THE SPECTRUM OF FATTY ACIDS IN LIPIDS OF SALVELINUS FONTINALIS IN RELATION TO THE ORIGIN, FEED AND BREEDING DENSITY

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ABSTRACT

The purpose of the observation was to determinate an effect of fish original, feed and breeding density, compared with the content and the composition of fatty acid of *Salvelinus fontinalis*. *Salvelinus fontinalis* was produced in the recirculation system of intensive breeding. Two danish complex feeds was used. Fatty acid were separated from the lipids by the means of transesterification and determined via gas chromatographic analysis. Quality of fish lipids was evaluated according to the amount of unsaturated fatty acids, especially the omega-3 group. The fish fed with ENVIRO had the highest amount of fatty acids although their ratio was unsatisfying. Muscle of fish from own breeding with lower density had also high amount of fatty acid. In all cases the fish with higher amount of lipids in muscle had worse quality of fatty acid in lipids due to ratio of polyenic acid.

Key words: fatty acid, gas chromatography, omega-3, transesterification

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INTRODUCTION

Fish lipids are a major source of unsaturated fatty acids, especially the omega-3 group, which lowers the density of cholesterol and reduces cardiovascular diseases. Omega-6 unsaturated fatty acids decrease also the HDL cholesterol, which is an undesirable effect. Omega-6 unsaturated fatty acids are also precursors of eicosanoids, which can be adversely applied in the pathogenesis of atherosclerosis and its complications (Schluz C. et al. 2005, Wang N. et al. 2009).

MATERIAL AND METHODS

Fish were fed the feed ORBIT 929 and ENVIRO 920. The same feed was used for fish of different origin. Sal_{OWN} is the name for fish from our own breeding. Two samples from an external supplier were tested: Sal_{SAV} and Sal_{MAZ}. Fish from our own breeding were bred at a density of 9, 15 and 18 thousands of pieces on breeding trough. The density of fish labelled Sal_{SAV} was 11.4, 11.6 and 18 thousands of pieces and Sal_{MAZ} was 13.1 thousands of pieces.

The content of fatty acid was determined as a percentage and as a concentration in $g \cdot kg^{-1}$, indicating the content of fatty acid in 1 kg of muscle. Fat content in dry muscle was determined using Soxhlet extraction. The yield indicates the percentage of fish body without guts.

The fatty acids were derivatised for gas chromatographic analysis by the means of transesterification. The internal standard (10 mg of methylpentadecanoate) dissolved in 2 ml isooctane was added to a flask with extracted lipids. 2 ml of sodium methoxide were added to each sample and heated. After 5 min boron trifluoride was used as a methylating reagent. The solution was heated for 5 more minutes. Then 2 ml of isooctane were added to the hot sample and after short time (1 min) 5 ml of supersaturated solution of sodium chloride were added and the separation of fatty acids methylesters was performed (short shaking, isooctane). After 15 min. the water and organic phases were separated and fatty acids methylesters were analysed by the means of capillary gas chromatography.

A gas chromatograph HP-4890D (Hewlett Packard, Germany) with flame-ionization detector was used for analysis of fatty acid. A capillary DB-23 column (60 m × 0.25 mm i.d. × 0.25 μm) bought from Agilent (Germany) was used to separate the volatiles. Temperature program was following: T_1 = 100 °C, t_1 = 3 min, 10 °C·min^{-1} to T_2 = 170 °C, t_2 = 0 min, 4 °C·min^{-1} to T_3 = 230 °C, t_3 = 8 min, 5 °C·min^{-1} to T_4 = 250 °C, t_4 = 15 min. N_2 flow rate was 1 ml·min^{-1}, injector temperature 270°C and detector temperature 280°C. Injection volume of samples was 2 μl. Gas chromatograph was controlled by CSW (version 1.7, Data Apex, Praha).

RESULT AND DISCUSSION

Tab. 1 shows the content of fatty acids in fish muscle and their percentage in the feed and fat. Feed ORBIT has a lower ratio of monoenic acids and higher ratio of polyenic acids. The amount of unsaturated fatty acid in muscle corresponds with feed which was used.

Fig. 1 shows the effect of feed on other related parameters. The feed ORBIT causes lower amount of fat in organism because dry muscle contain little fat and the yield is higher. On the other hand the fish which were fed with the feed ORBIT have higher quality of fat due to high content of omega-3 fatty acids.

Tab. 1 Comparison of fatty acids in the fat of Salvelinus fontinalis and feed ORBIT and ENVIRO

Feed	ORBIT		ENVIRO		ORBIT		ENVIRO		ORBIT	ENVIRO
Origin	Sal_{SAV}		Sal_{SAV}		Sal_{MAZ}		Sal_{MAZ}			
Density	11 400		11 600		13 100		13 100			
	%	$g \cdot kg^{-1}$	%	$g \cdot kg^{-1}$	%	$g \cdot kg^{-1}$	%	$g \cdot kg^{-1}$	%	%
C 14:0	2.70	0.82	2.67	1.14	2.27	0.56	2.42	0.88	2.95	1.79
C 16:0	11.89	3.59	11.99	5.14	12.71	3.04	11.83	4.26	11.49	9.99
C 16:1ω7	3.84	1.16	3.91	1.67	3.27	0.81	3.51	1.27	3.00	1.90
C 18:0	2.51	0.76	2.66	1.14	2.71	0.65	2.61	0.94	3.52	3.39
C 18:1ω9c	33.47	10.21	35.13	15.09	32.30	7.88	34.24	12.36	37.30	45.72
C 18:1ω7	3.18	0.97	3.14	1.35	2.87	0.70	3.01	1.09	2.92	3.24
C 18:2ω6c	13.69	4.17	14.42	6.19	13.73	3.35	15.06	5.45	18.23	16.91
C 18:3ω6	0.22	0.07	0.29	0.12	0.22	0.06	0.22	0.08	0.05	0.03
C 18:3ω3	4.13	1.27	4.13	1.77	4.20	1.02	4.44	1.61	6.22	7.41
C 18:4ω3	1.18	0.36	1.23	0.52	0.98	0.24	1.11	0.40	1.33	0.70
C 20:1	3.36	1.03	3.82	1.65	3.17	0.77	3.45	1.25	4.37	2.45
C 20:4ω6	0.53	0.16	0.46	0.19	0.61	0.14	0.50	0.18	0.23	0.22
C 20:4ω3	0.65	0.20	0.70	0.29	0.56	0.14	0.64	0.23	0.28	0.16
C 20:5ω3	4.05	1.22	3.50	1.49	4.00	0.95	3.60	1.30	3.48	2.63
C 22:4ω6	0.15	0.04	0.06	0.02	0.15	0.03	0.13	0.05	0.06	0.03
C 22:5ω6	0.14	0.04	0.12	0.05	0.13	0.03	0.14	0.05	0.15	0.14
C 22:5ω3	1.32	0.39	1.21	0.52	1.21	0.29	1.20	0.43	0.50	0.31
C 22:6ω3	12.98	3.84	10.57	4.50	14.93	3.49	11.88	4.26	3.94	3.02
saturated	17.10	5.16	17.33	7.43	17.69	4.25	16.86	6.08	17.96	15.16
unsaturated	82.9	25.12	82.67	35.43	82.31	19.90	83.14	30.01	82.04	84.84
ω-6	14.73	4.48	15.35	6.57	14.84	3.61	16.05	5.81	18.72	17.33
ω-3	24.31	7.28	21.34	9.09	25.88	6.13	22.87	8.23	15.75	14.23
ω-3/ω-6	1.65	1.63	1.39	1.38	1.74	1.70	1.42	1.42	0.84	0.82

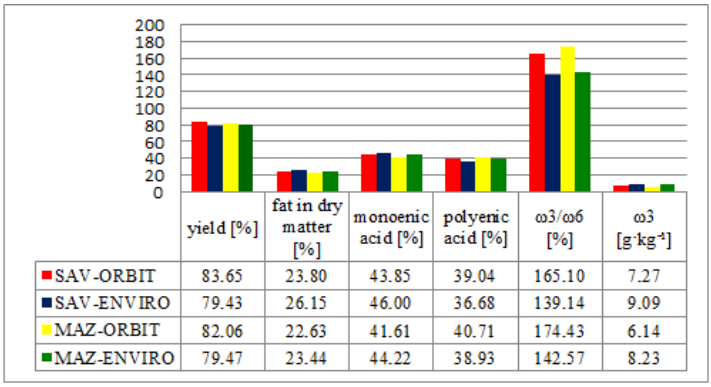


Fig. 1 Effect of the feed on the composition of fatty acid in fat of Salvelinus fontinalis

The effect of fish origin and breeding density on the content of fatty acids in fish fat can be seen in Tab. 2. The effect of breeding density is shown in more detail in Fig. 2.

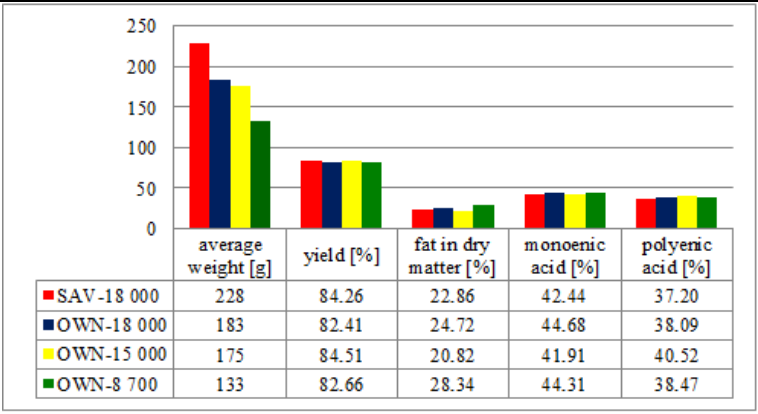
Fish with the lowest breeding density have the highest average weight. It causes the highest amount of fat in dry muscle, low yield, high amount of monoenic acids and low amount of polyenic acids. Fish with high breeding density (15 000 pieces) have the lowest average weight. It causes the lowest amount of fat in dry muscle, the highest yield, the lowest amount of monoenic acids and the highest amount of polyenic acids.

Tab. 2 Composition of fatty acid in fat of Salvelinus fontinalis bred with different density

Feed	ORBIT		ORBIT		ORBIT		ORBIT	
Origin	Sal_{SAV}		Sal_{OWN}		Sal_{OWN}		Sal_{OWN}	
Density	18 000		18 000		15 000		8 700	
	%	$g \cdot kg^{-1}$	%	$g \cdot kg^{-1}$	%	$g \cdot kg^{-1}$	%	$g \cdot kg^{-1}$
C 14:0	2.47	0.59	2.59	0.91	2.42	0.69	2.58	1.08
C 16:0	14.63	3.41	11.97	4.13	12.34	3.51	12.00	4.83
C 16:1ω7	3.43	0.71	3.66	1.28	3.20	0.91	3.62	1.51
C 18:0	3.27	0.76	2.66	0.92	2.80	0.80	2.65	1.07
C 18:1ω9c	32.52	7.80	34.23	11.89	32.43	9.29	33.76	14.35
C 18:1ω7	3.13	0.74	3.03	1.06	2.81	0.81	3.10	1.32
C 18:2ω6c	14.78	3.50	13.80	4.80	15.07	4.24	14.31	6.05
C 18:3ω6	0.20	0.05	0.25	0.09	0.24	0.07	0.25	0.11
C 18:3ω3	3.53	0.85	4.20	1.45	4.24	1.21	4.30	1.79
C 18:4ω3	0.95	0.23	1.18	0.41	1.10	0.31	1.20	0.50
C 20:1	3.35	0.80	3.76	1.32	3.47	1.00	3.82	1.66
C 20:4ω6	0.64	0.15	0.43	0.15	0.53	0.15	0.46	0.18
C 20:4ω3	0.50	0.12	0.65	0.23	0.63	0.17	0.62	0.26
C 20:5ω3	3.96	0.93	3.75	1.29	4.05	1.12	3.58	1.40
C 22:4ω6	0.14	0.03	0.09	0.03	0.12	0.03	0.10	0.04
C 22:5ω6	0.11	0.03	0.13	0.05	0.13	0.04	0.11	0.04
C 22:5ω3	1.16	0.28	1.14	0.39	1.20	0.33	1.19	0.49
C 22:6ω3	11.24	2.66	12.47	4.21	13.22	3.73	12.36	4.58
saturated	20.36	4.76	17.23	5.95	17.57	4.99	17.22	6.99
unsaturated	79.64	18.87	82.78	28.65	82.43	23.40	82.78	34.29
ω-6	15.87	3.75	14.71	5.11	16.08	4.53	15.23	6.42
ω-3	21.34	5.06	23.38	7.99	24.44	6.87	23.24	9.01
ω-3/ω-6	1.34	1.35	1.59	1.56	1.52	1.52	1.53	1.40

The origin has effect on weight and on the content of fatty acid. Sal_{SAV} samples have high average weight although the breeding density was the highest. However Sal_{SAV} have lower amount of fat in dry matter and higher yield. Quality of fat is higher in Sal_{OWN} due to higher amount of unsaturated fatty acids.

Statistically significant difference ($P < 0.05$) was determined only comparing Sal_{OWN} fed by ORBIT with breeding density 15 000 and Sal_{SAV} fed by ENVIRO with breeding density 11 600. Significant difference was in amount of monoenic and polyenic acids. This confirmed the effect of feed, origin and breeding density on quality of the fatty acids content.



	average weight [g]	yield [%]	fat in dry matter [%]	monoenic acid [%]	polyenic acid [%]
SAV-18 000	228	84.26	22.86	42.44	37.20
OWN-18 000	183	82.41	24.72	44.68	38.09
OWN-15 000	175	84.51	20.82	41.91	40.52
OWN-8 700	133	82.66	28.34	44.31	38.47

Fig. 2 Effect of breeding density on the amount and composition of fatty acid in fat of *Salvelinus fontinalis*

CONCLUSIONS

The fish with higher fat content provide higher income of health beneficial fatty acids although they have lower sensory quality. The ratio of omega-3 fatty acids is lower in fatter fish because they contain the fat of worse quality. However, the total content of omega-3 fatty acids is higher in these fish so it is preferable to consume fattier fish.

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