Mineral Composition of Fresh and Home-Canned Tomatoes[1]

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ABSTRACT

Atomic absorption spectrometry was used to analyze fresh and home-canned tomatoes for fourteen essential elements. The elemental content of fresh tomatoes was compared with that of home-canned tomatoes. Amounts of sodium, chloride, calcium, cobalt and nickel were significantly higher in canned tomatoes than in fresh tomatoes. Significantly lower amounts of silicon, phosphorus, potassium and manganese were found in canned tomatoes than in fresh ones. No significative differences in magnesium, iron, copper and zinc were observed between fresh and canned samples. Each element content is compared with the established and estimated Recommended Dietary Allowances (RDA). Comparison shows that fresh tomatoes are a relatively good source of potassium and iron, while only a fair source of sodium and calcium; canned tomatoes are a relatively good source of sodium, potassium and iron. The lowest element retention in the home-canned tomatoes was 65% for manganese and the highest was 7 455% for sodium.

COMPENDIO

Se ha utilizado espectrometría de absorción atómica para analizar el contenido de 14 elementos en tomates frescos y envasados en forma casera. El contenido elemental de los tomates frescos se comparó con el de los tomates envasados. Los valores para sodio, cloruro, calcio, cobalto y níquel fueron significativamente mayores en los tomates envasados. En los mismos se encontraron cantidades significativamente menores de silicio, fósforo, potasio y manganeso que en los tomates frescos. No se detectaron diferencias significativas en manganeso, hierro, cobre y cinc. El contenido de cada elemento se compara con las ingestas recomendadas ya establecidas o estimadas en la literatura. La comparación muestra que los tomates frescos son una buena fuente de hierro y potasio, mientras que son pobres en sodio y calcio; los tomates envasados son una fuente relativamente buena de sodio, hierro y potasio. El elemento que mostró menor retención en los tomates envasados fue el manganeso, con 65% , mientras que la máxima retención fue de 7 455% para el sodio.

INTRODUCTION

The work previously done on determining elements present in tomatoes (*Lycopersicon esculentum*) did not include the effect of the fruit-canning process on the element content of the fruit. Adams (1), Rutherford (17) and Church and Church (5) reported data on sodium, phosphorus, potassium, calcium, iron, cobalt, nickel and copper content in fresh and canned tomatoes. Lopez and Williams (14) compared the content of 16 essential elements in fresh and industrially-canned tomatoes. Using atomic absorption spectophometry, they reported the following values for fresh and canned tomatoes respecitvely: 5.80-26.7 mg/100 g for calcium; 30.0-234.7 mg/100 for chloride; 0.02-0.04 mg/100 g for cobalt; 0.07-0.08 mg/100 g for copper; 0.57-0.61 mg/100 g for iron; 11.3-9.19 mg/100 g for magnesium; 0.13-0.10 mg/100 g for manganese; 0.06-0.12 mg/100 g for nickel; 14.2-11.3 mg/100 g for phosphorus; 214.8-186.3 mg/100 g for potassium; 2.68-2.39 mg/100 g for silicon; 1.85-142.1 mg/100 g for sodium; and 0.17-0.23 mg/100 g for zinc. Lopez and Williams (14) also reported trace amounts of chromium, molybdenum and tin in both fresh and canned tomatoes.

No data are available relating to the effects of home-canning (glass jars) on the elemental composition of tomatoes.

The aim of this research was to evaluate and compare the content of 14 essential elements in fresh and home-canned tomatoes and to determine the influence of the preservation process on the retention of these elements.

Experiment methods

Sampling and sample preparation

The fresh and canned tomatoes were obtained from a farmers' cooperative. The tomatoes were harvested at Río Colorado, Argentina, in February, 1983 and home-canned within a few days of harvesting.

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Tomatoes for processing –only fruit with intense red color and without defects are used in home-canning– were washed with cold water and then dumped into a 10% lye solution at a temperature of 75-90°C for two minutes; then the tomatoes were peeled manually and rinsed with tap water. Tomatoes were placed in boiled 900 cm^2 bottles; 6 g of sodium chloride (common salt) and 1 g salicylic acid (2-hydroxybenzoic acid) were added, and the bottles topped off with tomato juice. The bottles were placed in a boiling water bath for 15 min, then sealed and heated another 15 min in the same water bath.

Five samples of fresh and preserved tomatoes were taken at a time for element analysis; 10 fresh, healthy tomatoes were randomly selected for each fresh tomato sample, while five bottles of tomatoes were mixed to provide each preserved sample. Tomatoes of each fresh sample were peeled and rinsed as described above, homegenized in a blender and aliquot dried at 85°C to constant weight. The same procedure was carried out with the preserved tomato bottles. The dry samples were ground with a mortar and pestle and ashed following the wet ashing procedure according to Simpson and Blay (19). This technique was used for atomic absorption spectrophotometric analysis of all elements except chloride. Quintuplicate 1.00 ± 0.05 g dried fresh and bottled tomato samples were analyzed (14). AOAC Method of Analysis 3067 (AOAC, -4) was used to prepare fresh and canned tomato samples for chloride analysis; triplicate 0.28 ± 0.06 g dried samples were moistened with 20 ml 5% Na_2CO_3 solution, dried at 80°C for 4 hours and ignited at 450°C for 1 hour. After washing and filtering the ash with hot water, the samples were ashed at 450°C overnight. The ash was dissolved in 5 ml of HNO_3 (1 + 4) and diluted to 100 ml in a volumetric flask (14).

Reagents and materials

a. Hydrochloric acid, reagent analytical grade, 37.5% (Merck);

b. Whatman No. 1 filter paper (Fisher);

c. Atomic absorption standards (Fisher);

d. Lanthanum solution: dissolve pure lanthanum oxide (Sigma) in distilled water and hydrochloric acid to obtain a 5% (w/v) solution;

e. Cesium solution: dissolve pure cesium chloride (Baker) in distilled water for a 5% (w/v) solution;

f. Phosphorus standard: dissolve analytical grade potassium dihydrogen phosphate (Sigma) in distilled water to prepare a 500 ppm solution;

g. Reagent for silicon: weigh 5.35 g ammonium chloride (Merck), add 7 ml of 30% ammonium hydroxide (Baker) and dilute to 100 ml with distilled water;

h. Sodium carbonate solution: dissolve 50 g analytical grade sodium carbonate (Merck) in distilled water and dilute to 1 000 ml to obtain a 5% (w/v) solution;

i. Silver nitrate standard (Fisher). Make appropiate dilution to obtain a 100 ppm standard solution;

j. Nitric acid 70% (Erba);

k. 1-pentanol (Merck), reagent grade;

l. Diethyl ether (Fisher), reagent grade.

Analytical procedure

A Perkin-Elmer Model 403 atomic absorption spectrophotometer with a four-inch burner head, standard air-acetylene flame and single element hollow cathode lamps was used to carry out the elemental analysis of the samples. Calibration of the spectrophotometer and setting of all experimental conditions were made in accordance to specifications in the instrument's users' guide.

According to Lopez and Willimas (14), appropiate dilutions were used to determine sodium, magnesium, potassium and calcium in all samples. Dilutions for magnesium and calcium analysis contained 1% (w/v) lanthanum to prevent potential interferences of certain anions, while for sodium and potassium analysis cesium chloride was added to the samples before dilution to obtain a final concentration of 1 000 ppm cesium (14).

Indirect determination, according to the method described by Parker (16), was used to evaluate the chloride content in both fresh and canned samples.

RESULTS AND DISCUSSION

Results are summarized in Tables 1, 2 and 3.

All data are presented on a wet fresh and wet canned basis. The average water content of the fresh tomatoes was 95.83% with a standard deviation of

± 0.21, while the mean moisture content of the bottled tomatoes was 95.33% (standard deviation of ± 0.19).

Table salt is, of course, the best source of sodium. Fresh tomatoes with 1.87-2.23 mg/100 g contain more sodium than other fruits, like apples with 0.87 -0.98 mg/100 g (21), and peaches and pears with 0.65 mg/100 g each (23). Canned tomatoes with 120-175 mg/100 g are a better source of sodium than fresh tomatoes, supplying 16.4% of the estimated RDA. The statistically significant difference ($P < 0.01$) is due to salt addition in the canning procedure, which is also responsible for the retention value of 7 455%. The sodium content of fresh tomatoes was comparable to the values reported by Adams (1) and Furr *et al.* (8). Foods containing less than 25 mg of magnesium/100 g are considered to be a poor source, taking into account that the established RDA value for magnesium is 300-350 mg/day. Fresh tomatoes with 11.25-13.37 mg/100 g and canned tomatoes with 10.98-12.84 mg/100 g supply only 3.51% and 3.33% of the RDA for magnesium, respectively. Compared with apples, with 2.43 -3.20 mg/100 g (22), peaches with 4.88 mg/100 g, apricots with 6.08 mg/100 g, and pears with 5.25 mg/100 g (23), tomatoes are a slightly better source of magnesium. The retention value of 95% shows a decrease in magnesium due to processing. Similar results were reported by Church and Church (5); Leveille *et al.* (13) and Koivistoinen *et al.* (12)

Significant differences ($P < 0.05$) were observed between the silicon content of fresh (1.97-3.14 mg/100 g) and canned (1.83-2.50 mg/100 g) tomatoes. The decreased amount yielded a retention value of 88% for silicon, for which the RDA has not yet been established or estimated.

The amount of phosphorus is reported to be 11.39 -18.97 mg/100 g for fresh tomatoes and 10.03-14.71 mg/100 g for the processed ones. Fresh tomatoes supply 1.93% of the established RDA for phosphorus, while canned tomatoes supply only 1.56% of the RDA, significant decrease of the phosphorus content due to processing, with a retention value of 81%. Similar results –14.2 mg/100 g of phosphorus for fresh tomatoes and 11.3 mg/100 g for canned tomatoes– were reported by Lopez and Williams (14). Compared with apples, supplying 2.5% of the established RDA (22), tomatoes are a fair source of phosphorus.

The amount of chloride is 24.89-35.27 mg/100 g for fresh tomatoes and 203.29-289.77 mg/100 g for canned tomatoes. Chloride significantly increased in the processed samples, with a 824% retention value. The statistically significant difference ($P < 0.01$) is due to sodium chloride utilization in the canning procedure. Allen (2) and Lopez and Williams (14) reported values of 34.0 mg/100 g and 30.0 mg/100 g for chloride in fresh tomatoes respectively. No recommended dietary allowance has been established for chloride.

Table 1.

Element	Fresh (mg/100 g)	Canned (mg/100 g)	Differences[a]
Sodium	2.03 ± 0.18[b]	151.34 ± 29.93	P1
Magnesium	12.40 ± 0.79	11.73 ± 0.58	NS
Silicon	2.47 ± 0.51	2.17 ± 0.30	P5
Phosphorus	15.23 ± 3.80	12.29 ± 2.30	P5
Chloride	30.18 ± 5.21	248.63 ± 40.36	P1
Potassium	204.60 ± 18.39	183.30 ± 16.81	P5
Calcium	6.03 ± 1.13	8.79 ± 1.90	P5
Chromium	< 0.015[c]	< 0.015[c]	NA
Manganese	0.20 ± 0.4	0.13 ± 0.02	P1
Iron	0.61 ± 0.09	0.63 ± 0.10	NS
Cobalt	0.03 ± 0.01	0.04 ± 0.01	P5
Nickel	0.07 ± 0.01	0.07 ± 0.02	P5
Copper	0.08 ± 0.02	0.09 ± 0.02	NS
Zinc	0.19 ± 0.04	0.21 ± 0.05	NS

a Statistical difference in paired "t" test: NA = not applicable; NS = no difference at 1% and 5% level; P5 = significant difference at 5% level; P1 = significant difference at 1% level

b Standard deviation

c Element below detection limit of the atomic absorption spectrophotometer

Table 2

Element	Percentage of retention in canned tomatoes
Sodium	7 455
Magnesium	95
Silicon	88
Phosphorus	81
Chloride	824
Potassium	90
Calcium	146
Chromium	*
Manganese	65
Iron	103
Cobalt	133
Nickel	128
Copper	112
Zinc	111

* Element below detection limit of the atomic absorption spectrophotometer.

Fresh tomatoes are a good source of potassium; many investigators have reported potassium values between 210-245 mg/100 g for fresh tomatoes (13, 14, 15); and values from 186 mg/100 g to 217 mg/100 g in canned tomatoes (1, 5, 14). Fresh tomatoes, with 185.41-221.19 mg/100 g of potassium, are a better source of this element when compared with other fruits like apples with 90.7 mg/100 g, peaches with 154 mg/100 g and pears with 111 mg/100 g (22, 23). Canned tomatoes showed a potassium content of 168.87-200.29 mg/100 g; there was a significant decrease in the potassium content of canned tomatoes due to processing, with a retention value of 90%. Although no RDA has been established for potassium, an amount of 2.5 g/day is considered to be the daily need (10). Fresh tomatoes and canned tomatoes supply about 11% and 9% of the requirement for potassium respectively.

Fresh and canned tomatoes are a relatively poor source of calcium because they supply only 0.73% and 1.07% of the established RDA for calcium (800 mg/day), but show amounts comparable to other fruits such as peaches with 10 mg/100 g, apricots with 12.5 mg/100 g, pears with 14 mg/100 g and apples with 5 mg/100 g (14, 22, 23). Other investigators like Furr *et al.* (7, 8), Koivistoinen *et al.* (12) and Lopez and Williams (14) have reported calcium values of 3.75-10.6 mg/100 g in fresh tomatoes. Calcium values in literature on canned tomatoes have a wide range because many canning procedures involve addition of variable quantities of calcium chloride together with the sodium chloride; canned tomatoes with as much as 26.7 mg/100 g have been reported (22). The chromium content of fresh and canned tomatoes was less than 0.015 mg/100 g, the minimum detection limit of the atomic absorption spectrophotometer. Values of 0.016-0.037 mg/100 g for fresh tomatoes and 0.002-0.004 mg/100 g for canned tomatoes were reported by Thomas, Roughan and Watters (20). With this values the chromium amount in fresh tomatoes is comparable to that reported by Toepfer *et al.* (21) and Cochran, Maxwell and Zucker (6) for apples (0.020-0.027 mg/100 g).

A retention value of 65% reflects the significant decrease in the amount of manganese found in canned tomatoes (0.13 mg/100 g) when compared to that found in fresh tomatoes (0.20 mg/100 g). Manganese contents of 0.10-0.14 mg/100 g were reported by Allen (2), Koivistoinen *et al.* (12), Leveille *et al.* (14) and Lopez and Williams (14) for fresh tomatoes. Compared with apples with 0.03 mg/100 g, citrus fruits with 0.02 mg/100 g, pears with 0.06 mg/100 g and peaches with 0.11 mg/100 g, tomatoes are a better source of manganese. No recommended dietary allowance has been set for manganese, but 5 mg/day is recongnized to be a good amount (NAS, 3).

Table 3

Element	Fresh tomatoes	Canned tomatoes
Sodium	0.22[b]	16.40
Magnesium	3.51[a]	3.33
Silicon	c	c
Phosphorus	1.93[a]	1.56
Chloride	c	c
Potassium	10.19[b]	9.17
Calcium	0.73[a]	1.07
Chromium	d	d
Manganese	4.09[b]	2.66
Iron	6.10[a]	6.28
Cobalt	3.00[b]	4.00
Nickel	c	c
Copper	4.00[b]	4.48
Zinc	1.23[a]	1.37

a RDA as set by Food & Nutrition Board, National Research Council (NAS, 1974). %RDA in 100 g serving for adult male.

b RDA estimated by Sarett (1974).

c RDA not established or estimated.

d Element below detection limit of the atomic absorption spectrophotometer.

One of the richest source of iron is liver with 8 mg/100 g. Fresh tomatoes with 0.51-0.70 mg/100 g and canned tomatoes with 0.53-0.72 mg/100 g, as well as apples with 0.10-0.14 mg/100 g, apricots with 0.42 mg/100 g and pears with 0.22 mg/100 g are all considered to be poor sources (2, 3). No significant difference (retention value of 103%) was observed between the amounts of iron found in fresh and canned tomatoes. These values are comparable with those reported by Lopez and Williams (14), Guthrie (10), Church and Church (5) and Leveille *et al.* (13). The RDA for iron has been established as 10-18 mg/day (NAS, 3); fresh can canned tomatoes supply respectively 6.10% and 6.28% of the established RDA in a 100 g serving.

A significant difference ($P < 0.05$), with a retention value of 133%, was detected between the cobalt content of fresh (0.02-0.04 mg/100 g) and canned (0.03-0.05 mg/100 g) tomatoes. The increase in the canned samples may have originated in some implements used while processing. Similar results were obtained by Lopez and Williams (14), reporting a cobalt content of 0.02 mg/100 g for fresh tomatoes and 0.04 mg/100 g for canned tomatoes. Compared with apples with less than 0.01 mg/100 g (22), tomatoes are a better source of cobalt. RDA for cobalt was estimated by Sarett (18) to be 1 mg/day; with this value, fresh and canned tomatoes supply 3% and 4% of the RDA respectively.

A slight increase was observed in the nickel content –fresh tomatoes with 0.06-0.08 mg/100 g and canned tomatoes with 0.08-0.10 mg/100 g– due to processing. This significant differences ($P < 0.05$) may be attributed to some nickel pick-up from implements during processing, Lopez and Williams (14) found values of 0.06 mg/100 g and 0.12 mg/100 g for nickel content in fresh and canned tomatoes respectively; Thomas, Roughan and Watters (20) reported nickel values of 0.002-0.025 mg/100 g for fresh and 0.004-0.121 mg/100 g for canned tomatoes.

Fresh tomatoes with a copper content of 0.06-0.08 mg/100 g and canned tomatoes with 0.07-0.11 mg/100 g are poor sources of copper, supplying 4.00% and 4.48% of the RDA estimated by Sarett (18) and Guthrie (10) –2 mg/day– respectively. Lopez and Williams (14), Leveille *et al.* (13) and Allen (2) reported similar copper values. Other fruits like apples with 0.04 mg/100 g, pears with 0.063 mg/100 g, apricots with 0.054 mg/100 g and peaches with 0.046 mg/100 g have comparable amounts (23). No significant difference was observed in the amount of zinc in fresch and canned tomatoes. Fresh tomatoes with 0.14-0.22 mg/100 g and canned tomatoes with 0.16-0.25 mg/100 g have more zinc than apples with 0.06 mg/100 g (22) and a comparable amount with peaches –0.20 mg/100 g (15). Comparable amounts of zinc in tomatoes were reported by Lopez and Williams (14), Furr *et al.* (8), Koivistoinen *et al.* (12) and Johnson, Strauss and Evans (11). A RDA value of 10-15 mg/day has been established for zinc. Fresh and canned tomatoes, in 100 g servings, supply about 1.23% and 1.37% of the RDA, respectively.

Sodium, chloride, calcium, cobalt and nickel showed significantly increased values as a result of processing. There were significantly lower amounts of silicon, phosphorus, potassium and manganese in the canned samples as compared to the fresh ones. No significant differences in magnesium, iron, copper and zinc were detected between fresh and canned tomatoes. Chromium was below the detection limit of the atomic absorption spectrophotometer in both fresh and canned tomatoes.

RDAs have been established for five of the fourteen elements determined. Fresh tomatoes supply up to 10.19% (potassium) of the RDAs, while canned tomatoes supply up to 16.40% (sodium). When compared to several other fruits like apples, peaches, pears and apricots, tomatoes have a higher content of most of the essential elements determined.

The results given here for fresh and canned tomatoes are comparable to those cited by Lopez and Williams (13). Any deviations from previous results are probably due to the method of analysis, differences in the canning procedures, and the effect of geographical location.

LITERATURE CITED

1. ADAMS, C.F. 1975. Nutritive Value of American Foods in Common Units. Agriculture Handbook no. 456 USDA, Washington, D.C., USA.

2. ALLEN, J.A. 1947. Dietetics for the Clinician 5th. Ed.

3. NATIONAL ACADEMY OF SCIENCES, NAS. 1974. Food and Nutrition Board: "Recommended Daily Dietary Allowances". National Research Council, Washington, DC, USA.

4. AOAC. 1975. Official Methods of Analysis, 12th. Ed. Washington, DC, USA. Association of Official Analytical Chemists.

5. CHURCH, C.F.; CHURCH, H.N. 1970. Food Values of Portions Commonly Used. Philadelphia, Pa, USA. J.B. Lippincott Co.

6 COAHRAN, D.; MAXWELL, R.C.; ZUCKER, M. 1973. Flow of chromium into apple fruit during development. Plant Physiology 52:84.

7. FURR, A.K.; KELLY, W.C.; BACHE, C.A.; GUTENMANN, W.H.; LISK, D.J. 1976. Multielement uptake by vegetables and millet grown in pots on fly ash-amended soil. Journal Agricultural Food Chemical 24:885

8 FURR, A.K.; KELLY, W.C.; BACHE, C.A.; GUTENMANN, W.H.; LISK, D.J. 1976. Multielement absorption by crops grown in pots on municipal sludge-amended soil. Journal Agricultural Food Chemical 24:889

9. GUTHRIE, H.A. 1971. Introductory Nutrition, 2nd Ed. St. Louis, MO, USA. The C.V. Mosby Co.

10. GUTHRIE, H.A. 1975. Introductory Nutrition, 3rd Ed. St. Louis, MO, USA. The C.V. Mosby Co.

11 JOHNSON, P.E.; STRAUSS, C.; EVANS, G.W. 1977. Metallocaloric ratios for copper, iron and zinc in fruits and vegetables. Nutrition Reports International 15:469.

12. KOIVISTOINEN, P.; AHLSTROM, A.; VARO, P.; NISSINEN, H. 1974. Mineral element composition of Finnish vegetables, fruits and berries. Acta Agricultural Scandinavica 24:131.

13. LEVEILLE, G.A.; BEDFORD, C.L.; KRAUT, C.W.; LEE, Y.C. 1974. Nutrient composition of carrots, tomatoes and red tart cherries. Federation Proceedings 33:2264.

14. LOPEZ, A.; WILLIAMS, H.L. 1981. Essential elements in fresh and canned tomatoes. J. Food Sci. 46:432

15. MURPHY, E.W.; WILLIS, B.W.; WATT, B.K. 1975. Provisional tables on the zinc content of foods. J. Am. Diet. Assoc. 66:345.

16. PARKER, C.R. 1972. Water Analysis by AAS. Springvale, NSW, Australia. Varian Techtron Pty Ltd.

17. Rutherford, J.W. 1983. Private communication.

18. SARETT, H.P. 1974. Nutrients in Processed Foods, Vol. 1, Vitamins, Minerals. Acton, Mass., USA. Publishing Sciences Group, Inc.

19. SIMPSON, G.R.; BLAY, R.A. 1966. Rapid method for the determination of the metals copper, zinc, tin, iron and calcium in foodstuffs by atomic absorption spectroscopy. Food Trade Review 46:35

20. THOMAS, B.; ROUGHAN, J.A.; WATTERS, E.D. 1974. Cobalt, chromium and nichel content of some vegetable foodstuffs. J. Sci. Food Agric. 25:771.

21. TOEPFER, E.E.; MERTZ, W.; ROGINSKI, E.E.; POLANSKY, M.M. 1973. Chromium in foods in relation to biological activity. J. Agric. Food Chem. 21:69

22 UPSHAW, S.C.; LOPEZ, A.; WILLIAMS, H.L. 1978. Essential elements in apples and canned applesauce. J. Food Sci. 43:449.

23 ZUBECKIS, E.; SIRON, G. 1963. Mineral composition of fruit at Vineland, Ontario, Report of the Horticultural Experiment Station and Products Laboratory, Vineland Station, Ontario, Canada.