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Seasonal Variations in Lipids and Fatty Acids of Japanese Anchovy, *Engraulis japonica*

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Abstract

The lipids and fatty acids in the tissues of Japanese anchovy, *Engraulis japonica*, were studied. Samples were harvested between June and December for adult anchovy, and between August and December for young anchovy, in 1972 from the coast near Hakodate, Japan.

The lipid contents in the tissues of adult samples varied from 1.3–10.7% for the flesh and from 2.6–26.1% for the viscera during the sampling period. Similar results were found for young fish, 0.9–2.4% for the flesh and 1.8–10.0% for the viscera. The contents of non-polar lipids, consisted mainly of triglycerides, varied with triglyceride contents, and accordingly, that of total lipids.

The iodine values of non-polar lipids for the flesh and viscera of adult samples changed from 161.7 to 187.0 and from 155.0 to 211.3, respectively, showing high levels of iodine values in both tissues when its lipid contents were comparatively low.

The contents of each fatty acid component in non-polar lipids from both adult and young samples fluctuated during the sampling season. The predominant fatty acids found were 16:0, 14:0 and 18:0 acids for saturates, 18:1, 16:1 and 20:1 acids for monoenes, and 20:5, 22:6 and 20:4 acids for polyenes with C_{16} acids most predominant. Coefficients of variation in the saturates were relatively lower than those in monoenes and polyenes. The contents of monoenes were similar to the variation in the lipid contents, and those of polyenes changed in contrast for the non-polar lipids of the flesh of adult fish.

The seasonal variation in lipid contents of adult anchovy seemed to be due mainly to differences in dietary intake rather than the metabolism during the spawning season, even with young immature fish. The monoenes, 18:1 and 16:1 acids in the fatty acid components, were selectively utilized rather than polyenes. This resulted in a decreased level of the monoenes during the season of food scarcity.

Introduction

The chemical compositions of fish are known to vary with the season in addition to the differences in individual, age, sex, and body parts. A marked variation is usually shown for the lipid contents to decrease during the spawning period. A decrease in flesh lipids during the spawning season coincides with gonad being maturation and utilization of the flesh lipids. Deng *et al.*[1] have reported that the time of the highest lipid content of mullet, *Mugil cephalus*, coincided with the pre-spawning period. DeWitt[2] has observed that the lipid in the liver of cod, *Gadus callarias*, was at the lowest level after spawning.

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Changes in lipid contents of fish are related to increasing and decreasing periods of the water temperature. Shimizu *et al.*[3] reported that the seasonal variation in the lipid level seemed to the result of seasonal fluctuation of water temperature and/or food intake of the fish. Lovern[4] has observed that during a period of intensive feeding by herring, *Clupea harengus*, the lipids were ingested at a very high level. We have previously pointed out that the seasonal variation in lipid contents for sardine, *Sardinops melanosticta*, which fed mainly on phytoplankton, was primarily from the dietary lipids[5].

Fish fatty acids derived from dietary sources or by biosynthesis can be altered by chain elongation or desaturation[6]. The utilization of the energy released by oxidation of fatty acids in fish is most evident[7], and as a result, the stored lipids decrease during times when food is scarce. However, the selectivity in utilization of fatty acids in the lipids by fish is not yet well known.

We determined the seasonal variation in the lipids for both adult and young anchovy, which fed mainly on zooplankton, to study the influence of the variation in the lipids from either the metabolism during the spawning period or food intake. In addition, the seasonal variation in the fatty acid compositions of the fish was also investigated to explain the utilization of fatty acids by fish.

Materials

The young (66–97 mm body length) and adult (126–142 mm) samples used in this study were collected between June and December in 1972 from a set net located at Kamiiso near Hakodate, Japan.

Table 1. *Sampling date and measurements of the anchovy.*

	Sampling date	Body length mm*	Body weight g*	Fatness index*
Adult	June 27	139	34.3	12.8
	July 7	141	32.1	11.5
	July 15	142	32.8	11.5
	Aug. 5	128	22.1	10.5
	Aug. 31	140	24.9	9.1
	Sep. 26	129	19.9	9.3
	Oct. 3	126	18.8	9.4
	Dec. 5	133	23.9	10.2
Young	Aug. 5	66	2.3	—
	Aug. 31	73	3.2	—
	Sep. 9	80	4.6	—
	Sep. 26	87	5.6	—
	Oct. 2	90	6.1	—
	Oct. 24	75	3.3	—
	Nov. 9	68	2.5	—
	Nov. 27	97	7.7	—
	Dec. 5	93	7.1	—
	Dec. 18	84	5.0	—

Each batch was composed of 20 specimens, except for one sample of 14 specimens of adult fish in August 5. * Mean value

Sampling date, mean body length and weight, and fatness index of the samples are given in Table 1. Each sampling was composed of 20 specimens of the same size taken randomly, except for one sample of 14 specimens of adult achovy in August.

The samples were divided into flesh and viscera, and then each tissue was used for the extraction of lipids.

Analytical Methods

Analytical methods, *i.e.*, lipid extraction, fractionation of non-polar and polar lipids by silicic acid column, preparation of fatty acid methyl esters, determination of fatty acid methyl esters by gas-liquid chromatography, analysis of components in non-polar lipids by thin-layer chromatography (TLC), all were done by the methods or conditions described previously[5]. The iodine value of non-polar lipids for adult samples was determined by duplicate analyses in the usual way. Triglycerides in non-polar lipids from adult flesh were separated in a column packed with silicic acid, using 10% diethyl ether-hexane after 4% diethyl ether-hexane as the solvent for development. It was ascertained that the triglyceride fraction had fewer contaminating components by analysis with TLC. The lipid content for the flesh was calculated on a dry weight basis by measuring the water content of the flesh with an infrared moisture meter.

Results and Discussion

Lipid content and characteristics of lipids In Tsugaru Strait, the Japanese anchovy are mainly caught by set net from late May to December. From January to the middle of May, the anchovy migrates from the coastal waters of the region, and the spawning of anchovy occurrs from June to August[8].

The contents of lipids, the proportion of non-polar and polar lipids, the iodine value of non-polar lipids, and the triglyceride contents in the non-polar lipids, for the flesh and viscera of the examined anchovy are given in Table 2. Through the sampling season, the lipid contents of the flesh for adult anchovy varied from a high of 10.7% in a June sample to a low of 1.3% in an October sample. Those of the viscera ranged from 26.1% in December to 2.6% in late August. The lipids were at high levels of 10.7% in June and 8.2% in December for the flesh, and 8.2% in September and 26.1% in December for the viscera. The lipid contents of the flesh showed a decreasing trend from June toward October; from 10.7% to 1.3 %.

In the case of young anchovy, there was also a marked variation in the lipid contents; between 0.9–2.4% for the flesh, and between 1.8–10.0% for the viscera. The decreasing tendency in the lipid contents of both tissues was recognized in the samples from early August to early October, and was greater for the viscera.

The decreased level of lipids in adult anchovy correlated with a spawning period and/or rising term for the ambient temperature and these results were consistent with the literature. Considering the similar trends for the lipids in young anchovy, however, it seems that a decrease in the lipid content of fish was influenced not only by the lipid metabolism during spawning but also by the availability of

Table 2. *Seasonal variation in lipid contents and the characteristics of lipids in the tissues for adult and young anchovy.*

	Sampling date	Lipid content %*1	Lipid content %*2	NL*3 content %*1	PL*4 content %*1	I.V.*5	TG*6 content %*7
Adult	June 27	10.7	37.4	9.8	0.9	179.4	94.7
	July 7	6.2	22.2	5.4	0.8	179.6	65.2
	July 15	4.0	16.1	3.2	0.8	177.4	58.0
Flesh	Aug. 5	2.4	10.5	1.8	0.6	183.7	44.5
	Aug. 31	2.2	9.8	1.5	0.7	187.0	42.6
	Sep. 26	2.9	11.8	2.2	0.7	172.8	79.9
	Oct. 3	1.3	6.3	0.7	0.6	178.3	78.5
	Dec. 5	8.2	30.2	7.2	1.0	161.7	95.7
	June 27	4.3	—	3.3	1.0	180.3	—
	July 7	3.5	—	2.3	1.2	202.9	—
	July 15	3.5	—	2.1	1.4	211.3	—
Viscera	Aug. 5	3.1	—	2.1	1.0	204.0	—
	Aug. 31	2.6	—	2.1	0.5	201.2	—
	Sep. 26	8.2	—	7.3	0.9	167.1	—
	Oct. 3	3.2	—	2.6	0.6	178.3	—
	Dec. 5	26.1	—	25.4	0.7	155.0	—
Young	Aug. 5	1.1	4.5	0.5	0.6	—	—
	Aug. 31	1.1	4.4	0.5	0.6	—	—
	Sep. 9	0.9	3.7	0.3	0.6	—	—
	Sep. 26	0.9	3.7	0.3	0.6	—	—
Flesh	Oct. 2	0.9	3.8	0.3	0.6	—	—
	Oct. 24	1.0	4.3	0.4	0.6	—	—
	Nov. 9	1.1	4.6	0.4	0.7	—	—
	Nov. 27	1.2	5.4	0.5	0.7	—	—
	Dec. 5	1.2	5.8	0.5	0.7	—	—
	Dec. 18	2.4	11.8	1.8	0.6	—	—
	Aug. 5	5.1	—	4.4	0.7	—	—
	Aug. 31	3.6	—	2.8	0.8	—	—
	Sep. 9	2.3	—	1.8	0.5	—	—
	Sep. 26	2.0	—	1.5	0.5	—	—
Viscera	Oct. 2	1.8	—	1.3	0.5	—	—
	Oct. 24	2.9	—	2.2	0.7	—	—
	Nov. 9	4.0	—	3.1	0.9	—	—
	Nov. 27	2.7	—	1.9	0.8	—	—
	Dec. 5	3.3	—	2.3	1.0	—	—
	Dec. 18	10.0	—	9.1	0.9	—	—

*1 % to wet weight basis *2 % to dry weight basis *3 Non-polar lipids *4 Polar lipids
*5 Iodine value *6 Triglyceride *7 % to non-polar lipids

dietary lipids derived from food intake. Shimizu *et al.*[3] have reported that the stored lipids in the flesh of yellowtail, *Seriola quinqueradiata,* were maintained with a decline in water temperature and with food scarcity in the winter season, then the stored lipids were rapidly utilized to the stagnation of food intake from spring to summer with rising temperature.

It is known that anchovy feed chiefly on zooplankton. Reports on the seasonal growth of planktonic copepods at the surface of the Tsugaru Straits showed major peaks in May, October and November[9]. The period of high lipid contents in the tissues for both the examined adult and young anchovy followed by one month from the season of abundant copepods. The shifts were obvious in the flesh and viscera of adult anchovy and the viscera for young fish. The same trend was also recognized for sardine, *S. melanosticta*[5]. The decreased trend for stored lipids in the flesh of anchovy can be caused by the scanty of dietary zooplankton in the feeding ground. Therefore, the seasonal variation in lipid contents seems to be due mainly to differences in dietary intake rather than the metabolism associated with spawning.

As given in Table 1, the variation in the fatness indices for adult anchovy nearly agreed with those in lipid contents of the tissue, indicating the influence of the stored lipids.

Non-polar lipids for the tissues of the samples were mainly triglycerides, as determined by TLC. The variation in non-polar lipids was influenced strikingly by the triglyceride contents, and accordingly, that in total lipids (Table 2). However, the polar lipid contents of the flesh were nearly constant during the sampling season.

The iodine values of the non-polar lipids for the flesh and viscera of adult

Table 3. *Seasonal variation in the fatty acid compositions of the non-polar lipids of the flesh from adult anchovy.*

Fatty acid	Season							
	June 27	July 7	July 15	Aug. 5	Aug. 31	Sep. 26	Oct. 3	Dec. 5
	Peak area %							
14:0	9.0	9.2	10.5	7.8	8.3	7.3	6.0	7.0
16:0	23.0	23.8	19.9	25.8	25.0	24.0	24.1	23.9
17:0	1.5	1.8	2.3	2.5	2.1	2.2	2.3	1.6
18:0	2.8	3.8	4.0	4.8	5.2	5.2	5.6	4.2
14:1	1.2	1.4	1.5	1.3	1.3	0.9	0.9	2.3
16:1	8.9	7.9	8.8	7.2	6.6	6.6	6.2	8.7
18:1	12.7	10.3	10.4	9.7	9.7	13.5	14.7	21.2
20:1	7.1	5.9	5.5	4.8	3.9	4.1	5.2	3.3
22:1	0.9	1.2	1.2	1.1	1.6	2.2	0.7	0.9
18:2	1.2	1.6	2.4	1.3	1.6	1.4	1.5	1.4
18:3	1.4	1.1	1.3	1.4	2.1	1.5	0.9	0.8
18:4	3.0	2.5	2.8	1.9	0.8	1.3	0.7	1.6
20:4	7.4	7.6	6.7	5.6	3.1	5.5	6.7	3.2
20:5	8.9	8.9	9.5	8.5	7.4	7.4	6.8	8.9
22:6	6.2	8.1	8.8	8.1	15.4	11.5	9.9	5.6
Sat.*1	38.0	40.4	38.7	43.1	43.1	40.6	40.7	39.5
Mono.*2	33.1	28.7	28.7	27.4	25.5	29.7	29.9	39.0
Poly.*3	28.8	30.8	32.6	29.5	31.4	29.7	29.3	21.5

*1 Saturates; to include the minor components (less than 2.0% in all the season) of 12:0, 13:0, 15:0 and 19:0 acids.

*2 Monoenes; to include the minor components (less than 2.0% in all the season) of 12:1, 13:1, 15:1, 17:1, 19:1, 21:1 and 24:1 acids.

*3 Polyenes; to include the minor components (less than 2.0% in all the season) of 20:2, 21:5, 22:2 and 22:5 acids.

Table 4. *Seasonal variation in the fatty acid compositions of the non-polar lipids of the viscera from adult anchovy.*

Fatty acid	Season							
	June 27	July 7	July 15	Aug. 5	Aug. 31	Sep. 26	Oct. 3	Dec. 5
	Peak area %							
14:0	10.4	6.3	7.8	6.2	6.8	7.6	5.7	9.8
16:0	14.8	23.6	31.8	31.5	20.4	25.1	23.5	21.7
17:0	1.8	1.9	2.5	2.3	2.7	2.8	2.5	1.9
18:0	4.0	4.4	4.9	7.5	7.6	5.9	6.9	4.3
16:1	9.0	8.0	9.0	8.0	6.4	7.5	5.1	10.0
18:1	17.4	10.4	9.7	13.2	11.6	12.2	13.8	18.9
20:1	6.5	2.8	1.6	2.2	2.7	4.0	4.1	3.4
22:1	1.0	1.1	0.9	1.4	2.7	1.7	2.5	1.0
18:4	2.3	1.9	2.1	1.2	1.0	1.3	1.0	3.9
20:2	0.2	0.1	tr*	tr	0.4	0.4	0.6	2.4
20:4	7.6	2.6	1.0	1.8	2.4	2.4	3.0	1.6
20:5	7.8	9.9	7.1	5.7	9.2	6.2	6.5	6.7
22:6	5.6	17.3	7.9	8.6	15.7	8.5	12.4	2.9
Sat.	33.3	38.2	50.3	49.8	39.6	45.0	40.8	41.2
Mono.	38.4	25.8	25.6	28.5	27.0	30.3	30.0	38.2
Poly.	28.3	36.0	24.0	21.6	33.5	24.7	29.1	20.7

* Trace Other abbreviations were same as Table 3.

samples changed between 161.7–187.0 and between 155.0–211.3, respectively. The iodine values for the anchovy were relatively high as compared with those for sardine, *S. melanosticta*[5]. These differences for the iodine values were due to the major diets; phytoplankton for sardine and zooplankton for anchovy. With high levels of iodine values in both tissues of anchovy, however, the lipid contents were comparatively low. It is suggested that the unsaturation in the component fatty acids was somewhat different from each other.

Fatty acid composition The seasonal variations in the fatty acid compositions of non-polar lipids for the tissues of the examined anchovy are given in Tables 3–5. In addition, the same variation in triglycerides for the flesh of adult samples are listed in Table 6. The contents of each fatty acid component in non-polar lipids or triglycerides fluctuated somewhat during the sampling season. The predominant fatty acids were 16:0, 14:0 and 18:0 acids for saturates, 18:1, 16:1 and 20:1 acids for monoenes, and 20:5, 22:6 and 20:4 acids for polyenes through the sampling period. The contents of C_{16}, composed of 16:0 and 16:1 acids based on the carbon atoms, were most predominant in general. The coefficients of variation in the saturates were relatively lower than those of monoenes and polyenes in both adult and young samples through the sampling season (Table 7).

The contents of C_{16} and C_{14} acids were nearly constant in non-polar lipids of the flesh for adult anchovy, and the variations of C_{18} and C_{20} acids corresponded with the seasonal changes of the lipids, while C_{22} acid contents varied inversely (Fig. 1). In non-polar lipids of the flesh of adult anchovy, the contents of monoenes fluctuated similarly to the lipids, but those of polyenes varied inversely

Table 5. *Seasonal variations in the fatty acid compositions of the non-polar lipids of the flesh and viscera from young anchovy.*

Fatty acid	Aug. 5	Aug. 31	Sep. 9	Sep. 26	Oct. 2	Oct. 24	Nov. 9	Nov. 27	Dec. 5	Dec. 18
	Season									
	Peak area %									
	Flesh									
14:0	8.7	6.3	5.9	3.2	4.4	7.2	5.0	4.9	5.1	6.3
16:0	23.1	29.8	28.1	32.1	35.0	33.8	30.6	28.9	33.6	20.9
17:0	2.2	2.1	2.2	2.2	2.0	2.3	2.2	1.8	1.9	2.1
18:0	8.0	5.8	5.7	6.7	5.9	5.9	4.6	4.2	4.1	3.9
14:1	1.2	0.5	0.5	0.9	0.8	1.0	0.3	0.9	0.9	2.0
16:1	11.3	8.5	8.3	5.0	6.0	8.9	5.8	6.1	5.8	7.4
18:1	10.8	11.3	9.6	12.2	9.5	11.8	7.5	9.9	10.0	9.4
20:1	1.3	0.6	2.2	2.7	2.2	4.3	1.3	2.5	1.5	2.9
22:1	1.9	2.1	2.1	2.2	1.1	0.8	1.8	2.0	2.1	1.8
18:3	1.1	0.4	1.6	1.8	1.6	1.4	1.7	2.5	1.6	0.8
18:4	1.5	0.3	1.3	1.3	0.9	2.2	2.2	2.5	1.3	2.7
20.2	1.0	0.4	1.2	1.3	3.1	2.0	0.6	0.6	tr	0.6
20:4	1.0	0.6	0.8	0.9	tr	1.1	0.7	1.5	1.6	2.9
20:5	7.8	11.5	10.0	8.6	6.5	4.8	12.0	9.0	7.5	13.2
22:6	7.1	12.3	13.8	10.0	15.6	5.0	14.4	14.1	14.8	11.3
Sat.	45.7	46.1	44.1	46.2	49.6	52.2	44.9	41.4	46.8	36.2
Mono.	30.7	26.0	24.9	25.7	21.5	29.3	20.0	24.6	23.2	27.8
Poly.	23.5	27.9	31.1	28.0	28.8	18.6	35.0	33.9	30.1	36.0
	Viscera									
14:0	5.7	7.5	6.5	3.1	3.0	5.4	6.8	5.0	3.6	8.0
16:0	26.2	25.4	19.4	26.4	21.4	19.8	22.1	22.5	24.7	21.4
17:0	2.0	1.8	1.8	2.0	1.9	1.6	1.9	1.7	2.1	2.0
18:0	5.8	7.7	7.0	8.8	8.9	7.5	6.3	5.8	6.3	4.4
16:1	9.3	9.2	8.7	4.4	4.6	5.9	7.0	5.7	5.0	8.5
18:1	11.2	11.1	10.8	11.8	10.9	15.3	9.2	12.0	13.3	10.9
20:1	1.2	0.9	2.1	3.2	2.3	7.1	3.9	2.7	1.6	3.3
22:1	0.9	2.8	2.7	3.3	3.2	1.5	1.5	2.2	1.9	1.7
18:2	1.5	1.4	1.3	1.4	1.3	1.4	1.5	1.6	2.0	1.6
18:3	1.4	0.6	2.1	2.1	2.0	1.1	2.9	2.9	1.8	1.0
18:4	1.4	0.9	1.5	0.8	1.7	4.2	3.7	2.9	2.1	2.7
20:2	0.7	0.2	0.8	0.6	1.9	2.3	1.1	0.8	0.6	0.5
20:4	0.5	0.7	1.3	1.5	0.9	4.4	0.8	0.9	1.1	3.7
20:5	10.8	11.1	10.5	7.3	8.7	7.3	10.9	10.0	8.7	11.2
22:6	14.5	9.5	12.9	15.9	18.3	5.8	10.5	13.4	15.1	7.7
Sat.	42.2	45.1	37.6	42.1	37.0	36.6	40.0	37.3	38.7	38.9
Mono.	25.8	26.3	29.1	26.3	25.5	34.6	26.3	27.2	27.5	30.6
Poly.	32.1	28.5	33.2	31.6	37.4	28.8	33.6	35.5	33.8	30.6

Abbreviations were same as Table 3.

(Fig. 2). That is, monoenes were clearly reduced in the flesh lipids, while polyenes obviously increased with a slight increase for saturates. Thus, the seasonal variations in the contents of polyenes agreed with those in the iodine values.

Table 6. *Seasonal variation in the fatty acid compositions of triglycerides of the flesh from adult anchovy.*

Fatty acid	Season							
	June 27	July 7	July 15	Aug. 5	Aug. 31	Sep. 26	Oct. 3	Dec. 5
	Peak area %							
14:0	7.4	9.2	9.7	9.1	8.7	7.0	6.6	7.0
16:0	18.1	19.3	18.6	22.0	19.4	21.6	19.5	16.4
17:0	1.4	2.0	2.0	2.2	2.9	2.6	2.9	1.2
18:0	2.8	3.4	3.1	5.2	5.5	5.2	5.3	3.8
16:1	7.9	8.2	8.2	8.0	7.6	7.2	6.8	7.7
18:1	10.8	11.2	8.1	10.1	10.9	11.8	12.6	17.1
20:1	7.4	7.1	6.8	6.1	6.2	3.0	5.7	3.6
22:1	0.8	0.7	1.2	1.3	1.9	2.3	1.8	2.0
24:1	0.6	0.7	0.9	1.5	1.1	2.1	1.3	1.6
18:3	1.6	1.8	1.9	0.9	2.4	1.7	2.2	0.9
18:4	3.1	2.9	2.5	1.8	1.8	1.7	1.5	2.3
20:4	7.0	7.2	7.4	6.4	6.6	4.2	5.8	4.2
20:5	12.9	8.5	7.5	7.2	6.6	7.5	6.7	12.0
22:6	10.6	8.1	12.6	7.4	7.9	12.4	10.9	9.0
Sat.	31.5	36.0	35.5	41.2	40.1	39.0	37.2	31.4
Mono.	30.1	31.6	28.7	30.6	32.1	29.5	32.3	35.4
Poly.	38.4	32.4	35.8	28.2	27.8	31.5	30.5	33.2

Abbreviations were same as Table 3.

Table 7. *Coefficient of variations in the contents for saturates, monoenes and polyenes in the fatty acid compositions for the tissues of adult and young anchovy.*

Fatty acid	$\bar{x}$*1	σ*2	$\sigma/\bar{x}$*3	$\bar{x}$	σ	$\sigma/\bar{x}$
	Adult					
	Flesh			Viscera		
Saturates	40.5	1.7	4.2	42.3	5.4	12.8
Monoenes	30.3	3.9	12.9	30.5	4.8	15.7
Polyenes	29.2	3.1	10.6	27.2	5.1	18.8
	Young					
	Flesh			Viscera		
Saturates	45.3	4.1	9.1	39.6	2.6	6.6
Monoenes	25.4	3.2	12.6	27.9	2.7	9.7
Polyenes	29.3	5.0	17.1	32.5	2.7	8.3

*1 Mean value *2 Standard deviation *3 Coefficient of variation

Similar results have been obtained for the sardine, *S. melanosticta*[5]. We have also observed that saturates and monoenes of non-polar lipids in the liver of a starved puffer, *Fugu vermiculare porphyreum*, were reduced slightly prior to a decrease of polyenes, in the early stages of starvation.

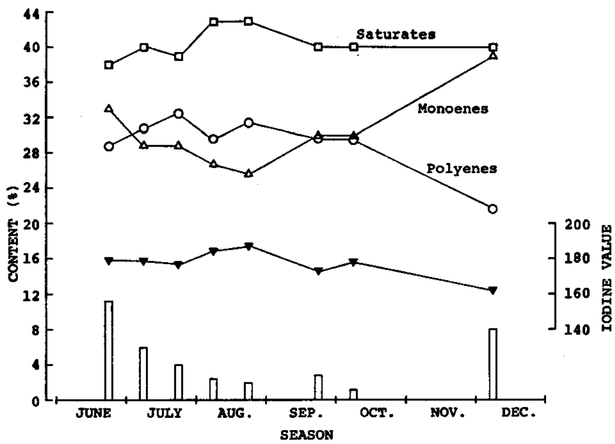

Fig. 1. Seasonal variations in the lipid contents (▭), and the contents of saturates, monoenes and polyenes of the non-polar lipids, and in iodine values (▾——▾) of the non-polar lipids, for the flesh of adult anchovy.

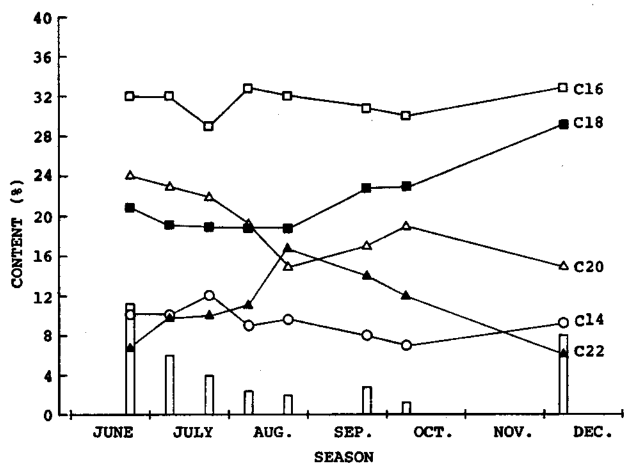

Fig. 2. Seasonal variations in the lipid contents (▭) and C_{14}, C_{16}, C_{18}, C_{20} and C_{22} acid contents of the non-polar lipids for the flesh of adult anchovy.

It is known that the fatty acid composition of the fish lipids are affected considerably by compound factors; diets, maturity, environmental temperature, and species[11]. Recently, Ueda[12] has reported that the variation in the fatty acid composition of mackerel, *Scomber japonicus*, was related to that in the lipid contents of the fish.

The results of our investigation suggest that, for the energy released by oxidation of fatty acids in the flesh of anchovy, monoenes such as 18:1 and 16:1 acids in the fatty acid components were selectively utilized rather than polyenes during the periods of food scarcity.

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