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THE IMPACT OF DIET ON THE SLAUGHTER YIELD, PROXIMATE COMPOSITION, AND FATTY ACIDS PROFILE OF FILLETS OF TENCH (*TINCA TINCA* (L.))

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ABSTRACT. The aim of the study was to determine the impact of diet (natural or formulated feed) on the biometric parameters, slaughter yield, proximate composition, and fatty acids profile of tench, *Tinca tinca* (L.). The study material was comprised of fish from earthen ponds that had fed on natural food (age 5+, mean body weight 420 g) and specimens obtained from intensive fattening on formulated feed in a recirculating system (age 3+, mean body weight 354 g). The tench fed formulated feed were characterized by a lower carcass and fillet yield, which resulted from higher viscera weight ($P < 0.01$). The meat of these fish contained less water (73.57 vs. 80.23%) and protein (16.52 vs. 18.19%), and more fat (8.85 vs. 0.58%) ($P < 0.01$). The qualitative fatty acid composition of the meat, similarly to the relative content of saturated fatty acids (SFA) and unsaturated fatty acids (USFA) was not dependent on the diet ($P > 0.01$). However, it was determined that the meat of the tench reared on formulated feed contained more monounsaturated fatty acids (MUFA) (42.15 vs. 27.90%) and less polyunsaturated fatty acids (PUFA) (33.62 vs. 46.92%) ($P < 0.01$). The higher MUFA content in the meat of the fish reared on formulated feed in comparison with that from the pond-reared tench stemmed primarily from the various contents of 16:1 (palmitoleic), 18:1cis9 (oleic), 20:1n-9 (gadoleic) and 22:1n-11 (cetoleic). The lower content of PUFA was primarily the result of differences in the amount of n-6PUFA, and to a lesser degree to that of n-3PUFA. The n-3/n-6 ratio in tench reared in recirculating systems and fed formulated feed was nearly two-fold higher than that noted in the pond-reared fish (3.60 vs. 1.93; $P < 0.01$). The meat of the fish fed intensively with formulated feed contained many-fold less 20:4n-6 (arachidonic, AA; 0.58 vs. 8.92%; $P < 0.01$), while the content of 20:5n-3 (eicosapentaenoic, EPA; 7.38 vs. 7.97%) and 22:6n-3 (docosahexaenoic, DHA; 12.91 vs. 13.87%) did not differ significantly statistically ($P > 0.01$).

Key words: TENCH (*TINCA TINCA*), SLAUGHTER YIELD, PROXIMATE COMPOSITION, FATTY ACIDS

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INTRODUCTION

In recent years there has been dynamic development in methods for rearing fish in closed recirculating systems. These types of systems permit the continuous monitoring and modulating of the majority of the environmental parameters that determine the results of fish rearing (*e.g.*, water temperature, oxygen concentration, ammonia concentration, nitrites, and carbon dioxide) (Summerfelt 1996, Singh et al. 1999). Controlling water temperature is particularly important when rearing fish species, such as tench, *Tinca tinca* (L.), which have specific thermal requirements (*e.g.*, Wolnicki 2005). Studies conducted in recirculating systems have focused on nutritional requirements (feed tests; *e.g.*, Wolnicki 2005), as well as the oxygen requirements and ammonia excretion of the juvenile stage of this species (Zakęś et al. 2006). The profitability of cultivating fish in recirculating systems depends on its intensification, which, in turn, requires the application of formulated feed (*e.g.*, Wolnicki 2005, Wolnicki et al. 2006). It is known that the application of formulated feed impacts the values of many zootechnical coefficients, including, among others, the slaughter yield, proximate composition, and fatty acids profile (*e.g.*, Shearer 1994, Jobling 2001).

Analyses of the impact feed (natural, grains, formulated feed) on the proximate composition and fatty acids profile of tench reared in ponds have been presented in a several publications (Steffens et al. 1998, Vácha and Tvrzicka 1998). In the case of these studies, the tench were reared under natural (variable) atmospheric conditions. The proximate composition of fish depends on many biotic and abiotic factors. In fish that are reared under natural atmospheric conditions (thermal regime and photoperiod) this also varies throughout the annual cycle (*e.g.*, Jobling 2001). Fish reared under optimal thermal conditions (non-variable) and fed to satiation are not subjected to natural, cyclic environmental variations. The comparison of the proximate composition and the fatty acids profile of these fish with those originating from the natural environment may provide researchers with valuable new data. These might provide significant information that allows conclusions to be drawn regarding the impact the intensive rearing of tench in recirculating systems has on the zootechnical and biochemical parameters mentioned above.

The aim of the current study was to determine the slaughter yield, proximate composition, and fatty acids profile of tench reared in recirculating systems on formulated feed and of specimens obtained from pond culture that had fed exclusively on natural food.

These fish, which had been reared under such different conditions, exhibited different growth rates. Thus, the fish used in the study were of similar size (body weight of approximately 400 g). The proximate composition of fish (the share of various chemical components) varies as body weight increases; therefore, comparing the meat quality (which was the primary aim of this publication) of different sized fish would have been futile.

MATERIALS AND METHODS

FISH AND REARING CONDITIONS

The study material was comprised of two groups of tench: the first was reared in earthen ponds and fed exclusively on natural food, while the second had been fattened intensively on formulated feed in a recirculating system. The specimens from the pond culture were obtained from the Dgał Experimental Hatchery, Inland Fisheries Institute in Olsztyn (DEH IFI). They were held in an earthen pond with a surface area of 0.21 ha in polyculture with common carp, *Cyprinus carpio* L., grass carp, *Ctenopharyngodon idella* (Val.), and acipenserids. These specimens were aged 5+ with a mean body weight of 420 g.

The fish that were fed exclusively formulated feed and reared in a recirculating system were also obtained from the DEH IFI. The mean body weight of these specimens was 354 g (aged 3+). They were the product of artificial spawning that had been stimulated with the hormonal preparation Ovopel (Horváth et al. 1997) and of initial rearing on formulated feed in recirculating systems (Wolnicki and Myszkowski 1998, Wolnicki et al. 2006). The fish were reared in rotation tanks made of artificial material and with a volume of 400 l. The fish were fed 2P Classic Trouvit feed (4.0 mm granules; for feed chemical composition see Table 1). In the final year of rearing the daily feed ration ranged from 0.5 to 0.7% of the stock biomass. The feed was delivered with an automatic band feeder 24 h d^{-1}.

Throughout the period when the tench were reared in recirculating systems the temperature and oxygen content of the water flowing out of the tanks was measured daily. Temperature ranged from 18.1-21.8°C, while the oxygen content did not fall below 5.8 mg O_2 l^{-1}. The water pH ranged from 7.76 to 7.95. The concentrations of total ammonia nitrogen (TAN = NH_4^+-N + NH_3-N) and nitrites NO_2-N were determined every 2-3 days. The ammonia concentration range was 0.33-0.70 mg TAN l^{-1}, and that of nitrites was 0.065-0.109 mg NO_2-N l^{-1}.

TABLE 1

Proximate composition, digestible energy (according to manufacturer data), and fatty acids profile of the formulated feed (% of the total fatty acids)

Specification	Value
Proximate composition	
Protein (%)	45.0
Fat (%)	16.0
Carbohydrates (%)	20.8
Ash (%)	8.5
Fiber (%)	1.7
Total phosphorous (%)	1.2
Digestible energy (MJ kg^{-1})	18.8
Vitamin A (IU kg^{-1})	10000
Vitamin D_3 (IU kg^{-1})	1500
Vitamin E (IU kg^{-1})	150
Fatty acids	
14:0	6.80
14:1	0.30
15:0	0.62
16:0	18.50
16:1	7.00
17:1	1.34
16:4	1.17
18:0	3.65
18:1cis9	12.24
18:1cis11	2.73
18:2n-6	4.60
18:3n-3	1.45
18:4	2.58
20:0	0.26
20:1n9	2.85
20:1n7	0.28
20:2	0.23
20:3n-6	0.13
20:4n-6	0.79
20:4n-3	0.78
20:5n-3	12.43
22:1n-11	3.08
22:1n-9	0.38
22:5n-6	0.37
22:5n-3	1.79
22:6n-3	13.64

In mid November ten specimens each were removed form the earthen pond culture and the recirculating systems. Immediately following capture, the fish were sacrificed and held for 24 h on ice. Following this, the fish were weighed to determine their body weight (BW ± 1g) and measured: total length (Lt ± 1 mm), body length (Lc ± 1 mm), head length (Lh ± 1 mm), maximum body height (h ± 1 mm), maximum body width (d ± 1 mm; Szlachciak 2000). The following were calculated: cephalic index (CI = Lh Lt^{-1}), relative body profile (Rp = h Lt^{-1}), and condition coefficient (K= (BW × 100) Lc^{-3}; Szlachciak 2000). After dissection, which included gutting, deheading with a simple cut, fin removal, filleting, and skinning the fillets, the viscera, head, fins, carcass, spine and ribs, fillets, and the skin were weighed. These data were used to determine the relative percentage share of these parts of the whole fish body weight.

DETERMINING THE PROXIMATE COMPOSITION OF THE MEAT

The skinned fillets were homogenized (mesh diameter – 3 mm), and then the contents of the basic components and the fatty acids profiles were determined. The water content was determined by drying the samples at a temperature of 105°C to a constant weight. The total protein content was determined with the Kjeldahl method using urea 6.25. The fat content was determined with the Soxhlet method with petroleum benzine as the solvent. The ash content was determined by mineralizing samples at a temperature of 550-600°C (AOAC 1975).

FATTY ACID ANALYSIS

The fatty acids profile was analyzed following the extraction of muscle lipids using the cold method according to Folch et al. (1957). The fatty acids were methylated with a mixture of chloroform: methanol: sulfuric acid (100:100:1) (Peisker 1964). Chromatographic separation was performed on an Agilent Technologies 6890 N gas chromatograph (USA), with a flame-ionizing detector (FID) and a 30 m capillary column with an internal diameter of 0.32 mm. The liquid phase was Supelcowax 10 (film thickness – 0.25 μm). The separation conditions were: carrier gas – helium; flow rate – 1 ml min^{-1}; temperatures: detector – 250°C, injector – 225°C, column – 180°C. Signals from the detector were registered by a Philips unit with a 1 mV scale at a tape rate of 10 mm min^{-1}. The identification of the particular acids was done by comparing the retention times with standards by Supelco (Bellefonte PA, USA).

STATISTICAL ANALYSIS

The values reported are the means ± S.E.M. obtained based on the analyses of 10 fish from each group (pond-reared fish that fed on natural food and fish reared in recirculation systems and fed formulated feed). The differences between the mean values of the studied determinants were calculated with one-way analysis of variance (ANOVA). When significant inter-group differences were determined ($P \leq 0.01$) further statistical analysis was performed with the Duncan test. The calculations were performed with the Statistica 6.0 PL program (SatSoft Inc., Cracow, Poland).

RESULTS AND DISCUSSION

Despite the different ages (5+ vs. 3+), the body weights of the pond tench that had fed on natural food and that of the fish from intensive culture reared on formulated feed were similar (Table 2; $P > 0.01$). This indicates that the growth rates of the two groups varied and that tench rearing time is substantially shorter under intensive conditions. It was noted that although the body weight was similar in the two analyzed groups, they differed with regard to total length, body length, and head length ($P < 0.01$). In turn, no significant differences were confirmed when maximum body height and width were compared ($P > 0.01$; Table 2).

TABLE 2

Biometric parameters and condition of tench from the analyzed groups (mean values ± S.E.M.)

Parameter	Tench – natural food (n = 10)	Tench – formulated feed (n =10)
Body weight – BW (g)	420a ± 40.6	354a ± 23.1
Total length – Lt (cm)	32.6a ± 1.44	26.7b ± 0.58
Body length – Lc (cm)	27.6a ± 1.40	22.8b ± 0.54
Head length – Lh (cm)	7.2a ± 0.20	5.7b ± 0.11
Maximum body height – h (cm)	7.6a ± 0.29	7.5a ± 0.23
Maximum body width – d (cm)	4.0a ± 0.17	4.3a ± 0.10
Relative body profile – Rp*	0.23a ± 0.01	0.28b ± 0.00
Cephalic index – CI**	0.22a ± 0.00	0.21a ± 0.00
Condition coefficient – K***	2.00a ± 0.15	3.00b ± 0.16

*$Rp = h\ Lt^{-1}$; **$CI = Lh\ Lt^{-1}$; ***$K = (BW \times 100)\ Lc^{-3}$

Values in the same row with different letter notation differ significantly statistically at $P < 0.01$

It is generally accepted that in comparison with other cyprinids the tench body is wide, but it has a small spine curvature (Brylińska and Bryliński 2000). The results of the current study confirmed that tench from the recirculating system had a higher relative body profile (Rp) coefficient; this stemmed from the fact that the specimens from this group had a shorter body length but a similar body height ($P < 0.01$) in comparison with the fish from the pond culture. No intergroup differences were noted with respect to the value of the cephalic index (CI) ($P > 0.01$; Table 2). Differences in condition were noted among the fish from the two groups. The value of condition coefficient K was higher in the fish from intensive culture (3.00 vs. 2.00; $P < 0.01$; Table 2). Wolnicki et al. (2003) also noted higher condition coefficients in juvenile tench fed exclusively on formulated feed in comparison with fish reared on formulated feed supplemented with natural feed (Chironomidae).

The dissection of the fish indicated that the slaughter yield of gutted fish and carcasses (deheaded and gutted), fillets with skin, and skinned fillets was lower in the tench from intensive rearing ($P < 0.01$; Table 3). The percentage share of the viscera was higher in the tench from intensive culture, while the share of the fins, head, spine with ribs, and the skin in both of the analyzed groups was not statistically significant ($P > 0.01$; Table 3). These data indicate that the different slaughter yield of the carcasses and the fillets stems from the different share of viscera in the total fish body weight. During dissection, it was determined that the digestive tracts of the tench were not full and that the fish from intensive culture were identifiable by the fat tissue surrounding the intestines, which comprised an average of 2.1% of the fish body weight (data not presented in the tables).

High-energy formulated feed can have a substantial impact on the proximate composition of fish, and, in effect, on the yield of its edible parts. Fish store excess energy from feed primarily as fat deposits in various parts of the body depending on the species (Jobling 2001). Tench from intensive culture deposited fat around the intestines, which meant that their slaughter yield and, accordingly, the skinned fillet yield (by 3.86%; $P < 0.01$; Table 3) was lower in comparison to that of the fish that had fed on natural food. The lower fillet yield did not, however, result from the different muscle mass of the tench, as is demonstrated by the equal values of fillets from the gutted carcass weight (Table 3).

TABLE 3

Slaughter yield of the tench from the analyzed groups (mean values ± S.E.M.)

Parameter	Unit*	Tench – natural food (n = 10)	Tench – formulated feed (n = 10)
Body weight	(g)	420.0a ± 40.6	354.0a ± 23.1
	(%)	100	100
Viscera weight	(g)	37.0a ± 4.6	48.0a ± 3.9
	(%)	8.81a ± 0.43	13.56b ± 0.67
Gutted fish weight	(g)	378.0a ± 36.4	301.0a ± 20.0
	(%)	90.00a ± 0.33	85.03b ± 0.64
Fin weight	(g)	10.0a ± 1.2	7.0a ± 0.6
	(%)	2.38a ± 0.18	1.98a ± 0.09
Head weight	(g)	60.0a ± 5.7	52.0a ± 3.0
	(%)	14.29a ± 0.29	14.69a ± 0.51
Carcass weight (without head and viscera)	(g)	308.0a ± 29.9	242.0a ± 16.9
	(%)	73.33a ± 0.42	68.36b ± 0.85
Spine and rib weight	(g)	49.0a ± 5.8	40.0a ± 2.9
	(%)	11.66a ± 0.51	11.30a ± 0.66
Fillet with skin weight	(g)	259.0a ± 24.7	202.0a ± 15.4
	(%)	61.66a ± 0.59	57.06b ± 0.96
Skin with scales weight	(g)	66.0a ± 7.6	53.0a ± 3.0
	(%)	15.71a ± 0.49	14.97a ± 0.57
Skinned fillet weight	(g)	193.0a ± 17,.	149.0a ± 12.5
	(%)	45.95a ± 0.99	42.09b ± 1.00
Loss	(g)	5.0a ± 0.0	5.0a ± 0.0
	(%)	1.19a ± 0.34	1.41a ± 0.18

** percentages based on the whole fish body weight*
Values in the same row with different letter notation differ significantly statistically at P < 0.01

Replacing natural food with formulated feed also had an impact on the proximate composition of the tench meat (Table 4). Although the ash content in the meat of the analyzed groups did not change (P > 0.01), the fat content increased significantly (by 8.27%), while there were decreases in the contents of water (by 6.66%) and protein (by 1.67%) (P < 0.01). The results obtained indicated that tench fed commercial feed store lipids not only as fat deposits near the intestines and possibly subcutaneously, but also as muscle fat. Thus, in the case of tench fed formulated feed exclusively, energy reserves are also stored in the muscles. According to Steffens et al. (1998), the content of muscle fat in tench feeding on natural food is 1.15%, while that in tench fed formulated feed is 10.2%. However, Quirós and Alvariňo (1998) determined that tench fed formulated feed throughout a year-long cycle contained more fat in the dorsal part of the large lateral muscle than did fish that were not fed during winter and fed a mixture of formulated feed and natural food (Diptera larvae and *Daphnia* sp.) during the remaining seasons of the year.

TABLE 4

Proximate composition of tench meat from the analyzed groups (% wet weight; mean values ± S.E.M.)

Specifiactaion	Tench – natural food (n = 10)	Tench – formulated feed (n = 10)
Water	80.23a ± 0.40	73.57b ± 0.43
Protein	18.19a ± 0.16	16.52b ± 0.18
Fat	0.58a ± 0.04	8.85b ± 1.02
Ash	1.08a ± 0.02	1.05a ± 0.02

Values in the same row with different letter notation differ significantly statistically at P < 0.01

The quality composition of the fatty acids in the meat of tench cultured intensively on formulated feed and that from traditional culture fed natural food was the same. Twenty-six fatty acids with carbon chain lengths from C14 to C22 were identified in the meat of both groups of fish (Table 5). These included 5 saturated (SFA), 9 monoenoic (MUFA), and 12 polyenoic fatty acids (PUFA). The relative combined share (% of all fatty acids) of unsaturated fatty acids (USFA) and SFA in tench meat from both groups compared did not differ significantly statistically ($P > 0.01$). The proportion of USFA to SFA in tench cultured on formulated feed or natural food was close at 3.12 and 2.97, respectively ($P > 0.01$; Table 5). However, statistically significant intergroup differences were determined for the total combined amounts of MUFA and PUFA. The tench fed formulated feed contained as much as 51% more MUFA and 28% less PUFA in comparison with the levels determined in the pond-reared tench that fed on natural food ($P < 0.01$). The fish from both groups also differed with regard to the combined contents of n-3PUFA and n-6PUFA. The tench reared on formulated feed had lower contents of these fatty acids (by 17 and 57%, respectively, in comparison with the levels determined in the pond tench; $P < 0.01$; Table 5).

Among the SFA, no statistically significant differences between the groups were determined in the amount of the dominant acid from this group – 16:0 (palmitic) ($P > 0.01$; Table 5). There were, however, differences in the amounts of the remaining fatty acids, namely 14:0 (myristic), 15:0 (pentadecanoic), 18:0 (stearic), and 20:0 (arachidic), while the tench from intensive culture contained a higher level of the first fatty acid ($P < 0.01$). In the MUFA group there were significant differences in the content of the most abundant fatty acid – 18:1cis9 (oleic), as well as in the other fatty acids with the exception of 22:1n-9 (erucic) ($P < 0.01$; Table 5).

TABLE 5

Fatty acids profile of tench meat from the analyzed groups (% total fatty acids; mean values ± S.E.M.)

Fatty acid	Tench – natural food (n = 10)	Tench – formulated feed (n = 10)
14:0	1.45a ± 0.13	4.66b ± 0.07
14:1	0.42a ± 0.04	0.19b ± 0.01
15:0	0.86a ± 0.03	0.49b ± 0.01
16:0	17.59a ± 0.42	17.15a ± 0.21
16:1	6.86a ± 0.36	11.57b ± 0.14
17:1	1.07a ± 0.02	0.95b ± 0.02
16:4	0.11a ± 0.02	0.48b ± 0.01
18:0	5.06a ± 0.32	1.77b ± 0.04
18:1cis9	12.76a ± 0.45	19.51b ± 0.31
18:1cis11	4.77a ± 0.29	3.25b ± 0.04
18:2n-6	5.76a ± 0.19	5.76a ± 0.14
18:3n-3	3.66a ± 0.28	1.16b ± 0.01
18:4	0.38a ± 0.05	1.39b ± 0.02
20:0	0.21a ± 0.01	0.16b ± 0.01
20:1n9	1.14a ± 0.33	4.00b ± 0.07
20:1n7	0.14a ± 0.01	0.25b ± 0.01
20:2	0.68a ± 0.06	0.36b ± 0.01
20:3n-6	0.64a ± 0.05	0.24b ± 0.01
20:4n-6	8.92a ± 1.06	0.58b ± 0.01
20:4n-3	0.72a ± 0.03	1.17b ± 0.01
20:5n-3	7.97a ± 0.20	7.38a ± 0.11
22:1n-11	0.71a ± 0.19	2.07b ± 0.06
22:1n-9	0.21a ± 0.01	0.36a ± 0.04
22:5n-6	0.70a ± 0.09	0.25b ± 0.00
22:5n-3	3.53a ± 0.32	1.93b ± 0.03
22:6n-3	13.87a ± 1.25	12.91a ± 0.61
Σ SFA	25.18a ± 0.41	24.23a ± 0.30
Σ USFA	74.82a ± 0.41	75.77a ± 0.30
USFA/SFA	2.97 a ± 0.21	3.12 a ± 0.11
Σ MUFA	27.90a ± 0.74	42.15b ± 0.40
Σ PUFA	46.92a ± 0.99	33.62b ± 0.59
n-3 PUFA	29.75a ± 0.79	24.55b ± 0.57
n-6 PUFA	16.02a ± 1.10	6.83b ± 0.12
n-3/n-6	1.93a ± 0.20	3.60b ± 0.10

SFA – saturated fatty acids; USFA – unsaturated fatty acids; MUFA – monoenoic fatty acids; PUFA – polyenoic fatty acids; n-3PUFA – n-3 polyenoic fatty acids; n-6PUFA – n-6 polyenoic fatty acids

Values in the same row with different letter notation differ significantly statistically at P < 0.01

Additionally, the meat of tench from intensive culture contained more 16:1 (palmitoleic), 18:1 cis9, 20:1n-9 (gadoleic), 20:1n-7, and 22:1n-11 (cetoleic), and less 14:1 (myristoleic), 17:1 (margaroleic), and 18:1cis11 ($P < 0.01$; Table 5). The dominant fatty acid among PUFA was 22:6n-3 (docosahexaenoic, DHA), the content of which did not differ significantly among the tench from the two groups ($P > 0.01$). A lack of intergroup differences was also noted with regard to 20:5n-3 (eicosapentaenoic, EPA) and 18:2n-6 (linoleic, LA). The remaining fatty acids occurred in various amounts in the tench reared on natural food and those cultured on formulated feed ($P < 0.01$; Table 5). The meat of tench cultivated on formulated feed contained more 16:4, 18:4, 20:4n-3 (eicosatetraenoic), and less 18:3n-3 (α-linolenic, LNA), 20:3n-6 (di-homo-γ-linoleic), 20:4n-6 (arachidonic, AA), 22:5n-6 (docosapentaenoic), and 22:5n-3 (docosapentaenoic, DPA) ($P < 0.01$).

The results presented indicate that the quality profile of the fatty acids of tench meat was not dependent on diet. However, the relative content of fatty acids was largely dependent on the diet. This refers to the combined content of MUFA and PUFA, the proportion of which, despite significant differences in the amount of USFA, was different. The meat of tench reared on formulated feed contained more MUFA and less PUFA. Bieniarz et al. (2001) reported an identical dependence with regard to common carp; in comparison to specimens that had been reared with supplemental grain, those cultivated exclusively on natural food had higher levels of PUFA, lower MUFA, and similar SFA. The main groups of neutral lipid fatty acids in most freshwater species are MUFA and SFA, while the phospholipids contain more PUFA, a similar amount of SFA, and less MUFA in comparison to the neutral lipids (Henderson and Tocher 1987). The accumulation of deposited fat in tench meat changed the relation between the share of phospholipids and triacylglycerols, which is confirmed by work focused on the lipid fraction composition of fish that differ in fat content (Poli et al. 2001, Regost et al. 2003, Cejas et al. 2004, Rodríguez et al. 2004). As a consequence, the MUFA and PUFA proportion in the tench fed formulated feed exclusively changed in comparison with that of the tench cultivated exclusively on natural food, whose meat contained several-fold less fat.

The higher MUFA content in the tench from recirculating systems in comparison with those cultivated on natural feed resulted mainly from the contents of 16:1, 18:1cis9, 20:1n-9, and 22:1n-11. The fatty acids present in the lipids of freshwater fish can come directly from the diet; however, some SFA and MUFA can be synthesized *de novo* from nonlipid precursors (Henderson 1996). The higher levels of 16:1 and 18:1cis9 in the fish fed the formulated feed, which had lower levels of these lipids, is an indication that this process occurred. It has also been established that the contents of 20:1n-9 and 22:1n-11 in the meat of wild freshwater fish is low (Linko et al. 1992, Ahlgren et al. 1994, Żmijewski et al. 2006). The preceding observations confirm the results of the current investigation with reference to the pond tench cultivated on natural food. However, the fatty acids mentioned above appear in significant quantities in the marine fish used to produce fish meal (Gruger 1967), and they were present in the formulated feed used to cultivate tench in recirculating systems (Table 1). The retention of these fatty acids from formulated feed can be viewed as the reason for the higher content of them in the tench fed this type of feed. It was also determined that the higher PUFA content in the tench reared on natural food also stems from the higher n-3PUFA and n-6PUFA. Vácha and Tvrzická (1998) also observed a tendency for a higher content of n-6PUFA in the ventral fillet and n-3 PUFA in the whole fillet of tench fed exclusively on natural food in comparison with specimens whose diet had been supplemented with wheat and barley. Conversely, Steffens et al. (1998) reported that the neutral lipids in tench from intensive cultivation (with formulated feed) are characterized by a higher share of n-3 fatty acids and a lower share of n-6 in comparison with tench from extensive (natural food) and semi-intensive (natural food plus wheat) culture.

The ratio of n-3/n-6 determined in tench cultivated on natural food was within the range reported by Henderson and Tocher (1987) for freshwater fish. It also concurs with the values reported by Ahlgren et al. (1994) for the dorsal meat of wild tench, which was 1.90 at a combined total PUFA content of 44.84%. The data published by Bieniarz et al. (2000) for tench inhabiting earthen ponds and feeding on natural food were also very similar. In the current investigation it was confirmed that the ratio of n-3/n-6 fatty acids determined for tench reared on natural food was close to two-fold lower than that determined in the meat of tench reared exclusively on formulated feed. This was due primarily to the difference in the combined content of n-6PUFA rather than that of n-3PUFA. Similar differences in n-3/n-6 ratios were also determined by Steffens et al. (1998).

Data regarding the individual fatty acids from the families mentioned above indicate that the dependence reported previously stems primarily from the several-fold higher (8.92 vs. 0.58%) content of AA in the tench reared on natural food. The tendency for high AA contents in wild fish is confirmed by Suzuki et al. (1986) for muscle lipids in carp, by Ahlgren et al. (1999) for grayling, *Thymallus thymallus* (L.), and Cejas et al. (2004) for white seabream, *Diplodus sargus* (L.). Adámek et al. (2003) confirmed that the tench diet under natural conditions is comprised primarily of zooplankton (Cladocera, Copepoda) and bottom sediments. Bell et al. (1994) reported that freshwater invertebrates contain more of the AA acid than does formulated feed. Unfortunately, although the current authors do not have information regarding the fatty acids profile of the natural feed of tench reared in ponds, the results obtained regarding the formulated feed indicate that the low AA content in the meat of tench from the recirculating system corresponds to the low level of this acid in the formulated feed applied. This confirms that the content of the AA acid in the meat of tench depended directly on the composition of the formulated feed, and that the desaturation/elongation process of the n-6 fatty acids with shorter carbon chains did not occur (Fig. 1).

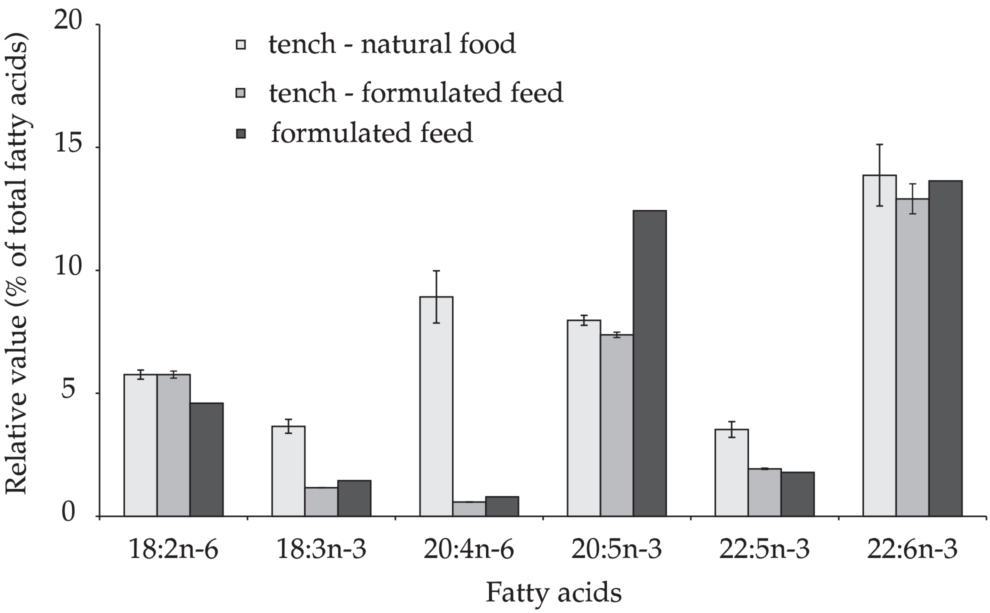

Fig. 1. Relative value of fatty acids in tench meat from the analyzed groups and in the formulated feed (% of the total fatty acids) (mean values ± S.E.M.).

The range of differences in the content of fatty acids belonging to the n-3 family between the tench from both groups was substantially lower, although the content of 18:3n-3 (3.66 vs. 1.16%) and 22:5n-3 (3.53 vs. 1.93%) was about two-fold higher, and that of 20:4n-3 (0.72 vs. 1.17%) was about two-fold lower in the tench fed formulated feed. This prompts the observation that, in the case of the current investigation, the content of the two dominant fatty acids from this family, EPA and DHA, did not differ in the groups of fish compared. These results, especially with regard to DHA, do not concur with the data reported by Quirós and Alvariňo (1998). According to these authors, the way fish feed has an impact on the amount of this fatty acid, and in the tench fed exclusively formulated feed (trout pellets: 3.07% DHA) it is lower that that determined in tench fed formulated feed and plankton. Further, Steffens et al. (1998) confirmed higher contents of DHA in tench fed formulated feed than in fish cultivated on natural feed. Thus, the data regarding the impact diet has on the contents of the DHA and EPA fatty acids are not unequivocal.

SUMMARY

In summation, it can be concluded that diet determined the slaughter yield, proximate composition, and the relative fatty acid content of tench. The fish fed formulated feed have lower carcass and fillet yields, which results from the higher viscera weight. The consequence of applying formulated feed was a shift in the amounts of all the basic components, with the exception of ash, as well as an increase in dry weight and the share of fat in it, while the protein content decreased. Replacing natural food with formulated feed resulted in lowering the relative content of n-6PUFA vs. n-3PUFA. The lower amount of n-3PUFA did not result from the quantity of the polyunsaturated, long-chain fatty acids DHA and EPA. In light of this, the meat of tench reared on artificial feed which contained more fat may be a valuable source of essential n-3 fatty acids for the consumer.

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STRESZCZENIE

WPŁYW DIETY NA WYDAJNOŚĆ RZEŹNĄ, PODSTAWOWY SKŁAD I PROFILE KWASÓW TŁUSZCZOWYCH FILETA LINA (*TINCA TINCA* (L.))

Celem niniejszych badań było określenie wartości rzeźnej, podstawowego składu ciała i profili kwasów tłuszczowych lina podchowywanego w obiegach recyrkulacyjnych na paszy sztucznej i osobników pozyskanych w wyniku chowu stawowego, odżywiających się wyłącznie pokarmem naturalnym.

Zbliżona masa ciała, pomimo różnego wieku, linów pochodzących ze stawów (masa 420 g, wiek 5+) i z intensywnego chowu (masa 354 g, wiek 3+) wskazuje na znacznie krótszy czas podchowu w warunkach intensywnych. Wydajność tuszy patroszonej, tuszy patroszonej i odgłowionej oraz filetów nieodskórzonych i odskórzonych była niższa u lina pochodzącego z chowu intensywnego, co wynikało z większej masy wnętrzności (tab. 3). Zastąpienie pokarmu naturalnego paszą sztuczną wpłynęło na skład podstawowy mięsa lina Zwiększyła się istotnie zawartość tłuszczu (o 8,27%), a obniżyła wody (o 6,66%) oraz białka (o 1,67%), natomiast zawartość popiołu nie uległa zmianie (tab. 4).

Jakościowy skład kwasów tłuszczowych mięsa lina z chowu intensywnego, żywionego paszą sztuczną i z chowu tradycyjnego na pokarmie naturalnym był identyczny. Relatywny łączny udział (% wszystkich kwasów tłuszczowych) kwasów nienasyconych oraz nasyconych (SFA) w mięsie lina z obu porównywanych grup nie różnił się istotnie. Stwierdzono natomiast różnice międzygrupowe w łącznej zawartości monoenowych kwasów tłuszczowych (MUFA) i polienowych kwasów tłuszczowych (PUFA). Lin żywiony paszą sztuczną zawierał o 14,25% więcej MUFA i o 13,30% mniej PUFA. Ryby z obu grup różniła także łączna zawartość n-3PUFA oraz n-6PUFA. Niższą zawartością wymienionych kwasów tłuszczowych (odpowiednio o 5,20% i 9,19%) cechowały się liny żywione paszą sztuczną.

Proporcja n-3/n-6 u lina podchowywanego w obiegach recyrkulacyjnych i żywionego paszą sztucznym była blisko dwukrotnie wyższa niż stwierdzona u ryb stawowych (3,60 wobec 1,93). Mięso ryb żywionych intensywnie paszą sztuczną zawierało wielokrotnie mniej 20:4n-6 (arachidonowy, AA; 0,58 wobec 8,92%), lecz zawartość 20:5n-3 (ikozapenaenowy, EPA; 7,38 wobec 7,97%) i 22:6n-3 (dokozoheksaenowy, DHA; 12,91 wobec 13,87%) nie różniła się istotnie (tab. 5).