



Human Health Risk Assessment of Heavy Metals Via Dietary Intake of Rainbow Trout from Samsun Fish Markets

Öztekin YARDIM* Levent BAT

University of Sinop, Fisheries Faculty, Department of Hydrobiology, 57000 Sinop, Turkey

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*ID: <https://orcid.org/0000-0002-7753-5922>
ID: <https://orcid.org/0000-0002-2289-6691>

***Corresponding author's:**

Öztekin YARDIM

University of Sinop, Fisheries Faculty,
Department of Hydrobiology, 57000 Sinop,
Turkey

✉: oyardim@sinop.edu.tr

Mobile telephone : +90 (533) 563 54 85

Telephone : +90 (368) 287 62 65

Fax : +90 (368) 287 62 68

Abstract: Fish are an important part of the diet of the local people in the coasts of the Black Sea. The concentrations of three essential (Fe, Zn, Cu) and three non-essential (Pb, Hg, Cd) heavy metals were determined in Rainbow trout from Samsun fish market. In the present study, the maximum amounts of the toxic metals were 0.014 Pb mg kg⁻¹ wet wt., 0.024 Hg mg kg⁻¹ wet wt. and 0.018 Cd mg kg⁻¹ wet wt. in the edible tissues of Rainbow trout. Maximum toxic heavy metal values are quite below the permitted values set by the Turkish Food Codex (TFC) and European Union legislation. Hazardous quotient (HQ) values showed that there was no apparent risk when each metal was analysed individually. Moreover, hazard index (HI) was also found to be less than 1. From the results the HQ of the heavy metals indicated that all Rainbow trout individuals were safe with no risk to consumers from Samsun.

Keywords: Hazard index, hazardous quotient, heavy metals, Rainbow trout, Samsun..

Samsun Balık Pazarlarından Gökkuşığı Alabalığı Tüketimi ile Ağır Metallerin İnsan Sağlığı Risk Değerlendirmesi

***Sorumlu yazar:**

Öztekin YARDIM

Sinop Üniversitesi, Su Ürünleri Fakültesi,
Hidrobiyoloji Bölümü, 57000 Sinop,
Türkiye.

✉: oyardim@sinop.edu.tr

Cep telefonu : +90 (533) 563 54 85

Telefon : +90 (368) 287 62 65

Faks : +90 (368) 287 62 68

Öz: Balıklar Karadeniz kıyılarında halkın beslenmesinin önemli bir parçasıdır. Canlılar için üç esansiyel (Fe, Zn, Cu) ve üç esansiyel olmayan (Pb, Hg, Cd) ağır metal konsantrasyonları Samsun balık pazarından alınan Gökkuşığı alabalıklarında belirlenmiştir. Bu çalışmada Gökkuşığı alabalığının yenilebilir dokularında tespit edilen toksik metallerin maksimum miktarları, 0,014 Pb mg kg⁻¹ yaş ağırlık, 0,024 Hg mg kg⁻¹ yaş ağırlık ve 0,018 Cd mg kg⁻¹ yaş ağırlık olarak bulunmuştur. Maksimum toksik ağır metal değerleri, Türk Gıda Kodeksi (TGK) ve Avrupa Birliği mevzuatı tarafından izin verilen değerlerin oldukça altındadır. Tehlikeli katsayı (TK) değerleri, her metal için ayrı ayrı analiz edildiğinde belirgin bir riskin olmadığını göstermiştir. Ayrıca, tehlike indeksi (Tİ) de 1'den az bulunmuştur. Sonuçlardan, ağır metallerin Tİ'si tüm Gökkuşığı alabalığı tüketiciler için hiçbir risk olmaksızın güvenli olduğunu göstermiştir.

Anahtar kelimeler: Ağır metaller, Gökkuşığı alabalığı, Samsun, tehlike indeksi, tehlikeli katsayı.

INTRODUCTION

There is increasing attention to detect heavy metal contamination in fish today (Bat & Arici, 2018). Essential metals are beneficial for humans, but non-essential heavy metals are extremely harmful. Intake of fish is one of the main pathways of heavy metal toxicity to people. Heavy metals are known the most marked forms of contamination in the marine ecosystem. This is since heavy metals are not simply biodegradable and as a consequence can be accumulated in human vital organs. This can cause serious illnesses and even deaths (Bat et al., 1999).

Fish is accepted necessary to a healthy diet because it has quality protein, high content of omega-3 polyunsaturated fatty acids, providing vitamins and a wide range of nutrients (De Lorgeril et al., 1994). Rainbow trout are very delicious and popular fish and are frequently consumed in Samsun, but information on the health risks of the heavy metals is rare. The hazard quotient (HQ), which is a ratio of determined amount of a contaminant to the reference dose level. If the ratio is less than 1, there will not be any explicit risk. On the other hand, an exposed people will lifetime health risks if the amount is equal to or higher than the reference dose (EFSA, 2010; European Food Safety Authority, 2012; EFSA, 2012; EFSA, 2014; EFSA, 2015). Risk estimation method was applied in the present study. The main objective of this study is to estimate the health risks of heavy metals, such as Fe, Zn, Cu, Pb, Cd and Hg via consumption of Rainbow trout to the people in Samsun using the HQ estimates.

MATERIAL AND METHOD

The origin of fresh samples (*Oncorhynchus mykiss* Walbaum, 1792) was fish markets of Samsun Balık Hali (Fishing Store). Rainbow trout samples collected randomly from different fish markets in 2017. A total of 20 Rainbow trout individuals were purchased as fresh. To obtain three homogeneous samples of each individuals for metal analysis, a portion of muscle tissue was taken from the dorsal muscles according to the process described by Bernhard (1976). Analyses was replicated three times. Concentrations were calculated on a wet weight basis.

Metal analysis in fish was performed using m-AOAC 999.10- ICP/MS (Inductively Coupled Plasma – Mass Spectrometer) method by accredited Environment Industrial Analysis Laboratory Services Trade Company (TÜRKAK Test TS EN ISO IEC 17025 AB-0364-T). EN 15763 European Standard methods was applied. The sensitivity of the method was determined according to the detection limits established for the ICP/MS, which were < 0.001 µg/L for Fe, Pb and Cd, < 0.01 Zn and Hg and < 0.0001 µg/L for Cu.

Health risk calculation

Estimated Daily Intake (EDI): For the EDI the average metal content in each individual was calculated and multiplied by the respective consumption rate. EDI was determined by the following equation (1):

$$(1) \text{ EDI} = C_{(\text{Metal amounts})} \times W_{(\text{fish intake})} / \text{Body Weight (70 kg for adults)}$$

Where,

$C_{(\text{Metal amounts})}$ = Heavy metal concentration in Rainbow trout (mg/kg); $W_{(\text{fish intake})}$ = Daily intake of fish (kg person⁻¹day⁻¹ wet wt.).

The average daily fish intake rate is 15 g in 2017 (TUIK, 2019).

Hazardous Quotient (HQ) and Hazard Index (HI): In this study a value of intake of these heavy metals in Rainbow trout was calculated to estimate the risk to human health via consumption. Hazardous Quotient (HQ) for people through the consumption of contaminated Rainbow trout was assessed by the ratio of EDI to the oral reference dose (Rf. D, mg/kg/day) for each metal. An estimate of risk to HQ through consumption of metal contaminated fish was calculated by the following equation (2):

$$(2) \text{ HQ} = \text{EDI} / \text{Rf. D.}$$

Oral reference doses (Rf. D.) mg kg⁻¹ day⁻¹ for Fe, Zn, Cu, Pb, Cd and Hg are 0.7, 0.3, 0.04, 0.004, 0.001 and 0.0005 mg/kg/day, respectively (The Risk Assessment Information System, 2019).

The HI is the sum of the HQs for all heavy metals, which was calculated by the equation (3):

$$(3) \text{ HI} = \sum \text{HQs} = \text{HQ}_{(\text{Fe})} + \text{HQ}_{(\text{Zn})} + \text{HQ}_{(\text{Cu})} + \text{HQ}_{(\text{Pb})} + \text{HQ}_{(\text{Cd})} + \text{HQ}_{(\text{Hg})}$$

If the HI value is less than 1, the local consumers exposed are said to be safe, if HI is equal to or higher than 1, it is considered unsafe for people's health, so potential health risk and related treatments and preventive measures should be taken.

Statistical analysis: Statistical significance of means was computed using one-way ANOVA and Duncan multiple range test were used to calculate the significant difference in the concentrations of studied metals, with a significance level of $P < 0.05$. Statistical analysis of data was performed by IBM SPSS 21.

RESULTS

Fe, Zn and Cu are essential heavy metals which may exert toxicity at high concentrations. Non-essential heavy metals such as Pb, Hg and Cd, have no biological functions and their intake can lead to adverse health effects (Bat, 2014; Bat, 2017). Results of the present study on heavy metals (Fe, Zn, Cu, Pb, Cd and Hg) in Rainbow trout

from Samsun fish markets are given in Figure 1. Pb, Hg and Cd levels were below the limit of quantitation values

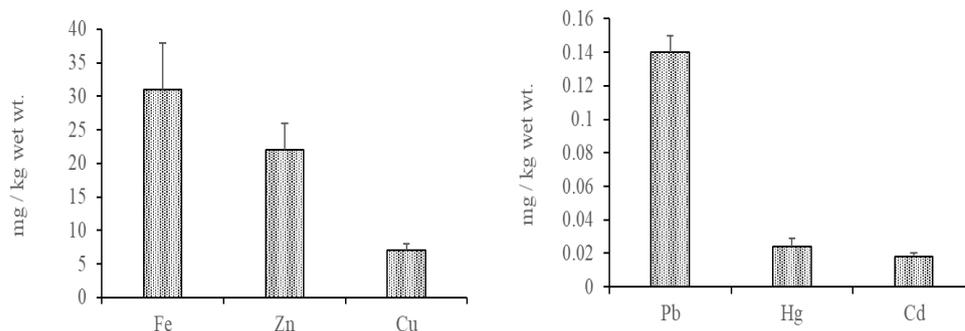


Figure 1. Fe, Zn, Cu, Pb, Hg and Cd levels in Rainbow trout from Samsun fish markets in 2017.

Currently, limit values permitted by international (EU) and national (Turkish Food Codex) organizations (European Commission, 2006; Turkish Food Codex, 2008) are not available for essential heavy metals (Bat et al., 2020). In the present study maximum non-essential heavy metal values determined in Rainbow trout are clearly below the permitted values set by the TFC and EU legislations. The maximum amounts set by the EC Regulation and TFC for Pb, Hg and Cd in Rainbow trout are 0.3, 0.50 and 0.050 mg/kg⁻¹ wet wt., respectively (Turkish Food Codex (TFC) No. 2008/26; Commission Regulation (EC) No. 1881/2006). The maximum amounts of the present study were 0.014 Pb mg kg⁻¹ wet wt., 0.024 Hg mg kg⁻¹ wet wt. and 0.018 Cd mg kg⁻¹ wet wt. in the edible tissues of Rainbow trout.

The low metals levels obtained for Rainbow trout in this study are in good agreement with previous studies from Sinop fish markets (Bat et al., 2018), from the Karakaya Dam Reservoir on the Fırat River in eastern

in some samples of Rainbow trout individuals. However, the mean values for each metal were given in Figure 1.

Anatolia (Varol et al., 2017) and from the Fırtına and Güneysu Rivers (Dizman et al., 2017).

The estimated exposure to studied heavy metals due to the Rainbow trout consumption was calculated, considering the mean values of this study and an average Turkish consumer (70 kg) in the year 2017 as a reference; it must be considered that the consumption of fish in Turkey is 17 g per day. Estimated daily intakes of heavy metals through the consumption of fish in the present study was less than tolerable daily intake limit set by the US-EPA, IRIS (2013). In the current study, the highest EDI was found as Fe. This was followed by Zn, Cu, Pb, Hg and Cd. HQ was calculated for each metal. HQ values were calculated on the basis of the oral reference dose, there was no apparent risk when each metal was analysed individually. Its sum (HI) was also found to be less than 1, which means that consuming fish is not harmful to human health.

Table 1. People health risk parameters in Rainbow trout from Samsun fish markets.

Health Risks	Heavy metals					
	Fe	Zn	Cu	Pb	Hg	Cd
EDIs	6.64×10^{-3}	4.71×10^{-3}	1.5×10^{-3}	3×10^{-5}	5.1×10^{-6}	3.9×10^{-6}
HQs	9.48×10^{-3}	1.57×10^{-2}	3.75×10^{-2}	7.5×10^{-3}	1.03×10^{-2}	3.86×10^{-3}
HI	8.43×10^{-2}					

The finding of the present study regarding HQs and HI showed that the consumption of Rainbow trout from Samsun fish markets was free of health risks. Regular monitoring of heavy metal contamination in seafood is necessary in order to reduce the health risk. Rainbow trout is one of the most widely and most frequently consumed fish. Thus, popular fish, such as Rainbow trout, can be used for biomonitoring the marine contamination.

According to the results of the present study and Turkish and EU legislations, the contribution of Fe, Zn, Cu,

Pb, Hg and Cd through Rainbow trout to the Turkish diet does not hazard a risk to the consumer from Samsun.

CONCLUSION

Average concentrations of essential and toxic metals in Rainbow trout were negligible. These values were far below the limit levels set by the TFC and EU Regulations. As a conclusion the contribution studied heavy metals through Rainbow trout to the Turkish diet does not pose a risk to the consumer, according to national and international legislations.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

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