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Evaluation of inorganic elements in cat's claw teas using ICP OES and GF AAS

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ABSTRACT

The determination of Ba, Ca, Cu, Fe, Mg, Mn, P, Pb, and Zn by inductively coupled plasma optical emission spectrometry (ICP OES), and Se by graphite furnace atomic absorption spectrometry (GF AAS), has been carried out in dry matter and teas from 11 samples of the cat's claw plant. The accuracy and precision values were verified against GBW 07604 (Poplar leaves) certified reference material and by the recovery test. Results showed a high content of Ca in the medicinal plant studied, followed by Mg and P. The values obtained showed that the elements studied have different concentrations depending on the method of tea preparation. The highest levels were observed in Ca and Mg, and the lowest for Se and Pb, by both infusion and decoction. Teas prepared from this plant were found to be at safe levels for human consumption, and may be suitable as sources of these elements in the human diet.

1. Introduction

The use of herbal medicines to relieve and treat many diseases has increased worldwide due to herbal medicine's mild features and low collateral effects (Başgel & Erdemoğlu, 2006). Medicinal plants play a major role in absorbing a number of essential elements in human nutrition (Nkono & Asubiojo, 1997).

Cat's claw plant is a plant from South and Central America, which has become relatively popular in many countries, because of its proven immunostimulatory and anti-inflammatory activities as well as its anti-cancer and antioxidant properties. The two most common species of cat's claw are *Uncaria tomentosa* and *Uncaria guianensis*. The main characteristic of these species, typical of tropical regions, is the thorns, which are in the shape of a cat's claw. Cat's claw (*U. guianensis*) is a creeping plant, which has difficulty climbing trees, because its thorns have curves, in the shape of the ram's horn (Shanley, Serra, & Medina, 2010). This species predominate in northern Brazil. The bark, roots and leaves of this plant are commonly used to make teas. Teas of this plant are used in popular medicine to treat various health problems, including rheumatism, arthritis, gastrointestinal disorders, viral infections and cancer (Heitzman, Neto, Winiarz, Vaisberg, & Hammond, 2005).

Tea is one of the most popular beverages around the world, after water. Studies have shown that tea consumption has beneficial health effects (Al-Oud, 2003). The consumption of tea is associated with a decrease in serum cholesterol, of inhibiting the oxidation of low density lipoproteins, decreased risk of cardiovascular disease and cancer (Chung, Schwartz, Herzog, & Yang, 2003). In tea also exist other compounds that are beneficial for human health such as fluoride, caffeine, catechins, flavonoids, and various minerals (Cabrera, Giménez, & López, 2003). Han, Zhao, Shi, Ma, and Ruan (2006) showed that the presence of trace elements in teas is because plants are usually grown in acidic soils where trace elements are most bioavailable to potential root absorption. Bioavailability of the elements depends on the composition of the soil (Pytlakowska, Kita, Janoska, Połowniak, & Kozik, 2012). Plants absorb trace elements through their roots. The rain, atmospheric dust, plant protection products, and fertilizers can also be sources of various elements for plants, which can be absorbed through the leaves (Łozak, Sołtyk, Ostapczuk, & Fijałek, 2002).

The study of the concentration of chemical elements in plants and teas it is important to evaluate their toxicological and nutritional values. Copper, for example, is mostly present in the soil in the form of Cu^{2+}, the form in which it is absorbed by plants, which performs the functions of protein synthesis, carbohydrate metabolism and symbiotic nitrogen fixation (Sodré & Lenzi, 2001). It is an important element in the process of biological transfer of electrons, and also is vital for the synthesis of red blood cells and the main-

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tenance of the structure and function of the nervous system (Dabbaghmanesh, Salehi, Siadatan, & Omrani, 2011).

Many studies have been carried out to determine the levels of trace elements in plants and teas using flame atomic absorption spectrometry (FAAS) (Amarante, Silva, Müller, & Müller, 2011; Dambiec, Polechońska, & Klink, 2013; Diniz, Dantas Filho, Müller, Fernandes, & Palheta, 2013; Paz-Rodríguez, Domínguez-González, Aboal-Somoza, & Bermejo-Barrera, 2015), graphite furnace atomic absorption spectrometry (GF AAS) (Kaličanin & Velimirović, 2013), inductively coupled plasma optical emission spectrometry (ICP OES) (Al-Oud, 2003; Başgel & Erdemoğlu, 2006; Froes, Borges Neto, Beinner, Nascentes, & Silva, 2014; Pytlakowska et al., 2012; Szymczycha-Madeja, Welna, & Pohl, 2014, 2015; Szymczycha-Madeja, Welna, & Zyrnicki, 2013), inductively coupled plasma-mass spectrometry (ICP-MS) (Milani, Morgano, Saron, Silva, & Cadore, 2015; Tokalıoğlu, 2012) and neutron activation analysis (NAA) (Mahani & Maragheh, 2011).

The purpose of this study was to investigate the levels of Ba, Ca, Cu, Fe, Mg, Mn, P, Pb, Se and Zn in the cat's claw plant and its teas, prepared via two different methods (infusion and decoction), to better understand its nutritional value and verify that it can be consumed without risk to human health.

2. Materials and methods

2.1. Instrumentation

The determinations of total concentration of Se in the plant digests and teas were carried out using a Varian Spectra AA 240Z atomic absorption spectrometer (Mulgrave, Victoria, Australia) equipped with a transverse Zeeman Effect background corrector and a longitudinal-heated graphite furnace atomizer. A selenium hollow cathode lamp was employed as a radiation source, operating at 8 mA. Absorbance signals were measured using the 196.0 nm line at a spectral resolution of 0.2 nm. All measurements were based on integrated absorbance. Argon (99.999% pure, Linde Gases, Ananindeua, PA, Brazil) was used as the purging gas (3.0 L min^{-1}) during all steps of the graphite furnace heating program, except atomization. The temperature program used for determination of Se is shown in Table 1.

An inductively coupled plasma optical emission spectrometry model iCAP 6500 (Thermo Fisher Scientific, Cambridge, England), with dual configuration (axial and radial) and operational software iTEVA was used for simultaneous multi-element determination of Ba, Ca, Cu, Fe, Mg, Mn, P, Pb, and Zn in plant digests and teas. Operating parameters were as follows: 1.15 kW of a RF power, 12 L min^{-1} of a plasma flow rate, 0.5 L min^{-1} of an auxiliary gas flow rate and 0.5 L min^{-1} of a nebulizer flow rate. Sample solutions were introduced into the plasma using a Concentric nebulizer and a Cyclonic type spray chamber. Analytical lines of Ba II 493.409 nm, Ca II 396.847 nm, Cu II 224.700 nm, Fe II 238.204 nm, Mg I 285.213 nm, Mn II 257.610 nm, P I 185.942 nm, Pb II 182.205 nm and Zn I 213.856 nm were measured. Argon (99.999% pure, Linde Gases, Ananindeua, PA, Brazil) was used to purge the optics and to form the plasma.

Table 1
GF AAS temperature program for determination of total selenium.

Step	Temperature (°C)	Time (s) (ramp, hold)	Ar flow rate (L min^{-1})
$Drying_1$	95	2, 10	3.0
$Drying_2$	120	10, 40	3.0
Ashing	1000	5, 10	3.0
Atomization	2000	0.8, 2	0
Cleaning	2400	1, 3	3.0

The acid digestion of samples was performed in a microwave oven, Start E (Milestone, Sorisole, Italy). A cryogenic mill, SPEX SamplePrep model 6770 (Metuchen, NJ, USA), was used for grinding cat's claw plant.

2.2. Reagents, solutions and samples

All reagents used were analytical grade. All dilutions were made using ultrapure water (resistivity 18.2 MΩ cm^{-1}) obtained from a Synergy-UV water purification system (Millipore, Bedford, USA). All glassware and plastic bottles used was previously decontaminated by immersion in a 10% (v v^{-1}) HNO_3 solution for 24 h and rinsed with distilled-deionized water before use.

All solutions and samples were stored in decontaminated polyethylene vials.

Nitric acid (Sigma–Aldrich, Steinheim, Germany), previously purified using a sub-boiling distillation system (Berghof, model BSP 929-IR, Germany) and H_2O_2 30% m m^{-1} (Impex, Brazil), was used to digest the samples.

Standard solutions for calibration were prepared by suitable dilution of the stock solutions containing 1000 mg L^{-1} (Sigma, USA): 1.0–5.0 mg L^{-1} for Ba and Pb and 2.0–10.0 mg L^{-1} for Ca, Cu, Fe, Mg, Mn, P and Zn in 5.0% (v v^{-1}) nitric acid.

A stock solution containing 1000 mg L^{-1} of selenium (Sigma, USA) was used for the preparation of the analytical curve, in 0.028 mol L^{-1} HNO_3.

$Pd(NO_3)_2$ and $Mg(NO_3)_2$ (Sigma, USA) were used as chemical modifiers.

The certified reference material GBW 07604 Poplar leaves (CRMs, Beijing, China) was used for accuracy of the method by ICP OES.

Eleven samples were studied in the experiment. The samples were acquired in herbal shops, the market Ver-o-Peso and at Embrapa Amazonia Oriental in Belém-PA. Different parts of the plant were obtained: bark (samples 1, 2 and 4), capsule (sample 3), liana (samples 5, 6, 7, 8 and 11) and leaves (sample 9 and 10).

2.3. Procedures

2.3.1. Sample preparation and analysis procedures

All samples were previously rinsed with tap water followed by deionized water, and then dried at 40 °C to constant weight. Dried samples were ground in a cryogenic mill. A two step program was applied: step I (pre-freezing): 10 min, step II (milling): 2 min intercalated by cycles of freezing of 2 min. Then, the samples were stored in labeled, tightly sealed polyethylene containers.

A mass of 0.25 g was weighed for each sample in replicate ($n = 3$) and digested with 4.0 mL of 7.0 mol L^{-1} HNO_3 and 4.0 mL of 30% (m m^{-1}) H_2O_2 in a microwave oven (Diniz, 2012). The heating program consisted of 3 steps: 800 W, 180 °C for 10 min; 800 W, 180 °C for 20 min; and ventilation for 50 min. The digests were transferred to volumetric flasks and diluted to 25.0 mL with ultrapure water. Blank experiments were carried out in the same way. The certified reference material analysis GBW 07604 (Poplar leaves) ($n = 3$) was made by using dissolving method mentioned above.

The determinations of selenium in the digests and teas were performed by GF AAS using a Pd + Mg solution as a chemical modifier. The heating program (Table 1) was established using solution containing 30 μg L^{-1} of Se in 0.028 mol L^{-1} HNO_3.

2.3.2. Infusion preparation

To prepare the infusion, 1.0 g of the dried sample was placed in a beaker and then 25 mL boiling water was added and the sample was covered and left at room temperature for 10 min. After cooling, the extract was filtered through quantitative filter paper