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Study of the mineral content of chocolate flavoured beverages

Nilva A.R. Pedro [a], E. de Oliveira [b], S. Cadore [a,*]

[a] *Universidade Estadual de Campinas, Instituto de Química, CP 6154, 13084-971, Campinas, SP, Brazil*
[b] *Universidade de São Paulo, Instituto de Química, CP 26077, 05508-900 São Paulo, SP, Brazil*

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Abstract

The concentrations of sodium, potassium, calcium, magnesium, sulfur and phosphorus (major elements) and iron, copper, zinc, selenium, molybdenum, chromium and manganese (minor elements) in chocolate-flavoured beverages from São Paulo State, Brazil, were determined. Different brands of this kind of beverage were analysed after digestion in a microwave oven and the quantification of the elements was done by inductively coupled argon plasma atomic emission spectrometry (ICP OES). Forty-four different samples from 13 different brands were studied, with significant differences in the contents of both major and minor elements formed between and within the different brands. However, it was possible to conclude that the samples analysed are good sources of K, Ca, Mg, S and P, and mainly those whose compositions included powdered milk. On the other hand, chocolate-flavoured beverages are shown to be poor sources of sodium. The data were examined by multivariate analysis with application of the method of pattern recognition (hierarchical grouping or cluster analysis).

Keywords: Chocolate-flavoured beverages; Mineral content; Microwave digestion; ICP OES

1. Introduction

Chocolate is a highly nutritious energy source, with a fast metabolism and good digestibility. The presence of cocoa, milk and sugar in its composition can be the warranty of an appropriate ingestion of proteins, carbohydrates, fats, minerals and vitamins (Campos & Benedet, 1994) but, unfortunately, it is not largely consumed by Brazilian people. Cheaper alternatives, commonly used by both children and adults at breakfast, are chocolate-flavoured beverages, which contain powdered cocoa, milk, sugar and flavour. Some companies also add vitamins, malt, eggs and honey to their products. The powdered mixture is usually ingested as a beverage by the addition of milk, although it may also be used in the preparation of cakes, pies, candies and ice-creams. Although many kinds of these products are commercially available, data about their mineral composition are rare.

The levels of essential minerals that occur in foods may change for many different reasons. Some of the sources of variation are biological, such as variety of plant, different fertilisations of a crop or different feeding principles for animals, as well as seasonal and annual factors. Other factors are related to differences in harvest, storage, and processing (Torelm & Danielsson, 1998). The presence of added components, other than milk, can considerably modify the levels of minerals in these products, since the levels that occur in cows milk depend on a number of factors, such as genetic characteristics, stage of lactation, environmental conditions and types of pasture (Gambelli, Belloni, Ingrao, Pizzoferrato, & Santaroni, 1999).

* Corresponding author. Tel.: +55 19 3788 3125; fax: +55 19 3788 3023.
E-mail address: cadore@iqm.unicamp.br (S. Cadore).

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Adequate ingestion of nutrients is usually assessed by using food composition tables but frequently the available tables are incomplete, old and untrustworthy, due to either the lack of a description of the analytical procedure utilised or to the utilisation of inadequate techniques.

Considering that there are few data on the mineral nutrient composition of chocolate-flavoured beverages consumed in Brazil, the aim of the present study is to obtain further information about the composition of different kinds of chocolate-flavoured beverages.

As the concentration of some species is very low, it is advisable to use sensitive techniques such as inductively coupled plasma atomic emission spectrometry (ICP OES), that allow simultaneous determination of major and minor constituents, without any change in the experimental parameters, as well as providing the desirable sensitivity (Montaser & Golightly, 1992).

Sample preparation is a critical step in quantitative analysis and a methodology is considered adequate if it is fast, reproducible, safe, free of contamination and requires low reagent consumption. Microwave oven-assisted digestion is largely applied for this purpose and has been widely used for food analysis (Sheppard, Heitkemper, & Gaston, 1994; D'Ilio, Alessandrelli, Cresti, Forte, & Caroli, 2002; Dolan & Capar, 2002; Noel, Leblanc, & Guerin, 2003).

In this work, the concentrations of the major elements, Na, K, Ca, Mg, S and P, and of the minor elements, Fe, Cu, Zn, Se, Mo, Cr and Mn, determined by ICP OES in various brands of chocolate flavoured beverages, are reported.

2. Materials and methods

2.1. Instrumentation and reagents

All measurements were made with a Perkin–Elmer Optima 3000 inductively coupled argon plasma atomic emission spectrometer (ICP OES). The instrument was equipped with an echelle-based polychromator with a segmented-array charge-coupled-device detector, a 40 MHz free-running generator (1.3 kW power) and a cross-flow nebulizer. A peristaltic pump was used for transport of the solutions to the nebulizer at a flow rate of 1 ml min^{-1}. The coolant gas flow was 15 l min^{-1} and auxiliary and carrier gas flows were 0.5 and 0.8 l min^{-1}, respectively. Measurements were carried out using the axial mode (except for potassium, which was measured with the radial configuration) with the torch position at 15 mm height and at the most sensitive wavelength (Table 1) for each element as well as the background equivalent concentration (BEC) for the elements studied.

Table 1
Wavelength and limit of detection of the elements studied

Elements	λ (nm)	BEC
Na	330.237	62.50
K	76.491	7.10
Ca	317.933	0.33
Mg	279.079	1.00
S	180.669	0.32
P	213.618	2.56
Fe	238.204	0.15
Cu	324.754	0.18
Zn	213.856	0.06
Se	196.026	2.50
Mo	202.030	0.26
Cr	205.560	0.20
Mn	257.610	0.05

Sample digestions were performed in a programmable focalised microwave oven (Spex, model MX-350).

All reagents were of analytical-reagent grade. De-ionised water was used throughout, supplied by a Milli-Q Plus reagent water system (Millipore Corp., resistivity of 18.2 MΩ cm).

2.2. Samples

The samples were purchased in shops from Campinas, SP. Forty-four samples of chocolate-flavoured beverages were collected, representing 13 different brands. The samples of each brand were acquired in different stores and they were from different lot numbers.

The minerals present in the compositions of these different brands are almost the same but seven brands have powdered milk in their composition, which may significantly alter the content of the studied elements. Table 2 shows the composition of the chocolate-flavour beverage from the 13 different brands analysed in this study. The basic composition is cocoa, sugar, soybean, lecithin, flavour and vitamins and some of them have the addition of maltodextrin, whey and/or powdered milk. For 12 brands, three distinct samples were acquired. Each sample was opened, homogenised and digested on the same day. The whole procedure was done in triplicate. From one brand, eight distinct samples of material were analysed, also in triplicate, to develop a statistical study.

2.3. Analytical method

2.3.1. Microwave sample digestion

The sample treatment procedure was that recommended by the equipment manufacturer: 1.5 g from each sample were weighed and, after digestion with 15 ml of concentrated nitric acid, each sample was submitted to microwave oven heating, corresponding to 30 W for 5 min and then 0 W for 5 min. After the addition of 2 ml of a 30% (v/v) H_2O_2 solution, each sample was treated at 120 W for 5 min. After cooling, the

Table 2
Composition of the studied chocolate flavoured beverages

Brand	Composition
A	Cocoa, sugar, milk, whey, vitamin, maltodextrin, soybean lecithin and flavour
B	cocoa, sugar, skim milk, whey, maltodextrin, soybean lecithin and vanilla flavour
C	cocoa, sugar, vitamin, maltodextrin, soybean lecithin and flavour
D	Maltose, glucose, milk, cocoa, honey, egg, $Ca_3(PO_4)_2$, $CaCl_2$, $NaHCO_3$, Na_2CO_3, vitamin, Fe, Mn and Zn, soybean lecithin, caramel dye and flavour
E	cocoa, sugar, vitamin, maltodextrin, soybean lecithin and flavour
F	cocoa, maltose, sugar, salt, milk, whey, vitamin, soybean lecithin and flavour
G	cocoa, sugar, rice flour, whey, skim milk, vitamin, soybean lecithin and flavour
H	cocoa, sugar, vitamin, maltodextrin, soybean lecithin and flavour
I	cocoa, sugar, soybean lecithin, vitamin and vanilla flavour
J	cocoa, sugar, milk, vitamin, salt, soybean lecithin and flavour
L	cocoa, sugar, milk, soybean lecithin and flavour
M	cocoa, sugar, soybean lecithin and flavour
N	cocoa, sugar, glucose, salt, vitamin, soybean lecithin, cartagena and vanilla flavour

solution was diluted to 25 ml with deionised water and filtered through a quantitative Whatman no. 40 filter, in order to eliminate residues of SiO_2 that may be present in the samples.

2.3.2. Constituents studied

Several constituents, both major and minor, were evaluated in the samples. They were chosen by considering nutritional requirements. Na, K, Ca, Mg, S and P were the major constituents studied, while Fe, Cu, Zn, Se, Mo, Cr and Mn were the minor constituents investigated.

2.4. Method validation

With the aim of verifying the efficiency of the method utilised in this work, the results were compared with those obtained using the dry ash method: 0.6 g of sample was weighed in an analytical balance and heated in a muffle furnace, at 500 °C, until a white ash was obtained. After cooling the material was diluted to 10 ml with 2% (v/v) HNO_3 solution.

2.5. Data treatment

In order to identify the relationship between the samples studied and the data, a multivariate analysis with application of the method of pattern recognition called hierarchical grouping (or cluster analysis) of samples and elements was used. The brands and the elements were analysed by similarity degree or distinction, resulting in a dendogram-type graph, using the method of Ward (Bruns & Faigle, 1985).

3. Results and discussion

The results of the analysis of chocolate-flavoured beverages were treated in two separate parts, one for major mineral components and another for minor constituents. The content of major mineral components is presented in Table 3, which shows the average of the concentration data and the relative standard deviation for the triplicate determinations.

It is notable that this kind of food is an excellent source of potassium and phosphorus and that it also

Table 3
Major element contents (mg/100 g) of chocolate flavoured beverages

Brand	Na	K	Ca	Mg	S	P
A	24.3 ± 2.2	494 ± 35	65.8 ± 5.7	108 ± 13	48.8 ± 21.7	127 ± 4
B	4.9 ± 3.3	464 ± 13	126 ± 2	109 ± 23	86.6 ± 5.1	102 ± 8
C	54.1 ± 8.9	340 ± 9	21.8 ± 2.5	84.6 ± 1.8	29.9 ± 1.3	97.1 ± 1.4
D	85.9 ± 13.9	525 ± 50	254 ± 46	84.4 ± 15.3	66.4 ± 4.7	254 ± 36
E	48.8 ± 4.9	319 ± 2	71.8 ± 0.7	54.8 ± 20.9	248 ± 6	97.5 ± 1.8
F	59.1 ± 10.7	508 ± 167	55.9 ± 30.8	70.0 ± 34.1	56.9 ± 15.8	249 ± 126
G	31.7 ± 0.7	516 ± 67	168 ± 1	60.5 ± 7.7	36.6 ± 6.4	149 ± 13
H	11.3 ± 0.1	404 ± 22	27.7 ± 3.5	60.5 ± 8.3	39.1 ± 8.3	109 ± 2
I	42.8 ± 6.2	437 ± 46	14.7 ± 0.5	69.0 ± 22.2	26.1 ± 1.5	92.1 ± 7.4
J	27.8 ± 1.8	473 ± 1	55.6 ± 0.6	95.9 ± 15.4	53.8 ± 15.6	132 ± 13
L	12.3 ± 2.8	662 ± 65	82.1 ± 1.8	82.4 ± 2.0	69.0 ± 15.2	295 ± 21
M	177 ± 23	134 ± 14	11.6 ± 1.1	36.3 ± 0.1	19.8 ± 1.0	51.7 ± 1.5
N	60.7 ± 2.4	391 ± 17	17.1 ± 1.8	70.2 ± 10.8	37.2 ± 3.8	96.5 ± 8.5

provides an adequate ingestion of calcium, magnesium and sulfur. On the other hand, the sodium content varies greatly (4.9–177 mg/100 g) but, for the majority of brands, the sodium content is low. Brand D seems to be the best source of Ca and, when Na is under consideration, brand M is the best.

As a result of the presence of powdered milk in their composition, brands A, B, D, F, G, J and L showed high levels of K, Ca, Mg, S and P. This was already expected because milk is considered one of the most important foods, supplying all these minerals (Guzmän & Göngora, 1992).

Table 4 shows that this foodstuff also contributes significantly to the intake of the minor constituents considered definitely essential for the human organism. Brand D, for instance, may be classified as an excellent source of Zn and Mn and also as the best source of Fe.

Among the studied chocolate flavoured-beverages, only brand D declares the content of some minerals on its label, allowing us to compare the indicated quantities with the results obtained by ICP OES, after the microwave oven assisted digestion. The declared contents of Ca, P, Fe, Mn and Zn are 480, 480, 7.5, 3.0 and 12 mg/100 g, respectively. The concentrations of Fe, Mn and Zn are in good agreement with the values obtained (9.3, 3.6 and 12 mg/100 g, respectively) while Ca and P showed values low by about 20–30%.

The consumption of this kind of chocolate beverage provides good amounts of both macro and microconstituents, including molybdenum, copper and chromium, that are usually present in dairy foods in very low quantities. According to Brazilian law, the content of chromium found in the samples exceeds the maximum permissible concentration for food, which is 0.1 $\mu g\ g^{-1}$ (Brasil & Leis Decretos, 1965), but, considering the levels of consumption of this beverage, that do not exceed 30 g/day, it cannot be characterised as potentially toxic. On the other hand, according to Tsalev and Zaprianov (1985), some authors recommended a daily dietary allowance of 50–200 μg.

In order to compare the total composition of one of the studied brands, but considering different lots, Tables 5 and 6 show the results for major and minor constituents for brand A. A good agreement may be observed between the replicates for each batch of both major and minor elements, but it is also notable that their concentration varies significantly, especially for lots 4 and 5, showing a lack of homogeneity among the different lots. The diversity of results is marked for K, Ca, P, Fe, Cu, Zn, Se and Mn. In this case, factors such as material origin, genetic variety of cocoa, fertilization process, weather and industrial procedure should be considered, as well as the composition of the added powdered milk that depends on the kind of cattle, their nutrition and the pasture utilised (Lopez-Mahïa, Losada, & Lozano, 1991).

In order to classify the samples, it is possible to use different statistical tools. Even when there is no information about the origin of the samples, it is important to know the similarities among them, allowing an adequate classification. One of the most used techniques is hierarchical grouping (Frank & Kowalski, 1982), that attempts to find two points with the most similarity (smaller distance). These points are then eliminated and replaced by their gravity centre. The similarity matrix is reduced by one dimension and another pair of points with high similarity is searched. This process goes on until most of the data have been placed in a group. Graphically the distances can be represented by a dendogram, that shows a series of lines, each of them representing a parameter under study (a sample, a brand or an element). Ward's method combines those two clusters that reveal, by their combination, the minimum increase in the total error or squared error within the individual groups. It is very difficult to state in advance which of the aggregation methods provides the best clustering

Table 4
Minor element contents (mg/100 g) of chocolate-flavoured beverages

Brand	Fe	Cu	Zn	Se	Mo	Cr	Mn
A	4.64 ± 0.92	0.51 ± 0.07	0.95 ± 0.08	0.43 ± 0.02	0.08 ± 0.02	0.05 ± 0.02	0.51 ± 0.10
B	5.35 ± 0.11	0.45 ± 0.06	0.89 ± 0.08	0.45 ± 0.01	0.08 ± 0.01	0.02 ± 0.01	0.56 ± 0.01
C	6.46 ± 0.98	0.50 ± 0.01	0.84 ± 0.04	0.43 ± 0.02	0.07 ± 0.01	0.06 ± 0.01	0.54 ± 0.06
D	9.30 ± 0.13	0.41 ± 0.09	11.9 ± 0.20	0.45 ± 0.03	0.26 ± 0.03	0.08 ± 0.02	3.59 ± .46
E	6.99 ± 0.22	0.43 ± 0.02	0.86 ± 0.05	0.44 ± 0.02	0.08 ± 0.0	–[a]	0.49 ± 0.01
F	8.15 ± 1.32	0.47 ± 0.20	1.28 ± 0.63	0.76 ± 0.15	0.09 ± 0.01	0.06 ± 0.02	0.82 ± 0.25
G	4.43 ± 0.27	0.36 ± 0.01	0.79 ± 0.11	0.43 ± 0.01	0.09 ± 0.01	[a]	0.71 ± 0.29
H	4.71 ± 0.57	0.45 ± 0.11	1.20 ± 0.37	0.31 ± 0.02	0.03 ± 0.0	0.02 ± 0.00	0.60 ± 0.10
I	5.00 ± 1.09	0.38 ± 0.08	0.70 ± 0.01	0.37 ± 0.04	0.11 ± 0.01	0.03 ± 0.01	0.42 ± 0.02
J	6.06 ± 0.67	0.66 ± 0.13	1.04 ± 0.13	0.39 ± 0.06	0.16 ± 0.06	0.07 ± 0.01	0.72 ± 0.15
L	8.60 ± 1.17	0.66 ± 0.15	1.67 ± 0.38	0.46 ± 0.03	0.07 ± 0.01	0.07 ± 0.0	0.49 ± 0.05
M	5.39 ± 0.19	0.26 ± 0.02	0.39 ± 0.10	0.42 ± 0.01	0.10 ± 0.01	0.04 ± 0.01	0.24 ± 0.01
N	5.13 ± 0.12	0.60 ± 0.14	0.66 ± 0.01	0.41 ± 0.02	0.09 ± 0.01	0.08 ± 0.01	0.48 ± 0.06

[a] <LD.

Table 5
Major element contents (mg/100 g) of individual lots of brand A

Lots	Na	K	Ca	Mg	S	P
1	22.3 ± 0.8	512 ± 6	61.6 ± 2.4	12.7 ± 3.1	88.2 ± 20.5	129 ± 2
2	22.0 ± 0.1	472 ± 5	60.1 ± 1.5	115 ± 1	60.8 ± 5.3	120 ± 1
3	22.6 ± 0.1	432 ± 6	65.5 ± 2.1	69.3 ± 3.2	34.5 ± 2.3	12 ± 9
4	25.6 ± 0.1	799 ± 2	175 ± 4	146 ± 13	86.6 ± 0.4	462 ± 2
5	30.4 ± 0.2	818 ± 5	193 ± 3	149 ± 1	92.0 ± 0.1	463 ± 4
6	32.5 ± 1.7	529 ± 8	76.1 ± 3.9	100 ± 2	35.2 ± 3.3	132 ± 2
7	26.4 ± 0.2	506 ± 10	67.5 ± 2.6	100 ± 2	37.4 ± 3.4	130 ± 2
8	26.8 ± 1.1	513 ± 6	63.9 ± 2.2	95.9 ± 1.2	36.8 ± 3.1	125 ± 1

Table 6
Minor element contents (mg/100 g) of individual lots of brand A

Lots	Fe	Cu	Zn	Se	Mo	Cr	Mn
1	5.74 ± 0.14	0.48 ± 0.02	0.95 ± 0.01	0.42 ± 0.06	0.10 ± 0.01	0.03 ± 0.01	0.43 ± 0.01
2	3.50 ± 0.09	0.40 ± 0.01	0.87 ± 0.10	0.45 ± 0.02	0.09 ± 0.02	[a]	0.35 ± 0.02
3	3.64 ± 0.27	0.48 ± 0.06	1.10 ± 0.07	0.41 ± 0.02	0.09 ± 0.01	0.04 ± 0.01	0.60 ± 0.11
4	9.31 ± 0.26	0.96 ± 0.01	2.49 ± 0.60	0.90 ± 0.05	[a]	0.04 ± 0.01	1.11 ± 0.04
5	9.81 ± 0.01	0.95 ± 0.01	2.01 ± 0.02	0.90 ± 0.09	0.06 ± 0.01	0.06 ± 0.01	1.18 ± 0.01
6	5.12 ± 0.24	0.52 ± 0.02	0.89 ± 0.06	0.47 ± 0.04	0.03 ± 0.01	0.07 ± 0.01	0.61 ± 0.03
7	4.54 ± 0.63	0.60 ± 0.02	0.97 ± 0.04	0.45 ± 0.03	0.06 ± 0.01	0.06 ± 0.01	0.56 ± 0.02
8	5.31 ± 0.21	0.56 ± 0.01	0.89 ± 0.01	0.41 ± 0.03	[a]	0.07 ± 0.01	0.51 ± 0.01

[a] <LD.

of data (Bruns & Faigle, 1985; Kellmer, Mermet, Otto, & Widner, 1998).

In this study, hierarchical grouping has been used in order to establish similarities among the different brands of chocolate flavoured beverages, concerning the mineral content. Fig. 1 shows the similarity among the 13 brands analysed and it is possible to classify them into five groups: one group is constituted of brands A, J, and B with 100% of similarity and by brand G with 98% of similarity with the brands of this group. Another group is constituted of brands I, N, H and C, with 100% of similarity among them and 93% in relation to A, J, B and G; brand E shows 90% of similarity to the brands of these two groups. Brand M shows a similarity of 80% to the previous groups while brands F and L, which have 95% of similarity with brand D, have only 75% of similarity to the other groups.

Brand M, which is isolated and with low degree of similarity to the other brands, shows low levels of Cu, Zn and Mn as well as high levels of K, Ca, Mg, S, P and specially Na, when compared to the other brands.

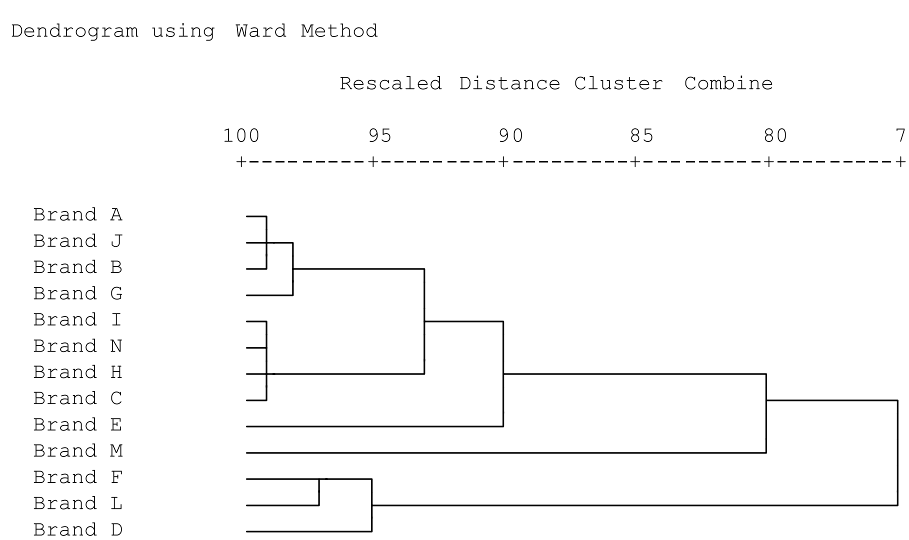

Fig. 1. Dendogram of similarity between chocolate-flavoured beverage brands.

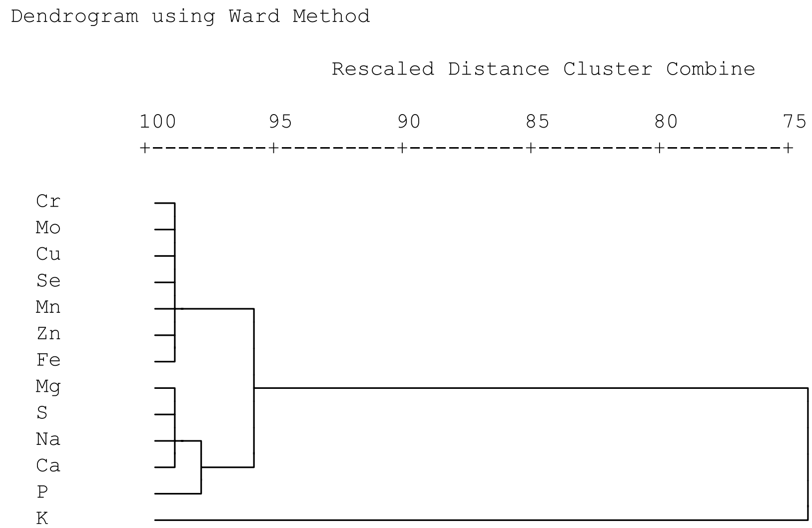

Fig. 2. Dendogram of similarity among the elements studied in chocolate-flavoured beverages.

The major source of Ca, S, P, Fe, Zn and Mn is sample D, which contains eggs, honey, several minerals and malt.

Fig. 2 represents the dendogram of similarity of the constituents studied. One of the groups corresponds to the micronutrients (Cr, Mo, Cu, Se, Mn, Zn and Fe) and it is possible to note that it shows 100% of similarity. The second group, containing Mg, S, Na and Ca, also shows 100% of similarity among its components and is 98% related to P. The similarity between the two groups corresponds to 95%. The element found in all chocolate-flavoured beverages analysed, in the highest concentration, is potassium, which appears isolated and shows only 75% of similarity in relation to the others.

The similarity among the eight lots studied for brand A shows two groups, represented in Fig. 3. The first one contains lots 1, 2, 3, 6, 7 and 8 and has 99% of similarity, while the second shows 99% of similarity between lots 4 and 5 and 75% in relation to the others. This agrees with the data from Table 5, in which the concentrations of K, Ca, P, Fe, Cu, Zn and Mn for these lots are higher than for the others.

Despite the fact that there is no study about the daily intake of chocolate flavoured beverages by Brazilian people, it is reasonable to estimate that it corresponds to 30 g, which is an adequate amount to supply the adequate ingestion of Fe, K, Ca, Mg, P, Cu and Zn considering the recommended dietary allowance (RDA) values (Linder, 1991).

The use of microwave oven-assisted digestion is nowadays largely used for different kind of matrices but the classical methods of sample treatment are still being used all over the world. In order to verify the efficiency and reliability of the described method, a comparison with the dry ash method was made. Table 7 describes the results obtained for three samples and it is possible to note that, according to the precision, both methods are good. Also, agreement among the results obtained for both methods is, in a general way, better than 90%. According to these results, the microwave-assisted wet digestion is recommended, mainly taking in account the time

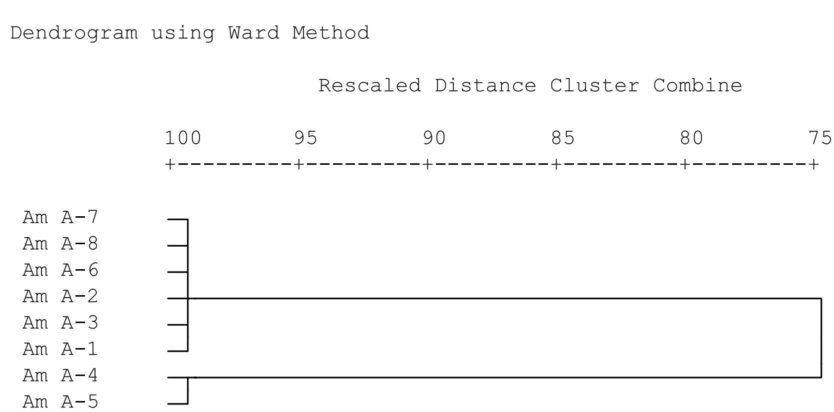

Fig. 3. Dendogram of similarity among different lots of brand A.

Table 7
Comparison between the microwave oven-assisted digestion and dry ash procedure for treatment of samples

Constituents	Sample 1 microwave	Sample 1 ash	Sample 2 microwave	Sample 2 ash	Sample 3 microwave	Sample 3 ash
Na	25.9 ± 0.2	21.8 ± 0.5	66.5 ± 0.7	68.6 ± 2.5	24.6 ± 2.5	27.5 ± 3.4
K	464 ± 4	476 ± 4	547 ± 9	596 ± 16	487 ± 8	481 ± 24
Ca	58.9 ± 2.0	55.3 ± 1.7	270 ± 5	279 ± 4	75.8 ± 5.6	72.5 ± 6.3
Mg	66.3 ± 1.0	66.2 ± 1.2	77.9 ± 2.0	79.1 ± 1.0	112 ± 8	105 ± 8
S	29.1 ± 0.5	27.1 ± 0.8	49.4 ± 0.7	43.9 ± 0.4	49.7 ± 5	50.2 ± 3.5
P	139 ± 3	134 ± 5	288 ± 2	261 ± 2	129 ± 9	124 ± 7
Fe	4.50 ± 0.12	4.24 ± 0.20	9.40 ± 0.02	9.83 ± 0.01	4.76 ± 0.95	4.36 ± 1.56
Cu	0.17 ± 0.02	0.13 ± 0.02	0.16 ± 0.01	0.13 ± 0.01	0.51 ± 0.06	0.53 ± 0.09
Zn	0.76 ± 0.02	0.70 ± 0.03	9.09 ± 0.10	9.53 ± 0.09	0.88 ± 0.09	0.85 ± 0.12
Se	0.25 ± 0.01	[a]	[a]	[a]	0.44 ± 0.03	0.40 ± 0.06
Mo	0.06 ± 0.01	0.04 ± 0.01	[a]	[a]	0.09 ± 0.02	0.08 ± 0.02
Cr	0.07 ± 0.02	0.18 ± 0.01	0.06 ± 0.02	0.06 ± 0.02	0.05 ± 0.01	0.05 ± 0.01
Mn	0.35 ± 0.01	0.34 ± 0.01	1.42 ± 0.05	1.31 ± 0.07	0.55 ± 0.12	0.55 ± 0.12

Concentration in mg/100 g.
[a] <LD.

expended: while 15 min is necessary for the temperature programme used for sample preparation with the microwave oven, the dry ash method requires about 6 h.

4. Conclusion

The determination of the concentration of several species, classified as macro and micro constituents, has been successfully carried out by ICP OES and provides information about mineral nutrients in chocolate flavoured beverages. The results showed a wide range of values for all the elements studied which depend on the brand of the product, but it was possible to confirm that this is an important kind of food for the ingestion of some essential elements.

The agreement between the results obtained by using microwave oven assisted digestion and the dry ash method is quite good, demonstrating the potentiality of the time saving microwave methodology for routine analysis.

This is a pioneer study in Brazil and the information obtained is very important in order to know the content of these elements in a kind of food which is consumed by a large proportion of the population.

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