.973% (P<0.05), but not different from that of producer, 38.497% (P>0.05). It reflects that the smoked fish product of producer A has the highest total MUFA among the treatments. It could brought about by the interaction of the coconut skin components that could increase the MUFA content. The present study also found higher total MUFA than that of previous report, in which Ilow B.R et al reported that total MUFA of several smoked marine fish ranged between 26.0% to 39.8%.

Total PUFA (Polyunsaturated Fatty Acid) consists of linoleic acid (C18:2n-6), linolenic acid (C18:3n-3), gama linolenic acid (C18:3n-6), arachidonic acid (C20:4n-6), eicopentanoicacid (EPA) anddocosadinoic acid(DHA). The present study found that the smoked skipjack product of producer A has the highest average total PUFA, 6.523%, but it is not different from those of producer B, 6.019% and producer C, 6.367% (P>0.05). Therefore, the smoked fish produced by the producer A has the best total PUFA over the other two producers. Ilow (2013) reported that total PUFA of the smoked marine fish ranged between 31.9% to 45.4%, while the present study found lower PUFA than previous study.

According Little S.O et al, the unsaturated fatty acid is not resistant to heat, and its stability will increase with saturation level. On the other hand, found that average omega-3 fatty acids, particularlyeicosapentaenoic acid (EPA) and docosahexanoic acid (DHA),are 1.67% and 2.50%, respectively[26].

Conclusion

This study concluded that the smoked skipjack tuna of Producer A had the lowest water content, a_w and fat level and the highest protein level.It had the lowest SFA and the highest MUFA and PUFA.

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