Toxicology Reports 1 (2014) 353–359

Contents lists available at ScienceDirect

Toxicology Reports

journal homepage: www.elsevier.com/locate/toxrep

Comparison of the nutritional and toxicological reference values of trace elements in edible marine fish species consumed by the population in Rio De Janeiro State, Brazil

Renata Jurema Medeiros[a,*], Lisia Maria Gobbo dos Santos[a], Jaylei Monteiro Gonçalves[a], Ana Maria Cheble Bahia Braga[b], Thomas Manfred Krauss[b], Silvana do Couto Jacob[a]

[a] Instituto Nacional de Controle de Qualidade em Saúde (INCQS/FIOCRUZ), Av. Brasil, 4365, Manguinhos, Rio de Janeiro, RJ, CEP: 21.040-900, Brazil

[b] Centro de Estudos em Saúde do Trabalhador e Ecologia Humana (CESTEH/ENSP/FIOCRUZ), Av. Brasil, 4365, Manguinhos, Rio de Janeiro, RJ, CEP: 21.040-900, Brazil

ARTICLE INFO

Article history:
Received 14 May 2014
Received in revised form 5 June 2014
Accepted 6 June 2014
Available online 28 June 2014

Keywords:
Inorganic elements
Health risk assessment
Fish
Seafood safety
Chemical contaminants
Essential elements

ABSTRACT

The present study estimated the human daily and weekly intake of inorganic elements due to consumption of fish in Rio de Janeiro state and the associated potential health risks posed by some toxic elements. All samples analyzed had values of Cd and Pb below the Maximum Tolerable Limits of 3.0 mg kg^{-1} for Pb and 1.0 mg kg^{-1} for Cd; only *Mugil cephalus*, *Cynoscion leiarchus* and *Caranx crysos* had As concentrations below 1 mg kg^{-1}, maximum limit established by Brazilian legislation. The higher values of Cd and Pb correspond to 0.22% of PTWI and the higher value of As corresponds to 8.6% of PTWI. None of the studied species showed values higher than PTWI. The higher values of Cu EDI found in *Pomatomus numida* correspond to 33.3% of RDA; Fe in *Salmo salar* and *Genypterus brasiliensis* corresponds to 4.3% of EDI; Mn in *Sardinella brasiliensis* corresponds to 7.4% of EDI; Zn in *S. salar* corresponds to 13.2% of EDI and Se in *S. salar* corresponds to 20.6% of EDI. Some species can be a good source of inorganic elements. For risk assessment, it is important to assess specific eating habits of each region to avoid underestimating the data.

1. Introduction

Trace elements such as Zn, Fe, As, Pb, Cd, Co, Cu and Mn can be classified as essential and toxic [1]. Essential elements are micronutrients that need to be daily consumed in adequate amounts in order to sustain normal physiological functions [2], but when associated with adverse health effects by dietary exposure, they are considered toxic [3]. On that account, the assessment of inorganic trace elements plays an important role in the substance risk evaluation.

Levels of inorganic trace elements in fish can diverge among different species and even among individuals of the same species due to the influence of environmental and biological factors, such as origin of the fish, sea environment, feeding habits and age [4–6]. The accumulation of toxic elements in fish tissue can result in significant dietary human exposure to environmental pollutants and therefore fish needs to be monitored regularly [7,8].

However, edible fish represents a valuable source of long-chain polyunsaturated omega-3 fatty acids (e.g. eicosapentaenoic acid), high quality protein and important

* Corresponding author. Tel.: +55 21 3865 5258.
E-mail address: renata.medeiros@incqs.fiocruz.br (R.J. Medeiros).

http://dx.doi.org/10.1016/j.toxrep.2014.06.005

organic and inorganic micronutrients (e.g. vitamin D, selenium) [9,10]. In order to balance the risk benefit, various health authorities recommend the ingestion of a certain amount of fish. The most common recommendation is one to two portions of a particularly oily fish per week, but more vulnerable groups, such as pregnant woman, should avoid fish from the top of the aquatic food chain, which could have higher levels of environmental pollutants [10–13].

According to the Food and Agriculture Organization [13] the world per capita food fish supply increased from an average of 18.1 kg (live weight equivalent) in 2009 to an amount estimated as 18.8 kg in 2011. Brazilian fish consumption also increased from 9.0 kg/per capita/year in 2009 [14] to 11.2 kg in 2011 [15]. Thus, we currently believe that the Brazilian population is already consuming fish near the minimum level recommended by the World Health Organization (WHO), 12 kg/per capita/year.

To ensure the safety of population health the Brazilian legislation determined the maximum tolerable levels, as 1.0 mg kg^{-1} for As and Cd and 3.0 mg kg^{-1} for Pb, for raw, frozen or chilled fish which are different from the values established by the European Community as maximum levels, 0.1 mg kg^{-1} for Cd and 0.4 mg kg^{-1} for Pb in muscle meat. However, there is a proposal for legislation of new food additives and contaminants in Brazil that aims to establish the same maximum tolerable values of the European Community legislation [16].

There is less data about the presence of inorganic trace elements in fish and sea food consumed in Brazil and consequently about their contribution to the dietary intake of the Brazilian population. The proposal of this study was to evaluate the levels of Fe, Mn, Zn, Co, Cu, As, Cd and Pb in 11 edible marine fish species commonly consumed by the population of Rio de Janeiro and Niterói cities and to compare them with appropriate nutritional and toxicological reference values and with data provided from other countries. The estimated daily intake (EDI) for these contaminants was calculated and the human risk assessment was evaluated by calculating the Hazard Quotient (HQ) which allows discussion about health risk due to fish consumption. Observed data can contribute for initiation of a broad discussion between nutritional benefits and the presence of contaminants in fish consumed in several Brazilian cities.

2. Materials and methods

2.1. Sampling

For this study, 11 edible marine fish species, widely consumed in the region (*Salmo salar*, *Sardinella brasiliensis*, *Pomatomus saltatrix*, *Micropogonias furnieri*, *Cynoscion leiarchus*, *Caranx crysos*, *Priacanthus arenatus*, *Mugil cephalus*, *Genypterus brasiliensis*, *Lopholatilus villarii* and *Pseudopercis numida*) were collected at Saint Peter Market from different suppliers. Saint Peter Market is a fresh fish market and distributor for the municipalities of Niterói, São Gonçalo and Rio de Janeiro, Brazil. Sampling extent was 5 samples for each species collected at different dates in the period from April to July 2009. Immediately after collection, the fish samples were transported to the laboratory in ice-cooled containers.

All fish were caught along the coast of Rio de Janeiro State, except *Salmo Salar* because it is imported from Chile and it was included in the study due to its high consumption in several Brazilian cities [17,18].

The fish were selected by size and weight. Every specimen was at least 2.0 kg in weight for *P. numida*, *M. cephalus*, *L. villarii* and *M. furnieri*, 1.5 kg for *P. arenatus*, *G. brasiliensis* and *P. saltatrix*, 0.5 kg for *C. leiarchus* and *C. crysos*, and 0.07 kg for *S. brasiliensis* which means it is an adult fish for this species.

Only *S. salar* was purchased as 2.0 kg fillets for each fish specimen studied. This is because these fish species are not naturally available in Brazil, being exported from Chile and arriving in Brazil without viscera and in some cases without the head hindering the correct measurement of weight and length.

2.2. Analytical determination of trace elements

For determination of Zn, Fe and Mn an Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) of Thermo Scientific, model iCAP 6300 and operational software iTEVA was used and for determination of Co, Cu, As, Cd and Pb an Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) of Thermo Fisher Scientific, model X-Series II with operational software PlasmaLab was used. All samples were analyzed in batches, with method blanks and known standards. The accuracy of the analytical procedure was checked by analysis of certified reference material SRM 2976 – *Mussel Tissue* from the National Institute of Standards (NIST). The results are shown in Table 1. The standard deviation was 18.2% for As, 9.8% for Pb, 0.4% for Cd, 8.75% for Zn and 19.2% for Fe. The parameters of sensitivity, linearity, selectivity, accuracy, precision, limit of detection and limit of quantification were established with tests from the reference material. The figures of merit for the elements analyzed are shown in Tables 2a and 2b. Details of sample preparation, analytical results and instrumental operating conditions are described by Medeiros et al. [19].

Table 1
Certified values of reference material NIST 2976 – *Mussel Tissue* and mean values experimentally obtained for trace elements ($n = 5$).

Elements	Certified values (mg kg^{-1})	Results obtained (mg kg^{-1})	Recovery (%)
As	13.3 ± 1.8	7.945 ± 1.45	70
Pb	1.19 ± 0.18	1.425 ± 0.14	119.8
Cd	0.82 ± 0.16	0.785 ± 0.03	94.6
Zn	137 ± 13	125.67 ± 11.0	91.7
Fe	171.0 ± 4.9	165.29 ± 31.9	103.5