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Analytical Methods

Determination of metals in soft drinks packed in different materials by ETAAS



Barbara Bruna A. Francisco, Daniel M. Brum, Ricardo J. Cassella *

Departamento de Química Analítica, Universidade Federal Fluminense, Outeiro de Sao João Batista s/n, Centro, Niterói, RJ 24020-141, Brazil

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ABSTRACT

The present work proposes a method for the direct determination of Al, Cu, Cr, Fe and Ni in Brazilian carbonated soft drinks by electrothermal atomic absorption spectrometry (ETAAS). Samples of different flavors packed in containers made of different materials (polyterephthalate ethylene and glass bottles, and aluminum and steel cans) were analyzed. The method was optimized by building up pyrolysis and atomization curves in sample medium and by evaluating the calibration approach. Under optimized conditions, recoveries in the range of 92–104% were obtained in the evaluation of method accuracy. The limits of quantification for Al, Cu, Cr, Fe and Ni were 2.3, 0.93, 0.17, 0.90 and 1.2 $\mu\text{g L}^{-1}$, respectively. Also, the impact of the material used in the packaging and flavor on the concentrations of each metal in the samples was evaluated. It was proved that neither flavor nor packaging material affected the concentrations of Al and Fe in the samples. On the other hand, the packaging material influenced the concentration of Cu, Cr and Ni, and only the flavor affected the concentration of Cu in the samples. These conclusions were based on the data obtained from the application of a two-way ANOVA evaluation at 95% confidence level.

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1. Introduction

Carbonated soft drinks are very popular beverages. Although their regular intake has been associated with human health problems (Heaney & Rafferty, 2001; Malik, Schulze, & Hu, 2006; Wyshak et al., 1989), carbonated soft drinks remain one of the most frequently consumed ready-to-drink beverages in the world. They present particular characteristics such as high sugar content and acidity, and are available on the market in several flavors. In Brazil, the most popular carbonated soft drinks are prepared from guaraná (a typical Amazonian fruit), lemon, grape and orange or are cola-based. Brazilian carbonated soft drinks are sold in four types of packaging: plastic (polyterephthalate ethylene, PET) and glass bottles, and aluminum and steel cans.

The preferred characteristics of a food packaging material is inertness, particularly with respect to interaction with the content (Siegmund, Derler, & Pfannhauser, 2004). Therefore, before a given material is used in the manufacture of packaging, several tests must be performed to evaluate the risk of contaminant migration from the packaging to the foodstuff. In the case of carbonated soft drinks, which are usually acid, this concern is strongly associated

with metals, because they are readily solubilized in an acidic medium.

Several analytical techniques are available for the quality control of foodstuff and the raw materials used to produce them. In the determination of metals in carbonated soft drinks, undoubtedly, atomic spectrometry-based techniques are the most popular (Amorim, Bof, Franco, Silva, & Nascentes, 2006; Castro & Baccan, 2005; García, Cabrera, Sánchez, Lorenzo, & López, 1999; López, Cabrera, Lorenzo, & López, 2002; Nkono & Asubioj, 1997; Onianwa, Adetola, Iwegbue, Ojo, & Tella, 1999). In some cases, samples must be pretreated in order to overcome possible interferences with the measurements. In this context, López et al. (2002) treated soft drinks (5 mL) with 1 mL of concentrated nitric acid and V_2O_5 in order to achieve convenient mineralization of the organic matter. The mineralization process was carried out for 90 min at 120 °C in a digestion block. The resulting solutions were analyzed by ETAAS in order to determine Al content. Aluminum concentrations in the samples varied between 45 and 1683 $\mu\text{g L}^{-1}$. Similarly, García et al. (1999) employed an HNO_3 – V_2O_5 mixture for the digestion of several soft drinks (juices and sodas), aiming at the determination of Cr by ETAAS. Chromium concentration in the samples was in the range of 3.6–60.5 $\mu\text{g L}^{-1}$. In neither case did the authors test direct injection of the samples into the instrument.

* Corresponding author. Tel.: +55 21 2629 2344; fax: +55 21 2629 2143.

E-mail address: cassella@vm.uff.br (R.J. Cassella).

Nkono and Asubioj (1997) investigated Co, Cu, Zn, Cd, Pb, Cr, Se and Ni levels in mineral waters and soft drinks from Nigeria, using the ICP-MS technique. Before introduction of the samples into the spectrometer they were heated at 120 °C with concentrated HNO₃ in order to reduce the influence of the organic matter on the measurements. As regards other types of beverages, Onianwa et al. (1999) also analyzed Nigerian carbonated soft drinks. Eight metals were determined in the samples and the authors concluded that the levels of metals in Nigerian beverages are comparable with those observed in other studies.

Castro and Bacchan (2005) determined Cu in Brazilian guaraná and lemon-based carbonated soft drinks by flame atomic absorption spectrometry (FAAS) after preconcentration of the analyte in Amberlite XAD-2 resin. In order to achieve suitable retention of Cu(II) by the hydrophobic resin, Cu(II) ions were reacted with 1,10-phenantroline and sodium dodecylsulfate (SDS) to form a neutral ion-pair, which presented high affinity with the resin. No consideration was given to the influence of flavor on the total concentration of Cu in the analyzed samples.

Amorim et al. (2006) employed a multivariate strategy for the optimization of instrumental conditions for direct determination of Al in carbonated soft drinks by ETAAS. Only five samples packed in PET bottles (two samples) and aluminum cans (three samples) were analyzed by the optimized method. Results obtained by the authors indicated that the Al concentration in the samples packed in aluminum cans was higher than the Al concentration in the samples packed in PET bottles.

More recently, Froes et al. (2009) tried to classify soft drinks according to the metal content. Thirty-five samples were analyzed by ICP OES and the individual concentrations of Al, Ba, Ca, Cd, Cr, Cu, K, Mg, Na, Ni, Pb, Sn and Zn were used to perform a multivariate analysis of the results. Four groups were identified by the authors, who observed that the classification was related to the nature of the sample. No effect of packaging material on the content of metals in the samples was reported.

Francisco, Caldas, Brum, and Cassella (2010) developed a method for spectrophotometric Al(III) determination in carbonated soft drinks after Al(III) reaction with phenylfluorone in the presence of cetylpyridinium chloride (CPC). Ten samples packed in PET bottles and aluminum cans were analyzed. The authors concluded that there was statistical difference (at the 95% confidence level) between the concentration of Al found in the samples packed

in aluminum cans and the Al concentration found in the other samples.

The goal of the present work was to develop rapid methods for the determination of Al, Fe, Cr, Cu and Ni in carbonated soft drinks using ETAAS. These analytes were chosen because they form part of the packaging materials (Al, Cr and Ni) or are present in the raw products used for carbonated soda drink manufacture (Fe and Cu). Once the method was developed, it was employed for the determination of these metals in 24 samples of carbonated soft drinks commonly sold in Brazil. Samples packed in different packaging (PET and glass bottles and aluminum and steel cans) were tested as well samples of drinks of different flavors (guaraná, cola, grape, orange and lemon). An evaluation of the effect of each of these parameters on the concentration of metals in the beverages was also performed.

2. Experimental

2.1. Apparatus

Integrated absorbance measurements were carried out with a Varian AA240Z graphite furnace atomic absorption spectrometer (Mulgrave, Australia) equipped with a GTA-120 atomization unit, a PSD-120 auto sampler and a longitudinal Zeeman-effect background correction system. The graphite tubes used in this work were manufactured from electrolytic graphite and covered with pyrolytic graphite (Varian, Part. Number 63-100011-00). The atomization was always performed directly from tube walls. The spectrometer was operated with individual hollow cathode lamps for Al, Cr, Cu, Fe and Ni with lamp currents of 10, 4, 7, 5 and 4 mA, respectively. The wavelengths were set at 396.2, 324.8, 357.9, 248.3 and 232.0 nm for Al, Cu, Cr, Fe and Ni, respectively. The spectral resolution was 0.5 nm for Al and Cu, and 0.2 nm for Cr, Fe and Ni. The protective gas used was argon with 99.99% purity (Linde Gases, Macaé, Brazil).

A Unique ultrasonic bath, model USC-1600 (São Paulo, Brazil), with a constant frequency of 40 kHz, was employed to eliminate gases from carbonated soft drinks before analysis.

2.2. Reagents and solutions

All solutions were prepared with high-purity deionized water (18.2 MΩ cm⁻¹ resistivity), obtained from a Direct Q-3 water purification system (Millipore, Bedford, MA, USA). Trace metal grade concentrated nitric acid provided by Tedia (Fairfield, OH, USA) was used to acidify the solutions and the samples.

A 1000 mg L⁻¹ stock solution of Al(III) was provided by Vetec (Rio de Janeiro, Brazil), whereas the 1000 mg L⁻¹ stock solutions of Cu(II), Cr(III), Fe(III) and Ni(II) were furnished by Spectrum (New Brunswick, NJ, USA). The diluted solutions of the analytes were prepared daily by suitable dilution of the stock solutions with a 1% v/v HNO₃ solution.

The samples evaluated in this work were packed in containers made of four different materials: aluminum, steel, glass and plastic. They were purchased in the cities of Niterói/RJ, Brazil, and Fortaleza/CE, Brazil (steel cans). All the samples were carbonated drinks classified as ready-to-drink beverages. Twenty-four carbonated soft drink samples were analyzed, categorized according to their flavor (lemon, orange, grape, guaraná and cola) and packaging type (steel, aluminum, plastic and glass). All samples were purchased and analyzed between 30 and 45 days of the packing date.

The samples were processed before analysis using the following procedure. First, they were transferred to decontaminated low-density polyethylene flasks and concentrated nitric acid was added until the acid concentration achieved 2% v/v. This procedure was

Table 1

Heating program employed for the measurement of metals by ETAAS. Pyrolysis and atomization temperatures are those optimized during the development of the method.

Step	Temperature (°C)	Ramp (s)	Hold (s)	Ar flow rate (mL min ⁻¹)
Drying	50	5	0	300
	120	40	10	300
Pyrolysis	1500 (Al)	1	6	300
	1000 (Cu)			
	1300 (Cr)			
	1400 (Fe)			
	1400 (Ni)			
Atomization	2500 (Al)	1	3	0
	2000 (Cu)			
	2700 (Cr)			
	2300 (Fe)			
	2400 (Ni)			
Cleaning	2600 (Al)	2	0	300
	2100 (Cu)			
	2800 (Cr)			
	2300 (Fe)			
	2500 (Ni)			

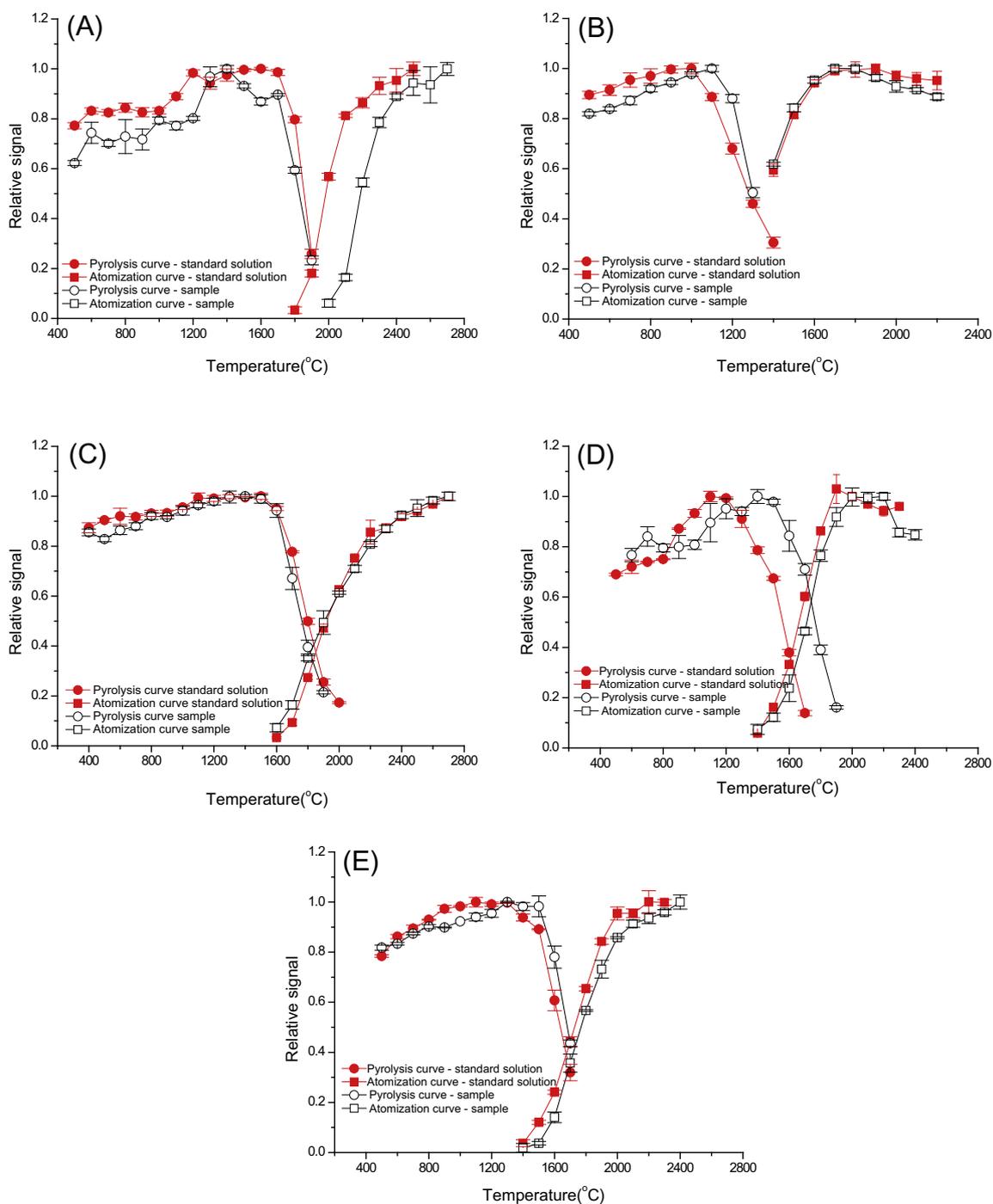


Fig. 1. Pyrolysis and atomization curves for (A) Al, (B) Cu, (C) Cr, (D) Fe and (E) Ni prepared with standard solutions (red lines) and sample medium (black line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 2

Slope ratios obtained in the comparison of standard addition and analytical curves. Details in the text.

Sample	Analyte				
	Al	Cr	Cu	Fe	Ni
Grape	1.00	1.00	1.00	0.97	1.00
Lemon 1	0.97	1.00	1.00	1.00	1.00
Lemon 2	1.11	1.00	1.00	0.98	1.00
Orange	1.00	1.00	1.00	0.98	1.00
Guaraná	1.00	1.00	1.00	0.99	1.00
Cola	0.94	1.00	1.00	0.96	1.00

employed to avoid metallic cations adsorbing to the flask walls. Afterwards, the samples were sonicated in the ultrasonic bath for 1.5 h in order to eliminate the dissolved CO₂.

2.3. Material decontamination

Appropriate quality assurance procedures and precautions were carried out to ensure the reliability of the results. The samples were carefully handled in order to avoid any contamination. All glassware and plastic flasks used in this work were decontaminated by washing with purified water followed by soaking, for 24 h, in a 10% v/v HNO₃ solution. Then, they were rinsed several

Table 3

Analytical features of the developed methods for the determination of metals in carbonated soft drinks by ETAAS.

Parameter	Al	Cu	Cr	Fe	Ni
Working range ($\mu\text{g L}^{-1}$)	0–20	0–50	0–20	0–20	0–50
Typical calibration curve	$A = 0.0035C - 0.0012$	$A = 0.0045C + 0.0161$	$A = 0.0278C + 0.0028$	$A = 0.0106C + 0.0033$	$A = 0.0054C + 0.0093$
r^2	0.9998	0.9994	0.9910	0.9990	0.9983
LOD ($\mu\text{g L}^{-1}$)	0.69	0.28	0.05	0.27	0.36
LOQ ($\mu\text{g L}^{-1}$)	2.3	0.93	0.17	0.90	1.2
Characteristic mass (pg)	25	20	3.1	8.3	16

times with purified water, dried at room temperature in a dust-free environment and stored in a clean place.

2.4. Determination of Al, Cr, Cu, Fe and Ni in soft drink samples for GFAAS

Absorbance measurements were performed by introducing 20 μL of sample (or standard solutions) into a graphite tube and running the appropriate heating program for each metal. Heating programs were established after optimization of pyrolysis and atomization temperatures. No chemical modifier was added in the determination of the analytes in order to minimize blanks and because the Zeeman-based corrector was efficient in correcting background signal even when lower pyrolysis temperatures were employed. The optimized heating programs are listed in Table 1.

2.5. Data handling and statistical methods

The determination of metals in the samples was performed through the independent analysis of three aliquots of the same packaging, using the optimized methods. The Grubbs test was used to identify possible outliers. The influence of each factor (flavor and container material) was evaluated using two-way Analysis of Variance (ANOVA), at 95% confidence level. The calculations were performed with an Excel sheet especially prepared for this purpose.

3. Results and discussion

3.1. Optimization of the heating program

The first step of this work was to establish a proper temperature program for the measurement of each metal in the samples. For this purpose, pyrolysis and atomization curves were built up for each metal by using aqueous standard solutions of the analytes and one sample (S1), which was diluted according to the concentration of each metal to be tested. The drying step of the heating program remained the same when samples or aqueous standards solutions were measured and when different analytes were evaluated. It was set to take into account the vaporization temperature of water and consisted of two parts: (i) when the system was heated from ambient temperature to 50 °C in 5 s; and (ii) when the tube was heated up to 120 °C in 40 s. The second part of the drying step was employed to ensure total vaporization of water contained in the samples (or standard solutions).

The pyrolysis and atomization curves for each metal in each medium are shown in Fig. 1. As can be seen, the thermal behavior of the analytes was very similar both in samples and the aqueous standard solution, despite the presence of a high concentration of sugar in the samples. The most prominent difference was the displacement of the atomization curves of Al and pyrolysis curves of Fe to higher temperatures when the samples were introduced into the graphite tube instead of aqueous standards solutions. This phenomenon can be attributed to the formation of more refractory Al

and Fe compounds inside the graphite cuvette because of the presence of organic and inorganic components of the samples. For the other metals under study, this displacement was negligible.

Pyrolysis and atomization temperatures used in the heating programs were set from the curves prepared in the sample medium in order to simulate the analytical conditions for real samples. Also, it is important to remark that the background signals were always efficiently corrected by the Zeeman effect-based device of the instrument and, for this reason, no tests with chemical modifiers were performed. The pyrolysis temperatures established for the method were 1500, 1000, 1300, 1400 and 1400 °C, for Al, Cu, Cr, Fe and Ni, respectively, and the atomization temperatures were 2500, 2000, 2700, 2300 and 2400 °C, respectively.

3.2. Evaluation of calibration strategy and recovery test

Once the correct heating program was established for the measurement of metals by ETAAS, the identification and evaluation of the correct calibration strategy for the method were performed in order to verify possible interferences, especially those non-specific interferences related to the physical characteristics of the samples.

In order to test for the occurrence of non-specific interferences, analytical curves prepared in acidified water medium (1% v/v HNO_3) were compared with standard addition curves prepared in the diluted sample medium. For this purpose, the six samples packed in plastic bottles were employed for the addition of analytes because it was expected that metal concentrations in these samples would be lower than in the other samples packed in glass, steel or aluminum containers. It is important to remark that, in the case of the construction of standard addition curves, each sample was diluted adequately before being spiked with the analytes. This procedure was especially important in the case of the metals that were found at higher concentrations, such as Al and Fe.

Comparison between standard addition and analytical curves was performed by analysis of the slope ratio, defined as the ratio of $S_{\text{SAD}}/S_{\text{ACU}}$, where S_{SAD} is the slope of the standard addition curve and S_{ACU} is the slope of the analytical curve built up with standard solution prepared in 1% v/v HNO_3 medium. As can be seen in Table 2, the slope ratio varied only between 0.96 and 1.11, indicating that, in the conditions established during method optimization, there were no matrix interferences in the determination of Al, Fe, Cr, Cu and Ni in the samples by ETAAS. This result indicated that all determinations of metals in the other samples could be carried out by the external calibration method.

In order to confirm the result obtained in the evaluation of possible matrix interferences, a recovery test was performed with the samples. For this test, two samples were spiked with different concentrations of the analytes at two levels and analyzed by the proposed method. The recovery percentages were calculated from the differences between the concentrations found for spiked and non-spiked samples. Samples were spiked with 5 and 25 $\mu\text{g L}^{-1}$ of Al(III), Cu(II) and Ni(II), and with 2 and 10 $\mu\text{g L}^{-1}$ of Fe(III) and Cr(III). Recovery percentages between 92% and 104% were observed, evidencing that matrix interferences were not present

Table 4
Results obtained in the determination of 24 samples of Brazilian carbonated soft drinks. Results expressed in $\mu\text{g L}^{-1}$, as mean \pm standard deviation of three independent determinations from the same packaging.

Sample	Flavor	Packaging	Al	Cr	Cu	Fe	Ni
P1	Guaraná	PET	144 \pm 5	0.41 \pm 0.02	<LOQ	187 \pm 5	13 \pm 1
P2	Cola	PET	222 \pm 15	1.0 \pm 0.1	<LOQ	282 \pm 5	<LOQ
P3	Grape	PET	216 \pm 9	0.42 \pm 0.02	9.2 \pm 0.6	398 \pm 8	<LOQ
P4	Orange	PET	215 \pm 12	0.74 \pm 0.04	<LOQ	202 \pm 2	<LOQ
P5	Lemon	PET	136 \pm 8	1.8 \pm 0.1	57 \pm 4	948 \pm 5	<LOQ
P6	Lemon	PET	149 \pm 8	0.43 \pm 0.02	42 \pm 3	271 \pm 3	<LOQ
A1	Guaraná	Al-can	148 \pm 10	2.8 \pm 0.2	2.7 \pm 0.2	453 \pm 12	13 \pm 1
A2	Cola	Al-can	375 \pm 12	2.2 \pm 0.1	2.6 \pm 0.2	934 \pm 21	12 \pm 1
A3	Grape	Al-can	213 \pm 7	2.7 \pm 0.1	8.1 \pm 0.5	1584 \pm 91	<LOQ
A4	Orange	Al-can	235 \pm 14	2.2 \pm 0.2	<LOQ	636 \pm 27	<LOQ
A5	Lemon	Al-can	237 \pm 5	3.4 \pm 0.2	60 \pm 3	1434 \pm 36	<LOQ
A6	Lemon	Al-can	34 \pm 2	2.2 \pm 0.1	32 \pm 2	370 \pm 7	<LOQ
S1	Guaraná	Steel	168 \pm 7	32 \pm 3	6.2 \pm 0.4	301 \pm 17	33 \pm 2
S2	Cola	Steel	121 \pm 3	4.5 \pm 0.4	7.2 \pm 0.5	862 \pm 37	43 \pm 3
S3	Grape	Steel	461 \pm 7	6.0 \pm 0.3	2.5 \pm 0.1	921 \pm 29	22 \pm 2
S4	Orange	Steel	191 \pm 14	3.2 \pm 0.2	14 \pm 1	338 \pm 7	21 \pm 2
S5	Lemon	Steel	292 \pm 14	4.7 \pm 0.4	20 \pm 1	1643 \pm 28	35 \pm 2
S6	Lemon	Steel	302 \pm 24	2.9 \pm 0.2	41 \pm 2	495 \pm 28	37 \pm 2
G1	Guaraná	Glass	200 \pm 10	<LOQ	47 \pm 2	1100 \pm 25	53 \pm 4
G2	Cola	Glass	142 \pm 5	<LOQ	<LOQ	330 \pm 27	40 \pm 2
G3	Grape	Glass	200 \pm 7	5.9 \pm 0.4	72 \pm 4	1687 \pm 76	35 \pm 1
G4	Orange	Glass	129 \pm 7	8.8 \pm 0.7	68 \pm 3	1480 \pm 92	65 \pm 5
G5	Lemon	Glass	181 \pm 8	<LOQ	46 \pm 2	970 \pm 18	53 \pm 3
G6	Lemon	Glass	193 \pm 13	3.4 \pm 0.2	44 \pm 2	1126 \pm 22	16 \pm 1

and that the ETAAS method optimized in this work was accurate for the determination of the metals under study in the samples.

3.3. Analytical features of the methods

The limits of detection (LOD, $\mu\text{g L}^{-1}$) and quantification (LOQ, $\mu\text{g L}^{-1}$) were calculated by using the following equations: $\text{LOD} = 3\sigma/S$ and $\text{LOQ} = 10\sigma/S$, where σ was the standard deviation of 10 blank measurements and S was the slope of the respective analytical curve. Sensitivity was also checked and assessed through the calculation of the characteristic masses, which can be defined as the mass of analyte necessary to achieve 99% transmittance (0.0044 absorbance). Information about the analytical features of the methods is given in Table 3. Precision was calculated from three independent determinations of metals in the samples ($n = 3$), and it was always lower than 8%.

3.4. Determination of metals in the samples

The ETAAS method proposed in this work was applied in the determination of Al, Cr, Cu, Fe and Ni in commercially available carbonated soft drinks. Twenty-four samples of carbonated soft drinks of different flavors (guaraná, cola, grape, orange and lemon) and packed in containers made of different materials were analyzed. The results are shown in Table 4 and Fig. 2.

Some important conclusions can be drawn from the results obtained in this study about the presence (and the migration) of metals in carbonated soft drinks that are kept in contact with different materials such as polyterephthalate ethylene (PET), aluminum, steel and glass. It is important to remark that metallic cans are lined with a thin layer of a polymeric material (Rexan Beverage Can Americas, 2004). Despite this protection, cleaving of the polymeric film always occur during handling of the metallic cans, thus allowing the liquid to come into contact with the metallic material of the recipient.

The concentrations of Fe and Al in the samples were always much higher than the concentrations of Cu, Cr and Ni. This behavior was expected because of the regular presence of Fe and Al in the raw material used in the production of carbonated soft drinks. Also, they are much more abundant and can be easily transferred during

washing and other processes employed in the treatment of empty packaging. It was not possible to distinguish statistically (two-way ANOVA test, 95% confidence level) the concentrations of Fe and Al in the samples of different flavors or in the samples conditioned in packaging of different materials. This probably occurred because the amount of these metals transferred from the surface of the packaging to the drink is much smaller than the amount already present in the drinks.

The same behavior was not verified for Cu, Cr and Ni. For these metals, statistical differences (two-way ANOVA, 95% confidence level) were observed among the concentrations in the samples because of the material used for packaging. Additionally, for Cu, there was a difference caused by the flavor. The lemon-based drinks presented high concentrations of Cu, independently of the packaging material, thus indicating that this metal can be present in high concentrations in the lemon ingredient, possibly because of the characteristics of feedstock employed in their production. Generally, it was possible to observe that carbonated soft drinks packed in PET bottles contained smaller concentrations of Cu, Cr and Ni, probably because of the very low concentration of these metals in their own packaging. This could also indicate that part of the Cu, Cr and Ni present in the samples packed with other materials was caused by the leaching of the packaging. This process was enhanced because of the pH of samples, which was in the range of 2.9–3.5.

Chromium and nickel were found in all samples stored in steel cans. This finding indicated that carbonated drinks are able to extract metals from the packaging at significant extension, since Cr and Ni are present in the composition of the steel used in the manufacture of the packaging. According to the Companhia Siderúrgica Nacional (National Steel Company of Brazil, CSN), which is responsible for the production of steel sheets used in the manufacture of cans, the proportion of Cr and Ni in the steel is 0.20% and 0.15%, respectively.

It is important to highlight that elevated concentrations of Cu and Ni were found in almost all samples packed in glass bottles. According to Dantas (2007), although glass is more resistant to acid than to basic solutions, glass walls suffer noticeable weathering when in contact with acid solutions such as carbonated soft drinks.

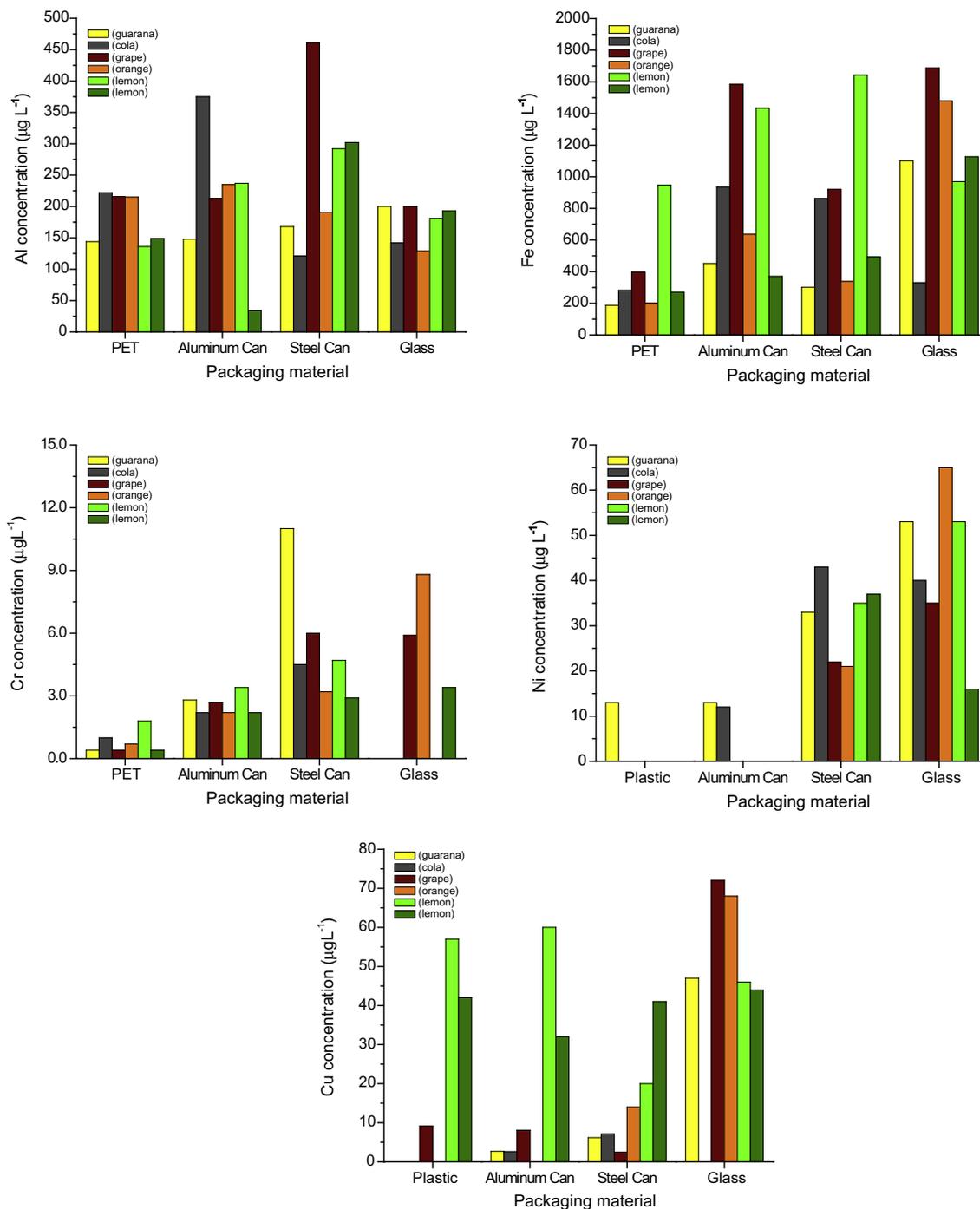


Fig. 2. Concentrations of Al, Cu, Cr, Fe and Ni in the samples analyzed in this work.

The intensity of this phenomenon can vary with the contact time, glass surface area and the volume of liquid (Janetti & Jaime, 2010).

4. Conclusions

The results obtained in this work showed that is possible to determine Al, Fe, Cu, Cr and Ni in carbonated soft drinks by ETAAS after minimum treatment of samples (dilution). The thermal behavior of the analytes in the diluted samples was very similar to that observed in standard solutions, except for Al and Fe, which presented a small displacement of atomization and

pyrolysis optimum temperatures, probably because of the formation of more refractory species inside the graphite tube.

The limits of quantification were good enough to allow the determination of the metals of interest in almost all 24 samples utilized in the study. Calibration could be performed by an external approach with standard solutions prepared in 1% v/v HNO_3 medium, which made the procedure simple and fast.

As mentioned previously, 24 samples of carbonated soft drinks of different flavors and conditioned in different packing materials were analyzed. The effect of both flavor and packaging material on the concentration of the analytes in the drinks was evaluated. For Al and Fe, no evidence that these variables influence their

concentration in the samples was found. On the other hand, it seems that for Cu, Cr and Ni, the effect of packaging material is significant, indicating that some migration of metals can occur from the packaging to the liquid. The acid characteristic of the samples could be responsible for this process. Additionally, lemon-based soft drinks presented higher Cu concentration than other samples, which can be attributed to the presence of this metal in the initial raw materials used in their production.

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