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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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# Proximate, Fatty Acid, Amino Acid and Mineral Composition of Tuna (*Thunnus* sp.) By-Product from West Sumatra Province, Indonesia

Sugeng Heri Suseno
Department of Aquatic Product Technology, Faculty of Fisheries and Marine Sciences,
Bogor Agricultural University, Bogor 16680, Indonesia

**Abstract:** Tuna is an important commodity of marine fisheries with the total production in 2011 amounted to 230,580 tonnes. Examples of exported tuna products are canned and froze tuna (tuna loin). On that products mentioned, not all parts of tuna are used, it will produce by-products which can be environmental waste. By-products of tuna can be developed to be products having added value. This study aimed to determine proximate, fatty acid composition, amino acid composition and mineral composition of tuna by-products from West Sumatra Waters. By-product used in this study comprised skin, gonad, red meat and tail. The result of study showed that the highest protein content was found in the skin (29.98%) and the highest fat was found in the tail (3.35%). The dominant saturated fatty acid (SFA) was palmitic acid, which the highest value can be found in the skin (17.00%). The dominant monounsaturated fatty acid (MUFA) was oleic acid, which the highest value can be found in the skin (13.47%). The dominant polyunsaturated fatty acid (PUFA) was DHA and the highest value of DHA can be found in the tail (24.18%). The highest amino acid content was glycine 6.18%, it can be found in the skin. The results of the analysis showed that the heavy metal content of the four samples had mercury concentration below 0.001 mg/kg, Pb concentration exceeded the maximum limit permitted in fish oil products and chromium concentration above the limit of the maximum contaminant level.

**Key words:** Amino acid, by-product, fatty acid, heavy metal, proximate, tuna

## INTRODUCTION

Tuna is an important commodities of marine fisheries. Tuna is the second largest commodity after shrimp contributing to national revenue. Indonesian Ministry of Fisheries and Marine Affairs (2012) showed that total tuna production in Indonesia for export in 2011 amounted to 230,580 tonnes. Main products of exported tuna are canned and froze products (frozen loin). In canned and froze products, most of production line only utilize meat, meanwhile the other part of tuna such as head, gonad, red meat and tail are not used, but just be a waste for environment.

The increasing of total tuna production year by year would increase the amount of tuna by-products. Lately, the concept of zero waste production (net production) is being discussed and encouraged to bloom into multiple producers and agencies. The concept of zero waste is a concept promoting the production process which minimizes effluent production to the environment. This also can be applied to the fishery production activities where fish passage is used for the production of meat and other parts are made in ordinary waste.

Tuna by-products needs to be developed in order to implement the zero waste production concept. Product development direction is determined from the characteristics of the fish section. Characteristics of the products can be seen in their physical and chemical properties. This study will discuss about the chemical composition of tuna by-products including proximate analysis, the composition of fatty acids and amino acids, as well as the levels of heavy metal of tuna by-products.

## MATERIALS AND METHODS

This study consisted of 2 step. The first step was to sampling conducted at Tuna Processing Industry in West Sumatera Province area, Indonesia and the second step was to analyze samples characteristics. Materials used in this study were by-products of tuna (*Thunnus* sp.) obtained from West Sumatera Province, it comprised skins, gonads, red meats and tails. Tuna by-products were obtained from tuna processing industry that have been taken from the raw materials in the waters of West Sumatra Province (kalimat ini bisa dipindahin ke atas supaya relevan).

Equipments used for sample preparation were knives, cutting boards, containers, trash bags and digital scales. Other equipments using was equipments for proximate analysis, analysis of fatty acid and amino acids composition and heavy metals analysis.

Samples of tuna by-products were characterized by a variety of analysis, such proximate analysis (moisture, protein, ash, fat and crude fiber) according to Indonesian National Standardization Agency (1992) method (SNI 01-2891-1992), analysis of fatty acid composition using Gas Cromatography according to AOAC (2005), analysis of amino acid profiles using High Performance Liquid

Chromatography according to AOAC (2005) and heavy metal content analysis according to APHA (2005).

## RESULTS AND DISCUSSION

**Chemical composition:** The chemical composition of tuna by-products was determined by proximate analysis. Chemical composition parameter analyzed were moisture content, protein, fat, crude fiber and ash content. The results of the proximate analysis of tuna by-products can be seen in Table 1.

Proximate analysis results showed that the highest protein content (29.98%) was found on the skin and the lowest protein content (18.98%) was found in gonads. Fish skin is one of the body's protein storage. Components of fish skin is collagen. Collagen is a connective tissue protein that belongs to a class of proteins that resemble fibrillar or scleroprotein threads nets (Hadiwiyoto, 1993). Swatland (1984) stated that collagen is the most important solids in the connective tissue, it contains glycine in large amounts, which is about one third of the number of amino acids in collagen are proline and hydroxyproline (23%). In addition, collagen contains other amino acids, such as glutamate, alanine and hydroxyproline.

Proximate analysis results showed that the highest moisture content (71.19%) was in the gonads and the lowest water content (58.59%) was contained in the red meat. The principle of water content analysis performed in this study is to measure the amount of water mass which is vaporized by the heat and not strongly bound in the tissue material. Water is important chemical composition for microbial growth and chemical reactions. High water content in by-products causes by-product is easy to be damaged (highly perishable) if it is not properly handled. Water can be utilized for microbial growth and chemical reactions in a tissues which involves protease enzymes such as cathepsin (Winarno, 2008).

The ash content is a mixture of inorganic or mineral components contained in a food. Foodstuffs consists of 96% organic matter and water, while the rest are mineral. It is also known as inorganic substance or ash content. The results of this study showed that the highest ash content was found in the tail. The tail of fish was dominated by bone structure that was composed of several types of minerals, especially calcium and phosphorus. High calcium and phosphorus in the tail was thought to cause the ash content in the tail was higher than in the gonads, red meat and tuna skin.

Result showed that the highest levels of carbohydrate was found in the red meat samples (12.51%). This was thought that the form of carbohydrate in the fish tissues was glycogen which was used as a second energy source needed for the movement of fish. Glycogen can be stored in the muscles and liver.

Table 1: Proximate composition of tuna by product (*Thunnus* sp.)

| | Results (%) | | | |
|---|---|---|---|---|
| Parameter | Skin | Gonad | Red meat | Tail |
| Protein (%) | 29.98 | 18.98 | 24.67 | 22.90 |
| Fat (%) | 3.13 | 1.68 | 0.92 | 3.35 |
| Water (%) | 60.14 | 71.19 | 58.59 | 67.27 |
| Crude fiber (%) | 0.94 | 0.62 | 1.49 | 0.65 |
| Ash (%) | 1.35 | 1.18 | 1.82 | 5.25 |
| Carbohydrate (%) | 4.46 | 6.35 | 12.51 | 0.28 |

**Fatty acid composition:** The aim of fatty acid profile analysis is to determine the fatty acid content, both saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). Fatty acid profile of tuna by-product can be seen in Table 2.

The results showed that the SFA content of the skin, gonads, meat and tail was 26.66, 18.77, 21.96 and 26.00%, respectively. SFA content of tuna by-product were dominated by palmitic acid. The highest content of palmitic acid was found in the tuna skin, while the lowest palmitic acid content was found in gonads. Crexi *et al.* (2010) stated that the palmitic acid is a dominant saturated fatty acid amounted 50% of the total saturated fatty acids.

MUFA content of skin, gonads, meat and tail were 23, 11.65, 14.66 and 19.38%, respectively. Monounsaturated fatty acids (MUFA) in the by product of tuna was dominated by oleic acid. The highest oleic acid content can be found in the tuna skin (13.47%). Oleic acids was essential fatty acids functioning as precursor of omega-3 fatty acids in animals (Charles, 2009).

Total PUFA in the tuna skin, gonads, meat and tail were 15.73, 19.19, 11.99 and 32.98%, respectively. High PUFA content of the tuna tail was due to its high DHA content (24.18%). The highest EPA content was found in the tail (4.26%), while the lowest content was in the red meat (1.17%). The lowest content of DHA can be found in the red meat (8.82%). High content of DHA in the tail may be caused by DHA function. DHA is a long chain fatty acid which is very potential to be used as energy reserves in large quantities. EPA and DHA are vital nutrients required to maintain health function of the cardiovascular system, human growth and intellectual development (Pike and Jackson, 2010). Fat content and fatty acid composition in fish vary among species of fish, sex, age, season, food availability, salinity and temperature of environment (Ackman, 1988).

**Amino acid composition:** Amino acids are organic components which contain amino and carboxyl groups. The composition of amino acid will determine the protein quality. Amino acid profile of tuna by- product can be seen in Table 3.

The results of amino acid analysis using HPLC instrument (High Performance Liquid Chromatography) showed that the four samples tested contained 15 kinds of amino acids. Essential amino acids detected

Table 2: Fatty acid composition of tuna by product (*Thunnus* sp.)

| | Results (%) | | | |
|---|---|---|---|---|
| Parameter | Skin | Gonad | Red meat | Tail |
| Caprylic acid, C8:0 | - | - | 0.1 | 0.06 |
| Lauric acid, C12:0 | 0.02 | 0.02 | - | - |
| Myristic acid, C14:0 | 1.45 | 0.83 | 0.83 | 1.79 |
| Pentadecanoate acid, C15:0 | 0.7 | 0.45 | 0.45 | 0.68 |
| Palmitic acid, C16:0 | 17 | 11.54 | 13.42 | 15.21 |
| Heptadecanoate acid, C17:0 | 1.01 | 0.68 | 0.72 | 1.04 |
| Stearic acid, C18:0 5.25 | 3.96 | 5.05 | 6.01 | |
| Arakhidat acid, C20:0 | 0.38 | 0.3 | 0.42 | 0.52 |
| Heneicosanoic acid, C21:0 | 0.11 | 0.08 | 0.13 | 0.12 |
| Behenic acid, C22:0 | 0.33 | 0.43 | 0.42 | 0.29 |
| Tricosanoate acid, C23:0 | 0.15 | 0.17 | - | - |
| Lignoserat acid, C24:0 | 0.26 | 0.31 | 0.42 | 0.28 |
| SFA | 26.66 | 18.77 | 21.96 | 26.00 |
| Myristoleic acid, C14:1 | 0.03 | n.d. | 0.02 | 0.04 |
| Palmitoleic acid, C16:1 | 3.72 | 1.93 | 2.29 | 3.8 |
| Elaidic acid, C18:1n9t | 0.2 | n.d. | 0.13 | 0.18 |
| Oleic acid, C18:1n9c | 13.47 | 8.65 | 10.66 | 13.8 |
| Cis-11-Eicosanoic acid. 20:1 | 0.28 | 0.54 | 0.74 | 0.96 |
| Erucic acid, C22:1n9 | 0.1 | 0.11 | 0.06 | 0.16 |
| Nervonic acid, C24:1 | 0.43 | 0.42 | 0.76 | 0.44 |
| MUFA | 18.23 | 11.65 | 14.66 | 19.38 |
| Linolelaidic acid, C18:2n9t | n.d. | 0.02 | - | - |
| Linoleic acid, C18:2n6c | 0.77 | 0.55 | 0.5 | 1.09 |
| γ-Linolenic acid, C18:3n6 | 0.05 | 0.04 | 0.03 | 0.13 |
| Linolenic acid, C18:3n3 | 0.2 | 0.2 | 0.1 | 0.42 |
| cis-11, 14-Eicosadienoic acid, C20:2 | 0.26 | 0.2 | 0.16 | 0.29 |
| cis-8, 11, 14-Eicosatrienoic acid, C20:3n6 | 0.13 | 0.08 | 0.06 | 0.17 |
| Arachidonic acid, C20:4n6 | 1.64 | 2.36 | 1.15 | 2.44 |
| cis-5, 8, 11, 14, 17-Eicosapentaenoic acid, C20:5n3 | 1.97 | 2.42 | 1.17 | 4.26 |
| cis-13, 16-Docosadienoic acid, C22:2 | 0.03 | n.d. | - | - |
| cis-4, 7, 10, 13, 16, 19-Docosahexaenoic acid, C22:6n3 | 10.68 | 13.32 | 8.82 | 24.18 |
| PUFA | 15.73 | 19.19 | 11.99 | 32.98 |
| Total of fatty acid | 60.62 | 49.61 | 48.61 | 78.36 |

Table 3: Amino acid profile of by product tuna (*Thunnus* sp.)

| | Results (%) | | | |
|---|---|---|---|---|
| Amino acid | Skin | Gonad | Red meat | Tail |
| Aspartate acid | 2.82 | 0.96 | 2.00 | 2.20 |
| Glutamate acid | 5.18 | 1.64 | 3.11 | 3.61 |
| Serine | 1.13 | 0.50 | 0.64 | 0.69 |
| Histidine | 0.86 | 0.30 | 0.96 | 1.48 |
| Glycine | 6.18 | 0.85 | 0.97 | 1.01 |
| Threonine | 1.51 | 0.55 | 0.93 | 1.00 |
| Arginine | 3.24 | 1.50 | 1.16 | 1.38 |
| Alanine | 3.66 | 0.83 | 1.41 | 1.32 |
| Tyrosine | 0.59 | 0.43 | 0.70 | 0.82 |
| Methionine | 0.82 | 0.24 | 0.23 | 0.57 |
| Valine | 1.40 | 0.73 | 1.14 | 1.28 |
| Phenylalanine | 1.23 | 0.51 | 1.01 | 0.94 |
| Isoleucine | 1.06 | 0.57 | 1.19 | 1.22 |
| Leucine | 1.97 | 0.96 | 1.91 | 1.85 |
| Lysine | 2.30 | 1.15 | 1.98 | 2.25 |
| Total of amino acid | 33.95 | 11.72 | 19.34 | 21.62 |

in samples of skin, gonads, red meat and the tail were histidine, threonine, arginine, methionine, phenylalanine, isoleucine, leucine and lysine. The non-essential amino acids detected in all four samples were aspartic acid, glutamic acid, serine, glycine, alanine, tyrosine and valine. Dominant amino acid which is found in all samples was glutamic acid, its value was 5.18% for skin, 1.64% for gonads, 3.11% for red meat and 3.61% for the tail. Glutamic acid contain glutamic ions which can stimulate some types of nerve in the human tongue. Glutamic acid and aspartic acid give a specific taste in seafood, but in the form of sodium salt, it will provide umami taste (Uju *et al*., 2009). Glutamic acid is the most important component in the formation of flavor in seafood. In general, amino acids which are most commonly found in marine molluscs are glutamic acid, aspartic acid, glycine and alanine (Derby *et al*., 2007). Glycine content in the tuna skin samples were found as dominant having value at 6.18%. This relates with the fish skin which contain collagen. Collagen is composed by glycine, proline and hydroxyproline.

Essential amino acids which dominated the total amino acids of the four samples were arginine, leucine and lysine. Arginine in the samples of skin, gonads, red meat and tail were 3.24, 1.50, 1.16 and 1.38%, respectively. Arginine is beneficial for improving endurance through lymphocytes production, it can improve the expenditure of growth hormone (HGH) and male fertility (Linder, 1992). Leucine content in the

Table 4: Content of heavy metal by product tuna (*Thunnus* sp.)

| | | Results (%) | | | |
|---|---|---|---|---|---|
| Parameter | Unit | Skin | Gonad | Red meat | Tail |
| Mercury (Hg) | mg/kg | <0.001 | <0.001 | <0.001 | <0.001 |
| Lead (Pb) | mg/kg | 0.588 | 1.210 | 2.610 | 1.700 |
| Chromium (Cr) | mg/kg | 2.560 | 1.120 | 0.700 | 3.270 |
| Arsenic (As) | mg/kg | <0.002 | <0.002 | <0.002 | <0.002 |

samples of the skin, gonads, red meat and tail were 1.97, 0.96, 1.91 and 1.85%, respectively. Leucine can stimulate brain function, increases muscle energy levels, helps reduce blood glucose levels, helps healing of bone, muscle and skin tissue (mainly to accelerate wound healing post-operative) (Harli, 2008). Lysine content in the samples of the skin, gonads, red meat and tail were 2.30, 1.15, 1.98 and 2.25%, respectively. Lysine has function as the base material of blood antibodies, it strengthens circulatory system, maintains the growth of normal cells through the forming of collagen tissue with the aid of proline and vitamin decreases excessive blood triglyceride levels (Harli, 2008).

**Heavy metal content:** Result of heavy metal analysis can be seen in Table 4. The results showed that the heavy metal content of the four samples had mercury content below 0,001 mg/kg. This value is still below the limit specified by the CRN (2006), fish oil is safe if it has a mercury content of <0.1 ppm. CRN (2006) also established a maximum limit for the content of other heavy metals such as Ni, Cd, Pb and As to be <0.1 ppm. The analysis showed that the four samples (skin, gonads, red meat and tail) contained lead (Pb) exceeding the maximum limit permitted in fish oil products. High Pb contents in the red meat tuna supposedly related to a fairly high fat content in the red meat which allow binding heavy metals and then trapped in fat. Lead (Pb) can be bound to the active enzyme and it causes enzymes inactivation, so the synthesis of red blood (Hb) is inhibited, as the result it can lead to anemia (Sorensen, 1991). Jalaluddin and Ambeng (2005) stated that the high content of Pb in aquatic organisms can be caused by the phenomenon of bioaccumulation in filter feeders organisms and biomagnification in organisms at higher trophic levels.

Chromium (Cr) is an element that has some role in human life. At low concentrations, it is essential micronutrient in animal and human nutrition, but at high concentrations, it is known to be carcinogenic when it present in the form of chromate. The analysis showed that all four samples tested had chromium concentration above the limit of the maximum contaminant level established by EPA (<0.1 mg/L or 100 ppb) (Anonymous, 2013). The source of chromium contamination is from the burning of coal and petroleum. Dust or Cr particles in the layer of air entering into water mainly carried down by the rain water. Cr metal has a high toxicity, especially $Cr^{6+}$ ions which are carcinogenic and can trigger cancer cells (Sorensen, 1991).

**Conclusion:** This study concluded that the highest protein content of tuna by product was found in the skin (29.98%) and the highest fat content was found in the tail (3.35%). The highest saturated fatty acid (SFA) was palmitic acid, its value in the skin was 17.00%. The dominant monounsaturated fatty acid (MUFA) was oleic acid, the highest value can be found in the skin (13.47%). The dominant polyunsaturated fatty acid (PUFA) was DHA, the highest value was found in the tail (24.18%). The highest content of amino acid was glycine (6.18%), it can be found in the skin. The results showed that the heavy metal content of the four samples had mercury content below 0.001 mg/kg, had lead (Pb) exceeding the maximum limit permitted in fish oil products and had chromium content above the limit of the maximum contaminant level.

## REFERENCES


Ackman, R.G., 1988. Concerns for utilization of marine lipids and oils. Food Technol., 42: 151-155.

Anonymous, 2013. Basic information about chromium in drinking water. http://water.epa.gov/drink/contaminants/basicinformation/chromium.cfm.

AOAC, 2005. Official Method of Analysis. Association of Analytical Chemist, Inc, Virginia.

APHA, AWWA, 2005. Standard Methods for the Examination of Water and Waste Water, 21th Edition. WPCF, New York.

Indonesia National Standardization Agency, 1992. How to test of food and drink (Cara uji makanan dan minuman) SNI 01-2891-1992. http://sisni.bsn.go.id.

Charles EO, 2009. Virtual chembook. elmhurst college. http:// www.elmhurst.edu/~chm/vchembook/index.html.

Council for Responsible Nutrition (CRN), 2006. Voluntary monograph. http://www.craus a.org/pdfs/O3 FINAL MONOGRAPH doc.pdf.

Crexi, V.T., L.M. Maurucio, A.D.Z.S. Leonor and A.A.P. Luiz, 2010. Production and refinement of oil form carp (*Cyprinus carpio*) viscera. Food Chem., 119: 945-950.

Derby, C.D., C.E. Kicklighter, P.M. Jhonson and X. Zang, 2007. Chemical Composition of Inks of Diverse Marine Molluscs Suggests Convergent Chemical Defenses. J. Chem. Ecol., 33: 1105-1113.

Hadiwiyoto, S., 1993. Fishery Product Technology Volume 1. Liberty, Yogyakarta.

Harli, M., 2008. Essential amino acid. http://www.suparmas.com.

Jalaluddin, M.N. Ambeng, 2005. Analysis of heavy metals (Pb, Cd and Cr) in sea shells (*Hiatula chinensis, Anadara granosa* and *Marcia optima*). Marina Chimica Acta, 6: 17-20.

Indonesian Ministry of Marine and Fisheries Affairs, 2012. Marine and Fisheries Statistics Book 2012. Centre of Data, Statistics and Information, Ministry of Marine and Fisheries Republic of Indonesia, Jakarta.

Linder, M.C., 1992. Nutritional Biochemistry and Metabolism with Adoption Chemistry. Aminuddin P, Translator. UI Press, Jakarta.

Pike, I.H. and A. Jackson, 2010. Fish oil: production and use now and in the future. *Lipid Technology*. WILEY-VCH Verlag GmbH and Co. KGaA,Weinheim. In: Houlihan D, Boujard T, JoblingM (eds) Food Intake in Fish. Blackwell Scientific, Oxford, 22: 354-375.

Sorensen, E.M., 1991. Metal Poisoning In Fish. Ellish Horwood Limited, England.

Swatland, H.J., 1984. Structure and Development of Meat Animals. Prentice-Hall Inc., Englewood Cliff, New Jersey.

Uju, Nurhayati T., B. Ibrahim, W. Trilaksani and M. Siburian, 2009. Characterization and recovery of proteins from minced fish wash water by osmosis membrane reserved. J. Fishery Products Processing (In Indonesia: J. Pengolahan Hasil Perikanan), 12: 115-127.

Winarno, F.G., 2008. Chemistry of Food and Nutrition. Mbrio Press, Bogor.