



## Nutritional Evaluation of Non-Conventional Vegetables in Brazil

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### ABSTRACT

The objective of this study was to characterize the nutritional compounds of interest present in vegetables known as non-conventional, in Brazil. The following evaluations were carried out: antioxidant activity, phenolic compounds, vitamin C, calories, carbohydrates, humidity, lipids, proteins, fiber, acidity and quantification of minerals (P, K, Ca, Mg, S, Cu, Fe, Mn, Zn and B). The species studied were *Amaranthus hybridus* L., *Amaranthus viridis* L., *Basella alba* L., *Eryngium campestre* L., *Hibiscus sabdariffa* L., *Lactuca canadensis* L., *Rumex acetosa* L., *Stachys byzantina* K. Koch, *Tropaeolum majus* L. and *Xanthosoma sagittifolium* L. Representative samples of plant structures of interest were harvested from each species suitable for human consumption such as leaves, flowers and flower buds. The results were submitted to multivariate analysis - principal components analysis (PCA). All the species present nutritional compounds of interest in different levels among the evaluated structures.

**Key words:** bioactive compounds, food safety, nutraceutical food, traditional vegetables.

### INTRODUCTION

In the past, some native or introduced vegetables were widely consumed by the population, in Brazil. However, due to the great supply of the so-called genetically improved modern vegetables – in a way, more attractive, mainly because they have already been very well inserted in the national and international market of seed production – many of these vegetables are no longer consumed. This happened due to the lack of supply in the market and, thus, these vegetables became unknown

to the new generations. However, some of these species are still consumed by rural, indigenous and quilombola (the “quilombos” were communities formed during the colonial period of Brazil by runaway slaves. Even today, they remain as independent communities, preserving the cultural heritage of their ancestors) populations being termed as non-conventional vegetables.

These vegetables are distributed in several botanical families and they are being redeemed and deposited in germplasm collections of public institutions with the aim of preserving biodiversity and studying the probable pharmacological

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potential and even the anti-nutritional principles of these species.

There are already reports of the nutritional potential of some species. The grain amaranths (*Amaranthus* spp.), for instance, presents calcium, magnesium, nitrogen, iron and phosphorus (Souza et al. 1999, Costa et al. 2008); the malabar spinach (*Basella alba* L.) presents varied rates of carotenoids and vitamins A and C (Brasil 2002, Batista et al. 2008, Oliveira et al. 2013); the roselle (*H. sabdariffa* L.) is rich in minerals, vitamins A and B1 and fibers (Brasil 2013); the sorrel (*Rumex acetosa* L.) presents nutritional and pharmacological potential in its constitution from minerals, antioxidants, vitamins, fibers, nutrients and proteins (Silva et al. 2013); the lamb's-ear (*Stachys byzantina* K. Koch) presents high levels of vitamin C, vitamin K, carbohydrates and antioxidant potential besides a wide range of bioactive compounds presented by species of the genus *Stachys*, widely used in the pharmacological industry (Asnaashari et al. 2010); the garden nasturtium (*T. majus* L.) presents, in its composition, vitamin C, minerals, carbohydrates, antioxidant power, essential oils besides potential pharmacological use because it presents a large spectrum of bioactive compounds (Niizu and Rodriguez-Amaya 2005, Embrapa 2006, Garzón and Wrolstad 2009, Mlcek and Rop 2011) and the arrowleaf elephant ear (*X. sagittifolium* L.) presents significant levels of carbohydrates, proteins, iron, minerals and vitamins A and C (Lu et al. 2005, Rodríguez et al. 2006, Brasil 2010, Ndabikunze et al. 2011). However, it is known that the levels of these compounds vary widely according to environmental, genetic and management factors (Melo et al. 2006, Costa et al. 2008, Arbos et al. 2010).

After the confirmation of its nutritional potential, the consumption of these non-conventional vegetables could be presented as an excellent option as a source of nutritional compounds especially for populations with lower

purchasing power, however, studies proving its nutritional properties are still incipient. It is known that some of these species may also exhibit antinutritional compounds such as protein inhibitors, calcium oxalates, tannins, nitrates, among others (Van Velzen et al. 2008, De Jesus Benevides et al. 2011).

Aiming to obtain a more in-depth knowledge about the potential of non-conventional vegetables, the objective of this study was to evaluate the nutritional compounds of interest in 10 species of non-conventional vegetables in Brazil.

#### MATERIALS AND METHODS

The analyzed species were *Amaranthus hybridus* L. (green amaranth), *Amaranthus viridis* L. (slender amaranth), *Basella alba* L. (malabar spinach), *Eryngium campestre* L. (field eryngo), *Hibiscus sabdariffa* L. (roselle), *Lactuca canadensis* L. (canada lettuce), *Rumex acetosa* L. (sorrel, two different cultivated varieties), *Stachys byzantina* K. Koch (lamb's ear), *Tropaeolum majus* L. (garden nasturtium) and *Xanthosoma sagittifolium* L. (arrowleaf elephant ear).

The samples were collected from the Germplasm Collection of Non-Conventional Vegetables located in the experimental garden of the Federal University of Lavras, Minas Gerais, Brazil, latitude 21°14'S, longitude 45°00'W and average altitude of 919 meters (3011,81 ft). The climate of the region is classified as humid temperate, with a hot summer and a dry winter, being, therefore, of the type Cwa in the Köppen classification. The species studied included different botanical families, growth habits and life cycle, as well as the potential for food use. They comprise varieties obtained from selections made by farmers, variant forms of cultivated species and wild species of the genera of interest for the national olericulture. The plant parts used for analysis were those usually

consumed as food in each species studied, and could be the leaves, the flowers or the floral buds.

In the field, about 60 plants of each species were conducted in a randomized block design with four replicates. Then, a sample was taken from the central – viable – plants of each block, just considering the internal plants of the block. The plants were conducted in a flowerbed in the field, they were irrigated by drip irrigation and the soil was fertilized with 150 kg.ha<sup>-1</sup> N, 60 kg.ha<sup>-1</sup> of K<sub>2</sub>O and 100 kg.ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub> given the good availability of P and K in the experimental soil, obtained by previous chemical analysis.

The samples were collected from the parts of each plant, at a complete stage of development in *Amaranthus* spp., *B. alba*, *E. campestre*, *Lactuca canadensis* L., *Rumex acetosa* L., *Stachys byzantina* K. Koch, *Tropaeolum majus* L. and *Xanthosoma sagittifolium*. The floral samples were collected after the anthesis in the species *Tropaeolum majus* L. and before the anthesis in the species *Hibiscus sabdariffa* L. The statistical design was completely randomized, with twelve treatments in triplicate and each treatment corresponding to a food structure of one species, at around 200 g per repetition.

The samples were sanitized and part used for the following evaluations: antioxidant activity according to Brand-Williams et al. (1995) and adapted by Rufino et al. (2007); phenolic compounds according to the colorimetric method developed by Singleton and Rossi (1965); vitamin C according to Strohecker and Henning (1967); total pectin according to McCready and McComb (1952); total carotenoids in the flowers of *H. sabdariffa* and *T. majus* according to Rodriguez-Amaya et al. (1976); anthocyanins according to Giusti and Wrolstad (2001); centesimal composition according to the Horowitz (2016); calorific value according to Osborne and Voogt (1978); acidity, lipids and humidity according to the Horowitz (2016); fiber according to Kjeldahl (1983) adapted by the Horowitz (2016) and nitrate according to

Cataldo et al. (1975). Another part of the samples was used for the quantification of the P, K, Ca, Mg, S, Cu, Fe, Mn, Zn and B minerals where the preparation of the samples and the determination of the nutrients followed the methodology proposed by Silva (2009).

The results were then normalized and submitted for an analysis of the main components using the Chemoface software (version 1.4). The analysis of the main components is a multivariate statistical tool whose principle is to study the behavior of many variables at the same time, reducing these variables by means of mathematical criteria, allowing visualizing in two-dimensional graphs only the most representative main components of the data sets (De Souza Pereira et al. 2014). The data was normalized and, then, decomposed into a covariance matrix. The results of the PCA were generated according to component scores. At the end, it was possible to load the biplot graphics with the two main components.

The main components present in the following datasets were analyzed: 1 - Antioxidant activity, phenolic compounds and Vitamin C, 2 - Nitrate, carbohydrates, lipids, proteins and crude fiber, 3 – Macronutrients (P, K, Ca, Mg and S) and 4 - Micronutrients (Cu, Fe, Mn, Zn and B) with the aim of characterizing the nutritional constitution of the species as well as to verify which components stood out between the constitution of each structure and species evaluated. The results of the statistical analyzes were expressed in “biplot” type charts, in order to determine possible trends and patterns in the results.

## RESULTS

In general, the dry weight of all the structures presented in their constitution levels of vitamin C, ranging from a minimum of 69.94 mg.100g<sup>-1</sup> on *H. sabdariffa*'s floral bud to a maximum of 195.58 mg.100g<sup>-1</sup> in *X. sagittifolium*'s leaves. The phenolic

levels also varied among the studied species with the lowest level being observed on *R. acetosa*<sup>1</sup> (8.74 mg.100g<sup>-1</sup>) and the highest on *S. byzantina* (209.40 mg.100g<sup>-1</sup>).

Although all the non-conventional vegetables evaluated showed high vitamin C levels, the analysis of the main components, between the variation of antioxidant activity and the vitamin C and phenolic contents, allowed the discrimination of the species between these levels, being that the two main components represented in the biplot graph (Fig. 1) represented 98% of all the observed variance, which proves the efficiency of this technique in the discrimination of these treatments. The treatments were well distributed in the quadrants of the graph, mainly according to their similarities between vitamin C and phenolic levels.

The species *T. majus* (leaf) and *A. hybridus* stood out mainly because they presented the highest rates of antioxidant activity and were also, among the highest values for the constitution in total phenols and vitamin C. The species *S. byzantina* presented the highest observed levels of total phenols as well as low levels of vitamin C, which has characterized it in presenting average capacity of free radical scavenging. The species *B. alba*, *A. viridis*, *X. sagittifolium* and *T. majus* (flower) presented high levels of vitamin C and average levels of phenols and antioxidant activity with the exception of *T. majus* flower that presented a high level of antioxidant activity (68.32%) when compared to other observed results. Among the other species evaluated, *L. canadensis*, *R. acetosa*<sup>1</sup>, *R. acetosa*<sup>2</sup>, *E. campestre* and *H. sabdariffa* were the ones to present levels of vitamin C, phenols and antioxidant activity ranging from low to average.

Indeed the high capacity of free radical scavenging in the leaves of *T. majus* can be linked to both the content of phenols (167.84 mg.100g<sup>-1</sup>) as well as the level of vitamin C (188.55 mg.100g<sup>-1</sup>). Meanwhile, the species *S. byzantina* presented a high level of phenols (209.40 mg.100g<sup>-1</sup>) but a

free radical scavenging capacity of only 46.51% showing that, in this species, the phenols detected by the analysis performed are not efficient as antioxidants. Another important fact is the difference in the capacity of free radical scavenging observed between the two morphological types of *R. acetosa*, where *R. acetosa*<sup>2</sup> presented this capacity about 4 times higher than *R. acetosa*<sup>1</sup>.

The floral bud of *H. Sabdariffa* presented pectin and anthocyanins in their constitution in values of 1450 mg.100g<sup>-1</sup> and 954.62 mg.L<sup>-1</sup> respectively. Despite high levels of anthocyanins, the floral buds of *H. sabdariffa* showed a low free radical scavenging capacity, about 20%, showing that in this species these pigments are not efficient as antioxidants.

Carotenoids were observed in the flowers of *H. sabdariffa* and *T. majus* at levels of 221.59 mg.100g<sup>-1</sup> and 711.84 mg.100g<sup>-1</sup> respectively.

All structures of the evaluated species presented nitrate content in their constitutions. The species *A. hybridus* and *T. majus* presented in their leaves the highest levels of this compound, being 169 mg.100g<sup>-1</sup> and 186 mg.100g<sup>-1</sup> respectively. For the other evaluated structures, the nitrate level ranged from a minimum average of 30 mg.100g<sup>-1</sup> for the leaves of *E. campestre* and *R. acetosa*<sup>1,2</sup>, with an average content of 128 mg.100g<sup>-1</sup> observed in the leaves of *A. viridis* and *X. sagittifolium*.

All the structures of the evaluated species presented humidity levels above 70% and below 93%, with higher values in *R. acetosa*, *B. alba* and *T. majus* (flowers) species (91% on average). Therefore, taking into account that water is the main component of the evaluated structures, it was analyzed the main components considering carbohydrates, lipids, proteins, fiber and nitrate as variables (Fig. 2), in order to discriminate the species, according to possible patterns in the contents of these compounds present in their structures, besides the water. The two main components represented in the biplot graph (Fig. 2) explained 73% of all the

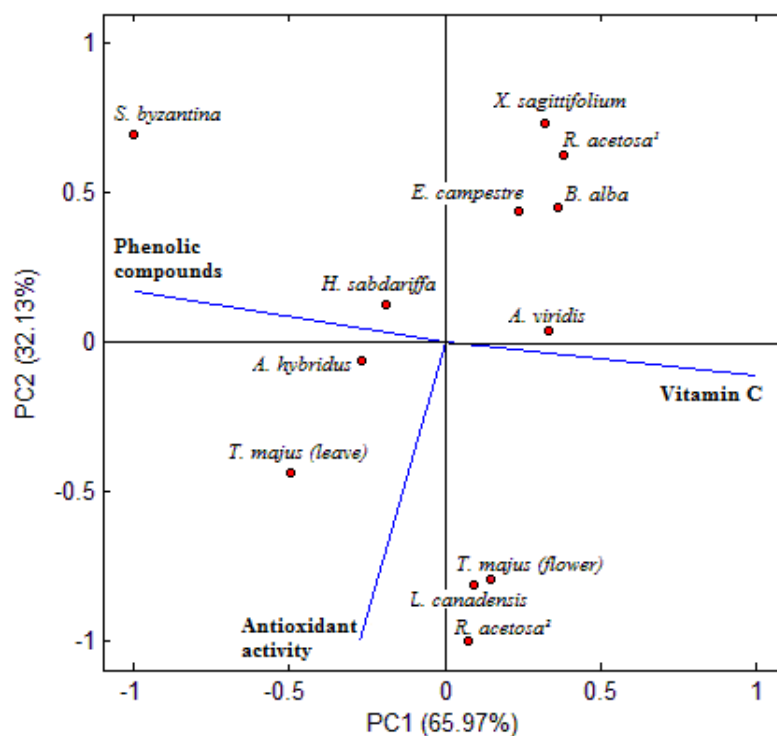


Figure 1 - Analysis of the main components related to the observed results for antioxidant activity, vitamin C and phenolic compounds.

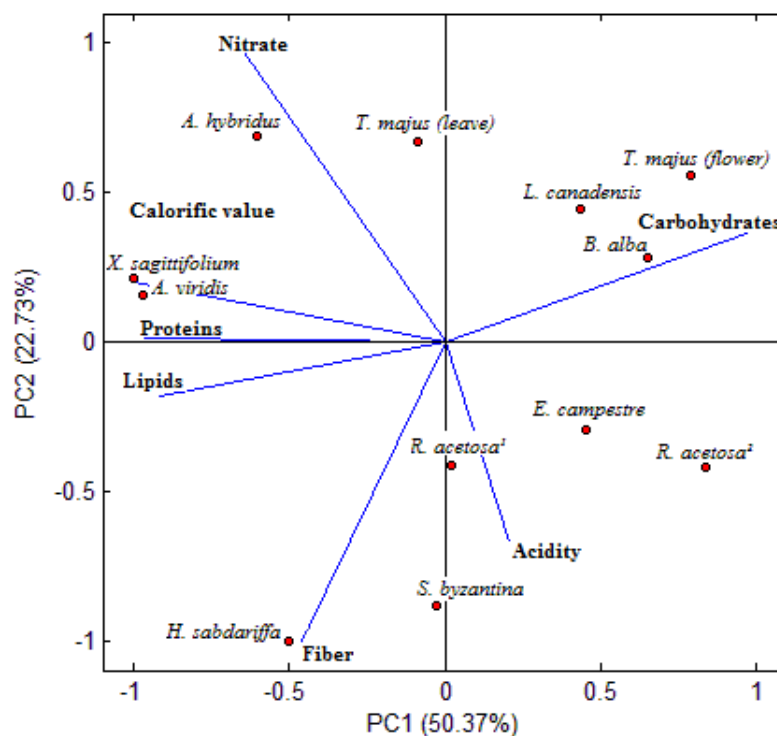


Figure 2 - Analysis of the main components related to the observed results for the levels of carbohydrate, acidity, fiber, lipids, proteins, calorific value and nitrate.

observed variance, which confirms the efficiency of this technique in the discrimination of these treatments. According to the nutritional similarities between the carbohydrate, lipid, protein, fiber and nitrate levels, the treatments were well distributed in the quadrants of the graph.

The species *A. viridis*, *S. byzantina*, *H. sabdariffa*, *A. hybridus* and *X. sagittifolium* stood out because they presented the highest nutritional levels observed in these evaluations. *T. majus* stood out because it presented the highest level of carbohydrates (8330 mg.100g<sup>-1</sup>) and lipids (1520 mg.100g<sup>-1</sup>) and a high level of proteins (3320 mg.100g<sup>-1</sup>). Consequently, the leaves of this species had the highest energy level, in a total of 60.32 kcal.100g<sup>-1</sup>. On the other hand, the flower, with greater commercial appeal, presented significantly lower values for these variables compared to the leaves and consequently presented lower calorific value. It is interesting to note also the variation in the content of these compounds between the two morphological types of *R. acetosa*, where *R. acetosa*<sup>2</sup> presented 32.7% and 25% more carbohydrates and lipids respectively, a characteristic already observed for antioxidant activity. Among the remaining species, *E. campestre*, *L. canadensis* and *T. majus* (flower), presented high levels of carbohydrates and intermediate values in the other evaluations, while the species *R. acetosa*<sup>1,2</sup> and *B. alba* presented the lowest values observed among these nutrients.

In the acidity level, the flowers of *H. sabdariffa* stood out (2.27 mg.100g<sup>-1</sup>), along the two morphological types of *R. acetosa*, which presented 1.72 mg.100g<sup>-1</sup> and 1.42 mg.100g<sup>-1</sup> for *R. acetosa*<sup>2</sup> and *R. acetosa*<sup>1</sup> respectively.

The highest levels of fiber were observed in *S. byzantina* leaves and in the floral buds of *H. sabdariffa* in values of 4570 mg.100g<sup>-1</sup> and 3950 mg.100g<sup>-1</sup> respectively. A low level of fiber was observed in *T. majus* flowers and in *B. alba* leaves within an average value of 640 mg.100g<sup>-1</sup>, while

intermediate levels were observed for the other structures of the evaluated species.

The structures of the evaluated species presented varied levels for the protein constitution, oscillating from a minimum average of 1320 mg.100g<sup>-1</sup> in *L. canadensis*, *E. campestre* and *Rumex acetosa*<sup>2</sup> leaves to the maximum of 5790 mg.100g<sup>-1</sup> in *A. viridis* leaves. The other species presented an intermediate constitution within an average of 3440 mg.100g<sup>-1</sup> presented by *T. majus*, *S. byzantina* and *X. sagittifolium* leaves and by the floral buds of *H. sabdariffa*. Further studies are required as regards the digestibility and bioavailability of these proteins in the human organism or animal organism, depending on each use and purpose.

The analysis of the main components among the mineral constituents allowed discriminating the species according to these elements (Figs. 3 and 4). In relation to the nutrients P, K, Ca, Mg and S, the main components accounted 77% of the total data variance; while for Cu, Fe, Mn, Zn and B nutrients, the major components accounted 88% of the total variance observed. These values prove the efficiency of this technique in discriminating the treatments used in each of these cases, since the treatments were well distributed in the quadrants of both graphs.

Among the nutrients P, K, Ca, Mg and S, the species *A. viridis*, *A. hybridus*, *X. sagittifolium* and *B. alba* stood out because they contained the highest levels, mainly related to the K component. Among these species, *A. viridis* was noted for having the highest levels observed in almost all evaluations, whereas *X. sagittifolium* stood out because it presented the highest level of P. In these same parameters, *T. majus* (flower and leaves) and *E. campestre* species also stood out because they presented high levels for a great part of the evaluated macronutrients, and the highest observed values for the levels of S and P. The species *T. majus* (flower and leaf) presented a prominent place, because, besides presenting the highest

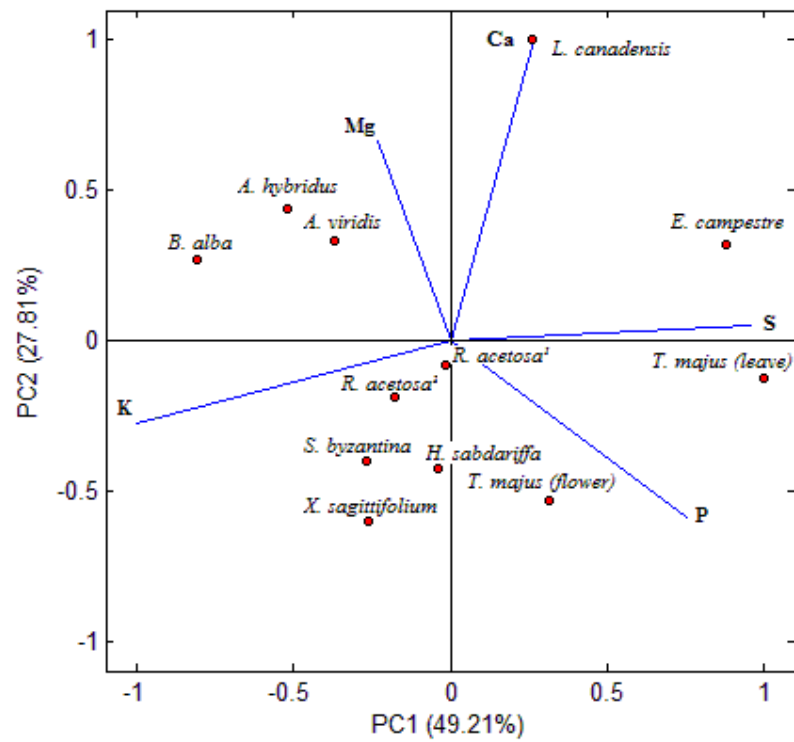


Figure 3 - Analysis of the main components related to the observed results for the levels of macronutrients P, K, Ca, S and Mg.

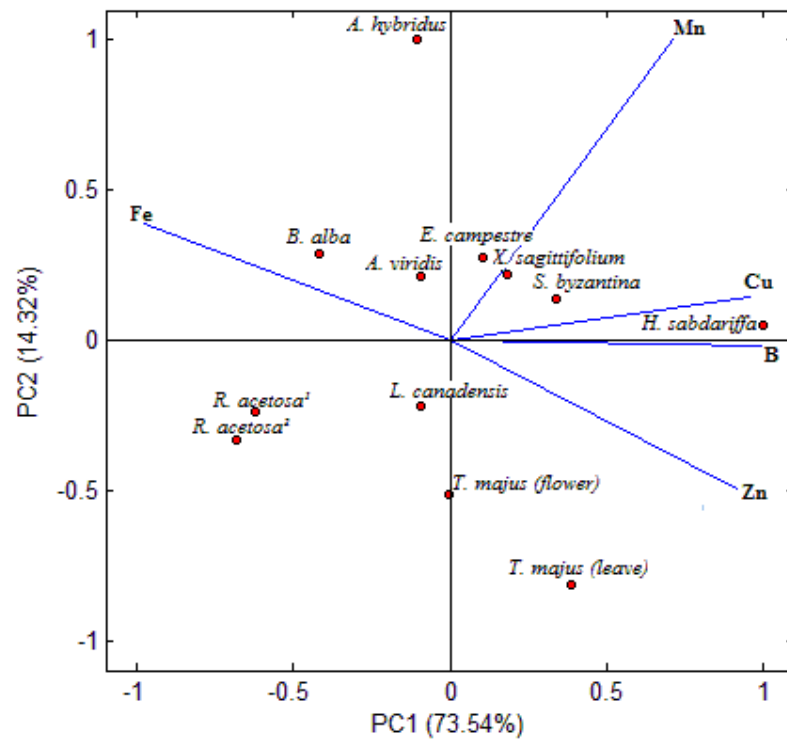


Figure 4 - Analysis of the main components related to the observed results for the constitutions of the species and structures in the micronutrient Fe, Cu, Mn, Zn levels.

average observed level for S ( $883 \text{ mg}\cdot 100\text{g}^{-1}$ ) it also presented high levels for the minerals P ( $525 \text{ mg}\cdot 100\text{g}^{-1}$ ) and K ( $1311 \text{ mg}\cdot 100\text{g}^{-1}$ ). On the other hand, the species *L. canadensis* and *H. sabdariffa* presented intermediate values among the evaluated macronutrients, with a highlight to *L. canadensis* which presented in its constitution the highest observed level for Ca ( $565 \text{ mg}\cdot 100\text{g}^{-1}$ ). The remaining two species, *R. acetosa*<sup>1,2</sup> and *S. byzantina*, presented minimum to intermediate levels for the evaluated macronutrients.

Among the nutrients Cu, Fe, Mn, Zn and B, the species *R. acetosa* stood out in both evaluated morphological types, mainly because they presented, among their mineral constituents, the highest levels of Fe (average of  $592 \text{ mg}\cdot \text{kg}^{-1}$ ) and among the highest levels for the other micronutrients evaluated. Regarding the mineral iron, the average value observed in the constitution of all the species and structures evaluated was  $21 \text{ mg}\cdot 100\text{g}^{-1}$ , well above the average described for the constitution of conventional hardwoods ( $0.7 \text{ mg}\cdot 100\text{g}^{-1}$ ) and a value not only surpassed by that presented in the floral bud of *H. sabdariffa* ( $0.04 \text{ mg}\cdot 100\text{g}^{-1}$ ).

*L. canadensis* species also stood out in relation to the constitution of their micronutrients, mainly because they presented the highest values for Zn ( $23.11 \text{ mg}\cdot 100\text{g}^{-1}$ ), B ( $5.32 \text{ mg}\cdot 100\text{g}^{-1}$ ) and Mn ( $5.75 \text{ mg}\cdot 100\text{g}^{-1}$ ). In these same parameters, *T. majus* (flower), *X. sagittifolium*, *E. campestre*, *A. viridis*, *A. hybridus* and *B. alba* species presented intermediate values for these evaluated nutrients, while *T. majus* (leaves), *H. sabdariffa* and *S. byzantina* species presented the lowest values for iron and manganese, and intermediate values for the other micronutrients.

## DISCUSSION

The vitamin C (ascorbic acid) is water soluble and fundamental in the synthesis of collagen, in the tissue repair and in the maintenance of the

proper functioning of various sectors of the human metabolism. It also has a role in the immune system, mainly because of its antioxidant properties, since human beings are unable to synthesize ascorbic acid and, as a consequence, need to ingest it through external sources (Lee and Kader 2000, Fuchs 2010). The mean vitamin C level observed in the evaluated species ( $139.00 \text{ mg}\cdot 100\text{g}^{-1}$ ) is superior in relation to those observed in the constitution of vegetables commonly used *in natura* such as salad, lettuce, broccoli, cabbage, cauliflower, spinach, cabbage and arugula which, on average, present 50 mg of this vitamin per 100 g of the vegetable (Lima 2011). According to the recommendations of FAO/WHO (2001), adults should consume a daily average of 30 mg of this vitamin.

Increasingly scientific importance has been attached to food health. In its normal assignments, human metabolism produces molecules called free radicals, which can react with proteins, lipids, DNA, RNA and other constituents of the organism that can be oxidized. These reactions can cause damage to tissues and organs, often related to degenerative diseases such as cancer. It is suggested the consumption of different biological sources of antioxidant compounds, through the use of products in the food that contains them in their constitution, such as oilseeds, cereals, vegetables (fruits, leaves and tubers), among others, aiming to delay the oxidizing effect and also the appearance of some diseases (Melo et al. 2006). The antioxidant activity in the food is closely related to the presence of components such as phenols, vitamin C, among others, as well as the efficacy of the antioxidant action of these compounds, when ingested, depends on the chemical structure and the rate of their concentrations in each food (Melo et al. 2006).

The antioxidant activity in foods is also generally related to the presence of pigments such as anthocyanins and carotenes (Melo et al. 2006). The anthocyanins observed in the constitution of *H. sabdariffa* are usually responsible for the blue-



purple color presented by foods, for example, the dark red in the strawberry (*Fragaria* spp.) (Pinto et al. 2012). These compounds take part in the energy metabolism, through the transformation of carbohydrates and other nutrients into energy and also present some antioxidant properties when ingested, and consequently, a detoxifying effect of the cells (Rocha and Reed 2014) as well as being able to be used as a natural dye in the food industry (Lopes et al. 2007). Among the different species of the genus, *H. sabdariffa* is used in the diet in the form of the consumption of its leaves *in natura* or of the dried flower buds for the production of jellies or teas (Brasil 2013).

The pectin level observed in its floral bud is significant when compared to other considered species, sources of this compound, that aim at the manufacture of sweets and jellies, such as the guavas (*Psidium guajava*) from the cultivar Pedro Sato with a total pectin level of 880 mg.100g<sup>-1</sup> (Linhares et al. 2005) and the strawberries (*Fragaria* spp.) from the cultivar Sweet Charles (Françoso et al. 2008) with a total pectin level of 750 mg.100g<sup>-1</sup>. Both values are well below the 1450 mg.100g<sup>-1</sup> observed in the constitution of the floral bud of *H. sabdariffa*.

The flowers of *H. sabdariffa* and *T. majus* presents high levels when compared to those obtained by Costa et al. (2014), which evaluated these compounds present in passion fruit flowers (90 mg.100g<sup>-1</sup>), mexican marigold flowers (110 mg.100g<sup>-1</sup>), red roses and white roses flowers (average of 23 mg.100g<sup>-1</sup>) as well as different *T. majus* flowers evaluated (yellow, red and orange) (average of 300 mg.100g<sup>-1</sup>). Carotenoids are natural pigments present in various fruits and vegetables, such as carrots, tomatoes, spinach, oranges and peaches. They are responsible for the appearance of yellow, red and orange color in foods and are classified among the most important compounds from a nutritional point of view. There are different types of carotenoids and, in general, when ingested,

they may have a strengthening function of the immune system, reducing the risk of degenerative diseases, and some are precursors of vitamins, which helps maintain the proper functioning of the human body. The anticancer function is also cited for these pigments, due to the antioxidant action, besides being highly important for the final quality of the food (Délia et al. 2008).

Some vegetable species also exhibit antinutritional and oxidant compounds, such as protein inhibitors, calcium oxalates, tannins, nitrates, among others (De Jesus Benevides et al. 2011). In the human body, an excess of nitrates can cause methemoglobinemia (a form of hemoglobin that does not bind to oxygen) besides being carcinogenic and teratogenic. The concentration of this compound in vegetables varies according to climatic conditions and agronomic crop management, as well as post-harvest storage conditions (Van Velzen et al. 2008).

Brazil does not have its own legislation regarding nitrate levels in food. As such, the country follows international law. The European Union sets maximum permitted levels for human consumption where products in excess of these values cannot be marketed. The acceptable daily intake (ADI) established by the Scientific Comitee on Food (SCF) is 3.65 mg/kg body weight (Eur-Lex 2006). The FAO/WHO establishes an acceptable daily intake of nitrate in human food of 3.7 mg/kg body weight. According to Van Velzen et al. (2008), about 85% of the nitrate absorbed in diets comes from vegetables and it is fully absorbed and processed almost completely by the human organism very efficiently regardless whether the vegetables have been cooked or not.

For comparative purposes, assuming the daily dose of 3.7 mg nitrate per kilogram body mass as a limit and considering an adult with a mass of 65 kg, on average, the acceptable daily intake could be a maximum of 135 grams of *Amaranthus hybridus* or *T. majus* leaves, species that presented

higher contents of this antinutritional compound. On average, for the other evaluated structures, the acceptable daily intake could be a maximum of 802 g for the leaves of *E. campestre* or *R. acetosa*, and a maximum daily intake of 187.90 g for the leaves of *A. viridis* or *X. sagittifolium*.

Within the limits elucidated, it would be safe to introduce such vegetables daily into a person's food as regards the nitrate levels obtained here as well as those levels considered acceptable for human consumption. It should be emphasized that there are other compounds considered antinutritional not verified in this work, and there is a clear need for further studies in this sector, until the daily use of these species in human food can be considered totally safe.

In order to meet the needs of human metabolism, the body must acquire from the exogenous environment, through the diet, compounds such as carbohydrates, lipids, proteins, minerals, among others, whose functions, besides structural, serves to supply the metabolic demand (Alberts et al. 2017).

In the literature, there are reports of the use of these two species *in natura*, sautéed and in drinks and juices in the cuisine of traditional populations (Brasil 2010, 2013). The contained acidity is well regarded to the palate considering juices and drinks, in the case of *R. acetosa* and teas and infusions produced with the floral buds of *H. sabdariffa*.

In the human body, food fibers, among other functions, are important mainly in maintaining the proper functioning of the digestive system. Proteins have structural and metabolic roles, which are essential for the maintenance of living organisms, and the daily recommendation for protein intake by an adult is, on average, 50 grams (0.11 pounds).

The two species of *Amaranthus* evaluated in this work, *A. hybridus* and *A. viridis*, especially the latter, stood out among the other species studied because they presented, in their constitutions, the highest levels for protein levels. *A. viridis* and *A.*

*hybridus* leaves and even most of the intermediate levels obtained for the other species showed crude protein values higher than those commonly found in some leafy vegetables normally marketed and consumed in Brazil, such as the garden lettuce (1300 mg.100g<sup>-1</sup>), the cabbage (2900 mg.100g<sup>-1</sup>), the spinach (2000 mg.100g<sup>-1</sup>) and the arugula (1800 mg.100g<sup>-1</sup>) (Lima 2011).

On average, the non-conventional vegetables studied, within the different structures and species, presented the mineral content of 407 mg of P, 1415 mg of K, 192 mg of Ca, 47 mg of Mg, 1 mg of Cu, 21 mg of Fe, 3 mg of Mn and 10 mg of Zn, all stipulated per 100 g of each plant sample. Vegetables considered conventional in Brazil such as lettuce, broccoli, kale, cauliflower, mustard and arugula present, on average, the contents of 45 mg of P, 331 mg of K, 101 mg of Ca, 22 mg of Mg, 0.04 Mg of Cu, 0.7 mg of Fe, 0.35 mg of Mn and 0.32 mg of Zn, stipulated in 100 g of the edible part (Lima 2011), values much lower than the averages observed in this study. In order to maintain the proper functioning of the metabolism, the human organism demands to absorb from external sources, through the feeding, different levels of minerals, which are therefore considered essential. The daily recommendations for the ingestion of these minerals vary around the demand of the organism for each element (Eur-Lex 2006).

The results of the nutritional composition of the structures and species analyzed indicate the possible uses for the different purposes presented by the industry and the cooking, suggesting the possibility of using these species as a source of antioxidant compounds and natural pigments in the form of food and for the industry, besides gathering the species evaluated in groups of nutritional similarities. However, for a correct inclusion in the daily diet, further studies are suggested, gauging the maximum recommended portions.

All species studied have varying levels of nutritional compounds of interest. The species *T.*

*majus* (garden nasturtium) and *A. hybridus* (green amaranth) contains the highest observed levels for antioxidant activity.

The species presented vitamin C in different levels among the analyzed structures, being that the highest levels of this vitamin were observed in the species *X. sagittifolium* (arrowleaf elephant ear), *T. majus* (garden nasturtium), *A. viridis* (slender amaranth), *A. hybridus* (green amaranth) and *B. alba* (malabar spinach) as well as when compared to conventional hardwoods.

*S. byzantina* (lamb's ear) presented the highest observed total phenolic level, as well as lower values for vitamin C levels, resulting in an intermediate antioxidant activity level.

The species *A. viridis* (slender amaranth), *H. sabdariffa* (roselle), *S. byzantina* (lamb's ear), *A. hybridus* (green amaranth) and *X. sagittifolium* (arrowleaf elephant ear) presented the highest levels of carbohydrates, lipids, proteins and fibers. *H. sabdariffa* also stood out for presenting pectin, anthocyanins and carotenoids in their floral buds.

*T. majus* (garden nasturtium), mainly in its leaf, presented the highest values observed for carbohydrates and caloric value, as well as high levels of proteins, lipids and fibers. This species, in its flowers and leaves, also presented high levels for most of the macronutrients evaluated, and the highest values observed for S. The species *E. campestre* (field eryngo) was also characterized by high levels of macronutrients, mainly S and P.

*A. viridis* (slender amaranth), *X. sagittifolium* (arrowleaf elephant ear) and *B. alba* (malabar spinach) presented high levels of P, K, Ca, Mg and S. In addition, the species *A. hybridus* and *A. viridis*, were even more notable for presenting in their leaves the highest levels of proteins, in addition to high levels for all minerals evaluated.

The species *X. sagittifolium* (arrowleaf elephant ear) was also noted for presenting among the highest levels observed for minerals K and Cu, and the highest level observed for P. The species *L.*

*canadensis* (canada lettuce), in turn, stood out to present the highest levels observed for the minerals Ca, Zn, B and Mn. Both varieties of *Rumex acetosa* (sorrel) stood out with the higher observed levels of Fe.

On average, the non-conventional vegetables studied presented nutritional levels higher than the averages described for the nutritional constitution of vegetables commonly used in human food.

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