RESEARCH ARTICLE OPEN ACCESS

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# Fatty Acid Profile of Snakehead (*Channa striata*) and Its By-Product by GC-MS

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**ABSTRACT**

The increasing demand for sustainable and high quality food sources has led to a growing interest in exploring alternative protein options. Fish-derived products, known for their nutritional value, unique flavour profiles, and potential health benefits, have gained significant attention. Among these, snakehead (*Channa striata*) and its by-products have emerged as promising resources for various food applications, including fish powder production. Fish powder holds immense potential in the food industry as a versatile ingredient, capable of enhancing nutritional content while minimizing waste. This research focuses on investigating the fatty acid composition and volatile compounds present in snakehead fish powder and its by-products. The study employs a combination of analytical techniques, namely gas chromatography-mass spectrometry (GC-MS) and lipid extraction methods, to identify and quantify fatty acids and volatile compounds in the fish powder samples, providing a comprehensive chemical profile. The data reveal variations in the fatty acid composition among different components of the snakehead powder samples, influenced by the fish's feeding habits. The presence of essential fatty acids, including omega-3 and omega-6, highlights the potential health benefits of consuming snakehead powder. In addition, the identification of odd-chain saturated fatty acids (OCS-FAs) in the samples indicates their potential contribution to human health. In particular, snakehead powder contains docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which have been reported preventive effects on heart disease in humans. In conclusion, snakehead powder is a valuable source of protein and essential fatty acids, with potential implications for human health. The study highlights the importance of incorporating polyunsaturated fatty acids (PUFAs) into the human diet, potentially through fish powder consumption. Overall, the findings highlight the potential benefits of snakehead meat, head, skin, and bone, encouraging the development of functional food products and their potential use in preventing stunting.

**ARTICLE INFORMATION**

**Submitted:** 09/08/2023
**Revised:** 09/10/2023
**Accepted:** 01/11/2023
**Published Online:** 01/11/2023

**Keywords:**
by-product
fatty acid
GC-MS
snakehead

**How to cite this article**: Puteri, N. E., & Febriansyah, M. I. (2023). Fatty Acid Profile of Snakehead (Channa striata) and Its By-Product by GC-MS. *Journal of Nutrition Science*, *4*(2), 60–65. doi:10.35308/jns.v4i2.8103

## Introduction

The global demand for high-quality and sustainable food sources has led to increased interest in exploring alternative protein sources. Fish-derived products have gained considerable attention due to their nutritional value, unique flavor profiles, and potential health benefits (Abbey, Glover-Amengor, Atikpo, Atter, & Toppe, 2017). Snakehead is an essential and valuable freshwater fish in Indonesia. Snakehead is native to Indonesia and found in various freshwater ecosystems, including rivers, lakes, and ponds. Snakehead is mainly collected from inland fisheries (92.8%), while the remaining is produced from aquaculture (Gustiano, Kurniawan, & Kusmini, 2021). They are consumed in various ways, and their consumption can vary by region. The meat is commonly utilized and taken from the body of the cork, while the head, skin and bones are thrown away. Their culinary versatility and presence in traditional dishes make them an indispensable part of Indonesian cuisine. In particular, snakehead (*Channa striata*) and its byproducts have emerged as promising resource for various food applications, including the production of fish powder. Snakehead is has wound-healing activity (Rahayu, Marcelline, Sulistyaningrum, Suhartono, & Tjandrawinata, 2016), essential minerals (Marimuthu, Thilaga, Kathiresan, Xavier, & Mas, 2012), essential amino acids (Mustafa, Widodo, & Kristianto, 2012), collagen (Rosmawati, Abustam, Tawali, Said, & Sari, 2018), and several bioactive compounds. Fish powder, obtained from the processing of snakehead and its by-products, has great potential for the food industries a versatile ingredient. It offers opportunities to enhance the nutritional content of various food products while minimizing waste. To fully exploit the potential of fish powder, a comprehensive understanding of its chemical composition is important.

This research aims to investigate the fatty acid composition and volatile compounds present in snakehead fish powder and its by-product. Fatty acids are essential components of the human diet, playing a crucial role in maintaining overall health. The identification and quantification of fatty acids in fish powder will show its nutritional value and potential health benefits (Molla et al., 2016). Additionally, volatile compounds are responsible for the unique aroma and flavor of foods. By analyzing the volatile profile of snakehead fish powder and its by-product, this study will provide valuable insights into the sensory attributes and culinary applications of these products. In addition, understanding the volatile composition can help identify potential off-flavors or undesirable compounds, enabling the development of strategies to improve the overall quality and consumer acceptance of fish powders.

To achieve these objectives, a combination of analytical techniques, gas chromatography-mass spectrometry (GC-MS) and lipid extraction methods, will be employed. These techniques will enable the identification and quantification of fatty acids and volatile compounds in the fish powder samples, thereby providing a comprehensive chemical profile (Molla et al., 2016). The outcomes of this research will contribute to the existing knowledge on the nutritional and sensory properties of snakehead fish powder and its by-product. The findings will not only benefit food industries involved in the production of fish-based products but also provide valuable insights for the development of functional foods, dietary supplements, and innovative culinary applications. Through this study, we tried to characterize the potential of snakehead (*Channa striata*) powder and its by-products, by evaluating their fatty acid and volatile compounds.

## Method

### Preparation of snakehead powder

The Snakehead (*Channa striata*) as the sample was collected from a traditional market in Ogan Ilir, South Sumatra. The fish were cleaned, gutted, washed, filleted and separated into meat (MT), head (HD), skin (SK) and bone (BN). The meat, head, skin, and bones of snakeheads were dried in a convection oven (GL4802, IONA, Singapore) at 70°C for 24 h. Then, each group of samples was ground with a blender and filtered through a stainless-steel sieve (10 mesh) to obtain fish powder. The sample was then stored at 4°C until ready for further analysis (Abbey et al., 2017).

### Lipid extraction

Lipid extraction was applied in order to isolate the fatty acids from the sample. Lipid was extracted from snakehead powder by using hexane (Caprino et al., 2008).

### Fatty acid analysis

After the extraction of lipid, the preparation of fatty acid methyl esters (FAME) for fatty acid analysis was performed (Ahmad et al., 2021). The extracted lipid was reacted with an acid catalyst and methanol. Analysis of fatty acid profile was done by using gas chromatography (Thermo Scientific, Trace 1310, Waltham, USA) coupled with single quadrupole mass spectrometer (Thermo Scientific, ISQ 7000, Waltham, USA). Nitrogen was used as the carrier gas (1 mL/min) of the fatty acid methyl esters. Fatty acid methyl esters were identified by comparison of retention time and standard fatty acid methyl esters mixtures.

### Data handling

Data was expressed as mean ± standard error of mean. Descriptive analysis was performed to fatty acid composition.

## Results

Fatty acids are natural components of fats and oils. Based on their chemical structure into saturated, mono-unsaturated and poly-unsaturated fatty acids. Representative chromatograms of the fatty acid in snakehead powder are shown in Figure 1. The chromatograms typically show single peaks. Each peak in the chromatogram corresponds to a specific fatty acid, and the area under each peak represents the relative abundance or concentration of that fatty acid in the sample.

Each peak in chromatogram can be identified and quantified. Table 1 contains information about the quantitative content (%) of various fatty acid compounds and related substances that may be relevant to be related to a biological or food-based study. The compounds are identified by their chemical nomenclature and are present in four different components.

## Discussion

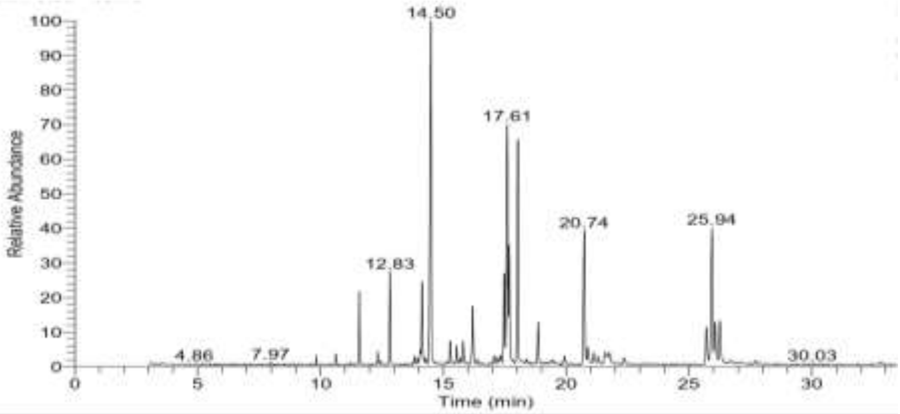
The fatty acid composition of snakehead powder can be related to the feeding habits of the fish which consumes phytoplankton that are usually rich in essential fatty acids (Mohanty et al., 2016; Sprague, Dick, & Tocher, 2016). Therefore, the fatty acid profile usually reflects the type of diet of the fish. Previous studies have also shown that processing can enhance lipid oxidation by increasing peroxide value and total oxidation value of fish oil. Then, the percentages of unsaturated fatty acids present in the samples are responsible for the major changes in fatty acid profile occurring during processing (Tenyang, Ponka, Tiencheu, Djikeng, & Womeni, 2020).

Palmitic acid was the most abundant fatty acid found in the powder of snakehead meat, skin, and bone. The other abundant mono-unsaturated fatty acid was stearic acid. The result is in good agreement with the previous findings. Palmitic acid and stearic acid were the dominating monounsaturated fatty acid in freshwater fish species and the by-products (Kandyliari et al., 2020; Tenyang et al., 2020). Myristic acid was also found in each sample. Myristic acid is a potential candidate for the prevention and treatment of type 2 diabetes mellitus and related diseases (Esperón-Rojas, Mendoza-Sánchez, & García, 2021).

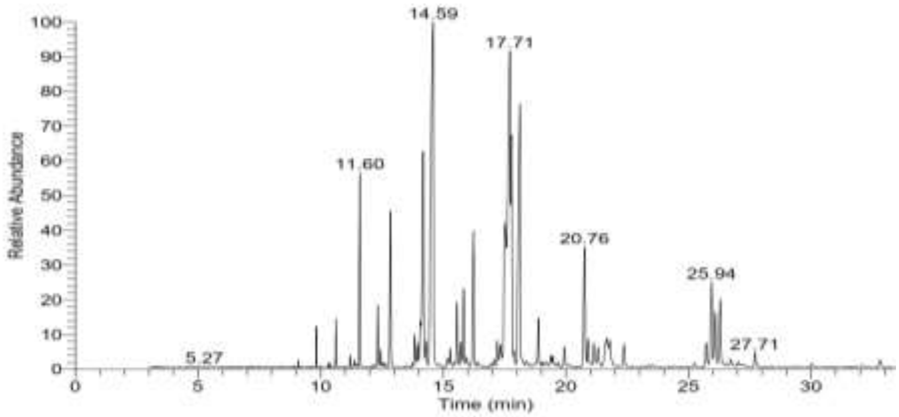

**doi:** https://doi.org/10.35308/jns.v4i2.8103 P- ISSN : 2723-2867, E-ISSN : 2723-2875

Arachidonic acid is also found in the powder of meat, skin, and head.

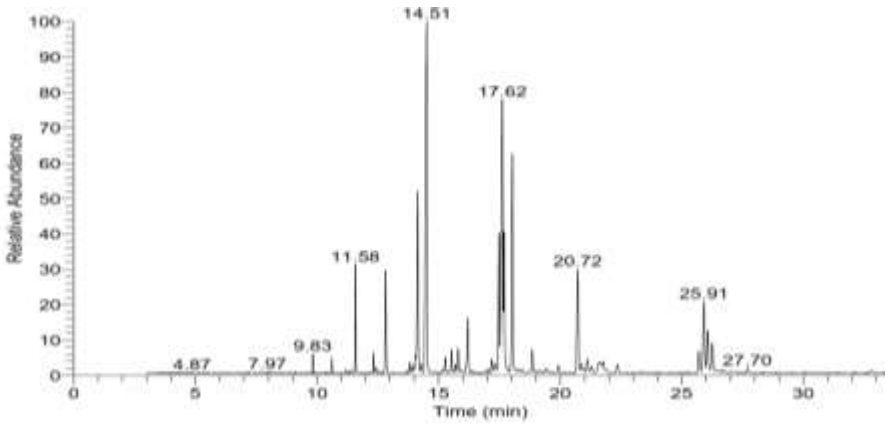
Fatty acids in plants and animals most commonly have an even number of carbons, but a small percentage of odd-numbered fatty acids are present in many species. However, the intake of odd-



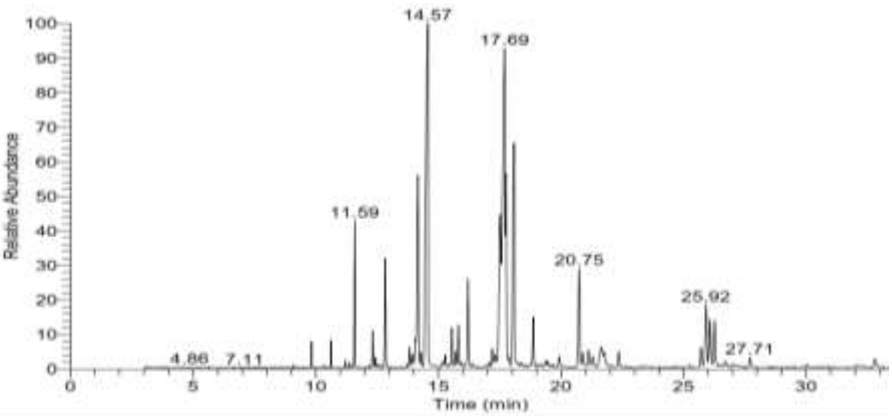

(a)




(b)




(c)




(d)


**doi:** https://doi.org/10.35308/jns.v4i2.8103 P- ISSN : 2723-2867, E-ISSN : 2723-2875

Figure 1. The chromatograms of fatty acid in snakehead powder from (a) meat; (b) head; (c) skin; and (d) bone

Table 1. Fatty acid composition of total lipid in meat, head, skin, and bone of snakehead

| Compound | Chemical Nomenclature | Quantitative Content (%) | | | |
|---|---|---|---|---|---|
| | | Meat (M) | Head (H) | Skin (S) | Bone (B) |
| Dodecanoic acid (Lauric acid) | C12:0 | 0.18 ± 0.01 | 0.42 ± 0.01 | | 0.33 ± 0.02 |
| Tridecanoic acid | C13:0 | 0.25 ± 0.00 | 0.57 ± 0.02 | 0.34 ± 0.01 | 0.39 ± 0.01 |
| Tetradecanoic acid (Myristic acid) | C14:0 | 2.11 ± 0.01 | 3.45 ± 0.01 | 2.93 ± 0.04 | 2.95 ± 0.02 |
| 13-methyltetradecanoic acid | C14:0 | 0.44 ± 0.01 | 1.04 ± 0.02 | 0.62 ± 0.01 | 0.78 ± 0.00 |
| Pentadecanoic acid | C15:0 | | 3.67 ± 0.01 | | 2.87 ± 0.03 |
| Hexadecanoic acid (Palmitic acid) | C16:0 | 19.05 ± 0.03 | 0.66 ± 0.01 | 20.97 ± 0.02 | 19.87 ± 0.01 |
| 10-methyl-hexadecanoate | C16:0 | | | | 0.24 ± 0.00 |
| 1,1-dimethoxyhexadecane | C16:0 | | 0.41 ± 0.00 | 0.61 ± 0.01 | 0.34 ± 0.01 |
| cis-10-heptadecenoic acid | C17:1 | 1.04 ± 0.05 | 1.89 ± 0.00 | 0.97 ± 0.03 | 1.21 ± 0.01 |
| Heptadecanoic acid (Margaric acid) | C17:0 | 2.77 ± 0.02 | 3.51 ± 0.01 | 2.55 ± 0.01 | 2.60 ± 0.00 |
| α-linolenic acid | C18:3 | | 0.62 ± 0.00 | | 0.56 ± 0.01 |
| Octadecanoic acid (Stearic acid) | C18:0 | 11.24 ± 0.01 | 10.05 ± 0.01 | 10.63 ± 0.03 | 9.46 ± 0.02 |
| 1,1-dimethoxyoctadecane | C18:0 | 1.92 ± 0.01 | 1.16 ± 0.01 | 1.06 ± 0.00 | 1.57 ± 0.04 |
| Nonadecanoic acid | C19:0 | 0.46 ± 0.02 | 0.56 ± 0.01 | 0.39 ± 0.00 | 0.38 ± 0.01 |
| 5,8,11,14-Eicosatetraenoic acid | C20:4 | 8.27 ± 0.01 | 4.37 ± 0.04 | 5.77 ± 0.03 | |
| Eicosanoic acid (Arachidic acid) | C20:0 | | 0.75 ± 0.03 | 0.52 ± 0.02 | 0.62 ± 0.01 |
| 4,7,10,13,16-docosapentaenoic acid | C22:5 | 2.32 ± 0.02 | 0.83 ± 0.03 | 1.24 ± 0.04 | 0.76 ± 0.01 |
| 4,7,10,13,16,19-docosahexaenoic acid | C22:6 | | | | 2.66 ± 0.01 |
| cis-7,10,13,16-docosatetraenoic acid | C22:4 | | 1.62 ± 0.02 | 2.26 ± 0.03 | 1.78 ± 0.01 |
| 20-methyl-heneicosanoate | C22:0 | 0.21 ± 0.01 | | 0.25 ± 0.02 | |
| Docosanoic acid (Behedic acid) | C22:0 | | 0.48 ± 0.02 | | |
| Tetracosanoic acid (Lignoceric acid) | C24:0 | | 0.31 ± 0.00 | | 0.45 ± 0.05 |

chain fatty acids are lower. Our findings showed that tridecanoic acid (C13:0), pentadecanoic acid (C15:0), and heptadecanoic acid (C17:0), as odd chain saturated fatty acids (OCS-FAs), were identified in snakehead powder. The role of C17:0 and C15:0 for human health has recently been reinforced following a number of important nutritional and biological observations. These OCS-FAs are generated by α-oxidation in peroxisomes, de novo lipogenesis, from the diet and by the gut microbiota (Ampong et al., 2022). Several studies of cardiometabolic diseases have shown that plasma OCS-FAs levels are associated with a lower risk of metabolic disease (Jenkins, West, & Koulman, 2015).

Each sample contained reasonable amounts of essential PUFAs. They are known sources of a group of polyunsaturated fatty acids (PUFAs), especially omega-3 and omega-6, which can prevent atherosclerosis and blood clots. These fatty acids have a preventive effect on coronary heart disease, autoimmune diseases, cardiac arrhythmias, lowering plasma triglyceride levels and blood pressure (Pal et al., 2018). Adequate intake of polyunsaturated fatty acids, especially omega-3, is important for optimal brain and cognitive development. Therefore, intake of these fatty acids is associated to the prevention of stunting, since there is sufficient nutrition that would support optimal functional development of tissues including the central nervous system (Rahmawaty & Meyer, 2020). However, high temperature during processing might attack the double bonds of unsaturated fatty acids presents in samples, resulting in the oxidation of lipids and the decrease in nutritional value. The presence of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) in suggests that snakehead powder may have a healing effect to alleviate muscle pain and inflammation. Therefore, snakehead has been suggested as a key component of a healthy human diet. Research indicates that there are two most beneficial omega-3 fatty acids EPA and DHA (Pal et al., 2018). According to a study, fish from India, including finfish, shellfish, and edible mollusks from both freshwater and marine environments, are excellent sources of DHA and EPA (Mohanty et al., 2016). Docosahexaenoic acid and eicosapentaenoic acid also been reported to have preventive effects on human coronary artery disease. Docosahexaenoic acid (DHA) is the main component of many cells, particularly brain neurons and retinal cells. It is crucial for fetal brain development, infant motor skill development, infant visual acuity, lipid metabolism, and cognitive support, and when combined with eicosapentaenoic acid (EPA), it helps prevent conditions such as atherosclerosis, dementia, rheumatoid arthritis, and Alzheimer's disease. Moreover, we also found eicosatetraenoic acid (ETA) and docosatetraenoic acid (DTA) in snakehead powder. Eicosatetraenoic acid (ETA) is found primarily in tissues in an esterified form and is released from cellular stores by phospholipase action. It promotes and modulates type 2 immune responses (Tallima & El Ridi, 2018).

Recent studies have found that abundant PUFA in fish feed can contribute to off-odor development in fish products due to increased oxidation susceptibility and the presence of odorant compounds linked to lipid sources and unsaturated fatty acids. Significant have findings emerged regarding the distinct off-odors generated by the two major ω-3 PUFAs in fish oil, namely DHA and EPA. Off-odors is not solely attributed to DHA and EPA, as simultaneous oxidation of other fatty acids in the oil, such as oleic and linoleic acids, also played a contributing role (Lee, Jiang, Brenna, & Abbaspourrad, 2018; Wen et al., 2023). The coexistence of lipoxygenase and hemoglobin in fish leads to a synergistic effect, intensifying the formation of off-odors resulting from the oxidation of polyunsaturated fatty acids (PUFAs). This collaborative interplay between lipoxygenase and hemoglobin amplifies the production of undesirable sensory attributes, highlighting their pivotal roles in the generation of off-odors in fish products. Specifically, the affiliation of lipoxygenase with a potent fishy odor and the association of hemoglobin with a distinctly severe oxidized oil odor have been documented (Hui-hon, 2013). Furthermore, the researchers identified 2,4-heptadienal (E,E) as a potential key contributor to the fishy odor, while the presence of hexanal and nonanal seemed to be responsible for the distinctive odor characterizing oxidized oil (Fu, Xu, & Wang, 2009).

## Conclusion

Snakehead powder was found shown to be a good source of protein and fatty acids. Palmitic acid and stearic acid were the dominant monounsaturated fatty acids in snakehead meat, head, skin and bone powder.. All samples contain essential fatty acids, especially PUFAs which are very good for health. Based on all the above facts, it is clear that PUFAs are important in human physiology and should be included in the human diet, perhaps in the form of fish powder as a rich source of these fatty acids. Our present results show that snakehead meat, head, skin and bones are beneficial to human health. Moreover, the powder of snakehead meat, head, skin and bone is potentially to be developed as functional food product and may be used to prevent stunting. In addition, it is necessary to optimize the snakehead powder into commercial product.

## Author Contribution and Competing Interest

First author contributed in designing the analysis, performing the analysis, and drafting the manuscript. Second author contributed in preparing sample, collecting the data, and interpreting the data. We declare that there is no conflict of interest.

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