KOREAN J. FOOD SCI. TECHNOL.
Vol. 20, No. 5, pp 674~682(1988)

Lipid Composition of Roe, Muscle and Viscus of *Liza Carinata*, a Species of the *Mugilidae* Family

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Abstract

Total lipids from the roe, muscle and viscus of *L. carinata* were analyzed for lipid composition by column chromatography, thin-layer chromatography and gas-liquid chromatography. The roe lipids were characterized by a high level of wax esters (63.1%) and a low proportion of trigiycerides (9.9%). The viscus lipids also contained wax esters (32.8%) as its main component, followed by free fatty alcohols and acids (23.5%). On the other hand, the muscle lipids were found to contain a large amount of triglycerides (66.1%) with a trace of wax esters. The main fatty alcohol component of roe and viscus wax esters was C16:0 alcohol (53.0%; 61.7%), accompanied by C18:1 alcohol (10.2%) in the former and by C15:0 alcohol (8.8%) in the latter. Considerable amounts of odd-numbered fatty alcohols were found in both wax esters. On the other hand, the fatty acids of the roe and viscus wax esters contained a high percentage of monounsaturated (49.7%-56.6%) consisting of C16:1, C18:1 and C17:1 acid, and a significant amount of polyunsaturated (41.2%-32.9%), particularly C20:5ω3. The fatty acid components of triglycerides and phospholipids were different among the tissues tested, especially between roe and muscle or viscus. The fatty acid compositions of free fatty acids from the muscle and viscus were characterized by a higher level of polyunsaturated fatty acids (46.0%-34.3%) compared to those of triglycerides in the roe, muscle and viscus (28.4%, 19.4% and 19.2%).

Key words: *Liza carinata*, wax ester, roe, *Mugilidae family*

Introduction

Triglycerides are generally accumulated in the tissues of marine animals as an energy reserve[1]. For this purpose, however, wax esters are stored in the muscles or livers for some fishes such as castor oil fishes(*Lepidocybium flavobrunneum*[2], *Ruvettus pretiosus*[2,3]), lantern fishes[4](*Stenobrachius leucopsarus, Triphoturus mexicanus, Lampanyctus ritteri*), and deep-sea teleosts(*Hoplostethus atlanticus*[5], *H. gilchristi*[5], *Laemonema longipes*[7] and *Lotella phycis*[8]).

On the other hand, some fishes such as mullet[9-12], *Mugil cephalus*, croaker[11], *Cynoscion nebulosus*, gourmi[13], *Trichogaster cosby*, and stock fish[9], *Merluccius capensis*, possess large amounts of wax esters in the roe lipids.

Liza carinata[14] belongs to the family *Mugilidae* and migrates to the river for spawning in the springtime, as does mullet, but it differs from mullet, particularly in its size (Fig. 1).

This fish is very popular in the southeastern part of Korea, especially in Pusan. However, according to fishermen, the roe of *L. carinata* can not be easily digested and often causes fatty diarrhea in humans when ingested in quantity.

These facts are interesting from the viewpoint of chemotaxonomy and comparative biochemistry and are also of concern to the food hygienists.

In this paper, the authors report the results of fractionation of the lipids of roe, muscle and viscus of *L. carinata*, and analyses of fatty acid or alcohol constituents of wax esters, triglycerides, free fatty acids and phospholipids of the lipids from both the tissues.

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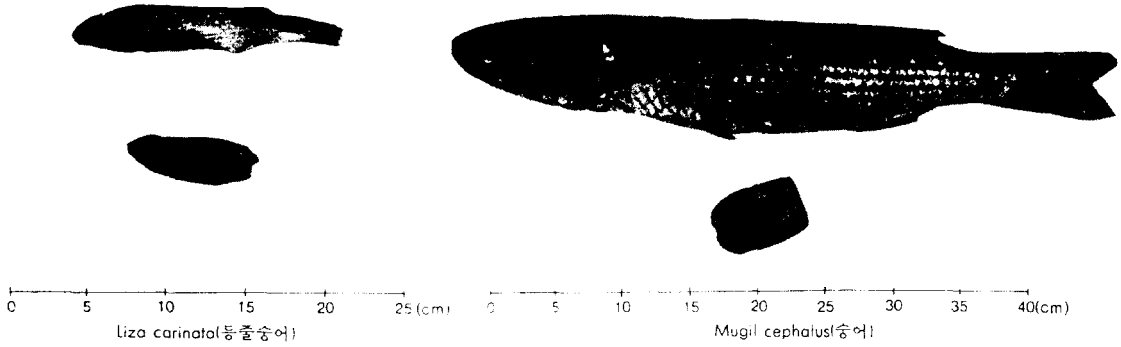

Fig. 1. Photographs of *Liza carinata* its roe (left), and *Mugil cephalus* & its roe (right).

Materials and Methods

Materials

L. carinata pregnant with roe was caught at Jang-Mock Bay, Goh-Je County, Kyeng Nam Province, Korea, on May 27, 1987, and was kept frozen for five days before use. This fish was about 24.7cm long, weighed 126.4g, and had roe weighing 75.9g.

All solvents were of extra pure grade(Oriental Chemical Industry Co., Ltd., Seoul, Korea) and were redistilled before use. 10% BF_3-methanol was obtained from Fluka A.G.(CH-9470 BUCHS, packed in Switzerland). Standard fatty acid methyl esters of C14:0, C15:0, C16:0, C16:1ω6, C16:2ω4, C17:0, C17:1ω8, C18:0, C18:1ω9, C18:2ω6, C18:3ω6, C18:3ω3, C19:0, C19:1ω9, C19:2ω6, C20:1ω9, C20:2ω6, C20:3ω6, C20:4ω6, C20:5ω3, C22:4ω3, C22:5ω3 and C22:6ω3, and standard alcohols, C14:0, C15:0, C16:0, C16:1ω7, C17:0, C18:0, C18:1ω9, C19:0 and C20:0, were purchased from Nu Check Pre., Inc.(Elysian, Minnesota, U.S.A.).

Total Lipid Extraction

Total lipids were extracted from the roe, muscle and viscera(all the internal organs without roe) of *L. carinata* with a mixture of chloroform-methanol (2:1, v/v) in a Waring Blendor following the procedure of Bligh and Dyer[15].

Analytical TLC plates coated with silica gel 60 F254 (20×20 cm, thickness 0.2 mm, E. Merck, Darmstadt, West Germany) were used for the qualitatively and quantitatively assay of the fractions of interest. The lipid classes were quantitatively fractionated by silicic acid column chromatography[16]; a small amount of total lipids (216.4-220.6 mg) was chromatographed on a column(1.8×32 cm) filled with silica gel 60 (70-230 mesh, 25g, E. Merck, Darmstadt, West Germany) with hexane, 2, 7 and 13% diethyl ether in hexane, then diethyl ether, 25, 50% chloroform in methanol(v/v), and eventually methanol, in order of increasing polarity.

In order to separate wax esters from sterol esters, the fraction eluted from a silicic acid column in the solvent of 2% diethyl ehter in hexane was rechromatographed on TLC with a mixture of hexane:benzene (6:4, v/v). The separated spots on TLC[28,29] were quantified by a Shimadzu dual wave length TLC scanner (CS-910), after they were charred with 50% $K_2Cr_2O_7$-H_2SO_4 solution and were rendered transparent by soaking them in liquid paraffin. The operating conditions were as follows: wave length, 35*n*m; slit height, 1.25mm;

scanning method, reflection zig zag by single -wave length.

For the purpose of identification and resolution of unknown and tailing peaks on gas-liquid chromatography(GLC), fatty acid methyl esters were further classified into subfractions on a silicic acid column impregnated with 20% silver nitrate[17,18] by solvents of hexane-benzene with increasing the ratio of benzene to hexane. The subfractions obtained were hydrogenated and analyzed on GLC.

Hydrogenation

A portion of fatty acid methyl esters was dissolved in hexane, including 5% palladium-charcoal catalyst, and was hydrogenated at room temperature and under atmospheric pressure for 4 hours.

Preparation of Fatty Acid Methyl Esters and Fatty Alcohol Acetates

Portions of wax esters, triglycerides and phospholipids were saponified with a mixture of 10% KOH-ethanol in a hot water bath for 20 minutes (in the case of wax esters, for 40 minutes), with a trace amount of BHA as an antioxidant. Fatty acids were methylated following the method of Metcalfe[19]. Alcohols purely isolated from the unsaponifiables of wax esters were acetylated overnight in a mixture of pyridine-acetic anhydride (1:1, v/v) in a refrigerator.

GLC of Fatty Acid Methyl Esters and Fatty Alcohol Acetates[20,21]

Fatty acid methyl esters and fatty alcohol acetates were analyzed under the same conditions, i. e., the instrument used was a Shimadzu GC-7A equipped with a hydrogen flame ionization detector and with 3mm×3m coiled packed with 15% diethylene glycol succinate on Neopak 1A (60/70 mesh, Nishio Industrial Co., Ltd., Tokyo, Japan). The column was operated at 190°C with a gas flow 35m/min. of nitrogen through the column. The detector and injection port temperature was maintained at 240°C. Peaks on GLC were identified by comparison with a mixture of methyl esters or alcohol acetates of standard fatty acids or fatty alcohols and by the equivalent chain length[22] calculated from a semilogarithmic plot of retention time versus chain length. Area percentage was recorded on a Shimadzu Chromatopac C-E 1B.

Results and Discussion

Yield and Composition of Lipids

The yield and composition of lipids extracted from roe, muscle and viscus of *L. carinata* are shown in Table 1 and Fig. 2. The lipid levels amounted to 18.5% in the roe, 8.5% in the viscus and 4.4% in the muscle. The lipids greatly vary with the tissues of *L. carinata* not only in amount but also in composition.

In TLC the roe and viscus lipids revealed one distinct spot corresponding to wax esters, and three other spots at the same Rf values of triglycerides, free fatty alcohols and acids, and sterols. It is noteworthy that the roe and viscus lipids contain high levels of wax esters, 63.1%, 32.8%, respectively. A considerable amount of free fatty alcohols and acids (23.5%) in the lipids of viscus are likely to be result from hydrolysis of the lipid components by lipases during storage. In contrast, the muscle lipids showed three main spots of triglycerides, free fatty alcohols and acids, and sterols, but they did not have a recognizable wax esters spot on TLC. The muscle lipids included triglycerides (66.1%) as a major component, accompanied by sterols (14.0%) and phospholipids (13.5%). This result is in strong contrast with those of roe or viscus lipids.

Detailed Composition of Lipids

Fatty Alcohol

The fatty alcohol components of wax esters in

Table 1. Yields and class compositions of total lipids from roe, muscle and viscus of *Liza carinata*

Tissue weight (g) / Lipid yield (%)			Roe 75.9 / 18.5		Muscle 13.6 / 4.4		Viscus# 6.9 / 8.5	
Lipid component*	Solvent	Volume (ml)	mg	%	mg	%	mg	%
Hydrocarbons	Hexane	100	1.0	0.4	0.7	0.3	0.4	0.2
Sterol esters	2% D.-H.***	400	tr.		11.2	5.2	18.2	8.7**
Wax esters			132.3	63.1	tr.		68.6	32.8
Triglycerides	7% D.-H.	300	20.7	9.9	142.5	66.1	27.2	13.0
Free fatty alcohol & acid	13% D. H.	300	4.0	1.9	1.9	0.9	49.2	23.5
Sterols	Diethyl ether	300	16.7	8.0	30.2	14.0	14.9	7.1
	25% $CHCl_3$-CH_3OH	200						
Phospholipids	50% $CHCl_3$-CH_3OH	200	34.9	16.7	29.2	13.5	30.8	14.7
	CH_3OH	250						

* : 216.4mg (roe lipids), 220.6mg (muscle lipids) and 219.9mg (viscus lipids) were mounted on a silica gel column (25g, Kiesel gel 60, particle size, 70-230 mesh, E. Merck, column size, 1.8×32cm), respectively.

** : Rechromatographed on TLC with a mixture of hexane:benzene (6:4, v/v), and quantified by TLC scanner after TLC plate charring.

*** : Diethyl ether in hexane (v/v)

#: All the internal organs without roe

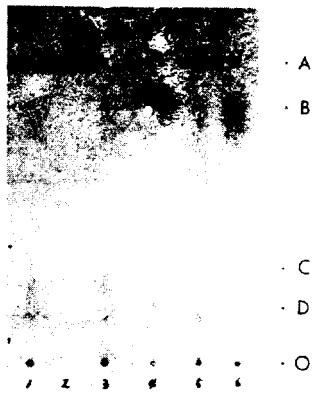

Fig. 2. Thin-Layer Chromatograms of the Lipids of Roe, Viscus and Muscle of *L. carinata*.
Adsorbent: Silica gel 60 F_{254} (0.2mm thickness, coated on 20×20cm alumina plate
Developing solvent: n-Hexane/diethyl ether (80/20, v/v)
A: Wax ester, B: Triglyceride, C: Free fatty alcohol and acid, D: Sterol, O: Origin
1. L. carinata roe lipid, 2. Cetyl palmitate, 3. Pollack roe oil, 4. Sesame oil, 5. *L. carinata* viscus lipid, 6. *L. carinata* muscle lipid

the lipids of roe and viscus of *L. carinata* are shown in Table 2. They are not nearly so diverse as the fatty acid, and did not contain long carbon chain (C22 and C24) and polyunsaturated fatty alcohols; the prevailing components are C16:0, C18:0, C15:0 and C14:0 alcohol for the saturated, and C18:1 and C16:1 alcohol for the monounsaturated fatty alcohols. Significant amounts of medium odd-numbered carbon chain fatty alcohols are also present.

C16:0 alcohol is the main component in the fatty alcohol moieties of wax esters of the roe and viscus, 53.0% and 61.7%, respectively. It is followed by C18:1 alcohol (10.2%), C18:0 alcohol (8.3%) and C16:1 alcohol (8.3%) in the roe wax esters, and C15:0 alcohol (8.8%), C18:0 alcohol (8.0%) and C14:0 alcohol (7.5%) in the viscus wax esters.

The ratios of C16:0 to C18:1 alcohol in the roe and viscus wax esters are 5.2 and 16.2. These values are higher compared to those of castor oil fish wax esters, 1.4-1.6[2], and to those of ovary wax esters of *Stromateus maculatus* and *Centrolophus* sp., 2.1-3.0[23], but the value for the roe wax

Table 2. Fatty alcohol composition of wax esters in roe and viscus of *Liza carinata*(area % as acetate)

Fatty alcohol	Roe	Viscus
C14:0	5.6	7.5
1	0.1	tr.*
C15:0	7.0	8.8
1	0.3	0.3
C16:0	53.0	61.7
1	8.3	4.7
C17:0	2.2	2.2
1	2.7	1.1
C18:0	8.3	8.0
1	10.2	3.8
C19:0	0.3	0.1
1	1.1	0.5
C20:0	0.7	1.4
1	0.1	tr.
Saturated	77.1	89.7
Monounsaturated	22.8	10.4
Even-numbered	86.3	87.1
Odd-numbered	13.6	13.0

* below 0.1%

esters is rather lower than those of roe wax esters of stock fish and mullet, 6.4[9] and 8.4-9.0[9-12].

Fatty Acid

Roe:

Fatty acid compositions of lipid classes from the roe lipids are given in Table 3. It appears that there are pronounced differences between fatty acids of the lipid classes of *L. carinata* roe.

Fatty acid compositions of wax esters and triglycerides of the roe lipids are characterized by a high level of monounsaturated fatty acids. In wax esters, C16:1 acid is the predominant component (21.4%), followed by C18:1 acid (17.9%) and C20:5ω3 acid (12.2%). In triglycerides, C16:1 and C16:0 acids are present as major components in equal amount (17.5%, 17.1%), with C18:1 acid (14.5%) the most abundant. On the other hand, fatty acids of phospholipids are specified by predominance of polyunsaturated fatty acids such as C20:5ω3 (18.1%), C22:6ω3 (11.9%) and C22:5ω3 (4.7%), although C16:0 and C18:1 acids are still the major components (18.5% and 10.3%).

Table 3. Fatty acid composition of the lipids of *Liza carinata* roe(area % as methyl ester)

Fatty acid	ECL*	Wax ester	Triglyceride	Phospho
C14:0		2.1	4.9	1.1
1		0.4	0.6	0.1
C15:0		0.9	4.0	1.2
1		1.0	1.5	0.4
C16:0		2.8	17.1	18.5
1		21.4	17.5	9.2
2		0.3	0.8	-
3		0.2	0.9	0.7
C17:0		0.2	1.2	1.1
1		7.1	5.5	2.5
3 ω ?	18.4	2.7	2.2	0.9
C18:0		3.0	3.0	7.0
1		17.9	14.5	10.3
2 ω 6		1.6	1.0	0.5
3 ω 6		0.7	0.8	0.1
3 ω 3		0.6	0.2	0.1
4 ω 3		3.2	2.0	0.9
C19:1		1.1	0.9	0.5
2 ω ?	20.1	1.0	0.8	0.2
4 ω ?	20.6	2.3	1.1	3.1
C20:1		0.8	0.8	0.3
3 ω 6		0.4	0.1	0.1
4 ω 6		1.9	0.4	2.7
4 ω 3		2.1	0.8	0.6
5 ω 3		12.2	4.8	18.1
C21:4 ω ?	22.4	0.6	0.4	0.6
5 ω 5		0.7	0.8	0.9
C22:4 ω 3		0.7	0.7	0.7
5 ω 6		0.3	1.1	0.9
5 ω 3		5.2	4.8	4.7
6 ω 3		4.5	4.7	11.9
Saturated		9.0	30.2	28.9
Monounsaturated		49.7	41.3	23.3
Polyunsaturated		41.2	28.4	47.7
Even-numbered		82.3	81.5	88.5
Odd-numbered		17.6	18.4	11.4

* Equivalent chain length

In the wax esters the ratio of C16:1 to C18:1 acid is 1.2. This value is rather close to those of mullet roe wax esters, 1.3-2.1[9-12], and to that of spermaceti wax esters of sperm whale, 0.7-2.0[24], but is very higher compared to 0.0-0.56 of wax esters in roe[9,13], muscle[2-6], liver[7] and other organs[23] of marine animals.

The fatty acids of longer chains such as C20:5ω3 acid and C22:6ω3 acid in the phospholipids are more abundant than in triglycerides, while C14:0 acid and C16:1 acid are much less. The levels of

odd-numbered chain fatty acids in wax esters and triglycerides are much higher compared to that in phospholipids.

Muscle:

Fatty acid compositions of triglycerides, free fatty acids and phospholipids of the muscle are presented in Table 4. Triglycerides contained a significantly high proportion of monounsaturated fatty acids(45.2%), such as C16:1 acid and C18:1 acid, compared to free fatty acid or phospholipids. Fatty acid moieties of triglycerides are characterized by predominance of C16:1 acid (23.1%) and C16:0 acid (20.6%), followed by C18:1 acid (14.9%), C14:0 acid (7.4%) and C20:5ω3 acid (6.6%).

In contrast, free fatty acids and phospholipids included significantly higher levels of polyunsaturated fatty acids (46.0-50.3%) such as C20:5ω3, C22:6ω3 and C22:5ω3 acid. It is of interest that polyunsaturated fatty acids are excessively present in free fatty acids. This result seems to be attributable to preponderant enzymatic hydrolysis of phospholipids over triglycerides[30].

Viscus:

Fatty acid profiles of lipid classes from the viscus are shown in Table 5. In the wax esters, C16:1 acid predominated(31.8%), followed by C18:1 acid(14.7%) and C20:5ω3(10.1%). The fatty acid composition of wax esters in the viscus is somewhat different from that in the roe; the former contains more medium chain fatty acids such as C14:0, C16:0 acid than does the latter, while much less of polyunsaturated fatty acids, such as C20:5ω3, C22:5ω3 and C22:6ω3 acid.

Fatty acid moeties of the triglycerides predominate C16:0 acid (22.3%) and C16:1 acid (21.4%), followed by C18:1 acid (15.0%), C14:0 acid (6.8%) and C20:5ω3 acid (5.0%). The fatty acid profile is in agreement with that of muscle triglycerides characterized by significantly high levels of medium chain fatty acids such as C14:0, C16:0 and C16:1 acid, and by low content of polyunsaturated fatty acids above carbon chain 20.

Fig. 4. Fatty acid composition of the lipids of *Liza carinata* musclelarea % as methyl ester)

Fatty acid	ECL*	Triglyceride	Free fatty acid	Phospholipid
C14:0		7.4	2.0	3.0
1		0.3	0.1	-
C15:0		2.4	1.1	0.8
1		0.7	0.2	0.5
C16:0		20.6	19.5	10.8
1		23.1	8.6	7.4
2		0.1	0.2	0.4
3		0.5	0.1	0.5
C17:0		0.1	0.6	0.7
1		4.9	2.2	2.0
3	18.4	1.7	0.9	0.8
C18:0		4.8	7.7	11.3
1		14.9	10.9	12.2
2 ω 6		0.9	0.7	0.5
3 ω 6		0.6	0.2	0.1
3 ω 3		0.3	0.2	0.2
4 ω 3		1.6	1.1	0.6
C19:1		0.6	0.5	0.4
2 ω ?	20.1	0.5	0.3	0.3
4 ω ?	20.6	0.7	1.5	1.3
C20:1		0.7	0.5	0.6
3 ω 6		0.2	0.2	0.3
4 ω 6		0.9	3.1	4.8
4 ω 3		0.3	0.9	0.8
5 ω 3		6.6	17.6	12.2
C21:5 ω 5		0.9	1.0	1.0
C22:4 ω 3		0.1	0.3	0.3
5 ω 6		0.2	0.9	1.2
5 ω 3		2.0	7.5	8.5
6 ω 3		1.3	9.3	16.4
Saturated		35.3	30.9	26.6
Monounsaturated		45.2	23.0	23.1
Polyunsaturated		19.4	46.0	50.3
Even-numbered		87.3	91.6	92.1
Odd-numbered		12.5	8.3	7.8

* Equivalent chain length

Fatty acid composition of the free fatty acids is characterized by a higher level of C18:0 acid (12.3%), compared to those of the wax esters (2.4%) and triglycerides (4.0%) in the viscus, although C16:0 acid (19.0%) and C18:1 acid (17.3%) are still major components. On the other hand, the fatty acid composition of phospholipids from the viscus constitutes 45.0% of saturated fatty acids chiefly composed of C16:0 acid (25.9%) and C18:0 acid (12.7%), and is in striking contrast with those of roe and muscle (28.9% and 26.0%).

Wax esters[25] are much more difficult to digest and absorb than triglycerides. Recently Sato and Tsuchiya[26,27] reported that rats weighing 50g

Table 5. Fatty acid composition of the lipids of *Liza carinata* visc. s (area % as methyl ester)

Fatty acid	ECL*	Wax ester	Triglyceride	Free fatty acid	Phospholipid
C14:0		3.3	6.8	1.4	3.4
1		0.4	0.1	0.1	
C15:0		0.9	3.1	1.2	1.9
1		.2	0.8	0.2	1.1
C16:0		3.1	22.3	19.0	25.9
1		31.8	21.4	8.6	7.3
2		-	0.2	-	0.3
3		0.5	0.5	0.1	0.2
C17:0		0.7	1.0	1.7	1.1
1		7.1	4.7	2.3	1.9
3 ω ?	18.4	2.7	1.7	0.2	0.5
C18:0		2.4	4.0	12.3	12.7
1		14.7	15.0	17.3	9.5
2 ω 6		1.4	1.0	0.1	0.3
3 ω 6		0.5	0.5	0.1	0.1
3 ω 3		0.	0.3	0.2	0.4
4 ω 3		4.0	1.4	0.9	0.9
C19:1		0.6	0.7	0.5	0.3
2 ω	20.1	0.7	0.4	0.2	
4 ω ?	20.6	2.0	0.5	2.0	2.2
C20:1		0.8	0.9	1.1	0.7
3 ω 6		0.2	0.1	0.6	0.2
4 ω 3		1.0	0.7	3.1	2.3
4 ω 3		1.3	1.0	1.0	0.5
5 ω 3		10.1	5.0	9.7	12.0
C21:4 ω ?	22.4	0.6		1	
5 ω 6		0.5	0.5	0.3	0.1
C2[illegible]		0.2	0.1	1.0	0.4
5 [illegible]		0.2	0.3	2.1	1.4
5 ω 3		3.2	2.9	6.5	3.5
6 ω 3		3.4	2.1	5.1	2.7
Saturated		10.4	37.2	35.6	45.0
Monounsaturated		56.6	43.6	30.1	20.8
Polyunsaturated		32.9	19.2	34.3	34.2
Even numbered		83.0	86.5	90.3	90.3
Odd-numbered		17.0	13.4	9.7	9.7

* Equivalent chain length

presented the symptoms of seborrhea, secreting fatty matter at a level of 1% of sperm whale oil corresponding to 0.5% wax ester to body weight, after 20 days of the administration, and they further observed that rats fed with a diet containing 10% octadecenyl oleate(oleyl oleate) had abnormal scour for several successive days from the third or fourth day of the experiment, and the.. they became soiled with the fatty excrements and eventually died.

However, further studies are necessary to clarify whether the wax esters of *L. carinata* roe are responsible for the occurrence of fatty diarrhea from ingestion of it.

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(1988년 9월 13일 접수)

등줄숭어의 알, 근육 및 내장의 지질조성에 관한 연구

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등줄숭어의 알, 근육 및 내장 지질의 지질 조성과 각 지질 분획의 알콜 및 지방산 조성을 조사하였다. 지질 함량은 알에 18.5%로 제일 많았고, 내장에는 8.5%, 근육에는 4.4%로 제일 적었다. 알의 지질 조성은 매우 특이하여 왁스 에스텔이 63.1%로 제일 많았으나, 트리글리세리드는 9.9%에 지나지 않았다. 이에 반하여 근육 지질의 경우는 트리글리세리드가 66.1%로 제일 많이 검출되었으나, 왁스 에스텔은 거의 존재하지 않았다. 내장 지질에도 왁스 에스텔이 32.8%나 검출되었다. 알콜 조성을 보면 세칠알콜(C16 : 0)이 알과 내장 왁스 에스텔의 중요한 성분으로 각각 53.0%, 61.7% 였으며, 그 다음으로 주요한 알콜은 알의 경우는 올레알콜(C18 : 1), 팔미토올레

알콜(C16 : 1) 및 스테아르알콜(C18 : 0)이, 내장의 경우는 펜타데카놀(C15 : 0), 스테아르알콜 이였다. 또 두 왁스 에스텔에는 C15 : 0, C15 : 1, C17 : 0, C17 : 1, C19 : 0 및 C19 : 1과 같은 기수 알콜도 상당량 함유되어 있었다. 알과 내장의 왁스 에스텔의 지방산 조성은 팔미토올레산, 올레산 및 헵타데카모노엔산과 같은 모노엔산이(49.7-56.6%)로 제일 많았으며 아이코 사펜타엔산도 상당히 함유(12.2%, 10.1%)되어 있었다. 또 알의 트리글리세리드의 지방산 조성을 보면 고도 불포화지방산 함량(28.4%)은 근육, 내장의 그것보다(19.4%, 19.2%) 보다 훨씬 높았으나, 스테아르산, 팔미트산과 같은 포화지방산 함량은 근육, 내장의 그것보다 약간 낮았다. 알의 인지질의 지방산 조성은 근육의 그것과 비슷하여 고도 불포화지방산이 약 50%로 내장의 34.2% 보다 훨씬 높았다. 근육에 있어서 유리지방산 조성이 인지질의 지방산 조성과 흡사한 것으로 보아, 이 유리지방산은 인지질의 가수분해물로 생각된다.