JURNAL PERIKANAN
UNIVERSITAS GADJAH MADA
Terakreditasi Ristekdikti No: 158/E/KPT/2021
ISSN: 2502-5066 (Online)
ISSN: 0853-6384 (Print)
Vol. 24 (1), 71-78
DOI 10.22146/jfs.68658

Fatty Acid Profile of Fresh and Smoked Indian Scad (*Decapterus russelli*)

Cindy Regina Magdalena Loppies*, Dwight Soukotta, Beni Setha & Eirene Tentua
Department of Fisheries Technology, Faculty of Fisheries and Marine Science, Pattimura University, Ambon, Indonesia
*Corresponding author, email: cindyloppies@yahoo.com

Submitted: 25 August 2021; **Revised:** 03 March 2022; **Accepted:** 01 March 2022

ABSTRACT Fishery products are a high source of nutrients, especially fatty acids. The smoking technology with liquid smoke is being developed to preserve fishery products. With this processing, fish are expected to be more durable and have better nutritional content, especially polyunsaturated fatty acids (PUFA), needed in the body. For this reason, research has been carried out to see the impact of fish processing with liquid smoke technology on the fatty acid profile of smoked Indian scad. The method used is the experimental method using coconut shell liquid smoke and samples of fresh and smoked Indian scad. The results showed that the fatty acid profile of fresh and smoked Indian scad contained 27 types of fatty acids consisting of 11 saturated fatty acids and 16 unsaturated fatty acids. The content of polyunsaturated fatty acids (PUFA) in fresh and smoked Indian scad is greater than the content of saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA). The high ratio of PUFA-ω3/PUFA-ω6 and the low value of Index of Atherogenic (IA) and Index of Thrombogenic (IT) of fresh and smoked Indian scad treated with coconut shell liquid smoke indicate the quality of fish fat is very good for consumption which is beneficial for health.

Keywords: Fatty acid profile; Indiana scad *Decapterus ruselli*; smoked fish

INTRODUCTION

The Indian scad is the most common type of pelagic fish caught by purse seine fishers in Maluku, which means that the production of this fish is abundant and sometimes excessive. When the production is abundant, the price of the Indian scad becomes relatively cheap even sometimes the excess catch will be thrown back into the sea even though the Indian scad is a marine product with high nutritional value. Apart from being a source of protein, the fat contained in this fish can also make a significant contribution and play an essential role in health because of several omega-3 fatty acids such as EPA and DHA.

One of the efforts to utilize the Indian scad is to process it into smoked form. It is hoped that this smoked Indian scad will become the favourite of the Maluku people who like smoked food ingredients. This smoked fish is very popular with the people of Maluku because of the savoury taste of the meat and the specific flavour and aroma of smoke with an attractive colour combination, from yellow to reddish-brown. Smoked Indian scad produced in this study were processed using smoking technology with liquid smoke.

Fumigation with liquid smoke technology can be widely used in Maluku because of the availability of abundant raw materials, particularly raw materials derived from agricultural waste such as coconut shells. Besides, processing smoked fish with this technology is very simple and easy to apply by the community. Besides, the procedure of manufacturing smoked fish with this technology is quite simple and easy to apply by the community. The application of liquid smoke to fish meat is processed by dipping or soaking the fish in the liquid smoke and then continued with the roasting process to produce cooked fish with a specific taste and aroma of smoke.

Several studies on the application of liquid smoke technology in the processing of smoked fish have been carried out in recent years, including its use as antimicrobial spoilage and its ability to prevent oxidative damage to fish fat (Apituley *et al*., 2006; Sari *et al*., 2006; Swastawati, 2008; Yuwati, 2011; Zuraida *et al*., 2011; Ernawati *et al*., 2012). Some of these studies show increased shelf life or durability of smoked fish produced from 1-2 days to 5 days (Rumahrupute, 1998; Manusiwa, 2001; Nendissa, 2004; Apituley, 2010). One of the development efforts of the above research is to conduct a study on the processing of the Indian scad using liquid smoke technology. Processing smoked Indian scad with liquid smoke is expected to maintain nutrient quality, especially fatty acids of smoked Indian scad produced. Therefore, this study aims to see the impact of fish processing with liquid smoke technology on the fatty acid profile of smoked Indian scad.

MATERIALS AND METHODS

Material

Fish used in this study were fresh Indian scad obtained directly from the Ambon "Arumbai" Traditional Market. The primary material for the manufacture of liquid smoke is a coconut shell, with a pyrolysis device found at the Fisheries Product Technology Laboratory, Pattimura University. The equipment used in this research is a pyrolizator or liquid smoke maker, a tool for redistillation, analytical balance, water bath, centrifuge, HPLC, GC and glassware for both preparation and analysis needs.

Methods

This research begins with manufacturing liquid smoke from coconut shells and then redistilled. Liquid smoke is made by pyrolysis of the raw materials mentioned above in a pyrolizator with a temperature of 400°C as done by

Tranggono *et al*. (1996), and the liquid smoke redistillation process is carried out at temperatures between 100-125 °C. The resulting liquid smoke redistilled is then applied to process smoked tuna. The application of liquid smoked redistilled in the processing of smoked Indian scad is carried out as follows; the fresh Indian scad is weeded to remove the head, gills, and bones, then split into a butterfly shape, washed, and cleaned. Furthermore, the pieces of Indian scad are then soaked in a 5% liquid smoke solution containing 5% salt for 7 minutes. The Indian scad that has been treated is then baked in the oven at 200 °C for ± 45 minutes until cooked. After cooking, the smoked fly fish is packaged in vacuum plastic and stored at room temperature for later analysis.

Fatty acid analysis

Fatty acid analysis with gas chromatography was performed at the Laboratory Terpadu IPB Bogor and follows a procedure where the composition of fatty acids is determined as "fatty acid methyl ester" (FAME) by gas chromatography. The formation of FAME from the sample was preceded by hydrolysis followed by esterification. 20-30 mg of the sample was placed in a Teflon-covered tube. Then, 1 ml of 0.5N NaOH was added and heated in a water bath for 20 minutes. Then 2 ml of 16% BF_3 and 5 mg/ml of the internal standard were added and reheated for 20 minutes. The sample was then cooled and added 2 ml of saturated NaCl and 1 ml of Hexane. The hexane layer was then transferred with a dropper into a tube containing 0.1 g of Na_2SO_4 anhydrous and left for 15 minutes. 5 ml of the liquid phase of the FAME standard mixture sample was then injected into the gas chromatography column. Operating conditions of Gas Chromatography: capillary column (cyannopropyl methyl sil), Injector temperature 200 °C, Detector temperature 230 °C, initial column temperature 190 °/15 minutes and final column 230 °C/20 minutes with column flow rate10 °C/minute, Carriergas H_2, gas H_2 flow rate 30ml/minute gas and N_2 20ml/minute, airflow rate 200-250 mL/minute.

Analysis of fat quality

From the analysis of fatty acid composition data, it can be determined that the quality of fresh and smoked Indian scad fish, namely the Index of Atherogenic (IA) and Index of Thrombogenic (IT), which calculated by the equation adopted from Ghaeni *et al*. (2013).

$$IA = \frac{(4 \times C14{:}0) + C16{:}0 + C18{:}0}{\Sigma MUFA + \Sigma PUFAn6 + \Sigma PUFAn3}$$

$$IT = \frac{(C14{:}0 + C16{:}0 + C18{:}0)}{0.5 \times MUFA + 0.5 \times PUFAn6 + 3 \times PUFAn3 + PUFAn3/PUFAn6}$$

Hypocholesterolemic and hypercholesterolemic ratios (Santos-Silva *et al*., 2002) can be obtained based on the following equation:

$$h/H = \frac{(C18{:}1 + C18{:}2 + C18{:}3 + C20{:}3 + C20{:}4 + C20{:}5 + C22{:}4 + C22{:}6)}{(C14{:}0 + C16{:}0)}$$

Polyene Index (PI), an indicator for the determination of lipid oxidation (Rodriguez *et al*., 2007; Telahigue *et al*., 2013; Apituley *et al*., 2019), can be calculated based on the following formula:

$$PI = EPA + \frac{DHA}{C16{:}0}$$

Flesh Lipid Quality Index (FLQ) as an indicator of the correlation between Omega-3 PUFA fatty acids (EPA and DHA) and total fat in fish is calculated by the equation proposed by Abrami *et al*. (1992).

$$FLQ = \frac{100 \times [EPA + DHA]}{\%\,Total\ Fatty\ Acid}$$

RESULTS AND DISCUSSION

Nutritional composition of fresh and smoked Indian scad

The nutritional composition of fresh and smoked Indian scad is known by performing a proximate analysis. The proximate analysis results of fresh and smoked Indian scad can be seen in Figure 1.

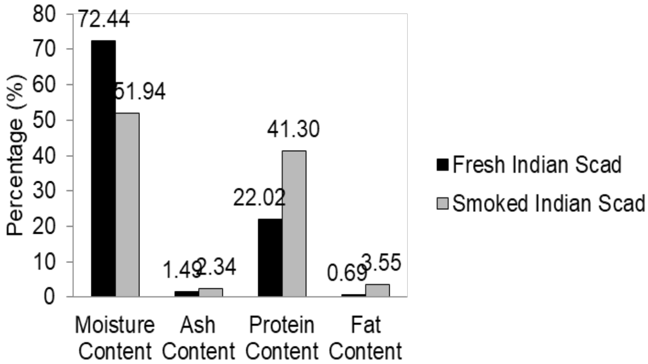

Figure 1. Proximate composition of fresh and smoked Indian scad.

From Figure 1, it can be seen that there are differences in the nutritional composition between fresh and smoked Indian scad. The moisture content in fresh Indian scad changed from 72.44% to 51.94% after a liquid smoking treatment. Moisture content is one of the principal characteristics of foodstuffs because water can affect appearance, texture, and taste. Smoked fish's maximum moisture content quality requirement is 60% (BSN, 2009). The smoked Indian scad products produced in the study still meet the specified smoked fish quality standards. According to Hadinoto *et al*. (2016), changes in moisture content during the smoking process are caused by heat and the withdrawal of water from fish body tissues by the absorption the temperature and duration of heating with the oven also affect the water content value. The high temperature used will cause reduced water in smoked fish to cause the texture to become hardened (Isamu *et al*., 2012).

Ash content is one of the parameters of the nutritional value produced by components of inorganic substances contained in fish (Santoso *et al*., 1996) and uses as an indicator of the presence of minerals in a food ingredient (Winarno, 2008). Ash and minerals in foodstuffs generally come from the food itself (indigenous) or outside the food during the processing of these foodstuffs (Puspitasari *et al.*, 1991). In Figure 1, it can be seen that the ash content of smoked Indian scad has increased when compared to the fresh Indian scad. This increase can occur due to the reduced moisture content of the Indian scad or due to the influence of salt given during the smoking process with liquid smoke. According to Kanoni (1993), this mineral increase can occur due to the deposition of mineral elements in salt during the soaking in a salt solution before the smoking process occurs.

In Figure 1, it is also seen that the protein content of Indian scad increased significantly from 22.02% (fresh) to 41.3% after being smoked. In addition to the reduced water, due to heating during the smoking process, the increase in protein content can also be caused by the salt presence, which causes the protein to be more concentrated. According to Suharjo (1998), the primary function of salt is to stimulate natural flavours, cause high osmotic pressure and reduce water content so that protein is more concentrated.

The fat content of the Indian scad also increased, as shown in Figure 1. The fat content of fresh Indian scad of 0.69% increases to 3.55% after being smoked. The increase in fat tends to be caused by reduced moisture content due to the heating process during the processing. According to Idah & Nwankwo (2013), the presence of heat affects the reduction in water and the nutritional composition of fish processed by smoking.

Fatty acid profile of fresh and smoked Indian scad

The analysis results of the fatty acid profile of fresh Indian scad and smoked Indian scad can be seen in Table 1. The results in Table 1 show that the fatty acid composition of fresh and smoked Indian scad consists of 27 fatty acids, including 11 saturated fatty acids and 16 unsaturated fatty acids. As with other fishery fats, saturated fatty acids from fresh and smoked Indian scad are dominated by palmitic acid (C16:0) and stearic acid (C18:0), while the unsaturated fatty acids in large quantities are oleic acid (C18:1n9), arachidonic acid (C20:4n6), eicosapentaenoic acid/EPA (C20:5n3), and docosahexaenoic acid/DHA (C22:6n3). Sunarya (1993) states that fish fat or oil has unique features in its fatty acid composition, containing polyunsaturated fatty acids (PUFA), including linoleic acid, linolenic acid, EPA, and DHA, the essential fatty acids that the body needs to maintain optimal health.

The fatty acid profile mentioned above includes omega-3 fatty acids such as linolenic acid (18:3n3), eicosapentaenoic acid/EPA (C20:5n3), and docosahexaenoic acid/DHA, indicates the high nutritional quality of fresh and smoked Indian scad. Long-chain PUFA fatty acids such as EPA and DHA show the uniqueness and characteristics that distinguish marine animal fat from land animal fat (Shahidi, 1998). Regulska-Ilow *et al.* (2013) stated that smoked marine fish fat is a good source of PUFA long-chain omega-3 fatty acids. The presence of PUFA is necessary for the prevention and treatment of cardiovascular disease, hypertension, arthritis, inflammation, autoimmune disorders, and cancer (Jones, 2002).

Table 1. Fatty acids of fresh and smoked Indian scad.

Fatty acid	Fresh Indian scad	Smoked Indian scad
Lauric Acid, C12:0	0.05	0.08
Myristic Acid, C14:0	2.98	3.03
Myristoleic Acid, C14:1	-	0.03
Pentadecanoic Acid, C15:0	0.48	0.53
Palmitic Acid, C16:0	15.93	15.87
Palmitoleic Acid, C16:1	2.71	2.91
Heptadecanoic Acid, C17:0	0.85	0.81
Cis-10-Heptadecanoic Acid, C17:1	0.17	0.19
Stearic Acid, C18:0	6.54	6.19
Elaidic Acid, C18:1n9t	0.07	0.05
Oleic Acid, C18:1n9c	4.86	5.96
Linoleic Acid, C18:2n6c	1.1	1.02
Arachidic Acid, C20:0	0.3	0.28
g-Linolenic Acid, C18:3n6	0.1	0.12
Cis-11-Eicosenoic Acid, C20:1	0.24	0.25
Linolenic Acid, C18:3n3	0.47	0.79
Heneicosanoic Acid, C21:0	0.07	0.05
Cis-11,14-Eicosedienoic Acid, C20:2	0.18	0.23
Behenic Acid, C22:0	0.21	0.21
Cis-8,11,14-Eicosetrienoic Acid, C20:3n6	0.13	0.14
Arachidonic Acid, C20:4n6	1.74	1.47
Tricosanoic Acid, C23:0	0.07	0.05
Cis-13,16-Docosadienoic Acid, C22:2	0.04	0.02
Lignoceric Acid, C24:0	0.21	0.15
Cis-5,8,11,14,17-Eicosapentaenoic Acid, C20:5n3	5.1	4.98
Nervonic Acid, C24:1	0.38	0.39
Cis-4,7,10,13,16,19-Docosahexaenoic Acid, C22:6n3	19.76	20.81
Fatty Acid Total	64.74	66.61
ΣSFA	11.55	11.23
ΣMUFA	8.43	9.78
ΣPUFA	8.86	8.77
PUFA/SFA	0.77	0.78
n-3 PUFA	25.33	26.58
n-6 PUFA	3.07	2.75
n3/n6	8.25	9.66

The content of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) from fresh and smoked Indian scad can be seen in Figure 2.

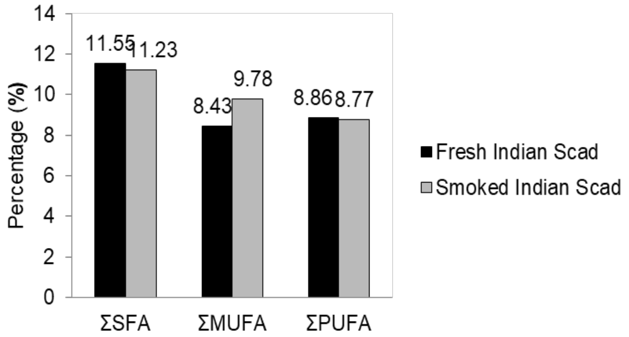

Figure 2. Profile of saturated and unsaturated fatty acids fresh and smoked Indian scad.

From Figure 2, it appears that the polyunsaturated fatty acids/PUFA content in fresh and smoked Indian scad is lower than the saturated fatty acid (SFA) and monounsaturated fatty acids (MUFA). The saturated fatty acids (SFA) content of fresh and smoked Indian scad is 11.55% to 11.23%, respectively. The monounsaturated fatty acid (MUFA) content of fresh and smoked Indian scad is 8.43% to 9.78%, respectively. The polyunsaturated fatty acids (PUFA) content is 8.86% to 8.77%.

Figure 2 shows a difference between saturated fatty acids (SFA) and unsaturated fatty acids, especially the MUFA and PUFA content of fresh and smoked Indian scad. This difference can cause by the physical properties of the fatty acids, both saturated and unsaturated fatty acids, which can change in the presence of heating during the smoking process of the smoked fish. Winarno (2008) stated that saturated fatty acids have a higher boiling point than unsaturated fatty acids with the same chain. Unsaturated fatty acids with many double bonds will have low boiling points, causing these unsaturated fatty acids to have a lower viscosity and boiling point than saturated fatty acids with the same chain.

The cause of difference in smoked Indian scad fatty acid content may also cause by the penetration rate of the components that make up liquid smoke, such as organic acids, carbonyl, and phenol and their derivatives, which affect the saturated and unsaturated fatty acid content of the smoked fish produced (Apituley *et al.*, 2014). Several organic acid components identified in several types of liquid smoke include propanoic acid, butanoic acid, myristic acid, lauric acid, palmitic acid, and other organic acids (Kadir *et al.*, 2010; Ratnawati & Hartanto, 2010). These organic acids can influence the fluctuating fatty acid content of the smoked Indian scad produced.

PUFA-n3 in freshwater and seawater fish, especially EPA and DHA, are fatty acids that are widely studied because of their health benefits, mainly to prevent diseases related to blood vessels or blood pressure and hypotriglyceridemia problems (Kris-Etherton *et al.*, 2002; Wozniak *et al.*, 2013). These fatty acids significantly affect the quality of the fat in these foodstuffs, and this can be seen clearly from several indexes of fat/lipid quality test proposed by some previous researchers such as the PUFA-n3/PUFA ratio, PUFA/SFA ratio, Index of Atherogenic (IA) and the Index of Thrombogenic (IT) as well as several other indexes (Okland *et al.*, 2005; Popovic *et al.*, 2012; Ghaeni *et al.*, 2013; Cieslik *et al.*, 2017).

The polyunsaturated fatty acid profile of PUFA-n3, PUFA-n6, the PUFA-n3/PUFA-n6 ratio, and the PUFA/SFA ratio of fresh and smoked Indian scad can be seen in Figure 3.

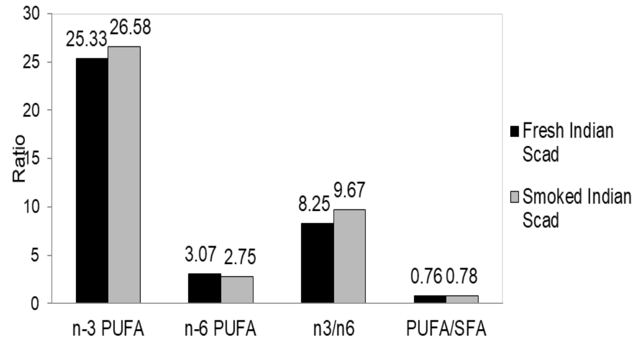

Figure 3. Profile of polyunsaturated fatty acid fresh and smoked Indian scad.

In Figure 3, it is shown that the PUFA-n3 content of smoked Indian scad was higher than PUFA-n3 of fresh Indian scad. Meanwhile, PUFA-n6 was lower when compared to fresh Indian scad. However, the PUFA-n3/PUFA-n6 ratio and the PUFA/SFA ratio of smoked Indian scad are higher than that of fresh Indian scad. The PUFA-n3/PUFA-n6 ratio of fresh and smoked Indian scad ranged from 8.25 to 9.67. Popovic *et al*. (2012) reported that the PUFA-n3/PUFA-n6 ratio of farmed and caught bluefin tuna ranged from 6.98 to 7.56. These results indicate that the fat quality of small pelagic fish such as Indian scad is no less good than that of large pelagic fish such as bluefin tuna. Mohanty *et al*. (2016) reported the PUFA-n3/PUFA-n6 ratio in 39 fish species, including *Thunnus albacore*, *Rastrelliger kanagurta*, *Katsuwonus pelamis*, *Euthynus affinis*, and several other species ranging from 0.80 to 5.6. Økland *et al*. (2005) stated that the high PUFA n3/PUFA-n6 would benefit a food ingredient. According to Osman in Zuraini *et al*. (2006), a good PUFA-n3/PUFA-n6 ratio for a healthy diet for humans is 1:1 – 1:5. The PUFA-n3/PUFA-n6 ratio in this study is in this comparison range. It indicates that the fat quality of smoked Indian scad and fresh Indian scad is good and will benefit health when consumed.

From Figure 3, it can also be seen that the high ratio of PUFA/SFA is in the range of 0.76 to 0.78. It indicates that the smoked Indian scad produced in this study has potential as a source of PUFA. For comparison, the minimum PUFA/SFA ratio recommended by the UK Department of Health is 0.45 (Cieslik *et al.*, 2017). The PUFA/SFA ratio in this study was not much different from the PUFA/SFA ratio of fresh "common carp" and "rainbow trout," which was in the range of 0.97 to 1.69 (Cieslik *et al.*, 2017) as well as from "yellowfin tuna" and "bluefin tuna" which ranging between 0.64-0.82 (Shiming *et al.*, 2013).

The above results are also supported by the Index of Atherogenic (IA), Index of Thrombogenicvalues (IT), hypocholesterolemic/hypercholesterolemic ratios (h/ H), and the polyene index (PI) of the fresh and smoked Indian scad, which can be seen in Figure 4.

Figure 4 shows a change in the value of the Index of Atherogenic (IA) and Index of Thrombogenic (IT) of fresh and smoked Indian scad, which is at the range of 0.57-0.61 and 0.26-0.28. Cieślik *et al*. (2017) stated that the IA and IT values of "common carp," "rainbow trout," and "Northern pike," both fresh and smoked were in the range of 0.26-0.27 for IA and 0.25-1.06 for IT. Meanwhile, Tonial *et al*. (2014), the IA and IT values for "Tilapia" fish ranged between 0.55 – 0.66 and 0.82 – 0.85. Kaya *et al*. (2008) & Apituley *et al*. (2019) also reported a change in the value of IA and IT in "sturgeon" fresh and smoked ranging from 0.31 to 1.01 for fresh fish and 1.24 to 1.93 for smoked fish. According to Boscaino *et al*. (2014), food ingredients are declared to have very high quality if they have a low Index of Atherogenic (IA) and Index of Thrombogenicvalues (IT).

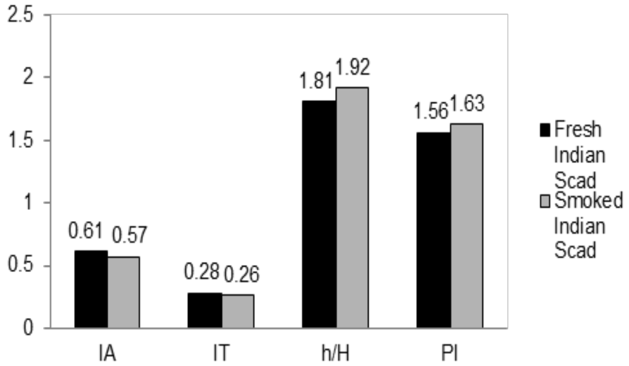

Figure 4. Quality index of fresh and smoked Indian scad.

The Index of Atherogenic (IA) and Index of Thrombogenic values (IT) can be used to determine the lipid quality of a food ingredient including fish and other fishery products (Ghaeni *et al*., 2013). The IA value provides an overview of the relationship between the number of the primary saturated fatty acids expressed as pro-atherogenic and the unsaturated fatty acids stated as anti-atherogenic. Pro-atherogenic plays a role in the lipid adhesion process in immune cells and blood circulation, while anti-atherogenic can inhibit plaque aggregation and minimize esterified fatty acids, cholesterol, and phospholipids to prevent coronary heart disease. Moreover, the IT value provides an overview of the relationship between saturated fatty acids (pro-thrombogenic) and unsaturated fatty acids (anti-thrombogenic) in terms of their tendency to prevent the occurrence of blood clotting processes (Ghaeni *et al*., 2013; Boscaino *et al*., 2014). The low value of IA and IT of smoked Indian scad show that the fat quality of smoked Indian scad is better than that of fresh Indian scad.

In Figure 4, it can also be seen that the hypocholesterolemic/hypercholesterolemic ratio (h/H ratio) from fresh and smoked Indian scad. The h/H ratio of fresh and smoked Indian scad is in the range of 1.81-1.92. Tonial *et al*. (2014) reported that the h/H ratio of tilapia was 1.56-1.63. On the other hand, Czech *et al*. (2015) reported the h/H ratio of several frozen marine animals such as shrimp, squid, mussels, and octopus which are 2.54; 2.13; 1.71; and 2.57, respectively. Santos-Silve *et al*. (2002) stated that the h/H ratio also greatly determines fat quality from foodstuffs. The higher the hypocholesterolemic fatty acids than the hypercholesterolemic fatty acids, the higher the fat in the foodstuffs is good for slowing atherosclerosis.

The high h/H ratio indicates the higher content of hypo-cholesterolemic fatty acids in smoked Indian scad than fresh Indian scad. It shows that smoked fish fat can inhibit the occurrence of atherosclerosis. The above results show that marine animals rich in omega-3 fatty acids have the potential as anti-atherogenic and anti-thrombogenic (Hu, 2001; Henderson *et al*., 2008). Czech *et al*. (2015) stated that the lipids of several marine animals such as shrimp, squid, clams, and octopus also could reduce the risk of heart disease or high blood pressure. Rilantono & Fadilah (1987) stated that a diet containing enough marine fish, especially phytoplankton-eating fish, can reduce the risk of coronary heart disease because it inhibits the process of atherosclerosis by lowering cholesterol levels in the blood, triglycerides, LDL and increasing HDL, as well as reducing the ability of thrombocytes to form thrombus clots.

Polyene Index (PI) is a good indicator of lipid oxidation (Telahigue *et al*., 2013). The index polyene was determined based on the levels of EPA and DHA compared to the levels of palmitic acid. The polyene index values of fresh and smoked Indian scad ranged from 1.56 to 1.63 (Figure 4). The PI values in this study are higher when compared to some previous studies such as mackerel (Scomberomorus commerson) of 0.64 and sharks (*Carcharhinus dussumieri*) of 0.45 (Apituley *et al*., 2019) as well as in cobia (*Rachycentron caradum*) of 0.27 (Apituley *et al*., 2019). The higher the polyene index value, the higher the food fat resistance to oxidation (Apituley *et al*., 2019). Therefore, the Indian scad, both fresh and smoked in this study, had excellent resistance to the oxidation process.

In Figure 5, it can be seen the FLQ (Flesh Lipid Quality) index value of fresh and smoked kite. The FLQ value indicates the correlation between omega-3 fatty acids (EPA and DHA) and the total fat contained in these foodstuffs; the higher the FLQ index, the higher the fat quality of the food source the fat (Abrami *et al*., 1992; Luczynska *et al*., 2017).

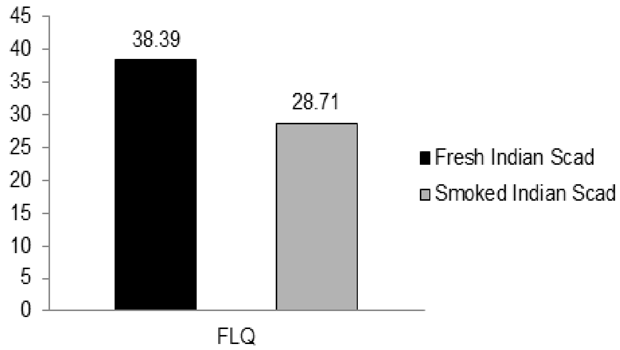

Figure 5. Index value FLQ (flesh lipid quality) of fresh and smoked Indian scad.

According to Figure 5, the FLQ index value of fresh Indian scad is higher than the FLQ index value of smoked Indian scad of 38.39 a nd 28.71, respectively. Łuczyńska *et al*. (2017) reported several FLQ index values of several types of fish, including Bream/*Sparus aurata* (30.14); Perch/*Percha fluviatilis* (33.22); Ide/*Leuciscus idus* (24.32); Carp/*Cyprinus carpio* (13.99), Rainbow trout/*Oncorhybcus mykis* (17.97) and vulture/*Clupea harengus* (13.01). The FLQ value of fresh and smoked Indian scad in this study was higher than some of the fish mentioned above. It indicates the high quality of the fat of both fresh and smoked Indian scad.

Overall, the results of this study indicate that the smoking process with liquid smoke technology on Indian scad does not result in loss or reduction in the quality of fat or lipids from Indian scad. Based on the fat quality indexes obtained in this study (PUFA ratio n-3/PUFA n-6; PUFA/SFA IA ratio, IT, h/H, and PI ratio), fresh Indian scad and smoked Indian scad showed no significant differences. The results above show that the fat compound from fresh and smoked Indian scad is suitable for consumption because of the benefits for health. Foods with a low content of saturated fatty acids provide more benefits for health, especially the heart, than foods with a high content of saturated fatty acids (Apituley *et al*., 2019).

CONCLUSION

The fatty acid profile of fresh and smoked Indian scad contains 27 types of fatty acids consisting of 11 saturated fatty acids and 16 unsaturated fatty acids. Unsaturated fatty acids from fresh and smoked Indian scad are dominated by palmitic acid (C16:0) and stearic acid (C18:0), while the unsaturated fatty acids in large quantities include oleic acid (C18:1n9), arachidonic acid (C20:4n6), Eicosapentaenoic acid/EPA (C20:5n3), and docosahexaenoic acid/DHA (C22:6n3).

The content of polyunsaturated fatty acids (PUFA) in fresh and smoked Indian scad is greater than the content of saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA). The high ratio of PUFA-ω3/PUFA-ω6 and the low value of Index of Atherogenic (IA) and Index of Thrombogenic (IT) of fresh and smoked Indian scad treated with coconut shell liquid smoke indicate the quality of fish fat is very good for consumption which is beneficial for health.

REFERENCES

Abrami, G., F. Natiello, P, Bronzi, D. McKenzie, L. Bolis & E. Agradi. 1992. A comparison of highly unsaturated fatty acid levels in wild and farmed eels (*Anguilla anguilla*). Comparative Biochemistry and Physiology B. 1: 71-82. https://doi.org/10.1016/0305-0491(92)90161-j

Apituley, D.A.N. 2010. Daya hambat asap cair cangkang kenari terhadap kerusakan oksidatif lemak ikan tatihu asap. Ichtyios. 9: 45-94.

Apituley, D.A.N., C.R.M. Loppies & B. Setha. 2019. Amino acid and fatty acid profiles of fresh tuna and smoked tuna International Journal of Recent Scientific Research. 10 (12): 36340-36347. http://dx.doi.org/10.24327/ijrsr.2019.1012.4903

Apituley, D.A.N., C.R.M. Loppies, D. Soukotta, P. Tamaela, E. Lokollo, E.E.E.M. Nanlohy, D.M. Nendissa, M.L. Wattimena & J. Louhenapessy. 2014. Asap Cair Sebagai Bipreservasi Dalam Upaya Pengembangan Teknologi Pengolahan Ikan Dengan Asap Cair di Provinsi Maluku. Research Report II (Ambon: Pattimura University-Unpublished).

Apituley, D.A.N., Z. Noor, S. Suparmo & P. Darmaji. 2006. Oksidasi protein daging merah dan putih dari ikan tongkol putih (*Thunnus* sp.) oleh sistim katalis logam CuSO4-H2O2 AGRITECH 25 45-94. https://doi.org/10.22146/agritech.9446

Boscaino, F., V. Ascierno, P. Saggese, R. Cozzolino, C.M. Motta & A. Sorrentino. 2014. Effectiveness of vacuum devices for home storage of rainbow trouts from game fishing lakes. African Journal of Science and Research. 3: 18-24.

BSN. 2009. Standar Nasional Indonesia Ikan Asap - Bagian 1: Spesifikasi (Badan Standarisasi Nasional). Jakarta.

Cieślik, I., W. Migdał, K. Topolska, B. Mickowska & E. Cieslik. 2017. Change of amino acid and fatty acid profile in freshwater fish after smoking. Journal of Food Processing and Preservation. 42 (1): e13357. https://doi.org/10.1111/jfpp.13357

Czech, A., E.R. Grela & K. Ognik. 2015. Effect of frying on nutrients content on fatty acids composition of muscles of selected freezing seafood. Journal of Food and Nutrition Research. 3 (1): 9-14. https://doi.org/10.12691/jfnr-3-1-2

Ernawati, E., H. Purnomo & T. Estiasih. 2012. Antioxidant effect of liquid smoke on oxidation stability of catfish (*Clarias gariepinus*) smokes sausage during storage. Jurnal Teknologi Pertanian. 13 (2): 119-124. https://jtp.ub.ac.id/index.php/jtp/article/view/366

Ghaeni, M., K.N. Ghahfakori & L. Zaheri. 2013. Fatty acids profile, atherogenic (IA) and thrombogenic (IT) health lipid indices in *Leigohnathusbindus* and *Upeneussulphureus*. Journal of Marine Science: Research and Development. 3: 138. https://doi.org/10.4172/2155-9910.1000138

Hadinoto, S., J.P.M. Kolanus & K.R.W. Manduapessy. 2016. Karakteristik mutu ikan cakalang (*Katsuwonus pelamis*) asap menggunakan asap cair dari tempurung kelapa. Majalah BIAM. 12 (1): 20-26. http://dx.doi.org/10.29360/mb.v12i1.2324

Henderson, S., J. Lampel & C.B. Hollenbeck. 2008. The effect of a 4:1 eicosapentaenoic acid/docosahexaenoic acid fish oil supplement on plasma lipid profile. Journal of the American Dietetic Association. 108 (9) 104-115. https://doi.org/10.1016/j.jada.2008.06.304

Hu, F.B. 2001. The balance between omega-6 and omega-3 fatty acids and the coronary heart disease. Nutrition. 17(9):741-742. https://doi.org/10.1016/S0899-9007(01)00620-7

Idah, P.A & I. Nwankwo. 2013. Effects of smoke-drying temperatures and time on physical and nutritional quality parameters of Tilapia (*Oreochromis niloticus*). International Journal of Fisheries and Aquaculture. 5 (3): 29-34. https://doi.org/10.5897/IJFA12.078

Regulska-Ilow, B., R. Ilow, K. Knikowska, A. Kawicka, D. Różańska & A. Bochińska. 2013. Fatty acid profile of the fat selected smoked marine fish. Rocz Panstw Zakl Hig. 64 (2) 299-307. http://wydawnictwa.pzh.gov.pl/roczniki_pzh/fatty-acid-profile-of-the-fat-of-selected-smoked-marine-fish?lang=en

Isamu, K.T, H. Purnomo & S.S. Yuwono. 2012. Physical, chemical, and organoleptic characteristics of smoked skipjack tuna (*Katsuwonus pelamis*) in Kendari City. Jurnal Teknologi Pertanian. 13 (2): 105-110. https://jtp.ub.ac.id/index.php/jtp/article/view/364

Jones, J.H.P. 2002. Effect of n-3 polyunsaturated fatty acids on risk reduction of sudden death. Nutrition Reviews. 60 (12): 407-409. https://doi.org/10.1301/002966402320964070

Kadir, S., P. Darmadji, C. Hidayat & S. Supriyadi. 2010. Fraksinasi dan identifikasi senyawa volatil pada asap cair tempurung kelapa hibrida. AGRITECH. 30 (2): 57-67. https://doi.org/10.22146/agritech.9674

Kanoni. S. 1993. Kajian protein daging fase pre rigor selama pendinginan sebagai emulsifier sosis. AGRITECH. 13 (3): 11-15. https://doi.org/10.22146/agritech.19267

Kris-Etherton, P.M., W.S. Haris, L.J. Appel and American Heart Association Nutrition Committee. 2002. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circulation. 106 (21): 2747-2757. https://doi.org/10.1161/01 CIR.0000038493.65177.94

Łuczyńska, J., B. Pazczyk , J. Nowosad & M.J. Luczynski. 2017. Mercury, fatty acids content and lipid quality indexes in muscles of freshwater and marine fish on the polish market. risk assessment of fish consumption. Int.J.Environ.Res.Public Health. 14 (10): 1120. https://doi.org/10.3390/ijerph14101120

Manusiwa, S.G. 2001. Pengaruh Waktu Pemanasan Terhadap Mutu Stea Ikan Cakalang (*Katsuwonus pelamis*) Asap Selama Penyimpanan .Undergraduate Thesis. Pattimura University. Ambon

Mohanty, B.P., S. Ganguly, A. Mahanty, T.V. Sankar, R. Anandan, K. Chakraborty, B.N. Paul, D. Sarma, J.S. Dayal, G. Venkateshwarlu, S. Mathew, K.K. Asha, D. Karunakaran, T. Mitra, S. Chanda, N. Shahi, P. Das, P. Das, M.S. Akhtar , P. Vijayagopal & N. Sridhar. 2016. DHA and EPA content and fatty acid profile of 39 food fishes from India. Food Bioactive Compounds against Diseases of the 21st Century. BioMed Research International. https://doi.org/10.1155/2016/4027437

Nendissa. D.M. 2004. Daya Hambat Asap Cair Tempurung Kelapa yang Sudah Dimurnikan Dengan Cara Redestilasi dan Absorbsi Dalam Zeolit Aktif Terhadap Bakteri Halofilik pada Ikan Tahitu (*Thunnus* sp.) Asap. Thesis. Universitas Gadjah Mada. Yogyakarta

Økland, H.M.W., I.S. Stoknes, J.F. Remme, M. Kjerstad & M. Synnes. 2005. Proximate composition, fatty acid and lipid class composition of the muscle from deep-sea teleosts and elasmobranchs. Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology. 140 (3): 437-443. https://doi.org/10.1016/j.cbpc.2004.11.008

Popovic. N.T., L. Kozacinski , I. Strunjak-Perovic, R. Coz-Rakovac , M. Jadan, Z. Cvrtila-Fleck & J. Barisic. 2012. Fatty acid and proximate composition of Bluefin tuna (*Thunnus thynnus*) muscle with regard to plasma lipids. Aquaculture Research. 43 (5): 722-729. https://doi.org/10.1111/j.1365-2109.2011.02880.x

Puspitasari, N.L., N.S. Palupi & N. Andarwulan.1991. Teknik Penelitian Mineral Pangan. IPB-press. Bogor.

Ratnawati, R & S. Hartanto. 2010 Pengaruh suhu pirolisis cangkang sawit terhadap kuantitas dan kualitas asap cair. Jurnal Sains Materi Indonesia 12 7-11. http://dx.doi.org/10.17146/jsmi.2010.12.1.4551

Rilantono, L.I & F. Fadillah. 1987. Peran Ikan Laut dalam Upaya Pencegahan Penyakit Jantung Koroner. Depertemen Kesehatan Republik Indonesia. Jakarta

Rodriguez, A., V. Losada, M.A. Larrain, V. Quitral, J. Vinagre & S.P. Aubourg. 2007. Development of lipid changes related to quality loss during the frozen of farmed coho salmon (*Oncorhynchus kisutch*). Journal of the American Oil Chemists' Society. 84 (8): 727. https://doi.org/10.1007/s11746-007-1098-5

Rumahrupute, B. 1998. Pengawetan Ikan Cakalang Asap Cair, Umur Simpan, Perendaman, dan Umur Simpan "Steak" Cakalang (*Katsuwonus pelamis*) Asap: Dengan Perlakuan Perendaman dan Penyuntikan Dalam Asap Cair dan Larutan Curing. Thesis. Universitas Gadjah Mada. Yogyakarta

Santoso, J., H. Sumaryanto, A. Hidayat & S. Mulya. 199 Pembuatan makanan bayi (Weaning Food) dari campuran tepung beras dan konsentrat protein ikan. Buletin Teknologi Hasil Perikanan. 2: 31-42

Santos-Silva, J., R.J.B. Bessa & F. Santos-Silva. 2002. Effects of genotype, feeding system and slaughter weight on the quality of light lambs II. Fatty acid composition of meat. Livestock Production Science. 77 (2-3): 187-194. https://doi.org/10.1016/S0301-6226(02)00059-3

Sari, R.N., A.B.U. Bagus & T.N. Widianto. 2006. Rekayasa alat penghisap asap cair untuk produksi ikan asap. Jurnal Pasca Panen dan Bioteknologi Kelautan dan Perikanan. 1: 65-73.

Shahidi, F. 1998. Functional Seafood Lipids And Proteins Functional Foods: Biochemical And Processing Aspects. Ed G Mazza. Florida. CRC Press. 381-390

Shiming, P., C. Chao, Z. Shi & L. Wang. 2013. Amino acid and fatty acid composition of the muscle tissue of Yellow fin Tuna (*Thunnus albacares*) and Bigeye Tuna (*Thunnus obesus*). Journal of Food and Nutrition Research. 1 (4): 42-45. https://doi.org/10.12691/jfnr-1-4-2

Suharjo, S. 1998. Pemberian Makanan Pada Bayi dan Anak. Kanisius. Yogyakarta.

Sunarya, S. 1993. Nilai Gizi Ikan dan Pengolahannya menjadi Sumber Pangan yang Bergizi. Student Seminar Paper. Universitas Juanda. Bogor.

Swastawati, F. 2008. Quality and safety of smoked catfish (*Aries talassinus*) using paddy chaff and coconut shell liquid smoke. Journal of Coastal Development 12. (1): 47-55. https://ejournal.undip.ac.id/index.php/coastdev/article/view/1207

Telahigue, K., T. Hajii, I. Rabeh & M. El-Cafsi. 2013. The changes of fatty acid composition in the sun-dried, oven-dried, and frozen hake (*Merluccius merluccius*) and sardinella (*Sardinella aurita*). African Journal of Biochemistry Research. 7 (8): 158-164. https://doi.org/10.5897/AJBR.9000231

Tonial, I.B., D.F. de Oliveira, A.R. Coelho, M. Matsushita, F.A.G. Coró, N.E. de Souza & J.V. Visentainer. 2014. Quantification of essential fatty acids and assessment of the nutritional quality indexes of lipids in tilapia alevins and juvenile tilapia fish (*Oreochromis niloticus*). Journal of Food Research. 3 (3): 105-114. https://doi.org/10.5539/jfr.v3n3p105

Tranggono, T., S. Suhardi, B. Setiaji, P. Darmadi, S. Supryanto & S. Sudarmanto. 1996. Identifikasi asap cair dari berbagai jenis kayu dan tempurung kelapa. J. Ilmu dan Tekn. Pangan. 1: 15-29.

Winarno, F.G. 2008. Kimia Pangan dan Gizi. M-brio press. Bogor.

Woźniak, M., P. Poczyczyński & K. Kozłowski. 2013. The nutritional value of selected species of fish from lake and fish farm of North-Eastern Poland. Polish Journal of Natural Science. 28 (2): 295-304. http://www.uwm.edu.pl/polish-journal/issues/no-28-22013

Yuwanti, S. 2011. Potensi asap cair sebagai antioksidan pada bandeng presto. AGRITECH. 25 (1): 81- 85. https://doi.org/10.22146/agritech.13378

Zuraida. I., S. Sukarno & S. Budijanto. 2011. Antimicrobial activity of coconut shell liquid smoke (CS-LS) and its application on fishball preservation International Food Research Journal. 8: 405-410. http://www.ifrj.upm.edu.my/volume-18-2011.html

Zuraini, A., M.N. Somchit, M.H. Solihah, Y.M. Goh, A.K. Arifah, M.S. Zakaria, N. Somchit, M.A. Rajion, Z.A. Zakaria & A.M. Mat Jais. 2006. Fatty acid and amino acid composition of three local Malaysian Channa spp. Fish. Food Chemistry. 97 (4): 674-678. https://doi.org/10.1016/j.foodchem.2005.04.031

How to cite this article Loppies, C.R.M., D. Soukotta, B. Setha & E. Tentua. 2022. Fatty acid profile of fresh and smoked indian scad (*Decapterus russelli*). Jurnal Perikanan Universitas Gadjah Mada. 24 (1): 71-78. DOI https://doi.org/10.22146/jfs.68658