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Chemical composition of medicinal plants used as auxiliary treatments for obesity

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The objective of this study was to find substances of pharmacological interest in a variety of medicinal plants, such as *Aloe vera* (L.) Burm. (aloe), *Simaba ferruginea* St. Hil. (calunga), *Baccharis trimera* (Less.) DC (carqueja), *Garcinia cambogia* Desr. and *Tournefortia paniculata* Cham. (Marmelinho), to aid in the treatment of obesity and other diseases. To reach this goal, phytochemical screenings were performed, percentage and mineral compositions were determined, and the content of a number of bioactive compounds in the medicinal plants were studied. Important substances with therapeutic potential, especially phenolic compounds, saponins and dietary fiber, were found in all plants, and significant levels of calcium were found in *G. cambogia* and *S. ferruginea*. The studied plants showed great diversity with regard to phytochemicals and have the potential to be used in pharmaceutical formulations that have possible health benefits. However, more studies must be conducted on these plants, because recommendations regarding the possible risks and benefits for human health would be premature at present; additional studies on toxicity, efficiency and safety are necessary, particularly in relation to the saponins found in all plants and to the high levels of phenolic compounds in *T. paniculata* (36.19 g 100 g^{-1} dry matter).

Key words: Phytochemical screening, percent composition, minerals, bioactive compounds, medicinal plants, obesity.

INTRODUCTION

The prevalence of obesity has increased steadily and is considered an important public health problem in developed countries and a global epidemic by the World Health Organization (WHO, 2010). A treatment for obesity is essential, because the condition is associated with various diseases, such as diabetes, some cancers and cardiovascular diseases, among others (Guh et al., 2009).

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Despite being one of the oldest diseases known to man, pharmacological options for the treatment of obesity are still limited and have many side effects (Mahan and Scott-Stump, 2008). The use of medicinal plants is being widely explored by consumers because of easy access, low cost, no need for prescriptions, and a belief in the absence of toxic effects. In addition, the pharmaceutical industry is interested in these plants as a viable alternative for the the future development of drugs that effectively and safely induce weight reduction (Mayer et al., 2009). Studies show that several natural products, including extracts and compounds isolated from plants, can be used for reducing body weight and preventing obesity (Souza et al., 2011; Simão et al., 2012).

Various medicinal plants such as *Aloe vera* (L.) Burm. (aloe), *Simaba ferruginea* St. Hil. (calunga), *Baccharis trimera* (Less.) DC (carqueja), *Garcinia cambogia* Desr. and *Tournefortia paniculata* Cham. (marmelinho) are used in the treatment of obesity (Souza et al., 2011; Simão et al., 2012, 2013). However, there is no scientific evidence for most of these plants regarding their efficacy and safety in the treatment of this disease; their use is solely based on popular beliefs, which emphasizes the need for scientific studies to elucidate the chemical constituents of these plants. The pharmacological/toxic understanding regarding their use in the treatment of obesity and other diseases is highly important.

The aims of this study were to perform phytochemical screening, determine chemical and percent composition as well as the bioactive compounds from the following medicinal plants: *A. vera*, *B. trimera*, *S. ferruginea*, *G. cambogia* and *T. paniculata*, and examine the potential for these substances as auxiliaries in the treatment of obesity.

MATERIALS AND METHODS

Sample collection and preparation

B. trimera (Less.) DC (carqueja) and *T. paniculata* Cham. (marmelinho) leaves as well as the stem bark of *S. ferruginea* St. Hil. (calunga) were acquired in the municipal market of Belo Horizonte, Minas Gerais in January 2011. The *B. trimera* and *T. paniculata* leaves were washed with tap and distilled water and then placed with the *S. ferruginea* stem bark in forced air circulating ovens to dry for 48 h at ±35°C. After drying, the leaves and the bark were individually ground in a Wiley-type mill, and the powders were stored in hermetically sealed flasks until analyzed. Commercially available samples of *Aloe vera* (L.) Burm. (aloe) and of *Garcinia cambogia* Desr., were acquired from FLORIEN, a distributor of pharmaceutical raw materials. The *A. vera* and *G. cambogia* samples were further processed by lyophilization of the plant mucilage (*A. vera*) and by spray drying (*G. cambogia*).

Analyses

Phytochemical screening

The powders obtained from the medicinal plants (FMP) were phytochemically screened. Specific reagents were used for each chemical group to induce chemical reactions that developed distinct colours and/or precipitates, which were characteristic for each class of substances (Matos, 1997). The specific groups of chemicals analyzed were the following: organic acids, reducing sugars, alkaloids, anthraquinones, azulenes, carotenoids, catechins, depsides and depsidones, coumarin derivatives, steroids and triterpenoids, flavonoids, cardiotonic glycosides, sesquiterpene lactones and other lactones, polysaccharides, proteins and amino acids, saponins and tannins.

Percent composition

The samples were placed in an oven at 105°C until a constant weight was reached to determine moisture content. The ether extract was determined using a Soxhlet continuous extractor. The crude protein was measured by the Kjeldahl method using the conversion factor 6.25 (N × 6.25). The percentage ash and fixed mineral residue were obtained from a defined quantity of samples by incineration (550°C) in a muffle furnace. The total soluble and insoluble dietary fiber was determined using an enzymatic method. The non-nitrogen extract was determined by the difference between 100 and the sum (in dry matter) of the ether extract, protein, ash and total dietary fiber. All methods used to determine percent composition in this study were performed using the methodology described by the Association of Official Analytical Chemists - AOAC (2005).

Mineral composition

The samples were subjected to a nitropercloric digestion in digester blocks with temperature control to quantify the minerals (Fe, Zn, Mn, Cu, Ca, Mg, P, K and S). Colorimetry was used to quantify P and S, flame photometry was used for K and atomic absorption spectrophotometry was used to determine amounts of Ca, Mg, Cu, Mn, Zn and Fe. The procedures used to analyze metal composition are described by Malavolta et al. (1997).

Phenolic compounds

The phenolic compounds were extracted with 50% methanol under reflux with three consecutive washes at 80°C. The extracts were collected and evaporated to 25 mL. The phenolic compounds were measured using the Folin-Denis reagent and tannic acid as a standard (AOAC, 2005).

Oxalic acid

The method developed by Loures and Jokl (1990) was employed to measure the oxalic acid. A hot extraction was performed with hydrochloric acid, and the oxalic acid was precipitated and quantified by titration of calcium oxalate with potassium permanganate.

Nitrate

Nitrate was extracted from the samples with distilled water at 45°C. Typically, a complex is formed by the nitration of salicylic acid under highly acidic conditions, and a distinct peak can be measured using a spectrophotometer at 410 nm in basic solutions (pH greater than 12). The absorbance of the material was directly proportional to the amount of nitrate present as long as no ammonium, nitrite, or

Table 1. Qualitative phytochemical screening of medicinal plants.

Constituent	*Aloe vera*	*Baccharis trimera*	*Simaba ferruginea*	*Garcinia cambogia*	*Tournefortia paniculata*
Organic acids	-	-	-	-	+
Reducing sugars	+	+	+	+	+
Alkaloids	-	-	-	-	-
Anthraquinones	-	-	-	-	+
Azulenes	+	+	+	-	-
Carotenoids	-	+	-	-	+
Catechins	-	-	-	+	+
Depsides and depsidones	-	+	+	-	+
Coumarin derivatives	-	-	-	-	-
Steroids and triterpenoids	-	+	+	-	+
Flavonoids	-	+	+	-	+
Cardiac glycosides	-	-	-	-	-
Sesquiterpene lactones and other lactones	-	-	-	-	+
Polysaccharides	+	+	-	-	-
Proteins and amino acids	+	+	+	+	+
Saponins	+	+	+	+	+
Tannins	-	-	-	+	+

The signs indicate the presence (+) or the absence (-) of the metabolite.

chlorine ions were present. Potassium nitrate was used as a standard (Cataldo et al., 1975).

Trypsin inhibitor

Trypsin inhibitors were extracted with 0.1 mol L^{-1} NaOH under magnetic stirring. After centrifugation at 10,000 × *g* for 60 min, an aliquot of the supernatant was used in the enzyme assay (Kakade et al., 1974). The trypsin activity was measured according to the methodology proposed by Erlanger et al. (1961). In total, 200 µL plant extracts and 200 µL enzyme were incubated in a water bath at 37°C for four time periods after the addition of 800 µL benzoyl-DL-arginine-p-nitroanilide (BApNA). The BApNA substrate solution (pH 8.2) was prepared in TRIS buffer (tris (hydroxymethyl) aminomethane) at 0.05 mol L^{-1} with 20 mmol L^{-1} $CaCl_2$. The reaction was stopped using 200 µL 30% acetic acid, and the product was measured using a spectrophotometer at 410 nm.

Saponins

The saponins were extracted with ethanol under stirring at room temperature for 60 min. The total saponin content was determined by the reaction of saponins with anisaldehyde, and digitonin was used as a standard (Baccou et al., 1977).

Statistical analysis

All data were collected in triplicate and presented as the mean ± standard deviation. The data were statistically evaluated by analysis of variance, and the means were compared using the Scott Knott test ($P < 0.05$) with the aid of the R software (R Development Core Team, 2011).

RESULTS AND DISCUSSION

Phytochemical screening is characterized by the identification of chemical compounds present in plant materials. The phytochemical screening results of substances FMPs are shown in Table 1.

The results indicated the presence of different metabolic groups of pharmacological interest in the plants examined, such as tannins (*G. cambogia* and *T. paniculata*), depsides and depsidones (*B. trimera*, *S. ferruginea* and *T. paniculata*), carotenoids (*B. trimera* and *T. paniculata*), and triterpenoids (*B. trimera*, *S. ferruginea* and *T. paniculata*), among other groups of metabolites.

Alkaloids and cardiac glycosides were not detected in any of the analyzed plants. The preliminary phytochemical screening provided a qualitative view of the chemical groups found in the plants, but further studies are needed to determine the concentration and characterization of these substances.

The results of the phytochemical screening are in agreement with other studies conducted on these plants, such as the study by Vasquez et al. (1996) on *A. vera* gel and its extracts, which showed the presence of saponins and the absence of tannins, flavonoids and alkaloids. Studies conducted by Rodrigues et al. (2009) on *B. trimera* showed the presence of flavonoids and saponins and the absence of alkaloids, anthraquinones, coumarins and cardiac glycosides. Moraes and Souza (2007) examined *T. paniculata* leaves and reported the presence of flavonoids and tannins as well as the absence of

Table 2. Percent composition of medicinal plants in g 100 g^{-1} dry matter.

Constituent	*Aloe vera*	*Simaba ferruginea*	*Baccharis trimera*	*Garcinia cambogia*	*Tournefortia paniculata*
Ether Extract	ND[2]	1.97±0.11[c]	2.49±0.20[b]	ND	3.88±0.21[a]
Crude Protein	1.54±0.11[d]	8.96±0.11[b]	7.15±0.22[c]	1.78±0.25[d]	10.78±0.35[a]
Ash	3.30±0.08[e]	8.53±0.04[b]	6.18±0.05[c]	34.18±0.24[a]	3.61±0.01[d]
Insoluble Fiber	5.20±0.18[d]	45.20±0.43[c]	64.67±0.50[a]	3.09±0.18[d]	46.71±0.80[b]
Soluble Fiber	5.77±0.33[b]	3.74±0.22[c]	1.60±0.07[d]	30.11±1.19[a]	1.16±0.05[d]
Total Fiber	10.97±0.42[d]	48.94±0.62[b]	66.26±0.53[a]	33.08±1.02[c]	47.87±0.86[b]
NNE[1]	84.18±0.51[a]	31.60±0.64[c]	17.93±0.60[d]	30.96±1.17[c]	33.86±0.11[b]

All data were collected in triplicate and represent the mean ± standard deviation. The same letter in rows indicates that the values do not differ by the Scott-Knott test (P <0.05). [1]NNE: Non-nitrogen extract. [2]ND: Not detected. The moisture content in the powders of the medicinal plants in g 100 g^{-1}: *Aloe* = 8.53; *Simaba* = 8.42; *Baccharis* = 8.56; *G. cambogia* = 3.94; *Tournefortia*: 9.90.

alkaloids. Studies performed by Subhashini et al. (2011) on *G. cambogia* revealed the presence of saponins, tannins, sugars, and proteins and the absence of flavonoids as well as a positive result for the alkaloids test. There were no studies found on the phytochemical screening of *S. ferruginia*.

The results of the chemical composition FMPs are shown in Table 2. In general, the contents of the ether extract were low, and *T. paniculata* had the highest content of ether extract (3.88 g 100 g^{-1} dry matter - DM). Ether extract was not detected in *A. vera* and *G. cambogia*. In addition, the contents of crude protein were relatively low, and the ash content was very high in *G. cambogia* (34.18 g 100 g^{-1} DM).

The highest content of dietary fiber (DF) was found in *B. trimera* (66.26 g 100 g^{-1} DM), and the lowest amount in *A. vera* (10.97 g 100 g^{-1} DM). In addition, a high content of soluble DF was found in *G. cambogia* (30.11 g 100 g^{-1} DM), and insoluble DF was found in *B. trimera* and *T. paniculata* at 64.67 and 46.71 g 100 g^{-1} DM, respectively.

Epidemiological studies suggest that dietary fiber is capable of preventing obesity and weight gain and reduces the risk for developing diabetes and cardiovascular diseases, among others (Liu et al., 2003).

In general, soluble DF helps in the treatment of obesity because it slows gastric emptying, glucose absorption, and reduces cholesterol in blood serum (Rique et al., 2002; Mello and Laaksonen, 2009). Conversely, insoluble DF accelerates intestinal transit and increases feces weight (Rique et al., 2002). Thus, the presence of DF in the composition of the analyzed plants can aid in the treatment of obesity.

The non-nitrogen extract or glicidic fraction consisted primarily of sugars. The highest content of sugars was found in *A. vera* (84.18 g 100 g^{-1} DM) followed by *T. paniculata* (33.86 g 100 g^{-1} DM), *S. ferruginea* (31.60 g 100 g^{-1} DM) and *G. cambogia* (30.96 g 100 g^{-1} DM).

In addition to the influence of macronutrients on the development of obesity, micronutrients, especially minerals, have received much attention because of their influence on body weight control. Table 3 shows the mineral contents FMPs examined in this study, which can be used as auxiliaries in the treatment of obesity. High levels of certain minerals were found in *A. vera*, such as potassium (1,009.44 mg 100 g^{-1} DM) and manganese (47.07 mg 100 g^{-1} DM). High levels of potassium (1,383.13 mg 100 g^{-1} DM), calcium (2,660.70 mg 100 g^{-1} DM) and iron (55.67 mg 100 g^{-1} DM) were found in *S. ferruginea*, and potassium (2,336.69 mg 100 g^{-1} DM) and iron (39.98 mg 100 g^{-1} DM) were found in *B. trimera*. In addition, high levels of calcium (7,273.23 mg 100 g^{-1} DM), sulfur (999.38 mg 100 g^{-1} DM) and iron (73.69 mg 100 g^{-1} DM) were found in *G. cambogia*.

Minerals play important roles in the human body, and one of them is regulation of metabolism. The absence of some minerals can cause metabolic problems, such as a slowing of the metabolism, which may lead to weight gain. In addition, some minerals can participate in the digestion of carbohydrates, fats and proteins and can act as aids in weight reduction.

The high levels of calcium shown in *G. cambogia* and *S. ferruginea* can be extremely effective for the treatment of obesity because calcium intake is involved in the regulation of body weight (St-Onge, 2005). Variations in the concentration of circulating calcium can affect food intake. High calcium content is known to decrease food intake because of the greater availability of calcium to ion channels. Several studies have shown that obese patients submitted to diets with high contents of calcium show a reduction in body fat (Heaney, 2003; Moore et al., 2004; Zemel et al., 2004).

Bioactive compounds present in plants can aid in health maintenance and in reducing the risk of disease; however, these compounds can cause damage to health if their concentration levels are too high. Thus, it is important to perform characterization studies on these

Table 3. Mineral composition of medicinal plants in g 100 g^{-1} dry matter.

Mineral	*Aloe vera*	*Simaba ferruginea*	*Baccharis trimera*	*Garcinia cambogia*	*Tournefortia paniculata*
P	44.40±0.00^{c}	83.84±6.31^{a}	83.84±6.31^{a}	76.44±0.00^{b}	44.40±0.00^{c}
K	1,009.44±6.31^{c}	1,383.13±27.48^{b}	2,336.69±49.31^{a}	742.59±69.31^{d}	495.75±12.82^{e}
Ca	845.45±6.31^{c}	2,660.70±16.68^{b}	612.42±0.00^{d}	7,273.23±33.46^{a}	381.06±23.10^{e}
Mg	258.74±6.31^{b}	163.79±0.00^{c}	142.17±0.00^{d}	419.88±6.01^{a}	147.98±6.41^{d}
S	258.74±27.51^{e}	731.60±10.92^{b}	630.65±12.63^{c}	999.38±63.32^{a}	527.19±23.54^{d}
Cu	13.12±0.21^{a}	3.10±0.32^{c}	7.81±0.76^{b}	3.38±0.38^{c}	2.04±0.27^{d}
Mn	47.07±0.49^{a}	5.24±0.11^{e}	13.47±0.27^{c}	18.75±0.11^{b}	7.00±0.17^{d}
Zn	1.57±0.23^{d}	2.20±0.16^{c}	3.84±0.00^{b}	6.51±0.15^{a}	1.40±0.05^{d}
Fe	2.58±0.38^{e}	55.67±0.16^{b}	39.38±1.44^{c}	73.69±0.65^{a}	11.51±0.43^{d}

All data were collected in triplicate and represent the mean ± standard deviation. The same letters in a row indicate that the values do not differ by the Scott-Knott test (P <0.05). The moisture content in the powders of the medicinal plants, in g 100 g^{-1}: *Aloe* = 8.53; *Simaba* = 8.42; *Baccharis* = 8.56; *G. cambogia* = 3.94; *Tournefortia*: 9.90.

Table 4. Contents of bioactive compounds of medicinal plants in dry matter.

Medicinal plant	Phenolic compounds (g 100 g^{-1})	Oxalic acid (g 100 g^{-1})	Nitrate (g kg^{-1})	Trypsin inhibitor (TIA mg^{-1})[1]	Saponins (g 100 g^{-1})
Aloe vera	0.15±0.02^{d}	ND[2]	0.77±0.01^{d}	ND	0.07±0.00^{d}
Simaba ferruginea	1.62±0.03^{c}	0.97±0.09^{a}	0.81±0.02^{c}	0.17±0.02^{c}	0.13±0.00^{c}
Baccharis trimera	4.03±0.21^{b}	0.91±0.03^{a}	2.68±0.12^{b}	6.26±0.32^{b}	0.54±0.03^{b}
Garcinia cambogia	0.09±0.01^{d}	ND	0.16±0.01^{e}	ND	0.07±0.00^{d}
Tournefortia paniculata	36.19±0.91^{a}	0.93±0.02^{a}	6.96±0.13^{a}	22.01±2.40^{a}	1.00±0.09^{a}

Data are the mean of three replicates ± standard deviation. The same letter in the columns indicates that the values do not differ by the Scott-Knott test (P <0.05). [1]TIA: trypsin inhibitor activity, in nmol min^{-1} mg^{-1}. [2]ND: Not detected. Moisture contents in the flours from medicinal plants, in g 100 g^{-1}: *Aloe* = 8.53; *Simaba* = 8.42; *Baccharis* = 8.56; *G. cambogia* = 3.94; *Tournefortia*: 9.90.

compounds in plant extracts. The bioactive compounds in samples FMPs are shown in Table 4.

Phenolic compounds were found in all plants; *T. paniculata* showed the highest content of phenolic compounds (36.19 g 100 g^{-1} DM), followed by *G. cambogia* (0.09 g 100 g^{-1} DM) and *A. vera* (0.15 g 100 g^{-1} DM) showed the lowest content. The maximum dose of phenolic compounds suggested for humans is approximately 1 g day^{-1} (Scalbert et al., 2005); thus, the daily limit is reached with only 3 g of *T. paniculata*. These plants are not typically used in food but have been used for the treatment of obesity. *T. paniculata* is notable among the plants examined in this study because of the health risks associated with its consumption, due to its high content of phenolic compounds concentrated in small quantities of the plant.

The concentrations of phenolic compounds found in the leaves of *B. trimera* (4.03 g 100 g^{-1} DM) were higher than those observed in other studies with this plant, whose levels ranged from 0.045 to 2.67 g 100 g^{-1} DM (Freitas et al., 2004; Souza et al., 2011; Oliveira et al., 2012). These differences may result from the methods of preparation (maceration and infusion) and by the use of other extraction solvents, such as ethanol, ethyl acetate, and butanol, among others.

The amount of phenolic exceeded the amount recorded by Moniruzzaman et al. (2012) for *A. vera*, which was 0.0008 g 100 g^{-1} DM. The authors also found that the leaves of *A. vera* have higher phenolic content than the gel, which indicates the leaves can be used as antioxidants. Conversely, the amount of phenolic for *G. cambogia* were lower than the amount reported by Subhashini et al. (2011), which was 7.5 g pyrocatechol 100 g^{-1} DM and also those recorded by Jantan et al. (2011) in 22 methanol extracts of different parts (leaves, trunks, bark and fruits) of nine *Garcinia* species showed amounts ranging from 0.44 to 6.28 g gallic acid 100 g^{-1} DM.

The different results could have been caused by the pattern used in the dosage, different extragents, different species; the parts of the plant used and the origin of the samples. No records were found in the literature on the

phenolic content of *S. ferruginea* and *T. paniculata*.

Some phenolic compounds, such as tannins, can inhibit certain digestive enzymes, such as amylase and trypsin, which can result in weight loss and help in the treatment of obesity (Monteiro et al., 2005). They also have multiple biological effects, such as antioxidants, anti-allergic, anti-inflammatory, anti-bacterial, anti-thrombotic, vasodilating and cardioprotective (Balasundram et al., 2006); these multiple biological effects have a broad field of application for the phenolics of these plants.

There was no significant difference between the plants *B. trimera*, *S. ferruginea* and *T. paniculata* regarding the content of oxalic acid, and oxalic acid was not detected in *A. vera* and *G. cambogia*. Oxalic acid content higher than 10 g are considered toxic to human health (Nappi et al., 2006); therefore, the amount of oxalic acid found in the plants examined in this study posed no health risk. The toxic effect of oxalic acid in the body has been associated with the reduction of bioavailability of some essential minerals, such as calcium, and the primary consequences are hypocalcemia and rickets, although absorption of iron, magnesium and zinc are also an issue (Siener et al., 2005).

Nitrate was also found in all plants with amounts ranging from 0.16 to 6.96 g kg^{-1} DM. The acceptable daily intake of nitrate is 5 mg kg^{-1} body weight (WHO, 2003). The excessive consumption of this compound can lead to cyanosis through the formation of metmyoglobin and neoplasms from the formation of N-nitroso compounds (Faquin and Andrade, 2004). Great quantities of the analyzed plants would have to be consumed by a 60kg person to reach 300 mg nitrate. Therefore, the contents of nitrate found in these medicinal plants should not be a health risk.

T. paniculata showed the highest potential for trypsin inhibition (22.01 trypsin inhibitor activity in nmol min^{-1} (TIA) mg^{-1} DM), followed by *B. trimera* (6.26 TIA mg^{-1} DM), and *S. ferruginea* (TIA 0.17 mg^{-1} DM). The presence of trypsin inhibitors was not detected in the plants *A. vera* and *G. cambogia*. Souza et al. (2011) observed the presence of trypsin inhibitors in aqueous and methanolic extracts of *B. trimera* leaves, which confirmed the results in this study that trypsin inhibition was found in *B. trimera*. However, these authors expressed their results in percentage of trypsin inhibition instead of in TIA mg^{-1} DM, which made it impossible to make comparisons with the activity observed in this study.

The presence of trypsin inhibitor, particularly in *T. paniculata*, resulted in specific inhibition of proteolytic enzymes, which can lead to decreased protein digestion and a decrease in the weight of animals. Saponins were found in all the studied species, and *T. paniculata* showed the highest amount (1.00 g 100 g^{-1} DM). The content of saponins recorded in this study for *B. trimera* (0.54 g 100 g^{-1} DM - ethanol extract) were within the range reported by Souza et al. (2011) for this plant, which ranged from 0.23 (aqueous extract) to 0.75 (methanol extract) g 100 g^{-1} DM. In the same study, these authors also found no hemolytic effect in tests conducted with extracts of this plant. The results in that study indicated a low toxicity of the saponins present in these leaves.

Saponins can cause many side effects, such as changes in reproduction and growth and a reduction in nutrient absorption because of changes in the permeability of cell membranes (Francis et al., 2002); this information highlights the need for studies to verify the toxicological potential of this phytochemical present in plant extracts. However, saponins may aid in the treatment of obesity because they can inhibit digestive enzymes and act on lowering cholesterol in human plasma by forming micelles in the small intestine with bile acids, thus preventing their reabsorption (Pereira and Cardoso, 2012).

Few articles related to the bioactive compounds found in the plants analyzed in this study were found in the literature (Souza et al., 2011; Moniruzzaman et al., 2012; Oliveira et al., 2012). Thus, there is a great need for more studies on these plants, and in particular, to examine any harmful effects resulting from their consumption by humans.

Conclusion

The plants examined showed high levels of substances, such as dietary fibers, some minerals, phenolic compounds, saponins and trypsin inhibitors, that have potential applications for weight loss. However, it is premature to recommend the use of these plants because of the possible risks to human health.

Additional studies on toxicity, efficacy and safety are necessary, particularly because of the saponins found in all plants examined and the high levels of phenolic compounds in *T. paniculata*.

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Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Association of Official Analytical Chemists (2005). Official methods os analysis of the association of the analytical chemists. 17. ed. Washington.

Baccou JC, Lambert F, Sauvaire Y (1977). Spectrophotometric method for the determination of total steroidal sapogenin. Analyst 102(1215):458-465.
Balasundram N, Sundram K, Sammar S (2006). Phenolic compounds in plants and agri-industrial by-products: Antioxidant activity, occurrence, and potential uses. Food Chem. 68(1):191-203.
Cataldo DA, Maroon M, Schrader LE, Youngs VL (1975). Rapid colorimetric determination of nitrate in plant tissutive by nitration of salicylic acid. Commun. Soil Sci. Plant Anal. 6(1):71-80.
Erlanger BF, Kukowsky N, Cohen W (1961). The preparation and properties of two new chromogenic substrates of trypsin. Arch. Biochem. Biophys. 95:271-278.
Faquin V, Andrade AT (2004). Acúmulo de nitrato em hortaliças e saúde humana. Lavras: UFLA/FAEPE, 2004. pp 88.
Francis G, Kerem Z, Makkar HP, Becker K (2002). The biological action of saponins in animal systems: a review. Br. J. Nutr. 88(6):587-605.
Freitas MSM, Martins MA, Carvalho AJC, Carneiro RFV (2004). Growth and yield of total phenols in coot [*Baccharis trimera* (Less.) DC.] In response to inoculation of mycorrhizal fungi in the presence and absence of mineral fertilizer. Rev. Bras. Plantas Med. 6(3):30-34.
Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH (2009). The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. BMC Public Health 9(88):1-20.
Heaney RP (2003). Normalizing calcium intake: projected population effects for body weight. J. Nutr. 133(1):268-270.
Jantan I, Farra AJ, Fadlina CS, Khalid R (2011). Inhibitory effects of the extracts of *Garcinia* species on human low-density lipoprotein peroxidation and platelet aggregation in relation to their total phenolic contents. J. Med. Plant. Res. 5(13):2699-2709.
Kakade ML, Simons N, Liener IE (1974). Determination of trypsin inhibitor activity of soy product: A collaborative analysis of an improved procedure. Cereal Chem. 51:376-382.
Liu S, Willett WC, Manson JE, Hu FB, Rosner B, Colditz G (2003). Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle- aged women. Am. J. Clin. Nutr. 78(5):920-927.
Loures A, Jokl L (1990). Microtécnica para determinação de ácido oxálico em folhas e derivados. In: Encontro Nacional de Analistas de Alimentos, 6, 1990, Curitiba. Resumos... Curitiba: Instituto de Tecnologia do Paraná. pp 59.
Mahan LK, Escott-Stump S (2008). Krause's food, nutrition, and diet therapy. 12th ed. Philadelphia: WB Saunders, pp 1359.
Malavolta E, Vitti GC, Oliveira AS (1997). Avaliação do estado nutricional das plantas. Piracicaba: Potafos. pp 319.
Matos FJA (1997). Introdução à fitoquímica experimental. 2.ed. Fortaleza: UFC pp 141.
Mayer MA, Hocht C, Puyo A, Taiara CA (2009). Recent advances in obesity pharmacotherapy. Curr. Clin. Pharmacol. 4(1): 53-61.
Mello VD, Laaksonen DE (2009). Dietary fibers: current trends and health benefits in the metabolic syndrome and type 2 diabetes. Arq. Bras. Endocrinol. Metabol. 53(5):509-518.
Moniruzzaman M, Begum R, Sohel A, Amrita B, Ibrahim K, Siew H (2012). *In vitro* antioxidant effects of *Aloe barbadensis* Miller extracts and the potential role of these extracts as antidiabetic and antilipidemic agents on streptozotocin-induced type 2 diabetic model rats. Molecules 17(11):12851-12867.
Monteiro JM, Albuquerque UP, Araújo EL (2005). Tannins: an approach to chemical ecology. Quím. Nova. 28(5):892-896.
Moore LL, Singer MR, Bradlee ML, Ellison RC (2004). Dietary predictors of excess body fat acquisition during childhood. Circulation 197(7): 5.
Moraes LD, Souza OV (2007). Reviews of Qualitative and Quantitative Variation of Secondary Metabolites in Tournefortia paniculata Cham (Boraginaceae). Rev. Bras. Biociên. 5(2): 1032-1034.
Nappi GU, Ribeiro-Cunha MR, Coelho JV, Jokl L (2006). Validation methods to determine phytic and oxalic acids in "multimisturas". Ciênc. Tecnol. Aliment. 26(4):811-820.
Oliveira CB, Comunello LN, Lunardelli A, Amaral RH, Pires MGS, Silva GL, Manfredini V, Vargas CR, Gnoatto SCB, Oliveira JR, Gosmann G (2012). Phenolic enriched extract of *Baccharis trimera* presents anti-inflammatory and antioxidant activities. Molecules 17(1): 1113-1123.
Pereira RJ, Cardoso MG (2012). Vegetable secondary metabolites and antioxidants benefits. J. Biotechnol. Biodivers. 3(4): 146-152.
R Core Team. R: A language and environment for statistical computing (2011). Viena: R Foundation for Statistical Computing; 2012. ISBN 3-900051-07-0. Available: http://www.R-project.org/
Rique ABR, Soares EA, Meirelles CM (2002). Nutrição e exercício na prevenção e controle das doenças cardiovasculares. Rev. Bras. Med. Esporte. 8(6):1-11.
Rodrigues CRF, Dias JH, De Melo RN, Ritcher RF, Picada JN, Ferraz A (2009). B. Genotoxic and antigenotoxic properties of *Baccharis trimera* in mice. J. Ethnopharmacol. 125(1): 97-101.
Scalbert A, Johnson IT, Saltmarsh M (2005). Polyphenols: antioxidants and beyond. Am. J. Clin. Nutr. 81(1):215-217.
Siener R, Hunow R, Seidler A, Voss S, Hesse A (2005). Oxalate contents of species of the Polygonaceae, Amaranthaceae and Chenopodiaceae families. Food Chem. 98(2):220-224.
Simão AA, Corrêa AD, Chagas PMB (2012). Inhibition of digestive enzymes by medicinal plant aqueous extracts used to aid the treatment of obesity. J. Med. Plant. Res. 6(47): 5826-5830.
Simão AA, Lage FF, Chagas PMB, Fraguas RM, Freire JM, Marques TR, Corrêa AD (2013). Antioxidants from Medicinal Plants Used in the Treatment of Obesity. Eur. J. Med. Plant. 3(3):429-443.
Souza SP, Pereira LLS, Souza AA, Santos CD (2011). Inhibition of pancreatic lipase by extracts of *Baccharis trimera* (Less.) DC. Asteraceae: evaluation of antinutrients and effect on glycosidases. Rev. Bras. Farmacogn. 21(3):450-455.
St-Onge MP (2005). Dietary fats, teas, dairy, and nuts: potential functional foods for weight control? Am. J. Clin. Nutr. 81(1): 7-15.
Subhashini N, Nagarajan G, Kavimani S (2011). *In vitro* antioxidant and anticholinesterase activities of *Garcinia combogia.* Int. J. Pharm. Pharm. Sci. 13(3): 129-132.
Vasquez B, Avila B, Segura D, Escalante B (1996). Antiinflammatory activity of extracts from *Aloe vera* gel. J. Ethnopharmacol. 55(1):69-75.
World Health Organisation (2010). WHO Global database on Body Mass Index. WHO: Geneva.
World HealtH Organization (2003). WHO Food additives series No 50. Safety evaluation of certain food additives. Fifty-ninth report of the joint FAO/WHO Committee on Food Additives. Geneva.
Zemel MB, Thompson W, Milstead A, Morris K, Campbell P (2004). Calcium and dairy acceleration of weight and fat loss during energy in obese adults. Obes. Res. 12(4):582-590.