CHAPTER 3

RESULTS AND DISCUSSION

In this study, the vegetables analyzed are Chinese kale, Chinese kale (young) , Chinese radish, Chinese white cabbage, coriander, cucumber, celery, leaf mustard, lettuce, chinese cabbage, multiplier onion, Chinese convolvulus, water convolvulus, and yard long bean. They were collected from four different gardens which are located in the following Tambons : Taling Chan, Prachathipat, Bangbautong and Saun Laung. Tambon Taling Chan is in Ampoe Taling Chan, Bangkok Metropolitan ; Tambon Prachathipat is in Ampoe Thanyaburi, Changwat Pathum Thani ; Tambon Bangbautong is in Ampoe Bangbautong, Changwat Nonthaburi ; and Tambon Saun Laung is in Ampoe Krathum Band, Changwat Samut Sakhon. These four gardens were selected for this study since the environment around them are different. The gardens at Taling Chan and Prachathipat are close to the roads but the traffic near Taling Chan garden is heavier. The garden at Bangbautong where it is among the farms is far away from the road, as well as the garden at Saun Laung where it is among gardens can be reached by vehicles.

Scientific names and Thai names of the vegetables analyzed are listed in Table 3. In order to minimize the influence of the variation of the concentrations of the interferences presented in different biological samples on the accuracy of results, the

Table 3 List of vegetables analyzed in scientific and Thai names

Scientific Name	English Name	Thai Name
Family Amaryllidaceae		
Allium cepa var. aggregatum Don.	Multiplier Onion	หอมแบ่ง
Family Compositae		
Lactuca sativa Linn.	Lettuce	ผักกาดหอม
Family Convolvulaceae		
Ipomoea reptans Poir.	Chinese Convolvulus	ผักบุ้งจีน
Ipomoea aquatica Forsk.	Water Convolvulus	ผักบุ้งไทย
Family Cruciferae		
Brassica chinensis Linn.	Chinese Cabbage	ผักกวางตุ้ง
Brassica juncea Cohh.	Leaf Mustard	ผักกาดเขียว
Brassica oleracea var. alboglabra Bail.	Chinese Kale	ผักคะน้า
Brassica chinensis Linn.	Chinese White Cabbage	ผักกาดขาว
Raphanus sativus Linn. var. Longipinnatus	Chinese Radish	หัวไช่เท้า (ผักกาดหัว)
Family Cucurbifaceae		
Cucumis sativus Linn.	Cucumber	แตงกวา
Family Leguminosae		
Vigna sesquipedalis Fruwirth.	Yard Long Bean	ถั่วฝักยาว

Table 3 (continued)

Scientific Name	English Name	Thai Name
Family Umbelliferae		
Apium graveolens Linn.	Celery	คื่นฉ่าย
Coriandrum sativum Linn.	Coriander	ผักชี

vegetable samples had all been analyzed by the method of standard addition. All vegetable samples collected for this study were in the consuming stage.

In trace analysis, the supporting electrolyte is necessarily added to prevent interferences and to eliminate the migration current, but it should be used in a small amount. The concentration of a supporting electrolyte is generally more than the determining ion about 100 times (59). If the concentration of the supporting electrolyte is high, the sensitivity will decrease (59). The supporting electrolyte also controls the diffusion process in the dissolution step of Pb(Hg), therefore, the choice of the supporting electrolyte is an important parameter (66). In this study, since the ash of the sample was dissolved in nitric acid, potassium nitrate was selected to be the supporting electrolyte and the sample solution was prepared in 0.02 M KNO_3.

The percentage of $Pb(NO_3)_2$ in the analar grade $Pb(NO_3)_2$ was found to be 99.99 by amperometric titration with a standard potassium dichromate solution.

Since the cathodic peak of Pb(II) ion in 0.02 M KNO_3 and 0.10 M HNO_3 solution at the HMDE showed at -0.45 V, the potential of -0.60 V was chosen for the deposition of Pb(II) ion. After a 20-minute electrodeposition at the HMDE, the anodic stripping voltammetry for Pb(II) ion was recorded. The cathodic and anodic stripping voltammograms are shown in Figure 1.

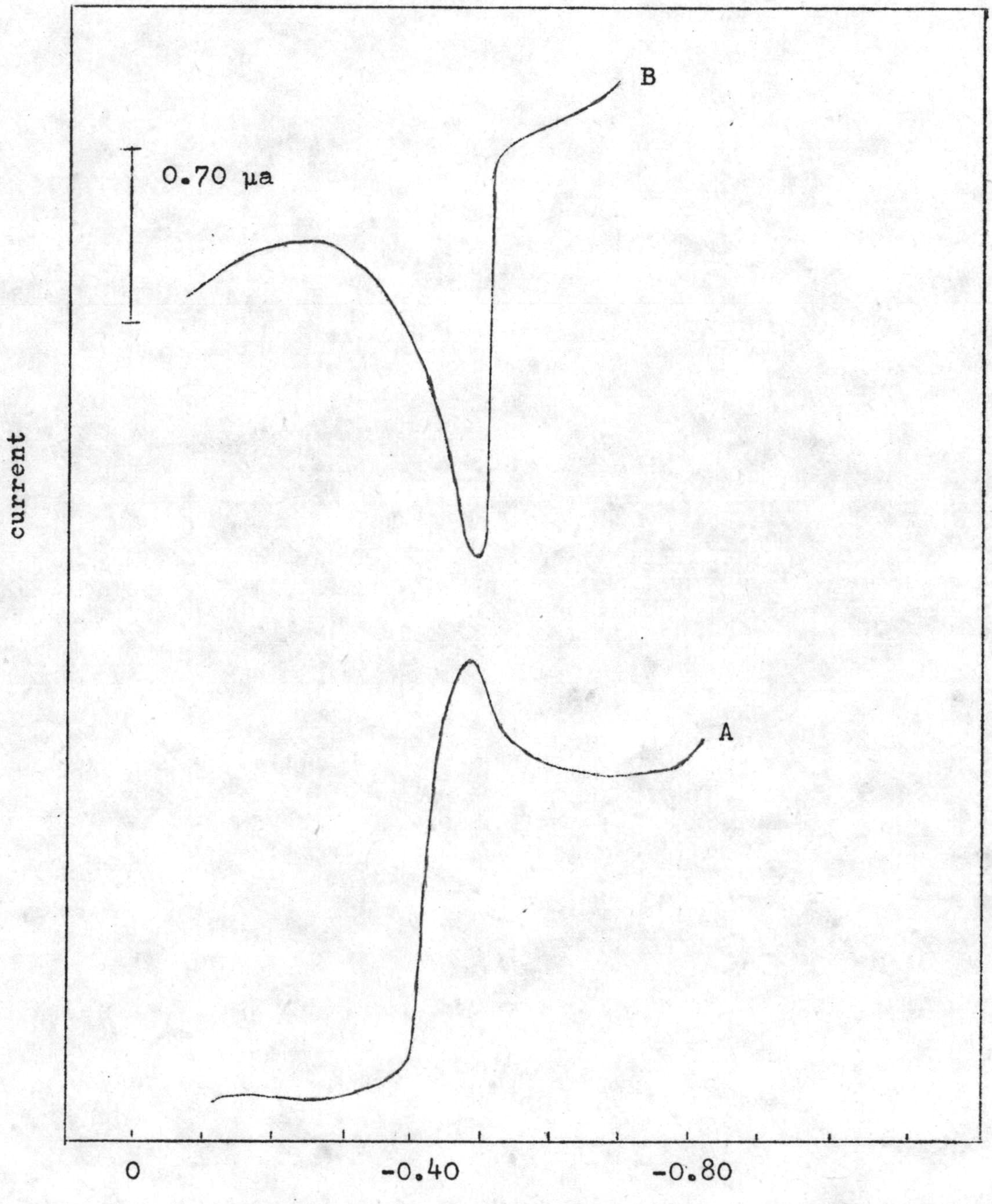

Figure 1 Cathodic voltammogram (A) and anodic stripping voltammogram (B) of Pb(II) ion in 0.02 M KNO_3 and 0.01 M HNO_3 solution, with the scan rate of 0.8 V/min.

A single anodic stripping peak of Pb(Hg) was obtained at -0.49 volt. The relationship between the anodic stripping peak currents for Pb(II) ion and the concentrations of the standard Pb(II) ion solutions in 0.02 M KNO_3 and 0.10 M HNO_3 was studied under the conditions mentioned. It was found that the anodic stripping peak currents for Pb(II)ion are directly proportional to the concentrations of Pb(II) ion solutions in the range of 9.99×10^{-8} M to 1.19×10^{-6}M. Data for this investigation and the plot of the anodic stripping peak current for Pb(II) ion and its concentration are illustrated in Table 4 and Figure 2, respectively. Therefore, the standard addition technique for analyzing lead in vegetable species was performed in this concentration range. The anodic stripping voltammograms of the solution from 82.70 g Chinese cabbage as well as the solution from 82.70 g Chinese cabbage with an addition of 0.050 cm^3 of 4.99×10^{-7}M Pb(II) ion are shown in Figure 3.

Results of the analyses of lead in various vegetable species grown at Taling Chan garden Prachathipat garden, Bangbautong garden and Saun Laung garden are listed in Tables 5,6,7 and 8, respectively. In this report, the weight of the fresh vegetable or the fresh weight is the weight of the green vegetable after removing soil, rinsing with tap water and drying at room temperature, as well as the ash weight is the weight of carbon-free ash of the vegetable. Codes represented the vegetable species are listed in Table 9.

Table 4 Conditions for the deposition of Pb(II) ion and data of anodic stripping analyses for Pb(II) ion at various concentrations in 0.02 M KNO_3 and 0.10 M HNO_3

Deposition		Concentration of Pb(II) ion	$i^*_{p,a}$
Potential(V)	Time(min)	(M)	(μa)
-0.60	20	1.19×10^{-6}	2.80 ± 0.11
		9.99×10^{-7}	2.26 ± 0.07
		8.99×10^{-7}	2.03 ± 0.02
		7.99×10^{-7}	1.80 ± 0.06
		6.99×10^{-7}	1.54 ± 0.03
		5.99×10^{-7}	1.33 ± 0.04
		4.99×10^{-7}	1.06 ± 0.04
		3.99×10^{-7}	0.81 ± 0.03
		2.99×10^{-7}	0.54 ± 0.02
		1.99×10^{-7}	0.30 ± 0.02
		9.99×10^{-8}	0.11 ± 0.01

*average anodic peak current ± mean deviation of more than 4 trials

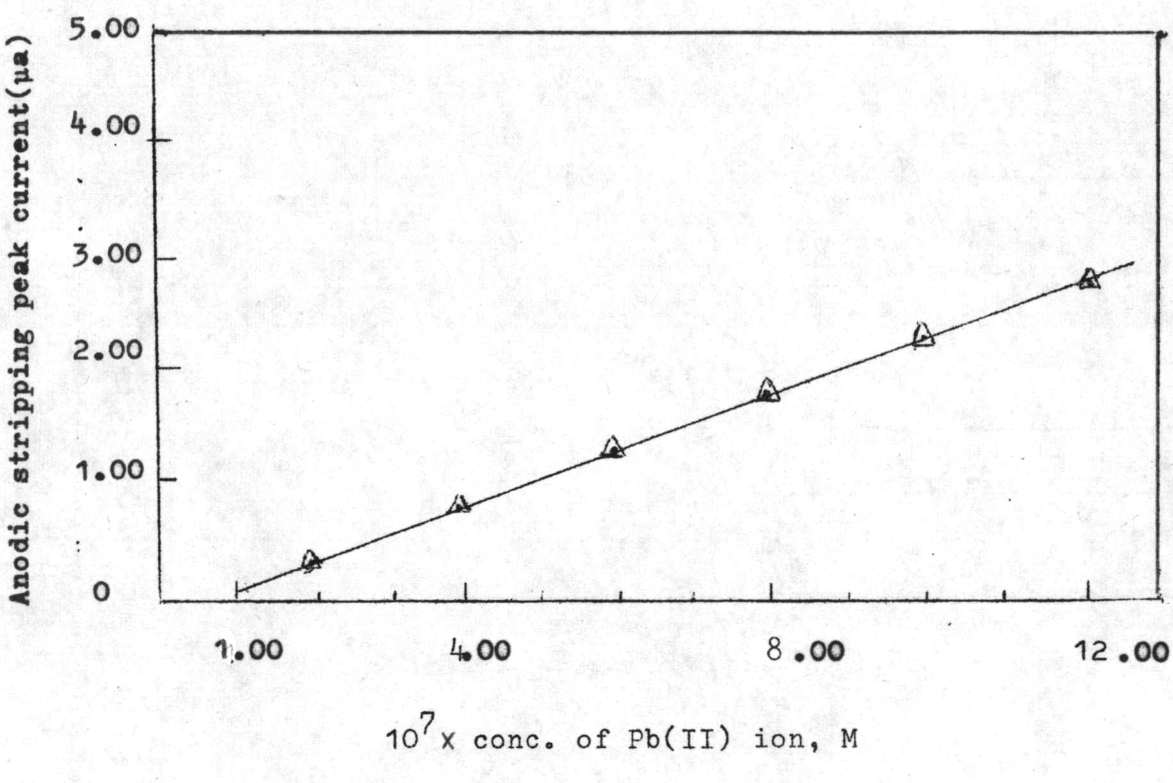

Figure 2 Linear dependence of anodic stripping peak currents on concentrations of Pb(II) ion using an electrodeposition time of 20 minutes at -0.60 V and the scan rate of 0.8 V/minute. The line drawn is the calculated least squares line.

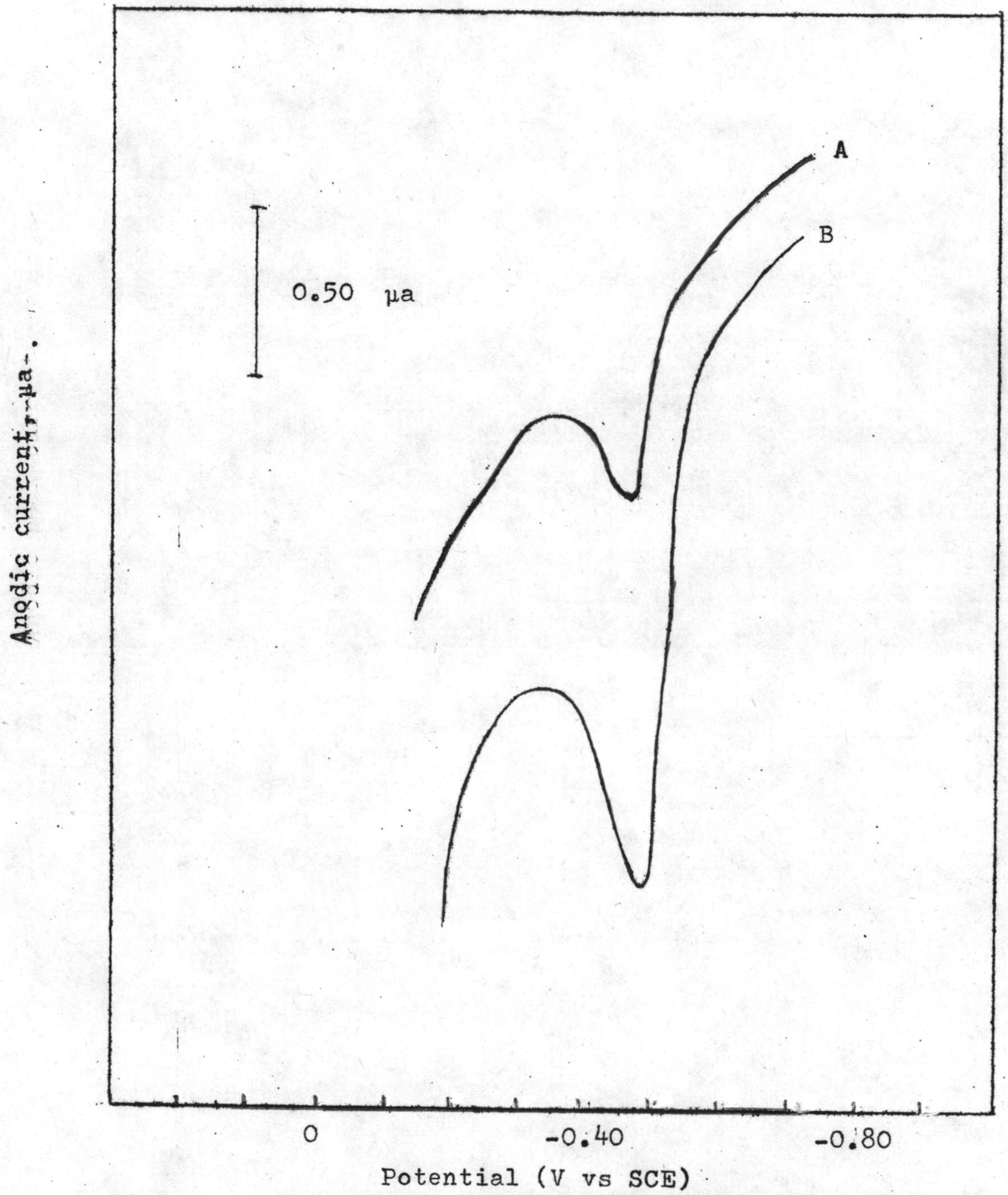

Figure 3 The anodic stripping voltammograms of (A) lead content in 82.70 g Chinesb cabbage and (B) lead content in 82.70 g Chinese cabbage with the addition of 0.050 cm^3 of 9.99×10^{-5}M Pb(II) ion, using a scan rate of 0.8 V/minute.

Table 5 Data of anodic stripping analyses of lead in various vegetable grown at Taling Chan garden.

Sample	$\bar{i}^{*}_{p,a}$ sample, μa	$i^{*}_{p,a}$ sample + std Pb(II)ion μa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found		Ash wt. of 1kg fresh vegetable, mg
				μg/g of vegetable ash	μg/kg of fresh vegetable	
Chinese Radish	none	0.62	0.040	none	none	7.62 ±0.08
	none	0.64	0.040			
Chinese White Cabbage	0.54	2.05	0.100	3.82 ±0.03	41.96 ± 3.91	10.97 ± 1.12
	0.78	1.65	0.060			
Cucumber	none	0.40	0.020	none	none	8.02 ±0.24
	none	0.32	0.020			
Celery	1.26	2.59	0.080	5.01 ±0.05	99.50 ±0.63	19.85 ±0.07
	1.33	2.73	0.080			
Leaf Mustard	0.27	0.40	0.020	3.95 ±0.08	53.39 ± 1.12	13.67 ±0.16
	0.26	0.38	0.020			
Chinese Cabbage	0.96	2.20	0.060	5.59 ±0.07	79.97 ± 1.17	14.81 ±0.55
	0.90	2.15	0.060			

* average of two trials

Table 5 (continued)

Sample	$i^*_{p,a}$ sample, μa	$i^*_{p,a}$ sample + std Pb(II)ion μa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found: μg/g of vegetable ash	Average of lead content found: μg/kg of fresh vegetable	Ash wt. of 1 kg fresh vegetable , mg
Multiplier Onion	0.53	1.60	0.060	4.53 ± 0.14	39.87 ± 0.11	8.80 ± 0.31
	0.52	1.60	0.060			
Yard Long Bean	none	0.40	0.030	none	none	20.01 ± 0.42
	none	0.38	0.030			

* average of two trials

Table 6 Data of anodic stripping analyses of lead in various vegetables grown at Prachthipat garden.

Sample	$i^*_{p,a}$ sample, μa	$i^*_{p,a}$ sample + std Pb(II)ion, μa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found: μg/g of vegetable ash	Average of lead content found: μg/kg of fresh vegetable	Ash wt. of 1 kg fresh vegetable, mg
Chinese Kale	0.78	1.50	0.050	3.93 ± 0.10	54.85 ± 1.46	13.91 ± 0.04
	0.80	1.50	0.050			
Chinese Radish	0.14	0.40	0.020	2.07 ± 0.07	13.68 ± 0.44	6.60 ± 0.02
	0.14	0.43	0.020			
Chinese White Cabbage	0.60	1.25	0.040	3.01 ± 0.02	38.81 ± 0.86	12.87 ± 0.22
	0.61	1.38	0.050			
Coriander	0.55	0.89	0.020	3.15 ± 0.10	51.47 ± 0.42	16.44 ± 0.75
	0.56	0.95	0.025			
Cucumber	0.07	0.50	0.030	0.55 ± 0.04	3.87 ± 0.05	7.39 ± 0.05
	0.07	0.51	0.030			
Celery	0.31	0.60	0.060	4.34 ± 0.09	113.35 ± 2.30	26.12 ± 0.01
	0.34	0.65	0.060			

* average of two trials

Table 6 (continued)

Sample	$i^*_{p,a}$ sample, μa	$i^*_{p,a}$ sample + std Pb(II)ion, μa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found: μg/g of vegetable ash	Average of lead content found: μg/kg of fresh vegerable	Ash wt. of 1 kg fresh vegetable, mg
Leaf Mustard	0.15	0.29	0.030	2.70 ± 0.10	39.23 ± 2.09	14.55 ± 0.20
	0.15	0.31	0.030			
Lettuce	0.32	0.96	0.030	1.81 ± 0.03	19.39 ± 0.41	10.65 ± 0.10
	0.33	1.02	0.030			
Chinese Cabbage	0.88	2.40	0.120	5.03 ± 0.20	73.72 ± 3.91	14.64 ± 0.56
	1.03	2.40	0.100			
Multiplier Onion	0.45	0.84	0.030	4.12 ± 0.23	37.23 ± 6.28	9.06 ± 0.20
	0.42	0.81	0.030			
Chinese Convolvulus	0.40	1.21	0.060	2.61 ± 0.05	35.88 ± 0.14	13.46 ± 0.32
	0.39	1.20	0.060			
Water Convolvulus	0.56	0.93	0.020	3.29 ± 0.17	38.96 ± 1.82	13.88 ± 0.40
	0.66	0.95	0.025			

* average of two sample

Table 6 (continued)

Sample	$i^*_{p,a}$ sample, μa	$i^*_{p,a}$ sample + std Pb(II)ion, ua	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found μg/g of vegetable ash	Average of lead content found μg/kg of fresh vegetable	Ash wt. of 1 kg fresh vegetable, mg
Yard Long Bean	none	0.41	0.030	none	none	18.02 $\pm$0.42
	none	0.39	0.030			

* average of two trials

Table 7 Data of anodic stripping analyses of lead in various vegetables grown at Bangbautong garden.

Sample	$i^*_{p,a}$ sample, μa	$i^*_{p,a}$ sample + std Pb(II), μa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content* found μg/g of vegetable ash	Average of lead content* found μg/kg of fresh vegetable	Ash wt. of 1 kg fresh vegetable, mg
Chinese Kale	1.32	1.80	0.040	5.66 ±0.16	80.06 ± 1.74	14.23 ±0.25
	1.25	1.71	0.040			
Chinese Kale (young)	0.40	0.78	0.020	1.78 ±0.02	33.43 ±0.97	18.82 ±0.45
	0.42	0.82	0.020			
Chinese Radish	0.29	0.81	0.050	2.76 ±0.08	20.96 ±0.62	7.59 ±0.62
	0.29	0.78	0.050			
Chinese White Cabbage	0.23	0.39	0.025	2.86 ±0.02	35.60 ± 1.40	12.54 ±0.50
	0.28	0.52	0.030			
Coriander	0.81	2.20	0.080	3.81 ±0.09	67.23 ± 1.19	17.66 ±0.11
	0.82	2.20	0.080			
Cucumber	0.13	0.71	0.020	0.50 ±0.07	3.15 ±0.07	6.05 ±0.02
	0.13	0.68	0.020			

* average of two trials

Table 7 (continued)

Sample	$i^*_{p,a}$ sample, µa	$i^*_{p,a}$ sample + std Pb(II), µa	cm^3 of 9.99×10^{-5} M $Pb(NO_3)_2$ added	Average of lead content found: µg/g of vegetable ash	Average of lead content found: µg/kg of fresh vegetable	Ash wt. of 1 kg fresh vegetable, mg
Celery	0.39	0.77	0.050	4.71 ± 0.08	104.13 ± 3.16	21.62 ± 0.28
	0.35	0.74	0.050			
Leaf Mustard	0.51	0.90	0.050	4.00 ± 0.01	56.81 ± 0.18	14.10 ± 0.07
	0.50	0.88	0.050			
Multiplier Onion	0.35	0.69	0.030	4.37 ± 0.01	42.47 ± 0.46	9.72 ± 0.31
	0.36	0.70	0.030			
Chinese Cabbage	0.63	1.05	0.040	6.27 ± 0.14	94.96 ± 2.10	15.11 ± 1.20
	0.66	1.08	0.040			
Chinese Convolvulus	0.84	1.75	0.040	3.00 ± 0.06	42.63 ± 1.04	13.81 ± 0.04
	0.72	1.61	0.040			
Yard long Bean	none	0.60	0.040	none	none	20.02 ± 0.61
	none	0.58	0.040			

* average of two trials

Table 8 (continued)

Sample	$i^{*}_{p,a}$ sample, µa	$i^{*}_{p,a}$ sample + std Pb(II), µa	cm^3 of 9.99×10^{-5} M $Pb(NO_3)_2$ added	Average of lead content found: µg/g of vegetable ash	Average of lead content found: µg/kg of fresh vegetable	Ash wt. of 1 kg fresh vegetable, mg
Leaf Mustard	0.15	0.35	0.040	2.31 ±0.04	32.70 ±0.62	14.2 ±0.15
	0.16	0.36	0.040			
Chinese Cabbage	1.01	2.11	0.100	6.17 ±0.03	104.03 ±0.51	16.86 ±0.35
	1.02	2.13	0.100			
Multiplier Onion	0.39	1.27	0.060	3.18 ±0.02	35.72 ±0.23	8.71 ±0.01
	0.37	1.25	0.060			
Chinese Convolvulus	0.20	0.63	0.050	2.45 ±0.04	27.20 ±0.98	12.07 ±0.42
	0.23	0.69	0.050			
Water Convolvulus	0.50	1.30	0.050	3.70 ±0.03	43.21 ±0.23	11.61 ±0.88
	0.54	1.63	0.050			
Yard long Bean	none	0.57	0.400	none	none	21.40 ±0.71
	none	0.60	0.400			

* average of two trials

Table 8 Data of anodic stripping analyses of lead in various vegetables grown at Saun Laung garden.

Sample	$i^*_{p,a}$ sample, µa	$i^*_{p,a}$ sample + std Pb(II), µa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found: µg/g of vegetable ash	Average of lead content found: µg/kg of fresh vegetable	Ash wt. of 1 kg fresh vegetable, mg
Chinese Kale	1.40	2.80	0.070	4.31 ± 0.05	56.61 ± .54	13.11 ± .64
	1.41	2.85	0.070			
Chinese Radish	none	0.82	0.050	none	none	6.63 ± 0.42
	none	0.84	0.050			
Chinese White Cabbage	0.52	1.70	0.60	3.62 ± 0.10	36.08 ± 1.18	10.70 ± 0.48
	0.49	1.40	0.050			
Coriander	0.49	1.53	0.065	2.46 ± 0.09	49.06 ± 1.74	19.93 ± 0.02
	0.42	1.33	0.070			
Cucumber	0.045	0.54	0.030	0.48 ± 0.01	3.11 ± .06	6.45 ± 0.07
	0.042	0.50	0.030			
Celery	0.80	2.80	0.100	5.23 ± 0.05	113.17 ± 1.23	21.61 ± 0.43
	0.75	2.68	0.100			

* average of two trials

Table 9 Codes used for representing vegetable species in Figures 4a, 4b, 5a, 5b, 6a, 6b, 7a , and 7b.

Codes	Common Names	Thai Name
A	Chinese Kale	คะน้า
B	Chinese Kale (young)	ยอดผัก
C	Chinese Radish	หัวไช่เท้า (ผักกาดหัว)
D	Chinese White Cabbage	ผักกาดขาว
E	Coriander	ผักชี
F	Cucumber	แตงกวา
G	Celery	ผักคื่นฉ่าย
H	Leaf Mustard	ผักกาดเขียว
I	Lettuce	ผักกาดหอม
J	Chinese Cabbage	ผักกวางตุ้ง
K	Multiplier Onion	ต้นหอม
L	Chinese Convolvulus	ผักบุ้งจีน
M	Water Convolvulus	ผักบุ้งไทย
N	Yard Long Bean	ถั่วฝักยาว

It was found that lead contents in various vegetable species from any garden were different due to the species. The decreasing order of lead content in one kilogram of the fresh vegetable species at Taling Chan garden is celery, Chinese cabbage, leaf mustard, Chinese white cabbage, multiplier onion, yard long bean, Chinese radish and cucumber (see Figure 4a). The highest concentration of lead was found in celery (99.50 ± 0.63 μg/kg) and no lead was found in yard long bean. Since the texture of each vegetable species is different, the decreasing order of lead content in one gram of the ash of vegetable species has a slight change from that in the fresh vegetable. The order is as the following, Chinese cabbage, celery, Chinese white cabbage, multiplier onion, leaf mustard and yard long bean (see Figure 4b). The content of lead in one gram of the ash of Chinese cabbage was found to be highest for this garden (5.59 ± 0.07 μg/g) and no lead was found in yard long bean, cucumber and Chinese radish.

For the Prachathipat garden, the decreasing order of lead content in one kilogram of the fresh vegetable is celery, Chinese cabbage, Chinese kale, coriander, leaf mustard, water convolvulus, Chinese white cabbage, multiplier onion, Chinese convolvulus, lettuce, Chinese radish, cucumber and yard long bean (see Figure 5a). The highest concentration of lead was found in celery (113.35 ± 2.30 μg/kg) and no lead was found in yard long bean. However, the decreasing order of lead content in one gram of the ash of vegetable species is Chinese cabbage, celery, multiplier onion, Chinese kale, water convolvulus, coriander, Chinese white cabbage,

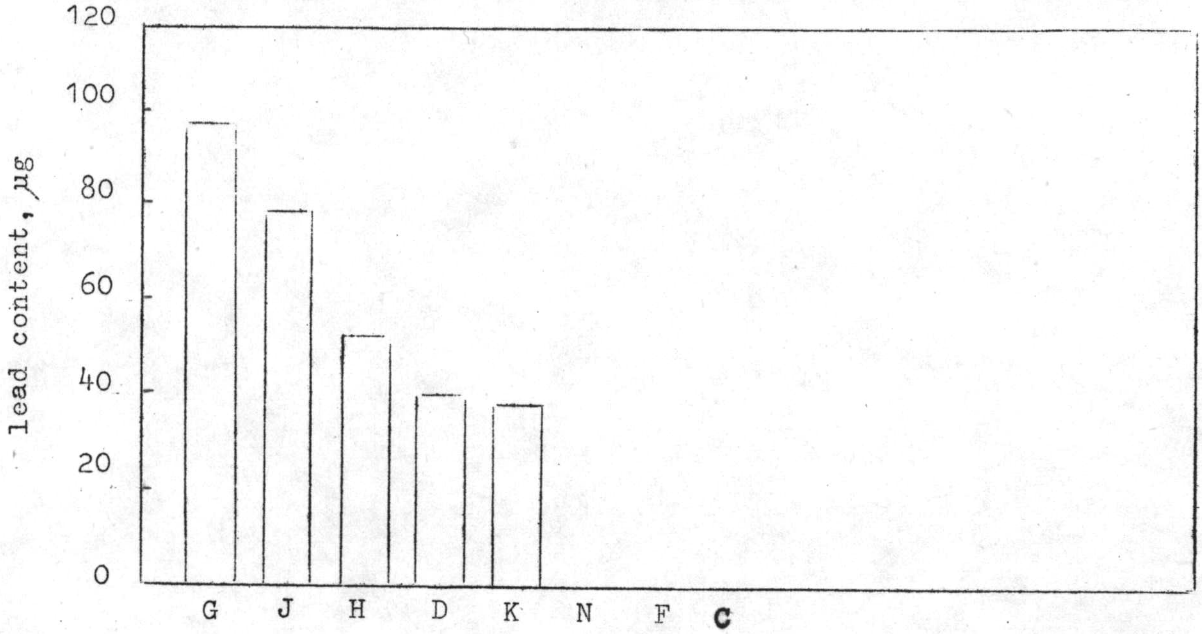

Figure 4a Lead content in one kilogram of the fresh vegetable of various species at Taling Chan garden

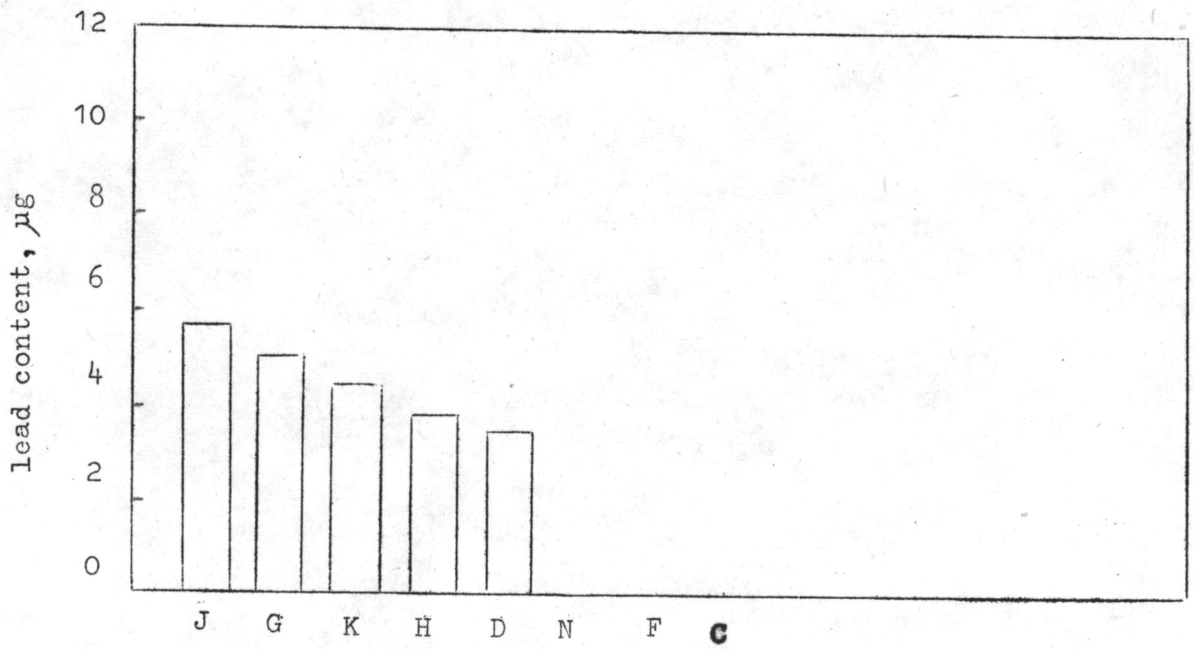

Figure 4b Lead content in one gram of the vegetable ash of various species at Taling Chan garden.

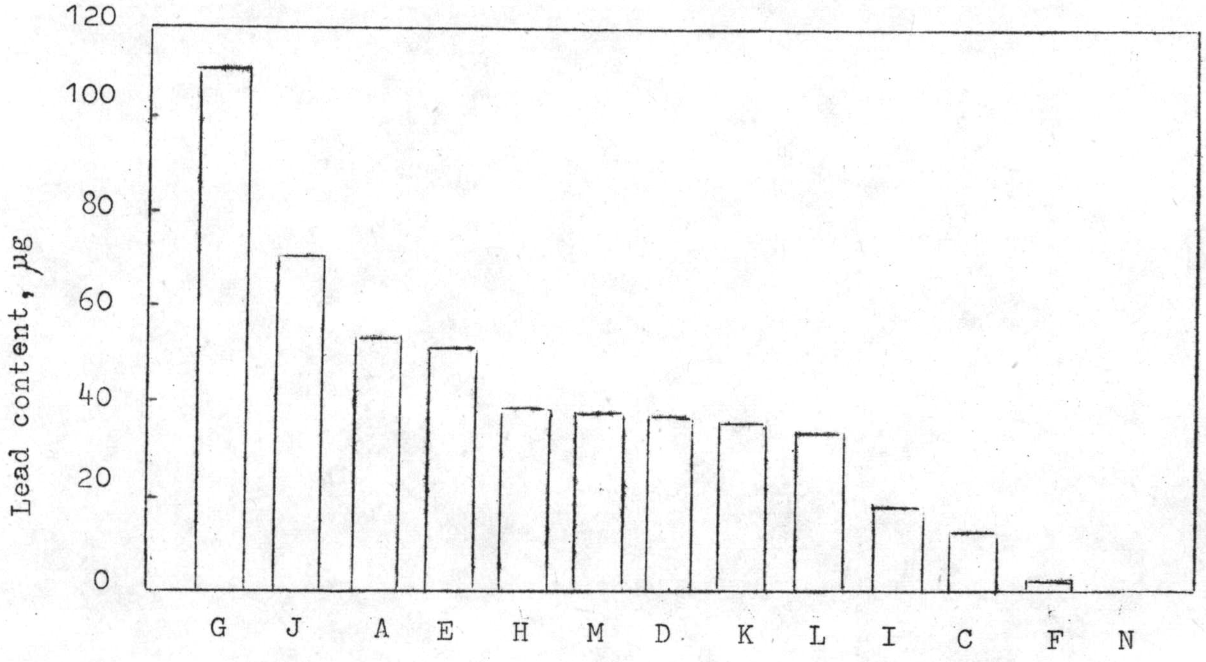

Figure 5a Lead content in one kilogram of the fresh vegetable of various species at Prachathipat garden.

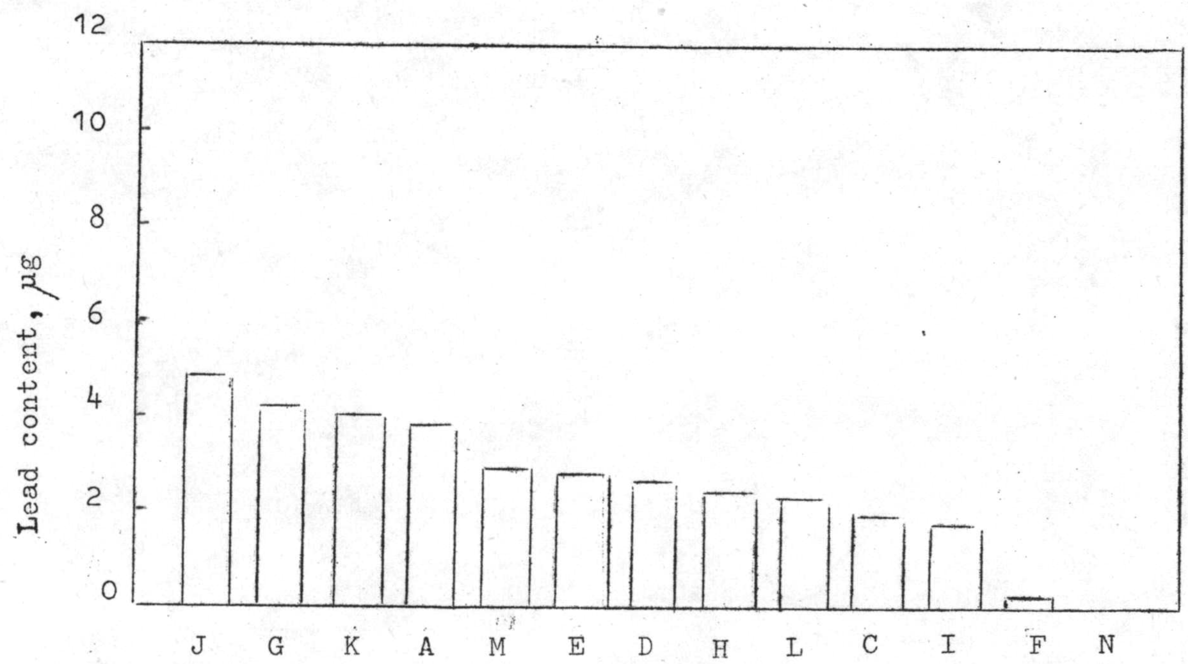

Figure 5b Lead content in one gram of the vegetable ash of various species at Prachathipat garden.

water convolvulus, leaf mustard, Chinese convolvulus, Chinese radish, lettuce, cucumber and yard long bean (see Figure 5b). The content of lead in one gram of the ash of Chinese cabbage was found to be the highest for this garden (5.03 $\pm$0.20 µg/g) and no lead was found in yard long bean.

For the Bangbautong garden, the decreasing order of lead content in one kilogram of the fresh vegetable species is celery, Chinese cabbage, Chinese kale, coriander, leaf mustard, Chinese convolvulus, multiplier onion, Chinese white cabbage, Chinese kale (young), Chinese radish, cucumber and yard long bean (see Figure 6a). The highest concentration of lead was found in celery (104.13 $\pm$ 3.16 µg/kg) and no lead was found in yard long bean. When the lead content in one gram of the vegetable ash of various species was oriented, the decreasing order was as the following, Chinese cabbage, Chinese kale, celery, multiplier onion, leaf mustard, coriander, Chinese convolvulus, Chinese white cabbage, Chinese radish, Chinese kale (young), cucumber and yard long bean (see Figure 6b). The content of lead in one gram of the ash of Chinese cabbage was found to be the highest for this garden (6.27 $\pm$0.14 µg/g) and no lead was found in yard long bean.

For the last garden in Tambon Saun Laung, the decreasing order of lead content in one kilogram of the fresh vegetable species is celery, Chinese cabbage, Chinese kale, coriander, water convolvulus, Chinese white cabbage, multiplier onion,

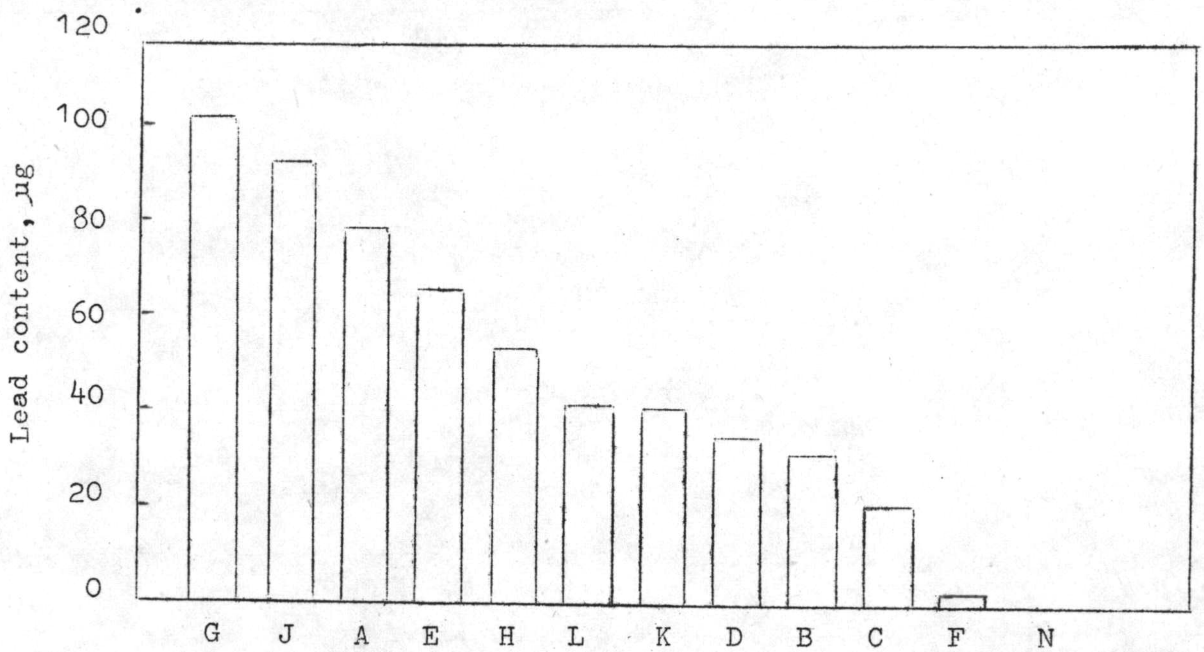

Figure 6a Lead content in one kilogram of the fresh vegetable of various species at Bangbautong garden.

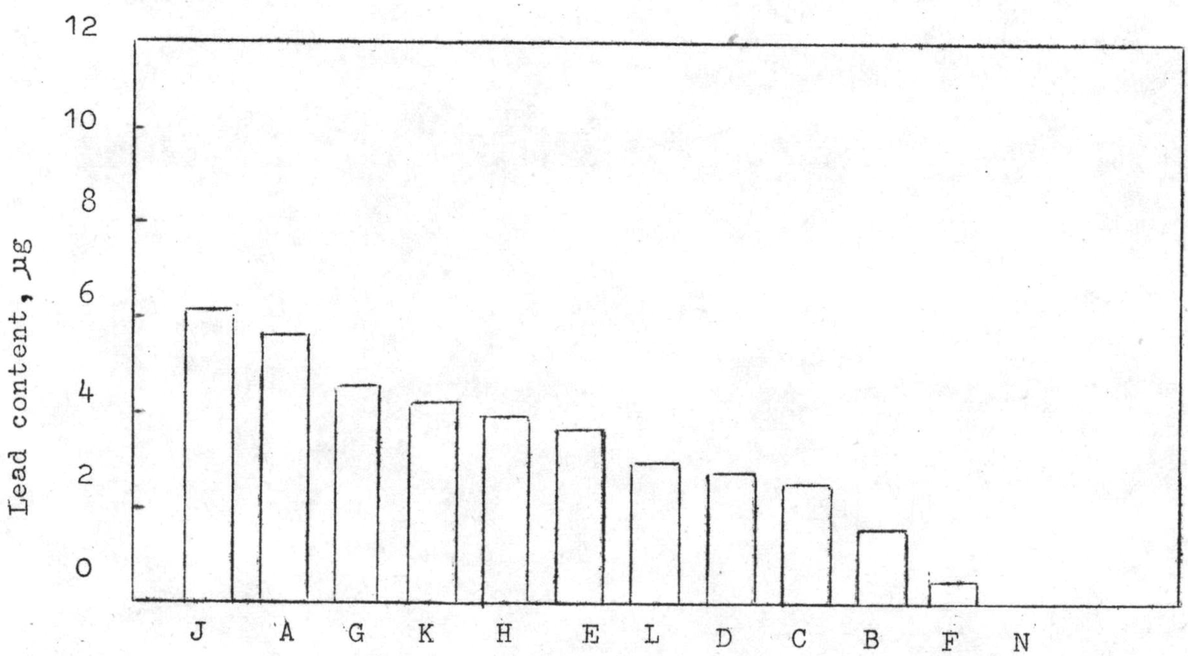

Figure 6b Lead content in one gram of the vegetable ash of various species at Bangbautong garden.

leaf mustard, Chinese convolvulus, cucumber, Chinese radish and yard long bean (see Figure 7a). The highest concentration of lead was found in celery(113.17 $\pm$ 1.23 µg/g) and no lead was found in yard long bean, and Chinese radish . When the order was oriented in the way of the lead content in one gram of the ash of vegetable species, the decreasing order was as the following, Chinese cabbage, celery, Chinese kale, water convolvulus, Chinese white cabbage, multiplier onion, coriander, leaf mustard, Chinese convolvulus, cucumber, Chinese radish and yard long bean (see Figure 7b). The content of lead in one gram of the ash of Chinese cabbage was found to be the highest for this garden (6.17 $\pm$0.30 µg/g) and no lead was found in yard long bean and cucumber.

From every vegetable garden studied, it indicated that celery is the species which has a maximum value of lead content in the fresh vegetable (99.50 - 113.35 µg/kg), Chinese cabbage is the species which contains a maximum value of lead content in the vegetable ash (5.03 - 6.28 µg/g), as well as yard long bean is the species of vegetables analyzed which contains no lead in both the fresh vegetable and its ash. These results illustrated an influence of the species or genus of a vegetable on the amount of lead in the vegetable. Owing to the difference in the textures between vegetable species analyzed, the maximum lead content in the fresh vegetable was found in celery while

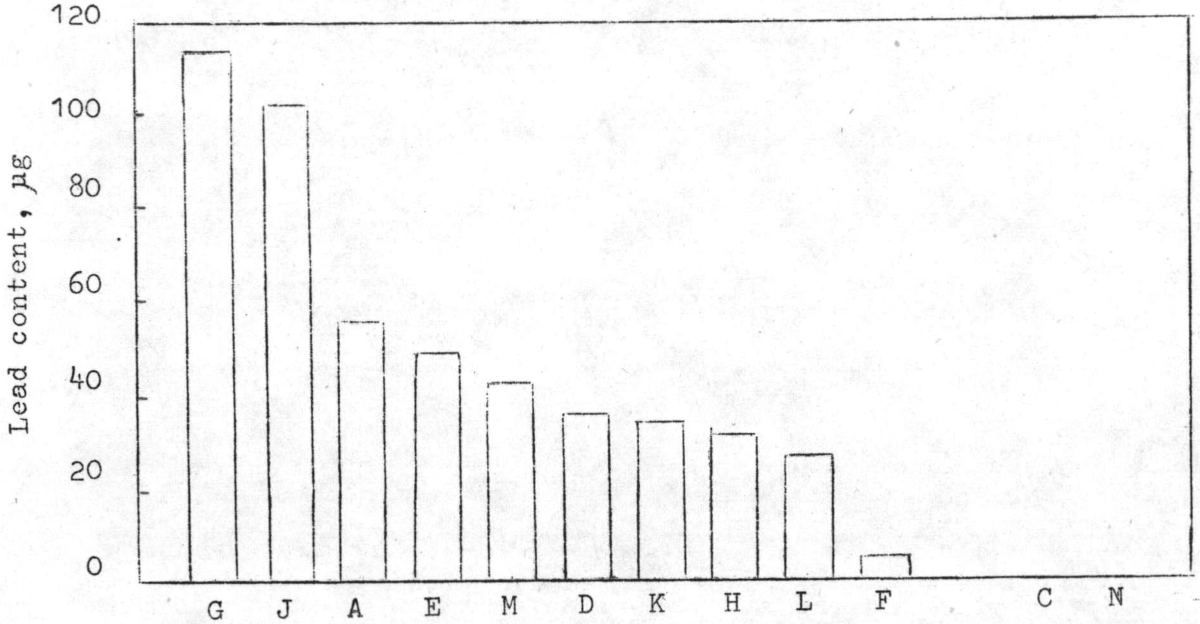

Figure 7a Lead content in one kilogram of the fresh vegetable of various species at Saun Laung garden.

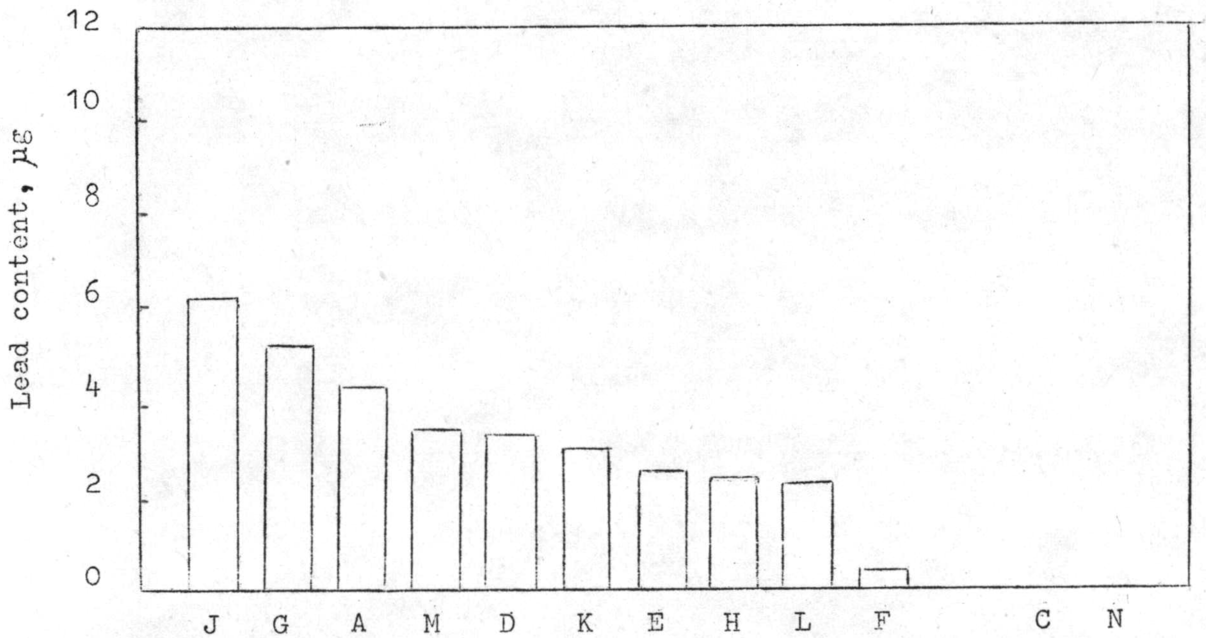

Figure 7b Lead content in one gram of the vegetable ash of various species at Saun Laung garden.

the maximum lead content in the vegetable ash was found in Chinese cabbage. Moreover, the decreasing orders of lead contents in a vegetable species between the fresh vegetable and its ash from any garden are slightly diverse. Multiplier onion from the Bangbautong garden is in the sixth order of the fresh vegetable, but it is in the ninth order of the ash. Multiplier onion from the Saun Laung garden is in the seventh order of the fresh vegetable, but it is in the eight order of the ash (see the decreasing orders on page 50, 52). These orientations of lead contents in vegetables between the decreasing orders for the fresh vegetables and for the ashes illustrated an influence of the texture of a vegetable on lead content in the vegetable. Since the numbers and structures of hydrocarbons (cellulose) oriented in various vegetable species have some variation,the amount of the mineral, nutrient and water uptake by each species is different. This can be seen when the same weights of various fresh vegetables were ashed, the weights of ashes obtained were not equal. These conversion factors for the weights of fresh vegetables to the ashes are also presented in Table 5-8. However, lead contents in anyone vegetable species which were grown in the four gardens studied resulted in some different values within a short range due to the different environment of each garden (see Table 10, 11). The inconsistency of the conversion factors of each vegetable species from the fresh vegetable to its ash between four gardens studied as shown in Table 12 also emphasized the effect of the environment on a vegetable composition.

Table 10 Comparison of lead contents in each fresh vegetable grown in the four gardens studied

Sample	lead content*, µg/kg of the fresh vegetable grown at			
	Taling Chan	Prachathipat	Bangbautong	Saun Laung
Chinese Kale		54.85 ± 1.46	80.06 ± 1.74	56.61 ±0.54
Chinese Kale (young)			33.43 ±0.97	
Chinese Radish	none	13.68 ±0.44	20.96 ±0.62	none
Chinese White Cabbage	41.96 ± 3.91	38.81 ±0.86	35.60 ± 1.40	36.08 ± 1.18
Coriander		51.47 ±0.42	67.23 ± 1.19	49.06 ± 1.74
Cucumber	none	3.87 ±0.05	3.15 ±0.07	3.11 ±0.06
Celery	99.50 ±0.63	113.35 ± 2.30	104.13 ± 3.16	113.17 ± 1.23
Leaf Mustard	53.39 ± 1.12	39.23 ± 2.09	56.81 ±0.18	32.70 ±0.62
Lettuce		19.39 ±0.41		
Chinese Cabbage	79.97 ± 1.17	73.72 ± 3.91	94.96 ± 2.10	104.03 ±0.51
Multiplier Onion	39.87 ±0.11	37.23 ± 1.28	42.47 ±0.46	35.72 ±0.23
Chinese Convolvulus		35.88 ±0.14	42.63 ± 1.04	27.20 ±0.98
Water Convolvulus		38.96 ± 1.82		43.21 ±0.23
Yard Long Bean	none	none	none	none

* average value ± mean deviation

Table 11 Comparison of lead contents in the ash of each vegetable grown in the four gardens studied

Sample	lead content *, µg/ g of the ash of the vegetable grown at			
	Taling Chan	Prachathipat	Bangbautong	Saun Laung
Chinese Kale		3.93 ± 0.10	5.66 ± 0.16	4.31 ± 0.05
Chinese Kale(young)			1.78 ± .02	
Chinese Radish	none	2.07 ± 0.07	2.76 ± 0.08	none
Chinese White Cabbage	3.82 ± 0.03	3.01 ± 0.02	2.86 ± 0.02	3.62 ± 0.10
Coriander		3.15 ± 0.10	3.81 ± 0.09	2.46 ± 0.09
Cucumber	none	0.55 ± 0.04	0.50 ± 0	0.48 ± 0.01
Celery	5.01 ± 0.05	4.34 ± 0.09	4.71 ± 0.08	5.23 ± 0.05
Leaf Mustard	3.95 ± 0.08	2.70 ± 0.10	4.00 ± 0.01	2.31 ± 0.04
Lettuce		1.81 ± .03		
Chinese Cabbage	5.59 ± 0.07	5.03 ± 0.20	6.27 ± 0.14	6.17 ± 0.03
Multiplier Onion	4.53 ± 0.14	4.12 ± 0.23	4.37 ± 0.01	3.18 ± 0.02
Chinese Convolvulus		2.61 ± 0.05	3.00 ± 0.01	2.45 ± 0.04
Water Convolvulus		3.29 ± 0.17		3.70 ± 0.03
Yard Long Bean	none	none	none	none

* average value ± mean deviation

Table 12 Comparison of conversion factors for the weights of fresh vegetables to the ashes between various gardens studied

Sample	conversion factor *, mg of the ash/kg of the fresh vegetable			
	Taling Chan	Prachathipat	Bangbautong	Saun Laung
Chinese Kale		13.91 ± 0.04	14.23 ± 0.25	13.11 ± 0.64
Chinese Kale (young)	7.62 ± 0.08		18.29 ± 0.17	
Chinese Radish	7.62 ± 0.08	6.60 ± 0.02	7.59 ± 0.62	6.63 ± 0.42
Chinese White Cabbage	10.97 ± 1.12	12.87 ± 0.22	12.54 ± 0.50	10.70 ± 0.48
Coriander		16.44 ± 0.75	17.66 ± 0.11	19.93 ± 0.02
Cucumber	8.02 ± 0.24	7.39 ± 0.35	6.05 ± 0.02	6.45 ± 0.07
Celery	19.85 ± 0.07	26.12 ± 0.01	21.62 ± 0.28	21.61 ± 0.43
Leaf Mustard	13.67 ± 0.16	14.55 ± 0.20	14.10 ± 0.07	14.2 ± 0.15
Lettuce		10.65 ± 0.10		
Chinese Cabbage	14.81 ± 0.55	14.64 ± 0.56	15.11 ± 1.20	16.86 ± 0.35
Multiplier Onion	8.80 ± 0.31	9.06 ± 0.20	9.72 ± 0.31	8.71 ± 0.01
Chinese Convolvulus		13.46 ± 0.32	13.81 ± 0.04	12.07 ± 0.42
Water Convolvulus		13.88 ± 0.40		11.61 ± 0.18
Yard Long Bean	20.01 ± 0.42	18.02 ± 0.42	20.02 ± 0.61	21.40 ± 0.71

* average ± mean deviation

The stage of maturity of a vegetable also showed an influence on the lead content in the vegetable, e.g., lead content in Chinese kale was found to be 48.68 - 56.61 μg/kg of the fresh vegetable and lead content in Chinese kale (young) was found to be 33.43 μg/kg the fresh vegetable.

Although all edible portions were used in the analysis, it may be concluded that lead uptake increased in the sequence of fruit, stem and leaf, e.g., no lead was found in yard long bean, the range of lead contents in Chinese radish was found to be none - 20.96 μg/kg of the fresh vegetable and the range of lead contents in leaf mustard was found to be 32.70 - 56.81 μg/kg of the fresh vegetable. This result corresponded to the paper of Motto, H.L., et al. (15). A difference in lead contents in the leaves of various species may be expressed by the morphological difference in leaf surface to volume ratio, but this attribution may prove imprudent.

The mechanism of lead (II) ion uptaken into vegetables divided into two pathways : the uptake of lead (II) ion from leaves and the uptake of lead (II) ion from roots. Uptake of heavy metals through leaves was proved to be true by references 67, 68 and 69. Krause, G.H.M. and Kaiser, H. (70) reported that lead uptake through leaves occured and followed by basipetal transport. Furthermore, guttation could be very well involved in such a process, since, according to Wilson (71), the guttation fluid usually contains some salts and organic acids. This could not only enhance solubility, but also ions uptake, since some plants are capable of reabsorbing salt crystals through hydrathodes (72). Differences in uptake could be due to either difference in particle sizes or differences in the solubility of the various oxides or interactions of cations with respect to uptake preference through leaves.

From this study, the surface areas of leaves of various vegetable species were found insignificant effect on lead contents in the vegetables.

The uptake of Pb(II) ion by plant roots were reported by references 15, 73, 74, and 75. All the results mentioned above were from the analyses of vegetables by the treatment of washing as preparing for cooking. These results indicated the domestic intake of lead content from vegetables by the people who live in Bangkok Metropolitan area and near by. Since domestic tap water contains trace amounts of lead as reported by Kanatharana (76), an additional study was performed for the comparison of lead contents in the vegetables between two washing treatments ; the treatment of shaking off dust and rinsing vegetables with tap water as preparing for cooking and another treatment by shaking off durt, rinsing vegetables with tap water and following with the double deionized water. Data of the anodic stripping analyses of lead in some vegetables and the results of lead contents in these vegetables are listed in Table 13 for the washing treatment with tap water and in Table 14 for the washing treament with double deionized water.

Table **13** Data of anodic stripping **analyses** of lead in various vegatables by rinsing vegetables with tap water.

Sample	$i^{*}_{p,a}$ sample, µa	$i^{*}_{p,a}$ Sample + std.Pb(II) µa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found		Ash wt. of 1 kg fresh vegetable, mg
				µg/g of vegetable ash	µg/kg of fresh vegetable	
Chinese Kale	1.32	1.80	0.030	5.66 ± 0.16	80.6 ± 1.74	14.23 ± 0.23
(Bangbautong)	1.25	1.70	0.030			
Chinese Kale (young)	0.40	0.78	0.020	1.77 ± 0.97	33.43 ± 0.97	18.82 ± 0.45
(Bangbautong)	0.42	0.82	0.020			
Coriander	0.81	2.20	0.080	3.81 ± 0.09	67.23 ± 1.19	17.02 ± 0.14
(Bangbautong)	0.82	2.20	0.080			
Chinese White Cabbage (Laun Laung)	0.52	1.70	0.060	3.62 ± 0.10	36.08 ± 1.18	10.70 ± 0.48
	0.49	1.40	0.050			

Table 13 (continued)

Sample	$i^*_{p,a}$ sample, μa	$i^*_{p,a}$ Sample + std Pb(II) μa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found		Ash wt. of 1 kg fresh vegetable, mg
				μg/g of vegetable ash	μg/kg of fresh vegetable	
Chinese Cabbage (Bangbautong)	0.63	1.05	0.050	6.17 ± 0.03	104.03 ± 0.51	16.86 ± 0.35
	0.66	1.08	0.050			
Water Convolvulus (Saun Laung)	0.50	1.50	0.050	3.70 ± 0.03	43.21 ± 0.23	11.61 ± 0.18
	0.54	1.63	0.070			

* average of two trials

Table 14 Data of anodic stripping **analyses** of lead in various vegetables after washing with tap water, and following with **deionized** water

Sample	$i^*_{p,a}$ sample, µa	$i^*_{p,a}$ sample + std Pb(II) ion, µa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found		Ash wt. of 1 kg fresh vegetable, mg
				µg/g of vegetable ash	µg/kg of fresh vegetable	
hinese ale	0.96	3.30	0.100	3.27 ± 0.30	48.68 ± 4.58	14.88 ± 0.03
angbautong)	0.95	1.65	0.040			
hinese ale young)	0.39	0.98	0.030	1.65 ± 0.01	30.00 ± 0.07	16.52 ± 1.61
angbautong)	0.38	1.00	0.030			
oriander	0.36	0.60	0.020	3.04 ± 0.17	62.70 ± 0.72	18.62 ± 0.34
angbautong)	0.35	0.58	0.020			

Table 14 (continued)

Sample	$i^*_{p,a}$ sample, μa	$i^*_{p,a}$ sample + std Pb(II) ion, μa	cm^3 of 9.99×10^{-5}M $Pb(NO_3)_2$ added	Average of lead content found		Ash wt. of 1 kg fresh vegetable, mg
				μg/g of vegetable ash	μg/kg of fresh vegetable	
inese ite bbage	0.42	1.23	0.050	3.27 ± 0.11	31.86 ± 1.12	9.62 ± 0.14
un Laung)	0.43	1.32	0.050			
inese bbage	0.38	0.74	0.030	5.35 ± 0.22	84.25 ± 1.09	16.19 ± 1.30
ngbautong)	0.39	0.75	0.030			
ter **nvolvulus**	0.54	1.49	0.070	3.61 ± 0.09	42.65 ± 0.17	11.81 ± 0.33
un Laung)	0.55	1.52	0.070			

* average of two trials

From Table 13 and 14, it can be seen that there was some trace amounts of lead from tap water deposited on the vegetables with a regular washing treatment as preparing for cooking. If we assume that the average consumption of various vegetables by Thais is about one kilogram per day, the maximum content of lead (113.35 µg/kg of the fresh celery), Thai's intake still does not exceed the Thai standard limit of lead in canned food (2 ppm) (77). However , vegetables are only one portion of food that man consumes everyday.