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Investigation of Zinc Content in Iranian Rice (Oryza Sativa) and its Weekly Intake

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Abstract: Zinc is an ubiquitous and essential element. It is widely used in the industries such as a protective coating of other metals, in dye casting and the construction industry and for alloys, automotive equipment, batteries and dental, medical, household applications, fungicides, topical antibiotics and lubricants. Human ingests Zn daily from food and beverages. One of the sources of Zn intake is rice for rice eating countries such as Iran. This investigation was conducted to determine Zn contents in a type of Iranian rice (Tarrom) and to assess the safety dietary intake of Zn from rice. A total of sixty rice samples were collected from four areas of Qaemshahr region in Mazandaran province of the north of Iran. The samples were collected in during harvesting of rice in fileds. Rice samples were digested by acid digestion method and analyzed by Atomic Absorption Spectrometer. To assess the dietary intake of Zn by rice, weekly intake was calculated based on average Zinc content in rice and weekly consumption of rice and dietary intake compared with the Provisional Tolerable Weekly Intake (PTWI) established by the JECFA (WHO/FAO). The results showed that average content of Zn in rice was (19.46±4.31) μg g^{-1} dry wt and range was 12 to 27.6 μg g^{-1} dry wt. Also average weekly intake of Zn from rice was 373.5 μg kg^{-1} of body weight/week and range was 231 to 531.3 It is 7% of PTWI recommended by WHO/FAO.

Key words: Rice · zinc · Iran · intake · oryza sativa · food

INTRODUCTION

Some heavy metals (the so-called trace elements) are essential in very small concentrations for survival of all life forms, such as Zinc, Copper, Iron, Chromium, Molybdenum and others. It is possible that not all are yet known. Despite this fact, it is often forgotten that in some circumstances, these can also be quite toxic. Heavy metals can enter the food chain from aquatic and agricultural ecosystems and threaten human health [1]. One such heavy metals, Zinc, are an ubiquitous and essential element that its content in various foods is vary. Zinc levels are 10-50 mg kg^{-1} in fresh edible portion of vegetables and 550 mg kg^{-1} in mongo beans. The human health effects associated with Zinc deficiency are numerous and include neuroses changes, oligospermia, impaired neuropsychological functions, delayed wound healing, immune disorders and dermatitis. These conditions are generally reversible when corrected by zinc supplementation [2].

Poisoning incidents with symptoms of gastrointestinal distress, nausea and diarrhea have been repoted after a single or short-term exposure to concentration of zinc in Water or beverages of 1000-2000 mg l^{-1} [2].

It is also known that people, especially those who take rice as staple food for daily energy, are inevitably exposed to significant amounts of heavy metals via rice [3] because fertilizers that are used in farm, had amounts of heavy metals. Its entering to the environment is from

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both natural and anthropogenic sources [1]. Zinc is widely used as a protective coating of other metals, in dye casting and the construction industry and for alloys. In organic zinc compounds have various applications, e.g., for automotive equipment, storage and dry cell batteries and dental, medical and household applications. Organo-zinc compounds are used as fungicides, topical antibiotics and lubricants. The main anthropogenic sources of zinc are mining, zinc production facilities, iron and steel production, corrosion of galvanized structures, coal and fuel combustion, waste disposal and incineration and the use of zinc-containing fertilizers and pesticides [2].

The Joint FAO/WHO Expert Committee on Food Additives (JCEFA) has set the Provisional Tolerable Weekly Intake (PTWI) for the Zinc of 5250 μg kg^{-1} of body weight/week. It was calculated based on the upper limit (45 mg day^{-1}) and body weight of 60 kg [4]. The present study attempted to determine Zinc content of Tarrom rice that cultivated in Qaemshahr region (Mazandaran province, North of Iran) and also to evaluate the safety of weekly intake from rice.

MATERIALS AND METHODS

Rice samples were collected in four areas in Qaemshahr region in Mazandaran province. The first step, samples were collected in rice farms when farmers harvested their crops. Collections were made by chance. A total of 60 rice samples were sampled from four major rice production areas that 15 samples took from any area.

To determine Zn concentration in raw rice, a portion of rice grains cleaned and about 2 g were taken and weighed, dried at 105°C for 48 h and weighed again to determine water content. Then, the sample was digested by a nitric-perchloric acid digestion method based on annual book of ASTM standards [5]. Each rice sample was refluxes in a premixed solution of concentrated nitric and perchloric (70%) acids (3+1) at the rate of 20 ml g^{-1} of sample. 2.5 ml of sulfuric acid (spg. 1.84) was added per gram of sample. Then, the mixture was swirled and allowed it to stand for 30 min. Then the beaker was covered with an acid-washed watch glass, places it on a hot plate and gradually increased the temperature until the mixture is boiling. The boiling was continued until evaporation had occurred and perchloric fumes were evolved. The heating was terminated when about less than 3 ml of a clear liquid obtained. Afterwards, deionized water was added to bring the digest to 25 ml. The digested solution was analyzed for Zn content by flame atomic absorption spectrometer (Chemtech, Eng and Alpha-4). Concentrations were expressed in terms of μg g^{-1} on a dry weight basis. Analysis was done by SPSS program. Analysis of variance (ANOVA) followed by multiple comparison (Scheffe) were employed to detect significances between or among samples. Weekly Zinc intake from rice was calculated by Zinc content in rice multiplied to weekly rice Consumption [6, 7].

RESULTS

The results of zinc contents in sixty samples of raw rice from four areas are shown in Table 1 separately. These results indicated that that average content of Zn in rice was (19.46±4.31) μg g^{-1} dry wt and range was 12 to 27.6 μg g^{-1} dry wt. ANOVA analysis showed that there was a significant difference in Zinc contents in rice ($p<0.003$).

Figure 1 shows the distribution of zinc content in Tarrom rice and reveals that 15% of rice samples had Zn content below 15 μg g^{-1}, while 13.3% contained more than 25 μg g^{-1} of Zn. Additionaly 71.67% samples had 15-25 μg g^{-1} of Zn.

Table 2 shows weekly intake of Zn from rice. According to the published papers, daily consumption of rice in Asia countries ranges between 158-178 g/person-day and the average is 165 g/person-day and the average body weight is 60 kg/person [7, 8]. Table 2 reveals that mean weekly intake of Zn from rice at this study was 373.5 μg kg^{-1} body weight/week. It was less than the Provisional Tolerable Weekly Intake (PTWI) recommended by WHO/FAO. Thus, the weekly intake of Zn from rice in this study was about 7% of PTWI.

Table 1: Zinc levels in Tarrom rice from four areas in Qaemshahr (μg g^{-1} dry wt)

Area No	Number of Samples	Mean ± S.D(a)	Minimum	Maximum
1	15	18.54±3.82	13.45	25.62
2	15	15.29±2.08	12.00	19.02
3	15	22.92±3.10	16.70	27.60
4	15	21.59±3.82	18.20	27.60
Total	60	19.46±4.31	12.00	27.60

(a): Data are Means ± Standard Deviation

Table 2: weekly dietary intake of Zn by eating rice

Item	Minimum	Maximum	Mean
Daily rice consumption (g day^{-1})	158	178	165
Weekly Zn intake (μg kg^{-1} body weight/week)	231	531.3	373.3

Table 3: Zinc contents in rice from various countries reported in literature

Areas or country	Mean of Zn ($\mu g\ g^{-1}$)	Reference
USA	23.00	[9]
Taiwan	14.70	[1]
Japan	22.90	[10]
Indonesia	22.89	[10]
China	21.19	[10]

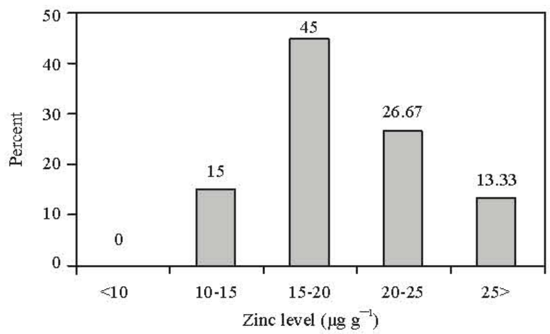

Fig. 1: Distribution of Zn levels in rice

DISCUSSION

As shown in Table 1, the present study showed that average content of zinc in raw rice produced in north of Iran was approximately 19.46±4.31 $\mu g\ g^{-1}$ dry wt with significant variation depending on the areas. Comparing the results in Table 1 with zinc content of rice from other countries it appears that the obtained values were similar to Zn content in Iranian rice. Table 3 presents the values of Zn that reported in literature.

Masironi *et al.* [11] studied one hundred samples of polished and 27 of unpolished rice from 22 countries and areas and analyzed for zinc content. Their results indicated that average zinc in polished and unpolished rice was 13.7 and 16.4 $\mu g\ g^{-1}$, respectively. Thus, polishing rice has Zn lower than unpolished rice.

Srikumar [12] showed that Zn contents in Indian wheat were higher than Indian rice and other cereals. Additionally, estimation of Zn daily intake was inadequate and was below the tolerable daily intake level.

As shown in Table 1, weekly intake of Zn from rice at this study was below the Provisional Tolerable Weekly Intake (PTWI) recommended by WHO/FAO. As discussed, Iranian people probably intake about 373.5 $\mu g\ kg^{-1}$ body weight/week from via rice. It is 7% of PTWI of Zn. But this values are 305 $\mu g\ kg^{-1}$ body weight/week in Taiwan people [1].

Zinc is essential element and its intake via rice low, thus it must supply by other foods. The reasons of lower Zn contents in this study is complex and must been study in next. Heavy metals contents in rice depend on soil (moisture, pH), redox potential, weather conditions, using of fertilizer, water and contamination rate. Solubility of metals is known to increase with a decrease in soil pH and hence plant metal uptake is higher in acidic soils than in calcareous soils. Metal Uptake due to soil pH under the present state is limited in both soils, but any reduction in pH soil in these farms could raise metal availability and metal Uptake by plants, which also could increase health risk. It is also known that there is a linear relationship between metal availability and organic matter content [13].

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