Volumen 38, Nº 3. Páginas 53-58
IDESIA (Chile) Septiembre, 2020

Antioxidant activity of nine medicinal plants with commercial potential

Actividad antioxidante de nueve plantas medicinales con potencial comercial

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ABSTRACT

Nine plants from the Puna ecoregion of northern Chile, traditionally used in ethnomedicine, were studied. The total content of phenolic compounds and their antioxidant capacity (ABTS, FRAP, and ORAC) were determined both in the dry material and in the infusions. To our knowledge, this is the first report on the antioxidant capacity for some of these plants and their infusions. Furthermore, these results show the diversity and complexity of the plants of the Chilean highlands with high potential to be used as a source of natural antioxidants in the reformulation and development of healthier foods.
Keywords: antioxidant activity, medicinal infusion, Northern Chile, Phenolic compounds.

RESUMEN

Se estudiaron nueve plantas de la ecorregión de puna del norte de Chile, utilizadas tradicionalmente en etnomedicina. El contenido total de compuestos fenólicos y su capacidad antioxidante (ABTS, FRAP y ORAC) se determinaron tanto en el material seco como en las infusiones. Según nuestro conocimiento, este es el primer informe sobre capacidad antioxidante para algunas de estas plantas y sus infusiones. Además, estos resultados muestran la diversidad y complejidad de las plantas del altiplano chileno con alto potencial para ser utilizadas como fuente de antioxidantes naturales en la reformulación y el desarrollo de alimentos más saludables.
Palabras clave: *actividad antioxidante, infusiones medicinales, compuestos fenólicos.*

Introduction

The use of medicinal plants to treat diseases is probably the oldest method that has been used to treat or deal with a disease. In South America, Andean communities have consumed medicinal plants as an alternative to traditional medicine over the decades, who prepared infusions, decoctions and wound dressings from it (Gastaldi *et al*., 2018; Villagrán and Castro, 2003). Some plants grow in habitats with altitudes ranging from 500 to 5000 meters above sea level in countries such as Chile, Argentina, Peru, Bolivia, Ecuador, Colombia, and Venezuela. In particular, the Andean communities of northern Chile and suburban societies, historically, have used medicinal plants as an interesting source of therapeutic agents (Table 1) (Moreira-Muñoz *et al*., 2016), such as *Senecio nutans* (Asteraceae), which is widely used for mountain sickness characterized by symptoms such as headaches, dizziness, vomiting, and fatigue (Paredes *et al*., 2016). Another genus of interest is the *Parastrephias* (Asteraceae). This genus has five different species: *P. lucida*, *P. lephidophylla*, *P. phyllicaeformis*, *P. quadrangularis* and *P. teretiuscula* (Cabrera, 1978). Most of these species are used by the native of the high Andes to relieve among other uses toothache, fractures, and bruises of bones (Villagrán *et al*., 2003). For many of these species have been reported multiple biological activities found in alcoholic extracts, such as anti-inflammatory activity, antioxidant, antibacterial, as well as the antifungal activity (Di Ciaccio *et al*., 2018; Echiburu-Chau *et al*., 2017; Zampini *et al*., 2009). In the last decade, studies on antioxidant activities of medicinal plants have increased remarkably due to increased interest of the healthy food industry in their potential of being

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Fecha de Recepción: 21 de marzo, 2020.
Fecha de Aceptación: 17 de mayo, 2020.

Table 1. Ethnobotanical data of the selected Andean plants from northern Chile.

Plant specie	Family	Common name	Voucher number	Part used	Traditional uses
Aldama helianthoides	Asteraceae	Sorona	184923	Stems, leaves	Anti-rheumatic, cancer, hepatitis, lower cholesterol
Aloysia tarapacana	Verbenaceae	Rika-Rika	184924	Aerial parts	Cold, diarrhea, anti-inflammatory, liver disorders
Azorella compacta	Apiaceae	Llareta	169936	Roots, flowers, seeds and resin	Diuretic, analgesic, diabetes, pneumonia
Baccharis alnifolia	Asteraceae	Chilka	184925	Whole plant, leaves	Bone pain, indigestión, anti-inflammatory, anti-rheumatic
Baccharis tola	Asteraceae	Ñacatola	184926	Aerial parts, leaves and stems	Gastro protective, Antiseptic, anti-inflammatory
Clinopodium gilliesii	Lamiaceae	Muña	184929	Aerial parts	Digestive disorders, altitude sickness, aphrodisiac
Dunalia spinosa	Solanaceae	Yara	184931	Leaves, fruits, Flowers	Diabetes, antiseptic, high altitude sickness
Parastrephia lucida	Asteraceae	Umatola	184936	Whole plant	Broken bones, analgesic, antiseptic, anti-inflammatory
Polylepis tarapacana	Rosaceae	Queñoa	179704	Bark, leaves	Respiratory diseases, diabetes, hypertension

used as a rich and natural source of antioxidants (Gonçalves *et al*., 2013; Li *et al*., 2013). However, many Andean plants have not been studied in their most common form of consumption such as decoction or infusion. This work aimed to determine the transfer of phenolic compounds and antioxidant activity in nine medicinal plants from northern Chile which could be used for the reformulation and the development of healthier food.

Materials and methods

Collection and sample preparation

Fresh aerial parts of these plants were collected from March to May 2019 from Andean Altiplano, northern Chile (3000 to 4100 m.a.s.l.). Each voucher specimens were deposited in the Herbarium from the Botany Department of the Universidad de Concepción, Chile. The fresh aerial parts of these plants were brought to the laboratory for drying at room temperature. After the drying process, the leaves were removed manually from the stems and then stored in airtight polyethylene bags until its use.

Ethanolic extraction

Dried and powdered aerial parts of each plant (1 g) were extracted with absolute ethanol for 30 minutes in the dark in an ultrasonic bath (100 mL, three times) to obtain an extract for total phenolics and flavonoid content and antioxidant analyses. The extract was immediately concentrated under vacuum.

Infusion extraction

Each infusion was prepared from the whole herb (stem and leaves), using 0.5 g of plant brewed for 5 minutes in 250 mL water at 100°C (Soto *et al*., 2019). The infusion was left to cool at room temperature and tested for bioactive compounds on the same day.

Total polyphenol and flavonoid contents

Total polyphenolic contents (TPC) were determined by the Folin-Ciocalteau method as reported (Parra *et al*., 2018). Determination of total flavonoid content (TFC) of the resin was performed as previously described (Parra *et al*., 2018).

Antioxidant assays

To measure the antioxidant activity of nine plants, we used the FRAP, TEAC, and ORAC assays. Every analysis was performed in BioTek Synergy HTX Multi-Mode Microplate Reader (Winooski, VT, USA) using 96-well microplates. For all antioxidant assays, a standard curve of Trolox was used, and results were expressed as Trolox equivalents gram dry weight (mmol TE/g of DW). The FRAP and TEAC assays were performed according to Soto with modifications (Soto *et al*., 2019).

Statistical analysis

All analyses were carried out in triplicate, and data are presented as means and standard

Table 2. Phenolic compounds, total flavonoids and antioxidant activities of the selected Andean plants from northern Chile.

Plant specie	Yield (%)	TPC (mg GAE/g DW)	TFC (mg QE/g DW)	TEAC (µmol TE/g DW)		
				FRAP	ABTS	ORAC
Aldama helianthoides	6.6	7.40 ± 0.07[c]	6.91 ± 0.08[c]	53.74 ± 1.54[f]	16.69 ± 0.03[d]	126.37 ± 0.01[d]
Aloysia tarapacana	19.8	16.55 ± 0.15[f]	7.02 ± 0.23[cd]	50.56 ± 0.76[df]	29.89 ± 0.06[f]	130.31 ± 0.01[e]
Azorella compacta	3.4	8.63 ± 0.15[d]	7.84 ± 0.11[cde]	41.35 ± 0.19[cd]	14.62 ± 0.03[c]	53.79 ± 0.01[b]
Baccharis alnifolia	12.7	4.42 ± 0.06[b]	1.24 ± 0.24[a]	13.29 ± 0.61[b]	6.19 ± 0.03[ab]	170.64 ± 0.01[g]
Baccharis tola	24.6	27.10 ± 0.33[g]	8.36 ± 0.40[ef]	52.21 ± 2.81[cdef]	30.86 ± 0.11[fg]	98.95 ± 0.01[c]
Clinopodium gilliesii	7.9	14.46 ± 0.23[e]	11.26 ± 0.14[g]	95.67 ± 1.21[g]	19.84 ± 0.06[abe]	51.55 ± 0.01[a]
Dunalia spinosa	4.3	2.44 ± 0.09[a]	1.54 ± 0.02[ab]	6.91 ± 0.07[ab]	4.80 ± 0.05[ae]	137.15 ± 0.18[f]
Parastrephia lucida	35.0	77.80 ± 0.38[i]	73.17 ± 1.19[i]	816.92 ± 5.46[i]	185.85 ± 2.44[i]	2904.38 ± 0.01[i]
Polylepis tarapacana	12.1	55.17 ± 0.10[h]	24.37 ± 0.20[h]	473.68 ± 0.55[h]	139.05 ± 0.33[h]	2352.91 ± 0.01[h]

* Superscript letters indicate significant differences ($p < 0.05$, one-way ANOVA).

deviations (SD). GraphPad Prism® 6 software was used for statistical analysis of the experimental data. One-way analysis of variance (ANOVA) was used for statistical analysis, where $p < 0.05$ were considered statistically significant.

Results and discussion

Bioactive compounds and antioxidant activity of the selected medicinal plants

Among the different phytochemicals in existence, phenolic compounds have been in the privileged spot for the last years, being studied and used in different application areas such as food, health, and pharmaceutical industries (Chirinos *et al.*, 2013). This work assessed the total polyphenol content (TPC), total flavonoid content (TFC), and antioxidant activity of nine medicinal plants from northern Chile used as an infusion. Polyphenol quantification in the ethanolic extracts of the plants studied (2.44 to 77.80 mg GAE/g DW), they revealed that values fell into the range reported in the literature for medicinal Chinese plants (Li *et al.*, 2013), medicinal Andean plants (Chirinos *et al.*, 2013), as well as in the range of the herbal tea (Oh *et al.*, 2013), and Asian tropical plant *G. velutinus* from Brunei Darussalam (Iqbal *et al.*, 2015), both considered rich polyphenol sources.

Since the antioxidant activity of a plant extract is determined by a mixture of compounds, it is convenient to evaluate this property through more than one method (Pisoschi *et al.*, 2016). Therefore, here we used the single electron transfer (SET) method, such as FRAP; as well as hydrogen atom transfer (HAT) in the ABTS and ORAC (Liang and Kitts, 2014). The FRAP values fluctuated between 6.91 to 816.92 µmol TE/g DW (Table 1), slightly less when compared to those reported for other medicinal plants (Jiménez *et al.*, 2015), but with values higher than those reported for Indian medicinal plants (Surveswaran *et al.*, 2007). While that the values of ABTS were between 4.80 to 185.85 µmol TE/g DW, these values were similar or superior to those reported in the literature for different medicinal plants from China (Li *et al.*, 2013). In the cases of ORAC values, *P. lucida* and *P. tarapacana* showed a high antioxidant capacity similar to Chilean berries, they are recognized by their powerful antioxidant activity (Chamorro *et al.*, 2019).

Bioactive compounds and antioxidant activity of the medicinal plant infusions

Three have been found report in the literature that describes the antioxidant capacity in infusions of medicinal plants from northern Chile (Larrazabal *et al.*, 2018; Rojo *et al.*, 2009; Soto *et al.*, 2019). The differences between this study and others may be due to the different sites and times of the plants collection (Jordán *et al.*, 2013), as well as, to an important extent, the mass:water ratio used and the different aqueous extraction methods. These results clearly show that not only the total content of bioactive compounds of the plants is important for the estimation of the therapeutic or toxic effects, but also the actual protocol of intake (Nischwitz *et al.*, 2017). The infusions were prepared with 0.5 g plant material for 5 min in 250 mL hot water. For brewing times over 5 min, a reduction in TPC could be observed, possibly due to the thermolability of the compounds (Larrazabal *et al*., 2018). To our knowledge, the antioxidant activity of many of these infusions have not been studied or lower values have been published than those found in this study. The polyphenol content found these herbs ranged from 27.80-567.50 mg GAE/L (see Table 3). The infusion of P. lucida showed the highest content of phenolic compounds, it followed *B. tola*, *D. spinosa* and *A. compacta*, all these plants have potential as antioxidant infusions. Moreover, the values found in this study were considerably higher than the value literature reported for the same plants (Rojo *et al*., 2009). The value of QE for P. lucida was considerably higher than those of Green Tea, and this value was the highest of all the plants analyzed. The content of flavonoids is similar to that reported in infusions of native plants of Argentine Patagonia (Gastaldi *et al*., 2018). TPC and AC are correlated (Table 4), with correlation coefficients for FRAP (0.8648), ABTS (0.9453), and ORAC (0.9500) similar to reported for another medicinal plant (Berłowski *et al*., 2013; Surveswaran *et al*., 2007). These correlations implied that phenolic compounds in these extracts could be the main components contributing to scavenging free radical activities, but not be responsible for reducing oxidant abilities. Moreover, the data showed that the antioxidant capacities measured by ABTS assay are strongly correlated with the ORAC (0.9065). The FRAP values fluctuated from 297.9 to 2164.25 µmol TE/L, however, the values found in other herbs which grow on the Chilean Altiplano under the same agroclimatic conditions, they were far greater than the value obtained here (Rojo *et al*., 2009). This difference could be attributed to the concentration of the infusions used in previous reported. In this work, it was used samples that are much closer to the real conditions under which an infusion for direct human consumption is prepared. TPC and FRAP reflect the presence of all the reducing substances in a given matrix, not just the polyphenolic compounds. Therefore, interpretations of these results should be considered as potential limitations. To strengthen our results, we have analyzed the antioxidant capacity through the ABTS and ORAC assays. ABTS assay showed values between 178.25 to 2426.65 µmol TE per liter (see Table 3). The values found in this work are below those reported for medicinal plants

Table 3. Yields, antioxidant activity and toxic elements of 9 Andean infusion tea plant extracts from northern Chile.

Plant specie	Yield (%)	TPC (mg GAE/L)	TFC (mg QE/L)	TEAC (µmol TE/L)		
				FRAP	ABTS	ORAC
Aldama helianthoides	6.6	27.80 ± 0.10[a]	27.50 ± 0.20[c]	347.50 ± 1.90[b]	270.70 ± 2.65[b]	89.3 ± 0.05[a]
Aloysia tarapacana	6.2	123.15 ± 0.35[de]	61.85 ± 0.95[e]	1071.00 ± 5.65[g]	900.95 ± 9.90[g]	930.00 ± 1.40[e]
Azorella compacta	8.3	169.10 ± 4.60[f]	76.95 ± 2.90[g]	516.85 ± 23.55[c]	288.15 ± 22.45[bc]	1106.50 ± 10.15[f]
Baccharis alnifolia	10.3	35.85 ± 0.60[ab]	8.05 ± 0.30[a]	618.75 ± 8.80[d]	546.25 ± 11.55[e]	599.50 ± 0.15[d]
Baccharis tola	8.9	225.6 ± 5.80[h]	71.65 ± 0.70[efg]	2164.25 ± 8.35[h]	1772.45 ± 13.20[h]	1145.75 ± 8.20[g]
Clinopodium gilliesii	4.3	81.80 ± 1.10[c]	79.35 ± 1.45[fgh]	664.75 ± 3.50[e]	430.60 ± 3.30[d]	259.95 ± 0.05[b]
Dunalia spinosa	24.5	172.40 ± 0.40[g]	9.85 ± 0.15[ab]	1001.60 ± 1.75[f]	716.80 ± 8.25[f]	1427.75 ± 9.15[h]
Parastrephia lucida	18.3	567.50 ± 4.00[i]	335.30 ± 7.75[i]	3566.85 ± 8.35[i]	2426.65 ± 13.20[i]	5400.45 ± 20.26[i]
Polylepis tarapacana	6.4	109.55 ± 1.35[d]	51.55 ± 2.75[de]	297.90 ± 1.05[a]	178.25 ± 3.20[a]	591.10 ± 0.95[c]

*Superscript letters indicate significant differences ($p < 0.05$, one-way ANOVA).

Table 4. Coefficients for the correlation between antioxidant capacities measured by ABTS, FRAP and ORAC assays, total phenolics and flavonoids content of 9 medicinal infusions from northern Chile.

	ABTS	FRAP	ORAC	Phenolics	Flavonoids
ABTS	1	0.9787	0.9065	0.9453	0.8158
FRAP	0.9787	1	0.8057	0.8648	0.7266
ORAC	0.9065	0.8057	1	0.9500	0.8562
Phenolics	0.9453	0.8648	0.9500	1	0.8620
Flavonoids	0.8158	0.7266	0.8562	0.8620	1

from Peru (Berłowski *et al.*, 2013). The results for ORAC assay showed values between 89.30 to 5400.45 µmol TE/L. The medicinal infusions of Andean northern Chile were similar than reported for the black and green tea (Floegel *et al.*, 2011).

Conclusion

The antioxidant capacities and total phenolics and flavonoids contents of nine infusions medicinal plants from northern Chile were evaluated using the FRAP, ABTS and ORAC assays as well as the Folin-Ciocalteu and aluminum trichloride methods, respectively. The antioxidant activity found suggests that compared to SET assays the HAT assays better estimate the antioxidant capacity of these beverages. The data show that the antioxidant capacities measured by ABTS assay are strongly correlated with the ORAC and phenolic compounds. *P. lucida* showed the highest antioxidant capacities and total phenolic contents. Moreover, *B. tola*, *D. spinosa* and *A. compacta*, all these plants have potential as antioxidant infusions, being similar to those of green tea.

Acknowledgments

This study was supported by Universidad de Tarapacá.

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