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Assessment and Identification of Heavy Metals in Different Types of Cooked Rice Available in the Philippine Market

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Abstract. Rice, especially white rice, *Oryza sativa* L. is the staple in the diet of various people including Chinese, Japanese, Korean and the other Asian countries. Many researchers have reported trace element concentrations, especially for As, Cd, Pb and the other elements in rice grains from various countries. The varieties of cooked rice were subjected to assess different toxicants as cadmium and chromium using flame atomic absorption spectroscopy. Results showed thatt the cadmium levels (0.0127-0.043 μ/g; safety limit: 0.2 μ/g or 0.004-0.027 mg/day) and chromium levels ($6.3x10^{-6}$-$6.5x10^{-6}$ μ/g; safety limit: 0.05-0.2 mg/day) exhibit potential health hazards. The cadmium level is relatively high and would thereby exhibit a major health concern since it accumulates chronically. This must be addressed accordingly by the regulatory agency to ensure the safety of the consumers.

Keywords: Rice, Cadmium, Chromium

1. Introduction

1.1. Background of the Study

Rice, especially white rice, *Oryza sativa* L. is the staple in the diet of various people including Chinese, Japanese, Korean and the other Asian countries (Jung, 2005). In the Philippines, rice is the main food eaten three times a day; with fish and seafood supplying the principal source of protein. The Philippine Carabao Center (PCC) estimated a weighted average of 93kg (0.255kg per day) per capita per year consumption of rice which peaked in the year 2008 with 128kg [1].

Many researchers have reported trace element concentrations, especially for As, Cd, Pb and the other elements in rice grains from various countries. Various studies have also focused on the investigation of a dietary reference intake (DRI) or a provisional tolerable weekly intake (PTWI) value for essential and trace elements by consuming food, drinking water and nutrition [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 including cadmium and lead via rice. Rice cropped even from non-polluted areas may be contaminated because of fertilizers that are used in farm, having Cd and Pb[3].

The input of potentially harmful heavy metals by anthropogenic activities has created a contamination problem in soil, air and water. Under natural conditions, concentrations of heavy metals are low in soils, except in those derived from shales. Once metals enter the soil they can be taken up by the standing crop, remain in soil in soluble and insoluble forms, or leach to groundwater. The first two are continuously changing in the seasonally flooded and non-flooded situations that support paddy rice growth [4]. The potential public health risk associated with dietary intake of heavy metals has become of increasing concern. Intake of heavy metals via the soil–crop system has been considered as the predominant pathway of human exposure to environmental heavy metals. Among the heavy metals, cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg) and arsenic (As) are commonly considered as toxic to both plants and humans. Bioavailability of heavy metals is mainly affected by total content of soil heavy metal, soil chemical and physical properties and plant species. Some authors have indicated that Cadmium is more bio-available to plants than other heavy metals, such as Zinc, Copper or Lead, having a higher biological absorption coefficient (BAC)[5](Llamas, 2000).

Higher accumulation of toxic heavy metals in rice grown in contaminated soils may lead to health disorder in humans in tropical countries, such as the Philippines, as rice is a staple diet. Despite this knowledge, there is limited analysis in the heavy metal contents of cooked rice in the Philippines.

The accumulation of toxic chemicals in rice poses a threat in the health of the Filipinos, as rice is a staple diet. The levels of chromium and cadmium uptake of rice and the presence of other contaminants, in relation to the high amount of consumption of rice in the Filipino diet, would require the need to ensure that the consumers are ingesting safe amounts and levels of such contaminants that might result to health hazards. The analysis of chromium and cadmium levels and presence of inorganic contaminants in ten varieties of cooked rice available in the Philippine market will provide baseline data for future investigations.

1.2. Objectives

The main objective of this study is to identify the contaminants present in the different varieties of cooked rice available in the Philippine market. Furthermore, it shall serve to meet the following specific objectives: 1) To determine the levels of chromium and cadmium in different varieties of rice using Atomic Absorption Spectroscopy 2) Compare the levels of cadmium and chromium in the selected rice samples to allowable limits set by FAO/WHO.

1.3. Scope and Limitation

This study would encompass the determination of the levels of chromium and cadmium on 10 types of cooked rice available in the Philippine market. It would also involve qualitative test on cyanide, sulphide, iodide, bromide and chloride. This study is limited to the determination of the said compounds. The amounts of cyanide, sulphide, iodide, bromide and chloride would not be determined.

2. Methodology

2.1. Research Design

This study followed descriptive exploratory research design. The unknown amounts of cadmium and chromium were explored using FAAS.

2.2. Locale of the Study

The samples were collected at market places in Manila, Philippines. These were stored and prepared at the University of the Philippines, Manila. The samples were analyzed using FAAS in the same vicinity.

2.3. Sample Collection

The rice market industry consists of different varieties of rice. In the Philippines, five types of rice are currently available based on their prevailing price: 1) NFA Premium Rice (P25/kg); 2) Regular Milled Rice (P35/kg); 3) Well Milled Rice (P32/kg); 4) Premium Rice (P40/kg); 5) Fancy Rice (P42/kg) Ten samples were collected using convenience sampling method within the Manila vicinity.

2.4. Preparation of Samples

Ten variety of rice grains will be cooked in the laboratory using distilled water in a beaker. For white rice varieties, one cup rice will be added to 1 3/4 – 2 cups water, will be covered, and will be brought to boiling. Then, the heat will be set to ‘low’ for 20 minutes. After 20 minutes, the beaker will be removed from heat and will be allowed to steam for 5 minutes. For brown rice, one cup rice will be added to 2 1/4 cups water, will be stirred once and covered, and will be brought to boiling. Then, the heat will be set to ‘low’ for 45 minutes. After 45 minutes, the beaker will be removed from the heat and will be allowed to steam for 10 minutes. The weight of each cup of rice grains shall be recorded prior to cooking.

2.5. Analysis of cadmium and chromium

Five grams of cooked rice will be digested in 10mL concentrated nitric acid in an open glass container overnight at room temperature, and the next day at 80^{o}C for 5 hours. The mixture will be allowed to cool to room temperature. Five grams were acid digested and the volume was adjusted to 50mL with distilled water. The resulting solution was analyzed using flame atomic absorption spectroscopy.

3. Results and Discussion

Standards of cadmium and chromium solution were prepared and analyzed using Flame Atomic Absorption Spectroscopy. A standard calibration curved was formed using different concentrations of cadmium and chromium expressed as parts per million-0.0099, 0.0525, 0.1595, 0.2978 and 0.0006, 0.0028,0.0080 and 0.0147 respectively. The Pearson-product correlation coefficient indicates a high degree of correlation and linearity between absorbance and concentration of the metals prepared for the standard curve. It shows a high degree of accuracy in methodological detection of cadmium and chromium (figures 1 and 2).

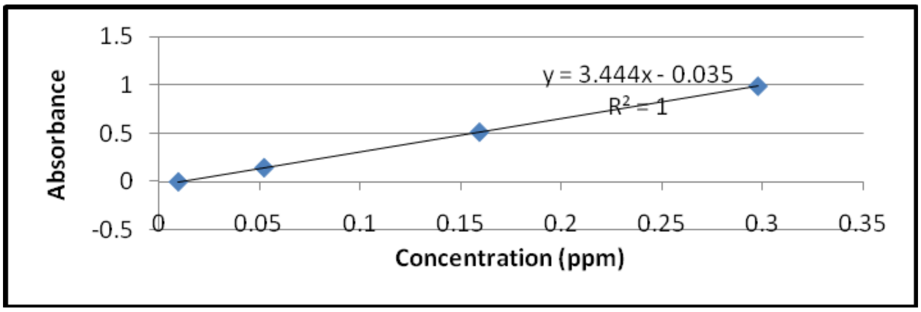

Fig 1: Graph of Cadmium Standard Calibration [Concentration (ppm) vs Absorbance]

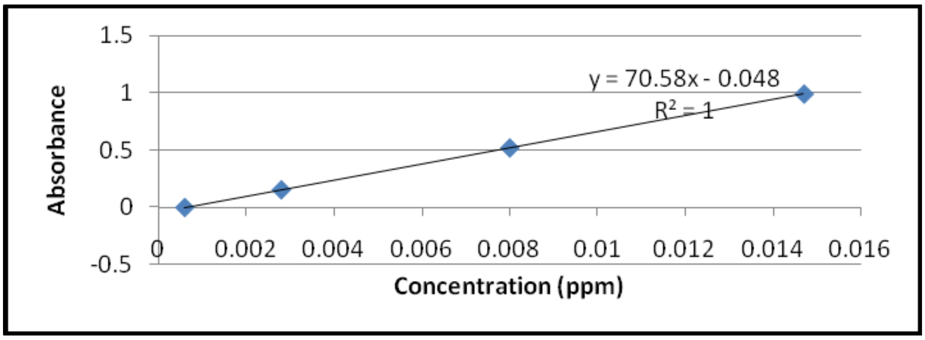

Fig 2: Graph of Chromium Standard Calibration [Concentration (ppm) vs Absorbance]

Using Flame Absorption spectroscopy, the levels of cadmium and chromium in different varieties of rice were obtained. These values were compared with the FAO/WHO recommended limit. The standards recommended limit of FAO/WHO for cadmium and lead is 0.2µ/g, The standards recommended limit of FAO/WHO for cadmium is 0.2 µg/g, but no specific recommended limit was set for chromium [6].The daily body tolerance of adult for cadmium and chromium is 0.004-0.027 mg/day and 0.05-0.2 mg/day respectively [7]. A range of 0.0127-0.043 µg/g of cadmium and 0.0006-0.0007 µg/g of chromium was detected in the ten varieties of rice samples. The results obtained using 5 gram samples did not go beyond the allowed safe limits but presence of these metals may indicate a major health concern for the population that relies on rice as the staple food, such as the Philippines. Between the two metals analyzed, the levels of cadmium in the rice pose a more essential and sensitive health risk and hazard (Table 1).

For a consumption of at least 314g of rice daily, the cadmium content of the rice would have exceeded the minimum daily body tolerance of adult. The level of chromium in the rice is relatively safe where at least 83 kg for an individual would be taken in a day to exceed the minimum daily body tolerance of adult. Cadmium oxide and cadmium salts and alloys are used in products such as nickel-cadmium dry batteries, solder, paint and plastic pigments. Acute poisoning due to cadmium is extremely rare, but chronic toxicity has been noted after occupational exposure and in instances after the diet or water supply has been contaminated (e.g. itai-itai disease in Japan) [8]. Chromium (VI) enters many types of cells and under physiological conditions can be reduced by hydrogen peroxide (H_2O_2), glutathione (GSH) reductase, ascorbic acid, and GSH to produce reactive intermediates, including Cr(V), Cr(IV), thiylradicals, hydroxyl radicals, and ultimately, Cr(III). Any of these species could attack DNA, proteins, and membrane lipids, thereby disrupting cellular integrity and functions. Chromium may either elicit its health hazard via acute or chronic intoxication.. Acute intoxication may manifest as: intense gastrointestinal irritation or ulceration and corrosion; epigastric pain, nausea, vomiting, diarrhea, vertigo, fever, muscle cramps, hemorrhagic diathesis, toxic nephritis, renal failure, intravascular hemolysis, circulatory collapse, liver damage, acute multisystem organ failure, and coma, and even death, depending on the dose. Chronic intoxication may result to: incapacitating eczematous dermatitis with edema (for skin contact), lung cancer, bronchitis, rhinitis, or sinusitis [9]

Stringent regulation needs to be conducted by the food industry to ensure the safety of the consumers. Further study needs to be conducted to determine the accuracy and precision of the results obtained. This study was limited to the detection of the possible contaminants, chromium and cadmium, on rice. It is therefore recommended that other metal contaminants must also be tested. To be able to efficiently evaluate the chromium and cadmium content of the rice, the following actions may be performed: 1) evaluation and assessment of the soil and environment to which the rice is planted; 2) heavy metal testing of uncooked rice to compare the relative quantity of both sample; 3) increase in sample size and trial to assess precision and accuracy of results.

Table1: Chromium and Cadmium levels in different varieties of rice

Rice Brand	Cadmium Levels	Chromium Levels
	ppm	ppm
Whole Grain	0.0127	0.0006
Sinandomeng	0.0132	0.0006
Violet Malagkit	0.0134	0.0006
Passion	0.0134	0.0007
Brown Rice	0.0143	0.0006
Jasmin	0.0138	0.0006
Malagkit	0.0143	0.0006
Denorado	0.0135	0.0007
Red Rice	0.0132	0.0007
NFA	0.0131	0.0006

4. Conclusions

Rice, being a staple food in the Philippines, needs be assessed efficiently in terms of safety for the protection of the consumer. Quantitative test using Flame Atomic Absorption Spectroscopy indicate cadmium levels (0.0127-0.043 μ/g; safety limit: 0.2μ/g or 0.004-0.027 mg/day) and chromium levels (0.0006-0.0007 μ/g; safety limit: 0.05-0.2 mg/day). This may result to a major health concern, especially in countries that treat rice as the staple food source, for cadmium accumulates chronically and the levels detected was relatively high despite the fact that it passed the safety limit set by World Health Organization (WHO). It is necessary that regulatory agencies test the other factors such as soil, water and other possible sources of contaminants to ensure consumer safety.

It is recommended that further test be performed to rice varieties. The assessment of other heavy metals is important to ensure the safety of the public. Soil, water and air detection could also be assessed for the following metal to correlate the data obtained. Precision and accuracy analysis could be done by increasing sample size and trials to increase the robustness of the results.

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