Turkish Journal of Fisheries and Aquatic Sciences 6: 23-27 (2006)

Effect of Vegetable Protein and Oil Supplementation on Growth Performance and Body Composition of Russian Sturgeon Juveniles (*Acipenser gueldenstaedtii* Brandt, 1833) at Low Temperatures

Erdal Şener[1,]*, Mustafa Yıldız[1], Esra Savaş[1]
[1] Istanbul University, Faculty of Fisheries, Department of Aquaculture, Ordu Cad. No: 200, 34470 Laleli, İstanbul, Turkey.

* Corresponding Author: Tel.: +90. 212 455 56 00/16448; Fax: +90. 212 514 03 79;
E-mail: sener@istanbul.edu.tr

Received 26 September 2005
Accepted 14 March 2006

Abstract

Effect of different feed compositions on growth performance and body composition of Russian sturgeon (*Acipenser gueldenstaedtii*) juveniles was studied. One control and three experimental diets were prepared with different ratios of soybean meal (20%, 10.5%, 33%, and 27%) sunflower meal (7%, 8.5%, 14.5%, and 10.5%) and corn meal (10%, 20.5%, 15% and 7.5%) substitute fish meal (40%, 35%, 25%, and 30%) as a protein source. Corn oil (2.5% in Group I and 10% in Group II) and sunflower oil (2.5% in Group I and 10% in Group III) also were substituted for fish oil (10% in control group and 5% in Group I) as a lipid source. Initial weight of fish was 143.89±2.84 g, following the feeding time the fish reached 67.92±1.90 g in the control group, and 1= 62.73±2.11 g, 2= 55.09±2.57 g and 3= 59.74±2.34 g in experimental groups, respectively ($P \leq 0.05$). Feed conversion ratio was found 2.57 in control group, 2.75, 3.06 and 2.86 in experimental groups, respectively and differences between the groups were found significant ($P \leq 0.05$). Hepatosomatic index and viscerosomatic index were significantly different ($P \leq 0.05$) between the initial and the final values of feeding trials. No differences were determined between the experimental groups ($P \geq 0.05$). Condition factors and specific growth rate were similar before and following the feeding trials in experimental groups. According to the body composition, crude protein and crude fat levels in the fish body were affected by the feeds ($P \leq 0.05$). Decreased protein level in the feed (Group III) resulted in poor protein level in the fish body. Crude fat in the fish body was similar in first (fish oil) and third (sunflower) group, but fat deposition in the body and liver of fish were higher in second (fish oil 5% + corn oil 2.5% + sunflower oil 2.5%) and third (corn oil 10 %) group. After the feeding trials, liver fat levels were similar whereas the fat levels of the liver were different from initial liver fat ($P \leq 0.05$) values of the other groups. Fish body and liver fat values were similar in control (fish oil) and Group III (sunflower oil) but different in the other groups ($P \leq 0.05$).

Key Words: Russian sturgeon, nutrition, vegetable protein and oil, growth performance, body composition.

Introduction

In the early times of the 20th century, most studies were being conducted on systematic and biology of sturgeons but rearing of the sturgeons in fish farms for meat consumption was less successful. In 1970s, *A. transmontanus* and *A. ruthenus* were successfully reproduced and some developments were made in the technology to breed. *A. baerii* was fully established in USSR and later exported to other countries such as France, USA, Italy, Japan, Germany and Poland. Sturgeon farming in western countries began during the 1980s, mainly as a consequence of conservation efforts for threatened wild populations. In 1999, the dominant species reared for production in Western Europe was white sturgeon (*A. transmontanus*). Russian sturgeon (*A. gueldenstaedtii*) farming was succeeded at a low level in some countries such as Austria, Hungary, Poland and the Netherlands (Chebanov and Billard, 2001; Williot *et al.*, 2001). In Turkey, first experimental trials on Russian sturgeon (*A. gueldenstaedtii*) began for restocking rivers in Black Sea Basin in 2002.

White sturgeon (*A. transmontanus*) and Siberian sturgeon (*A. baerii*) are two major species of sturgeon being commercially cultured outside Russia. The relative importance of Siberian sturgeon as well as Russian sturgeon will increase because they are either most widespread species or already subject to several on-growing projects. There is considerable information available on the growth of white sturgeon and other sturgeon species; however, information of Russian sturgeon farming is quite limited in English (Nathanailides *et al.*, 2002). There is little information on the effect of temperature on sturgeon growth. The optimum temperature for sturgeon growth appears to be closer to 23ºC than 26ºC, and the optimum feeding rates at 23 and 26ºC are 2.0-2.5% and 2.5-3.0% body weight/day, respectively (Hung *et al.*, 1993).

Protein and carbohydrate requirements and utilization by these fish have been studied by some researchers (Williot *et al.*, 2001; Xu *et al.*, 1993; Hung *et al.*, 1998; Deng *et al.*, 1998) as well as the dietary lipids in farmed sturgeon *A. transmontanus* (Xu *et al.*, 1993; Czesny *et al.*, 2000; Gawlicia *et al.*, 2002). Dietary lipids and retention of lipids, particularly in fillet, are parameters often discussed with respect to quality. The relationships between dietary lipids and deposition of fat in fillets of farmed fish have been studied for several species. In a study with white sturgeon (*A. transmontanus*), Hung *et al.* (1997) reported that dietary lipid levels between 26%

and 36% gave good growth without major effects on body composition, whereas 40% dietary lipids lowered specific growth rate and increased levels of liver lipids.

Fish are unique as a food item in that they provide long-chain n-3 polyunsaturated fatty acids. In farmed fish, the fatty acids as well as other fillet lipids may be altered by feeding (Lie, 2001). There are, however, a little information on nutrition and feeding especially by *A. gueldenstaedtii*. Hung *et al.* (1993) reported that the feed, protein, and energy intake required for maintenance at 23 and 26ºC was below 2.0% body weight/day when the fish were fed a diet with 41% protein and 3.2 kcal/ME/g. Body lipid content was significantly elevated when the feeding rates were increased from 2.5 to 3.0% body weight/day at 23ºC and from 3.0 to 3.5% body weight/day at 26ºC. The aim of this study is to investigate the effect of different kinds of diets on growth performance and body composition of Russian sturgeon.

Materials and Methods

Supply of Sturgeon

Fertilized eggs of Russian sturgeon (*Acipenser gueldenstaedtii*) were obtained from Krasnodar Research Institute of Fisheries in the Russian Federation on 13 January 2001. Fry were hatched in the early February 2001, and fish were grown at the Sapanca Inland Waters Research Center of Fisheries Faculty, Istanbul University. Fish were fed a commercial feed during this period and most of the sturgeon fingerlings were released to Sakarya River (Marmara Region in Turkey) in the early summer of the same year. 280 sturgeon juveniles were selected and distributed randomly in each tank for the feeding trial in this study.

Experimental Feeds and Feeding Trials

Feeding trials were conducted during the period between June 15 and August 21, 2001 for the sturgeon juveniles with an average initial weight 143.89±2.84 (mean±SEM, n=280) which were randomly allocated 280 L. of water (35 fish per tank) in duplicate 8 fiberglass tanks. Totally, four different diets (one control and three experimental) were formulated according to the previous results and nutrients requirements of sturgeon in Istanbul University, Sapanca Research Station. Soybean meal (20%, 10.5%, 33%, and 27%), sunflower meal (7%, 8.5%, 14.5%, and 10.5%) and corn meal (10%, 20.5%, 15% and 7.5%) were the substitute fish meal (40%, 35%, 25%, and 30%) as a protein source and corn oil (2.5% in Group I and 10% in Group II) and sunflower oil (2.5% in Group I and 10% in Group III) were also the substitute fish oil in experimental feeds.

Experimental feeds were produced at the Sapanca Research Center (Sakarya-Turkey) of Istanbul University as steam pressured pellets with laboratory type feed mill (KAHL-L, 173). Feeding was conducted two times a day and by hand. Adjusted daily feed portion was 2% of live weight. Fish were not fed in the weighting days. Water was supplied by aerated well water at a rate of 5 L min^{-1}, $tank^{-1}$. Water temperature pH and dissolved oxygen value of the water in the experimental tanks were measured and recorded daily. Water temperature was found 16±1ºC, the pH amounted to 7.1±0.7, and dissolved oxygen measured as 8.5 mg/L. Experimental diet formulation was shown in Table 1.

Table 1. Diet formulations and nutrients in experimental feeds

Feedstufs (%)	Control Group	Group I.	Group II.	Group III.
Fish meal	40	35	25	30
Soybean meal	20	10.5	33	27
Sunflower meal	7	8.5	14.5	10.5
Corn meal	10	20.5	15	7.5
Wheat meal	10.5	13	-	12,5
Fish oil	10	5	-	-
Corn oil	-	2.5	10	-
Sunflower oil	-	2.5	-	10
Premix*	2.5	2.5	2.5	2.5
Totally	100	100	100	100
Nutrients (%)[1]				
Dry matter	92.09±0.02^{b}	92.29±0.04^{b}	91.99±0.01^{b}	91.38±0.27^{a}
Crude protein	31.50±0.61^{ab}	32.20±0.95^{a}	32.18±0.27^{a}	29.30±0.07^{b}
Crude fat	17.79±0.18^{b}	18.61±0.21^{c}	15.25±0.12^{a}	15.33±0.13^{a}
Crude ash	10.94±0.07^{c}	9.83±0.02^{b}	8.57±0.20^{a}	10.24±0.08^{b}
Crude fiber	4.55±0.15^{a}	5.07±0.08^{b}	6.03±0.09^{d}	5.64±0.07^{c}
Nitrogen free extract	27.23±0.29^{a}	26.58±0.42^{a}	29.98±0.37^{b}	31.12±0.32^{b}
Total energy (KJ/g)	19.15	19.53	18.78	18.33

*: Premix of vitamin and mineral according to NRC (1993) recommendation for fish
[1]:Values are means ± SEM, n=3.

Chemical Analyses

Proximate composition of nutrients of the experimental feed and fish samples (n=5) collected at the initial and final time of the feeding trial was analyzed according to the AOAC (1980). Moisture, crude protein, ether extract, crude cellulose and ash in the experimental feed were analyzed, and gross energy value was calculated in respect of Halver (1972). Dry matter, crude protein, ether extract, ash and total fat content of the liver were analyzed in the homogenized fish samples obtained at the beginning and the end of the feeding trials.

Growth Performance

During the feeding trials, fish were weighed every two weeks according to the experimental groups. Live weight gain was recorded according to the difference between the final weight and the initial weight of fish. Feed conversion ratio (FCR) was calculated by the equation FCR = feed intake (dry weight) (g) / live weight gain (g). Specific growth rate (SGR) was calculated according to the equation SGR = (ln final weight–ln initial weight) x 100 / time in days. Condition factor (CF) was determined by the formula: (final body weight (g) / final total body length $(cm)^3$) x 100. Hepatosomatic index (HSI= [liver weight (g) / body weight (g)] x 100) and viscerosomatic index (VSI = [visceral weight (g) / body weight (g)] x 100) values were determined for observing fat accumulation in whole body and liver of the fish (Ricker, 1979).

Statistical Analyses

The difference between the growth performance and body composition of groups was analyzed with one-way analyses of variance (ANOVA) and Duncan's multiple range test with a statistical package program (SSPS version 10.0) for P≤0.05 at the end of feeding trials (Sümbüloğlu and Sümbüloğlu, 1998).

Results

There was no mortality in the Russian sturgeon feeding trials in this study. Growth performance parameters after the feeding trials were shown in Table 2. There was no significant effect of different kind of feeds on condition factor (CF) levels (P≥0.05).

Hepatosomatic index (HSI) and viscerosomatic index (VSI) values were found different at the begining and the end of the feeding trials (P≤0.05) but during the feeding trials control and experimental feeds were not affected these values (P≥0.05). While live weight gain was recorded with the best value in control group, Group II and III were recorded to have similar values (P≥0.05) but Group I was similar to control group and different than the experimental groups (P≤0.05). The best FCR value was found in the control group, and the difference between the control and experimental groups was found significant (P≤0.05). According to the SGR values, the difference between the groups was found not significant (P≥0.05).

According to the chemical analyses, body composition values of the fish were shown in Table 3. Moisture, crude protein, crude fat and crude ash contents in the whole body of fish were found different at the beginning and end of the feeding trials (P≤0.05). Difference of moisture content between the control groups, Group II and III was not found significant (P≥0.05) but higher than the Group I (P≤0.05). Difference of the crude protein contents between the control and experimental groups was found significant (P≤0.05). While the lowest value of crude protein was found in Group III (13.97%), the highest value was in Group I (15.97%). Crude fat contents in the whole body of fish were found in the highest value in Group I and II (4.91 % and 4.78 %, respectively) and in the lowest value in control group and Group III (3.14 % and 3.67 %, respectively) (P≤0.05). Liver fat contents had higher values in Group I and II (15.66 % and 15.06 % respectively)

Table 2. Growth performance of fish which were fed experimental feeds[1]

Groups	Initial	Control Group	Group I	Group II	Group III
Growth performance					
HSI	$3.40{\pm}0.38^{b}$	$2.39{\pm}0.20^{a}$	$2.26{\pm}0.18^{a}$	$1.81{\pm}0.13^{a}$	$2.48{\pm}0.33^{a}$
VSI	$24.79{\pm}1.85^{b}$	$11.39{\pm}0.38^{a}$	$9.83{\pm}0.25^{a}$	$10.48{\pm}0.73^{a}$	$12.14{\pm}0.70^{a}$
CF	$0.37{\pm}0.02^{a}$	$0.33{\pm}0.04^{a}$	$0.36{\pm}0.03^{a}$	$0.36{\pm}0.06^{a}$	$0.39{\pm}0.04^{a}$
LW (g)	143.89±2.84	211.81±7.05	206.62±5.81	198.98±6.15	203.63±8.70
LWG (g)	-	$67.92{\pm}1.90^{b}$	$62.73{\pm}2.11^{ab}$	$55.09{\pm}2.57^{a}$	$59.74{\pm}2.34^{a}$
FCR	-	$2.57{\pm}0.11^{a}$	$2.75{\pm}0.23^{ab}$	$3.06{\pm}0.16^{c}$	$2.86{\pm}0.09^{bc}$
SGR	-	$0.34{\pm}0.02^{a}$	$0.32{\pm}0.03^{a}$	$0.29{\pm}0.01^{a}$	$0.31{\pm}0.02^{a}$

[1]: Values are means ± SEM. n=5 for HSI (Hepatosomatic Index) and VSI (Viscerosomatic Index); n= 70 for CF (Condition Factor), LW (Live Weight), LWG (Live Weight Gain), FCR (Feed Conversion Ratio) and SGR (Specific Growth Rate).
Different superscripts indicate statistically significant differences between means at P≤ 0.05.
Mean were tested by ANOVA and ranked by Duncan's multiple range test.

Table 3. Body composition of fish which were fed experimental feeds[1]

Groups	Initial	Control Group	Group I	Group II	Group III
Body composition (%)					
Moisture	75.56±0.21[a]	79.05±0.30[c]	77.29±0.63[b]	78.83±0.08[c]	80.13±0.53[c]
Crude protein	12.87±0.01[a]	15.68±0.23[c]	15.97±0.10[d]	15.08±0.07[c]	13.97±0.09[b]
Crude fat	7.72±0.55[c]	3.14±0.16[a]	4.91±0.11[b]	4.78±0.09[b]	3.67±0.07[a]
Ash	1.79±0.01[c]	1.08±0.03[a]	1.52±0.12[b]	1.16±0.10[a]	1.03±0.01[a]
Liver fat	21.37±0.14[d]	9.16±0.14[a]	15.66±0.24[c]	15.06±0.08[c]	13.72±0.09[b]

[1]: Values are means ± SEM. n=3 for Moisture, Crude Protein, Crude Fat, Ash and Liver Fat.
Values in each row with different superscript differ at P≤ 0.05.
Mean were tested by ANOVA and ranked by Duncan's multiple range test.

than the control group (9.16 %) and Group III (13.72 %) (P≤0.05). Body and liver fat contents of Group I and II, which included corn and sunflower oil substitute fish oil, had higher value than the control group (P≤0.05), but fat deposition in the fish body of Group III group was found to be similar to the control groups (P≥0.05) and liver fat contents in the same group of fish were found lower than Group I and II but higher than the control group (P≤0.05). Crude ash contents in the whole body of fish were found similar in the control group, and Group II and III (P≥0.05) but different in Group I (P≤0.05).

Discussion

Technologies for the commercial culture of various sturgeon species have been established over the last 20-30 years and they are now available for fish farmers. The production of sturgeon meat for human consumption has begun more recently. White sturgeon (*A. transmontanus*) and Russian sturgeon (*A. gueldenstaedtii*) and various sturgeon hybrids showed an increase weight between 1 and 2 kilograms and 100% survival. Pelleted feeds were daily given 3-6% of body weight, and food conversion ratio (FCR) was relatively at 4.5-5.0, likely generating a high load of wastes. At temperatures of 21-23°C, market size (1.0 - 1.3 kilograms) was attained in 12 months (Chebanov and Billard, 2001).

There are some major points that arise from the present study on the growth performance of the Russian sturgeon. Information about feed intake of fish such as FCR is very critical to good nutrition and feeding. Estimate of feed intake of Russian sturgeon is very difficult because they are slow feeders. Water temperature and the feeding rate and the fish size are the three most important factors for feed intake and growth of fish. Water temperature (16±1ºC) was particularly effective on the growth performance of fish in our study (Hung *et al.*, 1993). Growth performance of the fish was not affected by different kind of diets according to the results in this study (Table 2). The best FCR value was found in the group of fish fed within the control diet including fish meal and fish oil.

According to the results of body composition of fish (Table 3), dietary proteins were reflected in the body composition of fish. This suggests that fish benefited both from animal and vegetable proteins as equally from good formulated feeds. But dietary lipids did not show the same effect in fish body composition. Since the body fat was replaced with the body water during the growth of fish crude fat content in the whole body of fish was naturally found higher at the beginning than at the end of the feeding trials.

Xu *et al.* (1993) reported that body composition of fish was not significantly affected by the dietary lipids. In particular, there was a long chain n-3 PUFA accumulating in the body and the liver of fish which were fed with vegetable oil added feeds. The lowest values were found in the fish bodies which were fed control diets including just only fish oil, body and liver fat contents. This situation showed that fish used dietary energy from fish oil better than the other lipid source. Similarly, body and liver fat accumulation in Group III of fish which were fed the diets including just only sunflower oil was similar to that of the control group and lower than Group I and II. It was shown that amongst the vegetable oils, sunflower oil had a better effect than the corn oil for Russian sturgeon lipid nutrition. In conclusion, when vegetable protein and vegetable oil substituted fish meal and fish oil they were not effective on the growth performance of Russian sturgeon but effective on the accumulation of body and liver fat contents.

References

Akyıldız, A.R. 1968. Yemler Bilgisi. Laboratuar Kılavuzu. Ankara Üniversitesi Ziraat Fakültesi Yayınları: 358, Ankara Üniversitesi Basımevi, Ankara: VII+207 pp.

AOAC (Association of Official Analytical Chemists) 1980. Official Methods of Analysis (13th edn.), In: W. Horwitz (Ed.), Washington, DC, USA, 1018 pp.

Chebanov, M. and Billard, R. 2001. The culture of sturgeons in Russia: Production of juveniles for stocking and meat for human consumption. Aquatic Living Resources, 14: 375-381.

Christie, W.W. 1992. Lipid Analysis. Pergamon, In: W.W. Christie, (Ed.) Advances in Lipid Methodology. The Oily Press, (1992 to 1997). Oxford, England: 52-56

Czesny, S., Dabrowski, K., Christensen, J.E., Eenennaam, J.V. and Doroshov, S.I. 2000. Discrimination of wild and domestic origin of sturgeon ova based on lipids and fatty acid analysis. Aquaculture, 189: 145-153.

Deng, D.F., Hung, S.S.O. and Conklin, D.E. 1998. White sturgeon (*Acipenser transmontanus*) require both n-3 and n-6 fatty acids. Aquaculture (Abstracts Lipids and Fatty Acids), 161: 333-335.

Dyuzhikov, A.T. and Serebyakov, E.V. 1964. Some features of ecology and duration of the sex cycle in the Volga River sturgeons. VNIRO Proceedings, 56: 105-115.

Folch, J., Lees, M. and Stanley, G.H.S. 1957. A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry, 226: 497-509.

Gawlicia, A., Herold, M.A., Barrows, F.T., Noüe, de la J. and Hung, S.S.O. 2002. Effects of dietary lipids an growth, fatty acid composition, intestinal absorbtion and hepatic storage in white sturgeon (*Acipenser transmontanus*) larvae. Journal of Applied Ichthyology, 18: 637-681.

Halver, J.E. 1972. Fish Nutrition. Academic Press. London, 713 pp.

Hung, S.S.O., Lutes, P.B., Shqueit, A.A. and Conte, F.S. 1993. Effects of feeding rate water temperature on growth of juvenile white sturgeon (*Acipenser transmontanus*). Aquaculture, 115: 297-303.

Hung, S.S.O., Storebakken, T., Cui, Y., Tian, L. and Einen, O. 1997. High energy diets for white sturgeon (*Acipenser transmontanus* Richardson). Aquaculture Nutrition, 3: 281-286.

Hung, S.S.O., Herold, M.A., Gawlicka, A. and Noüe, de la J. 1998. Effects of dietary lipids on growth and fatty acid composition of white sturgeon (*Acipenser transmontanus*) larvae. Aquaculture (Abstracts Lipids and Fatty acids), 61: 333-335.

Kiesslng, A., Pickova, J., Johansson, L., Asgard, T., Storebakken, T. and Kiessling, K.H. 1993. Changes in fatty acid composition of farmed rainbow trout (*Oncorhynchus mykiss*) in relation to ration and age. Food Chemistry, 73: 271-284.

Legeza, M.I. 1972. Role of abiotic environmental factors in the distribution of sturgeons (the family Acipenseridae, Pisces) in the Caspian Sea. Voprosy Ikhtyologii (Problems of Ichthyology), 12: 13-24.

Lie, Ø. 2001. Flesh quality- the role of nutrition. Aquaculture Research, 32 (1): 341- 348.

Nathanailides, C., Tsoumani, M., Papazogoly, A. and Paschos, I. 2002. Hatching time and post-hatch growth in Russian sturgeon *Acipenser gueldenstaedtii*. Journal of Applied Ichthyology, 18: 651-654.

Ricker, W.E. 1979. Growth Rates and Models. In: W.S Hoar, D.J. Randall and J.R. Brett (Eds.) Fish Physiology, Vol. 8. Academic Press, New York, XVII+786 pp.

Sümbüloğlu, K. and Sümbüloğlu, V. 1998. Biyoistatistik. Hatipoğlu Yayınları 53 (8. Baskı). Hatipoğlu Yayınevi, Ankara, 291 pp.

Williot, P., Sabeau, L., Gessner, J., Arlati, G., Bronzi, P., Gulyas, T. and Berni, P. 2001. Sturgeon farming in Western Europe: Recent developments and perspectives. Aquatic Living Resources, 14: 367-374.

Xu, R., Hung, S.S.O. and Germman, J.B. 1993. White sturgeon tissue fatty acid compositions are affected by dietary lipids. The Journal of Nutrition, 123: 1685-1692.