Food Chemistry **38** (1990) 113–118

Mineral Elements in Fresh and Canned Asparagus

G. Zurera-Cosano & R. Moreno-Rojas

Department of Food Hygiene and Technology, University of Cordoba, Medina Azahara 9, 14005 Córdoba, Spain

(Received 18 October 1989; revised version received and accepted 13 November 1989)

ABSTRACT

Six essential elements were determined in fresh and canned asparagus, taken at each step of the canning process, by atomic absorption spectrophotometry, to evaluate the contribution of these vegetables to the daily intake of these elements in Spain. The concentrations of the elements were 225·06 mg/kg, 1·116 mg/kg, 7·761 mg/kg, 731·80 mg/kg, 1·01 mg/kg and 3·455 mg/kg for calcium, copper, iron, magnesium, manganese and zinc, respectively. Concentrations were compared statistically at different stages of the process. The asparagus tip/rest ratio metal concentration was determined, and a greater capacity for concentration of heavy metals was observed in the tip with respect to the rest of the asparagus. From the mean levels of mineral elements obtained, their daily intake contributions were 637·5 μg/day for calcium, 2·33 μg/day for copper, 16·25 μg/day for iron, 190·5 μg/day for magnesium, 2·12 μg/day for manganese and 7·25 μg/day for zinc.

INTRODUCTION

All trace metals are natural constituents of soils, and enter the food chain via plant uptake from soils (Huffman & Hodgson, 1973). In some soils, the metal concentrations are being increased by addition of sewage sludge, some phosphate fertilizers (Schroeder & Balassa, 1963; Williams & David, 1973; Jaakkola *et al.*, 1979) and by other, less obvious sources.

The presence of mineral elements in foodstuffs depends, among other numerous factors, on the technological practices of production and

Food Chemistry 0308-8146/90/$03·50

manufacture (Lopez & Williams, 1985). One characteristic to be desired in food containers is that they should be inert, i.e. that no reactions of interchange between the foodstuff and the container should take place. At present the tinplate used in canned foods is hygienically safe to an acceptable degree, although possibly the solder of the flaps is the most problematical area of the container (Catalá *et al.*, 1977).

The purpose of this study was to determine and compare the concentration of copper, iron, zinc, calcium, magnesium and manganese in fresh and canned asparagus, and to determine the effects of canning operations on the amounts of these elements. At the same time it evaluates the contribution of asparagus to the daily intakes of these elements in Spain.

MATERIALS AND METHODS

Samples

Samples of asparagus were obtained from Egnolac, SA, Palma del Rio (Spain) and processed in our pilot-plant. The asparagus samples were conveyed to the processing line (fresh sample taken) where they were calibrated and classified. After that they were washed (washing sample taken) and peeled (peeled sample taken). They were then blanched by gradual immersion for 1, 2 and 3 min at 70°C (blanch sample taken). The asparagus samples were canned with the addition of brine and citric acid solution at pH 4·5, and the enamel cans were processed for 15 min at 115°C and cooled in water before storing (canned sample taken).

Ten samples were taken at each step of the canning process. The asparagus samples were divided into two portions: portion 1 of tip (1/3 of the total length) and portion 2 of rest of asparagus (2/3 of the total length). Each portion was placed on filter paper to eliminate excess moisture. Once dry, each sample was weighed (20 g) and dried in an oven at 80°C.

Chemical analysis

For analysis of asparagus samples, the technique described by Zurera *et al.* (1987) was followed. One gram of the dried sample was taken and mineralized, subsequently dissolving by mixing the ash with a mixture of $HCl\text{-}HNO_3$ at 50% in a ratio of 1:1 and filtering it on Whatman GF/C paper. The filtered product was placed in a 15 ml volumetric flask making up the level with the acid mixture used.

The determinations were performed with a Perkin-Elmer Model 2380 Atomic Absorption Spectrophotometer. A 10 cm 1-slot burner head and standard air–acetylene flame, and wavelengths of 324·8 nm, 248·3 nm, 213·9 nm, 422·7 nm, 285·2 nm and 279·5 nm for copper, iron, zinc, calcium, magnesium and manganese, respectively, were used. Simple element hollow cathode lamps were used for all elements. The instrument settings and other experimental conditions were in accordance with the manufacturer's specifications. The sensitivity obtained was 0·114 mg/litre, 0·248 mg/litre, 0·022 mg/litre, 0·220 mg/litre, 0·012 mg/litre and 0·034 mg/litre for copper, iron, zinc, calcium, magnesium and manganese, respectively. The mean recoveries for asparagus were Cu = 93%, Fe = 101%, Zn = 98%, Ca = 91%, Mg = 95% and Mn = 98%. For the calculation of the detection limit the criteria of the American Chemical Society (1980) and Mottola (1984) were followed. The concentration limits obtained (minimum concentrations detectable in fresh weight) were 0·023 mg/kg, 0·038 mg/kg, 0·157 mg/kg, 0·562 mg/kg, 0·369 mg/kg and 0·070 mg/kg for copper, iron, zinc, calcium, magnesium and manganese, respectively.

pH measurement

The pH was measured with a Radiometer CRISON Digit 502 pH meter fitted with an INGOLD 406-M4 combined electrode.

Statistical analysis

Data obtained from the chemical analysis of the samples were evaluated statistically using Model 1 and repeated measures analysis of variance (Sokal & Rohlf, 1969).

RESULTS AND DISCUSSION

Results are presented in Table 1. All data obtained from analyses of the asparagus samples are shown at fresh weight. Moisture content of the fresh products was determined to constant weight. The mean moisture content of the fresh asparagus was 92·19% with a standard deviation of $\pm 1·07$.

By means of a two factor analysis of variance, the existence of statistically significant differences in the metal concentration among the sampling points and between the two portions are observed (Table 2). The tip/rest ratio found for the group of samples analyzed is 1·77 for calcium, 1·34 for copper, 1·42 for iron, 1·44 for magnesium, 1·41 for manganese and 1·62 for zinc. It is therefore deduced that there is a greater capacity of concentration in the tip portion in comparison with the rest of the asparagus. The explanation of this higher capacity of concentration in the tip portion has, as yet, no firm

TABLE 1
Mineral Concentrations in Asparagus (Mean ± SD; mg/kg, fresh weight)

Sampling	*pH*	*Ca*	*Cu*	*Fe*	*Mg*	*Mn*	*Zn*
Fresh							
a	5·10	340·21 ± 53·67	1·45 ± 0·28	18·97 ± 6·83	124·44 ± 22·52	1·56 ± 0·31	4·37 ± 0·67
b	5·40	227·49 ± 38·61	0·97 ± 0·12	14·21 ± 3·22	88·33 ± 23·14	1·23 ± 0·27	2·33 ± 0·42
Washed							
a	5·08	269·11 ± 53·90	1·26 ± 0·17	8·19 ± 1·64	108·38 ± 16·40	1·35 ± 0·24	4·49 ± 0·73
b	5·70	148·66 ± 24·47	0·97 ± 0·13	6·84 ± 2·02	73·05 ± 5·47	1·02 ± 0·24	2·56 ± 0·38
Peeled							
a	5·11	230·00 ± 45·95	1·17 ± 0·15	5·74 ± 1·04	105·46 ± 14·83	1·04 ± 0·16	4·08 ± 0·69
b	5·36	130·51 ± 28·56	0·86 ± 0·12	3·55 ± 0·78	58·62 ± 7·68	0·67 ± 0·20	2·46 ± 0·67
Blanched							
a	5·07	241·70 ± 45·92	1·46 ± 0·29	7·79 ± 1·15	123·96 ± 20·60	1·17 ± 0·20	5·06 ± 0·77
b	5·10	156·21 ± 69·21	1·08 ± 0·21	4·00 ± 0·92	83·97 ± 13·84	0·65 ± 0·14	3·18 ± 0·64
Finished							
a	5·05	189·64 ± 14·53	1·03 ± 0·09	4·88 ± 0·60	74·50 ± 7·23	0·77 ± 0·05	3·38 ± 0·18
b	5·07	147·07 ± 10·62	0·87 ± 0·06	3·39 ± 0·34	66·87 ± 5·53	0·61 ± 0·06	2·59 ± 0·13
Total							
a	5·08	288·13 ± 72·11	1·27 ± 0·27	9·12 ± 6·03	107·35 ± 25·00	1·18 ± 0·34	4·28 ± 0·85
b	5·32	161·99 ± 52·00	0·95 ± 0·16	6·40 ± 4·47	74·17 ± 16·97	0·83 ± 0·31	2·62 ± 0·57

a = asparagus tip
b = rest of asparagus

TABLE 2
Determination of Significant Differences of Mineral Concentration (by means of a two-factor variance analysis. ANOVA table)

Source of variation	*Degrees of freedom*	*F values*					
		Ca	*Cu*	*Fe*	*Mg*	*Mn*	*Zn*
Between groups:							
sampling points	4	18·972[a]	9·459[b]	67·59[a]	17·403[a]	32·474[a]	9·689[b]
portions	1	198·592[a]	71·216[a]	23·93[a]	106·716[a]	61·515[a]	185·308[a]
interaction	4	7·862[a]	1·918[d]	1·45[d]	4·358[b]	1·709[d]	3·479[c]
Error	9						
Total	99						

[a] Significant at $p < 0{\cdot}001$.
[b] Significant at $p < 0{\cdot}005$.
[c] Significant at $p < 0{\cdot}05$.
[d] Non-significant at $p > 0{\cdot}05$.

scientific foundation. However, it is believed that it may be related to a greater enzymatic activity at the tip portion level in which there is a greater growth and cellular development when compared to the rest of the asparagus. This different capacity to concentrate metals by different anatomical parts of vegetables has been shown in a previous study (Zurera *et al.*, 1987; Zurera-Cosano *et al.*, 1987, 1988).

From results obtained in each one of the sampling points, a decreasing trend of the metal concentrations is observed. This significant decrease ($p < 0{\cdot}001$) is influenced by the canning operations. Thus, in the mechanical washing process, the diminution of the levels is due to the elimination of particles of soil adhering to the asparagus tissue. In the peeling process the diminution of the levels is due to the elimination of the outer skin of the asparagus. If we make a distinction between the tip and the rest we observe that this reduction is significantly lower ($p < 0{\cdot}001$) for the tip portion than for the rest of the asparagus. This difference is predictable since the tip portion remains almost intact during the peeling process.

However, after blanching, a small increase in the metal concentration levels is observed. This increase might be due to a systematic experimental error, or to contamination by the blanching water, favoured by the temperature of the process, which gives rise to a softening of the tissues and enables the metals to penetrate the asparagus.

In the finished product an important diminution of the mineral levels was observed that may be due to the dilution process which occurs inside the can during the sterilization process and which is favoured by the pH of the citric acid solution. For Lopez *et al.* (1986), these decreases were probably caused by the elements being extracted during washing prior to blanching and/or during thermal processing when mineral elements were leached into the brine.

Daily intakes estimation

Estimates carried out in Spain as regards the average consumption of these products per person/day are 2·1 g of the average food ration of 1387 g (Instituto Nacional de Estadística, 1985). If we take into account the mineral mean levels obtained (255·06 mg/kg, 1·11 mg/kg, 7·76 mg/kg, 90·76 mg/kg, 1·01 mg/kg and 3·45 mg/kg for calcium, copper, iron, magnesium, manganese and zinc, respectively), the contribution of these minerals is 637·5 μg/day for calcium, 2·3 μg/day for copper, 16·2 μg/day for iron, 190·5 μg/day for magnesium, 2·12 μg/day for manganese and 7·25 μg/day for zinc. This means a contribution of 0·08%, 0·16%, 0·05% and 0·04% of the Recommended Dietary Allowances (RDA) (Anon., 1980) for calcium, iron, magnesium and zinc, respectively. These percentages are similar to those contributed by other vegetables (Lopez & Williams, 1985; Lopez *et al.*, 1986).

ACKNOWLEDGEMENTS

The authors express their appreciation to the Direccion General de Extensión e Investigación Agraria for the facilities given for the use of the pilot plant and to Egnolac, SA for supplying the asparagus.

REFERENCES

American Chemical Society (1980). Guidelines for data acquisition and data quality evaluation in environmental chemistry. *Anal. Chem.* **52**, 22–42.

Anon. (1980). Food and Nutrition Board. *Recommended Daily Dietary Allowances.* National Academy of Sciences, National Research Council, Washington, DC.

Catalá, R., Duran, L. & Llacer, J. (1977). Contenido de plomo en conservas vegetales. *Rev. Agroquim. Tecnol. Alimment.*, **17**, 197–208.

Huffman, E. W. D. Jr & Hodgson, J. F. (1973). Distribution of cadmium and zinc/cadmium ratios in crops from 19 states east of the Rocky Mountains. *J. Environ. Qual.*, **2**, 289–91.

Instituto Nacional de Estadística (1985). *Encuesta de presupuestos familiares. Estudio sobre nutricion.* 5 DL, M-32466–85, Madrid, Spain.

Jaakkola, A., Korkman, J. & Koski, T. J. (1979). The effect of cadmium contained in fertilizers on the cadmium content of the vegetables. *J. Sci. Agric. Soc. Finland*, **51**, 158–62.

Lopez, A. & Williams, H. L. (1985). Essential elements and cadmium and lead in fresh, canned and frozen green beans (*Phaseolus vulgaris.* L.). *J. Food Sci.*, **50**, 1152–7.

Lopez, A., Williams, H. L. & Cooler, F. W. (1986). Essential elements and cadmium and lead in fresh and canned peas (*Pisum sativum* L.). *J. Food Sci.*, **51**, 604–7.

Mottola, H. (1984). La cinética en química analítica. In *Metodos Cineticos de Analisis.* Perez y Valcarcel, Córdoba, Spain.

Schroeder, H. A. & Balassa, J. J. (1963). Cadmium: Uptake by vegetable from superphosphate in the soil. *Science*, **140**, 812–20.

Sokal, R. R. & Rohlf, F. J. (1969). *Biometry.* W. H. Freeman and Co., San Francisco, CA.

Williams, C. H. & David, D. J. (1973). The effect of superphosphate on the cadmium content of soil and plant. *Am. J. Soil Res.*, **11**, 43–56.

Zurera, G., Estrada, B., Rincon, F. & Pozo, R. (1987). Lead and cadmium contamination levels in edible vegetables. *Bull. Environ. Contam. Toxicol.*, **38**, 805–12.

Zurera-Cosano, G., Rincon-Leon, F. & Pozo-Lora, R. (1987). Lead and cadmium content of some edible mushrooms. *J. Food Qual.*, **10**, 311–17.

Zurera-Cosano, G., Rincon-Leon, F., Moreno-Rojas, R., Salmeron-Egea, J. & Pozo-Lora, R. (1988). Mercury content in different species of mushrooms grown in Spain. *J. Food Prot.*, **51**, 205–7.