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Loss of Omega-3 fatty acids of Sturgeon (*Acipenser stellatus*) During Cold Storage

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ABSTRACT

In this research, the fatty acids composition of *Acipenser stellatus* tissues was identified by gas chromatography after extraction and methylation in fresh and frozen stages. Results showed that the maximum unsaturated fatty acids in the frozen fresh tissues of *A. stellatus* were 84.41 and 74.45%, respectively. The content of oleic acid, α-linolenic acid and docosahexanoic acid (DHA) in the fresh tissues were 43.71, 7.75 and 3.53%, respectively. These fatty acids were the most important polyunsaturate, which decreased to 41.39, 1.06 and 2.46%, respectively after one year freezing at -22ºC.

Key Words: *A. stellatus*; Caspian Sea; Cold storage; Fatty acids; Omega-3

INTRODUCTION

Sturgeons are the most important group among the fishes and 90% of their stocks are found in the Caspian Sea. These groups of fishes are much valuable because of caviar production as well as meat, which have a good taste and acceptability, and moderate market value. The most abundant species of these groups is *Acipenser stellatus*. Up to now, many studies have been done on biology and processing of these fishes (Keyvanfar, 1971, Dettlaf *et al*., 1993); however, mostly humans have threatened their production, because of several reasons (Hedayatifard & Yousefian, 1997). Many researches and projects have been also done on the best way of consuming of seafood and their processing in the world and also Iran (Moeini, 1989; Hall, 1997; Hedayatifard, 2003).

The most important suitable characteristics of the fish oils such as *A. stellatus* are the presence of un-saturated fatty acids in greater abundance in their fillet tissues. The surveys have been done on the compound of fatty acids of sturgeon fishes and the effects of diet during the culture on it (Isuyev & Musayev, 1989; Xu *et al.,* 1993; Chen *et al.,* 1995). The quantitative and qualitative compounds of these acids in many species of this family are still un-known, especially the effect of shelf life on the fatty acid composition, which was considered in this study.

There are 1 to 6 double bond links among carbon atoms in the un-saturated fatty acids. Their names (the number of these links & the location of the first double bond link) have been taken according to the length of carbon chain in a molecule. Some of these groups are oleic C16: 1, linoleic C18: 2, α-linolenicC18: 3, arachidonic C20: 4, eicosapantanoic (EPA) C20: 5 and docosahexanoic acid (DHA) C22: 6, which include the series of ω-3 and ω-6 (omega-3 & omega-6).

Many studies have been done on the fatty acids of different kinds of fishes as well as Acipenseridae during the last four decades (Hilditch & Williams, 1964; Lovern, 1964; Klenk, 1958; Stansby, 1990; Ackman, 1995). Present study investigated the fatty acid characteristics of most important species in the fisheries industries.

MATERIALS AND METHODS

Twenty samples of *Acipenser stellatus* were caught from the southern (Iranian) coasts of Caspian Sea. The fresh tissues of different parts of the fish were sent to the cold storage of fisheries office in Mazandaran province after sampling. The fatty acids were identified by gas chromatography (GC) after extraction and methylation of the lipids (AOAC, 2000) in frozen-fresh stages. The shelf time and temperature in cold storage were 12 months and -22ºC, respectively. The condition of injection to the gas chromatography was done as the following: detector: Flame Ionization, temperature of detector, columns and injection were 210, 190 and 200ºC, respectively. The volume of injected samples was 0.5 µL. The packed column material DEGS was 15% and gas flow rate was 45 mL min^{-1}.

After injection of the samples of methylester to the first of the column, the retention time was controlled and standard fatty acids were identified. Each sample was repeated three times and its average was calculated.

The analysis of variation and Tukey test were performed using the SPSS software to find significance of variance sources.

RESULTS

The content of the fatty acids in the *A. stellatus* tissue (Table I) and its gas chromatogram (Fig. 1) indicated that content of unsaturated and saturated fatty acids of the fresh tissue were 84.41 and 10.66%, respectively. The ratio of the average of un-saturated to saturated fatty acids was 7.92, while the content of un-saturated and saturated fatty acids of the frozen tissue were 74.45 and 9.93%, respectively and its ratio was 7.49 after one year cold storage. Total un-saturated fatty acids with one and several double bonds were 63.87 and 20.52%, respectively among the total identified fatty acids.

In the fresh tissue of this fish the total average of fatty acids of ω-3 and ω-6 were 16.64 and 3.9%, respectively among the total identified fatty acids. They were 8.98 and 4.11%, respectively during one-year frozen tissue. The ratio of ω-3/ω-6 for the fresh and frozen fishes was 4.26 and 2.18 respectively. Linoleic and arachidonic acids from ω-6 and α-linolenic, eicosapanthanoic and docosahexanoic acids from ω-3 were noted (Table II).

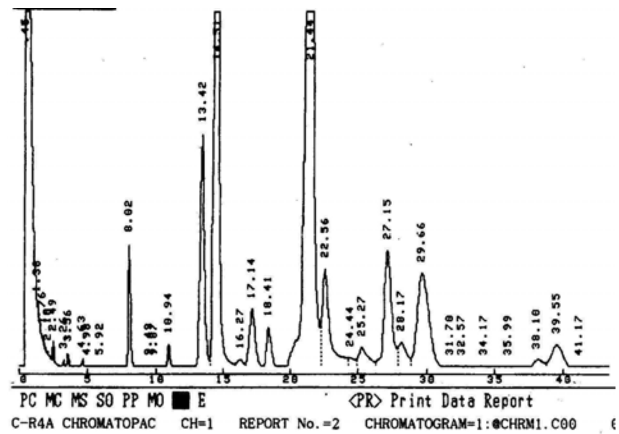
The average oleic acid (C18: 1) in the fresh (43.71%) or frozen (41.39%) tissues were more than the other fatty acids (Table I). In statistical analysis revealed significant ($P < 0.05$) difference in arachidonic, α-linolenic and miristic acids among the fresh and frozen fishes. There was also significant ($P < 0.05$) difference between the total content of un-saturated fatty acids of ω-3 and ω-6.

DISCUSSION

The results showed that un-saturated fatty acid content were greater than saturated fatty acids in *A. stellatus*. It was observed that the average amount of oleic (C18: 1) and palmitoleic acids (C16: 1) with 43.71 and 20.16%, respectively were in the maximum value in the fish tissue as compared to the other fatty acids. The average amount of the saturated fatty acids of miristic (C14: 0) with 1.83% was also in the minimum value (Table I). The present research indicated that the *A. stellatus* tissue has a great number of long-chain and un-saturated fatty acids like series of ω-6 (3.9%) and ω-3 (16.64%). Therefore, it can be concluded that the un-saturated fatty acid with one double bond such as oleic and palmitoleic acids (total = 63.87%) and un-saturated fatty acids with several double bonds of EPA and DHA (total = 8.89%) can be consisted as abundant fatty acids in the *A. stellatus* tissues.

Among the un-saturated fatty acids the series of ω-3 with several double bonds are found more than other groups in this fish tissue (Table II). These findings are in agreement with those reported by Hedayatifard and Moeini (2003), Chen *et al.* (1995), Xu *et al.* (1993) and Isuyev and Musayev (1989). It was also observed that the un-saturated fatty acids with the several double bonds are more in the marine fishes in comparison with the fresh water fishes. The fat and fatty acids quantity of Sturgeon fishes were changed by fishing season and developmental conditions during the year. For example, in the Russian sturgeon *A. guldenstaedti*, the amount of the fatty acids of

Fig. 1. Fatty acids Gas chromatogram of *A. stellatus* tissue



EPA increases from 5.93 to 7.37% (1.44%) and DHA increases from 6.34 to 8.72% (2.38%) during the fish development after 118 h after fecundity (Isuyev & Musayev, 1989).

The variability in the amount of fatty acids in Sturgeons, were affected by the fish species and their growth conditions (Table III). In addition, there was a difference between the amount of the fatty acids of cultural and marine sturgeons (Chen *et al.,* 1995); wild sturgeon showed greater level of fatty acids of 16: 0, 16: 1, 22: 4 (ω-6) and C22: 5 (ω-6). As can be seen, the level of unsaturated fatty acids with several double bonds and from the series of ω-3 in *A. stellatus* (16.64%) has an outstanding value (Table III). Thus, the fishes can be kept in good quality under the suitable storage temperature.

Decreasing routine in average of α-linolenic acis (7.75% to 1.06%) and DHA (3.53% to 2.46%) was obvious during preservation under cold condition (Table I). There was a significant ($P < 0.05$) difference between the variations of two above mentioned acids and increase in the arachidonic acid (0.51% to 1.07%) aspect of the time of preserving in the cold storage during 12 months freezing.

The lipids, which are the present in the fishes not only are liquid under the natural conditions, but also liquid under the separate analysis, which is because of the presence of the high amount of poly un-saturated fatty acids. These compounds are usually found as tri-glycerides (Moeini, 1989; Hedayatifard, 2003). The number of double bonds of carbon atoms chain in un-saturated fatty acids in fish and shellfish varied from 1 to 6 and the acids with pair carbon atoms comprised 97% of total fatty acids (Stansby, 1990). The number of carbon atoms in the structure of fatty acids was about 14 to 22 in *A. stellatus* in present research.

The properties of ethylenic bonds in un-saturated fatty acids of fishes in the geometric view, is known as cis model and it is possible to separate the carbon atoms in the above links with several double bonds, which convert them to the methylene parts (Klenk, 1958). The intensive presence of

Table I. Averages of fatty acids composition in the *A. stellatus* tissue in fresh and cold storage stages (g 100 g^{-1} lipid)

Freezing Stage	Fatty acid	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:4	C20:5	C22:6
		Miristic	Palmitic	Palmitileic	Stearic	Oleic	Linoleic	Linolenic	Arachidonic	EPA	DHA
Fresh fillet	average	1.83	7.39	20.16	1.44	43.71	3.39	7.75	0.51	5.36	3.53
	SD	1.19	1.81	0.35	1.02	1.62	0.25	3.27	0.73	0.48	2.41
1 month frozen	average	2.7	7.31	24.15	1.92	43.3	3.86	4.65	0.94	4	0.98
	SD	0.4	1.54	5.46	1.01	0.87	0.46	3.02	0.45	1.63	1.14
2 months frozen	average	2.6	8.1	21.42	1.63	40.98	3.44	3.22	1.2	4.7	1.04
	SD	0.51	1.36	3.86	1.25	1.06	1.34	3.39	0.14	0.86	1.25
4 months frozen	average	1.35	5.85	18.66	0.89	47.04	3.66	0.72	1.2	4.7	1.04
	SD	0.23	1.546	1.18	0.08	4.71	0.93	0.41	0.79	0.68	0.92
6 months frozen	average	1.93	6.45	20.65	0.98	48.03	3.68	0.65	1.97	3.86	1.04
	SD	0.11	1.3	1.61	0.04	1.41	1.1	0.08	0.42	0.5	0.14
8 months frozen	average	1.95	5.35	25.22	1.05	50.2	4.17	0.64	1.02	5.66	0.8
	SD	0.11	1.02	3.16	.021	0.12	1.64	0.57	0.12	1.6	0.8
10 months frozen	average	1.91	6.24	19.83	1.23	46.43	4.11	1.5	1.03	4.78	3.01
	SD	0.12	1.97	0.25	0.35	0.72	1.52	0.14	1.09	0.36	3.11
12months frozen	average	2.03	6.72	19.97	1.18	41.39	3.05	1.06	1.07	5.46	2.46
	SD	0.11	0.86	1..5	0.11	2.18	.012	.016	1.59	1.76	.045

Table II. Average of kinds of fatty acids series in *A. stellatus* (g 100 g^{-1} lipid)

Fatty acid series	In fresh fat tissue	In 12 months frozen
Saturated fatty acics	10.66	9.93
Unsaturated fatty acids	84.41	74.45
Omega-3 series (ω-3)	16.64	8.98
Omega-6 series (ω-6)	3.90	4.11
Monoenoic fatty acids	63.87	61.36
ω-3 + ω-6	20.31	13.09
EPA + DHA	8.89	7.92
Polyenoic fatty acids	20.52	13.09
High Unsaturated fatty acids	9.40	8.98

Table III. The comparison of averages of fatty acids in different sturgeon (*Acipenser spp.*) (g 100 g^{-1} lipid)

Fatty acid	A. stellatus	A. persicus	A. guldenstaedti	A. oxyrhynchus	A.transmontanus
Miristic	1.83	1.77	2.81	1.43	-
Palmitic	7.39	6.73	21.74	25.90	-
Palmitoleic	20.16	17.75	7.46	-	-
Stearic	1.44	1.23	8.71	2.61	-
Oleic	43.71	45.11	21.06	35.70	-
Linoleic	3.39	3.59	2.00	0.40	18.56
α-linolenic	7.75	2.8	-	0.26	1.41
Arachidonic	0.51	2.16	1.97	1.36	2.34
EPA	5.36	4.75	6.62	1.78	2.81
DHA	3.53	2.21	1.46	6.10	5.24
DHA + EPA	8.89	6.96	8.08	7.88	8.05
Reference	Present study	Hedayatifard & Moeini, 2003	Isuyev & Musayev, 1989	Chen ,et al., 1995	Xu, et al., 1993

un-saturated fatty acids with several double bonds indicated a high nutritional value of sturgeon fishes. From this point of view, the consumers who suffer from cardial diseases should not be forgotten. These findings may lead to decreased cardial diseases by consuming seafood fisheries products, especially fatty fishes (Ackman, 1995). Researches on interactive effect of series of fatty acids and vitamin E (which is a natural antioxidant) are being done on the immunological responses of human (Meydani, 1994).

Of course the presence of high un-saturated fatty acids with several double bonds in fish and aquatics tissues, increases the probability of its spoilage, because it has un-saturated fats. Nevertheless, we can not forget the benefits of consuming fish, because several studies have reported suitable methods about processing, preserving and controlling of the fish quality and shellfish (Hedayatifard, 2003; Hall, 1997; Huss, 1994; Moeini, 1989).

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