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Fatty acid composition of caviar and liver from cultured great sturgeon *(Huso huso)*

[1*]Abbas, E. M. and [2]Hrachya, G. H.

[1]*Shahid Rajaee Breeding and Restocking Fish Center, Sari, Mazandaran, Iran*
[2]*Yerevan State Medical University, Yerevan, Armenia*

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Abstract

In this study fatty acid composition of liver and caviar from 10 years old great sturgeon (Beluga, *Huso huso*) (n=5, average weight 50-60 kg) cultured in concrete circular tanks (8-m diameter, 1.5-m depth) at a density of 30 kg/m^3 for caviar production was determined. Saturated fatty acids (SFA) ranged from 19.08 to 21.87% of total fatty acid (TFA) being slightly higher in flesh. The fatty acid C16:0 was the main SFA in all samples. The highest level of monounsaturated fatty acid (MUFA) was with caviar (56.26% of TFA) followed by flesh (50.92% of TFA) and liver (45.05% of TFA). Liver contained the highest amount of polyunsaturated fatty acid (PUFA) (33.37% of TFA), n-3 fatty acids (15.80% of TFA) and docosahexaenoic acid (DHA; C22:6 n-3) (10.57% of TFA) ($P<0.05$). Caviar had the lowest content of eicosapentaenoic acid (EPA; C20:5 n-3) and n-3 fatty acids ($P<0.05$) whereas no difference in the content of N-6 fatty acids between liver, caviar and flesh was found ($P>0.05$).

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Introduction

Fish oil constitutes the major source of long chain n-3 (or omega-3) PUFAs (polyunsaturated fatty acids), including eicosapentaenoic acid (EPA) (20:5n-3) and docosahexaenoic acid (DHA) (22:6n-3) (Simopoulos, 2002; Larsen, 2010). The role of fish oil in human health promotion and disease risk reduction with respect to the vascular system has been well studied (Shahidi and Alasalvar, 2011). Omega-3 fatty acids are not synthesized in the human body, thus the inclusion of fish oil rich in those fatty acids in food products is essential (Jabeen and Chaudhry, 2011). Due to the decline of wild fish stocks as a result of over-fishing and habitat alternations, the consumption of cultured fish could provide or even more omega-3 essential fatty acids such as EPA and DHA than wild fish for the human body (Cahu *et al*., 2004).

In the Caspian Sea basin, the stock of the great sturgeon declined rapidly due to excessive fishing and habitat deterioration (Ercan, 2011; Ruban and Khodorevskaya, 2011). In response to the declining beluga stocks, commercial aquaculture production of Caspian great sturgeon (Beluga, *Huso huso*) has been started in the country and it became an important species for sturgeon aquaculture in Iran (Pourshamsian *et al.*, 2012). Beluga grows fast, has big size, and is highly appreciated for its tasty and boneless flesh (Ghomi *et al.*, 2012). Beluga is cultured in concrete indoor tanks using well water. At the age of 3 years old, males and females are sexed to indentify males for meat production, while females are reserved for caviar production which is sold at the local or international markets for human consumption (Masoudifard *et al*., 2011).

Fatty acid profiles of raw flesh of several farmed sturgeon species have been studied (Badiani *et al*., 1996, 1997; Paleari *et al*., 1997; Garcia-Gallego *et al*., 1999; Vaccaro *et al*., 2005; Jankowska *et al*., 2005). Monounsaturated fatty acids were the dominant class of fatty acids in some sturgeon species such as Adriatic sturgeon, white sturgeon, Siberian sturgeon and some sturgeon hybrid (Badiani *et al*., 1997; Jankowska *et al*., 2005). Sturgeon species such as Siberian sturgeon *(Acipenser baerii)*, Adriatic sturgeon *(A. naccarii)* and white sturgeon *(A. transmontanus)*, are reported to be the good source of n-3 essential fatty acids with 4.8-6.54g/100 g EPA and 8.7-9.7g/100 g DHA (Badiani *et al.*, 1997). However, no information is available on the nutritional quality of the liver, a by-product of beluga processing, based on their fatty acid profiles and essential omega-3 fatty acids. During the industrial processing of beluga for caviar, by-products including liver are generated. Fish liver oil has been known for its health benefit (Shahidi and Alasalvar, 2011). It is widely used as nutritional supplement because it contains vitamins A and D, and is an important source of omega-3 fatty acids, including docosahexaenoic acid (DHA) and

*Corresponding author.
Email: *abbasesmaeili45@yahoo.com*
Tel: +98-1513153234; Fax: +98-1513153240

eicosapentaenoic acid (EPA) for normal functioning of the brain, heart and the eye (Navarro-García *et al*., 2010; Amayo *et al*., 2014). No information regarding the fatty acid profiles of beluga liver has been reported. Therefore, this study aimed to measure the fatty acid profiles of caviar and liver from beluga and the results were compared with that of flesh.

Material and Methods

Fish samples

Beluga sturgeon (n = 5) with body weight ranging from 50-60 kg cultured in a local beluga farm in northern Iran (Sari, Mazandaran) were used to measure the fatty acid profiles. The fish were cultured for 10 years in concrete circular tanks (8-m diameter, 1.5-m depth) using well water with a relatively constant temperature of 20ºC throughout the year at a stocking density of 30 kg/m^3. The fish were fed 2% of body weight with a commercial diet containing 40% protein and 15% lipid. The major fatty acids of the diet were C16:0 (18.83%), C16:1 (3.17%), C18:0 (5.04%), C18:1 (27.78%), C18:2 (27.27%), C18:3 (8.99%), C20:5 (0.59%) and C22:6 (3.48%).

Lipid extraction

Lipid was extracted according to the method reported by Bligh and Dyer (1959). Fifty grams of sample was homogenized in a blender for 2 min with a mixture of 50 ml chloroform and 100 ml of methanol. Then, 50 ml of chloroform was added and further homogenized for 30 s. Finally, 50 ml of distilled water was added to the mixture and blended for 30 s. The homogenate was centrifuged (Avanti J-E, Beckman Coulter, Inc., USA) at 4,000 rpm for 15 min at 4°C. The supernatant was then transferred into a separating flask and the lower phase (chloroform phase) was drained off into a 250 ml Erlenmeyer flask containing 4 g of anhydrous sodium sulfate and shaken vigorously. The solution was then filtered through a Whatman no. 4 filter paper into a round-bottom flask. Rotary evaporator was used for solvent evaporation at 25°C.

Fatty acid analysis

Fatty acid composition of the oils extracted was determined by the method presented by Bligh and Dyer (1959). Fatty acid methyl ester was prepared as follows: Lipid samples (1 g) were diluted with 2 ml of 2 M potassium hydroxide in methanol followed by the addition of 7 ml n-hexane in a sealed tube. The mixture was then shaken using a vortex for 1 min and left for about 20 min in a water bath (temperature 50–55°C) until it had separated into two phases. From the top layer, fatty acid methyl ester was then taken for analysis by using Trace gas chromatography (GC) (Thermo Finnigan, Italy). The GC conditions were as follows: capillary column (Bpx-70, 60 m, 0.32 mm, i.d. 0.25 μm); the split ratio of 90:1; injection port temperature of 250°C; and flame ionization detector temperature of 270°C. Oven temperature was set at 195°C for 75 min. The flow rate of carrier gas (helium) was 1 mL min^{-1} and the makeup gas was N_2 (mL min^{-1}). The sample size injected for each analysis was 1 μL. The data are expressed as g/100 g of total fatty acids.

Statistical analysis

Data were analyzed using one way analysis of variance (ANOVA) and means were compared using Duncan's multiple range test using an SPSS package (SPSS 16.0 for Windows; SPSS Inc, Chicago, IL, USA). Data are expressed as the mean ± standard deviation (SD) and the probability value of $P < 0.05$ was considered significant.

Results and Discussion

The fatty acid profiles of farmed beluga sturgeon caviar, liver and flesh are shown in Table 1 and 2. Caviar contained 19.08% SFA, 52.26% MUFA and 23.86% PUFA. Liver consisted of 20.06% SFA, 45.05% MUFA and 33.37% PUFA whereas flesh contained 21.87% SFA, 50.92% MUFA and 25.81% PUFA. The MUFAs were found to be the major fatty acids in caviar, liver and flesh followed by PUFAs and SFAs. In several farmed sturgeon species, MUFAs were the main class of fatty acids such as the Adriatic sturgeon (*Acipenser naccarii)* (47.70%), white sturgeon *(Acipenser transmontanus)* (45.39%), and Siberian sturgeon *(Acipenser baerii)* (44.89%) (Badiani *et al*., 1997) and the sturgeon hybrid *Acipenser baerii* × (*Acipenser baerii* × *Acipenser medirostris*) (46.21%) (Jankowska *et al*., 2005). Caviar contained the highest MUFAs when compared to liver and flesh ($P<0.05$). Oleic acid (C18:1n-9) was the main MUFA followed by C16:1 in all samples. Liver contained higher amounts of MUFA (45%) than SFA (22%) and PUFA (33%). This result is consistence with the higher content of MUFA in balistid fish *(Sufflamen capistratus)* liver oil (40.61%) reported by Immanuel *et al*. (2009) and shark *(Galeocerdo cuvier)* liver oil (42.9%) reported by Navarro-Garcia *et al.* (2000). The content of EPA and DHA in liver oil was 1.9 and 19.57% TFA. EPA and DHA contents in marine fish species such as shark *(Carcharhinus falciformis)* liver oil were between 4-8.57 and 21.22-26.24% TFA (Navarro-

Table 1.Fatty acid profile of lipids extracted from caviar, liver and flesh of cultured great sturgeon

Fatty acids (% TFA)	Caviar	Liver	Flesh
C14:0	0.76±0.35^{b}	0.36±0.04^{c}	1.36±0.01^{a}
C14:1	0.05±0.00^{b}	0.03±0.00^{b}	0.09±0.02^{a}
C15:0	0.24±0.02^{ab}	0.17±0.01^{b}	0.30±0.05^{a}
C15:1	0.05±0.00^{a}	0.03±0.00^{a}	0.04±0.01^{a}
C16:0	15.83±0.07^{a}	16.81±0.01^{a}	17.62±1.04^{a}
C16:1	2.55±0.09^{b}	1.88±0.11^{c}	3.49±0.28^{a}
C17:0	0.28±0.00^{a}	0.24±0.01^{a}	0.31±0.04^{a}
C17:1	0.47±0.00^{a}	0.38±0.02^{a}	0.47±0.07^{a}
C18:0	1.96±0.19^{b}	2.52±0.20^{a}	2.27±0.01^{ab}
C18:1n9	52.00±3.35^{a}	41.41±0.57^{b}	45.09±1.55^{b}
C18:2n6	15.44±1.90^{a}	15.74±0.06^{a}	14.48±0.12^{a}
C18:3n6	1.56±0.33^{a}	1.05±0.07^{a}	0.34±0.10^{b}
C18:3n3	1.71±0.38^{a}	1.77±0.02^{a}	2.05±0.04^{a}
C20:1n9	0.92±0.02^{b}	0.61±0.02^{c}	1.21±0.04^{a}
C20:2n6	0.79±0.09^{a}	0.72±0.02^{a}	0.74±0.00^{a}
C20:3n6	0.41±0.04^{a}	0.47±0.03^{a}	0.16±0.00^{b}
C20:3n3	0.53±0.16^{b}	1.63±0.18^{a}	0.60±0.07^{b}
C22:1n9	0.24±0.08^{b}	0.26±0.00^{ab}	0.55±0.12^{a}
C20:5n3 (EPA)	0.77±0.26^{c}	1.90±0.02^{b}	2.42±0.02^{a}
C22:2n3 (DHA)	2.63±0.32^{c}	10.57±0.60^{a}	5.17±0.27^{b}

Table 2. Main classes of fatty acids of lipids extracted from caviar, liver and flesh of cultured great sturgeon

Fatty acids (% TFA)	Caviar	Liver	Flesh
ΣSFA	19.08±0.32^{b}	20.06±0.08^{ab}	21.87±1.30^{a}
ΣMUFA	56.26±3.13^{a}	45.05±0.08^{b}	50.92±1.07^{ab}
ΣPUFA	23.86±2.51^{b}	33.37±0.53^{a}	25.81±0.38^{b}
ΣN-3	5.65±0.81^{c}	15.80±0.27^{a}	10.16±0.52^{b}
ΣN-6	18.24±1.65^{a}	18.07±0.09^{a}	15.65±0.13^{a}

Garcia *et al*., 2000) and were 3.45 and 2.11% TFA in balistid fish liver oil (Immanuel *et al*., 2009).

Some differences in fatty acid compositions were noticeable among lipids obtained from caviar, liver or flesh. Caviar had the highest amount of C18:1n-9 FAs (52% of TFA) while the highest amount of C16:1 FAs was with flesh (3.5% of TFA). Among SFAs, palmitic acid (C16:0) (15.83-17.62% of TFA) was the major fatty acid followed by C18:0 (1.96-2.52% of TFA). Caviar contained slightly lower SFAs than liver and flesh. As shown in Table 2, liver had the highest amount of PUFAs followed by flesh and caviar. Fatty acid C18:2n6 was the main fatty acid in lipids derived from caviar, liver and flesh, being the same in all samples (14.48-15.74% of TFA) ($P>0.05$). It was noted that lipid from liver had the highest contents of docosahexaenoic acid (DHA; C22:6 n-3) (10.57% of TFA) that that from caviar (2.63% of TFA) or flesh (5.17% of TFA). The lipids from caviar contained the lowest eicosapentaenoic acid (EPA; C20:5 n-3) (0.77% of TFA) while beluga flesh exhibited the highest amount (2.42% of TFA).

The EPA (2.42% of TFA) and DHA (5.17% of TFA) content of beluga flesh were lower than those of other cultured sturgeon species such as the Siberian sturgeon with 6.54% EPA and 9.7% DHA, Adriatic sturgeon with 4.81% EPA and 8.77% DHA, and white sturgeon with 5.55% EPA and 9.06% DHA (Badiani *et al.*, 1997). The differences in fatty acid composition could be influenced by the diet fish consumed (Ghomi *et al.*, 2012). Higher n-6 fatty acids was found in caviar, flesh and liver of beluga that n-3 fatty acids. N-6/n-3 fatty acid ratio of liver, flesh and caviar were 1.14, 1.54 and 3.2, respectively. A significant higher content of n-3 fatty acids was found in liver lipids (15.80% of TFA) than those obtained from caviar (5.65% of TFA) or flesh (10.16% of TFA) ($P<0.05$), resulting in higher n-3/n-6 ratio in liver lipids (0.87). In general, the higher n-3/n-6 ratio is preferred because from a nutritional viewpoint, this is highly beneficial and desirable for the daily human diet (Usydus *et al*., 2011).

Conclusion

The cultured beluga liver oil could potentially be a suitable source of n-3 essential fatty acids, especially EPA and DHA which can also add value to the generated processing by-products and diverse the beluga sturgeon products.

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