International Journal of Agriculture and Biosciences 2025 xx(x): xx-xx.
https://doi.org/10.47278/journal.ijab/2025.035

RESEARCH ARTICLE
eISSN: 2306-3599; pISSN: 2305-6622

Characterization Profiling of Essential Fatty Acids in Patin Fish (*Pangasius hypophthalmus*) Oil from South Kalimantan, Indonesia

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ABSTRACT

Patin fish (*Pangasius hypophthalmus*) is a freshwater species with high economic value in the Indonesian aquaculture industry. South Kalimantan, Indonesia, comprises a significant population of Patin fish rich in essential fatty acids. Therefore, this study aimed to analyze fatty acids found in fish oil obtained from South Kalimantan, Indonesia. Gas Chromatography-Flame Ionization Detection (GC-FID) was used to analyze fish oil samples extracted through the wet rendering method without purification. The results showed that the 21 distinct types of fatty acids in Patin fish oil were 41.7% of the total composition. These included elaidic, palmitate, linoleic, and oleic acids present in high amounts, while omega-9 oil content was greater than omega-3 and 6. Additionally, the analysis of the peroxide value of 0.32 meq/kg, which was still below the maximum level recommended for the category of fish oil worthy of consumption. Patin fish oil was found to contain essential fatty acids beneficial for improving human health and preventing degenerative diseases.

Keywords: *Pangasius hypophthalmus*, Fatty acids, Fish oil, Omega, Indonesia.

Article History
Article # 24-1034
Received: 10-Dec-24
Revised: 08-Feb-25
Accepted: 13-Mar-25
Online First: 09-Apr-25

INTRODUCTION

Indonesia is categorized among the portion of the world with the greatest biodiversity and serves as a home to approximately 1,300 species of freshwater fish (Robin et al., 2023). Therefore, the country is considered the second-largest genetic resource for freshwater fisheries globally (Hilsdorf & Hallerman, 2017; Raghuvanshi & Kumar, 2021). This biodiversity is supported by extensive river streams, lakes, and wetlands, which include more than 500 lakes and seven wetlands covering approximately 1.4 million hectares (McManamay et al., 2017).

Patin fish (*Pangasius hypophthalmus*) belonging to the family Pangasiidae is a freshwater species widely recognized for its high nutritional value and frequently cultivated in various countries (FAO, 2020). According to Roberts and Vidthayanon (2023), the genus Pangasius comprises approximately 30 species distributed across Southeast Asia and South Asia. Patin fish is a prominent aquaculture commodity that has sustainable development in terms of seed production, breeding, feeding, and processing, as well as large cultivation areas, including the center located in South Kalimantan (Febrianty, 2021). This fish possesses a high economic value and is an important commodity in the

Cite this Article as: Hidayaturrahmah, Suprayogi A, Hanif N, Roosita K and Darusman HS, 2025. Characterization profiling of essential fatty acids in patin fish (*Pangasius hypophthalmus*) oil from South Kalimantan, Indonesia. International Journal of Agriculture and Biosciences xx(x): xx-xx. https://doi.org/10.47278/journal.ijab/2025.035

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national aquaculture industry (NOAA, 2023). Based on the trend of increasing fishing households by an average of 11%in 2021, an average annual growth of 7.86% was observed when Pangasius production reached 33,567.14 tons. The Ministry of Marine Affairs and Fisheries reported the total production of Pangasius at 408,539 tons in 2020, compared to 391,151 tons in 2018 (Ministry of Marine Affairs and Fisheries of the Republic of Indonesia, 2021; Ministry of Marine Affairs and Fisheries of the Republic of Indonesia, 2022) South Kalimantan has a significant Pangasius population, with a production rate of approximately 51,000 tons in 2024 (KKP, 2024). The aquatic environment of this area provides an ideal habitat for Pangasius breeding, due to conditions supporting fish growth and development (Tran et al., 2017; Nguyen & Davis, 2020*)*. Moreover, the local tradition and knowledge of breeding led to the inclusion of South Kalimantan among the main production centers (Febrianty, 2021). The diverse environmental and ecosystem conditions offer unique potential for initiating variations in fatty acid composition of Patin fish (Li et al., 2020; Syamsul et al., 2024).

Studies on fatty acid composition of Patin fish have been conducted in several areas, yet the results showed variations probably influenced by geographical and local environmental factors (Li et al., 2020). Pandiangan (2021) examined Patin fish (*Pangasius djambal*) oil from Medan Island in Indonesia, which contained greater total unsaturated fatty acids (MUFA and PUFA) than total saturated fatty acids (SFA). These results tend to vary in value in different areas when exploring several sub-varieties of fish. The distinct ecosystem in Kalimantan presents a unique opportunity to explore the specific fatty acid composition of Patin fish. Factors such as water temperature, salinity, food availability, and habitat types can influence fish metabolism, which affects fatty acid composition (Hastati et al., 2023).

Patin fish has a delicious taste and rich nutrient content, particularly essential fatty acids found in oil component, which is a value-added product increasingly demanded by the market. These fatty acids are beneficial to human health but cannot be produced by the body, suggesting the need to obtain from external sources (Rincón et al., 2020).

Patin fish oil is currently a fascinating subject of study in nutrition, specifically in the development of nutraceutical food products or supplements with significant health benefits (Cicero et al., 2021). The essential fatty acids contained in this oil have the potential to be used in nutraceuticals due to the health benefits, including anti-inflammatory, cardioprotective, and neuroprotective properties (Mozaffarian & Wu, 2024).

An investigation gap remains regarding fatty acid composition of Patin fish from South Kalimantan and oil characterization in the context of the potential for nutraceutical application. Therefore, this study aimed to identify fatty acid composition of Patin fish oil from South Kalimantan and characterize the properties. The results are expected not to only show the potential of Patin fish oil as an economical and effective health supplement but also to contribute positively to the well-being of the community and fishing industry development in Indonesia.

MATERIALS & METHODS

The Process of Extracting Oil from Patin Fish using the Wet Rendering Method

Patin fish oil was analyzed through Gas Chromatography combined with Flame Ionization Detection (FID) (Rincón et al., 2020). This was extracted at a temperature of 60°C using an unrefined wet rendering method, modified by not conducting purification. A total of 30 Patin fish samples were obtained from the Freshwater Fish Farming Center in Mandiangin, South Kalimantan, and the data were analyzed descriptively by calculating average values. Subsequently, the samples were removed from the icebox, cleaned, drained, and weighed to select those measuring 700-750g for oil extraction (Hidayaturrahmah et al., 2016). To facilitate the extraction process, Patin fish weighing approximately 750g was cut into small pieces, which were transferred into a stainless steel pot, and 500mL of distilled water was added. The fish was boiled for 30 minutes while stirring gently at 60°C and filtered to distinguish coarse oil from solids. A separatory funnel was used to separate oil from the water layer, then centrifugation was performed for 10 minutes at 10,000rpm and 10°C. The resulting oil was isolated from the sediment, with Fig. 1 presenting the comprehensive extraction method. Acid-base titration method was used to measure acid and peroxide levels in oil extract, which was characterized through yield and fatty acid analysis.

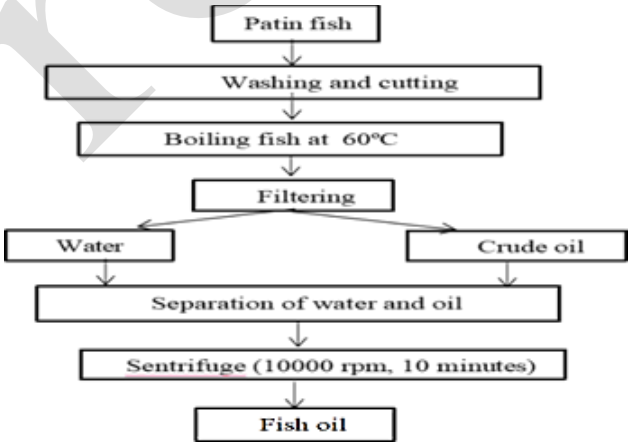

Fig. 1: Extraction of fish oil through wet rendering without purification.

The research has received an ethical review and information about passing the ethical review from the Research Ethics Committee of the School of Veterinary Medicine and Biomedical Sciences at Institut Pertanian Bogor University, number:147/KEH/SKE/XII/2023.

Fish Oil Characteristics

Chemical characteristics such as peroxide, saponification, fat content, and iodine values were evaluated based on the standard by the Association of Official Analytical Chemists (AOAC International, 2016). This process included determining the number of acids and peroxide present in Patin fish oil extract using acid-base titration method. Further oil analysis was conducted through Gas Chromatography combined with Flame Ionization Detection /GC-FID (Rohman et al., 2023).

RESULTS

Characteristics of Patin Fish (*P. hypophthalmus*) Oil Extract

The characteristics of Patin fish oil extracted using the wet rendering method without purification are shown in Table 1. The parameters measured include saponification rate, peroxide value, iodine value, and fat content. The saponification rate ranges from 116.72 to 118.97 mg/g, indicating the stability of fat oxidation in Patin fish oil. The low peroxide value (0.28-0.36 meq/kg) indicates a low level of oxidation, meaning the oil is of good quality and is not easily spoiled. The iodine value ranges from 10.2 to 12.69g, indicating different oxidation capacities of the fat. The fat content in the samples varies between 0.44 and 0.89%, indicating variations in the quality of the oil produced (Table 1).

Table 1: Characteristics of Patin fish (*P. hypophthalmus)* oil extract

No	Characteristics of Patin fish oil	1	2	3	Average
1	Saponification rate (mg/g)	118.97	116.72	118.41	118.41
2	Peroxide value (meq/kg)	0.32	0.28	0.36	0.32
3	Iodine value (g)	10.76	10.2	12.69	11.2167
4	Fat (%)	0.67	0.89	0.44	0.66667

The high saponification rate indicates that Patin fish oil has good stability against oxidation, which is important for maintaining oil quality during storage and use. The low peroxide value shows that the oil has minimal oxidative damage, meaning it is still fresh and suitable for consumption. The varying iodine values indicate that the oil has different capacities to bind oxygen, which can affect the stability and shelf life of the oil.

From these results, it can be concluded that Patin fish oil has good quality with low oxidation levels and high stability. The varying fat content indicates that there are factors affecting the quality of the oil, such as extraction methods and environmental conditions. Overall, this Patin fish oil has the potential to be used as a source of essential fatty acids beneficial for human health.

Oil Extraction Yield from Patin Fish

The general results of Patin fish oil extraction from 3kg of fresh meat using the wet rendering method without purification are presented in Table 2. From 3kg of fresh meat, 291.51g of crude oil and 250g of centrifuged oil were obtained, with an oil percentage of 8.30%. These results indicate the efficiency of the extraction method used and provide an overview of the amount of oil that can be obtained from Patin fish.

Table 2: General results of Patin fish (*P. hypophthalmus)* oil extract

Information	Weight
Fresh meat (g)	3,000
Crude oil (g)	291.51
Centrifuged oil (g)	250
Oil percentage (%)	8.30

The percentage of oil obtained from this extraction process shows that the wet rendering method without purification is quite efficient in producing oil from Patin fish. The crude oil obtained is then centrifuged to separate the oil from the sediment, resulting in purer oil ready for further analysis. These results are important for determining the efficiency and effectiveness of the extraction method used in this study.

With an oil percentage of 8.30%, this method shows good potential for use in the commercial production of Patin fish oil. The oil produced has good quality and can be used for various applications, including nutraceuticals and health supplements. These results also indicate that Patin fish is a potential source of oil with high essential fatty acid content.

The results of Patin fish oil extraction using the wet rendering method without purification are shown in Fig. 2. Fig. 2 consists of several panels depicting the Patin fish (A), the wet rendering extraction process (B), crude oil (C), and centrifuged oil (D). This figure helps clarify the results obtained from the extraction process and provides a visual representation of the final product.

Chromatographic Profile of Patin Fish (*P. hypopthalmus*) Oil Fatty Acids

The chromatographic profile of fatty acids in Patin fish oil obtained through gas chromatography is shown in Fig. 3. This figure illustrates the chromatographic peaks representing various types of fatty acids in Patin fish oil. This profile helps identify and measure the relative concentrations of each type of fatty acid present in the Patin fish oil sample.

From this chromatographic profile, it is evident that the largest peak is produced by elaidic acid, indicating that this fatty acid has the highest concentration in Patin fish oil. Other significant peaks include cis-10-pentadecanoic acid and linolelaidic acid. These three fatty acids are the main components in Patin fish oil and play significant roles in providing health benefits. This chromatographic profile also shows the presence of various other fatty acids in smaller amounts, such as palmitic acid and linoleic acid. This information is crucial for understanding the complete composition of Patin fish.

Peak Area of Fatty Acid Profile Results for Patin Fish (*P. hypophthalmus*) Oil

The peak area data of the fatty acid profile of Patin fish oil obtained through gas chromatography are presented in Table 3. This table lists the fatty acid names, retention times, areas, heights, area percentages, height percentages, tailing factors, and resolutions. This data provide detailed information about the fatty acid composition in Patin fish oil, including tridecanoic acid, palmitic acid, oleic acid, and others. This information is crucial for understanding the nutritional profile and potential health benefits of Patin fish oil (Table 3).

From this table, it is evident that the fatty acid with the largest peak area is elaidic acid with an area percentage of 39.80%, followed by cis-10-pentadecanoic acid with an area percentage of 35.01%, and linolelaidic acid with an area percentage of 14.44%. These three fatty acids are the main components in Patin fish oil and play significant roles in providing health benefits.

Table 3: Peak Area of Fatty Acid profile results for Patin fish (*P. hypopthalmus*) oil

	Name	Ret.Time	Area	Height	Area%	Height%	Tailing Factor	Resolution
1.	Tridecanoic Acid.CI3	13.254	402186	125284	5.8458	9.4072	1,204	0.000
2.	Cis-10-Pentadecanoic A	15.865	2408628	440364	35.0097	33.0657	0,744	22.619
3.	Palmitic Acid.C16.0	16,753	82011	22613	1.1920	1.6979	1,362	7.349
4.	Palmitoleic Acid.C16:1	17.169	8522	2994	0.1239	0.2248	1.802	4,802
5.	Cis-10-Heptadecanoic/	18,247	2016	1652	0.0293	0.1240	3.244	20.164
6.	Elaidie Acid.C18:1n9t	19.551	2737928	453601	39,7961	33.9845	0.703	13,971
7.	Linolelaidic Acid.C18:	20.880	993165	234851	14.4358	17.6343	0.921	9,845
8.	Linoleiec Acid.C18:2n6	21.508	16243	3922	0.2361	0.2945	1.188	5.858
9.	Arachidiec Acid.C20.0	21.971	28136	6491	0.4090	0.4874	1.206	4.248
10.	v-Linolenic Acid. C18.	22.495	44386	12955	0.6452	0.9727	1.063	5.054
11.	Hencicosanoic Acid.C2	24,193	27599	5486	0.4012	0.4119	1,073	15.039
12.	Beheme Acid.C22.0	25.563	47207	8855	0.6862	0.6649	1.350	10.076
13.	Cis-11,14,17-1 icosli	26,720	27357	5140	0.3976	0.3860	0.000	8.049
14	Cis-13,16-Docosadieno	29,557	12154	1792	0.1767	0.1346	1.072	17,146
15	Cis-5,8,11.14.17-Ficow	29,728	6454	979.	0.0938	0.0735	0.000	1.523
16	Nervome Acid,C24:1	36,336	35897	5807	0.5218	0.4361	0.000	68.027

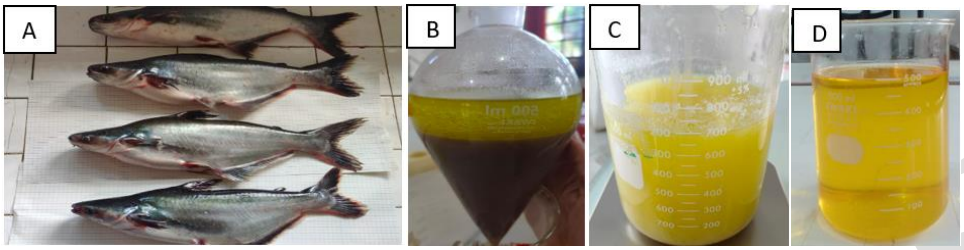

Fig. 2: Extraction of Patin fish (*P. hypophthalmus)* oil by wet rendering without purification; Patin fish *(P. hypophthalmus)* (A), Wet rendering extraction (B), Crude oil (C), Centrifuged oil (D).

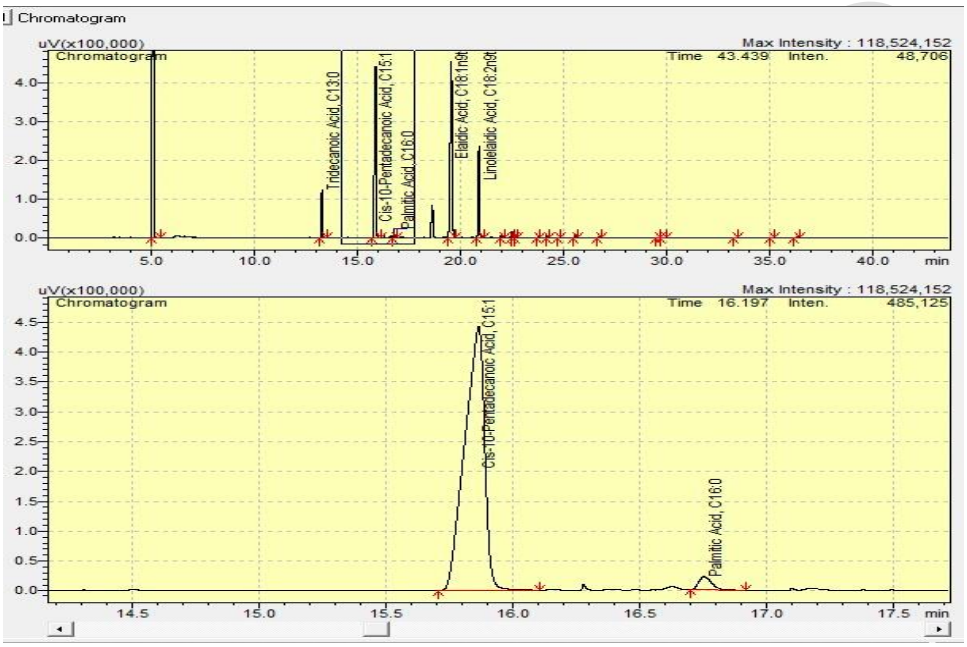

Fig. 3: Chromatographic profile of Patin fish (*P. hypopthalmus*) oil fatty acids.

Profiling of Fatty Acids in Patin Fish Oil Extract

The results showing the percentage profile of various types of essential fatty acids in Patin fish oil are presented in Table 4. This table lists various types of fatty acids, such as tridecanoic acid, palmitic acid, oleic acid, and others, along with their respective average percentages. These results show that Patin fish oil contains various essential fatty acids important for human health, including saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA).

From this table, it is evident that the fatty acid with the highest percentage is elaidic acid with a percentage of 8.36%, followed by palmitic acid with a percentage of 6.67%, and linolelaidic acid with a percentage of 6.10%. These three fatty acids are the main components in Patin fish oil and play significant roles in providing health benefits.

Grouping of Saturated Fatty Acids (SFA), Monounsaturated Fatty Acids (MUFA), and Polyunsaturated Fatty Acids (PUFA) in Patin Fish Oil (*P. hypophthalmus*)

The grouping of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) in Patin fish oil is shown in Fig. 4. The results indicate that Patin fish oil contains 27% SFA, 50% MUFA, and 23% PUFA, with the highest content being palmitic, elaidic, and linolelaidic acids. This grouping is important for understanding the nutritional composition and potential health benefits of Patin fish oil (Fig. 4).

Saturated fatty acids (SFA) in Patin fish oil mainly consist of palmitic acid (C16:0), which is the saturated fatty acid with the highest concentration. Monounsaturated fatty

acids (MUFA) are dominated by elaidic acid, while polyunsaturated fatty acids (PUFA) are dominated by linolelaidic acid.

Table 4: Fatty acid profile based on the relative average percentage of Patin fish (*P. hypopthalmus*) oil extract

	Fatty Acid	Average (%) W/W
1	Tridecanoic acid, C13:0	1.507
2	*cis*- 10-Pentadecanoic acid, C15:1	4.793
3	Palmitic acid, C16:0	6.67
4	Palmitoleic acid, C16:1	0.227
5	*cis*- 10-Heptadecanoic acid, C17:1	1.62
6	Elaidic acid, C18:1n9t	8.363
7	Linolelaidic acid, C18:2n9t	6.097
8	Linoleic acid, C18:2n6c	2.057
9	Arachidic acid, C20:0	0.48
10	y-Linolenic acid, C18:3n6	0.477
11	Heneicosanoic acid, C21:0	0.227
12	Behenic acid, C22:0	0.843
13	*Cis* -11, 14, 17-Eicosatrienoic acid methyl ester, (C20:3n3)	0.227
14	Nervonic acid, C24:1	0.357
15	*Cis* 13, 16 - Docosadienoic acid, docosahexanoic acid	0.127
16	*Cis* 5,8, 11, 14, 17 Eicosapentaenoic acid C20-5n3	0.103
17	Myristic acid C14:0	0.483
18	Stearic acid	1.29
19	Oleic acid	5.58
20	*Cis* 11 Eicosenoic acid C20;1	0.08
21	Eicosadienoic acid	0.11
	Total Fatty Acids	41.7

The experiment was performed in Triplicate.

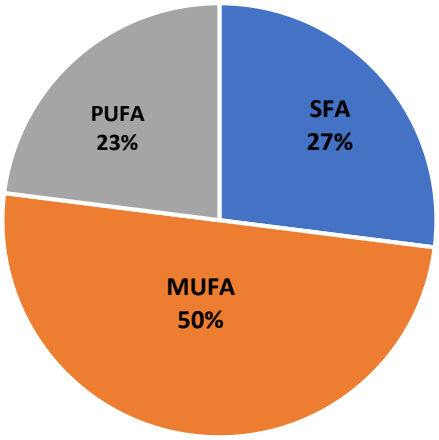

Fig. 4: Grouping of SFA, MUFA, and PUFA in Patin fish (*P. hypopthalmus*) oil.

This grouping also shows that Patin fish oil has a good balance between SFA, MUFA, and PUFA, which is important for overall health. The high MUFA content, especially elaidic acid, indicates that this oil can help maintain heart health and reduce inflammation. The significant PUFA content, especially linolelaidic acid, indicates that this oil is also beneficial for skin health and cell function.

Types of MUFA in Patin Fish (*P. hypophthalmus*) Oil

The various types of monounsaturated fatty acids (MUFA) in Patin fish oil are shown in Fig. 5. Oleic acid (C18:1n9) is the MUFA with the highest concentration, known for its heart health benefits. This figure helps identify the types of MUFA present in Patin fish oil and their contributions to health. In addition to oleic acid, Patin fish oil also contains significant amounts of elaidic acid (C18:1n9t). Elaidic acid is known for its anti-inflammatory effects and can help reduce the risk of heart disease. Other MUFAs present in Patin fish oil include palmitoleic acid (C16:1) and cis-10-pentadecanoic acid (C15:1), which also have important health benefits.

Types of SFA in Patin Fish *(P. hypophthalmus)* Oil

The various types of saturated fatty acids (SFA) in Patin fish oil are shown in Fig. 6. Palmitic acid (C16:0) is the SFA with the highest concentration, serving as an energy source and playing a role in hormone synthesis. The SFA fatty acid group in Patin fish oil comprised palmitic acid (C16:0) at the highest concentration (21.34%) and significant but lower amounts of tridecanoic acid (C13:0). Cis-10 pentadecanoic and Cis-10-heptadecanoic acids were present in small amounts, while henicosanoic acid (C21:0) and behenic acid (C22:0) were found to be minor components. Myristic acid (C14:0) and stearic acid had lower amounts compared to the other content, with Fig. 6 presenting the identified types of SFA.

The SFA content in Patin fish oil indicates that this oil can serve as a good energy source and play a role in various physiological processes in the body. Although SFAs are often associated with an increased risk of heart disease, some types of SFAs, such as stearic acid, have neutral or even positive effects on heart health. Therefore, it is important to consider the types and proportions of SFAs in the diet.

Types of PUFA in Patin Fish (*P. hypophthalmus*) Oil

Patin fish **oil** contains various types of PUFA, which have an important role in body health. Fig. 7 shows the types of PUFA in Patin fish oil.

The high PUFA content in Patin fish oil indicates that this oil can help maintain skin health, reduce inflammation, and improve cell function. PUFAs are also known for their heart health benefits and can help reduce the risk of chronic diseases such as diabetes and heart disease. Therefore, patin fish oil can be a good source of PUFAs for a healthy diet.

Omega-3 (ω-3), Omega-6 (ω-3), and Omega-9 (ω-3) Content in Patin Fish (*P. hypopthalmus)* Oil

The composition of omega-3, omega-6, and omega-9 fatty acids in Patin fish oil is presented in Fig. 8. The results indicate that Patin fish oil contains 2% omega-3, 10.8% omega-6, and 87.2% omega-9 fatty acids. This composition is important for understanding the health benefits of Patin fish oil, including its role in maintaining heart health and cognitive function (Fig. 8).

Omega-3, particularly EPA and DHA, is known for its significant health benefits, including improving cognitive function and reducing the risk of heart disease. Omega-6, such as linoleic acid, plays a role in cell function and skin health, while omega-9, such as oleic acid, is known for its positive effects on heart health by increasing good cholesterol (HDL) levels and lowering bad cholesterol (LDL) levels.

The high omega-9 content in Patin fish oil indicates that this oil can help maintain heart health and reduce inflammation. Although the omega-3 content is relatively low, this oil can still provide significant health benefits when combined with other sources of omega-3 in the diet. Overall, Patin fish oil has a balanced and beneficial fatty acid composition for health.

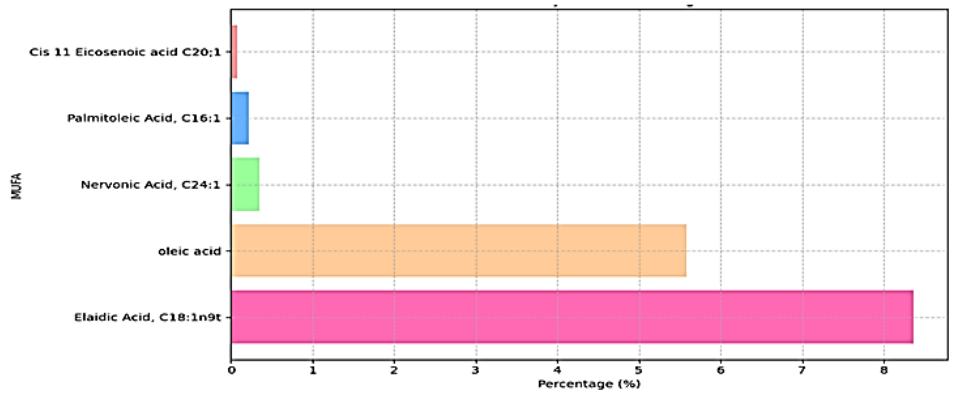

Fig. 5: Types of MUFA in Patin fish (*P. hypopthalmus*) Oil.

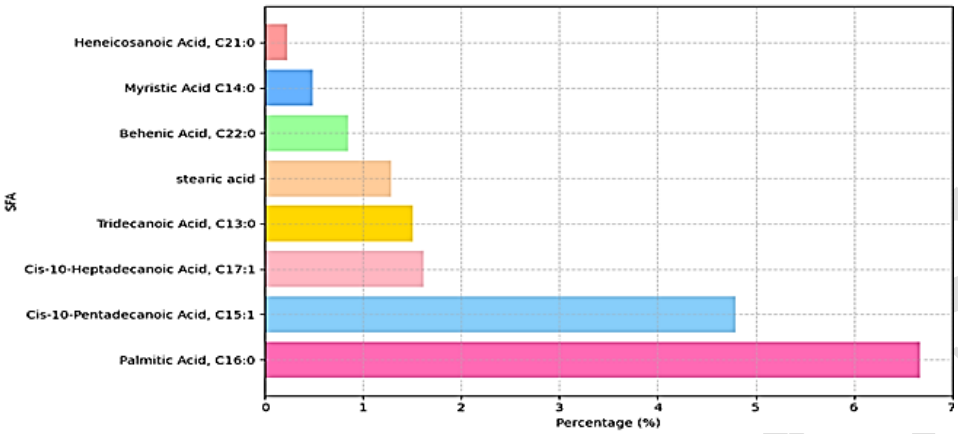

Fig. 6: Types of SFA in Patin fish (*P. hypopthalmus*) Oil.

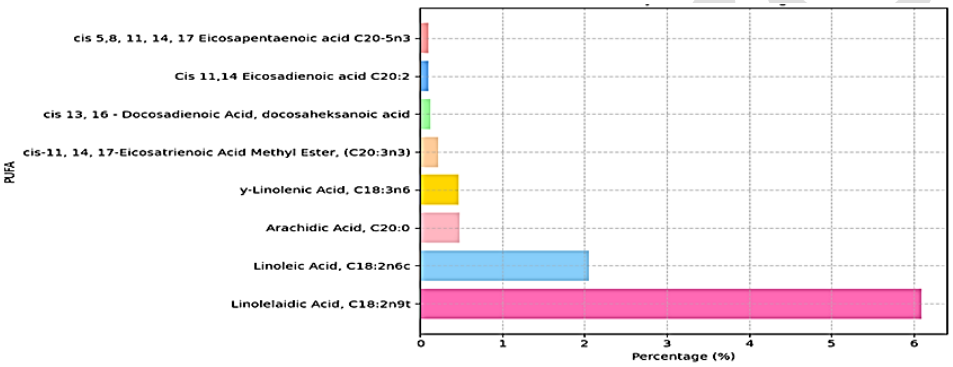

Fig. 7: Types of PUFA in Patin fish (*P. hypopthalmus*) Oil.

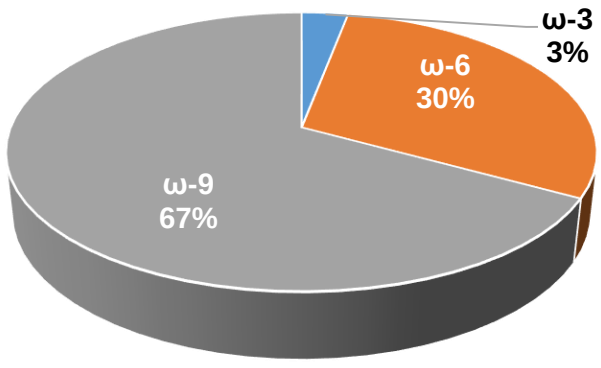

Fig. 8: Omega-3 (ω-3), omega-6 (ω-3), and omega-9 (ω-3) content in Patin fish (*P. hypopthalmus*) oil.

DISCUSSION

Fish oil characteristics, represented by the peroxide value parameter, are the major measure used to determine the level of oil damage. Oil comprising a smaller amount of peroxide has better quality (Hidayat et al., 2020). The peroxide value of Patin fish oil (0.32 meq/kg) was still below the maximum peroxide of 3.75meq/kg set by the international fish oil standard (IFOS) as the limit required for the category of oil suitable for consumption (Julaikha, 2014). A study by Suseno et al. (2020) reported that patin fish oil contained 0.08±0.03% free fatty acids, 7.48±0.23meq/kg total oxidation, and 2.70±0.20meq/kg peroxide value. In this context, the examined fish oil met the IFOS standard on the parameters of free fatty acids (≤1.5%), total oxidation (≤26.0meq/kg), and peroxide value (≤5.0meq/kg) (Suseno et al., 2020).

The studied fish oil samples had a very different oxidation capacity. The type of feed, cultivation location, and processing method are some of the components influencing this variation (Halim, 2018). The fat content in samples was very different, with values ranging between 0.44 and 0.89. Higher fat levels can generate oil containing omega-3 fatty acids, which are known to have significant health benefits (Lestari et al., 2020).

A study conducted on *Pangasius micronema* fish oil in the Samarinda East Kalimantan, Indonesian area using the dry rendering method, showed 7.80%±0.15% yield, 1.86±0.02% free fatty acids, peroxide of 6.66±0.26meq/kg sample, iodine of 82.97±1.85g/100g sample, and saponification rate of 199.81±3.86mg KaOH/g. The total fatty acid composition examined comprised saturated (14.65%) and unsaturated (85.31%) fatty acids, as well as omega-3 (3.66%), omega-6 (16.18%), and omega-9 (5.62%) fatty acids (Syamsul et al., 2024). These results were different from the study of Patin fish oil from South Kalimantan performed with a different extraction method, namely the wet rendering extraction. The observed difference was attributed to disparities in fish subtypes, the extraction method, and areas in Kalimantan. Environmental conditions, fish diet, and tissue type significantly influence fish oil composition and quality, leading to variations in fatty acid profiles, stability, and general effectiveness (Trilaksani et al., 2023).

South Kalimantan is characterized by extensive river systems and swamp areas, which significantly influence the water quality and aquatic life. Furthermore, the water bodies tend to have higher organic matter content due to the dense vegetation and peatlands. This can lead to water with higher levels of humic substances, affecting the chemical composition and types of fish found. The water in South Kalimantan is known for relatively lower salinity and higher turbidity compared to other areas (Halang et al., 2019). Samarinda is located in East Kalimantan and influenced by the proximity to the Mahakam River, which flows through a more urbanized and industrialized area. Fish oil samples can have different types and concentrations of fatty acids due to factors, including feed type, cultivation environment, and processing method (Putri et al., 2019). This suggests that various factors influencing the production and processing of Patin fish oil influence the nutritional quality (Trilaksani et al., 2023).

A study analyzing Patin fish fatty acids using the dry rendering method showed a total SFA of 49.34% and the total unsaturated fatty acids were 54.52%, consisting of 39.10% MUFA and 15.42% PUFA (Pandiangan, 2021). Research reported by Julaikha (2014) obtained 43.01% SFA, 37.46% MUFA and 14.86% PUFA in Siamese Patin fish oil extract, with the highest content being 30.07% palmitic, and 34.60% oleic respectively. The results reported on starch fish oil from South Kalimantan showed a greater MUFA content than SFA and PUFA. This difference can be attributed to the artificial feed majorly consumed by freshwater fish, while seawater fish often consume natural feed, specifically zooplankton rich in PUFA (Emedihealth, 2020; Temperoni et al., 2024).

The current study on Patin fish oil from South Kalimantan differed from previous investigations, where MUFA was greater (50%) than SFA and PUFA values. This was associated with disparities in the geographical environment of the area, causing variation in fatty acid content (Gonçalves et al., 2017). Additionally, differences in fisheries management were suspected regarding feeding, type of feed, water quality, and habitat (Vsetickova et al., 2019). MUFA content observed in this study was more dominant, with a percentage reaching 50%, compared to SFA and PUFA. This difference was presumed to be caused by variations in geographic and environmental conditions in South Kalimantan, which influenced the chemical composition of fish (Gonçalves et al., 2017; Putri et al., 2019; Vsetickova et al., 2019).

The geographic environment plays an important role in determining the quality and quantity of fatty acids in fish (Bandara et al., 2023). Factors such as water temperature, salinity, food availability, and specific habitat can influence fish metabolism, which affects fatty acid composition in the tissues (Vsetickova et al., 2020; Arts et al., 2021). Aripin and Nurhayati (2020) reported that fish living in water with cooler temperatures tended to have higher PUFA contents. However, fish inhabiting warmer water, such as in South Kalimantan, might comprise higher MUFA due to metabolic adaptation to local temperature and environmental conditions (Sandersfeld et al., 2017; Colombo et al., 2023; Kumar et al., 2023).

Patin fish oil contains various types of MUFA**,** which play an important role in body health (Calder, 2015). Fig. 5 shows that oleic acid comprises the highest concentration and is often found in olive oil. The function of oleic acid includes protecting heart health by maintaining good cholesterol (HDL) and decreasing bad cholesterol (LDL) levels, as well as reducing the risk of heart disease (Lu et al., 2024). In addition, elaidic acid present in significant amounts has potential anti-inflammatory effects (Balta et al., 2021).

Nor et al., (2021) detected a high content of omega-9 fatty acids and low omega-3 fatty acids in Patin fish oil. Fig. 8 is a pie chart showing fatty acid composition of Patin fish examined in South Kalimantan. Omega 9 (67%) is a type of MUFA that maintains balanced cholesterol levels to support heart health and contributes to cell membranes and cell function (Nor et al., 2021). Lubis et al. (2024) found that *Patin fish* oil comprised 37.5% omega 9 content present in higher amounts than omega 3 and 6. The reported percentage of omega 9 was lower when compared to the value (67%) obtained in this study conducted in South Kalimantan.

Conclusion

In conclusion, this study found that characterization profiling of *Patin fish* oil obtained from South Kalimantan, Indonesia through wet rendering without purification contained 21 types of fatty acids (41.7%), majorly comprising elaidic, palmitic, linolelaidic, and oleic acids. *Patin fish* oil consisted of seven types of SFA, MUFA, and PUFA each, while omega-9 content was higher than omega-3 and 6. The peroxide value measured was 0.32 meq/kg, which was still below the maximum limit recommended by IFOS for the category of edible oil.

Acknowledgment: This research was funded by the Indonesian Education Scholarship (BPI), facilitated by the Center for Education Financial Services (PUSLAPDIK) in collaboration with the Center for Higher Education Funding and Assessment (PPAPT). The funding was provided by the Ministry of Education, Culture, Research, and Technology,

and the Education and Fund Management Institution (LPDP) of the Ministry of Finance, Republic of Indonesia, under funding number 01541/J5.2.3./BPI.06/9/2022 and grant number 202209092017.

Conflict Interest: The authors have no conflict of interest to declare.

Author's Contribution: HRH: Project Conceptualization, Projects Administration, Data curation, Formal analysis, Writing original drafts, Review, and editing. AGS: Proficient Supervisor and Expert in Conceptualization, Data curation, Formal analysis, Writing original drafts, Review, and editing. NVH: Proficient Supervisor and Contributor in Conceptualization, Writing original drafts, Review, and editing. KTR: Proficient Supervisor and Contributor in Conceptualization, Writing original drafts, Review, and editing. HSD: Proficient Supervisor and Contributor in Conceptualization, Writing original drafts, Review, and editing.

Data Availability: All the data is present inside the article.

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