Jurnal Sains Kesihatan Malaysia **12** (1) 2014: 41-46

Kertas Asli/*Original Articles*

Nutritive Value and Fatty Acids Profile of Fresh Indonesian Eel (*Anguilla bicolor*) and Kabayaki

(Nilai Pemakanan dan Profil Asid Lemak Belut Indonesia Segar (*Anguilla bicolor*) dan Kabayaki)

R.A. HANGESTI EMI WIDYASARI, CLARA M KUSHARTO, BUDYWIRYAWAN, EKO SRI WIYONO & SUGENGHERISUSENO

ABSTRACT

Eel were known asa food source that contain high nutrients. Recently, the utilization of Eel for export purposes has remained high. The aimof this study were to analyze the nutritive value and fatty acids profile of fresh Indonesian eel and roasted eel (kabayaki). This study were conducted at P.T. Jawa Suisan Indah, Sukabumi District, West Java Province, and Kimia Terpadu Laboratorium Bogor Agricultural University, from October 2012 to May 2013. The proximate analysis on fresh Indonesian Eelshowed that it contained 17.68% of protein, 28.29% of fat, 42.03% of moisture, 3.93% of ash and 0.30% of crude fiber. While Kabayaki contains 32.70% of protein, 2.39% of fat, 48.32% of moisture, 2.37% of ash and 0.55% of crude fibre. The fatty acids composition of fresh Indonesian Eelconsisted of 22.78% saturated fatty acids (SFA), 32.84% monounsaturated fatty acids (MUFA), 11.4% polyunsaturated fatty acids (PUFA), 1.15% eicosapentaenoic acid (EPA) and 5.16% docosahexaenoic acid (DHA). While kabayaki contained 30.68% SFA; 31.1% MUFA; 10.39% PUFA; 0.70% EPA and 1.29% DHA.

Keywords: Indonesian Eel (Anguilla bicolor), kabayaki, nutritive value, fatty acid profile

ABSTRAK

Belut dikenali sebagai sumber makanan yang mengandungi nutrien yang tinggi. Baru-baru ini, penggunaan belut untuk tujuan eksport kekal tinggi. Tujuan kajian ini adalah untuk menganalisis nilai pemakanan dan profil asid lemak bagi belut Indonesia segar dan belut panggang (kabayaki). Kajian ini dijalankan di P.T. Jawa Suisan Indah, Daerah Sukabumi, Semenanjung Jawa Barat dan di Makmal Kimia Terpadu, Universiti Pertanian Bogor dari Oktober 2012 hingga Mei 2013. Analisis proksimat yang dijalankan ke atas belut Indonesia segar menunjukkan ia mengandungi 17.68% protein, 28.29% lemak, 42.03% air, 3.93% abu dan 0.3% gentian kasar. Manakala Kabayaki mengandungi 32.70% protein, 2.39% lemak, 48.32% air, 2.37% abu dan 0.55% gentian kasar. Komposisi asid lemak belut Indonesia segar mengandungi 22.78% asid lemak tepu (SFA), 32.84% asid lemak monotepu (MUFA), 11.4% asid lemak politepu (PUFA), 1.15% asid ekosapentaenoik (EPA) dan 5.16% asid dokosaheksaenoik (DHA). Kabayaki pula mengandungi 30.68% SFA, 31.1% MUFA, 10.39% PUFA, 0.70% EPA dan 1.29% DHA.

Kata kunci: Belut Indonesia (Anguilla bicolor), kabayaki, nilai pemakanan, profil asid lemak

INTRODUCTION

Fishery is one of the reliable sector expose to build a better future in Indonesia, since its has huge potential to contribute the Indonesian community full filment of nutrients. Fisheries products were known contain high amount of protein consumed by Indonesian people (KKP 2011). Apart from its protein content, fish also has specific nutrients, such as omega-3 (complex chain fatty acids) from *eicosapentanoic acid* (EPA) and *docosahexanoic acid* (DHA). Omega-3 fatty acids (especially Linoleic acid, EPA and DHA) were essential fatty acids which are able to maintain optimal healthstatus. Omega-3 fatty acids were said to be beneficial to helath such as decreasing blood cholesterol, increasing immunity, decreasing coronary heart risk, detaining *rheumatoid arthritis* symptoms, decreasing cancer activity, and increasing learning ability (Husaini 1989; Feliz & Felazquez 2002; Freeman & Junge 2005). Eel (*Anguilla bicolor*) is one of the fishery commodity in Indonesia. Based on Kottelat et al. (1993), there were at least five kind of eel fish in Indonesia such as *Anguilla bicolor, Anguilla borneensis, Anguilla marmorata, Anguilla celebesencis* and *Anguilla nebulosa*.

Information about Eel nutritive value were still remain scarce. However this kind of fish has high economic value in the market. Eel (*Anguilla sp.*) is one of cultivated fishery product which has high selling price and has been cultivated by intensive or extensive system especially in Asia (Altun et al. 2005; Heinsbroek 1991). Country like China needs annual supply of eel for raw materials that reach over

70,000 tons. However, their domestic production can only achieve 20,000 tons eel. Besides, Japan cansumption demanded for 300,000 tons eel per year. While Korea and Taiwan need 15,000 and 5,000 tons per year (KKP 2011), respectively. FAO (2010) estimates 8,440 world production of Eel valued for 36 millions USD.

Selling eel in fresh, frozen and processed form willhave different price in the market. *Kabayaki* is a roasted type of eel which normally eaten with sweet sauce called tare. Based on the potential of fresh eel and *kabayaki*, the main objective of this study was to analyze nutritive value and fatty acids profile of fresh and *kabayaki* eel (*Anguila bicolor*).

MATERIALS AND METHODS

This study consisted of two phases such as field survey and laboratory test (chemical composition analysis: proximate and fatty acids profile). To identify handling and technology process of roasted eel (*kabayaki*), field survey were conducted in frozen eel processing unit at Palabuhanratu, Sukabumi District, West Java Province, Fishery Station at Fisheries and Marine Science IPB, and chemical analysis were carried out at Laboratorium Kimia Terpadu IPB, and also other laboratorium at Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Science, IPB. Information obtained from interview with company owner and management. This study were done in October, 2012 to May, 2013.

Used materials for chemical analysis such as aquadest, selenium, n-hexane, HCl, Selenium-*mix*, concentrated H_2SO_4, $H_2SO_4$1, 25%, NaOH 40%, $NaOH_3$, 25%, boric acid, indicator (red and blue methyl), HCl 0, 1 N, etanol (proximate) fat or oil sample, standard solution, NaOH 0.5 N in methanol, standard solution, solution of NaOH 0,5 N in metanol, BF_3 16% solution, concentrated NaCl, hexane, Na_2SO_4 anhydrate (fatty acid).Used tools for chemical analysis such as vacuum oven, aluminium cup, porseline cup, oven, magnetic stirer, sentrifuge, measure glass, Kjehdahl flask, soxhlet extraction tools, Kjedahl extraction tools, desicator, filter paper, scale, fat flask, bunsen burner, distilation tools, erlenmeyer, beacker glass, chromatographic tools, syringe 10 µL, water bath, flask with teflon cover, analytical scale and micropippet.

Data and information that have been collected consist of information about kabayaki processing activity at PT Jawa Suisan Indah, Palabuhanratu, Sukabumi residence by structural interview in processing unit. Kabayaki processing such as, life eel stunned in cold temperature 0-5°C, eel head were cutted and the bone, bowels, and flesh filet were separated. This was followed by roasting, steaming, reroasting and then adding the sweet sauce (tare). Then, eel were packaged into plastic package and stored into the cold storage. Fatty acid profiles and proximate analysis were carried out on the end of product. The food analysis carried out on Kimia Terpadu Laboratory, Bogor Agricultural University were protein, fat, carbohydrate, moisture, ash, crude fiber contents, and also fatty acid of frost eel and *kabayaki*. Proximate analysis was based on AOAC (1995) standard method. Lipids were ectract by using chloroform: methanol (2:1, v/v) and were gravimetrically determined as described previously (Bligh & Dyer 1959).

FATTY ACIDS AND EPA-DHA

Sample analysis with chromatographic gas is based on components partition from liquid between mobile gas phase and stationary gas phase which issupporting inert component. The separated components must be volatile at the separation temperature, so that the operation temperature usually higher than standard temperature, and it is done the derivatisation process in the sample which hard to vapour.

In fatty acid analysis, It have to hydrolize the fat or oil first to become fatty acid, and then transformed into ester form which more easy to vapour. The transformation in this method were done with methylation so that the fatty acids methyl ester (FAME) were obtained. Then, this FAME were analyzed with chromatographic gas tools. Component identification were done by comparing the retention time with standard in same condition. Retention time were counted into recorder paper as space between the peak of solvent until the center of component which considered. Component content in the sample could be done with external and internal standard technique. The width of every component are proportional with the amount of component in the sample. To minimalize error caused by injected volume, sample preparation, dilution and any process, it is better to use internal technique standard. Beside that, it should be done correction to detector respon and interaction between component in the sample matrix while sample passing the column.

SAMPLE PREPARATION (HYDROLISIS AND ESTERIFICATION)

At first, the sample of fat or oil were measured until 20-30 mg in the flask covered teflon. After that, 1 mL NaOH 0.5 N in methanol were added and heated into water bath for 20 minutes. Then, 2 mL BF_3 16% and 5 mg/mL internal standard added and heated for 20 minutes. Cooled, and then 2 mL saturated NaCl and 1 mL hexane, were added into mixture and then shake firmly. Hexane layer were moved with pippet into tube contains of 0,1g Na_2SO_4 anhydrate and then left for 15 minutes. Then, liquid phase were injected in the chromatograpic gas.

FATTY ACIDS COMPONENT ANALYSIS, AS FAME

As much as 1 µl of solvent injected into column. If the gas carier and heating system are run perfectly, the peak of solvent will be seen less than 1 minute. After the pen back to zero, 5 µl mixture of FAME standard were injected.

Tools setting	
Column	Cyanopropil methyl sil (capilary column)
Column Dimention	p = 60 m, Ø is = 0.25 mm, 025 µm Film Tickness
N_2 Flow Rate	20 mL/menit
H_2 Flow Rate	30 mL/menit
Air Flow Rate	200 – 250 mL/menit
Injector Temperature	200°C
Detector Temperature	230°C
Column Temperature	Program temperatur - start 190°C stop 15 minutes - end 230°C stop 20 minutes Rate 10°C/minutes
Ratio	1 : 8
Inject Volum	1 µL
Linier Velocity	20 cm/sec

As much as 5 µl of preparation sample were injected, if the solvent peek had been seen all already. Retention time and peak of every component were measured. If the recoreder was equipped with integrator, the retention time and peak will directly obtained from integrator. The retention time were compared with standard to obtain information about the type from the sample components. For internal standard method, amount from each components in the sample could be counted by equation:

$$C_x = \frac{A_x R C_s}{A_s}.$$

whereas:

C_x = X component concentration
C_s = Standard internal concentration
A_x = X component peak width
A_s = Standard internal peak width
R = Detector respon to x component relative to standard

External standard method using the same method, difference laid in the separated sample and standar, the standard liquid were not added into the sample. The amount of component contains could be counted by equation:

$$\frac{\frac{A_x}{A_s} \times C_{standard} \times \frac{V_{sample}}{100} \times 100\%}{\text{Sample gram}}.$$

R DETERMINING METHOD

Mixture of X (pure) and S which known weight as W_x and W_s were done and made the chromatogram with equation:

$$W_x = A_x \cdot R_x \text{ and}$$
$$W_s = A_s \cdot R_s$$

From this equation, so that R could be counted as:

$$R = R_x = \frac{W_x \cdot A_s}{R_s W_s \cdot A_x}.$$

RESULT AND DISCUSSION

HANDLING AND TECHNOLOGY IN ROASTED INDONESIAN EEL PROCESSING

Life eel were fasted for 3 days to clean up its bowel, to relieve its odor and fishy taste of eel, the pond were flood with water continously. This process were done before eel entering the processing unit. Fresh fish has such characteristic which are clear eyes, red gill, bright color and compact flesh. Mucous in eel body were clean up first, because its mucous consist of many nitrogenic compound as nutrition source for contaminant microrganism during the process.

After eel enter the processing unit, the handling started from stunned by decreased its temperature approximately 0-5°C with adding some ice in the pond contain of eel. It is continuied with head cutting of the fish and dividing fish body into two part horizontally like butterfly, then the bowels, bones and flipper were separated. After that, eel were clened up, roasted, steamed and reroasted while flood with sweet sauce which is the speciality of *unagi kabayaki* product. The roasting and steaming tools were using up and bottom flame conveyor, so it is not need to reverse. In that process, contain 2 times roasting and interspersed with 1 time steaming. This steaming process were purpose on tendering the eel meat,while the roasting process were purpose on drying and compacting the product. Roasting process need 7 minutes and steaming process needs 5 minutes. Cooked *kabayaki* were covered with sweet sauce, the packed into *polystyrene* plastic and then frozen. *Kabayaki* is marketed into domestic and international market. This frozen product will last for 1 year if stored into chilling temperature storage -18°C or 2 years if packed into vacuum pack.

PROXIMAT ANALYSIS RESULT OF INDONESIAN FRESH EEL AND PROCESSED PRODUCT (*KABAYAKI*)

Nutritive value of fresh Indonesian eel (*Anguilla bicolor*), *kabayaki* and European eel (*Anguilla anguilla*) showed in Table 1. There are 3 kind of eel could be categorized as high protein food sources. There were slight difference between protein content in Indonesian eel and European eel, while fat and ash content in Indonesian eel higher than European eel. Those are presumably because of species difference, age, season, geographic and habitat that related to temperature, salinity and feed availability. Stansby (1981) and Monsen (1985) stated that fat and fatty acid content affected by species, sex, age, season, feed availability, salinity and water temperature.

TABLE 1. Proximate contain of eel in 100 gram fresh eel and *kabayaki* (%)

Component (%)	*Anguilla bicolor* *	*Anguillabicolor** (*Kabayaki*)	*Anguilla anguilla***
Protein	17.68	32.70	17.5
Fat	28.29	2.39	20.86
Carbohydrate	9.53	13.69	-
Moisture	42.03	48.32	60.12
Ash	3.93	2.37	1.05
Fibre	0.30	0.55	-

Source: *Primary Data, **(Özogul 2005)

Protein, carbohydrate, water and crude fiber content from fresh eel was increasing after processed to be kabayaki. Thus, suspected because of *tare* addition, sweet sauce and spacial seasoning from Japaness culinary, first roasting (*shirayaki*), steaming, and second roasting (*kabayaki*). Experiment by Gladyshev et al. (2007) showed that there is 0.5% moisture content increasing in trout (*Salmotrutta*) steaming process.

The decreasing of fat and ash content of *kabayaki* suspected because 2 times fillet roasting process in the first roasting process (*shirayaki*), interspread with steaming, which tenderizing the eel meat until the second roasting (*kabayaki*) so that the product appearance look more compact and dry. Fat content in eel decrease after it processed, this occur because processing with heat will break the fat components into volatile product like aldehide, keton, alkohol, acids, and hydrocarbon. Those product will affecting the flavour formation. Prabandari et al. (2005) stated that heating process could cause fat become volatile matter such as aldehide, keton, alkohol, acidand hydrocarbon which will vapour while heated. Fat content decreased because of steaming process were occured insilver catfish (*Rhamdiaquelen*) for 0.06% (Weber et al. 2008), while based on study which done by Bakar et al. (2007), 0.05% fat content decreased in king mackerel (*Scomberomorousguttatus*) becaused of steaming process.

INDONESIAN EEL FATTY ACID AND PROCESSED PRODUCT (*KABAYAKI*)

Oil or fat consist of fatty acids unit, based on its saturation fatty acid. Fatty acid could be categorized into 2 groups, unsaturated fatty acids and saturated fatty acids. The difference laid on the chemical bond, whereas the saturated fatty acid does not has double bond. This different causing chemical and physical difference on both fatty acids group (Ackman 1982). In the fish fat, it contains more fatty acid, especially unsaturated fatty acid C_{20}, C_{22}, and C_{24}, it has brought advantages to maintain human health. Fish fat consist of 25% saturated fatty acid and 75% unsaturated fatty acid (Brody 1965).

Fatty acids value is depend on double chain position and reaction ability. The most beneficial fatty acid are omega-3 and omega-6. Usually, fatty acids contain in fish almost the same with another kind animal. The difference is in the dominant type of its fatty acids. The main fatty acids in fat and fish oil is configurated as omega-3, while in the plant is configurated as omega-6 (Bimbo 1987). Natural fatty acids which included into omega-3 are linoleic acid (C18:, n-3), eicosapentaenoic acid or EPA (C20:5, n-3) and decosahexaenoic acid or DHA (C22:6, n-3) (Marinetti 1990), but EPA and DHA were dominated in fish fat (Husaini 1989).

Fatty acids profile in fresh eel and *kabayaki* could be seen in Table 2. Fatty acids composition in fresh eel were single chain unsaturated fatty acid (MUFA) 32.84%, saturated fatty acids (SAFA) 22,78% and complex chain unsaturated fatty acids (PUFA) 11.44%, while fatty acids composition in *kabayaki* were SAFA 30.68%, MUFA 31.1% and PUFA 10.39%. The major fatty acids contain which found in fresh eel, such as palmitic acid (17.64%) and myristic acid (2.24%), while *kabayaki* such as palmitic acid (17.17%) and stearic acid (7.06%). SAFA contain in fresh eel (22.78%) is lower than *kabayaki* (30.68%). The flesh of eel has white color, highly contain of unsaturated fatty acids which has many advantages like no other kind of animal has it, so that eel becomes the main dish which fullfill human appetite without worried of increasing body weight.

EPA (C20:5n-3) contain of *kabayaki* Indonesian eel were decrease 0,45% after first roasting proces (*shirayaki*), steaming and second roasting (*kabayaki*). DHA (C22:6n-3) contain of were decrease 3.87% after roasting and steaming process. The decreasing of EPA and DHA were occured because complex unsaturated fatty acids were easily oxidated and the oxidation rate increase with the lenght of processing time. Barrow et al. (2009) experiment stated that EPA and DHA were very easily oxidated by light, oxygen, and produce degradation products. One of degradation product from this fatty acids were aldehide which is causing odor. Gladyshev et al. (2007) experiment stated that EPA and DHA could be obtained by consuming marine products, nevertheless the unsaturated fatty acids contains from it could be decreased by oxidation while processing or cooking and storaging. Sidhu (2003) stated that consuming marine products which are rich of complex unsaturated fatty acid could decreasing coronary heart risk, decreasing hypertension, and diabetes. Examination result of omega-3 fatty acids could decreasing cholesterol, HDL, trigliceride and lipid of experiment mouse blood serum and also affect blood preasure (Sukarsa 2004).

CONCLUSION

1. Nutritive value of eel consist of protein, fat, carbohydrate, moisture contain, ash and crude fiber, respectively 17.68%; 28.29%; 9.53%; 42.03%; 3.93%; and 0.30%. While for Kabayaki Indonesian eel contain of 32.70%; 2.39%; 13.69%; 48.32%; 2.37% and 0.55%.

TABLE 2. Fatty acids contain of Indonesian eel in 100 g fresh condition and *kabayaki* (%)

Fatty Acid Parameters (%)	Fresh	*Kabayaki*
Saturated Fatty Acids		
Capric Acid, C 10:0	-	0.01
Undecanoic Acid, C11:0	-	0.02
Lauric Acid, C12:0	0.07	0.24
Tridecanoic Acid, C13:0	-	0.28
Myristic Acid, C14:0	2.42	2.41
Pentadecanoic Acid, C15:0	0.27	0.99
Palmitic Acid, C16:0	17.64	17.17
Heptadecanoic Acid, C17:0	0.24	1.83
Stearic Acid, C18:0	2.07	7.06
Arachidic Acid, C20:0	0.07	0.32
Heneicosaneic Acid, C21:0	-	0.06
Behenic Acid, C22:0	-	0.15
Tricosanoic Acid C23:0	0.00	0.07
Lignoceric Acid, C24:0	0.00	0.08
Σ SAFA	22.78	30.68
Single Chain Saturated Fatty Acids		
Myristoleic Acid, C14:1	0.05	0.07
Palmitoleic Acid, C 16:1	3.18	2.42
Cis-11, 14 Eicosaenoic Acid, C20:1	1.35	1.07
Nervonic Acid C24:1	0.04	0.02
Elaidic Acid, C18:1n9t	0.14	0.19
Oleic Acid, C18:1n9c	28.02	27.33
Erucic Acid C22:1n9	0.06	-
Σ MUFA	32.84	31.1
Complex Chain Saturated Fatty Acids		
Linoleic Acid, C18:2n6c	4.49	6.13
v-Linolenic Acid, C18:3n6	0.12	0.03
Linolenic Acid, C18 3n3	0.36	1.73
Cis-11, 14 Eicosedienoic Acid, C20:2	0.34	0.83
Cis-8,11,14 Eicosetrienoic Acid C20:3n6	0.29	0.16
Cis-11,14,17 Eicosetrienoic Acid C20:3n3	0.04	0.49
Arachidonic Acid C20:4n6	0.64	1.52
Cis-13,16-Docosadienoic Acid C22:2	5.16	0.02
Σ PUFA	11.44	10.39
Long Chain Unsaturated Fatty Acids		
Cis-5,8,11,14,17-Eicosapentaenoic Acid, C20:5n3	1.15	0.70
Cis-4,7,10,13,16,19-Docosahexaenoic Acid, C22:6n3	5.16	1.29
Total EPA DHA	6.31	1.31
PUFA/SAFA	0.50	0.38
DHA/EPA	4.49	1.85
Unindetified	26.63	25.30
Fatty Acids Total	73.37	74.70

Primary Data 2013

2. Fatty acid profile in fresh Indonesian eel (*Anguilla bicolor*), such as polyunsaturated fatty acid (PUFA) 11.44%; Eicosapentaenoic Acid (EPA) (C20:5n-3) 1.15% and Docosahexaenoic Acid (DHA) (C22:6 n-3) 5.16%, while Kabayaki Indonesian eel contains of (PUFA) polyunsaturated fatty acid (PUFA) 10.39%, EPA (C20:5n-3) 0.70% dan DHA (C22:6 n-3) 1.29%.
3. EPA and DHA (C22:6 n-3) contain (C20:5 n-3) of kabayaki eel were decrease respectively 0.45% and 3.87% after first roasting, steaming, and second roasting. The decreasing of EPA and DHA contain after processing wereoccur because unsaturated fatty acid were easily oxidate and the oxidation rate were increase simultaneously with the length of processing time.

ACKNOWLEDGMENT

Thanks are due to Marine Field Station, Palabuhanratu, Sukabumi Districtand Department of Fisheries Resource Utilization, Fisheries Faculty and Faculty of Fisheries and Marine Science, Bogor Agricultural University, Mr Hisayasu Ishitani (Jawa Suisan Indah Company, Palabuhanratu, Sukabumi District), Fisherman community in Palabuhanratu, Sukabumi District and Local Authority Sukabumi District and Dr. Ruzita Universiti Kebangsaan Malaysia.

REFERENCES

Ackman, R.G. 1982. Fatty acid composition of fish oil.In *Nutritional Evaluation of Long Chain Fatty Acid in Fish Oil*. edited by Barlow, S.M. & Stansby, M.E. Academic Press Ltd. London.

Altun, T., Tekelioglu, N., Nevsat, E. & Sagat Y. 2005. Some growth parameters on European eel (Anguilla Anguilla L, 1758) fed with different feeds. *E.U Journal of Fisheries & Aquatic Sciences* 22: 215-219.

[AOAC] Association of Official Analytical and Chemists. 1995. *Official Methods of Analysis the 16th ed.* USA: Virginia, Inc.

Bakar, J., Rahimabadi, E.Z. & Man, Y.B.C. 2007. *Lipid characteristics in cooked, chillreheated*.

Barrow, C.J., Nolan, C. & Holub, B.J. 2009. Bioequivalence of encapsulated and microencapsulated fish-oil supplementation. *Journal of Functional Foods* 1: 38-43.

Bimbo, A.P. 1987. The emergencing marine oil industry. *Journal American oils a Cemistry Society* 64: 5.

Brody, J. 1965. *Fishery by Product Technology*. The AVI Publishing Company Inc. Westport Connecticut.

FAO. 2010. *Fishery and Aquaculture Statistics.* 2010 FAO yearbook annuaireanuarin, A-1 & A-6.

Felix, M.L. & Velazquez, M. 2002. Current status of lipid nutritionwhite shrimp, Litopenaeusvannamei. *Food Chem*. 96: 36-45.

Freeman, M.W. & Junge, C. 2005. *Kolesterol Rendah Jantung Sehat*. Jakarta: PT Bhuana Ilmu Popular.

Gladyshev, M., Suschik, N., Gubanenko, G., Demirchieva, S. & Kalachova, G. 2007. Effect of way cooking on content of essential lpolyunsaturated fatty acid in muscle tissue of humpback salmon (*Oncorhynchusgorbuscha*). *Food Chemistry* 96: 446-451.

Heinsbroek LTN. 1991. A review of eel culture in Japan and Europe. *Aquaculture and Fishery Management* 22: 57-72.

Husaini. 1989. Nilai gizi ikan dan manfaatnya untuk kesehatan. Makalah pada Seminar Pemanfaatan Sumberdaya Laut untuk Konsumsi Pangan. Festival makanan se-Indonesia 28 Agustus 1989.

KKP (Kementerian Kelautan dan Perikanan). 2011. Naskah Pidato Dirjen Budidaya, Kementerian Kelautan dan Perikanan. Disampaikan dalam acara Seminar Minapolitan, 2011.

Kottelat, M., Whitten, A.J., Kartikasari, S.N. & Wirjoatmodjo, S. 1993. Freshwater Fishes of Western Indonesia and Sulawesi. Edisi Dwibahasa Inggris-Indonesia, Periplus ed. 293 p.

Marinetti, G.V. 1990. *Disorders of Lipid Metabolism.* New York and London: Plenum Press.

Özogul, Y., Özyurt, G., Özogul, F., Kuley, E. & Polat, A. 2005. Freshness assessment of European Eel (*Anguilla anguila*) by sensory chemical and microbiological methods. *Food Chemistry* 92: 745-751.

Prabandari, R., Mangalik, A., Achmad, J. & Agustiana. 2005. Pengaruh waktu perebusan dari dua jenis udang yang berbeda terhadap kualitas tepung limbah udang putih (Penaeusindicus) dan udang windu (Penaeusmonodon). *Enviro Scientiae* 1(1): 24-28.

Sidhu, K.S. 2003. Health benefits and potential risks related to consumption of fish or fish oil. *Regulatory Toxycology and Pharmacology* 38: 336-344.

Sukarsa, D.R. 2004. Studi aktivitas asam lemak omega-3 ikan laut pada Mencit sebagai model hewan percobaan. BuletinTeknologi Hasil Perikanan Volume VII Nomor I Tahun 2004. Dept, THP. FPIK.IPB hal 68-77.

Weber, J., Bochi, V.C., Ribeiro, C.P., Victorio, A.D.M. & Emanuelli, T. 2008. Effect of different cooking methods on the oxidation, proximate and fatty acid composition of silver catfish (*Rhamdiaquelen*) fillets. *Food Chemistry* 106: 140-146.

R.A. Hangesti Emi Widyasari
Clara M Kusharto
Department of Fisheries Resource Utilization
Faculty of Fisheries and Marine Science
Bogor Agricultural University
Jl. Raya Darmaga Kampus IPB Darmaga Bogor 16680
West Java, Indonesia

Sugengherisuseno
Department of Aquatic Product Technology
Faculty of Fisheries and Marine Science
Bogor Agricultural University
Jl. Raya Darmaga Kampus IPB Darmaga Bogor 16680
West Java, Indonesia

Budywiryawan
Eko Sri Wiyono
Department of Community Nutrition
Faculty of Human Ecology
Bogor Agricultural University
Jl. Raya Darmaga Kampus IPB Darmaga Bogor 16680
West Java, Indonesia

Correspondence author: Clara M. Kusharto
Email address: kcl_51@yahoo.co.id
Tel: +62811116178; Fax: +622518624907

Received: September 2013
Accepted for publication: November 2013