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CADMIUM, LEAD, ZINC AND COPPER CONTENTS IN SELECTED VEGETABLES AND FRUIT FROM GARDEN ALLOTMENTS OF THE SOUTH–WESTERN POLAND

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The contents of cadmium, lead, zinc and copper were determined in 64 samples of produce (19 strawberries, 16 tops of parsley, 16 dills, 13 lettuces). The produce was gathered directly from home-gardens located near Opole, Wroclaw, Legnica and Jastrzebie Zdroj.

The content of cadmium found was within the limits 0.0027–0.663 mg/kg. The contents exceeding the allowable value were found in three samples of dill. The determined quantity of lead ranged from 0.0047 mg/kg to 0.588 mg/kg and the exceeding of allowable contents was found in two dill samples, two lettuce samples and one parsley (greens). The level of zinc contents was between 0.716–34.76 mg/kg. In fourteen samples (3 parsley, 2 lettuces and 9 dills) the limits established before 2004 were exceeded.The contents of copper in produce was within 0.342–17.03 mg/kg. In seven samples (3 parsley and 4 dills) the allowable quantity of Cu established before 2001 was exceeded.

The highest amount of cadmium and copper was determined in samples taken near Jastrzebie Zdroj, while the largest quantity of lead and zinc was found in the produce collected in Legnica. The relatively smallest quantities of metals were found in the samples collected near Opole. A comparison of collected data with those available in the literature shows that the recorded level of contamination of the tested produce with heavy metals is close to levels determined for other industrial regions of the country but higher than the world's standards.

INTRODUCTION

The basic source of heavy metals to humans not exposed to them at work is food. Some metals, *e.g.* cadmium, lead, mercury and arsenic, are claimed to be one of the so-called "priority contaminants" that even in small quantities pose hazard to health of humans. Others, including copper, zinc and chromium, are indispensable for the proper course of physiological processes and have to be supplied to an organism in appropriate quantities since both their deficiency and excess are unfavorable to human health. In contaminated environment, both in soil, water and air, the occurrence of deleterious metals is often accompanied by increased levels of essential metals. As a consequence, excessive amounts of those elements are likely to penetrate to food cultivated on polluted areas. Due to the structure of consumption of various groups of food products, the highest contribution in the uptake of deleterious metals have plant products. Total elimination of cadmium, lead and other undesirable elements from those products is impossible, whereas culinary or technological treatment may only result in the removal of a minor part of contaminants from selected products.

The degree of metals accumulation in a plant is determined by its genus, species and anatomical part as well as time of exposure to environmental conditions. In most plants contents of cadmium, lead, zinc and copper are observed to decrease in particular parts of a plant in the following order: root – leaves – shoots – fruits and seeds, since metals absorbed by a plant from soil first face a root barrier that impairs their penetration into aerial parts of the plant [Piotrowska, 1997].

For a number of years, industrial regions of Poland – especially the Upper Silesia – have been excessively exploited. High concentration of heavy industry plants and a lack of ecological actions have caused that nowadays the Upper Silesia is the most polluted region of Poland. In spite of the fact that since 1996 the degree of natural environment pollution has been observed to decrease successively, long-term industrial emissions have resulted in the accumulation of various pollutants, including heavy metals, in soil [Report, 2003]. Although industrial regions are not the site of large-scale cultivation of vegetables, yet population inhabiting those areas may be exposed, even to a considerable extent, to the uptake of various industrial toxins with products originating from garden allotments often located in the vicinity of operating industrial plants.

Thus, a study was undertaken to examine contents of cadmium, lead, zinc and copper in selected vegetables and fruits originating from garden allotments from four regions of south-western Poland, including the Upper Silesia.

MATERIAL AND METHODS

The experimental material were 65 samples of plant products: strawberries (19), parsley leaves (16), lettuce (14), and

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dill (16) collected on the turn of June and July of 2005 in the area of the following cities: Opole, Wrocław, Legnica and Jastrzębie Zdrój. Most of the samples were obtained directly from garden allotments, the others were purchased at local markets taking into account cultivation site declared by the producer.

Having removed impurities and inedible parts, the samples were carefully washed under running water, then comminuted, homogenized, frozen and stored in plastic containers at a temp. of –18°C until analysed.

To determine contents of metals, 20-g samples were weighed and dry-mineralized in a muffle furnace at a temperature of 450°C for *ca*. 12 h. So incinerated sample was dissolved in 65% nitric acid (1 mL), evaporated and recombusted for 2 h at a temperature of 450°C. The ash obtained was dissolved in 2 mol/L nitric acid (25 mL). The elements were determined with the method of flame atomic adsorption spectrometry using a Varian AA240FS apparatus. Contents of zinc and copper were assayed directly in the mineralizate, whereas those of cadmium and lead after previous complexing with ammonium pyrrolidine dithiocarbamate (APDC) and extraction to isopropyl acetate (MBIK) [Szczepaniak, 2004].

To determine significance of differences between mean contents of the elements examined depending on the site of origin of the products, the results obtained were subjected to statistical evaluation using the analysis of variance with Duncan's test [Sobczyk, 2005].

RESULTS

Contents of cadmium and lead in strawberries, parsley leaves, dill and lettuce, depending on collection site, were presented in Table 1, whereas concentrations of zinc and copper in those products – in Table 2. Figures 1 – 4 depict mean contents of the metals assayed expressed as a percentage of permissible levels. The results obtained for concentrations of cadmium and lead were referred to permissible levels stipulated in the Regulation of the Minister of Health of 20th of April 2004 [Regulation…, 2004]. Due to deficiencies of copper and zinc occurring in daily food rations and relatively low levels of those metals in food products, since 2001 and 2004 copper and zinc, respectively, have not been limited as food contaminants. The results obtained were referred to permissible levels valid before legislative changes. A compilation of current (Cd, Pb) and recently valid (Zn, Cu) permissible levels of metal adopted as reference levels was presented in Table 3 [Regulation…, 2004; 2001, 1993].

The content of cadmium in the products examined ranged from 0.0027 to 0.633 mg/kg of fresh mass on average (Table 1). The highest concentrations of that element occurred in samples of dill, lower ones in samples of lettuce and parsley leaves, whereas the lowest ones in samples of strawberries. Significant differences in cadmium contents were demonstrated in products of the same type but collected in different regions. The highest contents of cadmium were reported fro samples originating from the environs of Jastrzębie Zdrój.

TABLE 1. Cadmium and lead contents in parsley (leaves), strawberries, dill and lettuce from south – western Poland.

Sample origin	Mean content of Cd (mg/kg)		Mean content of Pb (mg/kg)	
	Mean	Range (min-max)	Mean	Range (min-max)
Strawberries (n=19)				
Opole and district n=5	0.006[a]	0.003 – 0.011	0.013[a]	0.007 – 0.025
Legnica and district n=3	0.012[b]	0.009 – 0.015	0.013[a]	0.012 – 0.014
Jastrzębie Zdrój and district n=5	0.023[c]	0.009 – 0.034	0.009[a]	0.005 – 0.012
Wrocław and district n=6	0.007[ab]	0.004 – 0.010	0.013[a]	0.011 – 0.021
Parsley (n=16)				
Opole and district n=4	0.014[a]	0.012 – 0.016	0.060[a]	0.052 – 0.068
Legnica and district n=3	0.015[a]	0.012 – 0.017	0.242[c]	0.145 – 0.329
Jastrzębie Zdrój and district n=5	0.032[ab]	0.011 – 0.052	0.082[a]	0.041 – 0.166
Wrocław and district n=4	0.041[b]	0.012 – 0.099	0.147[b]	0.075 – 0.204
Dill (n=16)				
Opole and district n=4	0.062[a]	0.018 – 0.105	0.018[a]	0.013 – 0.023
Legnica and district n=3	0.087[a]	0.042 – 0.135	0.360[c]	0.279 – 0.433
Jastrzębie Zdrój and district n=5	0.318[b]	0.052 – 0.633	0.054[ab]	0.042 – 0.069
Wrocław and district n=4	0.064[a]	0.030 – 0.100	0.095[b]	0.034 – 0.229
Lettuce (n=14)				
Opole and district n=3	0.043[a]	0.039 – 0.047	0.461[c]	0.333 – 0.588
Legnica and district n=3	0.093[b]	0.055 – 0.131	0.206[b]	0.159 – 0.282
Jastrzębie Zdrój and district n=5	0.113[b]	0.039 – 0.191	0.021[a]	0.015 – 0.026
Wrocław and district n=3	0.032[a]	0.030 – 0.034	0.032[a]	0.029 – 0.037

Statistically homogeneous groups are denoted with the same letter.

TABLE 2. Zinc and copper contents in parsley (leaves), strawberries, dill and lettuce from south – western Poland.

Sample origin	Mean content of Cu (mg/kg)		Mean content of Zn (mg/kg)	
	Mean	Range (min-max)	Mean	Range (min-max)
Strawberries (n=19)				
Opole and district n=4	0.442[a]	0.342 – 0.541	1.578[c]	1.347 – 1.841
Legnica and district n=3	0.600[c]	0.526 – 0.638	0.799[a]	0.716 – 0.857
Jastrzębie Zdrój and district n=5	0.525[b]	0.438 – 0.636	1.220[b]	0.991 – 1.417
Wrocław and district n=4	0.482[ab]	0.370 – 0.598	1.689[c]	1.209 – 2.588
Parsley (n=16)				
Opole and district n=4	0.951[a]	0.80 – 1.11	4.838[a]	4.66 – 5.01
Legnica and district n=3	2.602[a]	2.34 – 2.97	13.965[c]	11.86 – 15.10
Jastrzębie Zdrój and district n=5	9.083[b]	1.88 – 17.03	7.619[b]	3.32 – 10.12
Wrocław and district n=4	1.587[a]	1.32 – 1.87	6.881[ab]	3.96 – 9.29
Dill (n=16)				
Opole and district n=4	1.651[a]	1.55 – 1.75	8.478[a]	6.50 – 10.45
Legnica and district n=3	3.079[b]	2.87 – 3.24	24.813[b]	20.44 – 33.72
Jastrzębie Zdrój and district n=5	5.421[c]	1.82 – 7.56	17.597[ab]	3.86 – 30.28
Wrocław and district n=4	1.339[a]	1.19 – 1.47	8.777[a]	3.67 – 11.32
Lettuce (n=14)				
Opole and district n=4	1.001[a]	0.95 – 1.05	6.647[a]	5.84 – 7.46
Legnica and district n=3	0.876[a]	0.76 – 1.02	10.210[b]	7.65 – 14.73
Jastrzębie Zdrój and district n=5	2.701[b]	1.81 – 4.00	6.565[a]	4.06 – 11.51
Wrocław and district n=4	0.360[a]	0.29 – 0.42	3.708[a]	3.58 – 3.86

Statistically homogeneous groups are denoted with the same letter

The only exception were samples of parsley leaves the greatest contamination of which was observed in Wrocław. Exceeded permissible level of Cd by 13.3, 179.2, and 216.5% was reported in three samples of dill from the area of Jastrzębie Zdrój.

In the investigated products, the mean content of lead ranged from 0.009 to 0.461 mg/kg (Table 1). Its highest concentrations were determined in samples of lettuce, whereas smaller ones in those of strawberries. Statistically highest contents of lead were found in parsley leaves and dill from the area of Legnica as well as in lettuce from the Opolszczyzna region. The content of lead determined in strawberries was identically low in samples from all regions examined. Exceeded permissible levels of lead were reported for two samples of dill and one sample of parsley leaves collected in Legnica as well as in three samples of lettuce from the Opolszczyzna region.

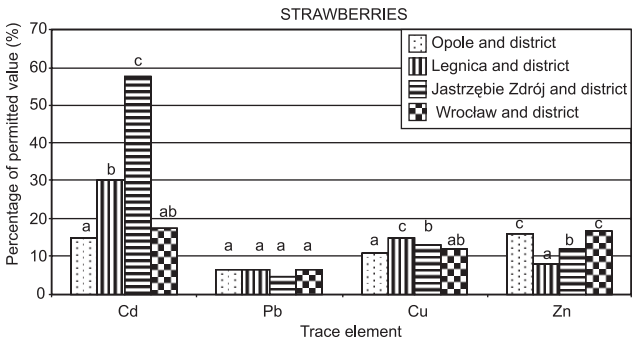

FIGURE 1. Cadmium, lead, copper and zinc contents in strawberries shown as a percentage of permitted value. Statistically homogeneous groups are denoted with the same letter.

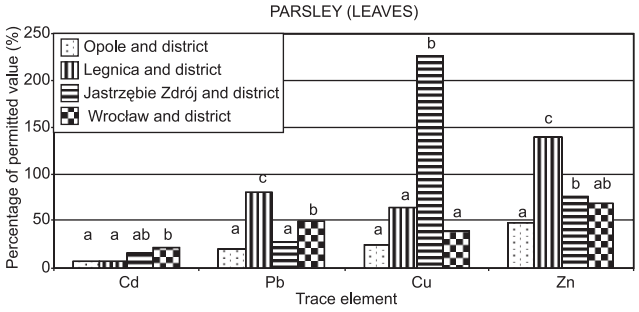

FIGURE 2. Cadmium, lead, copper and zinc contents in parsley (leaves) shown as a percentage of permitted value. Statistically homogeneous group are denoted with the same letter.

The content of zinc in the products analysed ranged from 0.799 to 24.813 mg/kg on average (Table 2). The lowest concentrations of that element were determined in samples of strawberries and the highest ones in dill. Mean contents of zinc demonstrated significant differences as affected by the site of origin. The highest concentrations of that element were found in samples of vegetables from Legnica and in samples of strawberries originating from the environs of Opole and

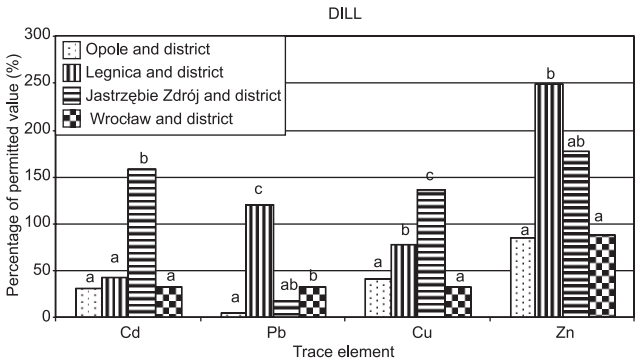

FIGURE 3. Cadmium, lead, copper and zinc contents in dill shown as a percentage of permitted value. Statistically homogeneous groups are denoted with the same letter.

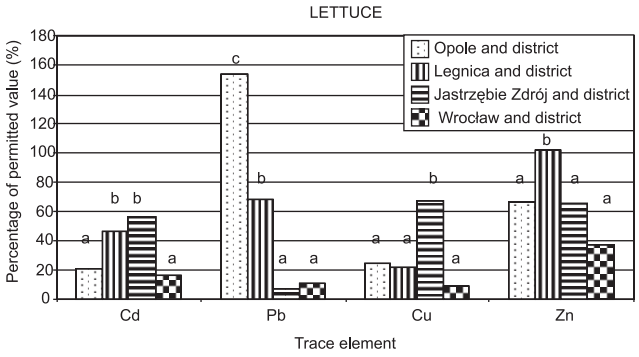

FIGURE 4. Cadmium, lead, copper and zinc contents in lettuce shown as a percentage of permitted value. Statistically homogeneous groups are denoted with the same letter.

TABLE 3. Permissible levels of Cd, Pb, Zn, Cu adopted as reference levels.

Material / Element	Strawberries	Parsley leaves	Lettuce	Dill
Cd* (mg/kg)	0.04	0.2	0.2	0.2
Pb* (mg/kg)	0.2	0.3	0.3	0.3
Zn** (mg/kg)	10	10	10	10
Cu*** (mg/kg)	4	4	4	4

* acc. to [Regulation…, 2004]; ** acc. to [Regulation…, 2001]; *** acc. to [Regulation…, 1993]

Wrocław. Exceeded levels of zinc as compared to permissible levels valid before 2004 were noted almost in all examined samples of vegetables from Legnica; one sample of parsley leaves, three samples of dill and one sample of lettuce from the environs of Jastrzębie Zdrój as well as in two samples of dill from the areas of Opole and Wrocław.

The content of copper in the products investigated can be claimed safe except for four samples of parsley leaves and four samples of dill from the area of Jastrzębie Zdrój, in which copper level was higher than the permissible level valid before 2001 (Table 2). Statistically the highest concentrations of that element were determined in samples of vegetables from the district of Jastrzębie Zdrój as well as in samples of strawberries from the area of Legnica. Lower contents of copper were reported in samples from the Opolszczyzna region and from Wrocław.

DISCUSSION

Despite a relatively low number of samples, differences can be observed in contamination with heavy metals of products originating from the four examined regions of southwestern Poland. The lowest contamination was demonstrated in the case of products originating from the Opolskie Province. Samples from Wrocław and its district were characterized by mean levels of the elements examined. In turn, the lowest contents of metal, especially of cadmium and copper, were determined in samples originating from the Silesia Province. According to literature data, all components of the natural environment of the Upper Silesia, *i.e.* water, soil and air, are characterized by the highest concentrations of cadmium, lead, zinc and copper as compared to other regions of Poland [Report, 2003].

In the area of Jastrzębiec Zdrój, near the site of sample collection there is located a hard coal mine KWK „Borynia". In samples from garden allotments located in the vicinity of the mine the determined contents of copper and cadmium appeared to be the highest. The highest concentrations of lead and zinc were found in vegetables originating from the area of Legnica, except for lettuce for which contamination with lead was the highest in samples from the region of Opolszczyzna. Contamination of the samples from the area of Legnica was linked, most of all, with the functioning of a Copper Steelworks "Legnica". Garden allotments the samples originated from were located *ca*. 30 km away from the steelworks. In turn, garden allotments of the Opolskie Province are located in direct vicinity of arterial roads with high traffic flow, *i.e.* Opole – Poznań and Opole – Wrocław. In addition, a Power Station "Opole" is located *ca*. 10 km away from one of them.

According to literature data [Piotrowska, 1997], the lowest contents of all elements examined were determined in strawberries. The highest concentrations of cadmium, zinc and copper were assayed in dill, whereas those of lead in lettuce.

Contamination of the products analysed is similar to that reported by other authors carrying out studies in industrialized regions of Poland. In vegetables originating from the area of Stalowa Wola, Kocjan *et al.* [2002] determined, on average, 0.037 mg Cd/kg, 0.0246 mg Pb/kg, 6.60 mg Zn/kg and 1.68 mg Cu/kg in parsley leaves (n=10) as well as 0.028 mg Cd/kg, 0.154 mg Pb/kg, 0.73 mg Cu/kg and 4.10 mg Zn/kg in lettuce (n=10). Kowalska–Pyłka *et al.* [1995] analysed contents of cadmium, lead, zinc and copper in vegetables from the region of Lubelszczyzna. The content of lead determined by them in lettuce (n=20) (0.115 mg Pb/kg) and dill (n=20) (0.436 – 0.567 mg Pb/kg) was similar to results obtained in the reported study. In contrast, concentrations of zinc and copper were a few times lower.

Higher contents of lead in parsley leaves grown both with the conventional (n=5) and ecological method (n=5) were determined in samples collected in the district of Cracow [Leszczyńska, 1999]. Levels of cadmium 0.04–0.07 mg/kg and zinc 4.09–13.9 mg/kg approximated those obtained in this

study. In turn, contents of copper were substantially lower and reached 1.13–2.00 mg/kg. In analyzing contents of heavy metals in selected vegetables from the area of the Upper Silesia Industrial Region, Śmigiel [1994] determined cadmium and lead in parsley leaves (n=6) at the levels of 0.02–0.77 mg Cd/kg and 0.076–0.87 mg Pb/kg, respectively. These were values about three times higher than those obtained in the reported study. Concentrations of cadmium, lead, zinc and copper exceeding the permissible levels several times were determined by Mikuła & Indeka [1997] in samples of parsley leaves collected from garden allotments located around the Płock refinery. They contained 3.21 mg/kg of lead, 0.34 mg/kg of cadmium, 25.4 mg/kg of zinc and 6.8 mg/kg of copper. Lower levels of cadmium and lead in lettuce (n=5) from the region of Lubelszczyzna were assayed by Czech & Rusinek [2005], *i.e.* 0.017–0.041 mg Cd/kg and 0.13–0.202 mg Pb/kg, respectively. Szymczak *et al.* [1999] also demonstrated lower contents of cadmium and lead in lettuce (n=4) originating from the area of Legnica, *i.e.* 0.079 mg Pb/kg and 0.016 mg Cd/kg, respectively.

It is estimated that in other European countries concentrations of metals in food products are usually lower as compared to Poland. In Denmark, a programme for monitoring contents of basic nutrients and contaminants in food products has been underway since 1983 [Larsen *et al.,* 2002]. Since that time it has been carried out in five-year cycles. The programme is aimed, among other things, at monitoring contamination degree of basic products available in Danish shops and at predicting on that basis potential hazards linked with excessive intake of various contaminants by humans. Under that programme, samples of the same materials are collected cyclically from the same regions. In samples of lettuce analysed in the years 1993-1997 the authors determined 0.0227 mg/kg of cadmium and 0.018 mg/kg of lead on average. These are substantially lower values than those assayed in the reported study.

Investigations carried out on the area of Greece were aimed at comparing contents of metals in vegetables growing in two regions of the north-western part of the country characterized by low pollution (area of the city of Preveza) and high industrialization (Ioannina) [Stalikas *et al*., 1997]. The experimental material were vegetables collected from local garden allotments and plantations. In samples of parsley leaves from the area of Ioannina the average contents of cadmium, copper, lead and zinc accounted for 0.003 mg Cd/kg, 0.36 mg Cu/kg, 0.01 mg Pb/kg and 0.97 mg Zn/kg, respectively. In the material collected in Preveza the contents of respective metals were found to reach: 0.002 mg Cd/kg, 0.025 mg Pb/kg, 0.88 mg Zn/kg and 0.29 mg Cu/kg in parsley leaves and 0.038 mg Cd/kg, 0.013 mg Pb/kg, 0.17mg Cu/kg and 1.01 mg Zn/kg in lettuce. Those values, irrespective of region pollution, are considerably lower than those obtained in the present paper. On the area of Turkey, investigations were carried out on samples of seven most often consumed fruits from seven regions of the country [Wójcik, 1997]. The level of lead determined in strawberries accounted for 0.02–0.037 mg Pb/kg and was higher than that obtained in the reported study.

In other countries of the world determined contents of metals are also lower. Delta of Jangcy river is the most industrially and economically developed region of China [Huang *et al*., 2006]. At this area concentrations of metals were analysed in vegetables originating from two regions of an urbanized city of Wuxi, with ca. 400 industrial plants including non-iron metals steelworks, as well as from typically rural Nanjing located far from large urban agglomerations. Lettuce originating from the area not exposed to unfavorable impacts of the environment was found to contain low quantities of metals, i.e. 0.08 mg Cd/kg, 0.00 mg Pb/kg, 0.41mg Cu/kg and 3.19 mg Zn/kg. In the urbanized area, in turn, those values were slightly higher (0.08 mg Cd/kg, 0.07 mg Pb/kg, 1.07 mg Cu/kg, 4.8 mg Zn/kg) and comparable with those obtained in this study in the least contaminated samples.

Low contents of metals in lettuce were also determined in samples originating from Tanzania [Bahemuka & Mufobu, 1999]. In that country agriculture is poorly developed and localized mainly along greater rivers of the country. In experiments carried out by Bahemuka & Mufobu samples of lettuce collected from farms located along rivers Sinza and Msimbazi contained on average 0.004 mg Cd/kg, 0.036 mg Pb/kg, 0.058 mg Cu/kg and 0.159 mg Zn/kg as well as 0.003 mg Cd/kg, 0.038 mg Pb/kg, 0.025 mg Cu/kg and 0.148 mg Zn/kg, respectively.

In Japan, the content of cadmium is precisely monitored in most often consumed products available on the market. In 519 samples of food products from local stores, Kikuchi *et al*. [2002] determined 0.008 mg/kg of cadmium in strawberries, 0.052 mg Cg/kg in parsley leaves and 0.017 mg Cd/kg in lettuce.

Investigations into the content of heavy metals in food products point to its great dependence on the degree of environment pollution. Lower levels of cadmium, lead, zinc and copper are determined in less industrialized regions as well as in countries paying greater attention to environment protection and ecological awareness of inhabitants.

CONCLUSIONS

1. Irrespective of cultivation site, amongst all products analysed the lowest contents of cadmium, lead, zinc and copper were found in strawberries. The highest accumulation of cadmium, zinc and copper was observed in dill, whereas that of lead in lettuce.

2. 56 out of the 64 samples examined met wholesome requirements in respect of levels of cadmium and lead, according to the valid legal regulations. Exceeded permissible levels of cadmium were reported in three samples of dill, whereas those of lead in two samples of lettuce, two samples of dill and one sample of parsley leaves.

3. Significant differences were demonstrated in contents of heavy metals between samples of the same material but originating from various regions. Relatively the lowest content of heavy metals was observed in samples from the region of Opolszczyzna (except for samples of lettuce characterized by the highest contamination with lead). The highest concentrations of cadmium and copper were determined in the material originating from the area of Jastrzębie Zdrój, whereas those of lead and zinc in the samples from Legnica.

4. Levels of the examined products contamination with heavy metals are similar to those assayed in samples from other industrialized regions of the country and usually higher as compared to available literature data referring to contamination of food products with heavy metals world wide.

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ZAWARTOŚĆ KADMU, OŁOWIU, CYNKU I MIEDZI W WYBRANYCH PRODUKTACH ROŚLINNYCH POCHODZĄCYCH Z OGRODÓW DZIAŁKOWYCH RÓŻNYCH MIAST POŁUDNIOWO–ZACHODNIEJ POLSKI

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Zawartość kadmu, ołowiu, cynku i miedzi oznaczono w 64 próbach produktów roślinnych (19 truskawek, 16 naci pietruszki, 16 kopru oraz 13 sałaty). Surowce pobierano bezpośrednio z ogródków działkowych z okolic Opola, Wrocławia, Legnicy i Jastrzębia Zdroju.

Oznaczenie zawartości metali wykonano metodą absorpcyjnej spektrometrii atomowej po uprzedniej mineralizacji prób na „sucho". Oznaczenie kadmu i ołowiu wykonano po uprzedniej ekstrakcji do ketonu MBIK, natomiast cynku i miedzi bezpośrednio z roztworu. Otrzymane wyniki porównano z aktualnymi (Cd, Pb) lub ostatnio obowiązującymi (Zn, Cu) dopuszczalnymi zawartościami metali w badanych produktach.

Zawartość kadmu w badanych produktach kształtowała się w granicach 0,0027 – 0,663 mg/kg. Przekroczenie zawartości dopuszczalnej stwierdzono w trzech próbach kopru. Oznaczone ilości ołowiu wynosiły od 0,0047 mg/kg do 0,588 mg/kg a przekroczenie zawartości dopuszczalnej odnotowano w dwóch próbach kopru i dwóch sałaty oraz jednej naci pietruszki. Poziom cynku w badanych produktach wynosił 0,716 – 34,76 mg/kg. W 14 próbach (3 naci pietruszki, 2 sałaty oraz 9 kopru) wykazano przekroczenie limitów obowiązujących przed rokiem 2004. Zawartość miedzi w surowcach roślinnych wynosiła 0,342 – 17,03 mg/kg. W 7 (3 naci pietruszki i 4 kopru) próbach odnotowano przekroczenie dopuszczalnych ilości Cu obowiązujących przed rokiem 2001.

Największe ilości kadmu i miedzi oznaczono w próbach pochodzących z okolic Jastrzębia Zdroju, natomiast największe ilości ołowiu i cynku w materiale z Legnicy. Stosunkowo najniższe ilości metali oznaczono w próbach z Opolszczyzny.

Na podstawie dostępnych danych literaturowych można stwierdzić, że poziomy zanieczyszczeń badanych produktów metalami ciężkimi są zbliżone do oznaczanych w próbach z innych uprzemysłowionych regionów kraju i wyższe od oznaczanych na świecie.