หอสมุดกลาง สถาบันวิทยบริการ จุฬาลงกรณ์มหาวิทยาลัย

CHAPTER IV

RESULTS AND DISCUSSION

The percentage of cadmium nitrate tetrahydrate and lead nitrate in their analar grade reagents, used for the preparation of standard solutions, were determined by potentiometric titration with the disodium salt of ethylenediaminetetra - acetic acid and amperometric titration with potassium dichromate, and they were found to be 99.34 and 99.80, respectively.

4.1 Differential pulse anodic stripping voltammetric behaviors of Pb(II) ion, Cd(II) ion and their mixtures

The differential pulse anodic stripping voltammetric behaviors of Pb(II) ion and Cd(II) ion at a glassy carbon electrode (GCE) were studied in the following electrolytes : 0.1 M HCl, 1.0 M HCl, 3.0 M HCl, 6.0 M HCl, 0.1 M HNO_3, 1.0 M HNO_3, 0.1 M H_2SO_4, 1.0 M H_2SO_4, 0.1 M $HClO_4$ and 1.0 M $HClO_4$. The voltammograms and data are shown in Figures 6 and 7 and Table 4. The result demonstrated that HCl was the best electrolyte since it provided the highest peak current of Pb(II) ion and Cd(II)ion. In 0.1 M HCl, the peak current of Pb(II) ion and Cd(II) ion were higher than those in 1.0 M HCl. However, the higher acid concentration yielded a complete dissolution of the ash of vegetable. Thus, 1 M HCl was selected as a supporting electrolyte for the simultaneous analysis of lead and cadmium in vegetables.

In order to obtain the high sensitivity for determining Pb(II) ion and Cd(II) ion, a comparative study was made between GCE and MTFGCE.

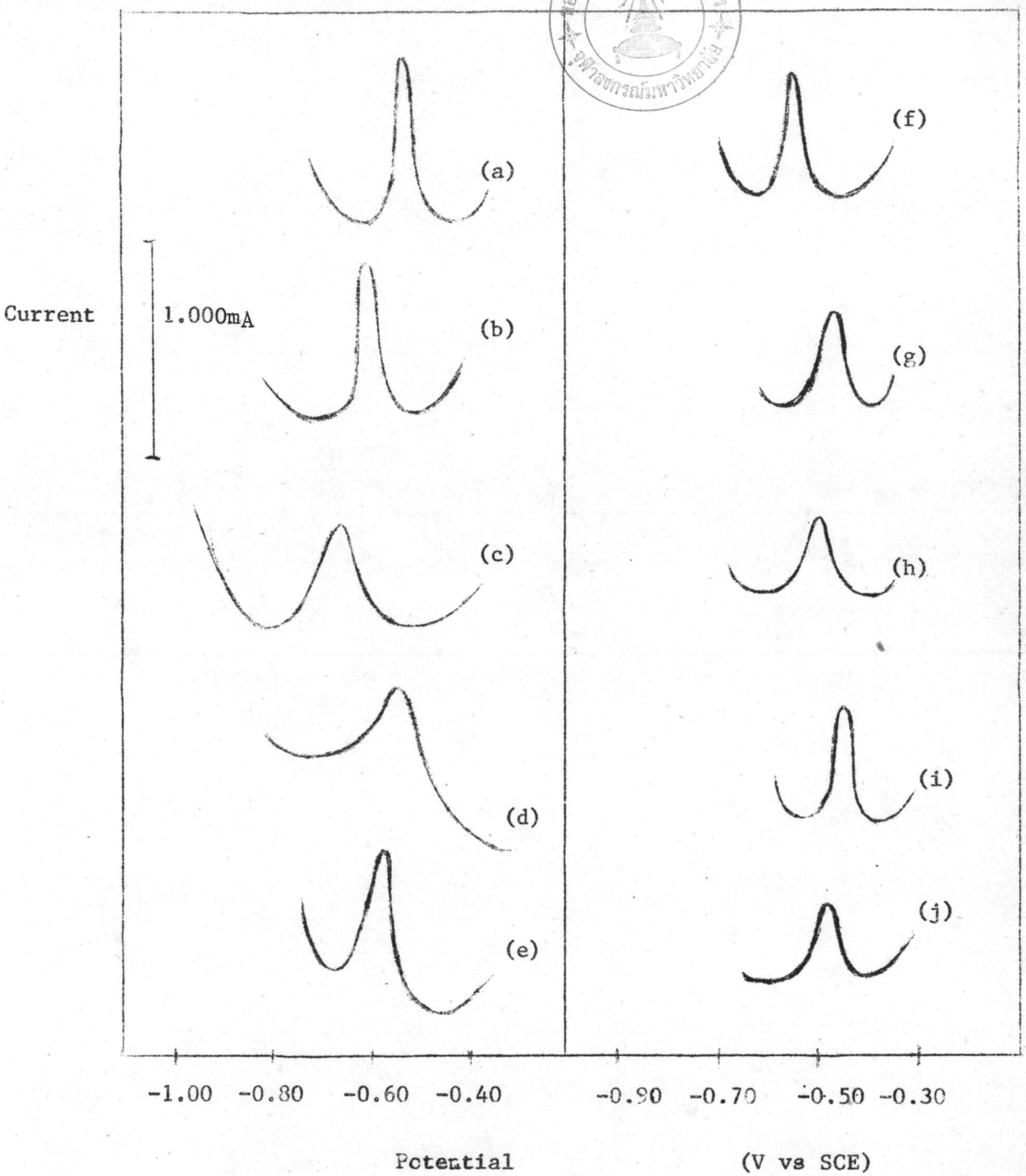

Figure 6. DPASV of 1.0 μg/cm^3 Pb(II) ion in (a) 0.1 M HCl (b) 1.0 M HCl (c) 3.0 M HCl (d) 6.0 M HCl (e) 0.1 M HNO_3 (f) 1.0 M HNO_3 (g) 0.1 H_2SO_4 (h) 1.0 H_2SO_4 (i) 0.1 M $HClO_4$ (j) 1.0 M $HClO_4$

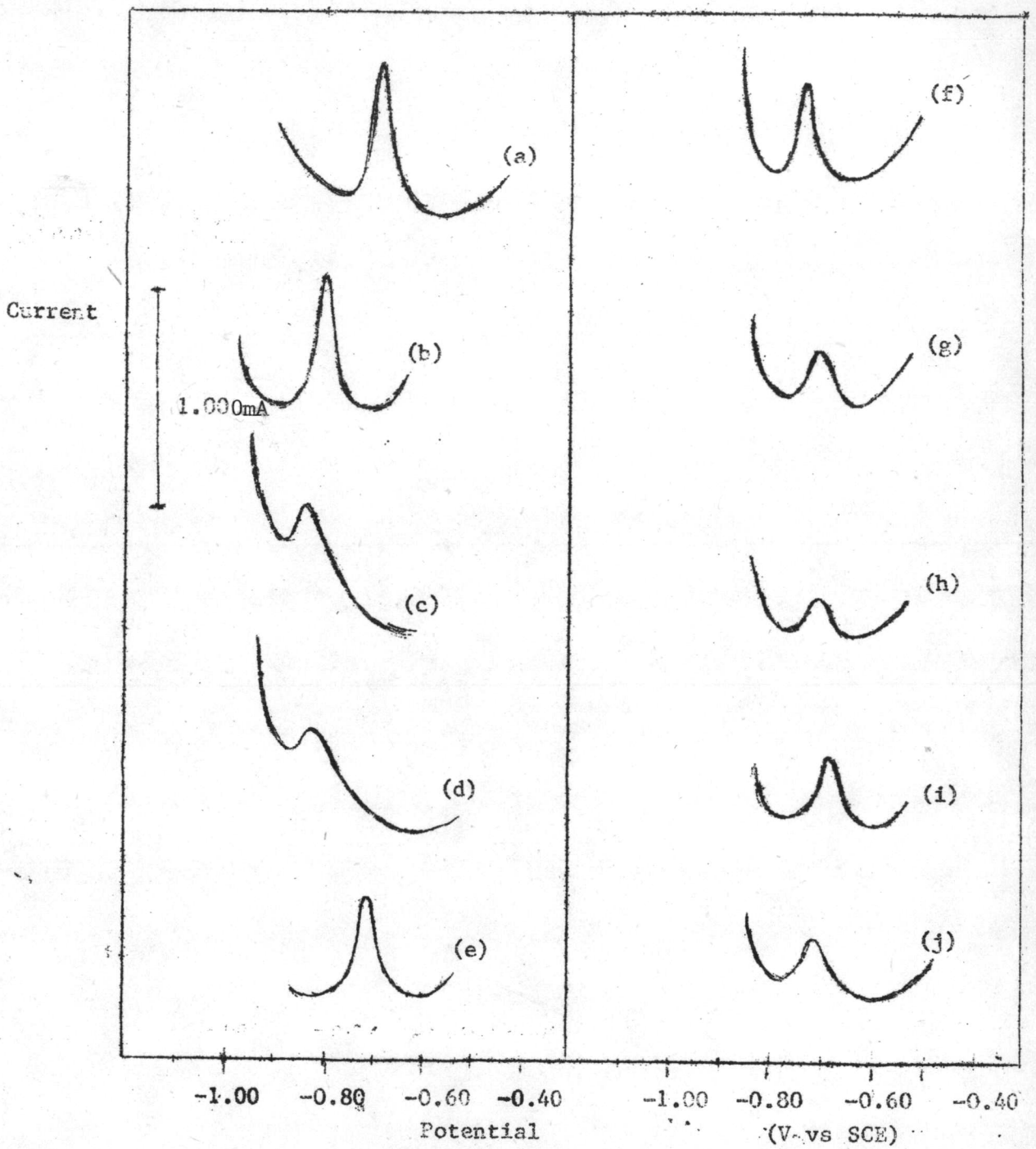

Figure 7 DPASV of 1.0 $\mu g/cm^3$ Cd(II) ion in (a) 0.1 M HCl (b) 1.0 M HCl (c) 3.0 M HCl (d) 6.0 M HCl (e) 0.1 M HNO_3 (f) 1.0 M HNO_3 (g) 0.1 M H_2SO_4 (h) 1.0 M H_2SO_4 (i) 0.1 M $HClO_4$ (j) 1.0 M $HClO_4$

Table 4 DPASV data of 1.0 $\mu g/cm^3$ of Pb(II) ion and 1.0 $\mu g/cm^3$ of Cd(II)ion in some supporting electrolytes

Supporting Electrolyte	Pb(II) ion		Cd(II) ion	
	E_p(V)	i_p^* (mA)	E_p(V)	i_p^* (mA)
0.1 M HCl	-0.52	0.822±0.040	-0.74	0.682±0.070
1.0 M HCl	-0.56	0.784±0.060	-0.80	0.654±0.052
3.0 M HCl	-0.62	0.472±0.050	-0.84	0.378±0.040
6.0 M HCl	-0.54	0.411±0.028	-0.85	0.326±0.060
0.1 M HNO_3	-0.52	0.715±0.042	-0.74	0.504±0.045
1.0 M HNO_3	-0.54	0.623±0.015	-0.76	0.420±0.010
0.1 M H_2SO_4	-0.48	0.424±0.060	-0.74	0.228±0.034
1.0 M H_2SO_4	-0.50	0.323±0.020	-0.76	0.142±0.022
0.1 M $HClO_4$	-0.46	0.444±0.010	-0.72	0.263±0.006
1.0 M $HClO_4$	-0.48	0.362±0.080	-0.74	0.184±0.006

* average peak current ± mean deviation of 3 trials

E_p = peak potential

It resulted that MTFGCE provided the higher peak current of both Pb(II) ion and Cd(II) ion (see Table 5). Thus, the selected working electrode in this study was a mercury thin film on glassy carbon electrode (MTFGCE).

The simultaneous analysis of Pb(II) ion and Cd(II) ion in the concentration range of 1.0-500.0 ng/cm^3 in 1.0 M HCl was studied. Data and the plot for this investigation are illustrated in Table 6 and Figures 8 and 9. The differential pulse anodic stripping peak current of each species in the mixtures was directly proportional to its concentration.

4.2 Analysis of vegetable samples

In this study, 56 vegetable samples of 14 different species from four different sources were investigated. Vegetables analyzed are listed in Table 7. They were purchased from three different markets in Bangkok metropolis, namely Bang Plad market, Tae Vait market and Sam Yan market and one garden located in Taling Chan. For each analysis, 10 g of the dry and ground sample were used and a final volume of 100.00 cm^3 sample solution in 1.0 M HCl was prepared. In order to minimize the influence of the variation of the concentrations of the interferences presented in different vegetable samples on the accuracy of results, the vegetable samples had all been analyzed by the method of standard addition. All vegetable samples collected for this study were in the consuming stage. The DPASV analysis of 10.00 cm^3 aliquot sample was carried out. The procedure for preparation and determination were mentioned in 3.3.4 and 3.3.5, respectively. The results from DPASV analyses of lead and cadmium in various parts of vegetables by dry

Table 5 Comparison of the peak currents of Pb(II) ion and Cd(II) ion in 1.0 M HCl between using the GCE and the MTFGCE

Concentration (ng/cm^3)	i_p (mA)	
	GCE	MTFGCE
A) Pb(II)ion		
1.0	undetectable	0.008±0.001
5.0	0.002±0.001	0.012±0.002
10.0	0.005±0.001	0.016±0.002
50.0	0.052±0.010	0.062±0.010
100.0	0.098±0.015	0.136±0.020
500.0	0.460±0.024	0.516±0.030
B) Cd(II) ion		
1.0	undetectable	0.004±0.001
5.0	undetectable	0.011±0.002
10.0	0.005±0.001	0.022±0.004
50.0	0.006±0.003	0.046±0.008
100.0	0.026±0.008	0.089±0.010
500.0	0.332±0.024	0.490±0.016

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Table 6 DPASV data of the simultaneous determination of Pb(II) and Cd(II) ion in the mixtures of them

Mixture (ng/cm^3)		i_p (mA)	
conc.Pb(II)ion	conc. Cd(II)ion	Pb(II)ion	Cd(II)ion
(1) 500.0	400.0	0.514±0.036	0.397±0.016
(2) 400.0	300.0	0.424±0.040	0.306±0.020
(3) 300.0	100.0	0.312±0.020	0.092±0.012
(4) 200.0	50.0	0.178±0.003	0.048±0.010
(5) 100.0	30.0	0.112±0.010	0.029±0.008
(6) 50.0	10.0	0.049±0.002	0.016±0.004
(7) 30.0	1.0	0.037±0.002	0.006±0.003
(8) 10.0	500.0	0.018±0.001	0.498±0.024
(9) 1.0	200.0	0.009±0.002	0.184±0.008

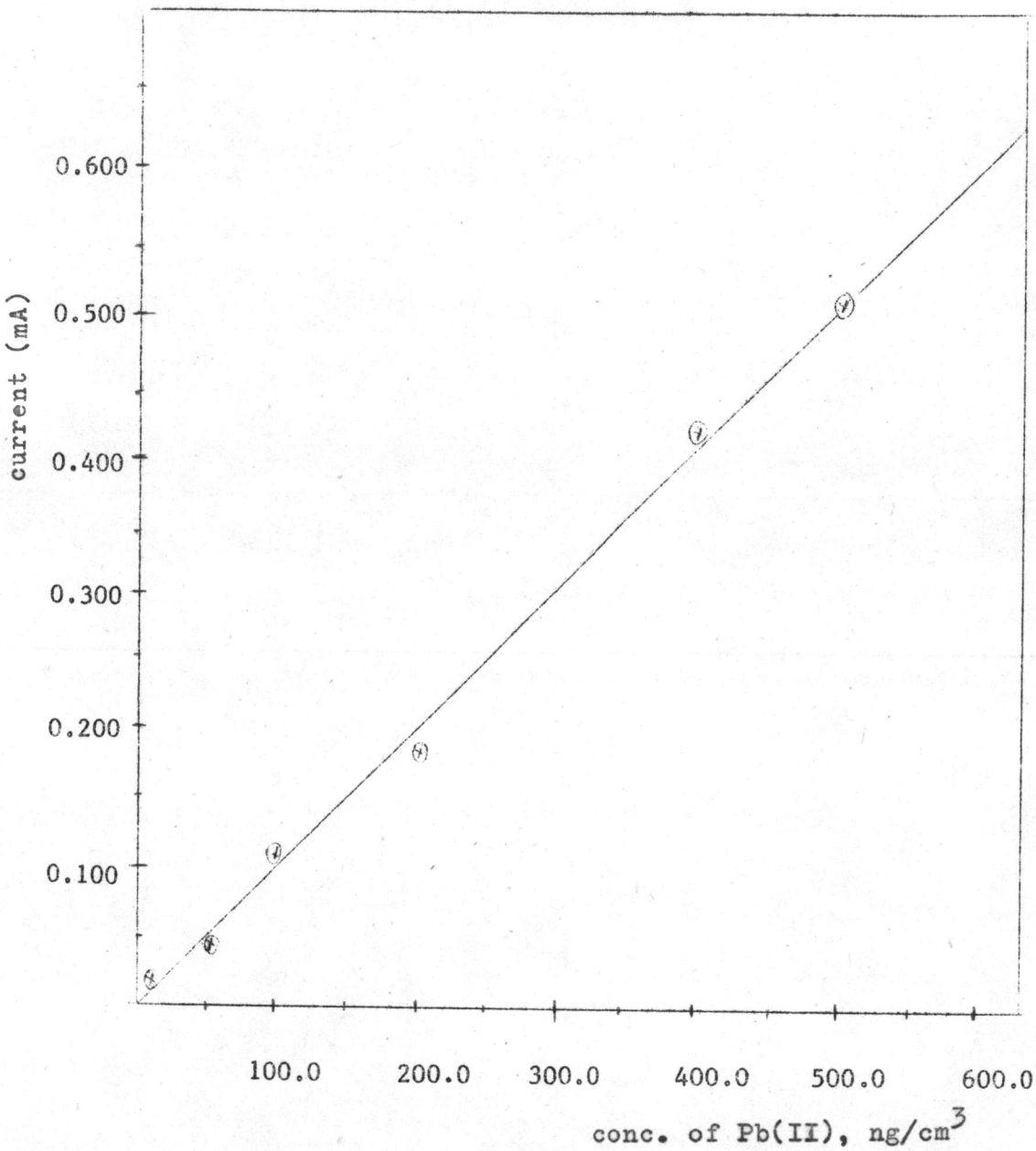

Figure 8. Linear dependence of peak currents on concentrations for DPASV analysis of Pb(II) in the Pb(II) - Cd(II) mixtures. The line was obtained from least square method.

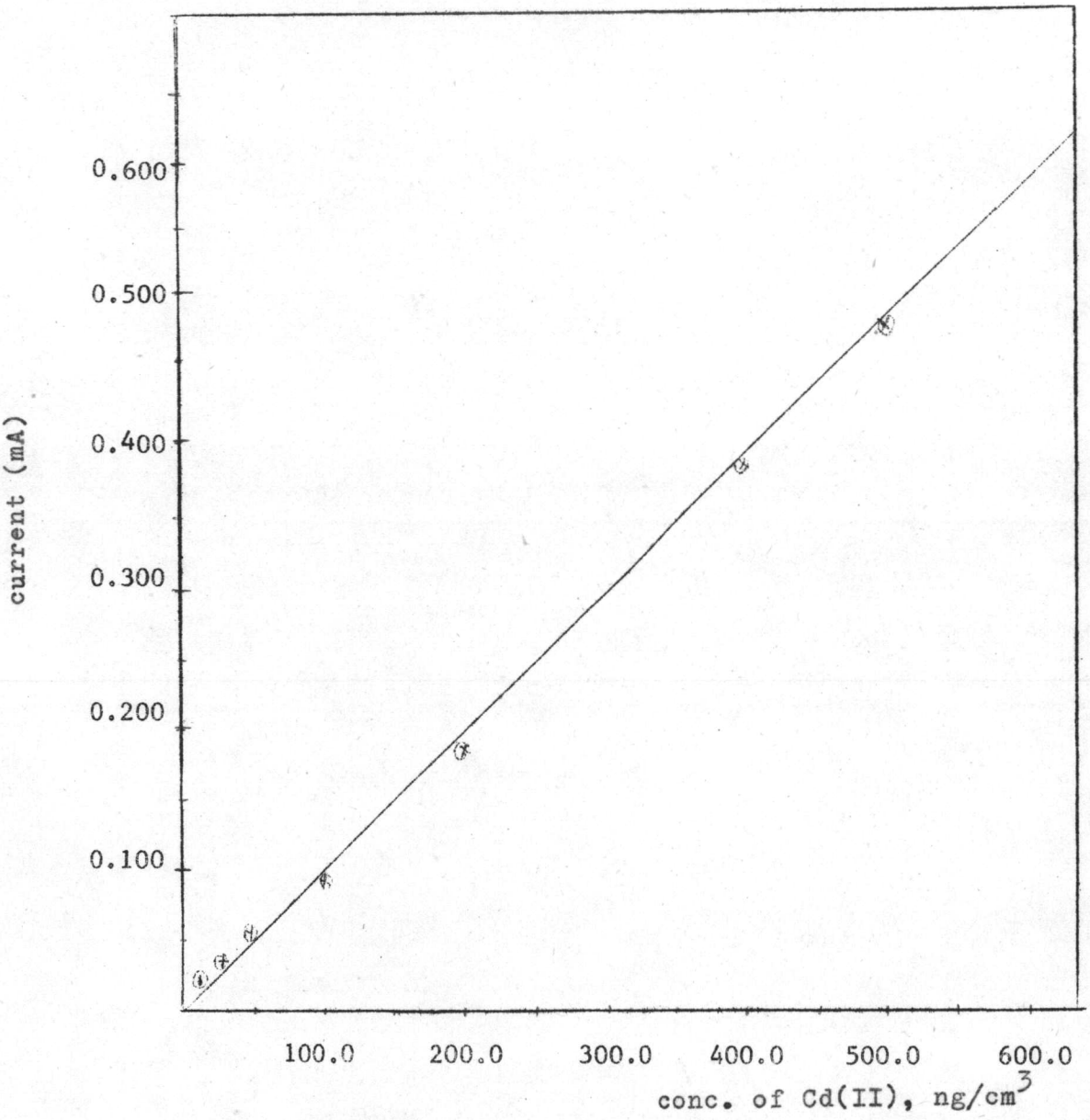

Figure. 9 Linear dependence of peak currents on concentrations for DPASV analysis of Cd(II) in the Pb(II) Cd(II) mixtures. The line was obtained from least square method.

Table 7 Vegetable crops analyzed

Scientific name	English name	Thai name
Family Alliaceae		
Allium ascalonicum Linn.	Multiplier onion	ต้นหอม
Allium tuberosum Roxb.	Chinese chives	กุยฉ่าย
Family Convolvulaceae		
Ipomoea aquatica Forsk.	Water convolvulus	ผักบุ้งไทย
	Chinese convolvulus	ผักบุ้งจีน
Family Cruciferae		
Brassica chinensis Jusl. var. parachinensis Tsen & Lee	Flowering white cabbage	ผักกวางตุ้ง(เขียว)
Brassica alboglabra Bail.	Chinese kale	ผักคะน้า
Brassica pekinensis Rupr. var. laxa Tsen & Lee	Celery cabbage	ผักกาดขาว
Brassica oleracea var. botrytis Linn.	Cauliflower	กะหล่ำดอก
Family Cucurbitaceae		
Cucumis sativus Linn.	Cucumber	แตงกวา
Family Mimosaceae		
Neptunia oleracea Lour.	Water mimosa	ผักกะเฉด
Family Papilionaceae		
Vigna sinensis	Long bean	ถั่วฝักยาว

Table 7 (continued)

Scientific name	English name	Thai name
Family Solanaceae		
Solanum melongena Linn	Egg plant	มะเขือยาว
Family Umbelliferae		
Apium graveolens Linn.	Celery	คื่นฉ่าย
Coriandrum sativum Linn.	Coriander	ผักชี

ashing method are listed in Tables 8-15. The dry basis data were calculated from dry weights of vegetable samples after being dried overnight in an electric oven to remove water content. Data on the fresh basis were obtained by calculation with respect to the weights of fresh vegetables after being washed with tap water and the double deionized water, and being left in open air to evaporate the adsorbed water on their surfaces.

In cases where the peak current was measured to be none, no addition of standard lead and cadmium solutions was performed.

The lead contents in various parts of vegetables from four different sources are shown in Tables 8-11. Lead was found in every vegetable species studied and also in every part of the vegetable. From Bang Plad market, the highest lead content in one gram of the dry vegetable, 11.14 µg Pb/g, was found in the stem of Chinese convolvulus and the lowest lead content, 0.79 µg Pb/g, was found in the leaf of coriander. On the fresh basis, the stem of coriander contained 0.74 µg Pb/g which was the highest amount and the stem of multiplier onion contained the lowest amount, 0.08 µg Pb/g.

Maximum lead content in various parts of vegetables from Tae Vait market was found in the stem of water convolvulus, both on the dry basis (18.64 µg Pb/g) and the fresh basis (1.43 µg Pb/g). Minimum lead contents were found in the stem of cauliflower on the dry basis (0.41 µg/g) and the leaf of celery on the fresh basis (0.02 µg Pb/g)

Among the analyzed vegetables from Sam Yan market, the stem of Chinese convolvulus contained the highest lead amount both on the dry

Table 8 Data of DPASV analysis of lead in various parts of vegetables purchased from Bang Plad market

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Chinese kale					
- leaf	0.056±0.005	0.176±0.010	1.98	0.86±0.04	0.12±0.02
- stem	0.023±0.004	0.099±0.008	2.97	0.84±0.02	0.10±0.02
Flowering white cabbage					
- leaf	0.132±0.014	0.281±0.012	5.93	4.43±0.20	0.62±0.05
- stem	0.110±0.008	0.204±0.009	2.97	3.12±0.04	0.13±0.02
Celery cabbage					
- leaf	0.163±0.020	0.311±0.016	4.95	5.05±0.10	0.40±0.08
- stem	0.271±0.006	0.532±0.008	9.89	8.94±0.10	0.37±0.03
Cauliflower					
- leaf	0.069±0.006	0.133±0.010	2.97	3.37±0.06	0.32±0.05
- stem	0.033±0.005	0.074±0.008	1.98	1.99±0.04	0.19±0.03
- flower	0.028±0.004	0.123±0.012	2.97	0.93±0.05	0.09±0.02
Chinese convolvulus					
- leaf	0.118±0.007	0.243±0.010	3.96	3.60±0.02	0.37±0.03
- stem	0.327±0.006	0.636±0.021	10.88	11.14±0.28	0.55±0.16

Table 8 (continued)

Vegetable sample	i_1^*(mA)	i_2^*(mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegatable sample
Water convolvulus					
- leaf	0.173±0.011	0.418±0.009	3.96	2.78±0.03	0.44±0.04
- stem	0.541±0.014	0.823±0.008	4.95	8.61±0.05	0.60±0.04
Water mimosa					
- leaf	0.058±0.005	0.102±0.016	0.99	1.34±0.04	0.28±0.02
- stem	0.052±0.004	0.009±0.006	1.98	1.41±0.02	0.18±0.03
Coriander					
- leaf	0.072±0.007	0.150±0.010	0.99	0.79±0.04	0.14±0.02
- stem	0.112±0.016	0.154±0.008	1.98	5.52±0.10	0.74±0.08
Multiplier onion					
- leaf	0.054±0.009	0.104±0.014	1.98	1.52±0.03	0.19±0.03
- stem	0.048±0.011	0.126±0.007	0.99	0.86±0.02	0.08±0.01
Celery					
- leaf	0.092±0.013	0.204±0.010	1.98	1.73±0.05	0.18±0.03
- stem	0.168±0.008	0.362±0.020	6.92	5.62±0.10	0.31±0.02

Table 8 (continued)

Vegetable sample	i_1^* (mA)	i_2 (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Chinese chives					
- leaf	0.073±0.008	0.159±0.010	2.97	2.15±0.07	0.20±0.04
Cucumber					
- fruit	0.262±0.003	0.658±0.008	4.95	2.86±0.03	0.11±0.02
Egg plant					
- fruit	0.081±0.008	0.164±0.010	1.98	1.94±0.03	0.10±0.02
Long bean					
- fruit	0.042±0.006	0.112±0.011	1.98	1.10±0.02	0.11±0.03

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the sample and the standard Pb(II) ion added

Table 9 Data of DPASV analysis of lead in various parts of vegetables purchased from Tae Vait market

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Chinese kale					
- leaf	0.084±0.020	0.192±0.013	2.97	2.23±0.07	0.25±0.03
- stem	0.071±0.011	0.143±0.008	3.96	3.62±0.05	0.21±0.04
Flowering white cabbage					
- leaf	0.058±0.008	0.118±0.008	1.98	2.28±0.04	0.33±0.04
- stem	0.132±0.013	0.228±0.014	4.95	2.29±0.03	0.16±0.02
Celery cabbage					
- leaf	0.346±0.008	0.622±0.024	10.88	11.43±0.11	0.82±0.02
- stem	0.430±0.016	0.668±0.018	9.89	14.48±0.16	0.68±0.04
Cauliflower					
- leaf	0.028±0.003	0.060±0.008	0.99	0.98±0.10	0.17±0.02
- stem	0.012±0.007	0.036±0.005	0.99	0.41±0.04	0.03±0
- flower	0.031±0.004	0.102±0.006	1.98	0.79±0.07	0.10±0.03
Chinese convolvulus					
- leaf	0.198±0.008	0.442±0.005	5.93	4.40±0.05	0.38±0.06
- stem	0.348±0.006	0.676±0.030	16.81	13.77±0.15	0.96±0.09
Water convolvulus					
- leaf	0.178±0.004	0.462±0.010	3.96	2.44±0.04	0.45±0.07
- stem	0.641±0.075	1.033±0.011	14.84	18.64±0.23	1.43±0.09

Table 9 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Water mimosa					
- leaf	0.062±0.009	0.123±0.005	0.99	0.89±0.04	0.22±0.02
- stem	0.043±0.003	0.104±0.007	0.99	0.63±0.03	0.07±0.01
Coriander					
- leaf	0.088±0.006	0.152±0.008	0.99	1.61±0.04	0.24±0.02
- stem	0.162±0.010	0.242±0.009	1.98	3.56±0.08	0.34±0.06
Multiplier onion					
- leaf	0.162±0.012	0.284±0.016	3.96	5.67±0.04	0.54±0.05
- stem	0.094±0.008	0.153±0.009	0.99	1.36±0.03	0.08±0.02
Celery					
- leaf	0.011±0.002	0.071±0.003	0.99	1.28±0.05	0.02±0.01
- stem	0.122±0.006	0.242±0.008	3.96	3.86±0.07	0.27±0.04
Chinese chives					
- leaf	0.149±0.005	0.253±0.010	1.98	3.08±0.03	0.23±0.02
Cucumber	0.241±0.010	0.684±0.007	4.95	2.43±0.04	0.09±0.02
- fruit	0.24±0.010	0.684±0.007	4.95	2.43±0.04	0.09±0.02
Egg plant					
- fruit	0.023±0.001	0.103±0.006	1.98	0.47±0.02	0.04±0

Table 9 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/of the fresh vegetable sample
Long bean - fruit	0.05±0.003	0.118±0.009	2.95	1.94±0.05	0.20±0.05

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the sample and the standard Pb(II) ion added

Table 10 Data for DPASV analysis of lead in various parts of vegetables purchased from Sam Yan market

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Chinese kale					
- leaf	0.093±0.016	0.154±0.012	3.96	5.43±0.02	0.70±0.08
- stem	0.153±0.010	0.278±0.008	4.95	5.52±0.03	0.30±0.06
Flowering white cabbage					
- leaf	0.061±0.004	0.103±0.008	1.98	2.71±0.02	0.32±0.02
- stem	0.152±0.006	0.338±0.010	4.95	3.60±0.03	0.15±0.01
Celery cabbage					
- leaf	0.118±0.006	0.203±0.016	2.97	3.91±0.01	0.27±0.01
- stem	0.232±0.014	0.430±0.025	9.89	9.95±0.03	0.47±0.03
Cauliflower					
- leaf	0.062±0.002	0.162±0.005	2.97	1.64±0.02	0.20±0.02
- stem	0.034±0.004	0.054±0.006	0.99	1.82±0.03	0.21±0.01
- flower	0.028±0.003	0.123±0.004	2.97	1.11±0.02	0.12±0.02
Chinese convolvulus					
- leaf	0.162±0.018	0.341±0.010	4.95	4.07±0.06	0.37±0.02
- stem	0.689±0.027	1.203±0.013	19.78	18.76±0.18	0.91±0.04

Table 10 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Water convolvulus					
- leaf	0.124±0.008	0.281±0.016	2.97	2.16±0.06	0.36±0.05
- stem	0.463±0.032	0.784±0.026	5.93	7.69±0.08	0.59±0.07
Water mimosa					
- leaf	0.072±0.004	0.128±0.020	0.99	1.03±0.03	0.20±0.02
- stem	0.121±0.012	0.169±0.011	1.98	3.96±0.05	0.53±0.04
Coriander					
- leaf	0.102±0.008	0.223±0.014	0.99	0.84±0.04	0.15±0.02
- stem	0.348±0.011	0.542±0.016	2.97	5.38±0.05	0.53±0.03
Multiplier onion					
- leaf	0.081±0.006	0.204±0.003	2.97	2.14±0.04	0.24±0.02
- stem	0.029±0.005	0.008±0.005	1.98	1.47±0.03	0.09±0.02
Celery					
- leaf	0.078±0.008	0.182±0.010	2.97	2.57±0.04	0.27±0.03
- stem	0.207±0.004	0.373±0.018	6.00	7.91±0.07	0.37±0.03

Table 10 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Chinese chives					
- leaf	0.122±0.006	0.178±0.010	1.98	3.59±0.04	0.31±0.03
Cucumber					
- fruit	0.269±0.014	0.644±0.023	4.95	3.28±0.05	0.12±0.02
Egg plant					
- fruit	0.011±0.001	0.062±0.009	0.99	0.21±0.01	0.02±0
Long bean					
- fruit	0.018±0.002	0.072±0.008	1.98	0.93±0.02	0.11±0.02

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the sample and the standard Pb(II) ion added

Table 11 Data of DPASV analysis of lead in various parts of vegetables grown at Taling Chan garden

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/f of the fresh vegetable sample
Chinese kale					
- leaf	0.110±0.008	0.192±0.013	3.96	4.87±0.03	0.81±0.04
- stem	0.113±0.012	0.255±0.024	6.92	5.03±0.04	0.38±0.02
Flowering white cabbage					
- leaf	0.104±0.012	0.311±0.008	5.93	2.39±0.02	0.20±0.02
- stem	0.128±0.018	0.271±0.021	5.93	4.99±0.03	0.19±0.02
Celery cabbage					
- leaf	0.115±0.010	0.206±0.005	2.97	3.54±0.02	0.21±0.03
- stem	0.361±0.016	0.704±0.015	9.89	8.78±0.05	0.32±0.03
Cauliflower					
- leaf	0.068±0.004	0.118±0.011	2.97	4.09±0.04	0.56±0.02
- stem	0.101±0.010	0.232±0.013	3.96	2.84±0.02	0.23±0.04
- flower	0.064±0.006	0.114±0.009	2.97	3.53±0.02	0.37±0.06

Table 11 (continued)

Vegetable sample	i_1^* (m_A)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Chinese convolvulus					
- leaf	0.112±0.008	0.238±0.020	3.96	3.10±0.05	0.36±0.02
- stem	0.313±0.016	0.602±0.023	10.88	9.61±0.04	0.60±0.07
Water convolvulus					
- leaf	0.308±0.009	0.498±0.014	4.95	2.79±0.03	0.040±0.04
- stem	0.564±0.017	0.833±0.021	5.93	11.09±0.05	0.85±0.03
Water mimosa					
- leaf	0.032±0.004	0.102±0.006	0.99	0.52±0.03	0.09±0.01
- stem	0.049±0.003	0.128±0.010	0.99	0.63±0.07	0.05±0.01
Coriander					
- leaf	0.062±0.003	0.121±0.012	1.98	2.36±0.04	0.31±0.04
- stem	0.311±0.011	0.444±0.019	2.97	6.81±0.12	0.48±0.07
Multiplier onion					
- leaf	0.089±0.007	0.153±0.016	2.97	3.73±0.06	0.37±0.03
- stem	0.062±0.003	0.101±0.009	1.98	2.66±0.05	0.15±0.02

Table 11 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Pb/cm^3 added	Average of lead content found	
				µg/g of the dry vegetable sample	µg/g of the fresh vegetable sample
Chinese chives					
- leaf	0.18±0.012	0.29±0.017	1.98	2.89±0.05	0.29±0.03
Cucumber					
- fruit	0.303±0.017	0.732±0.032	5.93	3.79±0.04	0.14±0.06
Egg plant					
- fruit	0.059±0.006	0.14±0.009	1.98	1.45±0.04	0.10±0.03
Long bean					
- fruit	0.028±0.002	0.113±0.008	1.98	0.82±0.02	0.09±0.01

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the sample and the standard Pb(II) ion added

Table 12 Data of DPASV analysis of cadmium in various parts of vegetables purchased from Bang Plad market

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Chinese kale					
- leaf	none	(a)	(a)	none	none
- stem	0.001±0.001	0.002±0.001	0.20	0.19±0.03	21.86±0.40
Flowering white cabbage					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
Celery cabbage					
- leaf	none	(a)	(a)	none	none
- stem	0.001±0	0.004±0.001	0.20	0.07±0.02	2.65±0.10
Cauliflower					
- leaf	0.004±0.002	0.008±0.002	0.30	0.23±0.05	26.56±0.20
- stem	0.002±0.001	0.004±0.001	0.20	0.19±0.03	18.14±0.18
- flower	0.002±0.001	0.008±0.003	0.30	0.10±0.02	8.66±0.32

Table 12 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Chinese convolvulus					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
Water convolvulus					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
Water mimosa					
- leaf	none	(a)	(a)	none	none
- stem	0.001±0	0.007±0.002	0.20	0.03±0.01	3.82±0.02
Coriander					
- leaf	none	(a)	(a)	none	none
- stem	0.004±0.001	0.009±0.002	0.20	0.16±0.02	21.58±0.60
Multiplier onion					
- leaf	0.005±0.002	0.013±0.003	0.20	0.12±0.02	14.95±0.36
- stem	none	(a)	(a)	none	none

Table 12 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Celery					
- leaf	none	(a)	(a)	none	none
- stem	0.001±0	0.005±0.001	0.71	0.16±0.06	8.74±0.32
Chinese chives					
- leaf	0.001±0	0.005±0.002	0.30	0.08±0.02	6.85±0.21
Cucumber					
- fruit	none	(a)	(a)	none	none
Egg plant					
- fruit	0.001±0	0.008±0.002	0.41	0.06±0.02	2.82±0.08
Long bean					
- fruit	none	(a)	(a)	none	none

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the sample and the standard Cd(II) ion added

(a) = the standard addition was not performed

Table 13 Data of DPASV analysis of cadmium in various parts of vegetables purchased from Tae Vait market

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Chinese kale					
- leaf	none	(a)	(a)	none	none
- stem	0.001±0	0.005±0.002	0.41	0.10±0.02	5.87±0.16
Flowering white cabbage					
- leaf	none	(a)	(a)	none	none
- stem	0.002±0.001	0.008±0.003	0.51	0.16±0.03	9.06±0.23
Celery cabbage					
- leaf	0.002±0.001	0.005±0.002	0.20	0.37±0.04	26.57±0.36
- stem	0.003±0.001	0.006±0.002	0.20	0.19±0.02	8.95±0.08
Cauliflower					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
- flower	none	(a)	(a)	none	none

Table 13 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Chinese convolvulus					
- leaf	0.001±0	0.002±0.001	0.10	0.10±0.02	8.57±0.20
- stem	0.002±0	0.003±0.001	0.30	0.04±0.01	1.86±0.12
Water convolvulus					
- leaf	0.001±0	0.003±0.001	0.20	0.05±0.01	9.09±0.12
- stem	0.001±0.001	0.005±0.002	0.52	0.12±0.03	9.28±0.08
Water mimosa					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
Coriander					
- leaf	none	(a)	(a)	none	none
- stem	0.003±0.001	0.012±0.002	0.20	0.06±0.02	5.96±0.12
Multiplier onion					
- leaf	0.004±0.002	0.013±0.003	0.41	0.18±0.04	17.33±0.24
- stem	none	(a)	(a)	none	none
Celery					
- leaf	none	(a)	(a)	none	none
- stem	0.003±0.001	0.009±0.002	0.41	0.17±0.08	11.99±0.21
Chinese Chives					
- leaf	0.001±0	0.005±0.001	0.20	0.04±0.02	3.26±0.15

Table 13 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Cucumber - fruit	0.001±0.001	0.008±0.003	0.61	0.09±0.04	3.32±0.11
Egg plant - fruit	0.001±0	0.004±0.002	0.20	0.06±0.02	5.49±0.26
Long bean - fruit	none	(a)	(a)	none	none

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the standard Cd(II) ion added

(a) = the standard addition was not performed

Table 14 Data of DPASV analysis of cadmium in various parts of vegetables purchased from Sam Yan market

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of fresh vegetable sample
Chinese kale					
- leaf	0.002±0.001	0.006±0.002	0.30	0.15±0.03	20.49±0.11
- stem	0.005±0.001	0.010±0.002	0.51	0.47±0.04	53.25±0.53
Flowering white cabbage					
- leaf	0.002±0.001	0.009±0.002	0.20	0.05±0.02	6.39±0.08
- stem	0.004±0.601	0.013±0.00	0.51	0.20±0.03	8.45±0.26
Celery cabbage					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
Cauliflower					
- leaf	0.002±0.001	0.008±0.002	0.30	0.10±0.02	12.47±0.31
- stem	none	(a)	(a)	none	none
- flower	0.001± 0	0.009±0.002	0.30	0.03±0.02	3.27±0.22
Chinese convolvulus					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none

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Table 14 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of fresh vegetable sample
Water convolvulus					
- leaf	none	(a)	(a)	none	none
- stem	0.001± 0	0.009±0.002	0.30	0.03±0.01	2.23±0.16
Water mimosa					
- leaf	none	(a)	(a)	none	none
- stem	0.001±0.001	0.009±0.003	0.20	0.03±0.02	4.04±0.10
Coriander					
- leaf	none	(a)	(a)	none	none
- stem	0.001 ± 0	0.003±0.001	0.30	0.12±0.03	11.60±0.72
Multiplier onion					
- leaf	0.004±0.002	0.011±0.003	0.30	0.16±0.04	17.36±0.24
- stem	0.003± 0	0.007±0.002	0.20	0.15±0.03	8.66±0.10
Celery					
- leaf	0.001± 0	0.005±0.002	0.30	0.08±0.02	8.12±0.18
- stem	0.007±0.002	0.013±0.004	1.12	0.94±0.06	44.26±0.27

Table 14 (continued)

Vegetable sample	i_1^* (mA)	i_2 (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Chinese chives - leaf	0.002±0.002	0.007±0.003	0.20	0.08±0.02	6.52±0.14
Cucumber - fruit	none	(a)	(a)	none	none
Egg plant - fruit	none	(a)	(a)	none	none
Long bean - fruit	none	(a)	(a)	none	none

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the sample and the standard Cd(II) ion added

(a) = the standard addition was not performed

Table 15 Data of DPASV analysis of cadmium in various parts of vegetables grown at Taling Chan garden

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Chinese kale					
- leaf	none	(a)	(a)	none	none
- stem	0.002±0.001	0.006±0.003	0.41	0.19±0.04	14.38±0.27
Flowering white cabbage					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
Celery cabbage					
- leaf	0.001±0	0.003±0.001	0.20	0.09±0.03	5.25±0.07
- stem	0.002±0	0.006±0.002	0.20	0.10±0.02	3.58±0.10
Cauliflower					
- leaf	0.003±0.001	0.010±0.002	0.30	0.13±0.03	17.97±0.42
- stem	0.002±0	0.009±0.002	0.41	0.12±0.01	9.28±0.08
- flower	0.002±0.001	0.008±0.00	0.30	0.10±0.02	10.70±0.30
Chinese convolvulus					
- leaf	none	(a)	(a)	none	none
- stem	0.001±0	0.002±0.001	0.20	0.01±0.01	0.77±0.06

Table 15 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Water convolvulus					
- leaf	0.001± 0	0.004±0.001	0.30	0.33±0.03	4.69±0.11
- stem	0.001± 0	0.006±0.002	0.61	0.12±0.04	9.19±0.06
Water mimosa					
- leaf	none	(a)	(a)	none	none
- stem	none	(a)	(a)	none	none
Coriander					
- leaf	0.002±0.001	0.006±0.002	0.20	0.11±0.03	11.38±0.16
- stem	0.001±0	0.003±0.002	0.30	0.15±0.02	10.01±0.11
Multiplier onion					
- leaf	0.001±0	0.006±0.001	0.30	0.06±0.02	7.66±0.21
- stem	0.001±0.001	0.010±0.002	0.20	0.02±0.01	0.89±0.10
Celery					
- leaf	none	(a)	(a)	none	none
- stem	0.001± 0	0.005±0.002	0.41	0.10±0.02	5.17±0.13
Chinese chives					
- leaf	none	(a)	(a)	none	none
Cucumber					
- fruit	0.001±0	0.015±0.003	0.61	0.05±0.02	1.67±0.09

Table 15 (continued)

Vegetable sample	i_1^* (mA)	i_2^* (mA)	µg Cd/cm^3 added	Average of cadmium content found	
				µg/g of the dry vegetable sample	µg/kg of the fresh vegetable sample
Egg plant - fruit	0.002±0.001	0.007±0.001	0.20	0.07±0.02	4.80±0.18
Long bean - fruit	none	(a)	(a)	none	none

* average peak current ± average deviation of 3 trials

i_1 = peak current of the sample

i_2 = peak current of the sample and the standard Cd(II) ion added

(a) = the standard addition was not performed

basis (18.76 µg Pb/g) and the fresh basis (0.91 µg Pb/g). Egg plant was found to contain minimum lead content both on the dry basis (0.21 µg Pb/g) and the fresh basis (0.02 µg Pb/g).

From Taling Chan garden, the maximum lead content was found in the stem of Chinese convolvulus both on the dry basis (11.09 µg Pb/g) and the fresh basis (0.85 µg Pb/g). The leaf and stem of water mimosa contained 0.52 µg Pb/g and 0.05 µg Pb/g which were the lowest lead amounts on the dry basis and the fresh basis, respectively.

The cadmium contents in various parts of vegetables in this study are shown in Tables 12-15.

The ranges of cadmium contents in various parts of vegetables purchased from Bang Plad market were found to be none - 0.23 µg Cd/g on the dry basis and none - 26.56 µg Cd/kg on the fresh basis. The maximum cadmium content was found in the leaf of cauliflower both on the dry basis (0.23 µg Cd/g) and the fresh basis (26.56 µg Cd/kg). The leaf of Chinese kale, the leaf and the stem of flowering white cabbage, the leaf of celery cabbage, the leaf and the stem of Chinese convolvulus, the leaf and the stem of water convolvulus, the leaf of water mimosa, the leaf of coriander, the stem of multiplier onion, the leaf of celery, cucumber, and long bean, were found to contain no cadmium.

Among vegetables purchased from Tae Vait market, the ranges of cadmium contents in various parts of vegetables were found to be none - 0.37 µg Cd/g on the dry basis and none - 26.57 µg Cd/kg the fresh basis. The maximum cadmium content was found in the leaf of

celery cabbage both on the dry basis (0.37 µg Cd/g) and the fresh basis (26.57 µg Cd/kg). No cadmium was found in the leaf of Chinese kale, the leaf of flowering white cabbage, the leaf, the stem and the flower of cauliflower, the leaf and the stem of water mimosa, the leaf of coriander, the stem of multiplier onion, the leaf of celery and long bean.

The highest amounts of cadmium found in vegetables from Sam Yan market were the stem of celery, 0.94 µg Cd/g on the dry basis and the stem of Chinese kale, 53.25 µg Cd/kg on the fresh basis. The ranges of cadmium contents in various parts of vegetables were found to be none - 0.94 µg Cd/g on the dry basis and none - 53.25 µg Cd/kg on the fresh basis. The leaf and the stem of celery cabbage, the stem of water convolvulus, the leaf of water mimosa, the leaf of coriander, cucumber, egg plant and long bean were found to contain no cadmium.

From Taling Chan garden, the ranges of cadmium contents in various parts of vegetables were found to be none- 0.33 µg Cd/g on the dry basis and none - 17.97 µg Cd/kg on the fresh basis. The maximum cadium contents were found in the leaf of water convolvulus, 0.33 µg Cd/g on the dry basis and the leaf of cauliflower, 17.97 µg Cd/kg on the fresh basis. No cadmium was found in the leaf of Chinese kale, the leaf and the stem of flowering white cabbage, the leaf of Chinese convolvulus, the leaf and the stem of water mimosa, the leaf of celery, Chinese chives and long bean.

The lead and cadmium contents in various parts of vegetables studied were compared in Tables 16-19. The following orders of lead and cadmium contents in each part of the vegetable studied were considered from the average value from four sources. The decreasing order of lead content in the stem of the vegetable on the dry basis was Chinese convolvulus, water convolvulus, celery cabbage, coriander, celery, Chinese kale, flowering white cabbage, cauliflower, multiplier onion and water mimosa. For the fresh basis, it was water convolvulus, Chinese convolvulus, coriander, celery cabbage, celery, Chinese kale, water mimosa, cauliflower, flowering white cabbage and multiplier onion. The decreasing order of lead content in the leaf of the vegetable on the dry basis was celery cabbage, Chinese convolvulus, Chinese kale, multiplier onion, flowering white cabbage, Chinese chives, water convolvulus, cauliflower, coriander and water mimosa. For the fresh basis, it was Chinese kale, celery cabbage, water convolvulus, Chinese convolvulus, flowering white cabbage, multiplier onion, celery, cauliflower, Chinese chives, coriander and water mimosa. In addition, the decreasing order of lead content in the fruit of the vegetable on the dry basis was cucumber, long bean and egg plant. For the fresh basis it was long bean, cucumber and egg plant.

The decreasing order of cadmium content in the stem of the vegetable on the dry basis was celery, Chinese kale, coriander, flowering white cabbage, celery cabbage, cauliflower, water convolvulus, multiplier onion, water mimosa and Chinese convolvulus. For the fresh basis it was Chinese kale, celery, coriander, cauliflower,

Table 16 Comparison of lead contents in the dry vegetable samples

Vegetable sample	lead content*, µg/g of the dry vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden	Average
Chinese kale					
- leaf	0.86±0.04	2.23±0.07	5.43±0.02	4.87±0.03	3.35±0.04
- stem	0.84±0.02	3.62±0.05	5.52±0.03	5.03±0.04	3.75±0.04
- leaf + stem	0.85±0.03	2.93±0.06	5.48±0.03	4.95±0.04	3.55±0.04
Flowering white cabbage					
- leaf	4.43±0.20	2.28±0.04	2.71±0.02	2.39±0.02	2.95±0.07
- stem	3.12±0.04	2.29±0.03	3.60±0.03	4.99±0.03	3.50±0.03
- leaf + stem	3.78±0.12	2.29±0.04	3.16±0.03	3.69±0.03	3.23±0.05
Celery cabbage					
- leaf	5.05±0.10	11.43±0.11	3.91±0.01	3.54±0.02	5.98±0.06
- stem	8.94±0.10	14.48±0.16	9.95±0.03	8.78±0.05	10.54±0.09
- leaf + stem	6.70±0.10	12.96±0.14	6.93±0.02	6.16±0.04	8.26±0.08
Cauliflower					
- leaf	3.37±0.06	0.98±0.10	1.64±0.02	4.09±0.04	2.52±0.06
- stem	1.99±0.04	0.41±0.04	1.82±0.03	2.84±0.02	1.77±0.03
- flower	0.93±0.05	0.79±0.07	1.11±0.02	3.53±0.02	1.59±0.04
- leaf+stem+flower	2.10±0.05	0.73±0.07	1.52±0.02	3.49±0.03	2.08±0.04

Table 16 (continued)

Vegetable sample	lead content*, µg/g of the dry vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden	Average
Chinese convolvulus					
- leaf	3.60±0.02	4.40±0.05	4.07±0.06	3.10±0.05	3.79±0.05
- stem	11.14±0.28	13.77±0.15	18.76±0.18	9.61±0.04	13.32±0.16
- leaf + stem	7.37±0.15	9.09±0.10	11.42±0.12	6.36±0.05	8.56±0.11
Water convolvulus					
- leaf	2.78±0.03	2.44±0.04	2.16±0.06	2.79±0.03	2.54±0.04
- stem	8.61±0.05	18.64±0.23	7.69±0.08	11.09±0.05	11.51±0.10
- leaf + stem	5.70±0.04	10.54±0.14	4.93±0.07	6.94±0.04	7.03±0.07
Water mimosa					
- leaf	1.34±0.04	0.89±0.04	1.03±0.03	0.09±0.01	0.84±0.03
- stem	1.41±0.02	0.63±0.03	3.96±0.05	0.05±0.01	1.51±0.03
- leaf + stem	1.38±0.03	0.76±0.04	2.50±0.04	0.07±0.01	1.18±0.03
Coriander					
- leaf	0.79±0.04	1.61±0.04	0.84±0.04	2.36±0.04	1.40±0.04
- stem	5.52±0.10	3.56±0.08	5.38±0.05	6.81±0.12	5.32±0.09
- leaf + stem	3.16±0.07	2.59±0.06	3.11±0.05	4.59±0.08	3.36±0.07

Table 16 (continued)

Vegetable sample	lead content*, µg/g of the dry vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan market	Average
Multiplier onion					
- leaf	1.52±0.03	5.67±0.04	2.14±0.04	3.73±0.06	3.27±0.04
- stem	0.86±0.02	1.36±0.03	1.47±0.03	2.66±0.05	1.59±0.03
- leaf + stem	1.19±0.03	3.52±0.04	1.81±0.04	3.20±0.06	2.43±0.04
Celery					
- leaf	1.73±0.05	1.28±0.05	2.57±0.04	1.45±0.04	1.76±0.05
- stem	5.63±0.10	3.86±0.07	7.91±0.07	2.88±0.06	5.07±0.08
- leaf + stem	3.68±0.08	2.57±0.06	5.24±0.06	2.17±0.05	3.42±0.07
Chinese chives					
- leaf	2.15±0.07	3.08±0.03	3.59±0.04	2.89±0.05	2.93±0.05
Cucumber					
- fruit	2.86±0.03	2.54±0.04	3.28±0.05	3.79±0.04	3.09±0.04
Egg plant					
- fruit	1.93±0.03	0.47±0.02	0.21±0.01	1.45±0.04	1.02±0.03
Long bean					
- fruit	1.10±0.02	1.94±0.05	0.93±0.02	0.82±0.02	1.20±0.03

* average value ± mean deviation of 3 trials

Table 17 Comparison of lead contents in the fresh vegetable sample

Vegetable sample	lead content*, µg/g of the fresh vegetable sample				
	Bang Plad market	Tae Veit market	Sam Yan market	Taling Chan garden	Average
Chinese kale					
- leaf	0.12±0.02	0.25±0.03	0.70±0.08	0.81±0.04	0.47±0.04
- stem	0.10±0.02	0.21±0.04	0.30±0.06	0.38±0.02	0.25±0.05
- leaf + stem	0.11±0.02	0.23±0.04	0.50±0.07	0.60±0.03	0.36±0.05
Flowering white cabbage					
- leaf	0.62±0.05	0.33±0.04	0.32±0.02	0.20±0.02	0.37±0.03
- stem	0.13±0.02	0.16±0.02	0.15±0.01	0.17±0.02	0.16±0.02
- leaf + stem	0.38±0.04	0.25±0.03	0.24±0.02	0.20±0.02	0.27±0.03
Celery cabbage					
- leaf	0.40±0.08	0.82±0.02	0.27±0.01	0.21±0.03	0.43±0.04
- stem	0.37±0.03	0.68±0.04	0.47±0.03	0.32±0.03	0.46±0.04
- leaf + stem	0.39±0.06	0.75±0.03	0.37±0.02	0.27±0.03	0.45±0.04
Cauliflower					
- leaf	0.32±0.05	0.17±0.02	0.20±0.02	0.56±0.02	0.31±0.03
- stem	0.19±0.03	0.03±0	0.21±0.01	0.23±0.04	0.17±0.02
- flower	0.09±0.02	0.10±0.03	0.12±0.02	0.37±0.06	0.17±0.03
- leaf + stem + flower	0.20±0.03	0.10±0.02	0.18±0.02	0.39±0.03	0.22±0.03

Table 17 (continued)

Vegetable sample	lead content*, µg/g of the fresh vegetable sample				
	Bang Plad market	Tae Veit market	Sam Yan market	Taling Chan garden	Average
Chinese convolvulus					
- leaf	0.37±0.03	0.38±0.06	0.37±0.02	0.36±0.02	0.37±0.03
- stem	0.55±0.16	0.69±0.09	0.91±0.04	0.60±0.07	0.69±0.09
- leaf + stem	0.46±0.10	0.54±0.08	0.64±0.03	0.48±0.05	0.53±0.06
Water convolvulus					
- leaf	0.44±0.04	0.45±0.07	0.36±0.05	0.40±0.04	0.41±0.05
- stem	0.60±0.04	1.43±0.09	0.59±0.07	0.85±0.03	0.87±0.06
- leaf + stem	0.52±0.04	0.94±0.08	0.48±0.06	0.63±0.04	0.64±0.06
Water mimosa					
- leaf	0.28±0.02	0.22±0.02	0.20±0.02	0.09±0.01	0.20±0.02
- stem	0.18±0.03	0.07±0.01	0.53±0.04	0.05±0.01	0.21±0.02
- leaf + stem	0.23±0.03	0.15±0.02	0.37+0.03	0.07±0.01	0.21±0.02
Coriander					
- leaf	0.14±0.02	0.24±0.02	0.15±0.02	0.31±0.04	0.21±0.02
- stem	0.74±0.08	0.34±0.06	0.53±0.03	0.48±0.07	0.52±0.06
- leaf + stem	0.44±0.05	0.29±0.04	0.34±0.03	0.40±0.06	0.37±0.04
Multiplier onion					
- leaf	0.19±0.03	0.54±0.05	0.24±0.02	0.37±0.03	0.34±0.03
- stem	0.08±0.01	0.08±0.02	0.09±0.02	0.15±0.02	0.13±0.02
- leaf + stem	0.14±0.02	0.62±0.04	0.17±0.02	0.26±0.03	0.24±0.03

Table 17 (continued)

Vegetable sample	lead content*, µg/g of the fresh vegetable sample				
	Bang Plad market	Tae Veit market	Sam Yan market	Taling Chan garden	Average
Celery					
- leaf	0.18±0.03	0.02±0.01	0.27±0.03	0.14±0.02	0.31±0.02
- stem	0.31±0.02	0.27±0.04	0.37±0.03	0.14±0.03	0.27±0.03
- leaf + stem	0.25±0.03	0.15±0.03	0.32±0.03	0.14±0.03	0.29±0.02
Chinese chives					
- leaf	0.20±0.04	0.23±0.02	0.31±0.03	0.29±0.03	0.26±0.03
Cucumber					
- fruit	0.11±0.02	0.09±0.02	0.12±0.02	0.14±0.06	0.12±0.03
Egg plant					
- fruit	0.10±0.02	0.04±0	0.02±0	0.10±0.03	0.07±0.01
Long bean					
- fruit	0.11±0.03	0.20±0.05	0.11±0.02	0.09±0.01	0.13±0.03

* average value ± mean deviation of 3 trials

Table 18 Comparison of cadmium contents in the dry vegetable sample

Vegetable sample	cadmium content*, µg/g of the dry vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden	Average
Chinese kale					
- leaf	none	none	0.15±0.03	none	0.04±0.01
- stem	0.19±0.03	0.10±0.02	0.47±0.04	0.19±0.04	0.24±0.03
- leaf + stem	0.10±0.02	0.05±0.01	0.31±0.04	0.10±0.02	0.14±0.02
Flowering white cabbage					
- leaf	none	none	0.05±0.02	none	0.01±0.01
- stem	none	0.16±0.03	0.20±0.03	none	0.09±0.02
- leaf + stem	none	0.08±0.02	0.13±0.03	none	0.05±0.01
Celery cabbage					
- leaf	none	0.37±0.04	none	0.09±0.03	0.12±0.02
- stem	0.07±0.02	0.19±0.02	none	0.10±0.02	0.09±0.02
- leaf + stem	0.04±0.01	0.28±0.03	none	0.10±0.03	0.11±0.22
Cauliflower					
- leaf	0.23±0.05	none	0.10±0.02	0.13±0.03	0.12±0.03
- stem	0.19±0.03	none	none	0.12±0.01	0.08±0.01
- flower	0.10±0.02	none	0.03±0.02	0.10±0.02	0.06±0.02
- leaf + stem + flower	0.17±0.03	none	0.04±0.01	0.12±0.02	0.08±0.02

Table 18 (continued)

Vegetable sample	cadmium content*, µg/g of the dry vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden	Average
Chinese convolvulus					
- leaf	none	0.10±0.02	none	none	0.02±0.01
- stem	none	0.04±0.01	none	0.01±0.01	0.01±0.01
- leaf + stem	none	0.07±0.02	none	0.01±0.01	0.02±0.01
Water convolvulus					
- leaf	none	0.05±0.01	none	0.33±0.03	0.10±0.01
- stem	none	0.12±0.03	0.03±0.01	0.12±0.04	0.07±0.02
- leaf + stem	none	0.09±0.02	0.02±0.01	0.23±0.04	0.09±0.02
Water mimosa					
- leaf	none	none	none	none	none
- stem	0.03±0.01	none	0.03±0.02	none	0.02±0.01
- leaf + stem	0.02±0.01	none	0.02±0.01	none	0.01±0.01
Coriander					
- leaf	none	none	none	0.11±0.03	0.03±0.01
- stem	0.16±0.02	0.06±0.02	0.12±0.03	0.15±0.02	0.13±0.02
- leaf + stem	0.08±0.01	0.03±0.01	0.06±0.02	0.13±0.03	0.08±0.02
Multiplier onion					
- leaf	0.12±0.02	0.18±0.04	0.16±0.04	0.06±0.02	0.13±0.03
- stem	none	none	0.15±0.03	0.02±0.01	0.04±0.01
- leaf + stem	0.06±0.01	0.09±0.02	0.16±0.04	0.04±0.02	0.09±0.02

Table 18 (continued)

Vegetable sample	cadmium content*, µg/g of the dry vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan market	Average
Celery					
- leaf	none	none	0.08±0.02	none	0.02±0.01
- stem	0.16±0.06	0.17±0.08	0.94±0.06	0.10±0.02	0.34±0.06
- leaf + stem	0.08±0.03	0.09±0.04	0.51±0.04	0.05±0.01	0.18±0.04
Chinese chives					
- leaf	0.08±0.02	0.04±0.02	0.08±0.02	none	0.05±0.02
Cucumber					
- fruit	none	0.09±0.04	none	0.05±0.02	0.04±0.02
Egg plant					
- fruit	0.06±0.02	0.06±0.02	none	0.07±0.02	0.05±0.02
Long bean					
- fruit	none	none	none	none	none

* average value ± mean deviation of 3 trials

Table 19 Comparison of cadmium contents in the fresh vegetable samples

Vegetable sample	Cadmium content*, µg/kg of the fresh vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden	Average
Chinese kale					
- leaf	none	none	20.49±0.11	none	5.12±0.03
- stem	21.86±0.40	5.87±0.16	53.25±0.53	14.38±0.27	23.84±0.34
- leaf + stem	10.93±0.20	2.94±0.08	36.87±0.32	7.19±0.14	14.48±0.19
Flowering white cabbage					
- leaf	none	none	6.39±0.08	none	1.60±0.02
- stem	none	9.06±0.23	8.45±0.26	none	4.38±0.12
- leaf + stem	none	4.53±0.12	7.42±0.17	none	2.99±0.07
Celery cabbage					
- leaf	none	26.57±0.36	none	5.25±0.07	7.96±0.11
- stem	2.65±0.10	8.95±0.08	none	3.58±0.10	3.80±0.07
- leaf + stem	1.33±0.05	17.76±0.22	none	4.42±0.09	5.88±0.09
Cauliflower					
- leaf	26.56±0.20	none	12.47±0.31	17.97±0.42	14.25±0.23
- stem	18.14±0.18	none	none	9.28±0.08	6.86±0.07
- flower	8.66±0.32	none	3.27±0.22	10.70±0.30	5.66±0.21
- leaf + stem + flower	17.79±0.23	none	5.25±0.18	12.65±0.27	8.92±0.17

Table 19 (continued)

Vegetable sample	Cadmium content*, µg/kg of the fresh vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden	Average
Chinese convolvulus					
- leaf	none	8.57±0.20	none	none	2.14±0.05
- stem	none	1.86±0.12	none	0.77±0.06	0.66±0.05
- leaf + stem	none	5.22±0.16	none	0.39±0.03	1.40±0.05
Water convolvulus					
- leaf	none	9.09±0.12	none	4.69±0.11	3.45±0.06
- stem	none	9.28±0.08	2.23±0.16	9.19±0.06	5.18±0.08
- leaf + stem	none	9.19±0.10	1.12±0.08	6.94±0.09	4.32±0.07
Water mimosa					
- leaf	none	none	none	none	none
- stem	0.03±0.01	none	4.04±0.10	none	1.02±0.03
- leaf + stem	0.02±0.01	none	2.02±0.05	none	0.51±0.02
Coriander					
- leaf	none	none	none	11.38±0.16	2.85±0.04
- stem	21.58±0.60	5.96±0.12	11.60±0.72	10.51±0.11	12.41±0.39
- leaf + stem	10.79±0.30	2.98±0.06	5.80±0.36	10.90±0.14	7.63±0.22

Table 19 (continued)

Vegetable sample	cadmium content*, µg/kg of the fresh vegetable sample				
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan market	Average
Multiplier onion					
- leaf	14.95±0.36	17.35±0.24	17.36±0.24	7.66±0.21	14.33±0.26
- stem	none	none	8.66±0.10	0.89±0.10	2.39±0.05
- leaf + stem	7.48±0.18	8.68±0.12	13.01±0.17	4.28±0.16	8.36±0.16
Celery					
- leaf	none	none	8.12±0.18	none	2.03±0.05
- stem	8.74±0.32	11.99±0.21	44.26±0.27	5.17±0.13	17.54±0.23
- leaf + stem	4.37±0.16	6.00±0.11	26.19±0.23	2.59±0.07	9.79±0.14
Chinese chives					
- leaf	6.85±0.21	3.26±0.15	6.52±0.14	none	4.16±0.13
Cucumber					
- fruit	none	3.32±0.11	none	1.67±0.09	1.25±0.05
Egg plant					
- fruit	2.82±0.08	5.49±0.26	none	4.80±0.18	3.28±0.13
Long bean					
- fruit	none	none	none	none	none

* average value ± mean deviation of 3 trials

water convolvulus, flowering white cabbage, celery cabbage, multiplier onion, water mimosa and Chinese convolvulus. The decreasing order of cadmium content in the leaf of the vegetable on the dry basis was multiplier onion, celery cabbage, cauliflower, water convolvulus, Chinese chives, Chinese kale, coriander, Chinese convolvulus, celery, flowering white cabbage and water mimosa. For the fresh basis it was multiplier onion, cauliflower, celery cabbage, Chinese kale, Chinese chives, water convolvulus, coriander, Chinese convolvulus, celery, flowering white cabbage and water mimosa. The decreasing order of cadmium content in the fruit of the vegetable on the dry basis was egg plant, cucumber and long bean. For the fresh basis it was egg plant, cucumber and long bean.

It can be seen that the order of lead and cadmium contents in various parts of vegetables were different both on the dry basis and the fresh basis. The lead and cadmium contents were varied from species to species, from plant part to part and source to source. This was also notified by the conversion factor for the dry weight to the fresh weight of each species of vegetables which was not identical. Even for the same vegetable species, if the sources were different, its conversion factor was not the same. Conversion factors were obtained by dividing the fresh weight of the vegetable (after evaporating the surface adsorbed water) by its dry weight (see Table 20). Therefore, this factor could be used to imply the water content in the vegetable.

By comparing lead and cadmium contents in the various parts of vegetables analyzed, the decreasing order was the stem, the leaf and

Table 20 Conversion factors for the dry weight to the fresh weight of vegetables (g of fresh weight/g of dry weight)

Vegetable sample	Source			
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden
Cauliflower				
- leaf	10.51	5.99	8.26	7.35
- stem	10.41	12.27	8.65	12.50
- flower	11.78	7.84	9.18	9.63
Celery				
- leaf	9.43	6.49	9.35	10.52
- stem	18.07	14.35	21.33	20.12
Flowering white cabbage				
- leaf	7.16	6.90	8.40	11.78
- stem	23.34	17.63	23.72	25.81
Chinese chives	12.31	13.51	11.51	10.01
Chinese convolvulus				
- leaf	9.74	10.39	11.12	8.52
- stem	20.10	19.88	20.58	17.19

Table 20 (continued)

Vegetable Sample	Source			
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden
Chinese kale				
- leaf	7.21	8.80	7.76	5.96
- stem	8.82	17.54	18.65	13.07
Celery cabbage				
- leaf	12.53	13.97	14.49	17.15
- stem	24.39	21.44	21.32	27.59
Coriander				
- leaf	5.51	6.84	5.69	7.63
- stem	7.51	10.40	10.18	14.18
Cucumber	27.49	26.82	27.00	26.87
Egg plant	20.20	10.74	12.05	15.20
Multiplier onion				
- leaf	7.96	10.51	9.04	9.98
- stem	11.42	16.98	15.72	18.05

Table 20 (continued)

Vegetable sample	Source			
	Bang Plad market	Tae Vait market	Sam Yan market	Taling Chan garden
Water convolvulus				
- leaf	6.30	5.41	6.03	6.97
- stem	14.36	13.04	13.00	13.05
Water mimosa				
- leaf	4.87	4.09	5.18	5.86
- stem	7.86	8.55	7.42	11.93
Long bean	10.38	9.80	8.36	9.58

the fruit. This indicated that higher lead and cadmium contents were found in the stem than in the leaf and the fruit of the vegetable which corresponded to the literature.[62,63,64]

With a few exception that some vegetables analyzed contained higher lead and cadmium contents in the leaf than the stem such as flowering white cabbage, cauliflower, multiplier onion and celery cabbage. This might come from the surface contamination of leaves with lead and cadmium from the atmosphere, fertilizers and pesticides. However, there were some evidences that only a small fraction of lead and cadmium absorbed on the surface of leaves.[65]

The average values of lead and cadmium contents in all edible parts of the vegetable are also illustrated in Tables 16-19. Since man ingests all the edible parts of the vegetable not only leaf or stem or fruit, these average values can be used to estimate the intake of lead and cadmium in the vegetable if man takes the equal amount of every part of the vegetable.