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Inventory and Characterization of Selected Deep Sea Fish Species as an Alternative Food Source from Southern Java Ocean and Western Sumatra Ocean, Indonesia

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***Abstract*—**Sixteen selected deep-sea fish obtained from Southern Java Ocean and Western Sumatra Ocean was analyzed to determine its proximate, fatty acid and mineral composition. The moisture content was ranged from 64.38 to 86.04 %, ash from 0.17 to 0.69 %, the fat content was 1.54 – 13.30 % while the protein content varied from 15.84 to 23.60%. Among the fatty acids, oleic acid and palmitic acid was the dominant MUFA and SFA. Linoleic acid was the highest PUFA found at the selected deep-sea fish. Phospor was the highest macroelement concentration on selected deep-sea fish, followed by K, Ca, Mg and Iod, Fe and Zn among microelement. The trace concentration was found at Se microelement.

***Keywords*—**deep-sea fish, fatty acid, microelement, macroelement, monounsaturated fatty acid, proximate, polyunsaturated fatty acids.

I. Introduction

THE search of potential alternative source for fish product is needed due to its extended market. According to [1], the world marine capture production reached 81.9 million tonnes at 2006, relatively decrease from previous years. That condition was a contrary with the trend of human consumption which was increased almost 10% from 2002 to 2006 (100.7 to 110.4 million tonnes). Contained water volume amounting to 85% of 70% world surface and seldom inhabited by organism, deep-sea is one of the potential alternative areas [2].

Deep-sea area is located under the shining depth area in the open ocean and is deeper than the continental shelf (>200 m). Baruna Jaya IV expedition led by The Agency for Marine and Fisheries, Research Ministry Marine Affairs and Fisheries, Indonesia found about 529 kinds of deep-sea fishes in the Southern Java and Western Sumatra Ocean, Indonesia [3].

Deep-sea fishes are considered to be not only food with good source of quality protein but also food with healthy components. Several kind of deep-sea fish already be important food and often looked in the markets.

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In Europe, deep-sea fish (Lunglip) known as cusk eel, Hung in New Zealand, Cangrio in South America and in Japan, Kingu is marketed by retail and rarely appears in restaurants. It is looked because of the good quality and unique meat texture.

The food consumption and metabolism of deep-sea fish wasn't much studied. Information on the proximate content and fatty acid distribution will be important due to its utilization. This overview will explain the proximate content, mineral and fatty acid compositions of selected deep-sea fishes caught in the Western Sumatra Ocean and the Southern Java Ocean.

II. Materials and Methods

A. Materials

Fish materials explained consisted of 16 species of deep-sea fishes (*Antigonia capros*, *Antigonia rubicunda*, *Caelorinchus smithi*, *Coryphaenoides* sp, *Cubiceps kotlyari*, *Diretmoides puciradiatus*, *Diretmoides veririginae*, *Gadella jordani*, *Lamprogrammus*, *Malakichthys*, *Neoscophelus microchir*, *Neoscophelus porous*, *Ostracoberyx dorygeny*, *Zenopsis conchifer*, *Lepidocibium flavobronneum*, and *Seriola* sp.) were caught using a trawler at depths of 372 to 1000 m in the Southern Java Ocean and the West Sumatera Ocean, Indonesia. The fish samples were kept frozen at -20 ^{0}C until analyzed.

B. Chemical analysis

Moisture content was determined by drying samples in an air circulation oven for 8 h at 100^{0}C. Samples for ash determination were heated in a furnace at 550^{0}C for 6 h to constant weight as described in the AOAC manual [4]. Crude protein was determined on the edible portions of fish from Kjeldahl nitrogen using a 6.25 conversion factor [4]. Lipids were extracted by using chloroform/methanol (2:1 v/v) and were gravimetrically determined as described previously [5].

C. Fatty acid analysis

Preparation of fatty acids methyl ester was carried out according to the method of [6]. Crude oil extract (20 µL) from deep-sea fish samples were trans-esterified in a pyrex tube by using 200 µL of borontrifluoride-methanol (20 % BF3) reagent and heating at 100 0C for 30 min. After cooling, 200 µL of n-hexane and 800 µL of distilled water were added to the mixture, which was then agitated manually for 1 min and centrifuged for 2 min. Approximately 100 µL of the upper n-hexane layer was transferred to a 150 µL glass insert for 2 ml vials after diluting the extracted hexane to obtain a suitable chromatographic response. Fatty acids were identified by comparing the retention times of FAME mixture with the standard myristic acid palmitic acid, stearic acid, oleic acid and linoleic acid. Two replicate GC analyses were performed and the results were expressed in GC area % as mean values ± standard deviation. The fatty acid composition of deep-sea fish oil triacyglyserol was directly analyzed using Gas Chromatography (GC) after methylesterification. One µL of each fatty acid methyl ester (FAME) sample was injected (split ratio 15:1) into a GC 17 A-SHIMADZU Gas Chromatography (Shimadzu Scientific Inc., USA) with flame ionization detector (GC-FID). A BPX 70 (SGE, Australia) column consisting of a 30 m x 0.32 mm fused silica capillary coated with 70 % cyanopropyl polysilphenylene-siloxane of 0.25 µm film thickness was used, with Hydrogen as the carrier gas at constant linear velocity (28 cm/s). The injector temperature was 250 0C and the detector temperature 280 oC. The oven was programmed as follows: 80 oC for 2 min, 5 oC/min to 200 oC for 10 min and 10 oC/min to 230 oC for a further 10 min. Total analysis time was 49 min and the last major fatty acid (24:1 n-9) was eluted at approximately 30 min. Chromatographic peaks were identified by comparing retention times with the PUFA standard.

TABLE I
PHYSICAL PROPERTIES AND EDIBLE PORTION OF SELECTED DEEP-SEA FISHES FROM SOUTHERN JAVA OCEAN AND WESTERN SUMATRA OCEAN

Fish Species	Length (cm)	Weight (g)	Fillet Weight (g)	Edible Portion (%)
Antigonia capros	15.00	80.00	25.00	31.25
Antigonia rubicunda	11.00	43.00	14.00	32.56
Caelorinchus smithi	22.50	63.00	19.00	30.16
Coryphaenoides sp,	59.00	646.00	234.00	36.22
Cubiceps kotlyari	15.50	43.00	20.00	46.51
Diretmoides puciradiatus	23.50	261.00	39.00	14.94
Diretmoides veririginae	20.00	124.00	83.00	66.94
Gadella jordani	22.50	62.00	24.00	38.71
Lamprogrammus	36.50	217.00	77.00	35.48
Malakichthys,	13.50	19.00	5.00	26.32
Neoscophelus microchir	22.00	111.00	37.00	33.33
Neoscophelus porous,	21.00	91.00	43.00	47.25
Ostracoberyx dorygeny	16.00	60.00	15.00	25.00
Zenopsis conchifer	44.00	964.00	326.00	33.82
Lepidocibium flavobronneum	41.17	466.67	249.33	53.43
Seriola sp.	59.67	400.00	216.67	54.17

C. Mineral analysis

Calsium (Ca), Magnesium (Mg), Kalium (K) and Zinc (Zn) mineral was analyzed using Atomic Absorption Spectrometer (AAS) according to [7], then Selenium (Se) was analyzed using [8] method.

III. RESULTS AND DISCUSSION

A. Edible Portion

The physical properties of selected deep-sea fish were shown at Table I. The edible portions were varied between 25.00-66.94%, except the *Diretmoides puciradiatus* had 14.94% of edible portions. Usually, pelagic fish had edible portions 45-75% and 30-70% respectively [9]-[10].

B. Proximate composition of fish muscle

Result of proximate analysis was shown in Table II. The water content was varied between 64.38 – 86.04 % and ash from 0.17 to 0.69 %. The highest moisture content was found at *Neoscophelus microchir* and the lowest value at *Lepidocibium flavobronneum*. According to [11] reported that the deep-sea fishes are high in protein and low in fat, the same result was found in this study. The fat content was 1.54 – 13.30 % while the protein content varied from 15.84 to 23.60%. The highest protein content was found at *Ostracoberyx dorygeny* and the lowest fat content was found

TABLE II
PROXIMATE COMPOSITION AND ENERGY VALUES OF EDIBLE PORTION OF THE DEEP-SEA FISH SPECIES (PER 100 G)A

Fish Species	Water (%)	Ash (%)	Fat (%)	Protein (%)
Antigonia capros	85.92	0.35	2.16	15.95
Antigonia rubicunda	79.15	0.27	3.01	17.52
Caelorinchus smithi	79.15	0.17	1.59	18.38
Coryphaenoides sp,	76.02	0.29	1.67	17.25
Cubiceps kotlyari	85.92	0.35	2.84	20.75
Diretmoides puciradiatus	85.92	0.27	1.82	16.38
Diretmoides veririginae	81.11	0.18	1.63	22.10
Gadella jordani	83.95	0.34	1.54	18.60
Lamprogrammus	80.83	0.28	2.12	18.22
Malakichthys,	64.38	0.38	3.16	15.99
Neoscophelus microchir	86.04	0.33	2.73	17.86
Neoscophelus porous,	76.02	0.34	2.11	15.84
Ostracoberyx dorygeny	70.60	2.20	3.60	23.60
Zenopsis conchifer	78.32	0.28	1.79	16.27
Lepidocibium flavobronneum	68.56	0.69	13.30	16.47
Seriola sp.	70.35	0.44	7.54	19.14

TABLE III
PHYSICAL PROPERTIES AND EDIBLE PORTION OF SELECTED DEEP-SEA FISHES FROM SOUTHERN JAVA OCEAN AND WESTERN SUMATRA OCEAN

Fish Species	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C18:3
Antigonia capros	0,53	65,79	284,92	17,90	341,33	55,73	13,53
Antigonia rubicunda	22,54	40,62	323,25	14,38	281,83	84,44	0,43
Caelorinchus smithi	0,20	52,76	228,64	14,11	343,53	78,03	0,42
Cubiceps kotlyari	20,55	45,13	279,59	53,35	360,56	62,43	0,72
Diretmoides puciradiatus	0,29	26,36	338,31	121,59	275,04	98,89	0,74
Diretmoides veririginae	0,26	87,83	340,12	10,89	351,23	48,81	0,60
Gadella jordani	0,45	31,41	326,59	63,46	326,59	71,42	11,24
Lamprogrammus	14,64	76,88	363,00	18,03	253,08	36,85	0,84
Malakichthys,	11,73	28,42	339,89	17,60	467,22	50,97	0,61
Neoscophelus microchir	0,46	64,99	374,74	20,27	354,39	49,42	0,55
Neoscophelus porous,	0,63	137,67	227,85	0,76	321,65	131,03	0,98
Ostracoberyx dorygeny	0,18	66,99	286,26	25,46	443,73	74,73	10,63
Zenopsis conchifer	0,29	74,75	310,96	20,65	395,35	61,48	0,62
Lepidocibium flavobronneum	0,24	2,71	4,00	6,15	73,38	4,85	0,65
Seriola sp.	0,54	1,52	6,99	12,67	66,17	3,61	0,58

at *Gadella jordani*. According to [12] category, almost all selected deep fish can be grouped as lean to low fat fish (lean <2% and low fat 2-4%) except be found at *Lepidocibium flavobronneum* (high fat > 8%) and *Seriola* sp. (medium fat 4-8%). This result is similar to the proximate test results for deep-sea fish species reported previously [13]. The different fat content each fish respectively can be influenced by age, seasons of year, food availability, and environment such as salinity and tempearature [14]-[15]

C.Fatty acid profile of deep-sea fish muscles

Fatty acid composition of selected deep fish oil was shown at Table III. Among the fatty acids, oleic acid and palmitic acid was the highest fat concentration at examined deep fish. the dominant PUFA observed was linoleic acid, while the highest SFA for all examined deep sea fish was palmitic acid. Range of fatty acid for examined deep sea fish were PUFA (4.11 to 99.63 mg/gr), MUFA (66.17 to 467.22 mg/g) and SFA (13.11 to 486.55 mg/g). The ratio SFA/PUFA was 6.57, then [MUFA +PUFA]/SFA was 1.51. It showed a dominant percentage of MUFA and PUFA relative to saturated fatty acid.

The highest value of PUFA was found at *Neoscophelus porosus* while the highest of SFA was *Lamprogrammus niger*. *Ostracoberyx dorygeny* had the highest concentration of oleic acid (443.730 mg/gr) while the lowest oleic acid was found at *Seriola* sp. (66.174 mg/gr).

The fatty acid composition of deep-sea fish examined were similar to that reported previously [16]. Deep sea fish is composed mainly of monoenoic fatty acid, which is important for industrial use in food processing of hydrogenated fish oil, and are raw materials of margarine, fat spread or shortening.

The fatty acid composition of fish tissue can be affected by diet, size, age, reproductive cycle, salinity, temperature, season and geographical location [17]. The fatty acid composition of different fish from the same species can vary because of diet, location, gender and environmental conditions [18]. The demersal fish contained more MUFA than pelagic fish, while pelagic fish contained more PUFA than demersal fish [19].

D. Macroelement and microelement composition

The macroelement and microelement evaluated by AAS analysis was performed at Table IV. Among the macroelement, Phosphor had highest concentration at selected deep fish. P concentration was ranging from 339.67 to 583.06 ppm. The other macroelement including Ca and K varied between 303.92 – 364.65 ppm and 338.18 – 415.50 ppm respectively. Magnesium had the lowest concentration, its ranging from 158.64 to 190.23 ppm. *Neoscophelus porosus* had the highest level at P and Ca while the lowest concentration of P was found at *Lamprogrammus niger*.

The microelement concentration also had shown at Table 4. Fe concentration was ranging from 4.14 ppm at Antigonia rubicund to 5.86 ppm at *Gadella jordani*. Iod concentration varied at highest value 11.89 ppm at Cubiceps kotlyari and lowest value 10.27 at *Gadella jordani*. *Ostracoberyx dorygeny* had the lowest concentration of Zn at 3.83, and *Neoscophelus porosus*,had the highest concentration of Zn at 4.25. Among the selected deep-sea fish analyzed, the Se component was not detected or in trace concentration.

TABLE IV
PHYSICAL PROPERTIES AND EDIBLE PORTION OF SELECTED DEEP-SEA FISHES FROM SOUTHERN JAVA OCEAN AND WESTERN SUMATRA OCEAN

Fish Species	Macromineral				Micromineral			
	Ca	K	Mg	P	Fe	Se	Iod	Zn
Antigonia capros	314,73	394,45	169,2	579,98	5,13	ND	11,55	4,17
Antigonia rubicunda	307,00	372,47	162,86	568,05	4,14	ND	11,46	4,21
Caelorinchus smithi	312,31	389,35	190,23	557,51	4,48	ND	10,37	4,21
Coryphaenoides sp,	358,48	376,08	158,64	548,33	4,48	ND	11,84	4,21
Cubiceps kotlyari	348,51	377,02	162,51	527,90	4,83	ND	11,89	4,21
Diretmoides puciradiatus	337,54	415,5	163,67	567,26	5,55	ND	10,80	4,22
Diretmoides veririginae	327,29	375,79	178,55	548,16	5,17	ND	10,65	4,21
Gadella jordani	303,92	407,89	166,91	559,62	5,86	ND	10,27	4,21
Lamprogrammus niger	317,18	410,5	164,87	339,67	5,21	ND	11,21	4,24
Malakichthys,	358,97	387,43	178,18	574,26	4,40	ND	10,72	4,13
Neoscophelus microchir	313,14	397,54	167,95	579,32	4,86	ND	11,23	4,23
Neoscophelus porosus,	364,65	395,76	171,62	583,06	4,49	ND	10,82	4,25
Ostracoberyx dorygeny	347,86	338,18	169,56	567,68	5,02	ND	10,28	3,83
Zenopsis conchifer	331,76	405,98	165,47	555,76	4,78	ND	10,88	4,17

IV. CONCLUSION

The selected deep-sea fish acquired from southern Java Ocean and Western Sumatra Ocean found had high protein content that potentially utilized. Almost all the selected fish was grouped at low fat fish. Mono unsaturated and saturated fatty acids were the highest fat compound, higher than poly unsaturated concentration. Among the macro and microelement, Phospor was the highest abundance on selected deep-sea fish, followed by K, Ca, Mg and Iod, Fe and Zn among microelement. The undetected Se concentration indicates that the microelement was at very low/trace concentration.

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