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Elements in raw leafy vegetables grown in *wadi* Al-shati (Central Sahara)

R. B. Voegborlo

Environmental Science Dept. Higher Institute of Technology,[a] *PO Box 68, Brack, Libya*

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Twelve leafy vegetables from *wadi* Al-shati in the Central Sahara Desert were analysed for essential and toxic elements by Flame Atomic Absorption and Emission Spectroscopy. Results indicated the following concentration ranges (in per cent on a dry matter basis), sodium 0·055–3·364, potassium 1·611–5·216, calcium 0·384–2·883 and magnesium 0·145–0·747. Copper, iron, manganese and zinc occurred in low amounts compared with the macro-elements. The levels of lead and cadmium in the samples were mostly below levels reported for vegetables from urban areas. It is concluded that the amounts of lead and cadmium in the vegetables tested are unlikely to constitute a significant health hazard to adults.

INTRODUCTION

Plants contain essential and toxic elements over a wide range of concentrations. Currently, industrial emissions to the atmosphere, land disposal of wastes and certain agricultural practices can lead to significant increases in plant elements. While some elements are essential to normal healthy growth, others such as lead, cadmium and mercury are exceptionally toxic and can be tolerated only at extremely low concentrations. The toxic nature of lead and cadmium and the major contribution made to the total body burden of these elements by food consumption are well documented (Browning, 1969; WHO, 1972*a*; Page & Bingham, 1973; Page, 1974; Mahaffey, 1977; DHSS, 1980; Bonner & Bridges, 1983). Available evidence on human exposure to lead indicates that, for the population as a whole, the diet is the most important route of exposure (DHSS, 1980).

Leafy vegetables form a substantial proportion of the diet for most of the peasant population of *wadi* Al-shati—a traditional agricultural oasis settlement in the Central Sahara desert (Libya)—which at present is uncontaminated by industrial activities. Nevertheless, there is little information on elements in the local vegetables. One of the difficulties in solving the food problems of developing countries is the scarcity of reliable data on the nutritional value of local foods (Rand & Young, 1983). Previous studies (Abdelgawad *et al.*, 1984) have reported the concentrations of Mn, Zn, Cu and Fe in several plant species from other parts of the country, but these studies provided only a little information on a few varieties of vegetables.

In this paper, the concentrations of Pb, Cd, Cu, Zn, Fe, Mn, Ca, Mg, Na and K in twelve common vegetables grown in *wadi* Al-shati are reported.

MATERIALS AND METHODS

Sample Preparation

Samples were obtained from peasant farms in the area and individual samples from a farm were bulked (2–3 kg) and transported in plastic bags to the laboratory for processing. Stem ends and stalks were removed and the leaves were carefully washed with deionised distilled water. They were then placed on sheets of paper and left to drain dry at room temperature. The samples were then dried in an oven (Gallenkamp, Model OV-445) at 80°C for 12 h and milled (Hammer mill, Model C680, Glen Creston, Middlesex, UK) to pass a 1·0-mm round-holed sieve. The mill was thoroughly cleaned between samples. The powder was packed in polyethylene bags and stored in a freezer until the analysis could be carried out.

Chemical Analysis

Accurately weighed samples of the powder (4–5 (±0·01) g) were ashed according to Baker *et al.*, (1964). They were preheated in a muffle furnace at 250°C for 2 h, then heated at 450°C overnight. The ash was dissolved in 8 ml of aqua regia (1:3, HNO_3:HCl) with warming, diluted to 25 ml with 5% HNO_3 and analysed for metals by flame atomic absorption spectrophotometry

[a] Present name: Faculty of Engineering and Technology, University of Sebha, PO Box 68, Brack, Libya

(Webber & Beauchamp, 1979) using a Perkin-Elmer Model 2380 AAS. Sodium and potassium were determined with a flame photometer (Beckman, KLiNa Flame). Standards and blanks were also prepared and analysed for each run. The calibration data were subjected to linear regression analysis using a microcomputer and commercial software, and calibration curves were constructed. Standards were prepared from commercial (E. Merck) concentrated standards for atomic absorption spectrophotometry.

All glassware was washed with detergent, soaked overnight in 10% (v/v) nitric acid, rinsed with deionised distilled water and dried before use. All chemical reagents used were of analytical grade (BDH Chemicals Ltd, Poole, England) and deionised distilled water with electrical conductivity of <1·0 $\mu S\ cm^{-1}$ (Ionmiser Model 6C, Houseman, Maidenhead, England) was used exclusively.

RESULTS AND DISCUSSION

The concentrations of the metals determined in the vegetables examined are presented in Table 1. Potassium was the chief metal present in all the vegetables. Lettuce had the highest amount (5·22%) while celery had the lowest (1·61%). Calcium was the next metal with high levels in all the samples. Rocket cress contained the highest value (2·88%) while cabbage contained the lowest (0·38%). Sodium and magnesium levels varied between 0·055 and 3·36% and 0·15 and 0·75% respectively. The variation exhibited by the levels of the metals could be due to differences in the soil composition and different rates of absorption of metals by the plants.

All the vegetables contained low levels of manganese (0·55–9·25 mg per 100 g), copper (0·13–0·63 mg per 100 g), zinc (0·69–2·47 mg per 100 g) and iron (4·74–53·04 mg per 100 g). Among the microelements, iron was predominant and exhibited greater variations between the vegetables. Copper levels were comparatively low, and in some cases lower than lead levels. However, the values for Cu and Zn were lower than those reported by Ndiokwere (1984). Although the irrigation waters of the *wadi* Al-shati area contain higher levels of iron (average: 5·27 mg $litre^{-1}$ and maximum: 16·8 mg $litre^{-1}$; Voegborlo R. B., unpublished data), compared to the coastal part of the country (Abdelgawad *et al.*, 1984) this was not reflected in the level of this metal in the vegetables tested. While data obtained in this study are higher than those reported for similar vegetables by Paul and Southgate (1976), they are generally lower than those reported for some Nigerian leafy vegetables except values of sodium which are significantly higher (Ifon & Basir, 1979).

The levels of Pb (0·06–0·66 mg per 100 g) and Cd (0·03–0·16 mg per 100 g) in the vegetables were generally low when compared with data reported for urban environments. This is expected because *wadi* Al-Shati is a less populated suburban environment with low traffic density and no industrial activities. These values may be considered to be background and the first reported data for the area. They could hence be considered a reference point for estimating the extent of contamination from the metals which is of particular importance when assessing the toxic effects of the metals. Although substantial work has been carried out in Europe and the United States in the field of heavy metal contamination of foodstuffs, data on this subject for the Maghreb and the Mediterranean areas are lacking. However, the lead and cadmium levels obtained in this study were mostly below those reported for vegetable crops grown in metropolitan Boston and Washington DC (Spittler & Feder, 1978; Preer *et al.*, 1980). The lead levels in the vegetables were mostly below the ranges reported for vegetables grown in New York City (Kneip, 1978), and those grown along freeways in southern California (Page *et al.*, 1971). The Cd and Pb levels reported here are also lower than those reported for leafy vegetables and crops collected at distances from a highway in Nigeria (Ndiokwere, 1984). Good agreements were observed when values of Cd and Pb obtained in this study were compared with comprehensive data reported by Fergusson (1991). For Pb, our values were within the range (0·05–6·7 mg per 100 g) reported for vegetables from Ireland. For Cd,

Table 1. Element concentrations in the vegetables

Vegetable	(mg per 100 g dry weight)						(per cent dry weight)			
	Pb	Cd	Cu	Zn	Mn	Fe	Ca	Mg	Na	K
Cabbage	0·34	0·03	0·13	0·69	0·57	4·74	0·384	0·145	0·084	2·933
Cumin	0·48	0·06	0·42	1·23	1·15	10·96	1·235	0·215	1·228	3·486
Dill	0·44	0·04	0·56	1·32	2·95	9·52	1·643	0·194	0·140	4·639
Celery	0·51	0·10	0·23	2·27	2·85	37·34	2·255	0·271	1·483	1·611
Sweet basil	0·46	0·03	0·29	1·01	3·10	53·04	1·054	0·223	0·055	2·644
Coriander	0·31	0·03	0·21	1·57	3·35	14·75	0·906	0·224	0·251	5·078
Chard	0·34	0·06	0·53	1·60	5·63	9·77	0·963	0·747	3·364	4·447
Mint	0·39	0·05	0·63	1·88	9·25	18·07	1·439	0·297	0·116	3·678
Parsley	0·34	0·04	0·54	1·31	3·54	13·40	1·235	0·191	0·242	3·702
Lettuce	0·29	0·04	0·33	2·47	1·34	7·55	0·622	0·177	0·230	5·216
Rocket cress	0·66	0·16	0·23	1·27	4·84	38·24	2·883	0·320	0·737	3·846
Cauliflower	0·06	0·03	0·19	0·84	0·62	3·09	0·435	0·144	0·096	2·861

vegetables from India and Ireland showed a range (0·005–0·06 mg per 100 g) within which our values fell. A similar trend was observed when our values were compared with values (0·02–2 mg per 100 g for Pb and 0·005–0·02 mg per 100 g for Cd) reported for edible plants. (Fergusson, 1991).

Because of the known toxicities of Pb and Cd the World Health Organisation (WHO) established a provisional tolerable weekly intake of 0·4 to 0·5 mg Cd (0·057–0·071 mg per day) and 3 mg Pb (0·429 mg per day) for adults (World Health Organisation, 1972*b*). Though a discussion of Cd and Pb tolerances in the diet is beyond the scope of this paper, it can be concluded from the above information that the content of Pb and Cd in the vegetables is unlikely to constitute a significant health hazard to adults.

Overall, the data presented here show that the vegetables examined in this study can be considered to be useful dietary sources of essential elements.

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