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Lead and Cadmium in Ethiopian Vegetables

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Pollution of the environment by heavy metals, such as lead and cadmium has become recognized as a world-wide public health hazard. The occurrence of environmental contaminants has therefore widely been studied over the last decades, particularly in industrialized regions. Data from developing countries, especially those in Africa, are, however, very scarce (Tumbo-Oeri 1988; Ukhun *et al* 1990; Nriagu 1992). In Ethiopia, one of the poorest countries in sub-Saharan Africa, relevant information is not available at all.

Environmental lead pollution occurs in Africa primarily through traffic emissions. Lead contents in gasoline sold in African countries remained high and are now among the highest world-wide (Nriagu *et al* 1996). Emission of cadmium into the environment can result from incineration of metal scrap, but in African countries, use of phosphate fertilizers, metal plating activities and abrasion from automobile tyres are likely to constitute the main sources. It is well known that vegetables absorb these metals from the soil and atmosphere by dusts deposited on their surfaces (Ndiokwere 1984; Tumbo-Oeri 1988).

The objective of this study was to investigate the lead and cadmium contents of vegetables sold on markets in two Ethiopian cities, the capital Addis Abeba and Gondar in the Nortwestern highlands.

MATERIAL AND METHODS

Fresh vegetables (4 leafy species and carrots; each 5 samples) were purchased ostensibly for consumption from various fruit sellers in the capital Addis Abeba (2.5 million inhabitants), as well as in Gondar, the third largest city (165.000 inhabitants) of Ethiopia. Gondar is situated in the northwestern highlands in an area without industrial activities and very low automobile traffic. The species collected constitute those consumed by the local population. Samples were taken June and July 1994. Vegetables were rinsed twice with tap water, and the outer 3-5 leaves were peeled. Samples were dried in the oven for 36 hours at 95°C. The material was ground and shipped to the lab at the University of Applied Sciences, Bingen, Germany where all analyses were done. Samples were again dried at 95°C and 200 mg of the samples were digested with 5 ml of 0.65% nitric acid

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(Suprapur, Merck, Darmstadt, Germany) in a microwave oven (MWS-1-IR; Berghof, Germany) for 3 hours. Lead and cadmium content of the sample extracts were determined by atomic absorption spectrophotometry (graphite furnace method) using a GBC 906 (Scientific Equipment Pty Ltd) at 283.3mm (Pb) and 228.8mm (Cd). The standard addition method was used, with triplicate determinations for each solution. Blank solutions among 5-groups were analysed. Measurements were made against solutions of concentrations between 5 and 40 ppb Pb and Cd. Reference material (leaves of *Pinus spec.* and *Fagus spec.;* Landesanstalt fuer Umweltschutz, Baden Wurttemberg) were analyzed to determine accuracy and precision of the methods. Statistical analysis was done using the Statistical Analysis System (SAS), Cary, NC. Differences between groups (Addis Abeba vs. Gondar) were tested for significance using the Mann-Whitney-Test.

RESULTS AND DISCUSSION

Lead concentrations ranged from 0.02 to 27.52 mg kg^{-1} in dry weight with a mean of 1.30 mg kg^{-1}, and a median of 0.65 mg kg^{-1} (Table 1). The lowest lead levels were found in carrots and the highest in silver beet, without a difference between the samples from the two cities. Cadmium concentrations ranged from 0.009 to 12.70 mg kg^{-1} with a mean of 0.66 mg kg^{-1}, and a median of 0.12 mg kg^{-1} (Table 2). Highest levels were found in lettuce samples from Addis Abeba. In general, vegetables with soft leaves (kale, lettuce, silver beet) had higher values than others (carrots or cabbage). Most species did not present significant differences in their metal content between samples collected in Addis Abeba and Gondar.
However, lead levels in lettuce from Gondar were significantly higher than in those from Addis Abeba (p = 0.006), as were cadmium levels in carrots from Gondar (p = 0.030), while the high concentrations found in lettuce from Addis was not significantly higher than the one of the samples from Gondar markets

Table 1. Lead in vegetables (mg kg^{-1} dry matter; 5 samples each) sold in markets of 2 cities, Gondar and Addis Abeba, Ethiopia 1994

	Lead (mg kg^{-1} dry weight)							
	Addis Abeba			Gondar			both cities	
	mean	SD*	median	mean	SD*	median	mean	median
cabbage	0.82	0.38	0.74	0.38	0.20	0.32	0.60	0.50
silver beet	1.71	0.50	1.89	6.45	11.78	1.20	4.08	1.52
lettuce	0.25	0.21	0.29	1.78	0.85	2.14	1.02	0.60
kale	0.70	0.21	0.77	0.77	0.21	0.75	0.73	0.76
all**	0.87	0.63	0.76	2.35	5.97	0.83	1.61	0.76
carrots	0.65	0.06	0.04	0.09	0.09	0.12	0.08	0.08
all	0.71	0.65	0.58	1.90	5.39	0.72	1.30	0.65

* standard deviation; ** sum of leafy vegetables

(p=0.072). It has to be taken into account that this cannot be generalized, since the sample size was very small. Local conditions might have been the reason for higher values in some of the samples (e.g. grown near roads).

Our results lie within the range of levels found in unpolluted areas in other countries, but it has to be recognized that values of lead and cadmium in vegetables are very variable (Alegria *et al* 1990; Nriagu 1992; Tumbo-Oeri 1986; Ukhin *et al* 1990). The concentrations of lead and cadmium reported here are generally slightly higher than those reported previously from Kenya, where levels up to 0.18 mg kg^{-1} lead and 0.08 mg kg^{-1} cadmium were found in cabbage and kale ten years ago (Tumbo-Oeri 1986). The source of the metals detected in our samples is unknown. The relatively high levels of cadmium in lettuce samples from Addis Abeba are probably due to the use of fertilizers, while lead contamination of some of the samples is likely to be due to petrol emissions along roadsides.

Table 2. Cadmium content in vegetables (5 samples each) from markets in 2 cities, Addis Abeba and Gondar, Ethiopia 1994.

	Cadmium (mg kg^{-1} dry weight)							
	Addis Abeba			Gondar			both cities	
	mean	SD*	median	mean	SD*	median	mean	median
cabbage	0.03	0.02	0.02	0.03	0.01	0.03	0.03	0.03
silver beet	0.20	0.04	0.21	0.26	0.16	0.20	0.23	0.21
lettuce	4.99	5.26	4.61	0.17	0.06	0.16	2.57	0.23
kale	0.66	0.91	0.18	0.11	007	0.10	0.39	0.13
all**	1.47	3.22	0.18	0.14	0.12	0.11	0.81	0.15
carrots	0.04	0.03	0.04	0.11	0.05	0.12	0.07	0.06
all	1.18	2.93	0.14	0.14	0.11	0.12	0.66	0.12

* standard deviation; ** sum of leafy vegetables

Exposure of consumers and related health risks are usually expressed as percentage intake of provisional tolerable weekly intake (PWTI), a reference value established by the WHO (1993). According to this, the weekly intake of metals from all sources should not exceed 0.05 mg kg^{-1} body weight (bw) and 0.0075 mg kg^{-1} bw for lead and cadmium, respectively. Though this varies certainly very much with the dietary pattern, and our sample size is too small to allow generalization, it can be concluded, that lead and cadmium intake from the analyzed vegetables would supply less than 1% of the PWTI.
However, follow-up studies should be conducted on a broader scale to monitor the bioaccumulation of lead and cadmium in order to evaluate whether any health risks from heavy metal exposure do exist in Ethiopia.

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