ORIGINAL ARTICLE

Determination of heavy metals in fruit vegetables produced from conventional farms in Kuala Selangor district

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Abstract:

Vegetable and soil contamination by heavy metals in the environment can exist due to extensive use of pesticides and other similar human activities. This study was conducted to investigate the effect of conventional farm soils and heavy metal uptake by *Cucumis sativus* (cucumber) and *Capsicum annum* (chili) from Kuala Selangor. Atomic Absorption Spectrometer (AAS) was used to detect the concentration of heavy metals in vegetables (n=30) and soil (n=30). All the samples were detected with heavy metals. Mean concentration of heavy metals tested in cucumber was Fe>Zn>Cu>Pb>Cd while chili was Fe>Zn>Pb>Cu>Cd. Independent T-Test analysis showed that only Cu and Zn had significant differences where $p < 0.05$. Pearson's test was conducted to identifying the association of concentration of heavy metal between vegetable and soil which showed positive strong association of Fe for cucumber and positive medium association of Pb and Fe for chili which might be due to irrigation of water and the usage of fertilizers. THQ and HI of all the collected samples were less than 1, indicating that there were no adverse effects on consumptions of these fruits and vegetables.

Keywords: Chili, conventional farming, cucumber, heavy metals, Health Risk Assessment (HSA)

1. INTRODUCTION

Food safety play an important role in public health and consumption of food has been reported as the route for human exposure to many environmental contaminants. Heavy metals in the environment can be found either naturally occur or due to anthropogenic activities. Some of them can be found naturally because of the enrichment in soil stems from parent-material weathering [1]. While conventional farming can cause heavy metal contaminated in soil and plant due to increase of using pesticides which can cause severe diseases such as cancer to the related farmers as well as to consumers.

With the rapid development of agriculture areas, heavy metals contamination in fruit vegetable is caused from many sources such as pesticide residue, atmospheric pollution, irrigation with treated sewage water and industrial emission. Unorganized urban and industrial developments have become two of the main factors of human activities that increased the concentration of heavy metals in the environment [2]. Therefore, plants can absorb heavy metals through roots and leaves. In addition, they can also take up metals by absorbing them from contaminated soils and from deposits on parts of the plants that are exposed to the air in the polluted environment [1]. The polluted air from industries and vehicles that keep on increasing in number from time to time. In fact, it can move miles away from the sources due to the presence of wind. Therefore, they can be deposited on the fruit vegetables surfaces during production, transport and marketing [2].

Exposure to heavy metals whether short term or long terms exposure will pose adverse effects to human health. Chemical toxicants can enter the human body through inhalation, ingestion, injection and absorption (dermal contact) [3]. Human can be exposed to heavy metals through inhalation, dermal and ingestion such as eating fruit vegetables which has been contaminated by heavy metals. Heavy metals can cause significant toxic impact on plants such as fruit vegetables if their presence are higher than the safe limits [4]. This showed that heavy metals can be transferred and accumulated in the plants. Fruit vegetables are essential part of the human meal. They are in nutrients and are important sources of carbohydrates, minerals, vitamins and fibres. Hence, accumulation of these metals into fruit and vegetables becomes a health concern as they can affect human health.

Food contamination has been monitored in Malaysia by many researchers, however, most of them investigate fruit vegetable from markets or supermarkets. To the best of our knowledge, direct investigate from conventional farms for fruit vegetables is limited. Therefore, this study aimed (1) to provide providing data on heavy metals concentrations in fruit vegetables and soils at selected conventional farms, (2) to determine the association between soil and fruit vegetables, and (3) to conducted human health risk assessment.

2. MATERIALS AND METHODS

This study was conducted in Kuala Selangor from five farms (A, B, C, D and E). Sample collection which consisted of 30 vegetables and 30 samples of soil were collected from the selected conventional farms. Each of them was in triplicated and put in a labelled brown paper bag. Soil samples were also collected from all cucumber and chili samples from all selected farms. Samples were put inside a labelled plastic with seal. Cucumber and chili samples were collected randomly from the farms according to the area specific for them. All samples were kept properly and brought to the laboratory for further analysis.

The vegetables were cut and chopped into small pieces and dried. Samples were then subjected to ashing in drying oven at 105^0C for 24 hours. Ashing process is when the samples in the crucible are placed in furnace at the temperature 200-250^0C and slowly raise the temperature 450^0C at a rate of no more than 50^0C and stand for 8 hours or overnight until completely ashed. After digesting them with acid, the samples were stored until analysis by using Atomic Absorption Spectrometer (AAS) [5].

Soil samples were grinded with pestle and mortar after removing larger particles. Then, they were mixed thoroughly by shaking. They were dried in an oven for 24 hours in a 40^0C. After that, sample digestion was done by using HNO_3, H_20_2 and HCl to maintain the heavy metals in the soil samples for further analysis using AAS.

Human Health Risk (HRA) which consisted of Total Hazard Quotient (THQ) and Hazard Index (HI) were then calculated by the equation below [6]:

$$THQ = \frac{C \times EFr \times ED \times FIR}{RfD \times BW \times AT} \times 10^{-3}$$

C is the concentration of heavy metals in vegetables that obtained from the sample analysis which expressed in mg/kg. EFr is the exposure frequency which consists of 365 days a year and ED is exposure duration 70 years as average lifetime. FIR is the food ingestion rate for consumption of vegetables every day in kg/day that is set to be at 0.301kg. Whereas RfD is the reference dose stated by United Stated Environmental Protection Agency (US EPA) which known to be an estimation of oral human daily exposure that do not cause any adverse effect during lifetime. The conversion factor is 10^{-3} [7]. The reference dose for Cd, Cu, Pb, Zn and Iron were 0.001, 0.01, 0.0035, 0.3 and 0.7 respectively. BW is the average adult body weight which is 60 kilogram. Meanwhile, AT is averaging time of exposure for non-carcinogenic effects which is 365 days/year multiply with the number of exposure year.

$$HI = \Sigma HQ \text{ (Cd, Pb, Cu, Zn and Iron)}$$

Hazard index (HI) was the sum of HQs for substances that affect the same target organ or organ system. Therefore, all the HQs for each parameter were added together in order to get the total exposure.

The data were statistically analyzed using the Statistical Package for the Social Sciences (SPSS) version 21. Analysis of variance ($p < 0.05$) of total heavy metal concentration among different species of vegetables and different farms was performed using independent t-test. Correlation analysis was conducted by a Pearson correlation, and the level of significance was set at $p < 0.05$ (two-tailed).

3. RESULTS AND DISCUSSION

Heavy metals were detected in all cucumber and soil. (Figure 5.1). The mean concentrations of selected heavy metals (cadmium [Cd], copper [Cu], zinc [Zn], lead [Pb] and iron [Fe]) in both samples ranged between 0.02 – 0.05, 0.16 – 3.58, 1.23 – 4.28, 0.12, – 0.8 and 1.25 – 9.48 mg/kg respectively.

Cadmium was the least detected in all samples with the reading of 0.034 mg/kg, meanwhile iron was the highest concentration 6.041 mg/kg. These findings demonstrated that the soils and cucumber across the study area was contaminated with heavy metal, which may be caused from application of pesticides, herbicides, fertilizers or due to environmental factors [3]. The concentration of Cu and Zn are said to be among the highest because they are essential elements that needed for plant growth [8].

Meanwhile, Pb and Cd were two of the lowest of heavy metal concentrate found in cucumber compared to Cu, Zn and Fe due to it being toxic elements and plus they were not required by the plants [8]. The concentration of lead, copper, cadmium, zinc and iron in soil ranged between 0.01– 0.9, 0.1– 0.51, 0.02 – 0.04, 1.77– 5.01 and 4.23 – 6.88 mg/kg respectively.

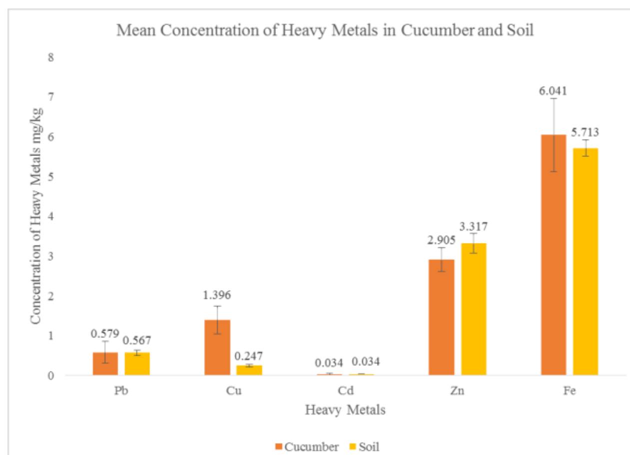

Figure 1:Mean concentration of heavy metals in cucumber and soil.

Heavy metals were also detected in all chilies and soils. Meanwhile, the concentration of lead, copper, cadmium, zinc and iron in soil ranged between 0.51 – 0.89, 0.07 – 0.44, 0.02 – 0.04, 2.67– 4.99 and 1.01– 5.22 mg/kg respectively. Fe shows the highest reading of 6.314 mg/kg and Cd has the lowest with 0.028 mg/kg. The order of the heavy metal accumulation in chili is Cd<Cu<Pb<Zn<Fe. This is the same findings from a previous study carried out in Algeria [9] where by Fe in chili the highest mean concentration

compared to Pb and Cd. This is because iron is first absorbed and translocated to enrich the aerial parts followed by Pb and Ni.

Fe has the highest mean concentration among all the tested heavy metals, where the reading was 6.314 mg/kg. This is because the existence of palm oil plantation nearby. A study by [10] in Northern Ethiopia also stated that this happened due to the usage of water irrigation which is contaminated with industrial effluents that may create a potential public health risk. Similar result was obtained by [11] in Peninsular Malaysia where Fe was one of the top heavy metal found with mean concentration of 1.29 mg/kg.

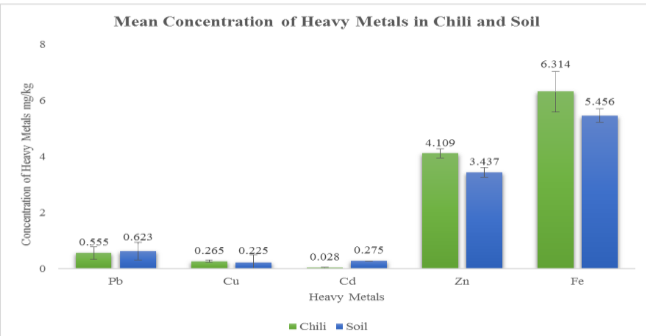

Figure 2:Mean concentration of heavy metals in chili and soil.

Independent t-test was used to prove that there is significant difference between concentration of heavy metals in cucumber and chili. From Table 1, the mean concentration found in cucumber and chili were summarized. The p-value obtained for Cu and Zn were less than 0.05 which were 0.003 and 0.001 respectively. This indicates that there is significant difference of concentration of heavy metal in cucumber and chili. *Cucumis sativus* is said to have bit higher heavy metal concentration because each vegetables reflected different efficiencies in adsorbing heavy metals. In fact, these might be due to other external factors due to its environment. The same goes with *Capsicum annum* where the concentration of heavy metals would vary dependent on a few factors such as seasonal, soil types and edible part of it [9]. This might also be due to the usage of fertilizers and pesticides in cultivating the crops [12]. Moreover, the increased concentration levels of heavy metals and the strong ability for all of heavy metals accumulation were depending on the types of vegetable and also external factors such as atmospheric heavy metal deposition especially in mining and smelting areas [7].

Table 1: Concentration of heavy metals in cucumber and chili.

Variable	Mean (mg/kg)		Minimum value (mg/kg)		Maximum value (mg/kg)		P-value
	Cucumber	Chili	Cucumber	Chili	Cucumber	Chili	
Pb	0.579	0.555	0.120	0.460	0.800	0.72	0.643
Cu	1.396	0.265	0.160	0.050	3.580	0.56	0.003*
Cd	0.034	0.028	0.020	0.020	0.050	0.04	0.105
Zn	2.905	4.109	1.230	3.230	4.280	4.99	0.001*
Fe	6.041	6.314	1.250	1.840	9.480	9.92	0.818

* P<0.05 indicates there is statistically significant difference of concentration of heavy metal between cucumber and chili.

with soil. It is a measure of the strength of the association between those two. Table 5.3 summarized the correlation analysis for Pb, Cu, Cd, Zn and Fe concentrations between vegetable and soil. It showed that only Fe has positive strong association with p-value +0.67 compared to Pb, Cu, Cd and Zn weak to medium association with +0.096, +0.167, +0.352 and -0.052 respectively. Similar result was obtained by [13] due to either the soil types which contained high Fe and Al contents or soil contamination has not occurred to some extent which can cause pollution.

Table 2: Association Concentration of Heavy Metals in Cucumber and Chili with Soil.

Association		
Type of Heavy Metals	r-value (cucumber)	r-value (chili)
Pb	0.096	0.418
Cd	0.352	-0.193
Cu	0.167	-0.322
Zn	-0.052	0.246
Fe	0.670	0.440

(+) and (-) value indicates the direction of the variables in linear graph.

The correlation analysis indicated that the vegetables are taking up the heavy metals from the soils [13]. There were positive coefficient for Zn with 0.246 which was similar to the study carried out by [13] with 0.501. This study also revealed that the soil, climatic factor and agronomic management direct the mobility and availability of a metal in the soil. In addition, plant genotype would determine the uptake by vegetable and translocation of the heavy metals to the edible portion.

Health risk assessment was carried out to identify whether the population have high risk of getting adverse effect from consuming the vegetable from the study area. From this study, it was shown that none of the health indices exceeded 1. From the table 3, it showed that the THQ for Cd is the second highest for chili with 0.141 while Cu for cucumber with 0.175. Both show highest reading for Pb. The order of the THQ is cucumber>chili where the THQ = 0.425 for cucumber and 0.332 for chili. This is the same finding as a study carried out by [11] in Peninsular Malaysia that found the THQ in cucumber is higher than in chili, the THQ in cucumber is 0.15, while in chili is 0.09. From the result, all the THQ and HI for cucumber and chili are less than 1 which means that it will not cause any adverse effect to human especially on consumption. This is because some of heavy metal can become toxic even at low concentration which was possibility to cause harm or severe effects especially when too much being exposed to human [1].

Table 3:THQ and HI for accumulation of heavy metals in cucumber and chili from the study area.

Type of vegetable	THQ					HI
	Pb	Cu	Cd	Zn	Fe	
Cucumber	0.425	0.175	0.169	0.049	0.043	0.861
Chili	0.332	0.033	0.141	0.069	0.045	0.620

If the value is ≥ 1 indicates that it can cause adverse health effects to the population when consumed.

4 CONCLUSION

This study provided the data particularly on heavy metal concentration in soil and vegetable, mainly in cucumber (*Cucumis sativus*) and chili (*Capsicum annum*) grown, sold and eaten in the selected farms located in Kuala Selangor District. From the result obtained, there are accumulation of heavy metals in both cucumber and chili. The highest heavy metal concentrations in the cucumber was observed Fe followed by Zn, Cu and Pb. While in chili still Fe followed with Zn, Pb, Cu and Cd. The trend in soils for both fruit vegetables was in the order of Fe > Zn > Cu > Pb > Cd. There is strong association for Fe in both cucumber and chili with soil. The concentration of this heavy metal varied significantly among different land use types [10]. Target Hazard Quotient (THQ) and Hazard Index (HI) calculated for cucumber (*Cucumis sativus*) and chili (*Capsicum annum*) were less than 1 which indicate no significant adverse health effects to the population that consume the vegetables on the study areas. It can be concluded that it is safe to consume cucumber and chili that are grown in the selected study area.

ACKNOWLEDGEMENTS

The author sincerely thanks all concerned laboratory assistants of Faculty of Health Sciences, UiTM for their contribution in this research work.

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