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Research Article

Potential of Long-Jawed Mackerel (Rastrelliger) Oil as the Source of Cholecalciferol and Omega-3 to Minimize the Risk of Psoriasis

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ABSTRACT

The impact of psoriasis extends beyond skin inflammation and can significantly impact the patients' mental health. Fish oil is considered an alternative to combat chronic dermatitis, mainly due to its omega-3 fatty acid and cholecalciferol contents. Long-jawed mackerel (Rastrelliger), an abundant fish in Indonesian waters, is recognized for its high omega-3 and cholecalciferol that competes with commercial and other local fish species. This study aims to analyze the nutritional content in Rastrelliger fish oil as an alternative for controlling psoriasis. This study also used the wet rendering method to compare fish oil from silver catfish and skipjack tuna. The three samples were analyzed using Fourier Transformed Infrared Spectroscopy (FTIR) spectroscopy to identify their Omega-3 and cholecalciferol contents. This process yielded 51 grams of oil from 292 grams of Rastrelliger fish. Rastrelliger's fat content was 1.83±0.03%, with a water content of 70.06±1.87%. FTIR spectrum indicated the presence of alkenes, carboxyl, methyl, and methylene groups, which are functional groups of Omega-3 fatty acids. The content in 100 grams of Rastrelliger fish was 2.2 grams of Omega-3 and 2.04 mcg of cholecalciferol. There is potential for controlling psoriasis, as the need for Omega-3 and cholecalciferol can be met. In conclusion, Rastrelliger fish oil demonstrates promising potential as a treatment measure for the autoimmune disease psoriasis.

Keywords: Fish oil; long-jawed mackerel; wet rendering; Omega-3; psoriasis

Introduction

Psoriasis is a skin disease that is classified as chronic papulosquamous and is known to affect people regardless of age or gender [1]. The appearance of this disease is caused by autoimmunity, which stems from genetic disposition and various environmental and lifestyle factors. Autoimmunity refers to a scene where parts of the body's immune system become overactive and attack normal tissues [2]. About 125 million people in the world have psoriasis. Meanwhile, the prevalence of psoriasis patients in Indonesia reaches 2.5% of the entire population, or around 6.5 million people [3]. More than just inflammation of the skin, psoriasis can also potentially affect the emotional health of the patient [4]. A study states that the higher the severity of psoriasis, the more impaired the patient's quality of life is [5]. Furthermore, autoimmune diseases such as psoriasis cannot be cured and can only be controlled [1]. Therefore, it is crucial to prevent the disease itself rather than treat it.

Several external psoriasis drugs such as corticosteroids and emollients can treat the symptoms. As for psoriasis therapy, called phototherapy, which is a treatment that utilizes ultraviolet (UV) light in the form of UV-A or UV-B, it can help accelerate the healing of psoriasis patients' skin. In the context of preventive measures,

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various complementary supplements can be consumed, one of which is fish oil [6]. Fish oil has Omega-3 anti-inflammatory fatty acids that have the potential to ward off inflammation in the skin. But ironically, Indonesia, which is known as a maritime country, apparently still imports more than 9,000 tons of fish oil [7]. A stability test-based study conducted in East Java found that only 12.5% of imported fish oil samples met the International Fish Oil Standards (IFOS) [8]. Meanwhile, Indonesia has local fish varieties that have the potential to be processed into fish oil, including long-jawed mackerel (*Rastrelliger*), also known as *Ikan Kembung.* According to the Statistics and Information Data Center of the Indonesian Ministry of Maritime Affairs and Fisheries, the volume of long-jawed mackerel production in Indonesia reached 443,882.58 tons in 2017. Its abundant production makes long-jawed mackerel one of the large-scale export commodities to neighbouring countries. Long-jawed mackerel cultivation that is native to Indonesia makes its condition fresh. Not only that, a study reported that long-jawed mackerel has a higher Omega-3 content than salmon [9], plus stores *cholecalciferol*. Therefore, in this study, researchers will explore and analyze the nutritional content of Omega-3, cholecalciferol, or vitamin D3 in long-jawed mackerel oil and compare it with silver catfish and skipjack tuna oil.

Materials and Methods

Design of Study

This study was conducted in the Chemistry Laboratorium of Bandung Institute of Technology. The materials used were long-jawed mackerel, silver catfish, and skipjack tuna, purchased from Superindo Semarang and Pasar Kambing South Jakarta. This study used standard laboratory equipment, such as an analytical balance, micropipette, distillation flask, desiccator, hotplate, and other laboratory glassware. The chemicals used were analytical grade chemicals without further purification, such as methanol. Water elimination was subjected to the sample before it was processed.

FTIR Analysis

The FTIR analysis used the KBr method. The KBr method is the technique where the sample is mixed with potassium bromide (KBr) powder as a matrix or holder [10]. For the analysis, water content in the sample should be removed beforehand. The stages of the water elimination process are as follows: (1) sterile petri dish in 10 cm diameter was washed and dried in the oven at a temperature of 40℃, (2) fish oil moisture was taken using a dropper and placed on a petri dish (around 5-7 drops), and (3) the sample was put into the oven at a temperature of 85℃ for 4 hours. The fish oil samples that free-water content were dripped and smeared on the KBr pellets.

Data acquisition and Analysis Methods

Fish oil extraction process

The extraction method used was wet pressing, also known as the wet reduction method. Wet reduction consists of 4 stages: fish vaporization, pressing, decantation, and centrifugation. Initially, the long jawed-mackerel fish 1.05 kilogram was cleaned using running water, separated from its faeces, and then cut into pieces to simplify the processing. After that, it was steamed in a stainless-steel steaming pot at 90-95℃ for 10-20 minutes. Then, the fish was pressed using a press to divide the fat-free solids or thorns from the liquid. To obtain the 'clean' oil, decantation should be carried out by gradually pouring in hot water, so the sediment remains at the bottom of the glass. Finally, centrifugation was carried out in a centrifuge to purify the oil further. For comparison, the extraction process was also conducted on 2 other fish species, namely silver catfish and skipjack tuna, following the same steps of the long-jawed mackerel preparation.

Determination of water content

Take one sample of fish oil that has been produced, then put it in the oven at 105℃ for 3-5 hours. After being removed from the oven, the sample is cooled in a desiccator for 30 minutes and then weighed. For more accurate results, this process was repeated several times until the weight of the sample stabilized. Moisture content was calculated using Equation 1 [11].

$$\frac{sample\ initial\ weight - sample\ final\ weight}{sample\ initial\ weight} \times 100\% \quad \text{(Eq. 1)}$$

Determination of fat content.

The method used was the Soxhlet method. A sample of fish oil was taken, added with petroleum ether, and allowed to settle for 5 hours. The extract was then dried in an oven at 105℃ for 2 hours.

After that, it was put in a desiccator for 30 minutes and weighed on an analytical scale to record the results. Fat content was then calculated using the Equation 2 [12].

$$fat\ content = \frac{W_1 - W}{W_2} \times 100\% \qquad \text{(Eq. 2)}$$

Information:
W = empty goblet weight (g)
W_1 = empty goblet weight + fat extract (g)
W_2 = sample weight (g)

Result and Discussion

Fish Oil Extraction Results

Long-jawed mackerel, skipjack tuna, and silver catfish are claimed to have high oil content (Figure 2). Long-jawed mackerel (*Rastrelliger*) is a fish species rich in free fatty acids and pigmentation, which is related to the release of free fatty acids from solid materials during fish thawing and the release of haemin (an acid hydrolysis product of hemoglobin). These factors contribute to the high oil content of long-jawed mackerel. Naturally, skipjack tuna (*Euthynnus affinis*) stores a lot of lipids in its wastes, such as the head, liver, and intestines. On the other hand, the liver of silver catfish (*Pangasianodon hypophthalmus*) is where high amounts of *alkylglycerols* and squalene are available, so a lot of oil is produced from this part. The cleanliness aspect of the fish for the extraction process by removing dirt, fins, heads, and thorns affects the results of the fish oil, which has minimal residue and appears filtered.

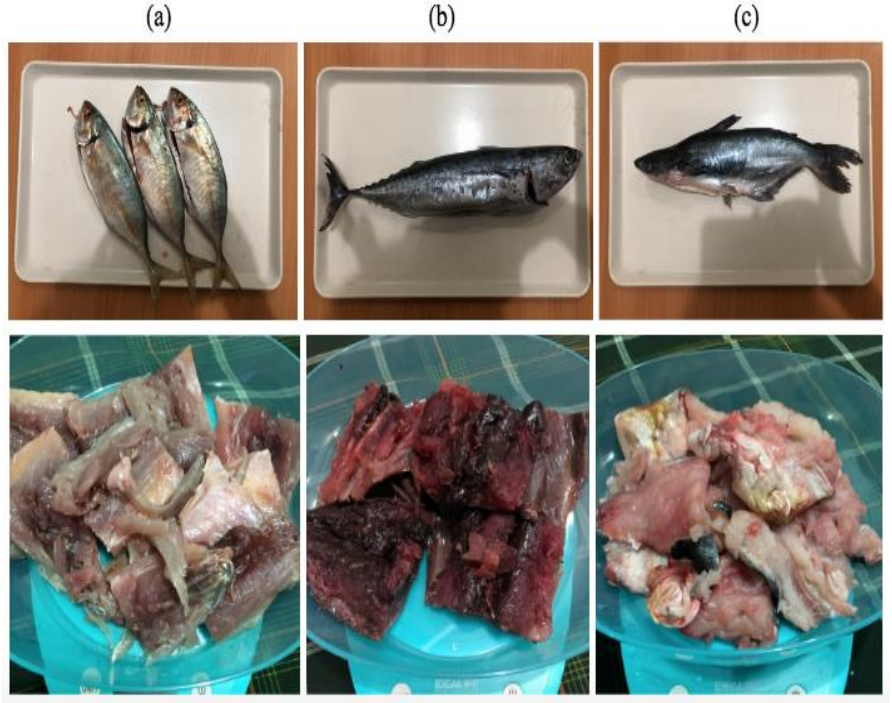

Figure 1. Variations of fish species used in this study: (a) long-jawed mackerel, (b) skipjack tuna, and (c) silver catfish. The top picture is the fish before cleaning and the bottom picture is the fish after cleaning along with its weight in grams.

Fish oil contains long-chain Omega-3 polyunsaturated fatty acids, such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Fish oil is generally used for cognitive-related purposes, such as early brain development supplements, dementia, or neuropsychiatry. In addition, fish oil also plays a role in healing cardiovascular, neurological, and immune diseases. In this study (Figure 3), fish oil was obtained by the extraction process of the wet rendering method or through steam heating, where the higher the temperature and the longer the steaming time significantly affected the greater volume of liquid oil extracted [13]. Wet rendering belongs to the green chemistry method using water-based extraction, so it has advantages in terms of safety compared to solvent extraction [14]. However, this extraction process also has the risk of causing considerable water content along with oil, hence the need for a water elimination process.

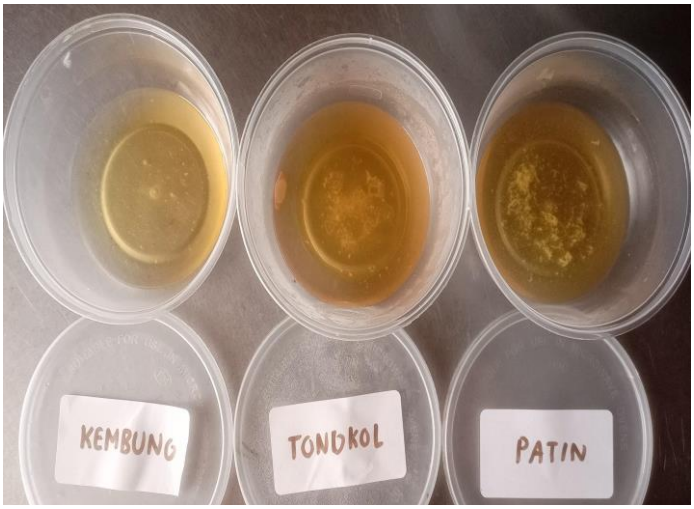

Figure 2. Fishes Oil Extraction Results

Long-jawed mackerel (*Rastrelliger*) is known to be one of Indonesia's large-scale export commodities, which means its abundance in the country is unquestionable. It is also sustainable for long-jawed mackerel to be purchased at affordable prices. Table 3 shows that the mass of oil produced from long-jawed mackerel is 17.47% of the 292-gram sample, which is considered to be decent. Although long-jawed mackerel and skipjack tuna come from the same type of water, namely sea water, the quantity of oil extracted from long-jawed mackerel is significantly less, which is a difference of 43 grams. This can occur because there is a probability that the peroxidic value will increase rapidly during storage, resulting in oil degradation [15]. Meanwhile, silver catfish is a type of freshwater fish that generally has a higher oil content than other types of fish [16], so it is not surprising that the mass of oil produced is categorized as abundant.

Table 1. Mass of Fish Oil Produced from the Extraction Process

Name of Fish	Mass of Fish Extracted (g)	Mass of Fish Oil Produced (g)
Long-jawed mackerel	292	51
Silver catfish	292	85
Skipjack tuna	292	94

Rendering is a method of extracting fish oil by treating the fish in heat. This method is widely chosen due to its easy process. In addition, rendering can be classified into two types, wet rendering and dry rendering. The difference between the two is in the presence of water in the extraction process. In the dry rendering process, the fish will be heated at high temperatures without water, while

the wet rendering process requires the presence of water. Wet rendering is considered to be more efficient as the quantity of oil produced is higher than dry rendering, and it lowers the risk of oxidation and nutrient degradation. Previous published research also explained that the wet rendering extraction method can produce silver catfish oil with better quality in terms of free fatty acid number, peroxide number, and organoleptic testing compared to the dry rendering method [17]. The use of temperature in fish oil extraction aims to damage the tissue by coagulating proteins on the cell membrane so that oil can be extracted [13]. It is reported that high temperatures will denature more proteins so that the oil more easily penetrates the cell walls and conversely, the oil will be more difficult to escape when in low temperatures. However, even too high a temperature can interfere with the process because proteins will denature and form solid structures that will ultimately inhibit oil release [18], generate free radicals, and trigger the formation of secondary oxidation [19]. In looking at the effectiveness of the extraction process through the wet rendering method, the determination of moisture and fat content is one of the important indicators. The moisture content of fish simply indicates the texture of the fish. As shown in Table 4, the moisture content of silver catfish is the highest because it has a softer texture than other types of fish. Meanwhile, the highest fat content was obtained from long-jawed mackerel about 1.83±0.03%. The type of fat found in fish generally has distinctive chemical characteristics unlike the type of fat that comes from land animals or plants. These fats consist of triglycerides containing various types of fatty acids, including many unsaturated compounds (double bonds) and fatty acids with long carbon chains, such as those with 22 or 24 carbon atoms. In addition to their specific chemical characteristics, the fats present in fish have varied nutritional values, such as Omega-3 fatty acids. Omega-3s are polyunsaturated fatty acids that are the sum of EPA and DHA. Its concentrate contains a specific spectrum indicated by the HC=CH trans, -C=O (ester), and -C-O (acid) groups [20]. In this study, the omega-3 fatty acids used will be analysed more deeply for the three types of fish used.

Table 2. Fat And Water Content Results of Several Types of Fish Oil

Name of Fish	Fat Content (%)	Water Content (%)
Long-jawed mackerel	1.83±0.03	70.06±1.87
Silver catfish	1.57±0.03	72.26±2.08
Skipjack tuna	0.26±0.06	69.62±2.21

Fish Oil Testing

To identify the nutrient content in fish oil, this study conducted confirmation testing using spectroscopic methods. Spectroscopy is defined as the study of the absorption and emission of light and other radiation by matter [21]. This method is based on the theory that molecules absorb light energy at their resonance frequencies at specific wavelengths. There are several spectroscopy types, including UV, NMR, Raman, and Infrared spectroscopy.

Infrared spectroscopy utilizes the vibration and movement of molecules to obtain information about the functional groups contained in molecules such as lipids, proteins, nucleic acids, and polysaccharides to map them in graphical form. When infrared light hits a sample, some light at the appropriate wavelength is absorbed, causing changes in the molecule's dipole moment and vibrational energy. An infrared spectrum can be obtained by measuring the absorption or transmission of light at each frequency. Identification can also be made by comparing the peaks seen at specific wavelengths in the spectrum with functional group data. The type of infrared spectroscopy used in this test is FTIR (Fourier transform infrared). The testing mechanism using FTIR is as follows: when the molecular sample to be tested

has been prepared, an interferogram for the sample will be taken using an interferometer and finally the data will be processed using the Fourier transform mathematical formula to convert the time-domain spectrum into a frequency-domain spectrum, in other words, an infrared absorption spectrum represented as transmittance or absorbance on the y-axis and wave number on the x-axis.

The main principle of FTIR lies in the amount of light absorbed at a particular wavelength, which at the same time gives information about the identity of the functional groups located at that wavelength. Therefore, the presence of solvents such as water in the sample can distort the FTIR graph because it can cover the solute spectrum with broad and intense peaks. It can be seen in Figure 4, that the peaks are too broad and non-specific, and some functional groups cannot be detected when compared to Figure 5. It can be concluded that water elimination is necessary in this study to obtain concrete and accurate results.

The FTIR spectra after water elimination confirmed the presence of alkene, carboxyl, methyl, and methylene which are functional groups found in Omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). As seen below, the functional group alkene is depicted by a double bond between two carbon atoms (C=C) and appeared as a strong peak between the 1670-1600 cm^{-1}. Additionally, a carboxyl group is a carbon atom double-bonded to an oxygen atom while also single-bonded to a hydroxyl group and visible in the 1780-1710 area of the spectrum. Furthermore, the bonds that make up the carboxyl groups are represented in different peaks according to the type of the bonds. For instance, the double bond of carbon and oxygen (C=O), the single bond between the same carbon with another oxygen atom (C-O), and the single bond made by the oxygen atom with hydrogen (O-H) are visible in the 1700s, 1000-1300, and 3200-3400 region respectively. In the same topic, methyl groups are one carbon atom bonded to three hydrogen atoms and were found in the peak within the 1450 area. Lastly, methylene groups are similar to methyl except that they bond only with two hydrogen atoms and are found in the 1465 area [22]

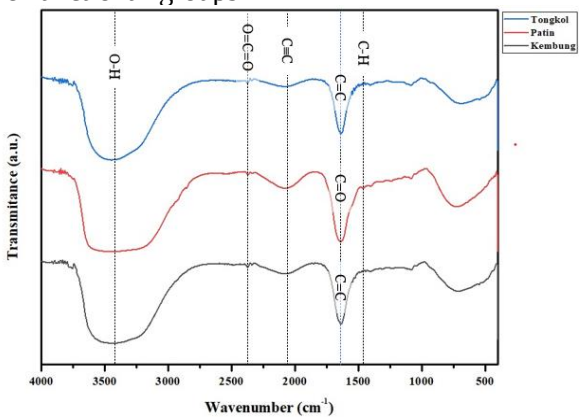

Figure 3. FTIR Spectra of Three Types of Fish Before Water Elimination

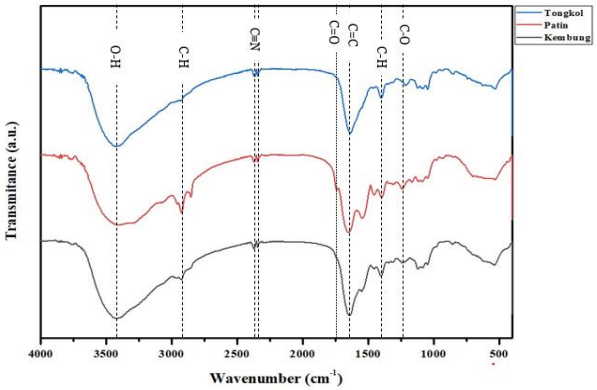

Figure 4. FTIR Spectra of Three Types of Fish After Water Elimination

Potential of Omega-3 for Psoriasis Control

According to an article from the National Institute of Arthritis and Musculoskeletal and Skin Diseases, psoriasis is a chronic, long-term disease that causes the immune system to become overactive, causing skin cells to multiply too quickly. The exact cause of the disease is still unknown other than the suspicion that there are many factors involved, including genetics, environment, disorders in the skin epidermis, and immune system dysfunction [23]. Therefore, the severity varies from person to person.

As an autoimmune disease, psoriasis cannot be cured and can only be alleviated. Studies by Gottlieb et al. [24] were the first to discover that T cells, which play an important role in the immune system as detectors of foreign antigens and determinants of subsequent immune action, are a factor in the onset of psoriasis. T cells that can release cytokines make them contribute to the triggering of inflammation and proliferation of skin cells (keratinocytes). Two types of cytokines can be produced: type 1 (Th1) and type 2 (Th2). Th1 cytokines are known as pro-inflammatory cytokines, while Th2 are known as anti-inflammatory cytokines that can restrain the production of type 1 cytokines by inhibition. Increased amounts of Th1 cytokines such as tumor necrosis factor-α (TNF-α), interleukin (IL)-2, interleukin (IL)-17, and interferon (IFN)-γ have been shown to play an important role in various chronic inflammatory diseases including psoriasis [25-27]. On the other hand, decreased amounts of Th2 cytokines such as interleukin (IL)-4, interleukin (IL)-5, interleukin (IL)-13, and interleukin (IL)-10 [28] are one of the symbols of inflammation. This immunological imbalance is thought to be one of the factors of psoriasis [29].

Omega-3 has two types of fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) that have anti-inflammatory and anti-oxidation properties [30-31]. Theoretically, this means that these fatty acids can reduce the effects of psoriasis in various ways, such as increasing the production of Th2 cytokines, inhibiting the synthesis of molecules with pro-inflammatory properties, or lowering the level of inflammation in the skin itself with their anti-oxidation properties. Jaudszus et al. [32] proved that EPA and DHA increase the amount of interleukin (IL)-10, which is a cytokine with anti-inflammatory properties [33] and can regulate T cells by preventing and limiting excessive specific and non-specific immune reactions that can result in tissue damage [34]. In addition, EPA and DHA which are eicosanoids or lipid-based signaling molecules from Omega-3 can inhibit the production of other eicosanoids such as arachidonic acid (ARA) which is derived from Omega-6 polyunsaturated fatty acids and is a pro-inflammatory molecule by inhibiting the enzyme responsible for making ARA from Omega-6 [35]. It can be concluded that proportionally higher consumption of Omega-3 polyunsaturated fatty acids may protect against inflammatory diseases, cancer, cardiovascular diseases, and other chronic diseases [36].

The dosage of Omega-3 to function for psoriasis survivors is 250-500 mg per day for at least three months with a balanced EPA and DHA content [37]. A comparison of the Omega-3 quantity content in commercial fish species that commonly use fish oil can be said to be similar. Per 100 grams, trout has 1.7 grams of Omega-3; salmon has 4 grams; sardines have 3 grams [38-41]. Meanwhile, local fish such as long-jawed mackerel, silver catfish, and skipjack tuna have 2.2 grams [42], 1.16 grams [43], and around 1 gram [44], respectively. This proves that long-jawed mackerel can compete superiorly as a fish oil rich in Omega-3 compared to other local fish. Likewise, Vitamin D is also used as a topical therapy against psoriasis [45], more specifically vitamin D3 or cholecalciferol. To be able to prevent or control psoriasis, a range of 30,000 to 60,000 IU of cholecalciferol is needed—1 IU = 0.025 mcg— in a span of 2-6 months. In 100 grams of long-jawed mackerel, there are about 81.6 IU of vitamin D3. That means 36.7-73.5 kilograms of long-jawed mackerel are needed to prevent and control psoriasis. If calculated for daily consumption, eating at least 0.6 kilograms of long-jawed mackerel every day for 2 months is necessary.

Long-jawed mackerel oil extract is an excellent consumption option as it is affordable, abundant in the market, and rich in Omega-3 fatty acids, vitamin D3 or cholecalciferol, as well as various other essential nutrients. This makes it an attractive alternative to getting fish oil's health benefits without spending more or worrying about availability in the Indonesian market.

Conclusion

This study demonstrated that mackerel fish oil contains EPA and DHA, as confirmed by FTIR

analysis. Water elimination in FTIR is necessary for accurate identification of functional groups. In addition, T-cell dysfunction is implicated in psoriasis development. T cells produce two cytokine types: proinflammatory (Th1) and anti-inflammatory (Th2). EPA and DHA possess anti-inflammatory and antioxidant properties, boosting Th2 cytokines' production. EPA and DHA inhibit proinflammatory eicosanoid production from Omega-6. The effective psoriasis control requires daily consumption of 0.6-1.2 kilograms of long-jawed mackerel for 2 months. For future research, it would be better to conduct other characterization tests such as tests for carbohydrate and protein content in the samples so that the results will be more comprehensive. Tests for quantitation of Omega-3 and Vitamin D by gas chromatography (GC) can also be carried out for more concrete results.

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