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Human health risks of heavy metals in okra (*Abelmochus esculentus*) and lettuce (*Lactuta sativa*) collected from selected farms in Peninsular Malaysia

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Research Article

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Abstract

The present study investigated the concentrations of Cu, Fe, Ni, Pb and Zn in fruit okra (*Abelmochus esculentus*) and leafy lettuce (*Lactuta sativa*) collected from selected farms in Peninsular Malaysia, based on cited and unpublished data. For the leafy lettuce, the metal concentrations (mg/kg dry weight) were 1.18-13.9 for Ni, 1.67-24.7 for Cu, 19.0-120 for Zn, 0.20-2.12 for Pb and 71.5-306 for Fe. For the fruit okra, the metal concentrations (mg/kg dry weight) were 1.19-14.4 for Ni, 5.93-20.2 for Cu, 23.7-123 for Zn, 0.01-2.21 for Pb and 43.9-172 for Fe. To estimate the human health risk assessment, all values of target hazard quotient for the 5 metals in the adults of Malaysian population were found below 1.00. This showed that there was no non-carcinogenic risk of the 5 metals via the consumption of okra and lettuce from the present study. Still, it is highly recommended that frequent monitoring of toxic chemicals besides heavy metals should be carried out for possible chemical contamination in the edible vegetables in Malaysia.

Keywords: Heavy metals; Health risk assessment; Okra; Lettuce

Introduction

High heavy metal reported in the agricultural vegetables is a public concern nowadays due to a noteworthy human health risks (HHR) of these metals [1-4]. There are many literature reported on the topics of heavy metal HHR such as those reported from Pearl River Delta, South China [5], a semi-urbanized area from Haryana state, India [6], a vegetable farm from North

China [7], a greenhouse vegetable farm from eastern China [8], southwestern China [9], Ethiopia [4], Dayu County [10], developed areas of Zhejiang Province, China [11], northern France [12], Kubanni River, Nigeria [13], Spelter, WV, USA [14], artisanal gold mining area from Tongguan, China [15], and northern Bangladesh [16]. For example [17] and Xue reported the heavy metal pollution in connection to HHR in the food crops irrigated with contaminated wastewaters from China. All the above literatures strongly indicated that the contaminated vegetables are an important aspect of food quality assurance that cannot be easily ignored [18].

The objectives of this study were to 1) assess the concentrations of Cu, Fe, Ni, Pb and Zn in Okra (*Abelmochus esculentus*, fruit) and lettuce (*Lactuta sativa*, leafy) were collected from 4 selected farms in Peninsular Malaysia, and 2) assess the HHRs of the 5 metals in the edible parts of vegetables.

Materials and Methods

Okra (*Abelmochus esculentus*, fruit) and lettuce (*Lactuta sativa*, leafy) were collected from 4 selected farms in Peninsular Malaysia (Table 1). The metal data in both types of vegetables collected in 2016 were cited from Aziran, et al. [19-21] while those vegetables collected in September 2013 and 2018 were unpublished data.

			DW					**WW**				
Common names	Sampling site	SD	Ni	Cu	Zn	Pb	Fe	Ni	Cu	Zn	Pb	Fe
Okra	Sikamat, Seremban.	Sep-13	1.86	5.93	123.09	1.35	171.57	0.18	0.56	11.69	0.13	16.30
Lettuce	Sikamat, Seremban.	Sep-13	3.24	1.67	19.00	0.20	115.07	0.22	0.11	1.29	0.01	7.82
Lettuce	Sikamat Seremban	11-Feb-18	13.98	16.39	61.46	1.99	286.71	0.95	1.11	4.18	0.14	19.50
Okra	Ara Kuda	13-Feb-18	14.41	15.94	67.81	0.00	61.36	1.37	1.51	6.44	0.00	5.83
Okra	Ara Kuda Penang	12-Oct-16	1.45	16.15	90.44	1.78	122.66	0.14	1.53	8.59	0.17	11.65
Lettuce	Ara Kuda Penang	20-Oct-16	1.18	24.67	81.50	2.12	85.99	0.08	1.68	5.54	0.14	5.85
Okra	Kg Sitiawan Manjung Perak	17-Nov-16	1.19	19.07	23.72	2.21	80.76	0.11	1.81	2.25	0.21	7.67
Lettuce	Kg Sitiawan Manjung Perak	9-Nov-16	1.22	23.35	105.65	1.23	305.86	0.08	1.59	7.18	0.08	20.80
Okra	Kuala Ketil Kedah	21-Dec-16	1.24	20.20	33.10	1.62	43.88	0.12	1.92	3.14	0.15	4.17
Lettuce	Kuala Ketil Kedah	8-Dec-16	1.46	18.19	120.24	1.98	71.50	0.10	1.24	8.18	0.13	4.86

Table 1: Concentration (mg/kg) of Ni, Cu, Fe, Pb and Zn of okra (*Abelmochus esculentus*, Fruit) and lettuce (*Lactuta sativa*, leafy), collected from 4 selected farms in Peninsular Malaysia. SD: sampling dates; DW= Dry weight; WW= Wet weight.

The lettuce and okra were kept in clean polyethene bags and transported to the laboratory for further analyses. The identification of the bitter gourd was done based on Chin & Yap [22]. 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 Cu, Fe, Ni, Pb, and Zn, all filtered samples were analysed by using a flame atomic absorption spectrophotometer (AAS) model Thermo Scientific iCE 3000 series.

	***Lagarosiphon major* 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
	Peach Leaves (NIST 1547).		
Ni	0.689	0.81	117
Fe	219.8	211	97

Table 2: 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).

For quality assurance and quality control, all glasswares used in this study were acid-washed. 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).

For the human health risk assessment, the basis in dry weight was converted into wet weight by using conversion factors of 0.096 and 0.068, for *A. esculentus* and *L. sativa*, respectively, followed those reported by Aziran, et al. [19-21]. The estimated daily intake (EDI, µg/kg/day) is calculated by using the following formula:

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

where;

Mc represents the metal concentration (µg/g wet weight) in the chili. The body weight (BW; kg) for adults is 62 kg and consumption rate (CR; g/person/day) for fruit and leafy vegetables is 32g and 43g, respectively, following the report for Selangor population [23].

In this study, a non-carcinogenic risk assessment method was based on Target Hazard Quotient (THQ), a ratio between the estimated dose of contaminant and the oral reference dose (RfD), below which there will not be any appreciable risk. If the THQ value is higher than 1.0, this means that the daily consumption of chili would likely result in negative health effects during a lifetime in a human population [24]. The THQ was determined with a formula described by USEPA [25].

$$THQ = EDI/ RfD$$

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 [26]. This study used the RfD as 4.00 µg/kg wet weight/day as proposed by FAO/ WHO (2013) [27] because RfD value for Pb was not available based on EPA's IRIS [26].

Results and Discussion

(Table 3) shows the concentration (mg/kg) of Ni, Cu, Fe, Pb and Zn of okra and lettuce collected from 4 selected farms in Peninsular Malaysia. The overall values of heavy metal concentrations (mg/kg dry weight) between okra (*Abelmochus esculentus*, fruit) and lettuce (*Lactuta sativa*, leafy), collected from 4 selected farms in Peninsular Malaysia, are presented in Table 3. For the leafy lettuce, the metal concentrations (mg/kg dry weight) were 1.18-13.9 for Ni, 1.67-24.7 for Cu, 19.0-120 for Zn, 0.20-2.12 for Pb and 71.5-306 for Fe. For the fruit okra, the metal concentrations (mg/kg dry weight) were 1.19-14.4 for Ni, 5.93-20.2 for Cu, 23.7-123 for Zn, 0.01-2.21 for Pb and 43.9-172 for Fe. Based on leafy lettuces grown on reclaimed tidal flat soils in the Pearl River Estuary (China), Li, et al. [2] reported the concentrations (mg/kg wet weight) of two variety of lettuces (*L. sativa* L. var. asparagina and *L. sativa* L. var. longifolia) were 2.42-3.98 for Zn, 0.54-0.57 for Cu, 1.97-0.32 for Ni, 0.06-0.13 for Pb. Lawal, et al. [13] showed that the average concentrations of Zn in the vegetable samples (farmlands grown along Kubanni River, Zaria, Nigeria), were above the FAO/WHO permissible limits. The present mean concentrations of Cu and Zn in lettuce and okra were lower than the maximum permissible levels suggested by FAO/WHO [27] (Cu: 40 mg/kg ww; Zn: 60 mg/kg ww) for leafy and fruit vegetables.

Leafy lettuce	Ni	Cu	Zn	Pb	Fe
Minimum	1.18	1.67	19.0	0.20	71.5
Maximum	13.9	24.7	120	2.12	306
Mean	4.22	16.9	77.6	1.50	173
Std Deviation	5.52	9.16	39.7	0.81	114
Fruit okra					
Minimum	1.19	5.93	23.7	0.01	43.9
Maximum	14.4	20.2	123	2.21	172
Mean	4.03	15.5	67.6	1.39	96.1
Std Deviation	5.81	5.64	40.9	0.83	51.4

Table 3: Overall statistics of heavy metal concentrations (mg/kg dry weight) between okra (*Abelmochus esculentus*, fruit) and lettuce (*Lactuta sativa*, leafy), collected from 4 selected farms in Peninsular Malaysia.

In general, the mean concentrations of Ni, Cu, Zn and Pb were slightly higher in the leafy lettuce than those in the fruity okra. In particular, the mean concentration Fe in the leafy lettuce (173 mg/kg dry weight) is significantly ($P< 0.05$) higher than that (96.1 mg/kg dry weight) in the fruity okra. This implied that the leafy lettuce had a higher risk of metal accumulation than in the fruit okra. This is supported by the findings reported by Hu, et al. [28]. The higher heavy metal levels found in the leafy lettuce than in the fruit okra might be due to the relatively large surface area of lettuce leaves [16].

Table 4 shows the values of EDI and THQ for Ni, Cu, Fe, Pb and Zn of okra and lettuce collected from 4 selected farms in Peninsular Malaysia. The values of EDI and THQ of the 5 metals in the Malaysian adults ranged from 0.001-10.7, and 0.0001-0.035, respectively. Therefore, all the THQ values for the 5 metals in the Malaysian adults are all below 1.0. This indicates there is no non-carcinogenic risk of Ni, Cu, Fe, Pb and Zn via the consumption of lettuce and okra from the present study. Roy & Mcdonald [14] reported that lettuce the potential to cause toxicological problems in men, women, and young children, as a result of Zn accumulation.

		EDI	**EDI**	**EDI**	**EDI**	**EDI**	**THQ**	**THQ**	**THQ**	**THQ**	**THQ**
Common names	Sampling site	Ni	Cu	Zn	Pb	Fe	Ni	Cu	Zn	Pb	Fe
Okra	Sikamat, Seremban	0.09	0.29	6.04	0.07	8.41	0.005	0.007	0.020	0.019	0.012
Lettuce	Sikamat, Seremban	0.12	0.06	0.71	0.01	4.29	0.006	0.002	0.002	0.002	0.006
Lettuce	Sikamat Seremban	0.52	0.61	2.29	0.07	10.7	0.026	0.015	0.008	0.021	0.015
Okra	Ara Kuda	0.71	0.78	3.32	0.001	3.01	0.035	0.020	0.011	0.0001	0.004
Okra	Ara Kuda Penang	0.07	0.79	4.43	0.09	6.01	0.004	0.020	0.015	0.025	0.009
Lettuce	Ara Kuda Penang	0.04	0.92	3.04	0.08	3.21	0.002	0.023	0.010	0.023	0.005
Okra	Kg Sitiawan Manjung Perak	0.06	0.94	1.16	0.11	3.96	0.003	0.023	0.004	0.031	0.006
Lettuce	Kg Sitiawan Manjung Perak	0.05	0.87	3.94	0.05	11.41	0.002	0.022	0.013	0.013	0.016
Okra	Kuala Ketil Kedah	0.06	0.99	1.62	0.08	2.15	0.003	0.025	0.005	0.023	0.003
Lettuce	Kuala Ketil Kedah	0.05	0.68	4.48	0.07	2.67	0.003	0.017	0.015	0.021	0.004

Table 4: Values of estimated daily intake (EDI) and target hazard quotient (THQ) for Ni, Cu, Fe, Pb and Zn of okra (*Abelmochus esculentus*, Fruit) and lettuce (*Lactuta sativa*, leafy), collected from 4 selected farms in Peninsular Malaysia.

Eliku & Leta [4], Islam, et al. [29] reported the THQs for heavy metals in the vegetables were also below 1. This suggested that people would not experience significant health hazards. On the other hand, Islam, et al. [30] reported that the THQ values of the studied metals (except Cr) from all vegetables from Bangladesh were higher than 1. This indicated that the consumption of these vegetables is likely to pose health risks to the target population.

Conclusion

The present study investigated the concentrations of Cu, Fe, Ni, Pb and Zn the leafy lettuce and fruit okra collected from 5 farming areas in Peninsular Malaysia. For the health risk assessment, al the THQ values for the 5 metals in the Malaysian adults are all below 1.00. This indicated that there is no non-carcinogenic risk of Cu, Fe, Ni, Pb and Zn via the consumption of vegetables from the present study. Nevertheless, it is still highly recommended that frequent monitoring of toxic chemicals besides heavy metals should be carried out in order to check for possible chemical contamination. This is important to reduce the possible toxicological impacts on human health due to toxic chemicals exposure via vegetable consumption.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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