STUDY OF SELECTIVE METALS ACCUMULATION IN GREEN MUSTARD (*BRASISSCA RAPA VAR. PARACHINESIS L.*) FROM CAMERON HIGHLANDS FARMLANDS, PAHANG

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ABSTRACT

There are many essential and non-essential elements including metals and radionuclides present in vegetables. Howeve r, the accumulation of the several metals and radionuclides might cause the contamination to vegetables itself. Green m ustard (Brasissca rapa var. Parachinesis L.) was selected to represent the vegetable in this study. Objectives of this stud y are to determine the concentration of metals and radionuclides in the samples and to calculate the enrichment factor (EF) and also to estimate the uptake, base on biological accumulation coefficient (BAC), for the various parts of selecte d vegetables. Three farmlands in the Cameron Highlands were studied namely Bharat, Kg Raja and Bertam area. The g reen mustard and soil samples were collected during the harvest season. Samples were dried, ground and sieved prior t o analysis. Analyses for both samples were done by using X-rays Fluorescence Spectroscopy (XRF) to measure the conc entration of Fe, Zn, Hg, U and Th. The concentration of all elements in the soils is lower than their concentration in the control soil, except for Zn, U and Th. The concentration of all elements in Green Mustard is lower than their concentrat ion in the soil where it was grown. The EF values in the Brasissca rapa var. Parachinesis L are lower than 2 except for U and Th, indicating some degree of contamination due to anthropogenic activities or naturally origin. The BAC values show that Zn and Hg were accumulated in the green mustard, depending on where the plant grows.

Keywords: Enrichment Factor; X-Ray Fluorescent (XRF); metals contamination; Cameron Highlands

ABSTRAK

*Terdapat banyak unsur yang berfaedah dan tidak berfaedah termasuk logam dan radionuklida hadir di dalam sayur-sa yuran. Namun pengumpulan beberapa logam dan radionuklida boleh menyebabkan pencemaran kepada sayur-sayuran tersebut. Sawi hijau (*Brasissca rapa L. var Parachinesis.*) telah dipilih untuk mewakili sayuran didalam kajian ini. Objek tif kajian ini adalah untuk menentukan kepekatan logam dan radionuklida dalam sampel dan untuk mengira faktor pen gkayaan (EF) dan menentukan tahap pengambilan logam dan radionuklida ini oleh setiap bahagian sawi hijau yang di pilih dengan mengira koefisien pengumpulan biologi (BAC). Tiga ladang pertanian telah dipilih di sekitar Cameron Hi ghlands untuk dikaji, iaitu Bharat, Kg. Raja dan Bertam. Sampel sawi hijau dan tanah dipungut pada musim menuai. S ampel perlu dikeringkan, dikisar dan diayak sebelum analisis dijalankan. Analisis untuk kedua-dua jenis sampel dilaku kan dengan menggunakan Spektroskopi Pendarflour Sinar-X (XRF) bagi mengukur kepekatan Fe, Zn, Hg, U dan Th. K epekatan semua unsur di dalam tanah adalah lebih rendah berbanding dengan tanah kawalan, kecuali bagi tiga unsur i aitu Zn, U dan Th. Kepekatan semua unsur dalam sawi hijau pula adalah lebih rendah dari kepekatan unsur tersebut di dalam tanah dimana ia ditanam. Nilai EF didalam Brasissca rapa var. Parachinesis L adalah lebih rendah dari 2 kecu ali bagi U dan Th yang menunjukkan adanya pencemaran akibat dari aktiviti antrapogenik atau dari tabii. Nilai BAC p ula menunjukkan bahawa Zn dan Hg berkumpul didalam sawi hijau bergantung kepada dimana ianya ditanam*.

Katakunci: Faktor Pengkayaan, Pendarflour Sinar-X, pencemaran logam, Cameron Highlands

INTRODUCTION

Titiwangsa main-range is the longest row act as the backbone of Peninsular Malaysia. It is started from the Thailand-Malaysia border in the north part till the south of Negeri Sembilan. The Cameron Highlands is located on this Titiwangsa main-range, having the area commonly known as the tourism highlands destination because of its temperature between 19°C to 21°C. The climate here is suitable for growing vegetables and Cameron Highlands is known to be the main producers of vegetables of the country. The farmers here grow vegetables based on the market demand, including green mustard (*Brasissca rapa var. Parachinesis L.)* which is being consumed by most people. Therefore, there is a need to study the metals and radionuclides uptake by this popular vegetable since the nature of the farmland being heavily loaded with fertilizers and pesticides, despite that the whole area is geologically sitting on the red-yellow podzollic soil with acidic to intermediate igneous rocks (Malaysian Soil Map, 1970). All of these factors can contribute to the accumulation of some metals including radionuclides in vegetables through bio accumulation process from the natural source and the anthropogenic activities.

The study of metals contamination in vegetables is becoming popular recently due to the health risk effect to the public (Santos *et al*. 2002; Devagi Kanakaraju, *et al* 2007; Shtangeeva, 2010). The cultivated soil is one of the crucial factors that may cause contamination to the plant. The metals contaminants in the study area need to be determined and it will give the pattern of the contamination (Dragovis *et al*. 2008). The important factor is the soil enrichment factor (EF), where the iron (Fe) concentration in the soil calculated against the iron concentration from the area that has no anthropogenic activity used as a crust, for the interest elements. Equation for the EF is as follows;

$$EF_M = ([M]/[Fe])_{soil} / ([M]/[Fe]_{crust}) \quad (1)$$

where,

[M] = any elements concentration

[Fe] = Fe concentration

Another factor, the Biological Accumulation Coefficient (BAC) is a measure of the uptake of the metals contamination from the soil into the plant (Maiti and Nandhini, 2006; Li, *et. al*. 2007; Sahibin, *et.al*. 2007). The BAC can be calculated by simply dividing the concentration of metal in plants with the concentration of metals in soil.

The objectives of this study are to determine the concentration of the metals contamination in the samples, to evaluate the uptake of the metals contamination from the soils to the various parts of *Brasissca rapa var. Parachinesis L*.

METHOD

Sample Collection

Green mustards and soils samples were collected from 3 different farmlands namely Kg. Raja (N 4° 35.691', E 101° 22.214'), Bharat Tea Plantation (N 4° 26.997', E 101° 21.923') and Bertam (N 4° 24.500', E 101° 26.248') located in Cameron Highlands in the State of Pahang. The random and judgemental sampling strategy was applied to obtain representative samples regardless of the size of each farm. Green mustard samples including its roots were collected around 5 kg (wet weight) from each sampling point in each farm. Soil samples were collected for 15 cm depth using hand auger, from various points in each farm and kept in label plastic bags. The control soil sample was collected from Parit Fall reserve forest (N 4° 28.508', E 101° 23.041'), since there is no anthropogenic activity in this area.

Sample Preparation

Green mustard was washed properly and separated into 3 parts i.e. leaves, stems, and roots before it was cut into small pieces. Then the samples were dried at 60°C in the oven to avoid the losses of volatile compound such as mercury and polonium at the higher temperature (Zaini *et al*., 1985). Dried samples were ground and sieved using 300 μm mesh sieve. Same technique was applied to the soil. The homogeneous samples were sealed inside the tight container before analysis to avoid from the absorption of moisture from the air.

Sample Measurement

The concentration of metals was determined using the MiniPal4 XRF instrument with high-resolution Si drift detector. The resolution for the instrument use is 145 kV with energy resolution at 5.9 keV with the 2048 multi-channel analyzer.

Before measurement, 2.5 grams of sample was weighed and compress by using FLUXANA compressor into the pallet. The matrix of the samples supposed to be same because XRF technique has the matrix dependence (Sieber, 2002*).*

RESULTS AND DISCUSSIONS

The metals concentrations in various parts of *Brasissca rapa var. Parachinesis L* and soil from the study area are presented in Table 1. Concentration of Fe is the highest among all, but the soil content is still lower than the control soil. In general, *Brasissca rapa var. Parachinesis L,* shows the highest concentration of Fe in root in the range of 765.87 to 1948.86 µg/g. The stem contains Fe in the range between 20.11 and 76.80 µg/g, while leaves show the concentration range between 89.01 and 269.85 µg/g. This result agrees with Vivek Singh and Garg (2004) finding where Fe is the essential element need by the vegetables. The presence of Fe is important since it involved in the redox reaction where it can be found in Fe^{2+} and Fe^{3+} forms. The mechanism takes place in the root of the plant (Sahibin *et.al*. 2007; Garrido *et al*. 2006; Gasim *et al*. 2007). The Fe concentrations in the soils show the range between 3251.70 and 4337.20 µg/g. However, the Fe concentration for the control sample is higher than the study area, which is 5018.73 µg/g. Fe is the elements with the highest concentration that have been determined consist in the soils in the world (Tarek Ammari *et.al.* 2006).

Table 1: Concentrations of Fe, Zn, Hg, U and Th (µg/g) measured in various parts of *Brasissca rapa var. Parachinesis L* and soils.

	Fe	Zn	Hg	U	Th
Control Soil	5018.73	246.37	0.05	0.34	1.41
Bharat					
L	269.85	261.19	0.05	0.35	1.47
S	76.80	251.27	0.03	0.38	1.66
R	1948.86	258.45	0.05	0.61	2.57
T	3251.70	249.71	0.02	0.81	3.76
Kg.Raja					
L	168.80	256.61	0.02	0.30	1.26
S	56.67	166.38	0.02	0.42	1.80
R	976.51	167.73	0.02	0.30	1.30
T	4337.20	253.10	0.03	0.45	2.10
Bertam					
L	89.01	264.05	0.02	0.25	1.11
S	20.11	250.79	0.02	0.37	1.60
R	765.88	256.41	0.02	0.47	2.06
T	4100.93	246.34	0.03	0.84	3.55

Note: L is leave, S is stem, R is root and T is soil.

Green Mustard from Bharat shows Hg concentration higher than the soil, while the other two locations are lower than the soil content. Overall, Hg shows low concentration range between 0.02 and 0.05 µg/g in the various parts of the green mustard and in soil, since it exist naturally in soil at low concentration. Therefore Hg is taken up by green mustard and distributed evenly throughout. The measured Hg concentrations in green mustard are lower than 0.05 µg/g as being set as allowable limit in the Malaysian Food Acts, 1983.

There are three elements i.e. Zn, U and Th have their concentrations in soil higher than control soil. This could be due to some anthropogenic activities carried out on the farmland. Zinc can be found naturally in the environment and is one of the essential elements that enhance the vegetables to growth. It is common to find Zn concentration higher in the leaf than other part of the plants, because it is needed by the vegetables for the formation of the auxin which is essential hormone of the leaf which helps the biosynthesis process of cytochrome. Cytochrome is important to maintain the leaves cuticles and the plasma integrity of the leaves itself (Nagole *et.al*. 2009). The concentration of Zn shows it is distributed evenly in all part of the green mustard with the concentration range from 256.61 to 264.05 µg/g.

The concentration range of U in the *Brasissca rapa var. Parachinesis L* is between 0.25 and 0.61 µg/g, while in the soil is between 0.45 and 0.84 µg/g. The concentration ranges of Th in green mustard and soil are between 1.11 and 2.57 µg/g and 2.10 and 3.76 µg/g, respectively. Both U and Th are taken up by green mustard with the highest concentration stay in its root. Both radionuclides exist naturally with the common ratio for Th/U in soil of about 3. The main source of

U usually from the soils originated from the evolution of earth and universe (Shtangeeva, 2008). The concentration of Th is a bit higher because the Th is the natural isotopes that also being produced in the Uranium decay series (Chibowski, 2000).

Enrichment factor (EF) was calculated to determine the deposition of metal in the green mustard from the study area and listed in Table 2. Hg has EF value less than 1 for all locations, while Zn is in the range of 1.224 to 1.579 µg/g. The enrichment factor values for U and Th are in between 1.532 and 3.677 and 1.732 and 4.178 µg/g, respectively. Increasing of EF values and the soil is having higher elemental concentration then the control indicate an increasing of contamination from anthropogenic activity. Moreover, the origin of the soil in the study area is from red-yellow podzollic soil with acidic to intermediate igneous rocks which naturally consist of U and Th.

Table 2: Enrichment Factor in Soil

	Zn	Hg	U	Th
Bharat	1.543	0.579	3.677	4.178
Kg.Raja	1.189	0.584	1.532	1.732
Bertam	1.224	0.619	3.028	3.093

Table 3: Biological Accumulation Coefficient

	Fe	Zn	Hg	U	Th
Bharat					
L	0.083	1.046	2.907	0.430	0.391
S	0.024	1.006	1.640	0.469	0.442
R	0.599	1.035	2.520	0.750	0.684
Kg.Raja					
L	0.039	1.014	0.923	0.667	0.600
S	0.013	0.657	0.827	0.925	0.857
R	0.225	0.663	0.904	0.670	0.621
Bertam					
L	0.022	1.072	0.692	0.301	0.312
S	0.005	1.018	0.692	0.439	0.450
R	0.187	1.041	0.769	0.557	0.580

Note: L is leave, S is stem, R is root and T is soil.

Table 3 shows the BAC values for each part of the green mustard from three different locations. Only Zn and Hg have the BAC values more than one that is an indication of accumulation of these elements in the various part of the plant. Green mustard from Bharat and Bertam show some accumulation of Zn in all part of it plant, but the samples from Kg. Raja only accumulate in its leaf. Similarly, green mustard from Bharat shows an accumulation of Hg in all part of the plant while samples from Kg Raja and Bertam is not. The rest of elements i.e. Fe, U and Th do not show any accumulation in the green mustard.

CONCLUSION

The heavy metals and radionuclides concentrations in plant samples can be determined by using XRF technique. The concentration of all elements in the soils is lower than their concentration in the control soil, except for Zn, U and Th. The concentration of all elements in Green Mustard is lower than their concentration in the soil where it was grown. The EF values in the *Brasissca rapa var. Parachinesis L* are lower than 2, except for U and Th having the EF values more than 2 indicating some degree of contamination due to anthropogenic activities or naturally origin. The BAC values show that Zn and Hg were accumulated in the green mustard, depending on where the plant grows.

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