Production value, chemical composition and colour of fillets of the reciprocal hybrid of Siberian sturgeon with green sturgeon (*Acipenser baeri* Br × (*Acipenser baeri* × *Acipenser medirostris* Ayres)

B. Jankowska[1], R. Kolman[2], M. Szczepkowski[3], T. Żmijewski[1]

[1]Department of Meat Technology and Chemistry, Faculty of Food Science, University of Warmia and Mazury in Olsztyn, Poland
[2]Department of Ichthyology, Institute of Inland Fisheries, Olsztyn, Poland
[3]Stocking Centre DGAŁ Z.R.J, Institute of Inland Fisheries, Olsztyn, Poland

ABSTRACT: Fillet yield, colour, chemical composition and fatty acid composition in the reciprocal hybrid (SSZ) of Siberian sturgeon with its crossbred with green sturgeon were analysed. It was found that fillet yield in relation to the weight of gutted and deheaded carcass did not deviate from the parent forms. SSZ does not keep the salmon-pink colour of tissue, which is typical of the father form. Its tissue contains more ($P \leq 0.01$) protein and less ($P \leq 0.01$) water than the parental tissue as well as less ($P \leq 0.01$) fat than the father's tissue. The percentage of MUFA in tissue lipids corresponds to their proportion in the father form, whereas the corresponding values for SFA and PUFA are closer to the father form and much higher ($P \leq 0.01$) than in the mother form. A 100 g portion of the SSZ tissue for consumption contains a higher total amount of n-3 acids as well as EPA and DHA than the parent fish, with a higher difference in comparison with Siberian sturgeon.

Keywords: sturgeon; hybridisation; fillet yield; colour; basic composition; fatty acids

Hybridisation, widely used in sturgeon breeding, is mainly aimed at improvement of its production value. The hybrids obtained as a result of such a breeding process usually manifest higher growth rate and survivability, they achieve sexual puberty earlier and they are better suited to intensive breeding (Burtsev, 1969; Burtsev *et al.*, 1987; Gershanovich *et al.*, 1987).

In 1995, the first crossbred of Siberian sturgeon with green sturgeon (SZ) was obtained. The examination of the new hybrid revealed its higher production value in comparison with the parent species (Kolman *et al.*, 1997). Numerous features, including tissue quality, have been found to be inherited to a greater extent from the father species (Kolman *et al.*, 1999; Jankowska *et al.*, 2002).

The experimental results of the hybrid production value encouraged researchers to carry out spawning with milt from its maturing males and fertilise the spawn of Siberian sturgeon. The reciprocal hybrid of Siberian sturgeon with green sturgeon – SSZ – was obtained in this way (Kolman *et al.*, 2003).

This objective of this study was to evaluate the tissue quality of the new hybrid SSZ and its application in determining the principles of inheritance of production values in Acipenseridae fish.

MATERIAL AND METHODS

Six specimens of a reciprocal hybrid (SSZ) Siberian sturgeon × (Siberian sturgeon × green sturgeon) – *Acipenser baeri* Br × (*Acipenser baeri* × *Acipenser medirostris* Ayres) were the subjects of the experiment. The hybrid was obtained by the fertilization of Siberian sturgeon spawn with the milt of a hybrid between Siberian sturgeon and green sturgeon (Kolman and Szczepkowski, 2003). The obtained fish at the age 1+ were bred in initial rearing pools with a closed water circuit. The experimentally controlled rearing lasted 60 days. Fish were randomly sampled for analyses at the end of this rearing phase. The pools were 1.6 m^3 each and the stocking was 30 fishes. The experimental sturgeons were fed standard trout granulated feed produced by Aller-Pl with reduced content of fat and of the following basic composition: dry matter – 93.04%, total protein – 46.89%, raw fat – 13.82% and ash – 8.72%.

The reed mixture was distributed continuously with belt feeders, and the daily dose was equal to 0.6% of the fish stock weight. The breeding was done in water at a temperature of about 20°C. The oxygen content in the water outflowing from the pools with fish did not drop below 70% of the saturation level and the concentrations of undissociated ammonia and nitrites did not exceed the values considered as harmful to Acipenseridae fish (Kolman, 1999).

After their total weight was established (BW ± 1 g), the fish were gutted, deheaded, the fins and bone plates were removed and the fillets were skinned. These parts were weighed and their relative contribution to the total weight of a fish as well as the fillet yield in relation to the weight of gutted and deheaded carcass was determined. The right-hand skinned fillet of each fish was used for the colour analysis and, after being ground (average 3 mm), it was analysed for basic components and fatty acid composition.

The colour was determined at three points of the dorsal part of the fillet, i.e. in the cephalic, middle and caudal parts, and the results were calculated as the mean values of the measurements. A Spectrocolor apparatus, manufactured by Dr Lange, with an 8 mm measuring hole, a D65 light source, a standard colorimetric observer with 10°C field of vision and SPECTRAL-QC computer software was used in the measurements. Before each measurement series, the apparatus was calibrated with the black and white standard manufactured by DR Lange. Trichromatic coordinates were established according to the CIE system (L*, a*, b*).

The water content was determined by the method of drying samples at a temperature of 105°C to the constant weight, total protein by Kjeldahl's method with the multiplier 6.25; fat by Soxhlet's method, with petroleum ether as solvent; ash was determined by the mineralisation of samples at a temperature of 550–600°C (AOAC, 1975).

Qualitative and quantitative analysis of the fatty acid composition was conducted after cold extraction of muscle lipids, according to Folch *et al.* (1957). Fatty acids were methylated with a mixture of chloroform : methanol : sulphuric acid (100 : 100 : 1) (Peisker, 1964). The mixture was separated chromatographically on an Agilent Technologies 6890 N gas chromatographer, with a flame ionisation detector (FID), a 30 m long capillary column of an inner diameter of 0.32 mm. The liquid phase was Supelcowax 10 and a film thickness was 0.25 µm. The separation conditions were as follows: carrier gas – helium, flow rate 1 ml/min, detector temperature 250°C, temperature of the injector 225°C, temperature of the column 180°C. The detector's signals were registered with a Philips recorder with a 1 mV scale at the tape movement rate of 10 mm/min. Individual acids were identified by comparing their retention times with Supelco (Bellefonte, PA, USA) standards.

The results of the yield and quality of the SSZ reciprocal hybrid tissue were compared with the results of previous studies into the following species: the mother species (Siberian sturgeon) and the father species (a hybrid of Siberian sturgeon with green sturgeon) (Jankowska *et al.*, 2002).

The results are the mean of three replications ± standard deviation (SD). The significance of differences (at $P < 0.01$) was calculated using a single-factor analysis of variance (ANOVA) with SNK (Student-Newman-Keuls) test. Calculations were done with a Statistica 6.0 PL software package.

RESULTS AND DISCUSSION

The evaluation of Siberian sturgeon and green sturgeon (SSZ) in comparison with their parent forms showed that the proportion of gutted and deheaded carcass and of the fillet in the whole fish was lower ($P \leq 0.01$) in SSZ. The difference in comparison with Siberian sturgeon (mother form) was over 12.84 and 9.90%; in the case of Siberian sturgeon × green sturgeon crossbred (father form) it was 9.69 and 7.22%, respectively (Table 1). Although the collective proportion of the head, spine, ribs, fins and bone plates (hard waste) did not differ much from the parent forms, the proportion of guts and gonads (soft waste) was much higher ($P \leq 0.01$). The difference, which results from the filling of the alimentary tract, caused a decrease in the carcass proportion and, in consequence, in that of the fillet.

Table 1. The yield of sturgeon fillet (mean ± SD) (own research, Kolman *et al*., 2002)

Item	Siberian sturgeon × (Siberian sturgeon × green sturgeon)			Siberian sturgeon			Siberian sturgeon × green sturgeon		
	weight (g)	proportion (%)	yield (%)	weight (g)	proportion (%)	yield (%)	weight (g)	proportion (%)	yield (%)
Whole fish	1 527 ± 158	100.00		1 415 ± 132	100.00		7 260 ± 643	100.00	
Carcass*	868 ± 97	56.84^a ± 2.15	100.00	986 ± 98	69.68^b ± 2.35	100.00	4 830 ± 396	66.53^b ± 1.76	100.00
Fillet with skin	668 ± 83	43.74^a ± 1.88	76.96^c ± 1.73	759 ± 87	53.64^b ± 2.18	76.98^c ± 2.03	3 700 ± 383	50.96^b ± 1.99	76.60^c ± 1.89
Soft waste**	259 ± 32	16.96^a ± 2.16		119 ± 23	8.41^b ± 2.47		470 ± 54	6.47^b ± 2.24	
Hard waste***	586 ± 66	38.38^a ± 1.71		537 ± 68	37.95^a ± 1.83		3 090 ± 264	42.56^a ± 2.43	

*deheaded and gutted; **guts, gonads; ***head, spine, ribs, fins, bone plates, values in the same lines denoted with different letters are significantly different at $P < 0.01$

Table 2. Colour parameters of a sturgeon fillet (mean ± SD) (own research, Jankowska *et al*., 2002)

Species – hybrid	L*	a*	b*
Siberian sturgeon × (Siberian sturgeon × green sturgeon)	67.70^a ± 5.06	-1.53^a ± 0.44	16.02^a ± 1.05
Siberian sturgeon	69.49^a ± 3.58	0.87^a ± 0.12	18.76^a ± 1.91
Siberian sturgeon × green sturgeon	59.20^b ± 2.15	5.69^b ± 0.34	25.62^b ± 1.75

Values in the same columns denoted with different letters are significantly different at $P < 0.01$

The fillet yield (76.96%) in relation to the carcass weight does not deviate from the value found for the parent forms (Table 1). It can therefore be stated that the muscle-to-skeleton ratio in the reciprocal hybrid is similar to that found in the parent forms which, in effect, produce the same fillet yield.

A reference in the colour parameters of an SSZ fillet to the parent forms shows that L* (lightness), a* (redness) and b* (yellowness) were very close to the values determined in Siberian sturgeon. However, all of the above colour parameters deviated ($P \leq 0.01$) from the values established for the crossbred of Siberian sturgeon and green sturgeon (Table 2). The reciprocal hybrid does not have the salmon-pink colour of the tissue, which is typical of the father form and which is inherited from green sturgeon. The colour of its tissue, as in the case of Siberian sturgeon (the mother form), is white-grey.

The comparison of the basic component content showed that a fillet from an SSZ contained more ($P \leq 0.01$) protein and less ($P \leq 0.01$) water than the parent forms. The protein content was different by 22.1 g/kg from Siberian sturgeon and by 13.1 g/kg from its crossbred with green sturgeon. The fat content in SSZ was 6.0 g/kg lower than the value established for the mother form and 25.0 g/kg higher ($P \leq 0.01$) than in the father form (Table 3). The data presented here indicate that the SSZ tissue differs from the parent forms in terms of the basic component content. In terms of the protein content, it is closer to the crossbred of Siberian sturgeon with green sturgeon; in terms of the fat content it is closer to Siberian sturgeon.

According to Badiani *et al.* (1997), significant differences were observed between the water, fat and protein content in the tissue of the three sturgeon species; *Acipenser baeri, A. naccari* and *A. transmontanus.* Interestingly, the protein content ranged from 186.4 to 194.7 g/kg, but the fat content range was broader – from 44.9 to 106.4 g/kg. In a similar manner, the hybridisation of Siberian and green sturgeon affected the fat content to the largest extent.

Table 3. The content of basic components (g/kg) in sturgeon tissue (mean ± SD) (own research, Jankowska *et al,* 2002)

Species – hybrid	Water	Protein	Fat	Ash
Siberian sturgeon × (Siberian sturgeon × green sturgeon)	$735.2^{a} \pm 5.5$	$165.1^{a} \pm 3.8$	$89.0^{a} \pm 5.8$	$9.8^{a} \pm 0.5$
Siberian sturgeon	$752.0^{b} \pm 7.5$	$143.0^{b} \pm 7.2$	$95.0^{a} \pm 3.9$	$9.0^{a} \pm 0.3$
Siberian sturgeon × green sturgeon	$774.0^{c} \pm 4.4$	$152.0^{c} \pm 4.1$	$64.0^{b} \pm 4.7$	$9.0^{a} \pm 0.4$

Values in the same columns denoted with different letters are significantly different at $P < 0.01$

The mixture of fatty acids from SSZ muscles, like in the parent forms, contained more monounsaturated fatty acids (MUFA) than saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA). In addition, the proportion of MUFA was similar to that in the father form and lower than that determined in the mother form. The sums of SFA and PUFA were also closer to the father form and much higher ($P \leq 0.01$) than in the mother form (Table 4).

Considering the proportion of particular fatty acids in these groups, the following relationships were significant: the highest SFA value, typical of SSZ, was a result of a variable proportion of the 16:0 (palmitic) acid, whose content is the highest. Its content was 2.58% higher than in the mother form, and 1.10% higher than in the father form.

The tissue from SSZ contained the dominating 1-unsaturated acid – 18:1 cis9 (oleic) in the amount lying between the corresponding values for the parent forms; the amount of the 16:1 (palmitoleic) acid was higher ($P \leq 0.01$) than in the mother form. The amounts of the 20:1 n-9 (gadoleic) and 22:1 n-11 acids were the lowest ($P \leq 0.01$). The total content of the latter two acids in the parent forms ranged from 10.55 to 14.95%; in SSZ it amounted to 5.88%. This value lies within the value range found out by Badiani *et al.* (1997) for the three sturgeon species bred in aquaculture. These acids are found in much higher amounts in bred fish than in those living in the wild, which was shown for Gulf sturgeon (*Acipenser oxyrinchus desotoi*), pikeperch (*Stizostedion lucioperca*) and turbot (*Scophthalmus maximus*) (Chen *et al.*, 1995; Sérot *et al.*, 1998; Jankowska *et al.*, 2003). The acids originate from artificial feed mixtures used for fish feeding that contain meal or fish oil, e.g. capelin oil (*Mallotus villosus*) (Gruger, 1967; Caballero *et al.*, 2002). The lower content of these acids in SSZ compared to the parent forms may result from its less intensive absorption or from bioconversion (Henderson, 1996). A similar diversification of the amounts of the acids in question was found in Siberian sturgeon and its crossbreds with green sturgeon which were fed the same feed mixture (Jankowska *et al.*, 2002).

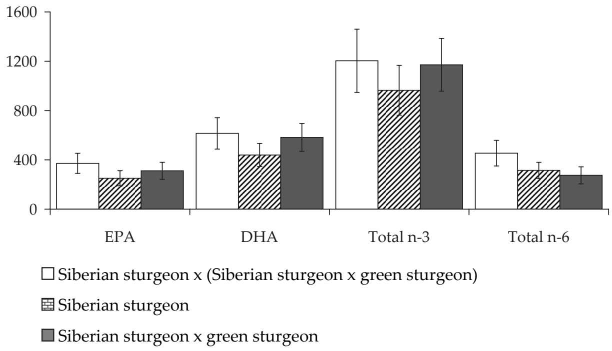

Figure 1. The content of n-3 PUFA and n-6 PUFA in sturgeon tissue (mg/100 g of tissue)

The proportion of PUFA, which is the most important in terms of the nutritional value of fish, reaching the level of 27.08%, was only 0.93% lower than in the father form and 6.61% higher ($P \leq 0.01$) than the mother form. Among the acids from this group, n-3 acids accounted for 19.58%, and n-6 acids for 6.59%; hence, the n-3/n-6 proportion was 2.97. SSZ had a higher ($P \leq 0.01$) percentage of n-6 acids than the parental species as well as a higher ($P \leq 0.01$) percentage of n-3 acids than the mother species. The higher content of the n-6 acids was determined mainly by the amount of the 18:2 n-6 (linoleic) acid ($P \leq 0.01$). The diversification of the n-3 acids proportion was decided mainly by the proportion of the acids: 20:5 n-3 (eicosapentaenoic acid, EPA) and 22:6 n-3 (docosapentaenoic acid, DPA), which was higher ($P \leq 0.01$) than in the mother species by 1.45% and 2.30%, respectively.

The presence of the two above-mentioned fatty acids is particularly interesting as they are the most characteristic components of fish lipids and their effect on the human body is favourable, or even therapeutic (Harrocks and Yeo, 1999; Uauy and Valenzuela, 2000). Consequently, the total amount

Table 4. Fatty acid composition (% of all fatty acids) in muscle fat of sturgeon (mean ± SD) (own research, Jankowska *et al.*, 2002)

Fatty acids	Siberian sturgeon × (Siberian sturgeon × green sturgeon)	Siberian sturgeon	Siberian sturgeon × green sturgeon
$C_{14:0}$	$4.47^{a} \pm 0.36$	$4.40^{a} \pm 0.68$	$4.87^{a} \pm 0.36$
$C_{16:0}$	$19.79^{a} \pm 1.92$	$17.21^{a} \pm 2.07$	$18.69^{a} \pm 0.30$
$C_{18:0}$	$1.91^{a} \pm 0.15$	$1.84^{a} \pm 2.20$	$1.67^{a} \pm 0.07$
Total SFA	$26.71^{a} \pm 1.92$	$23.93^{b} \pm 0.81$	$25.84^{a} \pm 0.04$
$C_{16:1}$	$8.18^{a} \pm 0.68$	$5.10^{b} \pm 0.28$	$6.43^{ab} \pm 1.30$
$C_{18:1\ cis9}$	$27.77^{ab} \pm 1.48$	$31.63^{a} \pm 0.68$	$25.51^{b} \pm 0.45$
$C_{18:1\ cis11}$	$2.80^{a} \pm 0.14$	$2.81^{a} \pm 0.14$	$2.82^{a} \pm 0.05$
$C_{20:1\ n-9}$	$3.97^{a} \pm 0.25$	$9.56^{b} \pm 0.45$	$6.56^{c} \pm 0.01$
$C_{22:1\ n-11}$	$1.91^{a} \pm 0.30$	$5.39^{b} \pm 0.11$	$3.99^{c} \pm 0.02$
$C_{22:1\ n-9}$	$0.64^{a} \pm 0.03$	$0.89^{b} \pm 0.07$	$0.59^{c} \pm 0.02$
Total MUFA	$46.21^{a} \pm 1.27$	$55.59^{b} \pm 0.27$	$46.15^{a} \pm 0.87$
$C_{18:2\ n-6}$	$5.63^{a} \pm 0.19$	$4.13^{b} \pm 0.29$	$4.36^{b} \pm 0.53$
$C_{18:3\ n-3}$	$1.22^{a} \pm 0.88$	$0.99^{a} \pm 0.14$	$1.21^{a} \pm 0.02$
$C_{18:4\ n-3}$	$1.25^{ab} \pm 0.12$	$0.92^{a} \pm 0.16$	$1.33^{b} \pm 0.02$
$C_{20:4\ n-6}$	$0.63^{a} \pm 0.07$	$0.48^{a} \pm 0.02$	$0.56^{a} \pm 0.06$
$C_{20:4\ n-3}$	$0.75^{a} \pm 0.07$	$1.01^{b} \pm 0.01$	$0.95^{ab} \pm 0.10$
$C_{20:5\ n-3}$	$5.46^{a} \pm 0.38$	$4.01^{b} \pm 0.13$	$6.04^{a} \pm 0.67$
$C_{22:5\ n-3}$	$1.45^{a} \pm 0.07$	$1.46^{a} \pm 0.11$	$1.87^{b} \pm 1.16$
$C_{22:6\ n3}$	$9.34^{a} \pm 0.72$	$7.04^{b} \pm 0.19$	$11.28^{a} \pm 0.71$
Total n-3	$19.58^{b} \pm 0.68$	$15.43^{a} \pm 0.74$	$22.68^{b} \pm 1.28$
Total n-6	$6.59^{a} \pm 0.12$	$5.04^{b} \pm 0.33$	$5.32^{b} \pm 0.45$
n-3/n-6	$2.97^{a} \pm 0.11$	$3.04^{a} \pm 0.06$	$4.26^{b} \pm 0.61$
Total PUFA	$27.08^{a} \pm 1.68$	$20.47^{b} \pm 1.07$	$28.01^{a} \pm 0.83$
Total USFA	$73.29^{a} \pm 1.92$	$76.07^{a} \pm 0.81$	$74.16^{a} \pm 0.04$

The fatty acids whose content in all sturgeon species is lower than 0.5%, i.e. 14:1, 15:0, 17:1, 20:0, 20:1 n-7, 20:2 n-6, 20:3 n-3, 21:1, 22:5 n-6, have been omitted

SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, USFA – unsaturated fatty acids

Values in the same lines denoted with different letters are significantly different at $P < 0.01$

of n-3, EPA and DHA acids in 100 g of fillet for consumption was compared. The results are presented in Figure 1; they show that the tissue of SSZ contains more of these acids than both of the parent forms. The difference is particularly striking in the case of Siberian sturgeon. Therefore, the back-breeding of Siberian sturgeon and green sturgeon favourably affects the quality of the hybrid's tissue in terms of the n-3 acid content, which is visible both in its increase in comparison with the mother form and in an increase in the total fat content in comparison with the father form.

In summing up it can be stated that the back-breeding of Siberian and green sturgeon yields a hybrid which is the equal of the parent forms in terms of fillet yield. Although it does not inherit the salmon-pink colour of tissue, which is so attractive to consumers, it can yield more long-chain, polyunsaturated, n-3 (LC n-3 PUFA) fatty acids, particularly in comparison with its mother form.

REFERENCES

AOAC (1975): Official methods of analysis of the association of official analytical chemists. Washington, DC 20044.

Badiani A., Stipa S., Nanni N., Gatta P.P., Manfredini M. (1997): Physical indices, processing yields, compositional parameters and fatty acid profile of three species of cultured sturgeon (genus *Acipenser*). J. Sci. Food Agric., *74*, 257–264.

Burtsev I.A. (1969): Poluchenie potomstva ot mezhrodovogo gobrida belugi so sterljad'ju. In: Cherfas B.I. (ed.): Genetika, selektsja i gibridizatsja ryb. Moskva, Izd. Nauka. 232–242.

Burtsev I.A., Nikolaev A.I., Arefjev B.A., Serebrjakova E.V., Slizchenko A.G. (1987): Osobennosti vozvratnykh form bestera i napravlenija selektsji s ikh ispol'zovaniem. In: Geneticheskie issledovanija morskikh gidrobiontov. Moskva, Sorn. Nauch. Trud., VNIRO, 143–156.

Cabarello M.J., Obach A., Rosenlund G., Montero D., Gisvold M., Izquierdo M.S. (2002): Impact of different dietary lipid sources on growth, lipid digestibility, tissue fatty acid composition and histology of rainbow trout, *Oncorhynchus mykiss*. Aquaculture, *214*, 253–271.

Chen I-C., Chapman F.A., Wei C-I, Portier K.M., O'Keefe S.F. (1995): Differentiation of cultured and wild sturgeon (*Acipenser oxyrinchus desotoi*) based on fatty acid composition. J. Food Sci., *60*, 631–635.

Folch H, Less M., Stanley H.A. (1957): A simple method for isolation and purification of total lipids from animal tissues. J. Biol. Chem., *226*, 497–499.

Gershanovich A.D., Pegasov B.A., Shatunovski M.I. (1987): Ekologiya i Fiziologiya molodi osetrovykh ryb. Moskva, Agropromizdat. 215 pp.

Gruger E.H. (1967): Fatty acid composition. In: Stansby M.E. (ed.): Fish Oil. Their Chemistry, Technology, Stability, Nutritional Properties, and Uses. Westport, Connecticut, The Avi Publishing Company. 3–31.

Henderson R.J. (1996): Fatty acid metabolism in freshwater fish with particular reference to polyunsaturated fatty acids. Arch. Anim. Nutr., *49*, 5–22.

Horrocks L.A., Yeo Y.K. (1999): Health benefits of docosahexaenoic acid (DHA). Pharm. Res., *40*, 211–225.

Jankowska B., Kwiatkowska A., Kolman R., Szczepkowska B. (2002): A comparison of certain characteristics of tissue of Siberian sturgeon (*Acipenser baeri* Brandt) and that of its hybrid with green sturgeon (*Acipenser medirostris* Ayres). E J P A U series Fisheries, *5*.

Jankowska B., Zakęś Z., Żmijewski T., Szczepkowski M. (2003): Fatty acid profile and tissue utility of wild and cultured zander, *Sander lucioperca* (L). E J P A U series Fisheries, *6*.

Kolman R. (1999): Jesiotry. Olsztyn, Wyd. IRŚ. 136 pp.

Kolman R., Krylowa V.D., Szczepkowska B., Szczepkowski M. (1999): Meristic studies of Siberian sturgeon (*Acipenser baeri* Brandt) and its crosses with green sturgeon (*Acipenser medirostris* Ayres). Czech J. Anim. Sci., *44*, 97–101.

Kolman R., Szczepkowska B. Jankowska B. Kwiatkowska A. (2002): Porównanie jesiotra syberyjskiego (*Acipenser baeri* Brandt) oraz jego krzyżówki z jesiotrem sachalińskim (*Acipenser medirostris* Ayres) pod względem wydajności rzeźnej i jakości mięsa. Kom. Ryb., *67*, 5–7.

Kolman R., Szczepkowski M. (2003): Nowy hybryd zwrotny jesiotra syberyjskiego (*Acipenser barii* Brandt) i krzyżówki jesiotra syberyjskiego z jesiotrem zielonym (*Acipenser medirostris* Ayres) – sztuczne tarło i przetrzymywanie wylęgu. In: Ryby drapieżne rozród, podchów, profilaktyka. Red. Z. Zakęś, K Dembskiej-Zakęś, T. Krzywosza i J. Wolnickiego. Wyd. JRS, 169–174.

Kolman R., Szczepkowski M., Kolman H. (2003): Otsenka proizvodstvennykh i meristicheskikh pokazateley hovogo vozvratnogo gibrida SSZ'a *Acipenser bari* Br. × (*A. baeri* × *A. medirostris*). Tavriiskii Nauk. Vestn., *29*, 108–113.

Kolman R., Szczepkowski M., Pyka J. (1997): Evaluation of Siberian sturgeon (*Acipenser baeri* Brandt) and green sturgeon (*A. medirostris* Ayres) hybrid comparing to the mother species. Arch. Ryb. Pol., *5*, 51–58.

Peisker K. (1964): Rapid semi-micro method for methyl esters from triglicerides using chloroform, methanol, sulphuric acid. J. Am. Oil Chem. Soc., *11*, 87–90.

Sérot T., Gandemer G., Demaimay M. (1998): Lipid and fatty acid composition of muscle from farmed and wild adult turbot. Aquacult. Int., *6*, 331–343.

Uayu R., Valenzuela A. (2000): Marine oils: the health benefits of n-3 fatty acids. Nutrition, *16*, 680–684.

Received: 04–09–20
Accepted after corrections: 05–01–12

Corresponding Author

Barbara Jankowska, Katedra Technologii i Chemii Mięsa, UW-M w Olsztynie, pl. Cieszyński, 10-718 Olsztyn, Poland
Tel. +48 89 523 32 95, fax +48 89 523 36 94, e-mail: barbara.jankowska@uwm.edu.pl