Heavy Metals Accumulation in Selected Plant Leaves Used in Food Preparation

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ABSTRACT

The objectives of the present study were to investigate heavy metals accumulation in three types of selected plant leaves that are commonly used in food preparation and the potential of the selected plant leaves to be the source of heavy metals contamination in food. Three types of selected plant leaves, namely Banana leaf, Pandan leaf and Noni leaf were self-pick at areas with highly exposed to heavy metals. Each type of selected plant leaf was picked at three different areas in Kuching, Sarawak. In order to investigate the migration of heavy metals into food, the glutinous rice was cooked in each of these leaves. Ash digestion method was chosen to digest the selected plant leaves while wet digestion was chosen to digest the glutinous rice cooked in selected plant leaf. Samples were analyzed to determine the selected heavy metals (Pb, Cu, Cr, and Ni) content using Flame Atomic Absorption Spectroscopy (AAS – Shimadzu AA-7000). The concentration of Cu, Cr, and Ni in the selected plant leaves were detected in the range of (4.70 ± 1.704 mg/kg to 12.45 ± 9.149 mg/kg), (66.60 ± 15.415 mg/kg to 203.30 ± 12.657 mg/kg) and (3.86 ± 0.305 mg/kg to 4.20 ± 3.062 mg/kg) respectively. Concentration of Cu, Cr, and Ni in glutinous rice were detected in the range of (0.52 ± 0.997 mg/kg to 14.62 ± 17.154 mg/kg), (23.85 ± 0.071 mg/kg to 129.15 ± 3.323 mg/kg) and (3.79 ± 4.518 mg/kg to 4.3 ± 7.502 mg/kg) respectively whereas Pb was not detected in all samples.

Keyword: *Heavy metals; Plant leaf; Atomic absorption spectroscopy; Ash digestion; Food preparation; Glutinous rice*

1. INTRODUCTION

The use of plant leaves as natural food wrappers have been a part of culture in Malaysia as it has a waterproof characteristic which impart their own fresh natural fragrance in foods cooked in them [1]. Plant leaves are easier to be obtained in this tropic region and reduce the cost of foods preparation. There are various types of plant leaves traditionally used as food wrappers such as banana (*Musa parasidiaca)* leaves, Pandan (*Pandanus amaryllifolius*) leaves and Noni (*Morinda citrifolia*) leaves. Coconut (*Cocos nucifera*) leaves and Palas (*Licuala spinosa*) leaves are folded into pouches and filled with rice and boiled in order to prepare *Ketupat* which is one of the signature dishes in Malaysia that are widely served for *Eid al-Fitr* celebration [1]. Thus, Palas (*Licuala spinosa*.) leaves and coconut *(Cocos nucifera)* leaves would have a high demand during this festive season.

These plants can grow wildly anywhere and can be obtained easily. It would be dangerous if these plant leaves were to be obtained from an industrial area. This is because plants that grow in industrial areas are contaminated with organic and inorganic pollutants including heavy metals which were disposed by the nearby factories [2]. Bain *et al*. [3] has shown that the major factors of soil contaminated with heavy metals were resulted by industrial activities instead of mining activities.

Heavy metallic elements can accumulate and migrate in the soil environment [4]. The accumulation of heavy metals in soil might affect plants that grow on it. Thus, foods cooked in those folded leaves might have the tendency to be contaminated with heavy metals. In fact, if the contaminated plants leaves affect the foods cook directly in them; this would cause adverse health impacts on human through primary food chain [5].

Therefore, the aim of this study is to analyze the selected heavy metals concentrations which are Pb, Cu, Cr and Ni in selected plant leaves used for food preparation and correlate the heavy metals in plant leaves and food as well as comparing the foods with the standard permissible limit from various organizations.

2. MATERIALS AND METHOD

2.1 Sampling location and collection

Glutinous rice was bought at random supermarket in Kuching, Sarawak and the brand was randomly chosen. A total of three samples from different types of plant leaves were collected at area with highly exposed to heavy metals. The selection of plant leaves areas collected were based on the easiest to be obtained. Table 1 showed the sampling coordination of selected plant leaves.

Table -1: Location of plant leaves samples.

Plant Leaf	Location	Area Coordination		
		A	B	C
Banana	Taman Sukma, Petrajaya, Kuching.	1˚35’57.6” N 110˚20’31.2” E	1˚36’13.5” N 110˚20’42.7” E	1˚36’22.4” N 110˚20’37.4“ E
Pandan	Tabuan Hj. Drahman, Kuching	1˚32’26.6”N 110˚22’32.2” E	1˚32’08.8”N 110˚37’62.1”E	1˚32’10.5”N 110˚22’36.3” E
Noni	Tabuan Hj. Drahman, Kuching	1˚32’24.3”N 110˚22’34.9” E	1˚53’71.3” N 110˚37’53.0”E	1˚53’67.9” N 110˚37’60.1” E

Figure -1: Sampling locations of (A) Banana leaf, (B) Pandan leaf and (C) Noni leaf.

2.1 Sampling and sample preservation for heavy metals analysis

Sample of plant leaves were cleaned and washed with distilled water and dried in an oven at 180 °C for 1 hour. The samples were grinded in a ceramic mortar and pestle until a fine powder were obtained [6]. 5.0 g of glutinous rice was wrapped in three different plant leaves and boiled for 45 minutes. The boiled rice was dried at 103 °C to 105 °C for 30 minutes in an oven and was then grinded into powdered form. The unwrapped glutinous rice was prepared in same steps as wrapped glutinous rice. All the glasswares for the analysis were free from metal contamination by soaking it in nitric acid for 24 hours and thoroughly wash with distilled water.

2.2 Samples digestion

Plant leaves (Ash digestion). 1 g of sample was placed in a crucible and heated at 450 °C for 90 minutes in a muffle furnace. The ash was dissolved with 5 ml of concentrated HCl solution in a fume hood. The residue was filtered into a 100 ml volumetric flask and the solution was made to 100 ml of calibration mark with ultrapure water

[7]. The digested solution was prepared in duplicate for each of samples and kept in polyethylene bottles for further analysis.

Glutinous rice wrapped in plant leaves (Wet digestion). In a fume hood, 0.5 g of each glutinous rice powder samples were weighed into 100 ml of conical flask and 5 ml of 65% HNO_3 was added. The digested solution was left for 30 minutes before heated it using a hot plate for 2 hours at 95 °C. Another 5 ml of 65% HNO_3 was added into the digested solution and continue heating using hot plate for another 2 hours [8]. The solution was then filtered into a 50 ml volumetric flask and added with ultrapure water until the calibration mark. The digested solution was prepared in duplicate for each of samples and kept in polyethylene bottles.

Unwrapped glutinous rice for control purpose. 0.5 g of unwrapped glutinous rice powder were weighed and prepared through same steps as glutinous rice wrapped in plant leaves [8]. Ultrapure water was use throughout the preparation and control was prepared in duplicate. The digested solution was kept in a polyethylene bottle for further analysis.

2.3 Analysis of heavy metals

The digested samples were analyzed for selected heavy metals which are Pb, Cu, Cr and Ni by using Flame Atomic Absorption Spectroscopy (AAS – Shimadzu AA-7000). Standard solutions for each heavy metal were prepared according to the estimated metal concentration range of a particular element present in selected plant leaves and glutinous rice.

3. RESULTS AND DISCUSSIONS

3.1 Copper (Cu)

Figure 2 shows the concentration of copper in selected plant leaves and cooked glutinous rice. It shows that, Banana leaf at area C with 12.45 ± 9.420 mg/kg shows the highest Cu concentration compared to Banana leaf at area A and area B with 5.98 ± 0.120 mg/kg and 7.03 ± 1.930 mg/kg respectively. Banana leaf of area C is high in Cu concentration as it grows nearby a heavy traffic road of Taman Sukma Kuching, as shown in Figure 1. Pandan leaf of area B showed high copper concentration with 6.21 ± 4.830 mg/kg compared to Pandan leaf of area A and C with 4.70 ± 1.704 mg/kg and 5.67 ± 0.325 mg/kg respectively. As shown in Figure 1, Pandan leaves of area B are grown in bushy area with many thrown rubbish. Meanwhile for Noni leaf of area B, the copper concentration detected higher in the amount of 9.83 ± 0.714 mg/kg compare to Noni leaf at area A and C. Noni leaves of area B were grown in drain area with heavy municipal waste inside the drain. According to Davydova *et al*. [9], circulation of heavy metal such as Cu was due to water flows from the drainage system where it wash away the heavy metals contamination from soils. The drainage system of area B was not in a good condition because the drain is clogged by municipal waste which caused no water flow occurred. Thus, the Noni leaves tend to have high Cu concentration as it taken up more Cu concentration directly from the drainage system [9].

However, the glutinous rice cooked in Banana leaf at area A showed higher concentration of copper which is 2.89 ± 0.686 mg/kg compared to glutinous rice cooked in banana leaves of area B (0.52 ± 0.997 mg/kg) and C (1.47 ± 0.233 mg/kg) respectively. According to Hajeb *et al.* [10], cooking method can even increase the heavy metals concentration in food as most of cooking method was not effectively removed heavy metals. The glutinous rice cooked in Pandan leaf of area C shows 3.55 ± 2.263 mg/kg of copper concentration which is the highest among other glutinous rice at all area. Meanwhile, glutinous rice cooked in Noni leaf of area B is at 14.62 ± 17.154 mg/kg which slightly higher compared to glutinous rice cooked in Noni leaf of area A which is at 12.3 ± 13.081 mg/kg. The concentration of Cu in glutinous rice cooked in Noni leaves of area A and area B is higher than their respective plant leaves due to the glutinous rice was cooked without any removal of heavy metals cooking method in which allow the glutinous rice to absorb higher Cu concentration [10]. Although the boiling process has been applied while cooking the glutinous rice, it does not remove the heavy metals effectively and it has no reagents to reduce the Cu concentration [10].

In this study, the Cu concentrations detected in glutinous rice were compared with standard limit regulated by Malaysian Food Regulation (MRF) with 30 mg/kg and World Health Organization (WHO) with 10 mg/kg. It was found that only glutinous rice in Noni leaves of area A and B exceeded the permissible regulated by WHO (10 mg/kg). However, all the glutinous rice samples analyzed were below than the permissible limit regulated by MFR. High Cu concentration detected in leaf samples collected was probably due to the municipal land site which is one of common sources of copper [11].

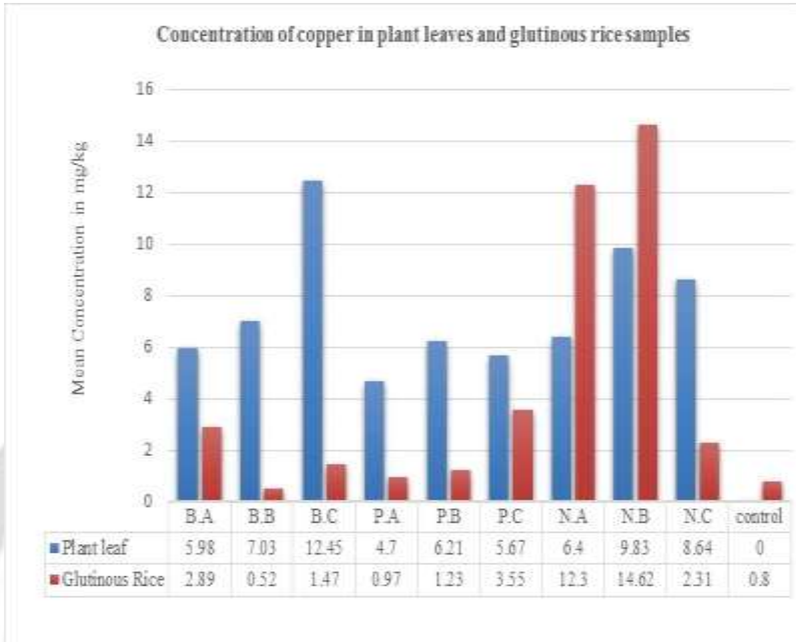

Figure -2: Concentration of copper (mg/kg) in plant leaves and glutinous rice samples.

3.2 Chromium (Cr)

Figure 3 shows high chromium concentration in Banana leaves of area B and C with 74.45 ± 22.557 and 78.15 ± 12.490 mg/kg respectively. Banana plants that grow at area C are highly exposed to heavy traffic road as it grows nearby the supermarkets and the playground of Taman Sukma, Kuching. However, high Cr content may result from soil to plant uptake. Based on the observation, the surrounding of area B showed only little grass grow with yellow in its colour. This indicates that these areas have been applied with pesticides. Meanwhile, the amount of chromium in Pandan leaf for area C is at 105.95 ± 7.849 mg/kg which slightly higher compared to the Pandan leaves of area A and B which is at 88.35 ± 1.768 mg/kg and 96.9 ± 17.961 mg/kg respectively. The Pandan leaf of area C was grown nearby the drainage system of Tabuan Haji Drahman as shown in Figure 1. The drainage system was clogged by municipal waste and therefore there is no flow of water occurred. According to Davydova *et al.* [9] drainage system helps in washed away heavy metals contamination in soils. However, the poor drainage system will not help the soil to reduce the heavy metals contamination and therefore the Cr contamination in soils still remain and caused the Pandan leaf to accommodate the Cr concentration in a large amount.

The glutinous rice cooked in Pandan leaf of area A has the highest concentration of chromium compared to other different area of Pandan leaves which is at 129.15 ± 3.323 mg/kg. The concentration of chromium in cooked glutinous rice of Noni plant leaf of area C is higher with 111.10 ± 3.394 mg/kg. Chromium concentration in all glutinous rice samples were detected above the permissible limit regulated by WHO (1.0 mg/kg).

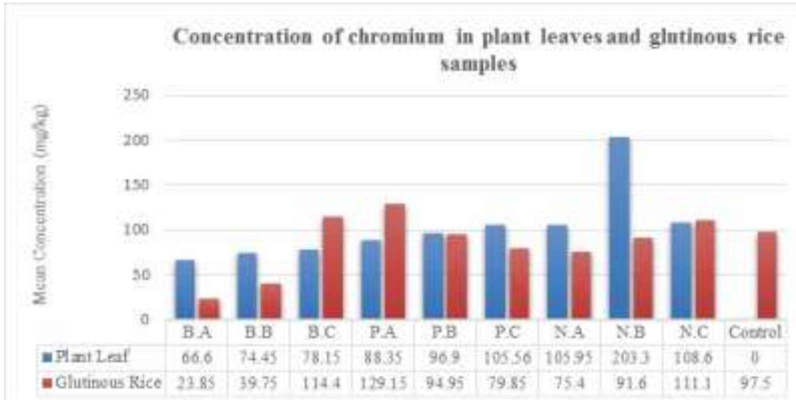

Figure -3: Concentration of chromium (mg/kg) in plant leaves and glutinous rice samples.

3.3 Nickel (Ni)

Figure 4 shows that Ni was not detected in Banana plant leaf, Pandan leaf and its respective cooked glutinous rice. According to Smith *et al.* [12], Ni concentration is lower in plant shoots rather than concentration in the plant roots. Smith *et al*. [12] also emphasized that Ni concentration also affected by the types of plant roots and the size of the plant roots. Banana plant leaf and Pandan leaf were not detected with Ni since both of the plant roots is fibrous type which has lower density to accumulate Ni concentration. Meanwhile, Noni tree have tap root that has the ability to absorb high concentration of Ni. Thus, the plant roots of Banana and Pandan were not able to translocate the Ni concentration up to the plant shoots which lead to no detection of Ni concentration in both plant leaves.

Noni leaf of area B has the highest Ni concentration with the concentration of 4.20 ± 3.062 mg/kg. Figure 1 showed that the Noni tree of area B grow directly from the drainage system. Meanwhile, the glutinous rice cooked in Noni leaf of area C has the higher concentration of Ni at 4.3 mg/kg compared to its respective plant leaf. Ni concentration was not detected in glutinous rice wrapped in Noni plant leaf of Area A although the Noni plant leaf area A was detected Ni concentration at 3.86 ± 0.305 mg/kg. This is probably due to raw glutinouse rice was throughly washed before it is cooked. As claimed by Sengupta *et al.* [13], washing rice before cooking until the water was clear will remove the heavy metals. However, there is no permissible limit of Ni concentration stated by any organization.

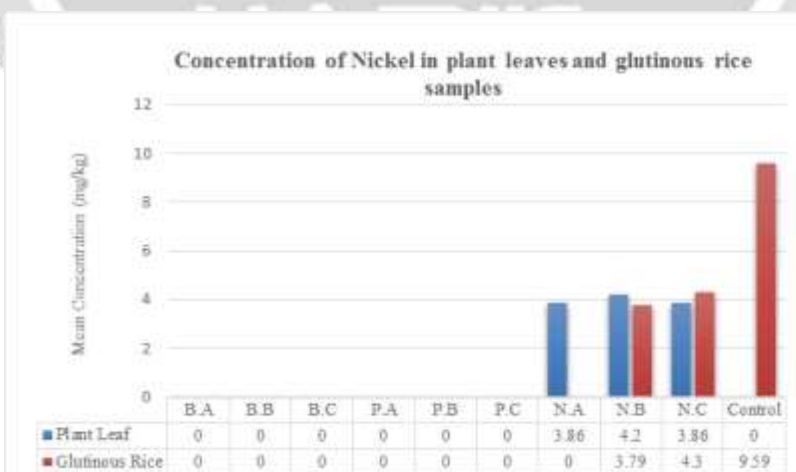

Figure -4: Concentration of nickel (mg/kg) in plant leaves and glutinous rice samples.

4. CONCLUSIONS

The used of Flame Atomic Absorption Spectroscopy (FAAS) instrument allowed the detection of heavy metals accumulation in selective plant leaves and glutinous rice cooked in respective selected plant leaves by using three standards solution. The concentration of Cu, Cr, and Ni in the selected plant leaves were detected in the range of (4.70 ± 1.704 mg/kg to 12.45 ± 9.149 mg/kg), (66.60 ± 15.415 mg/kg to 203.30 ± 12.657 mg/kg) and (3.86 ± 0.305 mg/kg to 4.20 ± 3.062 mg/kg) respectively. The results revealed that the concentrations of Cu and Cr in glutinous rice were above the maximum permissible limit regulated by WHO (10.0 mg/kg and 1.0 mg/kg respectively) which are (0.52 ± 0.997 mg/kg to 14.62 ± 17.154 mg/kg) and (23.85 ± 0.071 mg/kg to 129.15 ± 3.323 mg/kg) respectively. Meanwhile, there is no permissible limit regulated for Ni as stated by any organization.

5. ACKNOWLEDGEMENT

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