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Fatty Acid Compositions of Three Species of Marine Invertebrates

Bo-Young Jeong†, Soo-Kyung Moon and Woo-Geon Jeong*

Dept. of Nutrition and Food Science, Tong-Yeong National Fisheries College, Chungmu 650-160, Korea
** Dept. of Aquaculture, Tong-Yeong National Fisheries College, Chungmu 650-160, Korea*

Abstract

The lipid components of the gonad of sea urchin *Hemicentrotus pulcherrimus*, ark shell *Scapharca broughtonii* and "Gaebul" (Korea name, a worm) *Urechis unicinctus* were investigated. The total lipid (TL) contents of the sea urchin, the ark shell and the "Gaebul" were 6.10, 0.67 and 0.79%, respectively. The percentages of phospholipid (PL) in TL were higher in the "Gaebul" (72.4%) and ark shell(64.9%) compared to the sea urchin (41.7%). The major lipid classes of PL were phosphatidylcholine and phosphatidylethanolamine, and the former was rich in the sea urchin (56.2%) and the latter in the "Gaebul" (34.4%). In the class of non-polar lipid (NL), the major lipid classes were different from species ; the sea urchin was rich in triglyceride(TG, 89.0%), the ark shell rich in TG (69.2%) and cholesterol (ST. 26.8%) and the "Gaebul" rich in ST (70.7%). The prominent fatty acids of the sea urchin were 16 : 0, 14 : 0, 20 : 5n-3, 20 : 4n-6 and 20 : 4n-6 and 20 : 2NMID(non-methylene interupted dien). The percentage of 20 : 4n-6 was the highest of the investigated invertebrates, accounting for 19.8% in PL, but 22 : 6n-3 was not detected in the sea urchin. In case of the ark shell, the prominent fatty acids were 16 : 0, 18 : 0, 20 : 5n-3, 22 : 6n-3 and 22 : 2NMID, especially 22 : 6n-3(9.58%) was richer compared to that of the "Gaebul". The prominent fatty acids of the "Gaebul" were 20 : 5n-3, 16 : 0, 18 : 0 20 : 1n-9, 16 : 1n-7 and 14 : 0. The percentage of 20 : 5n-3 (22.0%) was highest in the PL of the "Gaebul" among the three invertebrates. These differences in the lipid components of all the sample is considered to be due to the different food habits and environmental condition of the invertebrates.

Key words : marine invertebrates, sea urchin gonad, ark shell, Gaebul, phospholipid and nonpolar lipid class, fatty acids

INTRODUCTION

Certain marine invertebrates are important marine foods, especially in Korea and Japan. These invertebrates are essential to the marine food chain, because they serve as the link in the transfer of energy from the primary precursors of the sea : the phytoplankton to upper tropic levels, the carnovorous fishes, mammals, and ultimately, man.

Joseph[1] has reviewed the lipid components of marine invertebrates in which the detailed fatty acid compositions obtained by wall-coated open-tubular (WCOT) column gas-liquid chromatography (GLC) have been reported but only in a small number of papers. The reports on the fatty acid composition of sea urchin are relatively common, because the gonad of sea urchins are considered gastronomic delicacies in the Orient. Kochi[2-4] analyzed the fatty acid compositions of the gonad lipid of sea urchins, *Strongylocentrotus pulcherrimus and S. crassispina*, and showed the occurence of 20 : 2 non-methylene interrupted dienes (NMID, Δ3,11 and Δ5,11). Takagi et al.[5] also analyzed the fatty acid compositions of the Atlantic sea urchin, *S. droebachiensis* and identified 20 : 2 NMID (Δ5,11 and Δ5,13) and 22 : 2 NMID (Δ7,13 and Δ7,15). These NMID fatty acids were also found in other species of sea urchins[6-8]. However, no information on the fatty acid compositions of ark shell and "Gaebul" (a worm), which are using as a marine food in Korea has been obtained so far.

In the present study, the detailed fatty acid compositions of the sea urchin, *Hemicentrotus pulcherrimus*, the ark shell *Scapharca brougtonil*, and "Gae-

† To whom all correspondence should be addressed

bul" *Urechis unicinctus* from the southern sea of Korea were investigated by GLC WCOT column.

MATERIALS AND METHODS

Samples

The gonad of sea urchin and ark shell were purchased from a fish market in Chungmu, Korea, in July 1991, and "Gaebul" in January 1992. The 6 ark shells were transported to the laboratory. The total wet organic tissues of the ark shell were removed. It amounted to 95.3g of their mean weight. Gaebul of 50 specimens were used for analyses and average weight 8 one specimen was 12.3g. About 200g of urchin gonad were subjected to analyses.

Lipid extraction

The samples were minced and extracted with chloroform/methanol according to the Bligh and Dyer procedure[9]. The total lipid (TL) content was gravimetrically determined.

Determination of PL and NL contents

The total phosphorus content of TL was spectrophotometrically determined according to the method of Bartlett[10]. The phospholipid (PL) content in TL was obtained by multiplying the phosphorus content by 25. The non-polar lipid (NL) content in TL was calculated from the difference between the TL and PL contents.

Determination of lipid class compositions of PL and NL

Lipid class compositions of PL and NL were determined according to the method of Ohshima and Ackman[11], using a Iatroscan MK-5, TLC/FID analyzer (Iatron Laboratories Inc., Tokyo, Japan).

Briefly, an aliquot of the chloroform solution of TL was spotted on the Chromarods-SIII (Iatron Laboratories Inc., Tokyo, Japan) with a single spotting action, using Drummond Microcap disposable pipets (1 μl, Drummond Scientific Co., Broomall, Pa., USA). The Chromarods were placed in a constant humidity tank over saturated sodium chloride solution for 10min and then immediately transferred to the developing tank. The solvent system for NL was a mixture of *n*-hexane/diethyl ether/formic acid (97 : 3 : 1, v/v/v).

For PL, acetone and a mixture of chloroform/methanol/water (65 : 35 : 4, v/v/v) were used as the solvent system. The Chromarods, after developing, were heated for 2min in an oven at 115° C and were scanned using an Iatroscan MK-5. The air and hydrogen flow rates for the Iatroscan analyzer were 2,000ml/min and 160ml/min, respectively, and the scan speed was set at 30sec/scan. Each peak components that appeared on a Iatrocorder TC-11 (Iatron Laboratories Inc., Tokyo, Japan) were calculated from standard curves previously obtained using authentic lipids.

Analysis of fatty acid composition

The TL was separated into PL and NL, using a silicic acid Seppak cartridge (25mm × 10 mm, i.d., Waters Associates, Milford, MA, USA) according to the method of Juaneda and Rocquelin[12]. Fatty acid compositions of TL, PL and NL were analyzed by GLC using a Shimadzu GC 14A (Shimadzu Seisakusho Co. Ltd., Kyoto, Japan) equipped with a SUPELCOWAX-10 fused silica WCOT column (30m × 0.25mm, i.d., Supelco Japan Ltd., Tokyo). The injector and detector were held at 250° C and the column at 195° C, respectively. The split ratio was 1 : 50. Helium was used as the carrier gas at a constant inlet pressure of 1.5kg/cm^2. The fatty acids in samples were identified by the equivalent chain length (ECL) and by comparing the R_t of the standard[13].

RESULTS AND DISCUSSION

Lipid contents

TL, PL and NL contents are shown in Table 1. The TL contents of sea urchin gonad, ark shell and "G-

Table 1. Lipid contents of sea urchin gonad, ark shell and "Gaebul" (%)

Class	Sea urchin	Ark shell	"Geabul"
Total lipid	6.10	0.67	0.79
Phospholipid	2.54	0.43	0.57
Non-polar lipid	3.56	0.24	0.22

Table 2. Lipid class compositions of phospholipid and non-polar lipid in sea urchin gonad, ark shell and "Gaebul"

(%)

Phospholipid				Non-polar lipid			
Class*[1]	Sea urchin	Ark shell	"Gaebul"	Class*[2]	Sea urchin	Ark shell	"Gaebul"
LPC	tr.	4.7	–	DG	–	–	–
PC	56.2	51.5	52.1	ST	4.9	26.8	70.7
PS	9.8	8.3	–	FFA	–	–	5.1
PI	–	–	5.5	TG	89.0	69.2	6.7
PE	21.8	25.4	34.4	GE	–	–	8.4
CA	12.2	10.0	8.0	SE	6.2	4.0	9.1
Total	100.0	99.9	100.0	Total	100.1	100.0	100.0

*[1] LPC, lyso-phosphatidylcholine ; PC, phosphatidylcholine ; PS, phosphatidylserine ; PI, phosphatidylinositol ; PE, phosphatidylethanolamine ; CA, cardiolipin

*[2] DG, diglyceride ; ST, free sterol ; FFA, free fatty acids ; TG, triglycerides ; GE, glyceryl ester ; SE, steryl ester

aebul" were 6.10, 0.67 and 0.79%, respectively. The percentages of PL in TL were either in the "Gaebul" (72.4%) and in the ark shell (64.9%) than in the gonad of sea urchin (41.7%).

The TL content of the gonad of sea urchin was more than that (4.09%) of *S. intermedius* harvested in December[8], and more or less than those reported for other species of sea urchins[7]. The PL content of the sea urchin was over twice that (33.3%) reported for *S. intermedius*[8]. The TL content of ark shell was similar to the result of Mun[14] for the same species of ark shell, while the PL content showed a great difference between both ark shell ; the percentage of PL in TL was 64.9% in the former, while that in the latter was 3.03%. Such a difference in the PL contents between the ark shells was considered due to the difference in the methods of determination ; the former was determined by phosphorus content in TL, but the latter was determined by TLC densitometry. The TL content of "Gaebul" was about half of the result (1.89%) reported for that harvested in May, Korea[15], whereas the percentage of PL was more than twice that (39.8%) in the latter. These results may be attributable to the differences in location and harvesting season[1].

Lipid class compositions of PL and NL

Table 2 shows the lipid class compositions of PL and NL of the three species of marine invertebrates. The phosphatidylcholine (PC), phosphatidylethanolamine (PE) and cardiolipin (CA) were commonly found in all the samples, but lyso-PC (LPC) occurred only in the ark shell, phosphatidylinositol (PI) occurred only in the "Gaebul" and sphingomyelin (SPM) was not found in any of the samples. In these samples, the prominent PL classes were PC and PE. The percentages of PC ranged from 51.5% (ark shell) to 56.2% (sea urchin), and those of PE ranged from 21.8% (sea urchin) to 34.4% ("Gaebul").

In general, the PL pattern of a marine organism is mainly determined by taxonomic position, particulary SPM is typical of animals at certain evolutionary stages[16]. That is, the SPM is poor or absent in lower animals and rich in higher animals[17]. Indeed, the SPM was not found in Japanese oyster[18], giant ezo scallop and sea urchin[8], as well as in all the samples of the present study, while SPM was found in ascidians[8,17] and a number of fishes[19].

On the other hand, lipid class compositions of NL showed a significant difference between species. The triglycerides (TG), sterols (ST) and steryl esters (SE) were commonly found in all the samples, but their proportions varied widely ; TG ranged from 89.0% (sea urchin) to 6.66% ("Gaebul"), ST ranged from 70.7% ("Gaebul") to 4.86% (sea urchin), and glyceryl esters (GE) and free fatty acids (FFA) were only found in "Gaebul".

These results in the sea urchin gonad were likely similar to those reported by slight differences between both samples. This may stem from species-specific or from the difference in the state and season collected, although both samples belong to the

Table 3. Fatty acid compositions of total lipid in sea urchin gonad, ark shell and "Gaebul" *1

(Area %)

ECL*2	Fatty acid	Gonad sea urchin	Ark shell	"Gaebul"
11.95	12 : 0	–	–	0.23±0.02
13.00	13 : 0	–	0.61±0.27	0.28±0.01
14.00	14 : 0	8.69±0.06	4.33±0.14	3.18±0.01
14.41	14 : 1n-5	0.58±0.05	0.60±0.14	–
14.68	15 : 0 anteiso	–	0.05±0.00	–
15.00	15 : 0	0.51±0.01	0.49±0.06	0.87±0.01
15.38	15 : 1n-6	0.15±0.00	0.86±0.12	0.19±0.01
15.52	16 : 0 iso	0.08±0.02	0.18±0.04	–
16.00	16 : 0	23.5 ±0.24	21.7 ±0.81	14.2±0.17
16.16	16 : 1n-9	–	1.30±0.06	0.62±0.01
16.30	16 : 1n-7	2.54±0.01	5.76±0.13	4.90±0.02
16.41	16 : 1n-5	1.52±0.02	–	–
16.50	17 : 0 iso	–	0.42±0.05	0.85±0.01
16.68	17 : 0 anteiso	0.19±0.00	0.42±0.05	0.34±0.03
16.90	16 : 2n-4	0.11 ±0.01	0.68±0.11	1.03±0.04
17.00	17 : 0	0.24±0.00	2.05±0.02	1.32±0.01
17.18	16 : 3n-4	0.05±0.00	0.26±0.06	0.67±0.02
17.26	17 : 1n-8	0.11±0.01	0.54±0.03	–
17.36	16 : 3n-3	0.17±0.00	0.25±0.06	0.64±0.01
17.49	17 : 2n-8	–	0.03±0.04	0.19±0.01
17.58	16 : 4n-3	0.52±0.02	0.58±0.09	4.27±0.14
17.67	17 : 2	0.25±0.01	–	–
18.00	18 : 0	3.24±0.02	9.26±0.11	6.74±0.02
18.12	18 : 1n-11	0.82±0.02	0.36±0.02	1.15±0.14
18.21	18 : 1n-9	4.86±0.05	1.91±0.06	2.66±0.08
18.28	18 : 1n-7	2.86±0.04	4.47±0.15	5.16±0.09
18.47	18 : 1n-5	0.34±0.01	0.13±0.04	0.20±0.03
18.61	18 : 2n-7	0.94±0.01	0.22±0.11	0.17±0.01
18.68	18 : 2n-6	1.37±0.01	0.93±0.02	0.97±0.06
18.88	18 : 2n-4	0.16±0.00	0.46±0.04	0.15±0.02
18.97	18 : 3n-6	–	0.26±0.01	0.16±0.01
19.00	19 : 0	0.50±0.01	0.25±0.02	–
19.14	19 : 1+18 : 3n-4	–	–	0.47±0.00
19.32	18 : 3n-3	0.89±0.01	0.39±0.01	0.13±0.00
19.64	18 : 4n-3	1.95±0.02	0.87±0.02	0.28±0.01
19.67	18 : 4n-1	–	–	0.16±0.02
19.92	19 : 3n-6	0.93±0.01	0.32±0.00	3.92±0.15
20.10	20 : 1n-15+11	3.97±0.06	2.65±0.02	6.86±0.03
20.15	20 : 1n-9	5.58±0.03	2.77±0.08	–
20.23	20 : 1n-7	1.35±0.01	3.17±0.07	1.50±0.06
20.31	20 : 2NMID (Δ5, 11)	4.73±0.14	0.69±0.03	–
20.37	20 : 2NMID (Δ5, 13)	1.85±0.10	0.36±0.01	0.28±0.11
20.44	20 : 2NMID	1.44±0.00	–	0.53±0.02
20.61	20 : 2n-6	1.09±0.01	0.30±0.00	0.63±0.05
20.89	20 : 3n-6	0.51±0.04	0.15±0.09	–
21.12	20 : 4n-6	8.14±0.04	2.77±0.03	2.37±0.01
21.27	20 : 3n-3	1.11±0.00	–	–
21.52	20 : 4n-3	0.88±0.01	0.24±0.00	–
21.77	20 : 5n-3	8.08±0.03	10.5 ±0.19	20.5 ±0.07
22.08	22 : 1n-11	–	0.39±0.02	–
22.17	22 : 1n-9	2.74±0.06	0.56±0.04	0.22±0.06
22.27	22 : 2NMID (Δ7, 13)	0.11±0.01	1.94±0.05	2.78±0.09
22.35	22 : 2NMID (Δ7, 15)	0.33±0.11	5.47±0.26	1.55±0.02
22.76	21 : 5n-3	–	0.52±0.02	0.60±0.05
23.10	22 : 4n-6	–	–	0.85±0.04
23.69	22 : 5n-3	–	0.77±0.50	2.55±0.13
23.98	22 : 6n-3	–	5.58±0.08	2.73±0.11
Saturated acids		37.0	39.8	28.0
Monoenoic acids		27.4	25.5	23.9
Polyenoic acids		35.6	34.8	48.1

*1 The data are presented as the mean±standard deviation of three determinations

*2 ECL, equivalent chain length

Table 4. Fatty acid compositions of polar lipid in sea urchin gonad, ark shell and "Gaebul" *

(Area %)

Fatty acid	Gonad sea urchin	Ark shell	"Gaebul"
14 : 0	2.78±0.04	2.08±0.10	4.29±0.24
14 : 1n-5	–	0.13±0.03	–
15 : 0 iso	–	–	0.30±0.06
15 : 0 anteiso	–	0.50±0.00	–
15 : 0	0.26±0.03	0.63±0.03	1.13±0.03
16 : 0 iso	–	0.16±0.02	0.24±0.03
16 : 0	14.9 ±0.22	24.3 ±0.27	16.5 ±0.06
16 : 1n-9	0.24±0.01	–	0.50±0.01
16 : 1n-7	0.93±0.03	1.95±0.06	4.98±0.05
17 : 0 iso	0.61±0.05	0.56±0.01	0.79±0.02
17 : 0 anteiso	0.18±0.03	0.36±0.05	0.55±0.04
16 : 2n-4	0.09±0.02	–	1.01±0.02
17 : 0	0.26±0.01	3.13±0.04	1.41±0.03
16 : 3n-4	–	0.29±0.00	–
16 : 3n-3	–	1.19±0.02	0.29±0.01
16 : 3n-1	–	–	0.13±0.01
17 : 2n-8	–	0.25±0.00	0.20±0.01
16 : 4n-3	2.79±0.04	0.90±0.01	2.81±0.02
18 : 0	3.94±0.04	8.65±0.04	6.50±0.06
18 : 1n-11	1.52±0.02	0.21±0.00	–
18 : 1n-9	2.41±0.04	1.33±0.08	2.65±0.04
18 : 1n-7	2.68±0.01	3.70±0.05	6.18±0.11
18 : 1n-5	0.41±0.02	0.45±0.01	–
18 : 2n-7	0.56±0.01	–	0.17±0.01
18 : 2n-6	0.88±0.00	0.94±0.03	0.53±0.01
18 : 2n-4	–	0.28±0.01	0.17±0.01
19 : 0	0.53±0.01	0.84±0.02	0.32±0.01
19 : 1+18 : 3n-4	–	–	0.40±0.04
18 : 3n-3	0.24±0.01	0.25±0.01	0.13±0.03
18 : 4n-3	0.20±0.01	0.33±0.01	0.33±0.01
18 : 4n-1	–	–	0.15±0.02
19 : 3n-6	–	–	2.87±0.02
20 : 0	0.34±0.01	0.18±0.01	0.15±0.01
20 : 1n-15+11	4.94±0.07	3.18±0.04	5.59±0.05
20 : 1n-9	3.59±0.34	3.22±0.03	–
20 : 1n-7	0.83±0.37	2.62±0.06	1.71±0.03
20 : 2NMID(Δ5, 11)	6.49±0.15	1.60±0.04	0.28±0.01
20 : 2NMID(Δ5, 13)	2.49±0.19	0.42±0.03	0.27±0.02
20 : 2NMID	0.50±0.13	–	0.53±0.00
20 : 2n-6	1.48±0.03	0.53±0.13	0.29±0.01
20 : 3n-6	–	0.06±0.00	–
20 : 4n-6	19.8 ±0.28	4.43±0.05	2.60±0.10
20 : 3n-3	0.26±0.03	–	–
20 : 4n-3	0.22±0.09	0.33±0.09	–
20 : 5n-3	21.5 ±0.50	9.95±0.16	22.0 ±0.20
22 : 1n-11	–	–	0.18±0.11
22 : 1n-9	1.16±0.03	0.28±0.05	0.62±0.01
22 : 2NMID(Δ7, 13)	–	2.68±0.02	2.47±0.03
22 : 2NMID(Δ7, 15)	–	6.09±0.07	1.52±0.02
21 : 5n-3	–	0.43±0.09	0.54±0.04
22 : 4n-6	–	0.30±0.02	0.62±0.04
22 : 5n-3	–	1.15±0.05	2.52±0.07
22 : 6n-3	–	9.58±0.15	2.52±0.09
Saturated acids	23.8	40.8	32.4
Monoenoic acids	18.7	17.1	22.6
Polyenoic acids	57.5	42.2	44.9

*The data are presented as the mean±standard deviation of three determinations

Table 5. Fatty acid compositions of non-polar lipid in sea urchin gonad, ark shell and "Gaebul" *

(Area %)

Fatty acid	Gonad sea urchin	Ark shell	"Gaebul"
14 : 0	12.2 ±0.19	8.87±0.19	5.24±0.07
14 : 1n-5	0.69±0.01	–	–
15 : 0 iso	–	–	0.24±0.01
15 : 0	0.64±0.01	0.71±0.03	1.55±0.02
16 : 0 iso	–	0.12±0.04	0.29±0.01
16 : 0	25.9 ±0.23	29.6 ±0.21	26.1 ±0.13
16 : 1n-7	3.19±0.05	10.1 ±0.05	5.71±0.05
16 : 1n-5	2.20±0.05	–	–
17 : 0 iso	–	0.13±0.01	0.79±0.03
17 : 0 anteiso	0.16±0.01	0.31±0.03	0.79±0.03
16 : 2n-4	0.19±0.03	0.99±0.04	–
17 : 0	0.20±0.01	1.79±0.01	2.61±0.03
16 : 3n-3	0.14±0.01	1.03±0.02	0.38±0.01
16 : 3n-1	0.18±0.00	0.18±0.02	0.22±0.01
17 : 2n-8	–	0.15±0.02	0.29±0.02
16 : 4n-3	0.41±0.01	–	–
18 : 0	2.06±0.07	6.76±0.06	10.4 ±0.08
18 : 1n-11	0.52±0.01	0.33±0.01	0.26±0.01
18 : 1n-9	5.27±0.11	2.09±0.04	6.14±0.25
18 : 1n-7	3.24±0.01	5.78±0.05	9.41±0.16
18 : 1n-5	0.31±0.02	–	–
18 : 2n-7	1.03±0.02	0.16±0.00	0.18±0.01
18 : 2n-6	1.80±0.03	0.84±0.02	0.77±0.01
18 : 2n-4	–	0.52±0.01	–
19 : 0	0.73±0.01	0.81±0.01	1.48±0.01
19 : 1+18 : 3n-4	–	–	0.16±0.01
18 : 3n-3	1.30±0.00	0.46±0.01	0.22±0.01
18 : 4n-3	3.49±0.02	1.44±0.03	–
20 : 0	0.67±0.01	0.27±0.00	0.28±0.07
20 : 1n-15+11	2.27±0.04	1.15±0.02	6.11 ±0.10
20 : 1n-9	4.78±0.00	1.72±0.04	–
20 : 1n-7	1.23±0.00	3.30±0.08	7.93±0.10
20 : 2NMID(Δ5, 11)	3.39±0.06	1.03±0.00	–
20 : 2NMID(Δ5, 13)	1.58±0.05	0.52±0.03	–
20 : 2NMID	1.23±0.01	–	–
20 : 2n-6	0.95±0.02	0.38±0.00	0.73±0.02
20 : 3n-6	0.49±0.02	–	–
20 : 4n-6	5.97±0.09	1.92±0.02	0.72±0.03
20 : 3n-3	1.10±0.03	–	–
20 : 4n-3	1.06±0.07	–	–
20 : 5n-3	7.57±0.17	12.7 ±0.29	3.92±0.06
22 : 1n-9	1.82±0.05	–	–
22 : 2NMID(Δ7, 13)	–	–	0.77±0.13
22 : 2NMID(Δ7, 15)	–	0.84±0.02	0.29±0.22
21 : 5n-3	–	0.14±0.14	–
22 : 5n-3	–	–	5.28±0.07
22 : 6n-3	–	2.83±0.05	0.79±0.04
Saturated acids	43.0	49.4	49.5
Monoenoic acids	25.5	24.5	35.7
Polyenoic acids	31.9	26.1	14.8

*The data are presented as the mean±standard deviation of three determinations

same species. No available information on the class compositions of "Gaebul" and ark shell have been found so far.

Fatty acid compositions of TL, PL and NL

The fatty acid compositions of the TL of three species of marine invertebrates are shown in Table 3. The number of identified fatty acids were 43 in the sea urchin, 49 in the ark shell and 44 in the "Gaebul", respectively. The prominent fatty acids were 16 : 0, 14 : 0, 20 : 4n-6, 20 : 5n-3 and 20 : 1n-9 in the sea urchin, 16 : 0, 20 : 5n-3, 18 : 0, 16 : 1n-7, 22 : 6n-3 and 22 : 2 NMID (Δ7,15) in the ark shell, and 20 : 5n-3, 16 : 0, 20 : 1n-9, 18 : 0 and 18 : 1n-7 in the "Gaebul", respectively. The percentages of polyenoic acids in the TL were the highest in the "Gaebul" and the lowest in the ark shell. However, the percentage of 22 : 6n-3 in the ark shell was 5.58%, the highest level in the three invertebrates, and no detection in the sea urchin. On the other hand, in the TL of the sea urchin, 20 : 4n-6, one of the important prostaglandin-precursors, was identified as one of the major fatty acids (8.14%) in the TL of the gonad of sea urchin, but the fatty acid was found as a minor fatty acid in the ark shell and the "Gaebul". Therefore, these results indicate that the diet of the invertebrates is different from each other. In general, sea urchin is a seaweed feeder, while ark shell and "Gaebul" are plankton feeders, and these animals ingest the decomposed materials of plants or animals sedimented at the bottom of the sea as nutrients. In fact, sea urchin was rich in 20 : 4n-6 and 20 : 5n-3 but poor in 22 : 6n-3. These distributions of the polyunsaturated fatty acids are very similar to those of seaweeds, *Undaria pinnatifida and Laminaria japonica*, the main diet of sea urchin[6,20]. Accordingly, this indicates that certain fatty acid compositions of the sea urchin are related to those of its diet. The NMID fatty acids were commonly found in the three invertebrates. The content of 20 : 2 NMID (Δ5,11) was rich in the sea urchin and that of 22 : 2 NMID (Δ7,15) rich in the ark shell. The biosynthetic pathways of the NMIDs were first suggested by Ackman and Hooper[21]. That is, 18 : 1n-7 and 18 : 1n-9 could be formed as the chain elongation products of 20 : 1n-7 (Δ13) and 20 : 1n-9 (Δ11), and then the two geometric isomers of 20-carbon NMIDs were biosynthesized from 20-carbon monoenes by desaturation of the 5-6 carbon bond ; 22-carbon NMIDs could then be formed by a 2-carbon chain elongation. Therefore, the content of 18 : 1n-9, a precursor of 20 : 2 NMID (Δ5,11), was relatively rich (4.73%) in the TL of the ark shell. The fatty acid composition of the TL in the sea urchin was similar to the results of Jeong[8] and Itabashi and Takagi[6] and Takagi et al.[7]. This study for the fatty acid compositions of the ark shell and "Gaebul" is the first such comprehensive study.

Table 4 shows the fatty acid compositions of the PL in the three invertebrate species. The prominent fatty acids of PL were similar to those of TL, but the percentages of polyenoic acids such as 20 : 5n-3, 22 : 6n-3 and 20 : 4n-6 were higher than those of TL. In the case of the sea urchin, the percentages of 20 : 5n-3 and 20 : 4n-6 in PL were more than twice those in TL. This indicates that the molecular species of PL such as phosphatidylcholine, phosphatidylethanolamine, etc mainly consisted of polyunsaturated fatty chains.

On the other hand, the percentages of saturated fatty acids of the NL in all the three invertebrates were higher when compared with those of TL and PL, respectively (Table 5). In the case of the ark shell, the percentage of 14 : 0 was higher in the NL (8.87%) than in TL (4.33%), and that of 16 : 0 was higher in the former (29.6%) than in the latter (21.7%). Therefore, this indicates that NL (mainly TG) is rich in the molecular species having the short and saturated fatty acid chains.

Consequently, these three invertebrates were rich in polyunsaturated fatty acids such as 20 : 5n-3, especially in the "Gaebul" that is one of the important invertebrates as a marine food in Korea. These differences in fatty acid compositions among the three marine invertebrates were considered to be due to their food habit and environmental conditions.

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3종의 해산 무척추동물의 지방산 조성

정보영† · 문수경 · 정우건*
통영수산전문대학 식품영양과
*통영수산전문대학 양식과

요 약

성게알, 피조개 및 개불의 총지질(TL)함량은 각각 6.10%, 0.67% 및 0.79%였으며, TL중 인지질(PL)은 성게알(56.2%)보다 개불(72.4%) 및 피조개(64.9%)에 많았다. PL의 주요지질인 포스타티딜콜린(PC)는 성게알(56.2%)에, 그리고 포스파티딜에탄올아민(PE)는 개불(34.4%)에 많았다. 비극성지질의 경우, 성게알은 트리그리세리드(TG, 89.0%)가, 피조개는 TG(69.2%) 및 유리스테롤(ST, 26.8%)이, 그리고 개불은 ST(70.7%)이 각각 주 성분이었다. 성게알의 주요지방산은 16 : 0, 14 : 0, 20 : 5n-3, 20 : n-6 및 20 : 2NMID(non-methylene interrupted diene)였으며, 20 : 4n-6는 PL의 지방산 조성중 19.8%로써 3종 무척추동물중 가장 높은 함량을 나타냈다. 그러나 22 : 6n-3는 성게알 지질에서는 검출되지 않았다. 피조개의 경우는 16 : 0, 18 : 0, 20 : 5n-3, 22 : 2NMID가 주요지방산이었으며, 특히 22 : 6n-3가 다른 무척추동물의 경우보다 많았다. 한편, 개불의 주요지방산은 20 : 5n-3, 16 : 0, 18 : 0, 20 : 1n-9, 16 : 1n-7 및 14 : 0였으며, 이중 20 : 5n-3, 16 : 0, 18 : 0, 20 : 1n-9, 16 : 1n-7 및 14 : 0였으며, 이중 20 : 5n-3는 PL에서 22.0%를 타나내어 3종 무척추동물중 가장 높은 함량을 보였다. 이들 3종 해산 무척추동물의 지질조성에서의 차이는 그들의 식습관 및 환경조건의 차이에 의한 것으로 생각되었다.