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Distribution of Cobalt, Lead, and Nickel in Various Vegetables from Kahramanmaraş, Turkey

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Currently, pollution of our agricultural soil and water is increasing and is often associated with many human health ailments. Soils contaminated with low levels of heavy metals and other trace elements are frequently used for growing vegetable crops and in such a situation, these toxic contaminants often accumulate in the edible portions of these agricultural plants and thereby enter the human food chain. The accumulation of heavy metals and metalloids in agricultural soils is of increasing concern due to the food safety issues and potential health risks as well as its detrimental effects on soil ecosystems (McLaughlin et al. 1999). Vegetables constitute essential components of the diet, by contributing protein, vitamins, iron, calcium and other nutrients which are usually in short supply (Thompson and Kelly 1990). They also act as buffering agents for acid substances obtained during the digestion process.

As part of our study, we collected vegetables from Kahramanmaraş of Mediterranean region of Turkey, and determined Co, Ni, and Pb by using graphite furnace unit of atomic absorption spectrometer (Perkin Elmer AA 800). These elements are particularly important because they are not biodegradable and can accumulate in human vital organs, producing progressive toxicity.

MATERIALS AND METHODS

Samples of the edible vegetables (10 of each other) were randomly collected from Kahramanmaraş groceries in January 2004. All vegetables were washed in fresh running water to eliminate dust, dirt, possible parasites or their eggs and then were again washed with deionized water (Zurera et al. 1987).

The edible parts of samples were weighted (5g) and oven-dried at 90°C for 24 h to moisture amount decrease, after 500°C to constant weight dry up. Three selected metals cobalt (Co), lead (Pb), and nickel (Ni) were measured using Perkin Elmer atomic absorption spectrometer (AA800). Solutions containing Co, Ni, and Co ions were obtained by dissolution of ash in 10 ml perchloric acid (60%) and nitric acid (65%) (Merck Darmstadt, Germany).

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The samples containing ash were covered with watch glasses and left overnight. The ash of the samples were measured and filtered by Whatman No 41 filter paper. Co, Ni, and Pb were determined directly in the ash solution after 1/5 dilution with distilled water. The following wavelengths were used for the studied metals: Nickel 232.0nm, cobalt 242.5nm, and lead 283.3nm. Analytical procedures have been described in detail in Analytical methods for atomic absorption spectrophotometer (Perkin-Elmer 1982).

A Perkin-Elmer model AA800 atomic absorption spectrometer equipped with a THGA graphite furnace and AS-100 furnace auto sampler was used for the investigation. Background correction was performed by means of the longitudinal Zeeman Effect. Platform atomization from transversely heated, pyrolytically coated graphite tubes was used. No modifications were made to the recommended temperature program for all the elements measured. Working solutions of each element 100µg/L were prepared daily by appropriate dilution from stock solution (1000mg/L; Custom-Grade Standards, Inorganic Ventures, US). Calibration solutions for each element were prepared from working solutions by furnace auto sampler. In order to validate calibration during measurements after every ten measurements of sample a calibration standard was read and method of standard addition to a honey sample was successfully applied (with 95% or better recovery). Calibration standards and blank were read three times. The samples (vegetable and method blank) were read twice and the mean values and the relative standard deviations were computed.

RESULTS AND DISCUSSION

The mean values of cobalt, nickel, and lead concentrations in the edible vegetables studied are given in Table 1. The concentration of Co in potato was ranging from 0.007 to 0.020 ppm. Ni and Pb in potato were ranging from 0.062 to 0.207 and 0.01 to 0.021 ppm, respectively. The minimum and maximum levels of Co, Ni and Pb in carrot were between 0.0-0.0, 0.0.-0.084, 0.009-0.030 ppm and in spinach were between 0.007- 0.01, 0.094-0.143, 0.005-0.009, respectively.

Nickel levels in the food items were generally higher than the corresponding lead and cobalt levels. But all of the metals that studied were in lower levels.

The variations of the metal contents observed in these vegetables depend on the physical and chemical nature of the soil and absorption capacity of each metal by the plant, which is altered by innumerable environmental and human factors and nature of the plant (Zurera et al. 1989). Principally, there are two major pathways for human exposure to soil contamination: soil-plant-human (food chain pathway) and soil-human (incidental soil ingestion) pathways. In this study, we focus our attention on the food chain pathway.

The standard levels of heavy metals in the vegetable and fruit with acceptable limits for Pb, Ni and Co were 2-13.4, 1-10 and 0.02-0.5 ppm, respectively (Herrick et al. 1990).

The amount of the metals that studied in this work found in the foods studied were generally same or lower than those reported for the vegetables consumed in other parts of the world (Geert et al. 1990; Tahvonen and Kumpulainen 1991; Tripathi et al. 1997; Stalikas et al. 1997; Onianwa et al. 2000; Türkdoğan et al. 2002). The findings of Türkdoğan et al. (2002) suggested that both the volcanic soil and the fruits and vegetables cultivated in Van region possess potential carcinogenic risk factors which may be related to the high prevalence of the regional upper GI cancers. They found that six heavy metals (Co, Cd, Pb, Mn, Ni and Cu) were very significantly higher in the fruits and vegetables.

Lead is a heavy metal found naturally in all parts of the world. It is found in many modern products such as pottery, batteries, and stabilizers for plastics, pigment for inks, electrical accessories and plumbing pipes. Due to the manufacture, utilization and disposal of these products, fine lead particles are released into the environment. Lead particles can enter air, water, soil, dust and food. Toxicity of lead is widely documented. Health hazards of lead include impairment of hearing ability, interference with the red blood cell formation leading to anemia, renal failure, increased frequency of miscarriages and still births. Others include reduced body immune system, low birth weights, premature births, reduced sperm counts and motility, (Goyer 1991; Benowitz and Goldschlager 1998). Fine particles of lead emitted into the environment can travel a long distance, causing pollution far from the source. The most significant pathways of lead exposure is by ingestion of lead painted surfaces, inhalation from automobiles and consumption of lead contaminated foods. It has been reported that traces of Pb can be detected in all plants and foodstuffs (Piscator 1985; Sherlock 1983). Pb concentrations in green vegetables, potatoes and other vegetables are high compared to similar food products from the UK, where levels of 0.01 and 0.02 mg g^{-1}, respectively, were found (Ysart et al. 1999), and also higher than in leafy vegetables and other vegetables from India which had Pb levels of 0.10 and 0.0041 mg g^{-1}, respectively (Tripathi et al. 1997).

One of the most important heavy metal in terms of its potential toxicity to plants and animals is nickel (Bazzaz et al. 1974; Kabata-Pendias and Pendias 1986). Nickel occurs naturally more in vegetables than in animal fesh (Ankle et al. 1993). In very trace amounts it may be beneficial as an activator of some enzyme systems (Underwood 1977), but its toxicity at higher levels is more prominent. It accumulates in the lungs and may cause bronchial haemorrhage or collapse. Other symptoms include nausea, weakness, dizziness, etc. (Nielsen 1977). However, nickel toxicity in humans is not a very common occurrence because the intestinal absorption of nickel is very low, being only about 2.5-6% (Underwood 1977; Bowen 1982). Apart from environmental contamination sources of nickel in foods, the metal may also be derived in foods from processing activities such as drying, cooking and canning in nickel-containing vessels (Underwood 1977; Arvanitoyannis 1990). Leafy vegetables accumulate higher amount of heavy metals like nickel (Ni) due to their more leafy vegetative growth (Sharma and Kansal 1986). In spinach the mean levels of Ni were higher than the corresponding lead and cobalt levels. Mohamed et al. (2003) found Co, Ni, and Pb in potato, carrot and spinach in concentrations of 1.47, 1.41, 1.41-10.74, 17.54, 17.14-2.81, 7.94, 9.44 ppm, respectively.

The level of cobalt in most foods is low. However, food is the largest source of exposure to cobalt in the general population. Food groups contributing most heavily to this intake were bakery goods and cereals (29.8%) and vegetables (21.9%) (Dabeka and McKenzie 1995). People living near mining and smelting facilities or metal shops where cobalt is used in grinding tools may be exposed to higher levels of cobalt in air or soil. Similarly, people living near hazardous waste sites may be exposed to higher levels of cobalt in these media. People who work in the hard metal industry, metal mining, smelting, and refining or other industries that produce or use cobalt and cobalt compounds may be exposed to substantially higher levels of cobalt, mainly from dusts or aerosols in air. Cobalt plays an important role in the metabolism of iron and synthesis of hemoglobin, and it is also a main composition of Vitamin B12 and other biological compounds. Several investigations showed that chronic cobalt deficiency in humans is one of the main risk factors for cardiovascular disease and vitiligo (Qiu 1979; Sun 1984; Zhang, 1996). This has increased the interests cobalt has a low order of toxicity in all species studied, including man. Daily doses of 3 mg Co $^{kg-1}$ body weight may be tolerated by sheep for many weeks without visible toxic effects (Underwood 1977). Nevertheless, ingestion or inhalation of large doses leads to pathological disorders.

In a study of Stalikas et al. (1997), they studied multi element concentrations in vegetables species (carrot, celery, leek, lettuce, onion, parsley, spinach, cauliflower and beet) grown in two typical agricultural areas of Greece. The mean values of contents (µg/g wet wt.) of Co, Ni and Pb in vegetable samples received from Ioannina were 0.041, 0.29, 0.09 and from Preveza were 0.014, 0.31, 0.062 µg/g wet wt, respectively. The results of this study were also higher than our findings.

Table 1. The mean values of cobalt, nickel, and lead concentrations in edible vegetables (ppm).

	mean	max	min	±ss
Ni	0.094			
Carrot (n: 12)	0.052	0.084	0.000	0.002
Potato (n: 12)	0.105	0.207	0.062	0.001
Spinach (n: 12)	0.125	0.143	0.094	0.004
Co	0.006			
Carrot (n: 12)	0.000	0.000	0.000	0.000
Potato (n: 12)	0.014	0.020	0.007	0.001
Spinach (n: 12)	0.004	0.010	0.007	0.000
Pb	0.01			
Carrot (n: 12)	0.008	0.02	0.00	0.000
Potato (n: 12)	0.016	0.021	0.010	0.001
Spinach (n: 12)	0.007	0.009	0.005	0.001

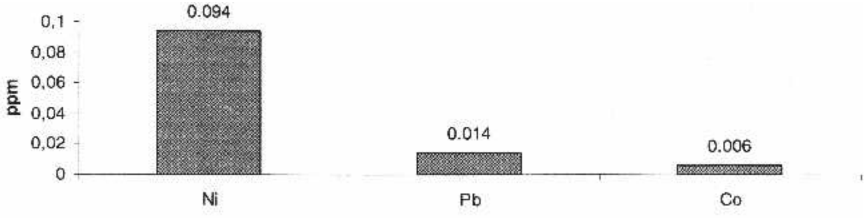

Figure 1. Mean values of nickel, lead and cobalt (ppm) in vegetables.

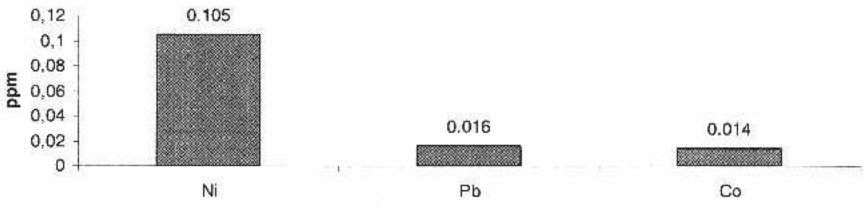

Figure 2. Mean values of nickel, lead and cobalt (ppm) in potatoes.

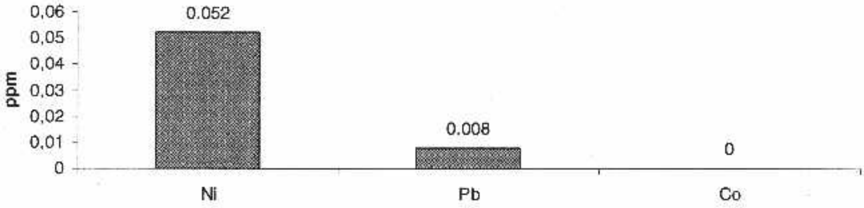

Figure 3. Mean values of nickel, lead and cobalt (ppm) in carrot.

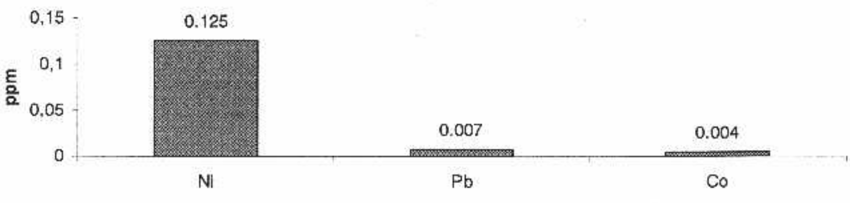

Figure 4. Mean values of nickel, lead and cobalt (ppm) in spinach.

The results of this study indicate that the daily intake of cobalt, nickel, and lead through edible vegetables from Kahramanmaraş city may not constitute a health hazard for consumers because the values are far below the recommended daily intake of these metals.

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