Cadmium Levels in Rice Product of South of Iran and its Daily Intake

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ABSTRACT: Cadmium is a toxic heavy metal. It enters soil through air and polluted water and sewages. Cadmium can accumulate in the human body, so WHO has set permitted levels for weekly consumption of cadmium containing foods (PTWI). Rice is one of the staple foods all over the world. Daily consumption of rice cultivated in soils with high levels of cadmium can impose serious hazards for humans. In this study, five rice samples from five different major rice producing cities of Khuzestan province were evaluated using ICP/MS. Results showed that in 4 sample cadmium levels were higher than permitted level by WHO/FAO (more than 1μg/kg.body weight. Day).

Key word: rice, cadmium, PTWI, Khuzestan

INTRODUCTION

Rice is the predominant staple food for 17 countries in Asia and the Pacific, nine countries in North and South America and eight countries in Africa. Rice provides 20 percent of the world’s dietary energy supply, while wheat supplies 19 percent and maize 5 percent. In addition to being a rich source of dietary energy, rice is a good source of thiamine, riboflavin and niacin (FAO, 2004). Pollution of the environment by heavy metals, such as cadmium, has become recognized as a worldwide public health hazards (Rubio et al. 2006). Ingestion of cadmium can rapidly cause feeling of nausea, vomiting, abdominal cramp and headache. Long-term ingestion of cadmium cause serious health problems (Jarup et al. 2009).

It's persistence in the environment and its very long biological half life, in order of 10-40 years, in the human body, especially in kidneys constitutes an additional toxic factor (Rubio et al. 2006). Dissolved cadmium is a poison, which enters the food chain in different ways. Plants absorb cadmium ions from water in the ground. The cadmium ions may have reached surface water through a generally increased leaching in an acid environment. On arable land, the presence of cadmium may also be a result of leaching of phosphate fertilizers and digested sludge. Cadmium absorbed in crops, e.g. rice and wheat, reaches people and animals (Enghag, 2004).

Soils contaminated by heavy metals from either aerial depositions or irrigation are likely to induce a corresponding contamination in harvested crops (Fu, 2008). The amount of metal ingested by man is strictly related to alimentary habits and their content in food stuff (Santos, 2004). Based on estimation of cadmium intake more than 80% percent of the cadmium intake comes from cereals, vegetables and potato (Jarup, 2004). The PTWI is defined by the joint FAO/WHO expert committee on food additives as an estimate of the amount of the chemical that can be ingested weekly over a life time without appreciable health risk. The PTWI for cadmium is 1μg cd/kg of body weight per day (Rubio, 2004).

Rice is an important part of human diet in Iran. According to statistics of agricultural ministry of Iran, Khuzestan province is at fifth level of rice production in Iran (statistical letter, 2008). In this study extent of cadmium in rice (Oryza sativa) at five major rice producing cities of Khuzestan province, southwest or Iran, were investigated. Results were compared with provisional tolerable weekly intake (PTWI) for cadmium, defined by FAO/WHO, and potential risk for local habitants were evaluated.

MATERIALS AND METHODS

Site description and sampling

Khuzestan province is located in south west of Iran. Five cities of Khuzestan (ie, Ahvaz (A: 31.5°N, 48.8°E), Shoushtar (B: 32°N, 49°E), Baghmalek (C: 31°N, 50°E), Dashtazadegan (D: 31.5°N, 48°E) and
Ramhormoz (E: 31.3°N, 49.5°N)) were selected for determining of cadmium. Randomly 3 samples were collected from rice paddies of each city.

**Sample analysis**

To remove dirt and dust from rice seeds, they were washed three times by distilled water and dried in 75°C oven for 72h. samples were grounded and kept in plastic bags in refrigerator until analysis. Each samples prepared according to Fu procedure (Fu et al. 2008). In summary 0.2gr of powdered sample weighted, 3ml of nitric acid added and predigested over night in 60°C oven. After cooling 2ml of hydrogen peroxide were added. The container placed in 60°C oven for 1h and the temperature increased to 160°C for 8 hours.

**Tolerable daily intake of cadmium**

Many contaminants are not cleared rapidly from the body and for them provisional tolerable weekly intake (PTWI) is calculated. These contaminants may accumulate within body. The weekly designation is used to stress the importance of limiting intake over a period of time (Herrman, 1999). In 1993, Jecfa established PTWI of 7μg/kg body weight, which indicates tolerable daily intake (TDI) of 1μg/kg body weight (WHO, 1993).

**Determining estimated daily intake (EDI)**

Daily intake depends on metal contamination and daily consumption of foods. In addition body weight can influence the tolerance of pollutant. EDI is a concept that take account these factors.

\[
EDI = \frac{C \times Cons}{Bw}
\]

Where C is concentration of heavy metals, Cons stands for daily average consumption and Bw indicates body weight. All statistical analysis were performed with SPSS 16.0 for windows release.

**RESULTS AND DISCUSSION**

**Heavy metals concentration in rice**

Five major rice producing cities of Khuzestan province were selected for determining cadmium. The results were shown in table 1 according to FAO/WHO codex permitted level of cadmium in rice is 0.2 mg/kg. Concentration of cadmium in all rice samples were higher than permitted level. The highest and lowest concentration were 521(A) and 243.45(E) μg/kg respectively. Ahvaz city is the center of Khuzestan province, so in addition to fertilizers high levels of cadmium may be due of air pollution. The results suggests that by increasing population of city and industrial centers cadmium concentration will be increased. A survey in E-waste recycling area in southeast of China showed that cadmium levels in soil samples were 1.19 μg/g which is 4 folds of Maximum allowable concentration. Cadmium levels in polished rice cultivated in polluted area were higher than commercial rice available in China (Fu et al. 2008). Measured cadmium concentration, combined with the food consumption data resulted in a total cadmium intake in the canary islands of 0.16 μg/kg body weight/day, which is below respective TDI of 1 μg/kg body weight/day (Rubio et al. 2005).

### Table 1. Cadmium content of rice samples

<table>
<thead>
<tr>
<th>area</th>
<th>samples</th>
<th>CLHM (μg/kg)</th>
<th>Mean</th>
<th>%E-CLHM</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3</td>
<td>200</td>
<td>417.48</td>
<td>100</td>
<td>360.75</td>
<td>521.00</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>200</td>
<td>486.42</td>
<td>100</td>
<td>463.65</td>
<td>514.55</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>200</td>
<td>433.55</td>
<td>100</td>
<td>419.75</td>
<td>453.05</td>
</tr>
<tr>
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<td>3</td>
<td>200</td>
<td>441.15</td>
<td>100</td>
<td>397.95</td>
<td>429.9</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>200</td>
<td>261.48</td>
<td>100</td>
<td>243.45</td>
<td>283.35</td>
</tr>
</tbody>
</table>

CLHM: Critical limit for heavy metal (μg/kg)
Mean: Average of concentration in rice samples (μg/kg)
%E-CLHM: Percentage of samples over CLHM in area (μg/kg)
Min: Minimum of concentration in samples
Max: Maximum of concentration in samples
Table 2. Mean estimated daily intake

<table>
<thead>
<tr>
<th>Area</th>
<th>samples</th>
<th>TDI (μg/kg.bw.day)</th>
<th>MEDI (μg/kg.bw.day)</th>
<th>%E-TDI</th>
<th>MinI (μg/kg.bw.day)</th>
<th>MaxI (μg/kg.bw.day)</th>
</tr>
</thead>
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<tr>
<td>A</td>
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<td>1.15</td>
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<td>1.43</td>
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<td>1.34</td>
<td>100</td>
<td>1.28</td>
<td>1.42</td>
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</tr>
<tr>
<td>C</td>
<td>3</td>
<td>1.19</td>
<td>100</td>
<td>1.15</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>1.21</td>
<td>100</td>
<td>1.09</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>0.72</td>
<td>0</td>
<td>0.67</td>
<td>0.78</td>
<td></td>
</tr>
</tbody>
</table>

TDI: Tolerable daily intake (μg/kg.bw.day)
MEDI: Average of estimated daily intake (μg/kg.bw.day)
%E-TDI: Percentage EDI over TDI (μg/kg.bw.day)
MinI: Minimum of EDI in area (μg/kg.bw.day)
Max: Maximum of EDI in area (μg/kg.bw.day)

**Dietary intake of cadmium and comparison with other studies**

Jecfa has set PTWI for cadmium 7 μg/kg of body weight. According to released data, daily consumption of rice in asian countries range between 158-178 g/person-day, with an average of 165 g/person-day. Average of body weight assumed 60kg. Tabl 2 shows estimated daily intake and it's comparison with TDI. The maximum was 1.43 μg/kg.bw which is 1.43-fold higher than TDI. It means that some people in that area, by daily consumption of rice may be in danger of receiving excessive amount of cadmium, in comparison with safety levels of PTWI. Minimum concentration of daily intake belongs to Ramhormoz. In this country both maximum and minimum concentration is lower than permitted levels. Among 15 samples, from 5 cities, 73.2% have cadmium levels higher than 1 μg/kg.

A study conducted in west of Iran determined cadmium levels by flame atomic absorption spectroscopy. It showed that Cd and Pb concentration in rice samples were lower than permitted levels (0.1 and 0.2 mg/kg for Cd and Pb respectively). (Falahi et al., 2010). Another study in north of Iran, showed that cadmium levels in rice (var: tarom) were 0.41 mg/kg which is much higher than permitted level introduced by FAO/WHO. (Zazoli et al. 2010).

In view of the long half life of cadmium, daily ingestion in food has a small or even a negligible effect on overall exposure. To assess long- or short-term risk to health due to cadmium exposure, dietary intake should be assessed over month and tolerable intake should be assessed over a period of at least 1 month. So committee decided to express tolerable intake as a monthly value in form of provisional tolerable monthly intake (PTMI) and established PTMI for cadmium is 25μg/kg body weight, so according to this new criteria TDI will be 0.88μg/kg body weight (WHO, 2011).

**REFERENCES**