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Trace Elements in Common Potatoes, Sweet Potatoes, Cassava, Yam and Taro

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Abstract: *The paper reports on the results of a survey of trace elements in common potatoes, sweet potatoes, cassava, yam and taro. The levels of aluminum, chromium, manganese, nickel, cobalt, molybdenum and cadmium in common potatoes, sweet potatoes, cassava, yam and taro consumed in Mato Grosso do Sul state, Brazil were evaluated. The concentrations were measured using a Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES, iCap 6000® - Thermo Scientific, USA). It was shown that the levels of biometals in tubers, with the exception of aluminum and chromium, vary in a broad range, but do not exceed the limits established by the Brazilian and International legislation when available. No major concerns were identified for the health of consumers. The concentrations of aluminum in all tubers (1.53 - 2.9 mg/kg) and chromium in taro (0.41 mg/kg) are higher, possibly reflecting the local soil characteristics or contamination and needing geochemical information.*

Keywords: *Common potatoes, Sweet potatoes, Cassava, Yam; Taro; Trace elements.*

1. Introduction

The mineral content of foods is being increasingly monitored in tropical countries. The legislation is stricter in those regions of Latin America, Africa and Asia where the population consumes mainly locally grown food. Consequently, it requires the acquisition of large sets of fundamental data on the occurrence and distribution of a variety of bioelements in soils and food, and population exposure to them. The results of such investigations [1, 2] can in turn provide better understanding of the role of trace elements in life processes and support the establishment of guidelines and regulations. Dietary exposures to toxic metals like cadmium is falling as a result of measures taken to reduce contamination of the environment and food.

Meanwhile, vegetables, and tubers in particular, are the most widely consumed in the typical Brazilian diet. They provide physiological energy reserves, thus, their contribution to the population diet cannot be neglected. The plants have been known for a long time, primarily adopted from the Indian inhabitants of Latin America. Unfortunately, the data concerning rare and exotic trace elements are limited. This paper is part of our research into mineral components content in food samples [3, 4], reporting on aluminum, chromium, manganese, nickel, cobalt, cadmium and molybdenum in common potatoes, sweet potatoes, cassava, yam and taro consumed in Campo Grande, the capital of Mato Grosso do Sul state, Brazil.

2. Material and Methods

2.1. Sample Collection

The roots regularly consumed by the local inhabitants were analyzed. Good quality fresh samples of common potatoes, sweet potatoes, cassava, yam and taro were purchased from the wholesaler CEASA (Central Supply of Mato Grosso do Sul state). This company is linked to the Agricultural Development and Rural Extension Agency of Mato Grosso do Sul which provides vegetables to supermarkets, small markets and trade in general located in the capital and other cities in the state.

Such centralized distribution ensures the homogeneity of samples and the randomization of their collection. The general characteristics of five common tubers are given in Table 1.

Table1. *General characteristics of roots selected for analysis*

Common name	Botanic name	State of origin, Brazil
Common potatoes	*Solanum tuberosum*	Paraná
Sweet potatoes	*Ipomoea batatas*	Mato Grosso do Sul
Cassava	*Manihot esculenta Crantz*	Mato Grosso do Sul
Yam	*Dioscorea ssp*	São Paulo
Taro	*Colocasia esculenta*	São Paulo

2.2. Analysis

Each tuber was washed thoroughly with double distilled water, peeled with a plastic peeler and washed again, this time with ultrapure water (Milli-Q, Millipore, Bedford, USA). To determine the humidity, the samples were first grated, and after recording the wet mass (*ca* 2 g of the edible part of each vegetable) the matter was dried in an oven at the temperature 65 ºC until attaining constant weight. Thence the oven was maintained at 105 ºC for 72 hours, according to published analytical technique [5]. These samples were accurately weighed on the microanalytical balance and processed with a mixture of 5 ml of nitric acid (65%, Merck) and 3 ml of hydrogen peroxide (35%, Merck Millipore) in the microwave digestion system Speedwave®, Berghof, Germany. The digestion was carried out according to the program presented in Table 2. After that, the solutions were cooled down to room temperature, diluted with ultrapure water to a final volume of 100 ml and analyzed.

Table2. *Parameters of sample digestion*)*

Step	Temperature (ºC)	Pressure (bar)	Stop (min)	Time (min)	Energy (%)
1	145	30	2	10	80
2	190	35	5	15	90
3	50	25	1	10	0

*) *In accordance to manufacturer`s scheme, from [6], with modifications.*

The concentrations of aluminum, chromium, manganese, nickel, cobalt, cadmium and molybdenum were measured using an Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES, iCap 6000® - Thermo Scientific, USA). Working standard solutions used for the construction of calibrating curves were purchased from Aldrich. All glassware were of Pyrex® glass. All materials, plastic or glass, were previously immersed for 24 h in a solution of Extran 5% (Merck), rinsed and immersed for at least 24 h in 10% nitric acid (Merck) solution for decontamination from any metal residue. Then they were washed with ultrapure water and dried at 40 ºC prior to analysis. The measurements were run in duplicates.

3. Results and Discussion

The moisture content of the samples, with the exception of taro was similar to the averages previously published in Brazil [4], thus reflecting stable storage conditions (Table 3).

Table3. *Moisture content of tubers studied (% wet weight)*

Tubercular roots	Present work	Brazilian average
Commom potato	86.1	82.9
Sweet potato	73	69.5
Cassava	59.0	61.8
Yam	67.4	73.7
Taro	86.2	73.3

As for the chemical elements involved, they are considered in the order of increasing atomic masses and discussed separately for each root (Table 4).

The results are given in Table 4. The data are expressed as means of duplicate determinations ± standard deviation.

Table4. *Trace elements concentrations (mg/kg of wet weight ± standard deviation) in edible tuberous roots compared to Brazilian averages and other sources.*

Roots/ Elements	Aluminum	Chromium	Manganese	Nickel	Cobalt	Molybdenum	Cadmium
Common potato							
Our data	1.99±0.0013	0.03±0.0012	0.96±0.002	0.01± 0.0011	0.04±0.001	0.03±0.001	0.01±0.0011
BTFC*)	-	-	0.1	-	-	-	-
Other sources	0.9 United Kingdom [7]; 0.93 Brazil/SP [8]	0.063 Greece [9]; 0.034 USA [10]	1.43 France [11]; 1.4 Spain [12]	0.007 France [11]; 0.029 Lybia [13]; 0.034 Brazil/SP [8]	0.051 USA [10]; 0.064 Lybia [13]	0.418 France [11]	0.007 Greece [9]
Sweet potato							
Our data	2.4±0.001	0.04±0.0012	4.18±0.001	0.26± 0.001	0.03± 0.001	0.02± 0.0002	0.04± 0.0011
BTFC	-	-	1.8	-	-	-	-
Other sources	1.01 USA [10]	0.034 Spain [14]	2.71 Spain [14]	0.056 Spain [14]	-	-	0.001 Spain [13]; 0.09 China [15]
Cassava							
Our data	1.53±0.001	0.08±0.0012	2.61±0.001	0.16± 0.002	0.03± 0.0002	0.05±0.0001	0.01±0.0011
BTFC	-	-	0.5	-	-	-	-
Other sources		0.05 Brazil/SP [8]	3.84 USA [10]	0.25 Nigeria [16]	-	-	0.13 Nigeria [16]
Yam							
Our data	1.95±0.002	0.03±0.002	0.12±0.001	0.01± 0.001	0.015± 0.001	0.05±0.002	0.02± 0.0011
BTFC	-	-	0.1	-	-	-	-
Other sources	-	-	-	0.014 Nigeria [15]	-	-	0.18 Gana [17]
Taro							
Our data	2.9±0.001	0.41±0.011	2.26±0.002	0.09± 0.0011	0.04± 0.0002	0.22±0.0003	0.12± 0.0011
BTFC	-	-	0.15	-	-	-	-
Other sources	-	0.044 Spain [14]	2.63Brazil/MS [18]	0.021 Spain [14]	-	-	0.35 China [15]

*) *Brazilian Table of Food Composition [19].*

The only known published values for aluminum range from 0.9 mg/kg (common potato) to 1.01 mg/kg (sweet potato). In this work the aluminum content of all analyzed roots was in the range 1.53 to 2.9 mg/kg. It was assumed elsewhere [3] that in the case of fruit juices excessive aluminum could have been leached from the foil used for the packages. Actually it is evident that for the tubers this explanation cannot be valid, so we deal with an endogenously bonded biometal and not a contaminant. Thus further investigations seem to be required to correlate the concentration of this metal with the soil characteristics of the various growing locations.

Despite the presence of tanning industry present in Mato Grosso do Sul the chromium levels for the roots studied were ranged from 0.03 to 0.06 mg/kg with the exception of taro which contained 0.41 mg/kg. The current Brazilian legislation allows the maximum level of 0.1 mg/kg [20]. The available values published so far are from not detectable to 0.044 mg/kg in Spain. They are of a similar order for common potato, sweet potato, cassava and yam.

The manganese contents observed in the present study for the roots vary in a broad range, from 0.12 mg/kg (yam) to 4.18 mg/kg (sweet potato), similar to reported manganese concentrations ranging from 0.1 mg/kg (common potato) to 3.84 mg/kg (cassava).

The nickel concentrations for all of the roots studied ranged from 0.01 mg/kg (yam) to 0.26 mg/kg (sweet potato). They are within reasonable interval 0.014 - 0.25 mg/kg reported so far, which actually may be narrower since the maximum values 0.26 and 0.25 mg/kg have been observed only for sweet potato in Mato Grosso do Sul and Nigeria, respectively. Even so, the local legislation allows the maximum concentration of 30 mg/kg for this element [20].

As for the cobalt content, its concentrations in the present study were also low: 0.01 – 0.04 mg/kg. They are lower than 0.051 mg/kg for common potato in the United States, but no published data are available for sweet potato, cassava, yam and taro.

The levels of toxic metal cadmium in all samples are acceptable: 0.01- 0.04 mg/kg for common potato, sweet potato, cassava and yam, and 0.12 mg/kg for taro. The latter concentration is very close to the value of 0.10 mg/kg established as a maximum for the tubers by the current Brazilian legislation [21].

The data on molybdenum concentrations in the roots analyzed are missing in literature, with the exception of the French common potato (0.418 mg/kg). In our study, the levels of this element were low, 0.004 - 0.01 mg/kg. It is not unusual since direct evidence for active plant uptake are lacking.

The present research was not intended to evaluate the nutritional capacity of tubers consumed in Brazil. No major concerns were identified for the heath of consumers. The data obtained here for biometal levels shows exclusively the population exposure to these minerals, concretely in Mato Grosso do Sul state, no assumptions made as to their real absorption or bioavailability.

4. CONCLUSIONS

- The levels of biometals in tubers, with the exception of aluminum and chromium, vary in a broad range, but do not exceed the limits established by the Brazilian and International legislation when available.
- The concentrations of aluminum in all tubers (1.53 - 2.9 mg/kg) and chromium in taro (0.41 mg/kg) are high, possibly reflecting the local soil characteristics or contamination and needing geochemical information.
- The concentrations of toxic metal cadmium do not exceed those established by the Brazilian legislation.

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