The Health Risks of Lead and Cadmium in Foodstuffs for the General Population of Taiwan

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Abstract

The present study evaluate the background levels of Cd and Pb in 1936 foodstuffs and to assess the health risks to the Taiwanese population associated with their general dietary consumption.

A higher concentration of Pb was found in shellfish (0.138 mg/kg) and cephalopods (0.093 mg/kg), and the Cd levels were 0.810 mg/kg in cephalopods and 0.315 mg/kg in shellfish. For Pb and Cd exposure, grain was the highest contributor, accounting for 31.27%-41.77% and 67.83%-86.26%, respectively, in each age group.

In terms of the cancer risk due to Pb exposure, the total cancer risk was 1.22 × 10-6 based on their median level for each sampling and 1.20 × 10-6 based on the 95% upper limit level of each sampling. The hazard index (HI) for Pb was higher than 1 for people younger than 12 years, whereas the HIs for Cd exposure were less than 1. The estimated Pb and Cd cancer risks were generally higher for infants and children than for adults. Due to the higher levels of Cd and Pb presented in grains compared with those in meat and fishery products, the health impacts to vegetarians and high grain consumers may be higher than those to normal consumers.

Keywords: Pb; Cd; Health risk assessment; Food; Average daily intake

Introduction

Rapid industrial development and the accompanying increase in environmental pollution have led to increased levels of toxic metals such as lead (Pb), cadmium (Cd), and mercury (Hg) in environmental water, soil, wastewater, and agricultural environments. Due to the low mobility of heavy metals, they can easily accumulate in the environment. The analyses of environmental chromium (Cr), copper (Cu), manganese (Mn), nickel (Ni), and zinc (Zn) have revealed significant correlations between their levels in soils and in crops, such as fruits, grains, and vegetables, there by posing a potential health risk to consumers [1].

Pb is carcinogenic to humans, irrespective of whether it is received orally or inhaled. Furthermore, Pb toxicity is a major threat to young children and developing fetuses and can cause central nervous system damage and a reduced intelligence quotient (IQ) [1]. In adults, the increased occurrence of chronic kidney diseases [2] and cardiovascular diseases [3] are related to Pb exposure as is increased systolic blood pressure [1]. The International Agency for Research on Cancer (IARC) has classified Cd as a Group 1 human carcinogen and Pb as a Group 2A possible human carcinogen. Moreover, chronic dietary exposure to Cd is associated with renal conditions and bone defects [4]. In a National Health and Nutritional Examination Survey (NHANES) from 1999 to 2004, blood Pb and Cd were associated with aberrant testosterone and sex hormone-binding globulin [5]. Therefore, metal contamination of food has recently attracted increasing attention in regard to food safety [6,7] due to metal exposure being associated with food composition [8,9]. Studies of the concentrations of Cr, Ni, Cu, Arsenic (As), Cd, and Pb in fish species have shown that Pb levels in fish often exceed safe limits, and As and Pb are particularly hazardous, even at the low levels of fish consumption typical in Bangladesh [10]. Furthermore, Cr, Ni, Cu, As, Cd, and Pb are also found in cereals, pulses, vegetables, fruit, fish, meat, eggs, and milk in Bangladesh [11]. In a study of the Pb and Cd levels in aquatic life found in bay regions in South China, the highest levels of Pb and Cd were found in wild clam (Veremolpascabra), and the Pb and Cd contents in wild fish were 0.4 and 22.2 times, respectively, those found in farmed fish, indicating that "growth dilution" occurs for Cd in farmed fish but not for Pb [12].

In Bangladesh, the estimated daily intakes (EDIs) of Cr, Ni, As, Cd, and Pb are higher than the maximum tolerable daily intake (MTDI), indicating their high dietary intake. The combined metal hazard quotients (ΣHQs) from rice, fruit, vegetables, and fish are higher than 1 [11]. In Algeria, the EDI and the total HQ (THQ) have been reported to exceed the thresholds for Pb (EDI: 15.66 μg Pb/kg body weight (bw)/day; THQ: 4.37), which constitutes a significant health risk over a lifetime of exposure [8].

From the Total Diet Study (TDS) data collected in France, it was suggested that Cd in cereal products is associated with mineral fertilizers and sewage sludge, as well as agricultural fertilizers, which contribute to the Cd levels of food cultivated locally [3]. For infant consumption, Cd exposure from commercial infant formula, solid food, and beverages was found to exceed the tolerable weekly intake (TWI) of 2.5 μg Cd/kg bw established by the European Food Safety Authority (EFSA). Due to the bio-concentration factor (BCF), values of Pb and Cd are higher than 100 for most fish species [10], indicating that fish have the potential to accumulate Pb and Cd from river water and that people may be exposed to increased levels of heavy metals by ingesting organisms that...
exhibit bio-concentration or bioaccumulation of pollutants. Pb and Cd assessments in recent research have focused on aquatic biotic species; however, from the point of view of health risk assessment, other foods, such as cultivated crops, grains, domestic livestock, and poultry, are still potential risks and must not be ignored.

In Taiwan, increased levels of industrial emissions present a potential hazard to cultivated food. However, relatively few studies have been performed to evaluate food safety with respect to metal content. Therefore, the present study aims to evaluate the background levels of Cd and Pb, for which the Taiwanese government has defined a safety limit, in 1939 foodstuffs. Furthermore, this study aims to assess the health risks to the population of Taiwan presented by the general dietary consumption of these foodstuffs.

Materials and Methods

Food sampling

We grouped all counties and cities in Taiwan into seven areas by geographic characteristics. To be as representative of food consumption in Taiwan as possible, the population density in each county and city was tabulated and used as the basis to calculate the sample number for each food. A total of 1939 foodstuffs from eight food categories, including meats, visceras, eggs, grains, fishery and seafood products, oils, dairy products, and baby food, were purchased. The production quality of the foods was ranked from 1 to 7, and the top 1 or 2 in each city or county was selected for sampling. Samples were purchased from supermarkets and traditional markets in towns or villages in the selected cities or counties. Oils, dairy products, and baby food were purchased from large supermarkets because they are canned or packed foods and equally available in all areas of Taiwan. The fishery and seafood products were purchased in large fishing ports or fishery markets, such as Taichung port in central Taiwan, Suao port in eastern Taiwan, and Bisha port in north Taiwan.

Overall, 400 different meats, 100 different visceras samples, 180 eggs, 453 grains, 239 fishery and seafood products, 203 oils, 209 dairy products, and 155 baby food samples were purchased around Taiwan during 2014. The food samples were put into plastic bags at room temperature, except for the milk, powder, and oils. The foods were homogenized separately, passed through a 250 μm mesh sieve, and put into a sterilized centrifugal tube for storage until analysis.

Analysis of food samples

The food samples were processed using the methods outlined by the Taiwanese Food and Drug Administration (FDA) [13]. Two pretreatment methods were utilized for Pb and Cd analyses: one for meat, visceras, eggs, grains, fishery products, dairy products, and baby food and the second for oil products. To facilitate digestion, 0.3 g of homogenized food sample was weighed and placed in a 55 mL Teflon PFA tube with 10 mL of 65% ultrapure nitric acid (HNO\textsubscript{3}, analytical grade, Merck). The samples were then digested using a 1800 W microwave oven (Mars Xpress microwave digestion system, CEM). The temperature of the samples was raised from room temperature to 170°C over 20 min, held at 170°C for 20 min, and then allowed to cool to room temperature. The digestion solution was subsequently filtered using a 0.45 μm PVDF syringe filter and diluted with 0.2% HNO\textsubscript{3} to a final volume of 40 mL. Inductively coupled plasma spectroscopy (ICP-MS, Perkin Elmer Sciex ELAN DRC II, San Jose, California, United States) was used to determine the Pb and Cd concentrations. The method for oil used 0.3 g of oil in a 55 mL Teflon PFA tube with 10 mL of 65% ultrapure nitric acid. The samples were then placed into a 60°C water bath for 20 min and subsequently digested in a microwave digestion system. The temperature was raised to 120°C over 15 min, held at 120°C for 5 min, raised to 160°C over 10 min, held at 160°C for 5 min, raised to 170°C over 10 min, held at 170°C for 25 min, and then allowed to cool to room temperature.

Data quality control

For the determination of Pb and Cd contents, an internal standard (100 μL of 10 μg/L Rh, Fluka Int.) was added to the filtered solution for quality control. The accuracies of the analytical method and instrumentation were validated using certified reference materials from the Perkin Elmer Pure Elan 6100 DRC (Lot#6-218). In this study, the recovery efficiency tests for Pb and Cd were conducted using the same sample analysis procedure with the addition of a standard solution prior to extraction. The recovery rates were 89.6%-101.1% (Pb) and 79.4%-82.5% (Cd) from meat and visceras; 94.0%-113.0% (Pb) and 76.2%-82.6% (Cd) from grains, eggs, dairy products, and baby food; 93.5%-112.5% (Pb) and 79.1%-80.9% (Cd) from fishery products; and 113.0%-119.0% (Pb) and 56.3%-62.0% (Cd) from oils. The detection limit was selected as a concentration slightly lower than the lowest concentration of the calibration curve. Measure ments at this concentration were repeated seven times to estimate the standard deviation, and the method detection limit (MDL) was set to three times this standard deviation. The detection limits were 0.07 and 0.08 ng/L for Pb and Cd, respectively, and the MDLs were 0.04 and 0.007 μg/L for Pb and Cd, respectively.

Cancer risk assessment for the daily intake of Pb and Cd

Cd and Pb have been classified as human carcinogens (Group 1) and as probably carcinogenic to humans (Group 2A), respectively, by the International Agency for Research on Cancer (IARC). Pb has been shown to cause elevated occurrences of lung, kidney, and brain cancer in some studies, but the results were not consistent among the studies (IARC Monographs 87, 2006). Cd has been shown to cause lung cancer via inhalation in human studies (IARC Monographs 100C). The oral slope factor for Pb is 0.0085 (mg/kg/day)\textsuperscript{-1} in renal tumors by oral ingestion [14,15]. However, owing to the fact that Cd exposure via the inhalation pathway affects the lungs, the cancer risk presented by Cd exposure through food consumption has not been fully analyzed. The daily intakes of Pb and Cd from food consumption were calculated by multiplying the concentrations (ng/g) of Pb and Cd in eight food groups and the consumption rate (g/d) in different age groups. The formula used to determine the lifetime average daily dose (LADD) is

\[
LADD_{ingestion} \text{ (mg/kg/day)} = \frac{C \times IR_{ingestion} \times AF \times EDL}{BW \times AT}
\]

where C is concentration (μg/g), IR\textsubscript{ingestion} is the daily consumption of each food (g/day) in each age group according to survey results related to the diet of the Taiwanese population, AF is the absorption factor (% (100% was used in the present study), BW is the average body weight (kg) in each age group, ED is the exposure duration in years, and AT is the average lifetime in years (80.0 years in 2013 in Taiwan).

The formula used to calculate cancer risk is

\[
Risk = LADD_{ingestion} \times Oral \text{ Slope Factor}
\]

where the oral slope factor is 0.0085 (mg/kg/day)\textsuperscript{-1} for Pb exposure (The Risk Assessment Information System, RAIS).

Non-carcinogenic risk assessment for daily intake of Pb and Cd

The formula used to calculate the average weekly dose (ADD\textsubscript{ingestion}) is
The health risks of lead and cadmium in foodstuffs for the general population of Taiwan.

The hazard quotient (HQ) is calculated as follows:

\[
HQ = \frac{ADD_{	ext{exposure}}}{RfD}
\]

where \( C \) is the concentration (μg/g), \( IR_{	ext{exposure}} \) is the daily consumption of the food (g/day) in each age group, \( AF \) is the absorption factor (%) (100% is adopted in the present study), and \( BW \) is the body weight (kg) based on the average body weight of Taiwanese people in each age group.

The results and discussion

Pb and Cd concentrations in Taiwanese foods

In the present study, Pb and Cd levels lower than the MDL are presented by 33.1% and 29.8%, respectively, of the samples. We found that 0.2% of the Cd concentrations in these samples exceed the MDL, as well as 0.6% of Pb in the UK [16]. The proportion of samples with Pb levels above the international food standard set by the Codex Alimentarius Commission (Codex) is 71.3% of the meat samples, 71.3% of the grain samples, and 79.1% of the fishery product samples. However, only 1.7% of the samples present Pb levels over the Codex standard (Table 1).

The highest concentrations of Pb are found in shellfish (0.138 mg/kg) and cephalopods (0.093 mg/kg), while the Cd levels are 0.810 mg/kg in cephalopods and 0.315 mg/kg in shellfish (Table 2). The lowest levels of Pb are found in duck viscera (0.006 mg/kg), goose viscera (0.002 mg/kg), and in eggs (0.0073-0.0076 mg/kg), while the lowest levels of Cd are found in eggs (0.0006-0.0007 mg/kg) and meat (0.001-0.010 mg/kg).

### Table 1: The detection rate and the exceeded rate of maximum level in Pb/Cd measurements in food

<table>
<thead>
<tr>
<th>Foodstuffs</th>
<th>Pb</th>
<th>Cd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CODEX</td>
<td>CODEX</td>
</tr>
<tr>
<td>Meat (N=400)</td>
<td>71.3%</td>
<td>4.3%</td>
</tr>
<tr>
<td>Visceral (N=100)</td>
<td>63.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Egg (N=180)</td>
<td>53.9%</td>
<td>-</td>
</tr>
<tr>
<td>Grains (N=453)</td>
<td>71.3%</td>
<td>2.6%</td>
</tr>
<tr>
<td>Fishery products (N=239)</td>
<td>79.1%</td>
<td>-</td>
</tr>
<tr>
<td>Milk and dairy (N=209)</td>
<td>58.4%</td>
<td>33.9%</td>
</tr>
<tr>
<td>Oil (N=203)</td>
<td>52.7%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Baby food (N=155)</td>
<td>66.4%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Total (N=1939)</td>
<td>66.9%</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 2: Mean levels in alternative foods in Taiwan (mg/kg fresh weight)

- Vitamin levels in foodstuffs
- Mean levels of Pb and Cd in foodstuffs
Many countries have reported that the levels of metals in various foods, including the Pb and Cd levels reported in the second French TDS, were below the maximum levels set by the European regulation [17]. Furthermore, the metal levels in various fruits and vegetables sold in Egyptian markets were also below the recommended tolerable levels proposed by the Joint FAO/WHO Expert Committee on Food Additives in 1999 [18]. However, in India, the Cd concentration in vegetables (e.g., 2.57 µg/g in cauliflower) was much higher than the European Union (EU) standard, and the Pb concentration in vegetables (e.g., 1.56 µg/g in cauliflower) was also considerably higher than the EU and WHO standards. The contributions of these vegetables to the intakes of Cd and Pb were 47% and 9%, respectively, of the provisional tolerable daily intake [19]. In China, the Cd concentration in vegetables ranged from 0.001 to 0.101 µg/g, and the Pb concentration ranged from 0.001 to 0.655 µg/g [20]. The FAO European Co-operative Research Network on Trace Elements in Grains reported that pasta showed the highest level of Cd (50.4 ± 0.4 µg/kg dry wt.) and whole bread showed the highest level of Pb (59.2 ± 8.0 µg/kg dry wt.) [21]. The estimated mean Pb dietary intake from the consumption of gari, a staple food in most West African diets, was similar to the benchmark dose lower confidence limit (BMDL) [22]. In the EU market, Cd exposure to infants consuming commercial baby food, especially in soy-based infant formula, exceeds the limit established by the EFSA, whereas the Pb levels do not [23]. These data are not consistent with our study, which indicates high levels of Pb (0.432 µg/g) and Cd (0.060 µg/g) in rice powder infant food. Yi et al. [24] also reported that Cr, Cd, Hg, Cu, Zn, Pb, and As in water, sediment, and fish in the Yangtze River posed moderate to considerable ecological risk. The high contents of Pb and Cd in soybeans and rice products may be in related to soil contaminants [25], and serious metal pollution is related to the proximity to industrial emission sites, e.g., power plants [26] and mining areas [27]. Therefore, the Cd levels in foodstuffs may exhibit geographical variations that are dependent on the proximity of industrial or other polluting locations (Table 3).

Significantly, Pb and Cd levels in vegetables and grains may be a problem in other countries due to the different possible pollutant sources and the impact they have on the safety of cultivated foods, with rice, vegetables, and cultivated fish or seafood being particularly important. For example, in a study conducted in Chile, the fish and shellfish group exhibited the highest levels of Cd (277 ng/g wet wt.), while the sugar group exhibited the highest levels of Pb (251 ng/g wet wt.) [28]. Furthermore, a study conducted in South China indicated that the uptake of Cd from snapper fish accounted for 98.2% of the total dietary intake [29]. However, another study in South China has showed that the most important contributor to Hg, Cd, and Pb intake was aquatic products [30]. In a study conducted at the Biuko Blato reservoir, Pb concentrations were reported to be higher than 1 mg/kg in most samples of carp and catfish muscle, and the highest Pb level was found in the samples of catfish kidneys [31]. In Taiwan, the highest levels of Cd were found in cephalopods (810 ng/g wet wt.) and shellfish (315 ng/g wet wt.). In South China, the highest concentration of Cd detected was 0.110 mg/kg in animal viscera (i.e., chicken and pig liver) [30], which is significantly higher than the 0.015 and 0.020 mg/kg in chicken and pig liver, respectively, detected in the samples analyzed in the present study. In Iran, the concentrations of Pb, Cd, Cu, Zn, and Se in dairy products collected from five industrial regions were below the international permissible limits, indicating the relative safety of consuming Iranian milk and dairy products [32]. Singh et al. [33] reported that wastewater irrigation led to the accumulation of metals in vegetables, and lower accumulation was found in rice and wheat. Conversely, a study conducted in Spain found that animals reared in areas historically used for mining, smelting, and refining metals exhibited Pb and Cd levels that were 19%-84% and 9%-43%, respectively, above the EU maximum residue level (MRL) for farm-reared meat [27]. Therefore, metal contaminants present in biota or cultivated food in different scenarios can result from either the contamination of soil and water or from industrial emissions. **Average daily intakes of Pb and Cd in different age groups**

The median daily dose of Pb for each age group is shown in Figure 1. The highest daily doses are 0.32 and 0.34 µg/kg/day in the 0-3 and 3-6 year-old groups, respectively. Those calculations are based on the median Pb level in foods; however, the average daily dose shows a similar trend, with the highest doses being 0.92 and 0.86 µg/kg/day in the 0-3 and 3-6 year-old groups, respectively. The 95% upper limit dose showed the highest value of 3.15 µg/kg/day in the 0-3 year-old group, followed by 2.77 and 1.95 µg/kg/day in the 3-6 and 6-12 year-old groups, respectively (Figure 1). The most obvious difference among each age group is found in the daily dose calculated based on the 95% upper limit dose. For Cd, the mean daily dose shows a similar trend in that the highest doses are 0.97 and 0.57 µg/kg/day in the 0-3 and

<table>
<thead>
<tr>
<th>Areas</th>
<th>Meat (N=400)</th>
<th>Visceral (N=100)</th>
<th>Egg (n=180)</th>
<th>Fish and fishery products (N=239)</th>
<th>Grains (n=453)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pb (µg/g)</td>
<td>Cd (µg/g)</td>
<td>Pb (µg/g)</td>
<td>Cd (µg/g)</td>
<td>Pb (µg/g)</td>
</tr>
<tr>
<td></td>
<td>mean (Range)</td>
<td>mean (Range)</td>
<td>mean (Range)</td>
<td>mean (Range)</td>
<td>mean (Range)</td>
</tr>
<tr>
<td>Northern regions</td>
<td>0.044 (N.D.-1.108)</td>
<td>0.002 (N.D.-0.017)</td>
<td>0.044 (N.D.-0.289)</td>
<td>0.024 (N.D.-0.214)</td>
<td>0.01 (N.D.-0.143)</td>
</tr>
<tr>
<td>Chu-Mia</td>
<td>0.02 (N.D.-0.135)</td>
<td>0.006 (N.D.-0.053)</td>
<td>0.005 (N.D.-0.010)</td>
<td>0.051 (N.D.-0.339)</td>
<td>0.006 (N.D.-0.018)</td>
</tr>
<tr>
<td>Central region</td>
<td>0.027 (N.D.-0.274)</td>
<td>0.005 (N.D.-0.097)</td>
<td>0.009 (N.D.-0.042)</td>
<td>0.022 (N.D.-0.138)</td>
<td>0.006 (N.D.-0.038)</td>
</tr>
<tr>
<td>Yun-Chi-Nan</td>
<td>0.009 (N.D.-0.064)</td>
<td>0.002 (N.D.-0.016)</td>
<td>0.011 (N.D.-0.098)</td>
<td>0.02 (N.D.-0.118)</td>
<td>0.005 (N.D.-0.023)</td>
</tr>
<tr>
<td>Kaung-Ping</td>
<td>0.014 (N.D.-0.194)</td>
<td>0.003 (N.D.-0.010)</td>
<td>0.015 (N.D.-0.048)</td>
<td>0.004 (N.D.-0.010)</td>
<td>0.005 (N.D.-0.049)</td>
</tr>
<tr>
<td>Yilan</td>
<td>0.015 (N.D.-0.097)</td>
<td>0.004 (N.D.-0.034)</td>
<td>0.009 (N.D.-0.030)</td>
<td>0.006 (N.D.-0.022)</td>
<td>0.004 (N.D.-0.019)</td>
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<tr>
<td>Hua-Tung</td>
<td>0.076 (N.D.-0.132)</td>
<td>0.001 (N.D.-0.009)</td>
<td>0.032 (N.D.-0.061)</td>
<td>0.003 (N.D.-0.006)</td>
<td>0.011 (N.D.-0.015)</td>
</tr>
</tbody>
</table>

Table 3: The concentrations of heavy metals in different areas.
Food components responsible for exposure to Pb and Cd

In 0-3 year-olds, the highest contributions to Pb exposure dose are 32.28%, 20.46%, 18.97%, and 14.60% from grains, baby food, fishery products, and eggs and dairy products, respectively (Figure 3). For the 6-65 year-olds group, grains, meat, and viscera all contribute over 30% to the total Pb exposure. For the people over 65 years of age, grain presents the highest contribution of up to 41.77%, and the contribution of fishery products is also high at 30.4%. However, the contributions from the other food groups are low compared to grains and fishery products. For Cd exposure, the highest contribution is 67.83%-86.26% from grains, while eggs and dairy produce contribute 3.68%-18.83% and meat and viscera contribute 2.16%-9.95%. In Spain, the FAO European Co-operative Research Network on Trace Elements showed that the dietary intakes of Pb and Cd from cereals contributed less than 15% of the maximum permissible international intake standards [21]. In a study performed in southwestern China, comparing the Cd levels in the blood and urine of local residents with the Cd levels in locally produced vegetables showed that dietary exposure to Cd through vegetable ingestion was a major exposure pathway for local populations [35]. The data indicated that grains and vegetables are the most important contributor to the accumulating health risks of Pb and Cd, even considering the high levels of Pb and Cd in fishery products. This is different in western countries (Figure 4).

Health risks from Pb and Cd exposures through food consumption

In terms of Pb exposure, the total cancer risk is 1.22 × 10^(-6) based on the median level of each sampling and 1.20 × 10^(-6) based on the 95% upper limit level of each sampling (Table 4). The noncarcinogenic risk is estimated for the total dietary intakes of Pb and Cd compared with the RfD or PTWI [36]. The HI for Pb exposure is higher than 1 in people under 12 years old based on the average Pb concentrations in different foods. While the HIs for Cd exposure are less than 1, the HIs for Pb exposure are all above 1 for all age groups. The HIs are calculated on the basis of the 95% upper limit concentrations, as well as Cd exposure (Table 5). On a body weight basis, the estimated Pb and Cd cancer risks are generally higher for infants and children than for adults, as reported in the United Nations Environment Program (2008). Meanwhile, due to the higher daily intake doses of Cd and Pb in grains than in meat and fishery products, the health risks to vegetarians vary from those of normal consumers. Furthermore, fishery products make the predominant contribution to the metal intake of residents in small island countries. Although many studies have reported that metal
The proportion of samples with Pb levels above the international food standard set by the Codex Alimentarius Commission (Codex) was 71.3% of the meat samples, 71.3% of the grain samples, and 79.1% of the fishery product samples. However, only 1.7% of the samples presented Cd levels over the Codex standard. In people over 65 years of age, the estimated Pb and Cd cancer risks were generally higher for infants and children than for adults owing to the main content of baby food being brown rice powder. The daily intake doses for Cd and Pb in grains were higher than those in meat and fishery products. Consequently, a higher risk may be presented to vegetarians compared to normal consumers.

**Acknowledgements**

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