

Heavy Metals in Bitter Gourd (*Momordica charantia*): Human Health Risk Assessment

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Abstract: *Momordica charantia* (bitter gourd) were collected between May and December 2016 from Kg. Ara Kuda (Penang), Kuala Ketil (Kedah) and Sg. Rengat, Jerantut (Pahang) of Peninsular Malaysia. The metal concentrations (mg/kg dry weight) the edible fruity bitter gourd ranged from the three farming sites were 8.00-16.1 for Cu, 46.0-118 for Fe, 0.18-1.98 for Ni, 0.79-1.46 for Pb and 17.2-46.8 for Zn. For the human health risk assessment via consumption of the bitter gourds, all the target hazard quotient values for Fe, Cu, Ni, Pb, and Zn were below 1.00. This indicated that there were no non-carcinogenic risks of Fe, Cu, Ni, Pb, and Zn via the consumption of bitter gourds from the three farming sites. However, it is still advisable that regular monitoring of heavy metals in the bitter gourds be conducted in order to check for possible toxicological risks of the bitter gourd consumption.

Keywords: Human health risk; Heavy metals; Fruity vegetable

1. INTRODUCTION

Oral consumption of metal-contaminated vegetables is of public concern because these bioaccumulated metals could create complicated health problems in the consumers (Khan et al. 2008). According to Ghous et al. (2015), *Momordica charantia* is a common fruity vegetable besides being used as a traditional medicine in South Asia. It is under the Family: *Cucurbitaceae* and commonly known as “bitter gourd”. It is an annual and climber plant (Savsatli et al., 2016). Besides being a traditional medicinal plant, it is also a cultural plant. It can adapt well in many ecological conditions (Savsatli and Seyis, 2014), including many tropical and subtropical countries.

The bitter gourd is a potential source of enrichment of phenolic compounds (Islam et al., 2011; Gupta et al., 2011). Therefore, it has pharmacological values for many diseases. The fruits of bitter gourd contain laxative, antibilious, emetic and stomachic effects (Arya et al., 2011). Verma (2015) reported that all parts of the bitter gourd are beneficial for human and there is a distribution of elemental concentrations in different parts of the plant

while Kosanovic et al. (2009) stated that bitter gourd is an important source of essential Ca, Mg, Mn, Cu and Zn.

The objectives of this study were to 1) assess the concentrations of Fe, Cu, Ni, Pb, and Zn in bitter gourd *M. charantia* from three farming areas of Peninsular Malaysia, and 2) assess the human health risks of the above five metals in the collected bitter gourds.

2. MATERIALS AND METHODS

Bitter gourds *M. charantia* were collected between May and December 2016 from Kg Ara Kuda (Penang), Kuala Ketil (Kedah) and Sg. Rengat, Jerantut (Pahang) of Peninsular Malaysia (Table 1).

The samples were kept in clean polyethylene bags and transported to the laboratory for further analyses. The identification of the bitter gourd was done based on Chin and Yap (1999), and Prohens and Nuez (2008a, 2008b). In the laboratory, the samples were washed with distilled water to remove soil particles. Later, they were cut into small pieces using a clean knife and were dried in an oven at 60°C for 72 hours days until a constant dry weight.

For determination of heavy metals, all filtered samples were analysed by using a flame atomic absorption spectrophotometer (AAS) model

Thermo Scientific iCE 3000 series for Cu, Fe, Ni, Pb, and Zn. All data obtained from the AAS were presented in mg/kg dry weight basis.

Table1. Heavy metal concentrations (mg/kg dry weight) in the bitter gourd *Momordica charantia* (fruit) collected from three farms in Peninsular Malaysia.

Site		Cu	Fe	Ni	Pb	Zn	S.date	Source of irrigation	Reference
Sg Rengat, Jerantut, Pahang	Rengat	8.00 (0.49)	46.0 (2.81)	0.80 (0.05)	0.80 (0.05)	46.8 (2.85)	12-May-16	Private farms, a river, distance from highway, surrounded by forest.	This study
Ara Kuda, Penang	Ara	16.1 (0.98)	46.9 (2.86)	1.99 (0.12)	1.46 (0.09)	29.0 (1.77)	12-Oct-16	Tube well and stream	This study
Kuala Ketil, Kedah	Ketil	14.5 (0.89)	118 (7.18)	0.18 (0.01)	0.79 (0.05)	17.2 (1.05)	8-Dec-16	Tube well and stream	This study
Overall Peninsular Malaysia	3 sites	8.00-16.1 (0.49-0.98)	46.0-118 (2.81-7.18)	0.18-1.99 (0.01-0.12)	0.79-1.46 (0.05-0.09)	17.2-46.8 (1.05-2.85)			

Note: Values in brackets are presented in wet weight basis (mg/kg wet weight).

For quality assurance and quality control, all the glassware used in this study were acid-washed to avoid external contamination. Two certified reference materials (CRM) were used to check for the analytical procedures of the present method. The CRMs analysed were

Lagarosiphon major N.60 and Peach Leaves (NIST 1547). The recoveries for the CRM *Lagarosiphon major* N.60 were 97.4, 120.2, 119% for Zn, Cu and Pb, respectively, while CRM Peach Leaves (NIST 1547) were 97.0 and 117% for Ni and Fe, respectively (Table 2).

Table2. Comparison of metal concentrations (mg/kg dry weight) between certified and measured values. The certified values are based on certified reference materials were *Lagarosiphon major* N.60 and Peach Leaves (NIST 1547).

<i>Lagarosiphon major</i> N.60			
	Certified value	Measured value	Recovery (%)
Cu	51.20 ± 1.9	61.54 ± 1.4	120.2
Zn	313 ± 8	304.85 ± 3.4	97.4
Pb	64 ± 4.00	76.3 ± 2.40	119
<i>Peach Leaves</i> (NIST 1547)			
Ni	0.689	0.81	117
Fe	219.8	211	97.0

For the human health risk assessment, the basis in dry weight was converted into wet weight by using a conversion factor of 0.061. The assessment included estimated daily intake (EDI) and target hazard quotient (THQ) values, as shown in the following formulas:

$$EDI = (Mc \times CR) / BW$$

where;

Mc= the metal concentration in bitter gourds (mg/kg wet weight).

CR= the consumption rate of bitter gourds (345 g/day for adults and 232 g/day for children) and average body weight (55.9 kg for adults and 32.7 kg for children) (Wang et al. 2005).

In this study, a non-carcinogenic risk assessment method was based on THQ, a ratio between the estimated dose of contaminant and the oral

reference dose (RfD), below which there will not be any appreciable risk. The THQ was determined with a formula described by USEPA (2000):

$$THQ = EDI / RfD$$

where;

EDI= estimated daily intake calculated previously;

RfD= the oral reference dose. The RfD (µg/kg wet weight/day) values used in this study were Fe: 700, Ni: 20.0, Cu: 40.0, and Zn: 300, provided by the EPA’s Integrated Risk Information System online database (IRIS 2000). This study used the RfD as 4.00 µg/kg wet weight/day as proposed by FAO/ WHO (2013) because RfD value for Pb was not available based on EPA’s IRIS (2000).

Table3. Values of estimated daily intake (EDI) of heavy metal concentrations in *Momordica charantia* collected from selected farms in Peninsular Malaysia.

	Adults					Children				
Consumption rate of vegetables (g/day)	345					323				
Body weight (kg)	55.9					32.7				
	Cu	Fe	Ni	Pb	Zn	Cu	Fe	Ni	Pb	Zn
Rengat	3.01	17.32	0.30	0.30	17.62	4.82	27.72	0.48	0.48	28.20
Ara	6.07	17.65	0.75	0.55	10.93	9.71	28.25	1.20	0.88	17.50
Ketil	5.47	44.32	0.07	0.30	6.46	8.75	70.93	0.11	0.48	10.33

Note: All metal data were converted to wet weight basis using a conversion factor of 0.061 for the calculation of EDI.

Table4. Values of target hazard quotient (THQ) of heavy metal concentrations in *Momordica charantia* collected from selected farms in Peninsular Malaysia.

	Adults					Children				
RfD(µg/kg wet weight/day)	40.0	700	20.0	4.00	300	40.0	700	20.0	4.00	300
	Cu	Fe	Ni	Pb	Zn	Cu	Fe	Ni	Pb	Zn
Rengat	0.075	0.025	0.015	0.075	0.059	0.121	0.040	0.024	0.121	0.094
Ara	0.152	0.025	0.037	0.137	0.036	0.243	0.040	0.060	0.220	0.058
Ketil	0.137	0.063	0.003	0.074	0.022	0.219	0.101	0.005	0.119	0.034

3. RESULTS AND DISCUSSION

3.1. Concentrations of Fe, Cu, Ni, Pb, and Zn

The metal concentrations (mg/kg dry weight) in the bitter gourd collected from three farms are given in Table 1. The ranges of metal concentrations (mg/kg dry weight (wet weight)) from the three sites were 8.00-16.1 (0.49-0.98) for Cu, 46.0-118 (2.81-7.18) for Fe, 0.18-1.99(0.01-0.12) for Ni, 0.79-1.46 (0.05-0.09) for Pb and 17.2-46.8 (1.05-2.85) for Zn.

Based on *M. charantia* collected from reclaimed tidal flat soils of Pearl River Estuary (China), Li et al. (2012) reported the Cu and Zn levels (mg/kg wet weight) were 0.71 and 1.46, respectively. Khan et al. (2013) reported the metal concentrations (mg/kg wet weight) *M. charantia* from Swat District, northern Pakistan as 0.05 for Cu, 0.06 for Ni and 0.09 for Zn. Based on *M. charantia* grown around effluent sites of District Sargodha (Pakistan), Bibi et al. (2014) showed that the concentrations (mg/kg dry weight) of Ni, Cu and Zn in bitter gourds at both sites were 4.78-5.6 for Ni, 20.2-22.7 for Cu, and 52.3-61.8 for Zn. Therefore, the intake of *M. charantia* was not safe for consumption in the sampling area.

3.2. Health Risk Assessments

The values of EDI and THQ of the five heavy metals in bitter gourd for adults and children are shown in Tables 3 and 4, respectively. All the THQ values for Fe, Cu, Ni, Pb, and Zn in both adults and children were found below 1.00. This indicates that there is no non-carcinogenic risk

of Cu, Fe, Ni, Pb, and Zn via the consumption of the bitter gourd from the three farms. In general, the THQ values of heavy metals in children are higher than those in adults.

Zhang et al. (2017) reported that THQ values heavy metals were greater than one for adolescents in Kunming City (China), indicating non-carcinogenic risk of heavy metals to the adolescents. Islam et al. (2016) reported that THQs for Cu and Zn were below 1 based on vegetables in Bogra District. This indicated that consumers would not experience significant health hazards of metals via ingestion of the vegetable. Khan et al. (2017) reported the concentrations of Mo, As, Mn, Ni and Zn were higher than the maximum permissible limits in the bitter gourd irrigated with domestic wastewater. Unni et al. (1992) studied the effect of Pb on germination, growth, chlorophyll a, b and total chlorophyll contents in *M. charantia* in a hydroponic system. They found that chlorophyll content is useful *in vivo* indicator of heavy metal toxicity for calculating the upper critical tissue concentrations. Ghous et al. (2015) determined the levels of antioxidant, metal chelating and antiglycation activities of aqueous extracts of *M. charantia* fruit flesh and fruit pulp fractions.

4. CONCLUSION

Based on the THQ values for Cu, Fe, Ni, Pb, and Zn in both adult and children, there were no non-carcinogenic risks of the five metals through the consumption of bitter gourds from

the three farms. However, there is a need for regular monitoring of heavy metals in order to check for possible contamination of bitter gourd.

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