ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Evaluation of bred fish and seawater fish in terms of nutritional value, and heavy metals

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ABSTRACT

In many parts of the world consumption of fish and seafood comprises a key proportion of man's diet and health. Despite of having many benefits, eating fish can be dangerous for instance the existence of nonorganic material, especially heavy metals, in some fish is dangerous. There are numerous fish breeding pools across the Lorestan province of Iran and the majority of the people living in these areas consume these kinds of fish, so, we were impelled to carry out a study to compare the nutrients and also heavy metals existent in freshwater fish and seawater fish available to the public across Khorramabad city of Iran. In this cross-sectional study, 9 samples of each five species of freshwater and sea water fish were purchased and their total protein, fat, omega 3, 6, and 9 fatty acids and also their heavy metals content including mercury, lead and cadmium of them were measured. There were no significant differences between mean protein content of the two types of fish. The amount of total fat and omega 3, 6 and 9 fatty acids of freshwater fish was higher than of seawater fish ($P>0.001$). The levels of cadmium in seawater fish was significantly higher than freshwater fish ($P>0.001$), and as for the level of mercury and lead, no significant difference was observed between the two types of freshwater fish and seawater fish. According to the results, we recommend that people can secure a part of their protein and unsaturated fatty acids need by consuming freshwater fish.

KEY WORDS: Marine, Freshwater, Nutritional value, Heavy metal.

1. INTRODUCTION

In many parts of the world consumption of fish and seafood comprises a key proportion of man's diet and health. Fish meat is a good source of high quality protein, vitamins, important minerals such as iodine and Fluorine (Jafari, 2001; AminiRanjbar, 1999). The existence of polyunsaturated fatty acids (PUFAs), in fish is another advantages of fish consumption, this is due to the fact that these fatty acids are not produced by the human body and they are in taken from the diet (Chen, 2001). Numerous studies have emphasized the irrefutable and important role fish and seafood consumption in prevention of the cardiovascular diseases, hypercholesterolemia, a number of cancers (e.g. breast cancer, prostate cancer), rheumatoid arthritis, multiple sclerosis, and also regulation of blood pressure, and prevention of goiter and Iodine Deficiency disorders. Omega3 decreases serious and average pain of dysmenorrhea, and improves the nervous system and the vision of premature infants, (Al-Saleh, 2000; Sharma, 2019; Fuentes, 2010; Grigorakis, 2007; Ramos-Filho, 2010; Harel, 1996). Despite of having many benefits, eating fish can be dangerous for instance the existence of nonorganic material, especially heavy metals, in some fish is dangerous (Dolativan, 2004). Heavy metals are hydrophilic materials and are easily dissolved in water and then, they penetrate into fish and humans can be affecting by eating any seafood (Oksuz, 2011). Due to the extreme increase in production of factories and extreme industrialization more and more poisons and heavy metals are being dumped in rivers and seas across the globe, this pollution poisons the marine life and so humans are poisoned as well. As these dangers increase, scientists and policy makers concern about it, so as a result more studies are being carried out on marine life (Oksuz, 2011; Periago, 2005; Fallah, 2011).

Among all the heavy metals, mercury is one of a kind; mercury exists in both organic and non-organic form. Nonorganic mercury can shape shift and turn into methyl mercury, an extremely poisonous substance. Methyl Mercury has a long half life time as a result it could abrade for long times in nature and easily accumulate in living tissue. This substance easily bonds with sulphorous amino acids, methionine, and cysteine, and can easily accumulate in the tissue of any living being. The main part of fish that we consume is the fishes' muscle, so fish muscle is the main cause of conduction of mercury to the human body (Khoshnamvand, 2013). More than 90% of the mercury in our food is absorbed by the digestive system and in the human body; the central nervous system is the primary target of organic mercury, it effects, and damages the memory, learning ability, and sense of touch. Nonorganic mercury mainly damages the kidneys and the cardiovascular system. Scientists recommend that the permitted and limited amount of mercury for the human body is 0.5 mg/kg of body weight (Clemens, 2012). Cadmium is mainly stored in fish in the form of $CdC1_2$; this form of cadmium is mainly stored in the human kidneys. Another dangerous heavy metal is lead. Lead too is mostly conducted to the human body by eating poisoned marine life and polluted air. When lead is observed into the human body it is stored in several places: bones, teeth, liver, lungs, kidney, spleen and the brain. Lead too is conducted to the human fetus by the blood. According to the several studies, the amount of heavy metals in a fish depends on several factors: the climate that the fish lives in, what the fish eats, the fish's age, length, weight and gender (Squadrone, 2013). Even though, consuming fish has many benefits for humans but the existence of afore mentioned heavy metals is dangerous to public health (Olmedo, 2013).

Because there are numerous fish breeding pools across the Lorestan province, and Khorramabad city and that the majority of the people living in these areas consume these kinds of fish, we were impelled to carry out a study to compare the nutrients and also heavy metals existent in freshwater fish and seawater fish available to the public across Khorramabad city of Iran.

2. MATERIALS AND METHODS

In this study, 9 samples of each five species of freshwater fish: North bred salmon, South bred Salmon, North bred carp, Seimare bred carp and silver carp were compared with 9 samples if each five species of seawater fish including: Tuna, Tiger tooth croaker, Rabbitfish, *Saurida tumbil,* and indo-pacific king mackerel.

Nine samples of each fish species were randomly bought from fish sellers from across Khorramabad city and they were immediately cleaned, then their back and stomach muscles were removed. The removed muscles were washed in cold water and stored in a freezer at -80^{oc} for analyses. In order to extract the fat and to determine the amount of omega 3, 6, and 9, their standards were bought from Sigma and Merck Company.

Total fat of the fish were removed using Soxhletmethod (AOCA, 2000). The fatty acids omega 3, 6 and 9 were extracted from the fat by GC (gas chromatography), model Varian cp3800 (AOCA, 2000).

The amount of proteins was calculated by Kjeldahl method. The heavy metals lead, cadmium, and mercury were also evaluated by atomic absorption methods (AOCA, 2000).

Finally total fat, total protein, omega3, 6, and 9 fatty acids, lead, mercury and cadmium existent in both bred and seawater fish was compared together. It should be noted that nutrients and heavy metals were calculated according to the wet weight of the fish samples. Also, meaningful level was 0.05.

3. RESULTS

In table 1 the amount of nutrients and heavy metals existent in the different types of fishes has been reported. Accordingly the difference between the amounts of protein, total fat, omega 3, 6, and 9 and heavy metals in different type of fish was significant. (table1).

Table.1.The comparison between the total protein, total fat, omega 3, 6, and9 fatty acids, lead, cadmium and mercury in different species of fish (9 fish of each species)

Type of fish	Mercury (ppm)	Cadmium (ppm)	Lead (ppm)	Omega9 (%)	Omega6 (%)	Omega3 (%)	Fat (%)	Protein (%)
Rabbitfishes	0.11 ±0.006	0.051 ±0.002	0.88 ±0.06	1.06 ±0.10	0.53 ±0.05	0.15 ±0.02	2.29 ±0.23	20.59 ±0.23
Saurida tumbil	0.17 ±0.004	0.07 ±0.001	0.75 ±0.04	0.58 ±0.1	0.34 ±0.06	0.14 ±0.03	1.55 ±0.28	20.44 ±0.09
tiger tooth croaker	0.3 ±0.004	0.17 ±0.06	0.9 ±0.09	0.75 ±0.10	0.35 ±0.5	0.09 ±0.02	1.58 ±0.21	20.37 ±0.09
Tuna	0.41 ±0.02	0.86 ±0.05	0.84 ±0.04	0.85 ±0.28	0.43 ±0.15	0.18 ±0.06	1.92 ±0.64	20.51 ±0.12
Indo-pacific king mackerel	0.298 ±0.003	0.17 ±0.006	0.84 ±0.04	0.64 ±0.08	0.30 ±0.04	0.15 ±0.02	1.48 ±0.19	19.54 ±0.07
North bred salmon	0.297 ±0.006	0.123 ±0.012	0.74 ±003	2.26 ±0.09	0.81 ±0.04	0.35 ±0.02	5.56 ±0.20	20.07 ±0.09
North bred Carp	0.14 ±0.002	0.027 ±0.01	1.01 ±0.07	1.79 ±0.12	0.71 ±0.04	0.19 ±0.01	4.03 ±0.28	20.01 ±0.11
Silver carp	0.38 ±0.02	0.064 ±0.006	0.91 ±0.05	0.92 ±0.14	0.53 ±0.08	0.27 ±0.04	2.47 ±0.37	19.90 ±0.13
Seimare bred carp	0.36 ±0.005	0.001 ±0.001	0.95 ±0.03	2.59 ±0.08	0.92 ±0.04	0.53 ±0.15	5.56 ±0.16	19.99 ±0.40
South bred Salmon	0.137 ±0.006	0.057 ±0.006	0.76 ±0.007	0.95 ±0.13	0.47 ±0.07	0.31 ±0.04	2.71 ±0.37	20.76 ±0.11
Total	0.23 ±0.12	0.158 ±0.244	0.86 ±0.1	0.13 ±0.7	0.54 ±0.21	0.24 ±0.13	2.92 ±1.55	20.32 ±0.45
*P - value	0.001	0.001	0.006	0.003	0.003	0.002	0.002	<0.001

***By using kruskalwallis examination test with the meaning full level of 0.05**

The fish were ranked according to the amount of protein. In this ranking, south bred salmon had the most amount of protein and indo-pacific king mackerel had the least amount of protein. According to the results, there was no significant difference between the amounts of protein existent of different type of fish. Also, the fish have been ranked in accordance to the amount of their total fat, that South bred salmon and Seimare bred carp had the most amount of total fat, but indo-pacific king mackerel, Sauridatumbil, tiger tooth croaker, and tuna had the least amount.

Moreover, seimere bred crap had the most amount of omega 3, but tiger tooth croaker had the least amount. Seimare bred carp had the most amount of omega6, but indo-pacific king mackerel, sauridatumbil, tiger tooth croaker, tuna and south bred salmon had the least amount of omega6. North bred salmon and Seimare bred carp had the most amount of omega9, but the Sauridatumbil, Indo-pacific king mackerel, Tiger tooth croaker, tuna, Silver carp, and South bred salmon had the least amount of omega 9, respectively.

According to the heavy metals amounts: lead, cadmium, and mercury, the North bred carp contained the most amount of lead, South bred salmon, *Saurida tum*bil, North bred salmon, Tuna, Indo-pacific king mackerel, and Rabbitfishes had the least amount of lead. Tuna contained the most amount of cadmium, but Seimare bred carp, North bred carp, Rabbitfishes, North bred salmon, and Silver carp had the least amount of cadmium. Again Tuna contained the most amount of mercury, but Seimare bred carp contained the least amount of mercury.

The total amount of protein, total fat, the omega 3, 6, and 9 fatty acids, the total amount of lead, cadmium, and mercury in seawater and freshwater fish were presented in table 2. According to these results, between proteins content of two types of fish was not statistically differences although, total fat, omega 3, 6 and 9 fatty acids content of freshwater fish were statistically more than seawater fish. Moreover, cadmium content of seawater fish was statistically more than freshwater fish, although, lead and mercury content of two types of fish were not significant differences. Also, we analyzed and compared the amount of lead, mercury, and cadmium in seawater and bred fish. Lead, cadmium, and mercury, the North bred carp contained the most amount of lead, South bred salmon, *Saurida tumbil*, North bred salmon, Tuna, Indo-pacific king mackerel, and Rabbitfishes had the least amount of lead. Tuna contained the most amount of cadmium, but Seimare bred carp, North bred carp, Rabbitfishes, North bred salmon, and Silver carp had the least amount of cadmium. Again Tuna contained the most amount of mercury, but Seimare bred carp contained the least amount of mercury.

The seawater samples contained average of 0.84ppm lead, but the bred fish contained on average of 0.87ppm. This difference in the amount of lead is not statically meaningful while seawater fish contained an average of 0.26ppm of mercury; the bred fish contained the average of 0.198ppm, this difference too is not statistically different. The mean amount of cadmium available in the two types of fish was significantly different. Bred fish contained 0.05ppm of mercury, extremely less than seawater fish which contained 0.26ppm.

The total amount of protein, total fat, the omega3, 6, and 9 fatty acids, the total amount of lead, cadmium, and mercury in seawater and freshwater fish were presented in table 2. According to these results, between proteins content of two types of fish was not statistically differences although, total fat, omega3, 6 and 9 fatty acids content of freshwater fish were statistically more than seawater fish. Moreover, cadmium content of seawater fish was statistically more than freshwater fish, although, lead and mercury content of two types of fish were not significant differences.

Table.2. Comparison of the amounts of protein, fat, omega 3, 6, and 9, lead, cadmium, and mercury in seawater and freshwater fish

Type of fish		Mercury (ppm)	Cadmium (ppm)	Lead (ppm)	Omega9 (%)	Omega6 (%)	Omega3 (%)	Fat (%)	Protein (%)
Seawater fish	No	45	45	45	45	45	45	45	45
	Mean	0.26	0.26	0.84	0.78	0.39	0.14	1.8	20.29
	SD	0.11	0.31	0.07	0.22	0.11	0.04	0.43	0.41
Farmed fish	No	45	45	45	45	45	45	45	45
	Mean	0.198	0.05	0.87	1.70	0.69	0.33	4.07	20.35
	SD	0.13	0.04	0.12	0.71	0.18	0.12	1.40	0.5
Total	No	90	90	90	90	90	90	90	90
	Mean	0.23	0.16	0.86	1.24	0.54	0.24	2.92	20.32
	SD	0.12	0.24	0.10	0.72	0.21	0.13	1.56	0.4
*p-value		0.17	>0.001	0.46	>0.001	>0.001	>0.001	>0.001	0.870

*According to Mann Whithney test carried out at 0.05 meaning full level

DISCUSSION

According to the findings of this study, there was no significant relationship between the amount of protein extent in seawater and bred fish.

Esmailzadeh, found that there is no significant relation between average amount of energy, protein, and ash extentent in North Sea white fish and bred grass carp (Esmailzadeh, 2003).

In another study, carried out by Moradi, the amount of protein available in fish was 18.7±19.26%. According to these findings we can conclude that there is no significant difference between amounts of protein in different species of fish, and that the protein content of fish depends on the fish's natural characteristics, e.g. the fish size. Any species of fish can gain its required protein from its food portion, and composition or type of fish food has no significant effect on the protein in the fish's muscle tissue (Moradi, 2012).

The results of this study showed that not only the amount of total fat and omega fatty acids existent in different species of fish is different, but also bred fish significantly contains more total fat and omega3, 6, and 9 fatty acids. Esmaielzadeh, indicated that bred fish contains more fat, and oleic fatty acid, in turn North Sea white fish contains more calcium, phosphorous, and iodine (Esmailzadeh, 2003). Sharma, compared the amount of fats existent in sea water and bred fish, the study demonstrated that bred fish contains a meaningful amount fatter than seawater fish, this could be due to the difference in the fishes diet (Sharma, 2010).

Numerous studies have shown that the difference in the amounts of total fat and unsaturated omega3, 6, and 9 fatty acids existent in different types of fish is due to factors such as these: the fish's age, gender, diet, pregnancy period, metabolism, season of fishing, the water temperature (Fuentes, 2010; Periago, 2005; Mahaaffey, 2004; Alasalvara, 2002).

Mahaffey reported that different fish contain different amounts of mercury, i.e. sharks posses more than 1ppm, sward fish contains around 1ppm, clams and oysters have 0.02 ppm of mercury, this study shows that piscivorous fish are higher in Hg than fish that subsist on plants and insects, it is also said that the bigger the fisher had the longer a fish ages, the more mercury it will contain. (Mahaaffey, 2004).

Storelli, studied tuna fish, they found that a 4 kg tuna contains near 0.48ppm of mercury in its tissue, and a tuna weighing more than 8 kg contain almost 1.4ppm of mercury (Storelli, 2002). The two studies above have shown that the amount of mercury in a fish's tissue varies from fish to fish (Mahaaffey, 2004; Storelli, 2002).

In the Mahaffey study it was said that fish such as salmon, mackerel, and herring are high in ω-3 fatty acids, (the affore mentioned fish) contain an average of 1.5 g of omega 3 per 100 gr of body weight, and they possess less than 0.1 ppm of mercury. The study also showed that fish which contain less or about 0.3 gram of omega 3 per 100 gr of body weight possess more mercury in comparison to fish with a lot of omega 3, about 10 times more. It is also reported that the fatty acid composition of fish and shellfish varies with species, temperature of the water in which the fish are grown or are caught, and their food (Mahaaffey, 2004).

Cai, carried out a study on fish which live and bred in deep waters, this study was carried out in china and its aim was to calculate the amount of heavy metals, mercury and arsenic, extant in the fish. The findings suggest that the fish which live in deep waters contain more heavy metals, the fish's gills and livers contained the most amounts of heavy metals in comparison to the fish's muscles (Cai, 2012).

Interestingly in Cai's study, they found out the fish's size had an opposite relation to the amount of heavy metals extent in the fish, the bigger fish were the less amount of heavy metals they contained. Also they concluded that this fact might be due to the fish's metabolism and its growth period. Cai suggested that the difference in the amounts of heavy metals in different fish could be due to the fish' diel, the ecology that a fish lives in, or the fish's metabolic and biological traits (Cai, 2012).

Norouzi, studied two types of fish in Geshm, they discovered that poisonous heavy metals are mostly competed in a fish's liver, not the fish's muscle, and that the amount of heavy metals stored in a fish's liver varies from fish to fish (Norouzi, 2012).

In a study that Turkmen, carried out on 8 species of Mediterranean deep water fish they found that the amount of heavy metals in the sample's muscles was less than the determined standard, the 8 species of fish contained between 0.05 – 0.12 ppm cadmium and between 0.45-0.58ppm lead (Turkmen, 2013).

By studding 2 species of Meditranian sea fish, Cogun, found that the fish's tissue contained 1.1-1.3 micrograms of cadmium per 1 gram body weight, the fish tissue also contained 5.7-9.4 microgram of lead per 1 gram of body weight. He also concluded that during the summer the fish contain more heavy metals this is due to the factors such as: during the summer water leads decrease, the fish's metabolism and diet change. Cogun also noted that cannier fish and fish which live in deeper waters had more heavy metals in their gills, livers, and the least amount of heavy metals in their muscle tissues (Cogun, 2006).

Dural, too carried out a study on 2 species of Mediterranean sea fish, their finding showed that per 1 gram of body weight the fish contained 0.06-0.13 micrograms of cadmium, he believes this is because of the fish's metabolism, movement, and swimming (Dural, 2006). In the Tepe, study on 8 species of meditranian sea fish, the fish contained 0.01- 0.40 micrograms of cadmium, and 0.11-1.15 micrograms of lead per1 gram of body weight, Tepe believes that the fish's diet, and the residue of ships dumped in the meditranian Sea are the main reasons that the fish are polluted (Tepe, 2009).

When Costa, studied fish in North east braid they found that the amount of mercury in a fish has a meaningful relationship to the season of the year, the fish's size, and the fish's growth. Costa noted that in drier seasons, the water levels decrease and so the fish's are more polluted by heavy metals (Costa, 2009).

Sobotic, studied the different species of fish in Danoob River, they noted that the fish where polluted with mercury, zinc, and arsenic. He attributed this to the water pollution. (Sobotic, 2013).

Fallah, studied and compared the amounts of heavy metals existent in both seawater and bred water rainbow trout, he believed that the difference in heavy metal poisoning of the fish was due to the difference in the fish's living ecosystem and diet. (Fallah, 2011).

EbrahimiSirizi, studied Esoxluciusn from Anzali wetland; the fish respectively contained an average of 0.82 and 0.22 microgram of cadmium and lead. She noted that the amount of cadmium extent in a fish has a significant negative relation with body weight and body length of fish, and the cadmium existent was more than standard. He believes that the fish's diet, and the ecosystem that the fish lives in are the main causes of heavy metal poisoning, the fish's ecosystem polluted by agricultural waste. (Ebrahimi-Shirazi, 2012).

Shahryari studied 60 samples of Tiger tooth croaker and Big eye snapper fish, he calculated that Big eye snapper contained 0.063 microgram of cadmium and 0.442 microgram of lead, Tiger tooth croaker contained 0.064 mirogram of cadmium and 0.48 microgram of lead. The amount of heavy metals calculated was below standard (Shahryari, 2005).

By studing 105 samples of bred Tiger tooth croaker, Big eye snapper, and carp, Pourmoghadas, found that the fish respectively contained an average of 0.063, 0.064 and 0.058 ppm of cadmium, 0.442, 0.48 and 0.482 ppm of lead, 0.224, 0.42, and 0.39 ppm of mercury. The amount of heavy metals calculated was below standard, also the fact that the fish contained more lead and cadmium could be because the water was polluted with agricultural waste. (Pourmoghadas, 2010).

Khoshnamvand, calculated the amount of mercury in the tissue of silver carp fish from Sanandej Ghslagh Dam. The fish tissue contained 367 nanograms of mercury per gram of body weight, this amount was below standard. The amount of mercury had a meaningful relationship with the fish's age, size, and weight, that is as the fish become older, and bigger the amount of mercury increase. This could be because of bioaccumulation or mercury's long half-life (Khoshnamvand, 2010). Askari, calculated that Biao fish contained 0.023, 0.346, 9.903 milligrams of mercury, cadmium, and lead, respectively. (Askari, 2011).

According to our study and Borden the numerous studied mentioned above, it is clear that the pollution of fish with heavy metals, especially cadmium, is a global problem. Based on all the studies mentioned, we can name a few causes for this heavy metal poisoning: dumping of agricultural and industrial waste into rivers and seas, boats and ships leaking oil and fuel into water systems, roads being close to water sources, the car gases gets dissolved into the water.

4. CONCLUSION

According to the finding of this study, both seawater and bred fish contain almost the same amount of protein, and that bred fish contain less cadmium, and contain more omega3, 6, and 9 fatty acids compared to seawater fish. We propose that families add bred fish to their diets, because bred fish is cheaper than seawater fish. By incorporating bred fish into their diet people not only gain more protein but also help the economy of cities which are farther away from seas. We also propose that more studies be carried out on more species of fish so that better and more accurate conclusions could be made.

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