Slaughter yield, proximate composition, and flesh colour of cultivated and wild perch *(Perca fluviatilis* L.)

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ABSTRACT: The aim of this research was to determine the slaughter yield, proximate composition, and flesh colour of cultivated and wild perch *(Perca fluviatilis*). The study material was composed of fish obtained from intense fattening on formulated feed (age 1+, mean body weight (BW 116 g)) and wild specimens caught in a lake (age 3+, BW 119 g). The biometric traits of the two groups of fish did not differ with regard to body weight, total length (Lt), body length (Lc), or condition coefficient ($P > 0.01$). The cultivated perch had both higher maximum body height (H) and relative body profile (Rp) ($P \leq 0.01$). The cultivated perch has a significantly lower slaughter yield ($P \leq 0.01$). This dependence stems from the heavier viscera, which included more perivisceral fat and larger liver. Cultivated perch had significantly higher values of the viscerosomatic (VSI; 12.0 vs. 6.4), hepatosomatic (HSI; 1.9 vs. 1.7), and perivisceral fat (IPF; 7.0 vs. 1.2) indices. The analysis of the proximate composition of fillets from wild and cultivated perch indicated that the ratios of protein, fat, water were significantly different ($P \leq 0.01$). The higher content of dry matter in the cultivated perch was a result of higher fat and protein contents. The fillets of the two groups of perch differed with regard to the saturation of green and yellow pigment; the cultivated perch exhibited lower values of parameter a* and higher values of parameter b* ($P \leq 0.01$).

Keywords: *Perca fluviatilis*; slaughter yield; proximate composition; flesh colour

The aim of experimental aquaculture is to identify the potential for cultivating new species of aquatic animals, and this also includes percoid species (Brown et al., 1996; Mélard et al., 1996; Kestemont and Mélard, 2000). Some studies focus on determining the impact intensive feeding with formulated feed has on the slaughter yield and flesh quality of these species of fish. Rearing fish under strictly controlled conditions can alter their slaughter yield, proximate composition, and other parameters of the flesh. The formulated feed used for intensive fattening plays a significant role since fish feed has a direct impact on the abovementioned indices (Lie, 2001). In previous studies, one of the current authors demonstrated that the pikeperch, *Sander lucioperca* (L.), among others, can be successfully fattened on formulated feed in recirculating systems (Zakęś, 2003). This method produces fish that have a higher fat content than wild fish. Thus, in 100 g of edible flesh there is a higher percentage of healthful unsaturated fatty acids, including eicosapentaenoic (EPA) and docosahexaenoic (DHA) acid (Jankowska et al., 2003).

The results of the research on the slaughter value of perch (*Perca fluviatilis* L.) include those from studies on the impact of the protein/energy proportion in the feed on the gutting and filleting yield and the proximate composition and organoleptic values of the flesh (Mathis et al., 2003). The impact of various amounts of fat in the feed on the proximate composition of perch and the dependence between the type of dietary fat and the fatty acids profile of the perch were also analyzed (Xu et al., 2001; Xu and Kestemont, 2002). Kestemont et al. (2001) investigated the impact of various amounts of fats in the feed containing an antioxidizing additive on the content of lipids and the fatty acid composition of perch flesh. From the potential con-

sumer's point of view, a comparison of the slaughter value of cultivated and wild perch appears to be of interest. To date, only Mairesse et al. (2004, 2005) have undertaken investigations to evaluate the organoleptic and technological properties of cultivated and wild perch.

The aim of the present study was to determine the slaughter yield, proximate composition, and flesh colour of perch of comparable body weights that were reared in recirculating systems on formulated feed and of wild individuals obtained from natural lakes that fed on natural feed.

MATERIAL AND METHODS

Fish, origin

The experimental material was composed of perch that were fattened intensively with formulated feed at the Dgał Experimental Hatchery of the Inland Fisheries Institute in Olsztyn, Poland. Larvae obtained from artificial breeding were reared in basins 1 m^3 in volume that were a part of the recirculating system. After the specimens had attained a body weight (BW) of approximately 2 g, the larvae were transferred to basins 2 m^3 in volume. Throughout the rearing period, the fish were fed slightly in excess with Nutra Classic (TROUVIT, France) trout granulate. In the last six months of fattening, the fish were fed T-2P Classic feed of the following chemical composition (manufacturer's data): protein 45%, fat 16%, carbohydrates 20.8%, ash 8.5%, cellulose 1.7%, total phosphorus 1.2%, vitamin A 10 000 IU/kg, vitamin D3 1 500 IU/kg, vitamin E 150 IU/kg. The digestible energy was 18.8 MJ/kg, and the pellet size was 4.0 mm. The feed (daily ration of 0.3–0.5% of the stock biomass) was delivered with an automatic feeder for 24 hours a day. The stock density during the last two months of rearing was 40 to 60 kg/m^3. Water temperature and oxygen concentration at the outlet were measured daily, while the concentrations of nitric compounds and pH at the outflow were measured every three days. The water temperature during rearing ranged from 17.9 to 22.8°C. The oxygen concentration did not drop below 5.1 mg O_2/l. The concentration of total ammonia nitrate (TAN = NH_4^+–N + NH_3–N) was 0.08–0.52 mg TAN/l and that of nitrite was 0.019–0.236 mg NO_2-N/l. The water pH ranged from 7.79 to 8.43.

The second group of fish was composed of wild perch caught in the autumn with a seine in Dgał Wielki Lake (Mazurian Lakeland, Northern Poland). The surface area of the lake is 94.5 ha, the maximum depth is 17.6 m and the average depth is 5.3 m. The ichthyofauna is dominated by *Cyprinidae*, northern pike (*Esox lucius* L.) and European perch (*Perca fluviatilis* L.).

The environmental conditions in this lake corresponded to those that prevail in eutrophic and dimictic lakes (Brylińska, 2000).

Biometric and technological data collection procedures

In mid-November, 18 specimens of both the cultivated (age 1+) and wild (age 3+) fish were removed from the basins. Scales from the fish were used for age determinations (Brylińska, 2000). Immediately after removal from the basins, the fish were sacrificed and held for 24 hours on ice. Then, they were weighed (BW ± 0.1 g) and measured for total length (Lt ± 1 mm), body length (Lc ± 1 mm), and maximum height (H ± 1 mm) (Szlachciak, 2000). The morphometric and weight measurements were used to calculate the relative body profile (Rp = H/Lt) and the condition coefficient ($K = (BW \times 100)/Lc^3$). After dissection, or gutting, simple cut deheading, fin removal, and fillet skinning, the viscera, perivisceral fat, liver, head, fins, fat, spine with ribs, unskinned fillets, skin, and skinned fillets were weighed (to the nearest ± 0.1 g). Based on the total fish body weight and the weight of the various parts, the slaughter yield following gutting, deheading, filleting, and fillet skinning was determined for each specimen. The percentage proportions of the head, spine with ribs, fins, and skin were calculated based on total BW. The following indices were also calculated: viscerosomatic VSI = 100 × (viscera weight (g)/BW (g)); hepatosomatic HSI = 100 × (liver weight (g)/BW (g)); perivisceral fat IPF = 100 × (weight of the perivisceral fat (g)/BW (g)).

Determining the proximate composition of fish flesh

The proximate composition of the fillets was determined after they had been ground (mesh size – 3 mm). The water content was determined by drying the samples at a temperature of 105°C to

a constant weight. Protein was determined by the Kjeldahl method using a conversion factor of 6.25, and fat was determined by the Soxhlet method using petroleum ether as the solvent. Ash was determined by combusting the samples at a temperature of 550–600°C (AOAC, 1975).

Determining flesh colour

Measurements of the flesh colour of skinned fillets were done immediately after the fish had been filleted. Three samples were taken from the dorsal part of the fillet in the anterior, mid, and posterior sections, and the result was the mean value of these three measurements. The instrument used was a CL-4606 Spectro-color (Hoch Lange GmBH, Germany) spectrophotometer with an aperture diameter of 8 mm, a D65 light source, a standard colorimetric observer with a 10° field of vision, and SPECTRAL-QC software. The trichromatic coordinates were classified according to the CIE pattern: L* (lightness), a* (red–green spectrum), b* (yellow–blue spectrum). The chromaticity (saturation) $C^* = (a^{*2} + b^{*2})^{1/2}$ and the hue $H^* = \arctan (b^*/a^*)$ were also calculated.

Statistical analysis

The values reported are the means ± S.E.M. obtained by the analysis of 18 fishes (cultivated and wild). The differences between the mean values of the studied parameters were calculated by single-factor analysis of variance (ANOVA). When statistically significant differences between groups were confirmed ($P \leq 0.01$), Duncan's test was applied. Calculations were done with software Statistica 6.0 PL (StatSoft Inc., Kracow, Poland).

RESULTS AND DISCUSSION

The data obtained indicate that the perch cultivated with commercial trout feed have a substantially faster growth rate. The body weights and total lengths of the cultivated fish at age 1+ were comparable to those attained by wild fish at age 3+. The results of biometric measurements of the two groups indicated that the wild and cultivated perch did not differ regarding their body weight, total length, body length, or condition ($P > 0.01$, Table 1). However, the spine curvature and relative body profile (Rp) ($P \leq 0.01$) were more pronounced in cultivated perch.

Table 1. Biometric parameters of cultivated perch (reared in recirculating systems on formulated feed) and wild perch from natural conditions (mean value ± S.E.M.)

Parameter	Cultivated perch (n = 18)	Wild perch (n = 18)
Body weight – BW (g)	119.4^a ± 8.50	116.1^a ± 4.30
Total length – Lt (cm)	20.1^a ± 0.5	20.8^a ± 0.3
Body length – Lc (cm)	17.1^a ± 0.5	18.2^a ± 0.3
Maximum body height – H (cm)	5.3^a ± 0.2	4.7^b ± 0.1
Relative profile – Rp*	0.30^a ± 0.00	0.26^b ± 0.00
Condition coefficient – K**	1.47^a ± 0.03	1.29^a ± 0.02
Weight after gutting (g)	105.0^a ± 7.7	108.7^a ± 3.9
Viscera weight (g)	14.3^a ± 1.3	7.4^b ± 1.0
Liver weight (g)	2.3^a ± 0.2	2.0^a ± 0.1
Perivisceral weight (g)	8.4^a ± 0.9	1.4^b ± 0.3
Head weight (g)	28.4^a ± 2.0	27.7^a ± 1.1
Fish weight after gutting and deheading (g)	76.7^a ± 5.6	81.0^a ± 2.7
Fin weight (g)	3.0^a ± 0.2	2.4^b ± 0.1
Weight of spine with ribs (g)	10.5^a ± 1.1	10.7^a ± 0.6
Weight of fillets wit skin (g)	63.1^a ± 4.7	67.7^a ± 2.3
Skin weight (g)	12.1^a ± 1.1	12.1^a ± 0.6
Skinned fillet weight (g)	50.9^a ± 3.6	55.6^a ± 1.8

*Rp = H/Lt; ** $K = (BW \times 100)/Lc^3$; values in the same row with different letter indices differ statistically significantly ($P \leq 0.01$)

Table 2. Slaughter yield of cultivated and wild perch (in % of fish body weight) (mean values ± S.E.M.)

Item	Cultivated perch (n = 18)	Wild perch (n = 18)
Gutted fish	88.0^a ± 0.3	93.7^b ±1.3
Viscerosomatic index – VSI*	12.0^a ± 0.3	6.4^b ± 0.8
Hepatosomatic – HSI*	1.9^a ± 0.1	1.7^b ± 0.1
Perivisceral index – IPF*	7.0^a ± 0.31	1.2^b ± 0.4
Head	23.8^a ± 0.4	23.9^a ± 0.4
Fish after gutting and deheading	64.2^a ± 0.4	69.8^b ± 0.7
Fins	2.5^a ± 0.1	2.1^b ± 0.1
Spine with ribs	8.8^a ± 0.4	9.2^a ± 0.3
Fillets with skin	52.6^a ± 0.5	58.4^b ± 1.2
Skin	10.2^a ± 0.2	10.4^a ± 0.3
Skinned fillets	42.5^a ± 0.5	47.9^b ± 0.7

*explanation in Materials and Methods section; values in the same row with different letter indices differ statistically significantly ($P \leq 0.01$)

The dissection of the fish revealed that the wild and cultivated perch did not differ with respect to the weight of the muscles, skin, or spine with ribs ($P > 0.01$; Table 1). Statistically significant differences between groups were noted in the comparison of the weights of the viscera and perivisceral fat ($P \leq 0.01$). By determining the relative percentage proportion of these parameters in the total body weight, the following dependences were noted: the slaughter yield of the cultivated perch was lower by more than 5% (93.7 vs. 88.0%) in comparison with wild perch ($P \leq 0.01$; Table 2). Similar relationships were determined between the two fish groups with regard to carcass yield (gutted and deheaded), skinned fillets, and unskinned fillets. The yield of skinned fillets from cultivated perch was 42.5%, while that of the wild fish was 47.9% of the total BW ($P \leq 0.01$; Table 2). The values of the analyzed indices VSI, HSI, and IPF ($P \leq 0.01$; Table 2) were higher in cultivated perch.

The two groups of fish also differed in the technological parameters such as gutting yield and filleting yield. The slaughter yield of the cultivated perch was lower at each stage of initial processing ($P \leq 0.01$). This was linked directly to the higher VSI index of the perch from this group. Similarly, Mathis et al. (2003) reported that the VSI index was one of the parameters that were correlated with filleting yield, and its value determined for a representative sample of fish is a potential index that can be used to determine the filleting yield of the whole population. It was confirmed that differences in filleting yield and VSI index were not only characteristic of wild and cultivated perch, they were noted in cultivated fish from different rearing systems (extensive, semi-intensive, intensive). Intensifying rearing conditions resulted in increased values of the VSI and IPF indices, and their highest values were noted in fish from intensive rearing in recirculating systems (Mairesse et al., 2005). Additionally, it was demonstrated that feeding the perch formulated feed caused an increase in the value of the HSI index. Similarly, Xu et al. (2001) confirmed that the value of the HSI index increased as the energy content of the feed increased; the highest HSI values and the largest quantities of fat in the liver were noted in perch that received feed with the highest fat content.

The increase of fat deposits in the abdomen also led to changes in slaughter yield in other predatory fish species such as rainbow trout, *Oncorhynchus mykiss* (Walb.), (Jobling et al., 1998), Atlantic salmon, *Salmo salar* L. (Jobling and Johannes, 2003), and European sea bass, *Dicentrarchus labrax* (L.), (Boujard et al., 2004). However, the application of formulated feed did not always lead to changes in the slaughter yield. Significant differences were not confirmed in the values of this parameter in cultivated and wild pikeperch; the only tendency that was noted was the lower fillet yield in specimens from intensive rearing (Jankowska et al., 2003). It can be inferred, however, that these differences are related to species characteristics, the environmental conditions of rearing, and also the quantity and quality of the feed (Jobling, 2001).

Table 3. Proximate composition of fillets from cultivated and wild perch (% wet weight; mean values ± S.E.M.)

Component	Cultivated perch (n = 18)	Wild perch (n = 18)
Water	77.3^{a} ± 0.2	80.9^{b} ± 0.1
Protein	20.1^{a} ± 0.1	17.6^{b} ± 0.2
Fat	1.3^{a} ± 0.1	0.3^{b} ± 0.0
Ash	1.3^{a} ± 0.0	1.2^{a} ± 0.0

Values in the same row with different letter indices differ statistically significantly ($P \leq 0.01$)

The proximate composition data indicates that the contents of water, protein and fats in the fillets of cultivated and wild perch differed significantly statistically ($P \leq 0.01$; Table 3). Cultivated perch contained more protein (20.1% vs. 17.6%) and fat (1.3% vs. 0.3%); however, the water content in the fillets of cultivated perch was lower than that in wild perch (77.3% vs. 80.9%). It was confirmed that the fat and water content was inversely dependent (Shearer, 1994). It was also determined, however, that the fillets of cultivated perch, which had a lower water content, also contained a higher quantity of protein. Similarly, according to Periago et al. (2005), the wild European sea bass differs from cultivated specimens not only in the fat and water content, but also in the higher protein content. Since the ability of predatory fish to utilize carbohydrates is limited, their diets must contain fat, which is exploited primarily as a source of energy (Lie, 2001). Increasing the energy value of feed led to the improved utilization of protein and it resulted in a protein-sparing effect. The commercial feed applied in the present study contained 16% fat, and the corresponding increase in the protein can be viewed as a consequence of the more effective utilization of this feed component. The results obtained from the present research are supported by the observations of Xu et al. (2001), who confirmed that an increased fat content in the feed given to perch resulted in improved protein utilization. Mathis et al. (2003) concluded that the application of high-energy feed in the rearing of European perch also led to the reduced excretion of nitric compounds. The protein-sparing effect of high-energy diets was also reported in groups of cultivated fish such as red tilapia, *Oreochromis mossambicus* (Peters) × *O. urolepis* (Norman), gilthead sea bream, *Sparus aurata* L., rainbow trout, and Chinese longsnout catfish, *Leiocassis longirostris* Günther (Beamish and Medland, 1986; De Silva et al., 1991; Vergara et al., 1996; Weatherup et al., 1997; Pei et al., 2004).

The fat content of the fish of a given species can be highly differentiated and is impacted by factors such as feed type and access, and, as a rule, wild fish usually contain less of this component in comparison with cultivated specimens (Lanari et al., 1999; Jobling, 2001; Alasavar et al., 2002; Orban et al., 2003; Boujard et al., 2004; Gonzáles et al., 2006). Similar dependences were also confirmed by the current authors in previous studies conducted on other predatory freshwater fish species such as pikeperch and European wels, *Silurus glanis* L. (Jankowska et al., 2003, 2007). The fat content in the flesh of wild perch (present study) was similar to that of 0.54% determined by Litwińczuk et al. (2000) in fish from Polish lakes. Due to this fat content level, perch are classified as lean fish (Macrae et al., 1993). Although intensive fattening conducted in recirculating systems led to nearly a five-fold increase in fat content in comparison with that of wild specimens, its amount did not exceed 2%, which is the value that separates lean fish from low-fat fish (Jobling, 2001). Similar results were obtained by Mathis et al. (2003) indicating that the application of formulated feed with a fat content range of 11.9–22.2% led to a fat content in the dorsal fillet of perch that ranged from 1.23% to 1.35%. However, Xu et al. (2001) confirmed that the flesh of perch fed formulated feed containing from 11.7 to 19.3% fat contained as much as 5.1–5.0% of this component. These differences can be related to the fact that the utilization of feed by fish and their fat metabolism can depend on a variety of factors such as fish age and size, feed composition, and feed ration (Shearer, 1994).

Excess energy provided by the diet is stored as triglycerides in the muscles and/or in other deposits in the fat tissues of the fish (Kiessling et al., 2001). Depending on the season, wild perch store their energy reserves primarily either in perivisceral fat or in the gonads (Sulistyo et al., 1998, 2000). However, it was observed in the studied cultivated perch that the applied formulated feed led

Table 4. Colour of fillets from cultivated and wild perch (mean values ± S.E.M.)

Parameter	Cultivated perch (n = 18)	Wild perch (n = 18)
L*	44.12^{a} ± 0.33	46.21^{a} ± 0.20
a*	-5.38^{b} ± 0.32	-3.68^{a} ± 0.12
b*	9.87^{b} ± 0.21	6.01^{a} ± 0.18
C*	11.24^{b} ± 0.80	7.05^{a} ± 0.32
H*	-1.07^{a} ± 0.11	-1.02^{a} ± 0.10

Values in the same row with different letter indices differ statistically significantly ($P \leq 0.01$)

not only to an increased amount of intestinal fat but also to increased fat contents in the muscles. This is confirmed by the fact that in addition to storing fat in the body cavity, this fish can also store excess energy in other forms. Simultaneously, the range of changes in the muscle fat content and in the perivisceral fat in reared perch, in comparison with wild specimens, was very similar with quantities of muscle fat increasing about five times and that of perivisceral fat approximately six times. However, according to Xu et al. (2001), European perch deposits excess fat from feed mainly around the intestines and in the liver.

The flesh colour of both groups of fish was determined by similar values of parameters L* and H* ($P > 0.01$; Table 4). Significant differences between the cultivated and wild specimens were noted in parameters a* and b*. The flesh from the former specimens had lower values of parameter a* (–5.38% vs. –3.68) and higher values of b* (9.87% vs. 6.01) ($P \leq 0.01$; Table 4). These results regarding the lightness of the perch flesh indicate that no significant differences occurred between the groups. High values of parameter L*, which are typical of fish with white flesh, were noted for both the cultivated and the wild perch. Parameter a* had negative values (green hue), while the values of parameter b* were positive (yellow hue), but the values in the two perch groups differed. Although the chromaticity of the green and yellow hues was higher in the cultivated perch, it was not confirmed that the total colour saturation of the hues or their shades was dependent on the origin of the perch. The comparison of these results with those from other predatory freshwater fish species studied by the current authors (i.e. pikeperch and wels) indicated that the tendencies were similar in all three species (Jankowska et al., 2003, 2007). The lightness, chromaticity, and the shade of the flesh colour of fish from intensive culture did not differ from those of wild fish or of fish reared under extensive conditions. Similarly, Gonzáles et al. (2006) revealed that the fillets of wild and cultivated yellow perch, *Perca flavescens* (Mitch), differed in the lightness of colour. However, the difference was only in the saturation of hues that are components of both the green and the yellow. Wild perch expend more energy moving than do those kept in basins, which may consequently contribute to different values of a*. Bjornevik et al. (2003) observed that although the value of a* is always negative, it differed between the specimens of cod, *Gadus morhua* L., which indicates different activity levels. The varied growth rates of the perch inhabiting different conditions have a potential impact on the quantity and diameter of the muscle fibres, and this could also have had an impact on fillet colour (Johnston, 1999; Johnston et al., 2000). However, for example, in the case of cod no dependence was confirmed bet-ween the structure of the muscle fibres and the values of parameter a* (Bjornevik et al., 2003). It cannot be excluded that the different amounts of fat in the fillets of the two perch groups, which resulted from the different chemical composition and energy value of the feed, had an impact on this parameter.

REFERENCES

Alasavar C., Taylor K.D.A., Zubcov E., Shahidi F., Alexis M. (2002): Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*): total lipid content, fatty acid and trace mineral composition. Food Chem., 79, 145–150.

AOAC (1975): Official Methods of Analysis. Association of Official Analytical Chemists. Washington, USA.

Beamish R.W.H., Medland T.E. (1986): Protein sparing effects in large rainbow trout, *Salmo gairdneri*. Aquaculture, 55, 35–42.

Bjørnevik M., Karlsen Ø., Johnston I.A., Kiessling A. (2003): Effect of sustained exercise on white muscle structure and flesh quality in farmed cod (*Gadus morhua* L.). Aquac. Res., 34, 55–64.

Boujard T., Gèlineau A., Covès D., Corraze G., Dutto G., Gasset E., Kaushik S. (2004): Regulation of feed intake, growth, nutrient and energy utilization in European sea bass (*Dicentrarchus labrax*) fed high fat diets. Aquaculture, 231, 529–545.

Brown P.B., Dabrowski K., Garling D.L. (1996): Nutrition and feeding of yellow perch (*Perca flavescens*). J. Appl. Ichthyol., 12, 171–174.

Brylińska M. (2000): Freshwater Fish of Poland. PWN SA, Warsaw. (in Polish)

De Silva S.S., Gunasekera R.M., Smith K.F. (1991): Interaction of varying dietary protein and lipid levels in young red tilapia: evidence of protein sparing. Aquaculture, 95, 306–318.

Gonzáles S., Flick G.J., O`Keefe S., Duncan S.E., McLean E., Craig S.R. (2006): Composition of farmed and wild yellow perch *(Perca flavescens*). J. Food Compos. Anal., 19, 720–726.

Jankowska B., Zakęś Z., Żmijewski T., Szczepkowski M. (2003): A comparison of selected quality features of the tissue and slaughter yield of wild and cultivated pikeperch (*Sander lucioperca* (L.)). Eur. Food Res. Technol., 217, 401–405.

Jankowska B., Zakęś Z., Żmijewski T., Ulikowski D., Kowalska A. (2007): Slaughter value and flesh characteristics of European catfish (*Silurus glanis*) fed natural and formulated feed. Eur. Food Res. Technol., 224, 453–459.

Jobling M. (2001): Nutrient partitioning and the influence of feed composition on body composition. In: Houlihan D., Boujard T., Jobling M. (eds.): Food Intake in Fish. Blackwell Science Ltd., Oxford, UK, 354–375.

Jobling M., Johansen S.J.S. (2003): Fat distribution in Atlantic salmon *Salmo salar* L. in relation to body size and feeding regime. Aquac. Res., 34, 311–316.

Jobling M., Koskela J., Savolainen R. (1998): Influence of dietary fat level and increased adiposity on growth and fat deposition in rainbow trout, *Oncorhynchus mykiss* (Walbaum). Aquac. Res., 29, 601–607.

Johnston I.A. (1999): Muscle development and growth: potential implications for flesh quality in fish. Aquaculture, 177, 99–115.

Johnston I.A., Alderson R., Sandham C., Dingwall A., Mitchell D., Selkirk C., Nickell D., Baker R., Robertson B., Whyte D., Springate J. (2000): Muscle fibre density in relation to the colour and texture of smoked Atlantic salmon (*Salmo salar* L.). Aquaculture, 189, 335–349.

Kestemont P., Mélard C. (2000): Aquaculture. In: Craig J.F. (ed.): Percid Fishes, Systematics, Ecology and Exploitation. Blackwell Science, Oxford, UK, 191–224.

Kestemont P., Vandeloise E., Mélard C., Fontaine P., Brown P.B. (2001): Growth and nutritional status of Eurasian perch *Perca fluviatilis* fed graded levels of dietary lipids with or without added etoxyquin. Aquaculture, 203, 85–99.

Kiessling A., Pickova J., Johansson L., Øsgård T., Storebakken T., Kiessling K.-H. (2001): Changes in fatty acid composition in muscle and adipose tissue of farmed rainbow trout (*Oncorhynchus mykiss*) in relation to ration and age. Food Chem., 73, 271–284.

Lanari D., Poli B.M., Ballestrazzi R., Lupi P., D'Agaro E., Mecatti M. (1999): The effects of dietary fat and NFE levels on growing European sea bass (*Dicentrarchus labrax* L.). Growth rate, body and fillet composition, carcass traits and nutrient retention efficiency. Aquaculture, 179, 351–364.

Lie Ø. (2001): Flesh quality – the role of nutrition. Aquac. Res., 32, 341–348.

Litwińczuk A., Król J., Skałecki P., Olesiuk E. (2000): Slaughter yield and the proximate composition of the flesh of fish from lakes in the Łęczyńsko-Włodawskie Lakeland. Ann. UMCS Sec., EE 18, 175–181. (in Polish)

Macrae R., Robinson R.K., Sadler M.J. (1993): Encyclopaedia of food science, food technology and nutrition. Academic Press, London, UK.

Mairesse G., Thomas M., Gardeur J.-N., Brun-Bellut J. (2004): Reared perch *v*. wild perch – first results about organoleptical and technological quality. J. Fish Biol., 65, 321–321.

Mairesse G., Thomas M., Gardeur J.-N., Brun-Bellut J. (2005): Appearance and technological characteristics in wild and reared Eurasian perch, *Perca fluviatilis* (L.). Aquaculture, 246, 395–311.

Mathis N., Feidt C., Brun-Bellut J. (2003): Influence of protein/energy ratio on carcass quality during the growing period of Eurasian perch (*Perca fluviatilis*). Aquaculture, 217, 453–464.

Mélard C., Kestemont P., Grignard J.C. (1996): Intensive culture of juvenile and adult Eurasian perch (*P. fluviatilis*): effect biotic and abiotic factors on growth. J. Appl. Ichthyol., 12, 175–180.

Orban E., Nevigato T., Di Lena G., Casini I., Casini I., Marzetti A. (2003): Differentiation in the lipid quality of wild and farmed seabass (*Dicentrarchus labrax*) and gilthead bream (*Sparus aurata*). J. Food Sci., 68, 128–132.

Pei Z., Xie S., Lei W., Zhu X., Yang Y. (2004): Comparative study on the effect of dietary lipid level on growth and feed utilization for Gibel carp (*Carasius auratus gibelio*) and Chinese longsnout catfish (*Leiocassis longirostris* Günther). Aquac. Nutr., 10, 209–216.

Periago M.J., Ayala M.D., López-Albors O., Abdel I., Martínez C., Garcia-Alcázar A., Ros G., Gil F. (2005): Muscle

cellularity and flesh quality of wild and farmed sea bass, *Dicentrarchus labrax* (L). Aquaculture, 249, 175–188.

Shearer K.D. (1994): Factors affecting the proximate composition of cultured fish with emphasis on salmonids. Aquaculture, 119, 63–88.

Sulistyo I., Fontaine P., Rinchard J., Gardeur J.N., Migaud H., Capdeville B., Kestemont P. (2000): Reproductive cycle and plasma levels of steroids in male Eurasian perch *Perca fluviatilis*. Aquat. Living Resour., 13, 99–106.

Sulistyo I., Rinchard J., Fontaine P., Gardeur J.N., Capdeville B., Kestemont P. (1998): Reproductive cycle and plasma levels of sex steroids in female Eurasian perch *Perca fluviatilis.* Aquat. Living Resour., 11, 101–110.

Szlachciak J. (2000): Body shape, colouring, biometric and meristic characters. In: Brylińska M. (ed): Freashwater Fish of Poland. PWN SA, Warsaw, 49–64. (in Polish)

Vergara J.M., Robaina L., Izquierdo M., de la Higuera M. (1996): Protein sparing effects of lipids in diets for fingerlings of gilthead sea bream. Fish Sci., *62*, 624–628.

Weatherup R.N., McCracken K.J., Foy R., Rice D., McKendry J., Maris R.J., Hoey R. (1997): The effects of dietary fat content on performance and body composition of farmed rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 151, 173–184.

Xu X.L., Fontaine P., Mélard C., Kestemont P. (2001): Effects of dietary fat levels on growth, feed efficiency and biochemical composition of Eurasian perch *Perca fluviatlis.* Aquac. Int., 9, 437–449.

Xu X., Kestemont P. (2002): Lipid metabolism and fatty composition in tissues of Eurasian perch *Perca fluviatilis* as influenced by dietary fats. Lipids, 37, 297–304.

Zakęś Z. (2003): Pikeperch, *Sander lucioperca* production in recirculating systems. Bull. VURH Vodňany, 1/2, 136–140. (in Czech with English summary)

Received: 2006–10–04
Accepted after corrections: 2007–05–16

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