

Heavy metals in livers, gills and muscle of *Dicentrarchus labrax* (Linnaeus, 1758) fish species grown in the Dardanelles

Çanakkale Boğazı'nda yetiştirilen *Dicentrarchus labrax* (Linnaeus, 1758) ciğerlerinde, solungaçlarında ve kaslarında ağır metaller

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Abstract

Heavy metals accumulation assessment was carried out in the livers, gills and muscle tissues of the Sea bass *Dicentrarchus labrax* (Linnaeus 1758) fish species grown in an experimental fish farm in the Dardanelles. The concentrations of the metals in muscle are (mg kg⁻¹, dry wt) Al 37±28; Cd 0.19±0.22; Cr 3.5±1.7; Cu 3.0±0.5; Fe 41±0.5; Hg 0.027±0.007; Pb 20±15; Zn <0.01 and Al, Cd, Cu, Cr, Hg and Fe were found in the order of liver>gill>muscle while the Pb and Zn levels follows the sequence gill>liver>muscle. These Pb and Cd levels are near the permissible limits for human consumption.

Key words: Trace metals, fish, livers, gills, Dardanelles.

Introduction

Trace elements occur in biological systems and they may exert harmful effects on algae, animal and human life depending on the concentration. These elements are introduced into environment through various routes such as industrial processes and discharge, smelting processes, fuel and coal combustion.

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Heavy metal contamination is very important for human health because of their toxicity and their tendency to accumulate in food chains. Fish are located in the aquatic food chain and may accumulate metals and pass them to humans through food causing chronic or acute diseases. Along with many other factors, retention time of fish in polluted waters affects the heavy metal accumulation in these organisms (Schuhmacher et al. 1992).

Fish farming is a very important and rapidly growing commercial activity in Turkey. It resembles 14.6% of total fish harvest (630,000 ton including fresh water and sea fishing) and Seabass farms produce 25% (26,000 ton), Çanakkale city including the Dardanelles produces about 1.5% of the total farms (TUGEM report, 2004). There is a little information about the effect of heavy metal pollution on the fish farming in the Dardanelles. In a previous study, total lipid content of *Dicentrarchus labrax* (Linnaeus 1758) from the fish farm in the Dardanelles was determined by Sağlık et al. (2003).

In this study, the accumulation of heavy metals in *D. labrax* liver, gill and tissues taken from a fish farm in the Dardanelles were investigated.

Materials and Methods

Samples of cultured Seabass, *Dicentrarchus labrax* (Linnaeus 1758) was collected from a sea farm in the Dardanelles. Fish are sampled from a fish population in floating sea cage. They were regularly fed with a commercial feed including 45% protein and 18% lipid. The fish were sampled with a net following a 24 hour food deprivation and placed in an empty plastic container and transported to the laboratory in an ice box, stored at -45°C until analysis.

The muscle samples of the fish were prepared from the tail part of the skinned fish. Following that liver and gill samples were dissected. The samples were pooled, dried at 85°C to constant weight and then homogenized. One gram of dry fish sample was put into a glass beaker, 10 ml conc. HNO₃ added and heated on a hot plate at 120°C for 30 min. after the colored smoke which indicates the oxidation of organic material disappeared then 5 ml of conc. HClO₄ was added and continued to heat until dry. The samples were dissolved in 1M HCl and diluted to 50 ml in volumetric flasks. For the Hg analysis 0.5 g of powdered sample which was dried at 45°C oven was put into a glass tube and 2 ml conc. HNO₃ added and heated on the hot plate at 60-70°C for 3 h. and dissolved material diluted to 10 ml. the samples were transferred into acid washed

plastic bottles for the analysis. The accuracy of the analysis was verified by analysing the IAEA's certified reference material. The heavy metal concentrations were determined by atomic absorption spectrophotometer (Shimadzu 6701F). Values were expressed as the mean of three analyses for each sample.

All reagents used were of analytical grade (Merck). Deionized water was used throughout the study. All glassware was carefully cleaned with 1M HCl followed by thorough rinsing with deionised water before use.

Results and Discussion

The amounts of Al, Cd, Cr, Cu, Fe, Hg, Pb and Zn in $\mu\text{g/g}$ dry tissues in muscle, liver, gill of *Dicentrarchus labrax* (Linnaeus 1758) are summarized in Table 1. The distribution pattern of Al, Cd, Cr, Cu, Fe and Zn follows the order liver>gill>muscle; while Hg and Pb follow the sequence: gill>liver>muscle. The liver tissues in fish are often recommended as an indicator of water pollution than any other organ because of the tendency of liver to accumulate pollutants of various kinds at higher levels their environment as reported by Galindo et al. (1986). Various studies suggest that metal uptake by fish performed via food that constitutes the major pathway for accumulation in liver and then muscle. However, when contamination occurs, concentration of metals in certain tissues increases in proportion with that of seawater. Gills appear to be the primary route of uptake of certain metals such as Pb.

In liver the highest accumulation was observed for copper because of various complexes that copper forms with mercapto and disulphide groups present in the enzymes (Schuhmacher et al. 1992). A recent study showed that copper accumulates in liver 20-40 times more than it does in muscle of the same species (Farkas et al. 2000). Another study also showed that copper is the highest accumulated metal in all above in liver for the Sea bass taken from Italian farms (Dugo et al. 2006). All above studies above are in good correlation with our result.

Liver	Cu>Fe>Al>Pb>Zn>Cd>Cr>Hg
Muscle	Fe>Al>Pb>Zn>Cu>Cr>Cd>Hg
Gills	Fe>Al>Pb>Cr>Cu>Cd>Hg>Zn

Table 1. Mean heavy metal concentrations in liver, gills and muscle of fish species collected from sea farm in the Dardanelles (mg kg⁻¹, dry wt) (n=3).

Tissue		Al	Cd	Cr	Cu	Fe	Hg	Pb	Zn
<i>D. Labrax</i>	Muscle	37±28	0.19±0.22	3.5±1.7	3.0±0.5	41±0.5	0.027±0.007	20±15	<0.01
	Gills	54±44	0.58±0.27	3.4±0.6	5.0±1.0	160±28	0.053±0.013	49±24	20±2
	Liver	74±49	6.20±5.00	6.4±1.9	2029±995	185±52	0.051±0.016	27±5.0	25±12
<i>D. Labrax</i> ¹	Muscle	-	<0.01-0.04	-	<0.1	-	-	<0.02-0.4	<0.5-7.2
Fish species ²	Muscle	-	0.015	-	-	-	0.071±0.049	0.01	-
	Liver	-	1.81±1.30	-	-	-	0.035±0.011	0.015	-
<i>L. cephalus</i> ³	Muscle	-	0.030±0.030	4.575±4.912	0.278±0.297	-	-	0.020±1.040	29.36±22.59
	Gills	-	0.012±0.004	2.540±1.180	0.790±0.873	-	-	0.230±0.250	11.06±12.61
<i>C. regium</i> ⁴	Muscle	-	0.95	0.82	4.21	-	-	6.58	-
	Gills	-	3.03	3.96	20.09	-	-	20.10	-
Tolerance levels ⁵ (w wt)		-	0.1	-	5	-	-	0.5	50

1 (Dalman et al. 2006)

2 (Johansen et al. 2000) Average value from the fish species including Spotted fish, Greenland halibut, Atlantic cod, Greenland cod, Golden redfish.

3 (Demirak et al. 2006)

4 (Canlı and Kalay 1998)

5 (ITS 2000) for all fish species

A study of heavy metal concentrations in muscle, gill and liver of three fish species showed that mercury accumulated in muscle in each species while the other metals were found higher levels in liver and gills (Farkas et al. 2000). This result contradicts with our findings for Hg because in our study Hg accumulates equally in liver and gills and much higher than muscle as it is reported in the work of Abreu et al. (2000).

Heavy metal analysis of the wild Seabass taken from Perşembe, eastern Black sea showed the accumulated metals in muscle as follows: Cd: 0.24; Cr: 0.18; Cu:1.01 , Fe:30 ; Pb:<0.05, Zn:25.7 (Topçuoğlu et al. 2002). This result is comparable with our findings and except Cd, all the other metal concentrations analyzed are much lower in fish from Perşembe. This finding indicates the heavy metal pollution in the Dardanelles. When these values are compared with another study on the wild pelagic fish (*Boops boops*) from north Aegean sea near the Dardanelles indicates that the pollution level of the Dardanelles except for copper concentrations is lower Cu 1.9/3.8; Cr 1.4/5.0; Zn 24/94; Fe 21/313; flesh/gills in ppm (Catsiki et al. 1999).

Toxicity of lead and cadmium

Hutton, (1987) suggested that the major health problems of Pb are manifested in three organ systems namely the haematological, nervous and renal systems. In the haematological system, Pb interferes with the last stage of haem synthesis, the incorporation of Fe into protoporphyrin, catalyzed by haem synthetase. Acute effects of Pb on the central nervous system are generally seen in children and are manifested by severe encephalopathy that can culminate in coma and death (Hutton 1987). However, the potential hazards of metals transferred to humans are probably dependent on the amount (g wet weight) of fish consumed by an individual. The average dry/wet weight ratio for fish samples is 0.15. For example, an adult who consumed 0.5 kg of fish collected from Dardanelles weekly would take in approximately 1.5 µg ($20 \mu\text{g}/\text{kg} \times 0.5 \text{ kg} \times 0.15$) of Pb each week. This is already equal to the recommended limit for the provisional tolerable weekly intake (PTWI) of Pb (1500 µg/adult) (FAO/WHO, 2004). According to this an adult should not consume more than 0.5 kg of fish collected from Dardanelles.

For cadmium toxicity the kidney is the main target organ. The critical cadmium concentration in the renal cortex that would produce a 10% prevalence of low-molecular-weight proteinuria in the general population is about 200 mg/kg, and would be reached after a daily dietary intake of about 175 µg per person for 50 years. Similar to Pb, if

an adult consumes approximately 0,5 kg of fish collected from a farm from Dardanelles per day, would take in approximately 14. µg (190 µg/kg × 0,5 kg × 0,15) of Cd weekly. This is lower than the recommended limit for PTWI of Cd (400-500, µg/adult) (FAO/WHO, 2004) However, if the person consumes more fish (>2kg/day) the value will exceed the recommended limit.

Turkey legislation establishes maximum levels for and Cd, Cu and Pb of the metals studied, above which human consumption is not permitted: 0.1 mg kg⁻¹ for Cd, 5 mg kg⁻¹ for Cu and 0.5 mg kg⁻¹ for Pb (all expressed in wet mass) (ITS, 2000). These limits for Cd and Cu were just under the limits but Pb exceeded in the muscle of the fish analyzed in this study.

Among the metals analyzed, levels of Cd. Cu and Pb in muscle of farmed *D. labrax* from the Dardanelles are above or very close to the acceptable limits.

Özet

Çanakkale boğazında özel bir balık çiftliğinde yetiştirilen Levrek balıklarında *Dicentrarchus labrax* (Linnaeus 1758) ciğer, solungaçlar ve kas dokularında ağır metal birikmesi üzerindeki bu çalışmada balık etinde bulunan metal konsantrasyonları (mg kg⁻¹) Al 37±28; Cd 0.19±0.22; Cr 3.5±1.7; Cu 3.0±0.5; Fe 41±0.5; Hg 0.027±0.007; Pb 20±15; Zn <0.01'dir. Al, Cd, Cu, Cr, Hg ve Fe konsantrasyonları sıralaması ciğer>solungaç>kas dokuları şeklindedir. Pb ve Zn seviyeleri ise solungaç>ciğer>kas dokusu şeklindedir. Ölçülen Pb ve Cd seviyeleri insan sağlığı için limit değerlerin civarında olduğu tespit edilmiştir.

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