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Fatty Acid Profiles of Tropical Eel (*Anguilla* sp.,) By-products

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Abstract: Prospect of eel by-products as fish oil source can be explored to give an additional value. The moisture content, fat content and fatty acid profiles of tropical eel (*Anguilla* sp.,) by-products were investigated. Results showed that highest fat content was found in bone (22.03%). Highest moisture content was found in viscera (75.64%). Palmitic acid, oleic acid, EPA and DHA were dominant fatty acids in eel by-products. Oleic acid composition of head was higher than others. Highest EPA and DHA composition were found in viscera and its value were 4.43 and 18.51%, respectively.

Keywords: By-products, fat, fatty acid profile, moisture, tropical eel

INTRODUCTION

Eel (*Anguilla* spp.) is a freshwater fishery commodities with the high world market demand and the demand increases year by year. Eels are catadromous species that hatch in the sea but migrate as elvers (pre-juveniles) to freshwater to grow to adulthood (Seo *et al*., 2013). *Anguilla* includes 19 species of eel distributing worldwide. There are four species which are commercially important. These are *Anguilla anguilla* in Europe, *Anguilla japonica* in the Far East, *Anguilla rostrata* in North America and *Anguilla australis* in Australia and New Zealand. The demand of eel in the international market reached 300 thousand tons/year. Market demand for eel has increased due to its white flesh, good flavor and high yield of flesh (Ozogul *et al*., 2006). Eels are known as fishery commodity, rich in protein, fat, minerals and vitamins compared to other fish species (Seo *et al*., 2013). Seo *et al*. (2013) showed that the cultured species *Anguilla japonica* contained 9.85-11.53% EPA, 15.73-20.86% DHA and 15.08-18.46% oleic acid. The study of Salma and Missaoui (2013) showed that european eel from different season (autumn, winter, spring and summer) had lipid content which was dominated by oleic acid (29.64-42.89%). EPA and DHA content of european eel from different season was ranging at 1.64-2.46% for EPA content and 2.87-3.36% for DHA content. Beside rich in omega-3 fatty acids, eels (*Anguilla anguilla*) were also rich in fat-soluble vitamins, such as vitamin A (468 μg/100 g) and vitamin E (4.32 μg/100 g).

Eels are usually processed before retailing and process techniques include smoking, jellying, pickling and kabayaki for the Japanese market. Processing eel into kabayaki or gel product will certainly produces by-product. Yield of processed eel in kabayaki processing can reach 60%, it can be inferred that about 40% by-products are produced and it have not been optimally utilized (Listianingsih, 2013). Eel by-products which comprise of head, bone and viscera can be utilized to reduce the discard to environment. By-products of eel are predicted to have a great potential as a source of important nutrition, for instance the avalaibility of some essential fatty acids. Significant value can be added if protein and lipid are recovered from the fish processing by-products for subsequent use in human food products. Fish by-product utilization for lipid production as a cheaper choice than utilization of muscle for extracting its lipid could generate significant revenue for fish processing industry and environment. The information about fatty acid composition of eel by-products is important, so we can explore its potency as raw material for recovering its lipid content. This study aimed to characterize basic data about fat content, moisture and fatty acid composition of eel's by-products in the form of head, viscera and bone.

METHODOLOGY

Materials and equipments: Main materials used in this study were by-products of kabayaki industry obtaining from PT. Jawa Suisan Indah, Palabuhan Ratu, West Java-Indonesia. By-products which would be characterized comprised of head, bone and viscera part. Other materials were hexana, NaOH, methanol, BF_3, NaCl, anhydric Na_2SO_4 and Fatty Acid Methyl Ester (FAME) standard (Supelco 37 component FAME MIX). Some equipments which were used were knife, cutting board, basin, evaporating dishes, some glasses, water bath, fat flask, soxhlet tube, oven, gas chromatography SHIMADZU GC2010 plus AFA PC with a cyanopropyl methyl sil column (capillary column), 10 mL syringe, teflon-covered tubes, analytical balance and micro pipette.

Methods: Tropical eel by-products were prepared and weighed for chemical analysis requirements. Some analysis conducted were moisture content analysis (AOAC, 2005), fat content analysis (AOAC, 2005) and fatty acid analysis (AOAC, 2005).

Moisture (AOAC, 2005): Evaporating dish was dried in the oven at 105°C for 1 h. Evaporating dish placed into the desiccator (approximately 15 min) and then weighed. As much as 5 g of sample was inserted into the dish and then dried in oven at 105°C for 5 h. Once the process was completed then the dish was inserted into the desiccator, it was awaited until cool and then weighed again:

$$\% \text{ Moisture } = \frac{W_1 - W_2}{W_1} \times 100\%$$

where,
W_1 : Sample weight before drying
W_2 : Sample weight after drying

Fat content (AOAC, 2005): A total of 5 g sample (W1) was inserted into the filter paper which both ends of the wrap closed by fat-free cotton and inserted into the fatty sheath, then the sample inserted into the fat flask which had been weighed as W2. Fat flask was subsequently connected to soxhlet tube. The fatty sheath was inserted into the extractor chamber of soxhlet tube and doused by fat solvents (hexana). Reflux process was done for 6 h. Mixture of fat solvent and extracted fat in a fat flask was distilled until all the fat solvent evaporated. At the time of distillation, solvent would be accommodated in the extractor chamber, the solvent removed so it could not be back into the flask, then fat flask was dried in oven at a temperature of 105°C, after that the flask was cooled in a desiccator until it reached a weight constant (W3):

$$\% \text{ Fat content } = \frac{W_3 - W_2}{W_1} \times 100\%$$

where,
W_1 : Sample weight (g)
W_2 : Weight of flask without fat (g)
W_3 : Weight of flask containing fat (g)

Fatty acid profile (AOAC, 2005): A total of 20-40 mg of fat or oil in a teflon-covered tube was added by 1 mL of NaOH in methanol, then heated in a water bath for 20 min. Furthermore, as many as 2 mL of 20% BF_3 and 5 mg/mL of internal standard added to the mixture and the mixture was heated again for 20 min. The mixture was cooled and then added by 2 mL of saturated NaCl and 1 mL isooctana, subsequently the mixture was shaken well. Isooctana layer formed was transferred with the aid of pipette into a tube containing approximately 0.1 g of anhydrous Na_2SO_4 and then awaited for 15 min. Liquid phase formed was separated, while 1 mL of oil phase was injected, previously injection of FAME standard mixture was performed. Retention time and peak of each component was measured and compared with the standard retention time to get information about the types and fatty acid components in the sample. Determination of fatty acid content in the samples can be calculated by using the formula as follows:

$$\text{Component content of samples } = \frac{\text{Ax/As} \times \text{Cstandard} \times \text{Vsample} / 100}{\text{Sample weight}} \times 100\%$$

Information:
Ax : Sample area
As : Standard area
Cstandar : Standard concentration
Vsample : Sample volume

RESULTS AND DISCUSSION

Results showed that the highest moisture can be found in the viscera sample (75.64%) and the lowest moisture was contained in the bone sample (52.71%). The highest fat content was found in the bone sample (22.03%) and the lowest fat content was found in the viscera sample (1.91%). Head of eel contained 27.15% of Saturated Fatty Acid (SFA) which was dominated by palmitic acid (21.21%), its Monounsaturated Fatty Acid (MUFA) content was 37.94% with oleic acid (31.99%) as a dominant fatty acid and it Polyunsaturated Fatty Acid (PUFA) content was 6.85% which was dominated by linoleic acid (5.32%), EPA (1.84%) and DHA (7.28%). The content of SFA, MUFA and PUFA in viscera sample was 31.59, 8.20 and 27.99%, respectively. Palmitic acid (16.67%) dominated the SFA of its sample. Oleic acid (4.48%) was found in eel viscera and dominated its MUFA content. Eel viscera contained DHA (18.51%), EPA (4.43%) and linoleic acid (1.37%). Eel bone contained SFA at 24.96%, MUFA at 32.16% and PUFA at 11.98%. SFA content of the eel bone was dominated by palmitic acid (19.33%). MUFA content of the eel bone was dominated by oleic acid (27.4%). The content of PUFA of eel bone was dominated by linoleic acid (4.66%), EPA (1.15%) and DHA (4.52%). The result of this study is shown in Table 1 and Fig. 1.

The differences of omega-3 fatty acid content in different tissues can be related to the tendency of omega-3 fatty acids concentration. The study of Falch (2006) showed that maturity of cod could influence concentration of some fatty acids in the tissue. Roe of cod which would spawn contained higher PUFA content compared to its liver and viscera. Cod roe had 14.00±0.00% EPA and 26.30±0.01% DHA. Total lipid found in cod viscera was about 2-9% and total lipid in cod liver was about 43-69%. Chantachum *et al*. (2000) informed that oil from non pre-cooked skipjack tuna head contained 0.6% linolenic acid, 0.1% eicosapentaenoic acid and 18.8% docosahexaenoic

Table 1: Fat content, moisture and fatty acid profile of tropical eel (*Anguilla* sp.,) by-products

	Result		
Parameter	Head	Viscera	Bone
Fat content (%w/w)	16.91	1.91	22.03
Moisture (%w/w)	61.48	75.64	52.71
Fatty acid (%w/w)			
Lauric acid, C12:0	0.08	0.09	0.09
Tridecanoic acid, C13:0	-	0.12	n.d
Myristic acid, C14:0	2.70	4.81	2.42
Pentadecanoic acid, C15:0	0.32	1.35	0.28
Palmitic acid, C16:0	21.21	16.67	19.33
Heptadecanoic acid, C17:0	0.31	1.34	0.28
Stearic acid, C18:0	2.40	5.88	2.42
Arachidic acid, C20:0	0.11	0.53	0.10
Heneicosanoic acid, C21:0	n.d	0.14	n.d
Behenic acid, C22:0	0.02	0.26	0.02
Tricosanoic acid, C23:0	n.d	0.09	n.d
Lignoseric acid, C24:0	n.d	0.31	0.02
SFA	27.15	31.59	24.96
Myristoleic acid, C14:1	0.06	0.02	0.05
Palmitoleic acid, C16:1	3.98	2.86	3.03
Cis-10-heptadecanoic acid, C17:1	0.12	0.21	0.10
Elaidic acid, C18:1n9t	0.17	0.10	0.14
Oleic acid, C18:1n9c	31.99	4.48	27.40
Cis-11-eicosenoic acid, C20:1	1.47	0.19	1.32
Erucic acid, C22:1n9	0.08	0.07	0.06
Nervonic acid, C24:1	0.07	0.27	0.06
MUFA	37.94	8.20	32.16
Linolelaidic acid, C18:2n9t	n.d	0.04	n.d
Linoleic acid, C18:2n6c	5.32	1.37	4.66
γ-linolenic acid, C18:3n6	0.17	0.11	0.12
Linolenic acid, C18:3n3	0.45	0.74	0.36
Cis-11, 14-eicosedienoic acid, C20:2	0.38	0.20	0.33
Cis-8, 11, 14-eicosetrienoic acid, C20:3n6	0.36	0.13	0.26
Cis-11, 14, 17-eicosetrienoic acid, C20:3n3	0.06	0.04	0.05
Arachidonic acid, C20:4n6	0.97	2.19	0.53
Cis-13,16-docosadienoic acid, C22:2	0.02	0.03	n.d
Cis-5, 8, 11, 14, 17-eicosapentaenoic, C20:5n3	1.84	4.43	1.15
Cis-4, 7, 10, 13, 16, 19-docosahexaenoic acid, C22:6n3	7.28	18.51	4.52
PUFA	16.85	27.79	11.98
Total fatty acid	81.94	67.58	69.10
Not detected fatty acid	5 FA	0 FA	5 FA

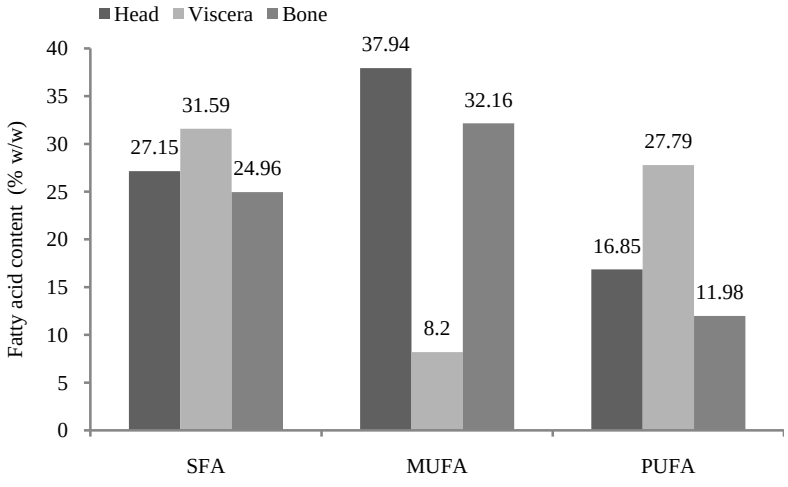

Fig. 1: SFA, MUFA and PUFA content of tropical eel (*Anguilla* sp.,) by-products

acid. The different result between tuna head and eel head was caused by different species observed. Sahena *et al*. (2010) added that fish oil from indian mackerel viscera extracted by soxhlet contained 9.31% EPA and 9.98% DHA, while extracted fish oil from its head contained 10.38% EPA and 10.88% DHA. Razak *et al*. (2001) showed that oil extracted from freshwater eel (*Monopterus albus*) contained EPA at 0.26% for body

oil and 0.26% for head oil, while DHA content of body oil and head oil was 6.21 and 6.11%, respectively. Both body and head oil extracted from freshwater eel was dominated by arachidonic acid (8.25% for body oil and 8.77% for head oil). Fish lipid is mainly stored in fish body in the subcutaneous tissue, belly flap, mesenteric tissue, head, muscle tissue and liver (Ackman, 1994). Fish oils which are extracted from non-consumable parts of the fish, such as head, skin, central bones and viscera may contribute to the total level of fatty acids, thus increasing the nutritional value of the fish. The seasonal changes, environmental effect of tropical fish species and also in the post-spawning period could result the distinctive difference of saturated, monounsaturated and polyunsaturated fatty acids content in fish lipids (Osman *et al*., 2001).

The n-6/n3 ratio is a good index for comparing relative nutritional value of fish lipid for different species (Piggott and Tucker, 1990). Optimal balance for these ratios in human body is 1:1 (Simopoulos, 1989), while World Health Organization (WHO) recommends n-6/n-3 ratio of not more than 5.0 in total human diet (Vujkovic *et al*., 1999). Result showed that the n-6/n-3 ratios of eel head, viscera and bone were 1:1.65, 1:14.73 and 1:1.21, respectively.

As a result showed, the highest content of PUFA found in eel viscera samples. Eel viscera is potential to be developed into a source of DHA, in which DHA is a fatty acid which is important for brain and retinal development. DHA can be found in the structure of phospholipid membranes, especially in parts of the brain and retina (Estiasih, 2009). Eel head and bone contained oleic acid in high amount, so it have the potency to be developed as a source of omega-9 fatty acids. In the human health, oleic acid is beneficial for maintaining healthy skin. Oleic acid is also known to have a physiological effect to prevent cancer, autoimmunity and inflammatory diseases, in addition to its ability to facilitate wound healing (Sales-Campos *et al*., 2013).

CONCLUSION

Tropical eel by-products still have an economic value which can be explored related to its nutritional value. Highest fat content could be found in eel bone (22.03%). Highest moisture content was found in eel viscera (75.64%). Palmitic acid dominated the saturated fatty acid content of eel's by product and its value were 21.21% (head), 16.67% (viscera) and 19.33% (bone). Monounsaturated fatty acid content of eel by-products was dominated by oleic acid and its highest value was found in head (31.99%). Eel by-products were considered as raw material rich in omega-9. Viscera was rich in DHA (18.51%) and EPA (4.43%), so it is potential to be developed as a source of omega-3 fatty acids.

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