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SEASONAL VARIATION IN LIPID COMPOSITION OF IMMATURE ARCTIC CHARR, *SALVELINUS ALPINUS* (L), CAUGHT IN THE LITTORAL ZONE IN LAKE TAKVATN, NORTHERN NORWAY

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ABSTRACT

Seasonal variations in total lipid content and neutral lipid composition were observed in immature Arctic charr (30–40 g) taken in the littoral zone of Lake Takvatn in June, August and October. The neutral lipid content varied from 74 to 83% of the total lipid, and was dominated by triacylglycerols (TAG). The TAG content was highest in fish caught in August. The fatty acid composition in TAG differed little, and had a high proportion of 18:1, 16:1, 16:0 and 18:2 (n–6). The content of 22:6 (n–3) was low. The polar lipid fraction contained high amounts of 22:6 (n–3), and was characterized by a relativly high proportion of arachidonic acid (20:4 n–6).

INTRODUCTION

Until 1984, the oligotropic Lake Takvatn, Northern Norway, was dominated by a stunted population of Arctic charr, *Salvelinus alpinus* (L.). In 1984 an intensive fishing program started in Lake Takvatn, and the total catch from 1984 to 1987 was 470.000 charr (23 tonnes) (A. Klemetsen, personal communication, 1989). Today the charr of Lake Takvatn is esteemed as an excellent food and sports fish, and there are many individuals in the range of 500 g to 700 g. The anadromous Arctic charr has been the preferred strain for commercial aquaculture of charr in Norway. However, Arctic charr from Lake Takvatn seems a suitable material for commercial aquaculture, and possesses a comparable growth potential provided suitable food and feeding conditions are offered (Ringø, 1987; Ringø and Nilsen, 1987).

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The lipid composition of hatchery-reared Arctic charr derived from the Takvatn stock has been investigated, and some information exists about the lipid composition of wild caught Arctic charr (Ringø and Nilsen, 1987). However, no information was available about seasonal variation in lipid composition of wild caught charr. Seasonal variations in total lipid and neutral lipid composition have been described for wild masu salmon (*Onchorynchus masu*) (Ota, 1976; Ota and Yamada, 1974 a,b) and sweet smelt (*Pleucoglossus altivelis*) (Ota and Tagaki, 1977).

This work presents analytical data on the lipid composition in muscle tissue from Arctic charr (*Salvelinus alpinus* L.) sampled in the littoral zone in lake Takvatn, Northern Norway.

MATERIAL ANS METHODS

FISH. Ten immature Arctic charr, *Salvelinus alpinus* (L.), (30–40 g) were taken in each sampling in mid June, August and October from the littoral zone in Lake Takvatn, Northern Norway.

CHEMICAL ANALYSES. Muscle tissue samples were taken immediately caudal of the dorsal fin. Ten fish were analysed for each sampling, except for the determination of lipid class distribution, which was performed on pooled samples.

Water content was determined by drying samples for 48 hours at 105° C. Total lipid was determined by the method of Folch et al. (1957) and samples were stored at –20° C in chloroform:methanol (2:1) with 0.05% BHT added.

Thin layer chromatography with flame ionization detection (TLC–FID) was performed on a Iatroscan TH–10 Mark IV analyzer equipped with Chromarod Sill. The detector was operated with an air flow of 2000 ml/min and a hydrogen flow of 160 ml/min. The scan speed was set at 3.3 mm/s and integration was carried out with a Spectra-Physics SP 4270 integrator. The Chromarods were developed to the 10 cm mark on the frame in hexane/chloroform/formic acid (49.9:49:9:0.2), (73.7:25.5:0.8), and (88:11:1) to separate neutral lipids and chloroform/metanol (50:50) to separate phospholipids. The rods were dried 35° C for 20 minutes prior to scanning.

Triacylglycerols and polar lipid were separated by thin layer chromatography (TLC) on silica gel 60 plates as described by Tocher and Sargent (1984) using hexane/diethylether/acetic acid (80:20:2) as solvent. The proportion of fatty acids in triacylglycerols and total polar lipids were determined by gas chromatography (Hewlett Packard, Model 5890 A) using a SP 2330 capillary column (30 m × 0.25 mm i.d) and helium as the carrier gas, as

described by Haug et al. (1988). The individual fatty acids were identified by comparison with known standards using a Hewlett Packard 3393 A integrator.

RESULTS

The results of mean water and total lipid contents of muscle tissue from wild caught Arctic charr sampled from the littoral zone in lake Takvatn are given in Table 1. The average water content was about 80% of the dry weight. Differences were seen in total lipid content, and highest contents were observed in fish caught in August.

Table 1. Mean water and total lipid content (± standard deviation) in Arctic charr, *Salvelinus alpinus* (L.), from Lake Takvatn. N = number of specimens analysed.

Charr caught in mid	N	Water content (%)	Total lipid (% of dry wt)
June	10	81.5 ± 2.5	10.5 ± 1.3
August	10	80.4 ± 2.3	13.3 ± 0.8
October	10	81.7 ± 2.8	10.0 ± 1.2

The contents of neutral lipid (% of total lipid), and lipid class distribution in neutral lipid are presented in Table 2. The neutral lipid content varied from 74 to 83% of total lipid. The triacylglycerol content in the neutral lipid fraction was highest in fish caught in August and lowest in fish caught in October. The content of free fatty acids differed between the fish investigated. Lowest content (1–2%) was observed in charr caught in June and August, and highest content (15%) in fish caught in October.

Table 2. Total polar lipid and total neutral lipid, and lipid classes (% of total lipid) in the neutral lipid in Arctic charr from Lake Takvatn. Samples from ten fish were pooled prior to further treatment.

	charr caught in mid		
	June	August	October
Total polar lipid	26	18	17
Total neutral lipid	74	82	83
Hydrocarbons	3	1	8
Triacylglycerols	66	75	52
Diacylglycerols	1	1	3
Monoacylglycerols	1	1	2
Free fatty acids	1	2	15
Sterols	2	2	3

Table 3. Fatty acid composition (%) (± standard deviation) in triacylglycerols from Arctic charr caught in Lake Takvatn. Ten specimens were analysed.

	charr caught in mid		
	June	August	October
saturates	20.4	19.1	19.6
14:0	2.7 ± 0.3	2.9 ± 0.3	3.0 ± 0.3
16:0	13.9 ± 1.2	13.4 ± 1.1	13.0 ± 1.3
18:0	3.8 ± 0.3	2.8 ± 0.3	3.6 ± 0.3
monoenes	42.0	46.1	43.9
16:1a	13.6 ± 0.8	14.9 ± 0.9	15.0 ± 1.0
18:1b	21.7 ± 1.8	25.9 ± 1.9	22.8 ± 2.0
20:1	3.1 ± 0.3	2.8 ± 0.3	2.6 ± 0.3
22:1	3.6 ± 0.3	2.5 ± 0.3	3.5 ± 0.3
(n-6)PUFA	13.3	13.8	11.7
18:2	11.8 ± 1.4	11.8 ± 1.4	9.0 ± 1.0
20:4	0.9 ± 0.1	1.6 ± 0.4	1.9 ± 0.3
22:5	0.6 ± 0.1	0.4 ± 0.1	0.8 ± 0.1
(n-3)PUFA	15.5	14.9	15.2
18:3	2.9 ± 0.4	3.3 ± 0.4	3.0 ± 0.4
18:4	0.9 ± 0.2	0.7 ± 0.1	1.2 ± 0.2
20:5	6.2 ± 0.5	5.8 ± 0.5	5.8 ± 0.6
22:5	1.7 ± 0.2	1.4 ± 0.1	1.3 ± 0.2
22:6	3.8 ± 0.4	3.7 ± 0.4	3.9 ± 0.3

16:1a; 16:1 (n–9) + 16:1 (n–7)
18:1b; 18:1 (n–9) + 18:1 (n–7)

The fatty acid composition in triacylglycerols (TAG) of charr caught in June, August and October differed little and showed high level of 18:1, about 23.5% (Table 3). The relative contents of n–3 polyunsaturated fatty acids (PUFA) in the TAG were low, approximately 15%. The fatty acid 22:6 (n–3) accounted for about 4%. Arctic charr taken in Lake Takvatn was characterized by a high proportion of 18:2 (n–6) (11%), and low levels of the monoenes 20:1 and 22:1 in TAG (c. 3%).

The polar lipid fraction contained more than 40% PUFA's with 22:6 (n–3) as the major fatty acid (Table 4). Arachidonic acid (20:4 n–6) constituted about 8.5% of the total polar lipid fatty acids in fish caught in June, but a somewhat smaler proportion was observed in the charr caught in August and October.

Table 4. Fatty acid composition (%) (± standard deviation) in total polar lipid from Arctic charr caught in Lake Takvatn. Ten specimens were analysed.

	charr caught in mid		
	June	August	October
saturates	23.8	26.7	27.9
14:0	0.7 ± 0.2	1.0 ± 0.2	2.2 ± 0.3
16:0	21.1 ± 1.8	23.4 ± 2.0	22.8 ± 1.9
18:0	2.0 ± 0.1	2.3 ± 0.2	2.9 ± 0.2
monoenes	10.1	11.3	11.5
16:1a	2.3 ± 0.3	2.5 ± 0.3	2.0 ± 0.3
18:1b	5.5 ± 0.4	7.0 ± 0.5	6.9 ± 0.4
20:1	1.2 ± 0.2	1.0 ± 0.1	1.2 ± 0.1
22:1	1.1 ± 0.1	0.8 ± 0.2	1.4 ± 0.2
(n-6)PUFA	11.0	9.0	7.3
18:2	2.1 ± 0.2	1.6 ± 0.2	1.6 ± 0.2
20:4	8.4 ± 0.9	6.9 ± 0.8	5.3 ± 0.6
22:5	0.5 ± 0.0	0.5 ± 0.1	0.4 ± 0.1
(n-3)PUFA	46.7	47.0	42.7
18:3	1.2 ± 0.2	1.3 ± 0.2	1.6 ± 0.1
18:4	0.4 ± 0.0	1.3 ± 0.0	0.4 ± 0.0
20:5	14.7 ± 1.2	14.1 ± 1.0	11.0 ± 1.0
22:5	2.6 ± 0.3	2.2 ± 0.1	1.8 ± 0.2
22:6	27.8 ± 2.2	28.1 ± 2.0	27.9 ± 2.3

16:1a; 16:1 (n–9) + 16:1 (n–7)
18:1b; 18:1 (n–9) + 18:1 (n–7)

DISCUSSION

The total lipid contents observed in muscle of wild caught Arctic charr is similar to results reported for wild "ezoiwana" (*Salvelinus leucomaenis*) (Ota and Yamada, 1975), brook trout (*Salvelinus fontinalis*) and lake trout (*Salvelinus namaycush*) (Kinsella et al., 1977). The current study indicated variations in the total lipid content in wild caught charr depending on sampling time. Similar findings have been reported in residual masu salmon (*Oncorhynchus masu)* with a lipid content of 4.9, 3.5 and 2.0% in muscle tissue of fish caught in July, August and October, respectively (Ota and Yamada, 1974 b).

The seasonal variations found, in neutral lipid and triacylglycerols (TAG) contents in muscle tissue corresponded to reports from wild sweet smelt (*Plecoglossus altivelis*) and juvenile masu salmon (Ota, 1976; Ota and Takagi, 1977). In the present study the proportion of free fatty acids was surprisingly high in fish caught in October. High free fatty acid contents have been

reported previously for masu salmon caught in May (Ota, 1976) and sweet smelt caught in October (Ota and Takagi, 1977). A high content of free fatty acids has been observed in hatchery-fed Arctic charr starved for 25 and 50 days (Ringø et al., in prep.). This may indicate that Arctic charr caught in October in Lake Takvatn had starved for some time.

The TAG fatty acids in the present study decreased in the order monoenes > PUFA > saturates. However, in salmonid fresh water species, saturates have been reported to be more abundant than PUFA (Gunstone et al., 1978; Ota and Yamada, 1974). In the TAG PUFA's in the present study the (n–3) exceeded the (n–6) series. Similar findings have been reported in other wild caught salmonid fresh water fishes.

We observed a high proportion (12%) of linoleic acid (18:2 n–6) in triacylglycerols in fish taken in June and August. However, wild caught Arctic charr with an approximate body weight of 40 g, taken in May from Lake Takvatn had a proportion of linoleic acid of about 5% (Ringø and Nilsen, 1987). The monoenes 20:1 and 22:1 in TAG constituted approximately 3.5% of each (Table 3). According to Yamaguchi et al. (1988), wild coho salmon had 20:1 and 22:1 contents of 16.0% and 9.0%, respectively. The low contents of 20:1 and 22:1 observed in TAG in the present study, indicate a low content of these fatty acids in prey organisms, since fatty acid composition of fish lipids is highly dependent upon dietary dietary fatty acids.

Amundsen (1989) reported that the diet for Arctic charr in the littoral zone in Lake Takvatn (1986) was dominated by chironomid pupae in June and August, surface insects in July and September, zooplankton in October. Nevertheless similar proportions of fatty acids in the triacylglycerols were observed in the present study. Further studies on the lipid composition in prey organisms are therefore of great importance.

The polar lipid fraction in charr caught in lake Takvatn was dominated by 22:6 (n–3). Similar findings have been reported for other wild caught salmonids in fresh water (Ackman and Takeuchi, 1986; Gunstone et al., 1978; Ota and Yamada, 1974). The 22:6 (n–3) content in the polar lipids observed in the present study was somewhat lower than that reported in hatchery-fed charr (Ringø et al. in prep.). The content of 20:4 (n–6) in the polar lipid fraction was high in Arctic charr in the Lake Takvatn. A high 20:4 (n–6) content in total polar lipid has been reported for several fresh water fishes (for review see Henderson and Tocher, 1987).

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