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Full Length Research Paper

Cadmium content in rice and its daily intake in Ghaemshahr region of Iran

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This investigation surveyed Cadmium (Cd) content of Iranian rice (*oryza saliva*) which is predominant rice culture in north of Iran. A total of 60 samples were collected from Ghaemshahr region in Mazandaran province (North of Iran). The samples were collected in during harvesting of rice in field. The first step, grains of raw rice were digested by acid digestion method and then were analyzed for Cadmium by atomic absorption spectrometer. To assess the daily intake of Cd by rice, from daily consumption of rice was calculated. The results showed that average concentration of Cd in rice was 0.40± 0.16µg/g dry wt and ranged from 0.12 to 0.83 µg/g dry wt. The Cd content in the rice samples was found to be upper the FAO/WHO Guidelines. Also average weekly intake of Cd from rice was 7.7µg/kg body weight/week that it was approximately 10% more than to the maximum weekly intake recommended by WHO/FAO.

Key words: Rice, Cadmium, Iran, intake, *Oryza Sativa*.

INTRODUCTION

Cadmium (Cd) is one of the most well-known environmental intoxicants to humans (WHO, 1992). It is one of the elements that have no constructive purpose in the human body. In mammals, cadmium which is virtually absent at birth accumulates with time, especially in the liver and kidneys that can lead to health problems (WHO, 2004). Its presence in nature and entrance to human's food chain causes the serious damage in kidneys, lungs, bones and also anemia and sometime hypertension (Afshar et al., 2000).

It is also known that people, especially those who take rice (*Oryza sativa*) as staple food for daily energy, are inevitably exposed to significant amounts of cadmium via rice; even rice cropped from non-polluted areas may contain cadmium (Watanabe et al., 1996) because fertilizers that are used in farm may have small amounts of Cd. Its entering to the environment is from both natural and anthropogenic sources (Lin et al., 2004). The most important anthropogenic sources of soil pollution to cadmium are industrial sludge sewage discharging, applying super phosphate fertilizers, burying non-ferrous wastes in land and locating agricultural fields close to lead and zinc mines or refining factories (Afshar et al., 2000).

The major source of cadmium intake is rice for rice eating countries. It was identified as the major source of cadmium intake among of Itai-Itai disease endemic in Jinzu river basin in Japan in the mid 20th century (Shimbo et al., 2001). Approximately 50% of the daily intake of Indonesian comes from rice and for the Japanese, it is about 40 to 60% (Rivai et al., 1990). Thus, heavy metals such as Cd contaminate and accumulate in both agricultural products and sea food through water, air and soil pollution if waste discharges are not properly treated. For example, cadmium polluted rice resulting from the illegal discharge of wastewaters from chemical plants and metal recycling factories was reported in Taiwan (Lin et al., 2004). Moreover, heavy metals can enter the food chain from aquatic and agricultural ecosystems and threaten human health indirectly (Watanabe et al., 1989). It is known that Cd content is much higher in rice bran than in

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Table 1. Cadmium contents in rice from various areas in Qaemshahr.

Sampling area	Sample number	Range (µg/g dry wt)	Mean±SD (µg/g dry wt)
A	15	0.16-0.83	0.53±0.2
B	15	0.12-0.58	0.36 ± 0.14
C	15	0.13-0.65	0.33± 0.14
D	15	0.16-0.66	0.37±0.15
Total	60	0.12-0.83	0.40± 0.16

polished rice grains (which essentially consist of albumen) (Zhang et al., 1998).

The Joint FAO/WHO Expert Committee on Food Additives (JCEFA) has proposed a maximum level of 0.2 mg/kg cadmium in rice but the community warned that "people who eat a lot of rice from regions containing the higher levels of cadmium could be significantly exposed". JECFA has set the Provisional Tolerable Weekly Intake (PTWI) for the cadmium of 7 µg/kg of body weight (WHO, 2004). The objectives of this study were to determine cadmium content of raw rice (var: tarrom) in Qaemshahr region in Mazandaran province in the north of Iran and also and to assess cadmium intake from rice based on weekly cadmium intake from rice.

MATERIALS AND METHODS

Collection of samples

Rice samples were collected in four areas in regions between Qaemshahr and Sari in Mazandaran province. The first step, samples were collected in rice farms when formers 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.

Preparation and analysis of Samples

To determine Cd concentration in raw rice, a portion of rice grains were cleaned and about 2 g were 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 based on ASTM standards (ASTM, 2000). Each rice sample was added to a premixed solution of concentrated nitric and perchloric (70%) acids (3+1) at the rate of 20 ml per gram of sample. 2.5 ml of sulfuric acid (spg. 1.84) was added per gram of sample. Then, the mixture was swirled and allowed to stand for 30 min. Thereafter, the beaker was covered with an acid-washed watch glass, and placed on a hot plate. The temperature was gradually increased until the mixture started 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 remained. Afterwards, deionized water was added to bring the digest to 25 ml. The digested solution was analyzed for Cd content by flame atomic absorption spectrometer (Chemtech, Eng and Alpha-4). Duplicate digestion of each sample was done and analyzed two or three times at a wave length of 229 nm. Concentrations were expressed in terms of mg/kg on a dry weight basis. Statistical analysis was done by SPSS programme. Analysis of variance (ANOVA) followed by multiple comparison were employed to detect significances between or among samples.

Estimation of Cadmium intake

Weekly or daily cadmium intake from rice was calculated by cadmium content in rice multiplied to weekly (daily) rice consumption (Rivai et al., 1990; Nogawa and Ishizaki, 1979). Whenever possible, monitoring data from dietary intake studies are to be compared with acceptable or tolerable levels recommended by the Joint FAO/WHO Expert Committee on Food Additives. Hence, the total dietary exposure levels of Pb determined in this study were compared with the provisional tolerable weekly intakes (PTWIs) by the JECFA to assess potential health risks faced by consumers (WHO, 1996; WHO, 2004; WHO, 1987). For toxicants that may accumulate in the body, such as lead, cadmium and mercury, the tolerable intakes are expressed on a weekly basis to allow for daily variations in intake levels because the real concern is prolonged exposure to the contaminants (Lee et al., 2006).

RESULTS AND DISCUSSION

Cadmium content in rice

The results of cadmium contents in sixty samples of raw rice from four areas are shown in Table 1. These results indicated that the mean value of Cd concentration in rice 0.40± 0.16 µg/g on dry wt basis and range is 0.12 – 0.83 µg/kg dry wt. The food sanitary standard of Cd in rice on FAO/WHO codex was 0.2 µg/kg. Therefore, the average content of Cd in Iranian rice is over the maximum permitted level for rice. The results revealed that Less than 12% of rice samples had Cd content below 0.2 mg/kg and also the amount of Cd content in 88% samples were above 0.2 µg/kg level. ANOVA analysis showed that there was a significant difference in cadmium contents in rice ($P<0.003$).

Comparing the results in Table 1 with Cd content of rice from other countries, it appears that the obtained values are higher in Iranian rice. Table 2 presents the values of Cd that reported in literature (Watanabe et al., 1996). The mean cadmium content values in rice reported to data are 50 ng/g dry wt for Japan in 1998-2000 (Shimbo et al., 2001) and 0.01 mg/kg dry wt to Taiwan in 2004 (Lin et al., 2004). When the present observation is compared with the values reported in previous studies in Iranian rice, it is appears that there has been changes in Cd contents and

Table 2. Intake of Cadmium via rice [(weekly dietary intake of Cd by eating rice) (µg/kg body weight/week)].

Item	Min	Max	Average
Daily Rice Consumption (g/day)	158	178	165
Provisional tolerable weekly intake (µg/ week for an average 60 kg adult)	-	-	420
Weekly Cd intake (µg/kg body weight/week)	7.4	8.3	7.7
Weekly Cd intake (µg/week for an average 60 kg adult) by rice	442	498	462

may have been increasing gradually. Additionally, the average Cd contents in the rice samples of this survey is higher than in a similar survey conducted in 1993 and 1998 then the Cd contents is increasing. Afshar et al. (2000) determined Cd content in Amol rice (a kind of Iranian rice) and found that mean Cd concentration was 0.09 mg/kg. The studies of Khani and Malekoti (2000a,b) showed that averaged Cd content in raw rice produced in north of Iran was 0.34 mg/kg with a range of 0.25 - 0.45 mg/kg. The authors also showed that Cd content of soil increased gradually from 33 mg/kg in 1998 to 34 mg/kg in 1999. With increase in rice consumption, this situation could easily pose a great threat.

There were a substantial difference in Cd contents among in various areas in Asia and elsewhere (Lin et al., 2004). Investigation of Cd content of rice from different countries revealed a range of 0.0008 to 0.13 mg/kg with the average being 0.03 mg/kg. The reasons for higher Cd contents in rice are complex. Whereas Cd in rice grains is from soil and rice harvested from paddy fields tend to contain Cd at a high level (Watanabe et al., 1996; Nogawa and Ishizaki, 1979), absorption of Cd from soil to the rice grain is extensively modified by the redox potential of the soil, which is affected by the degree of water cover of the paddy (Watanabe et al., 1996; Valdares et al., 1983). Solubility of metals is known to increase with a decrease in soil pH and hence plant metal uptake is higher in acidic soils. Therefore, any reduction in soil pH in these farms could raise metal availability and metal uptake by plants, which ultimately could increase health risk. It is also known that there is a linear relationship between metal availability and organic matter content (Basta and Tabatabai, 1992).

Watanabe et al summarized Cadmium contents in rice from various areas reported in Literature. They reported that mean cadmium contents of rice was 2.67, 15.54, 39.55, 21.77, 55.70, 18.5, 29.02, 133.20, 25.8, 17.41, 33.92, 15.82, 0.85,7.43 ng/g in Australia, China, Taiwan, Indonesia, Japan, Korea, Thailand, Malaysia, Philippines, Vietnam, Canada, Columbia, Finland, France, Italy, South Africa, Spain and USA, respectively (Watanabe et al., 1996).

Dietary intake of cadmium

The intake of Cd was estimated by multiplication of daily consumption with Cd contents in rice (Shimbo et al., 2001; Zhang et al., 1998). The codex committee on food additives and contaminants of the joint FAO/WHO Food Standards program has proposed draft levels for typical daily exposure and theoretical tolerable weekly intake (PTWI) for some of heavy metals in cereals such as rice. JECFA has set PTWI for the cadmium at 7 µg/kg of body weight (WHO, 2004).

According to the published papers, daily consumption of rice in Asia countries ranges between 158-178 g/person-day with an average is 165 g/person-day, and the average body weight is 60 kg/person (Rivai et al., 1990; Nogawa and Ishizaki, 1979). The Table 2 shows weekly intake of Cd from rice. The weekly intake of Cd from rice in this study was 7.7 µg/kg body weight/week accounts for more than 10% of total dietary Cd intake. Table 2 reveals that weekly Cd intake from rice were below the maximum weekly intake recommended by WHO/FAO. However, with other foods that contain Cd such as fish, wheat and vegetable, the Cd situation could worsen in the future.

As shown Table 2, the Cd intake via rice is the highest in this study compared to the studies in other countries (Watanabe et al., 1996; Lin et al., 2004; Shimbo et al., 2001). This high value may be due to the large amount of fertilizer used in rice fields with high values of Cd. Iranian probably take in more than 57% of Cd through rice but this values are 7-32% in Japanese (Shimbo et al.,2001) and 3% in Taiwanese (Lin et al., 2004). Approximately 50% of the daily Cd intake of Indonesians comes from rice (Rivai et al., 1990). Thus, health risk due to Cd intake is higher in Iran and this risk increases with consumption of vegetable, fish and other foods containing Cd. Periodical monitoring of Cd rate of contamination and consumption is thus necessary to assess the overall exposure level in the community. Treatment and remediation of polluted soils and environment as well as prevention of using of high Cd fertilizer could reduce health risk.

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