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Research Article
Anti-aging and Nutraceutical Characterization of Plant Infusions used in Traditional Medicine

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Abstract
Objective: The present study was conducted to evaluate the nutraceutical and anti-aging potential of 7 Plant Infusions (PI) used in traditional medicine. **Methodology:** *In vitro* collagenase inhibitory (Col-I), *in vitro* elastase inhibitory (Ela-I) and *in vitro* hyaluronidase inhibitory (Hya-I) activities of plant infusion were determined. Percentage of Inhibition Activity (IA) for both anti collagenase and anti elastase assays was calculated. Total Phenolic Content (TPC) and Total Flavonoid Content (TFC) of plant infusions was determined. Condensed tannins content was analyzed using the acidified vanillin reagent. Data were analyzed using one-way analysis of variance followed by Tukey test for comparisons among means with a significance level of 5%. Pearson correlation coefficient was used to determine correlations among means. **Results:** Results showed that *Paullinia cupana* seeds and *Camellia sinensis* leaves exhibited the highest content of total phenolic, flavonoid and condensed tannins. All the samples showed great radical scavenging activity (227.74-788.04 µmol TE/g PI) in the ORAC assay and also exhibited high *in vitro* antihypertensive activities (IC_{50}, 0.0000113- 4.3333300 µg mL^{-1} against angiotensin-converting enzyme). *Cochlospermum vitifolium* plant infusion was the only one able to inhibit the 50% of the activity of aging-related enzymes (elastase, collagenase and hyaluronidase). **Conclusion:** Overall, some of the evaluated extracts presented high antioxidant capacity and *in vitro* inhibitory potential of the enzymes assessed, thus they could be added to food matrices as plant-based materials with nutraceutical and anti-aging effects on human skin and health.

Key words: Anti-aging, nutraceutical, bioactive compounds, infusions, traditional medicine

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

All over the world, plant extracts have been used in Traditional Medicine (TM), which is considered to be the main form of health care or its complement[1]. Nearly of 10,000 plant species are used for this purpose[2]. However, it is claimed that the chemical, pharmacological and biomedical validation of the biological activity of plants have been carried out only in a few species, arising the need to analyze and determine the bioactivity of medicinal plants[2]. The most common form of consumption of medicinal plants is as infusions, which have been exploited by different markets of food and pharmaceutical products, converging in the development of nutraceutical and nutricosmetic products, which are defined as nourishing foods with health and/or outer-beauty benefits[3].

Nowadays, study continues to find natural Angiotensin Converting Enzyme (ACE) inhibitors, which are an alternative for the treatment of hypertension, since, ACE plays a significant role in renin-angiotensin-aldosterone system, by converting the angiotensin I into angiotensin II, which is a vasoconstrictive agent, responsible for the mechanisms that lead to the increment of blood pressure[4].

On the other hand, another health-related concern that has been increasing in recent years, is extrinsic skin ageing, which results mainly from exposure of skin to solar UV radiation causing alterations in the extracellular matrix (ECM), due to the production of lipid peroxides, enzymes and Reactive Oxygen Species (ROS)[5]. This promote the expression of ECM degrading enzymes, such as collagenase, elastase and hyaluronidase, resulting in the presence of wrinkles[6].

In the present study, it was evaluated the potential nutraceutical effects of seven medicinal plants: *Paullinia cupana*, *Rhododendron simsii*, *Cochlospermum vitifolium* and *Camellia sinensis* (White, Green, Oolong and Black), which have widely consumed traditionally by the population as infusions for the beneficial effects on health attributed to them (Table 1). This study was conducted to assess their inhibitory activity of ageing-related enzymes (elastase, collagenase and hyaluronidase), the hypertension modular enzyme (ACE) as well as their radical scavenging activity and phytochemical content, in order to determine their potential use for the development of nutraceutical/nutricosmetic products.

MATERIALS AND METHODS

Chemicals: All solvents were analytical grade. Porcine pancreatic elastase (EC 3.4.21.36), hyaluronidase from bovine testes (EC 3.2.1.35), collagenase from *Clostridium histolyticum* (EC 3.4.24.3), hyaluronic acid, 2-furanacryloyl-L-leucylglycyl-L-prolyl-L-alanine (FALGPA), N-(methoxysuccinyl)-Ala-Ala-Pro-Val 4-nitroanilide (MAAPVN), Epigallocatechin gallate (EGCG) and others were purchased from Sigma Chemical Co. (St. Louis, USA).

Preparation of plant infusions: Plant materials were provided by the Well Life™ Company. Common and botanical names of plants as well as the parts used for analysis are described in Table 1. Plant infusions were prepared according to the Ratnasooriya and Fernando method[7], by adding 2 g of fresh and grinded material to 100 mL of boiling water, brewing for 5 min and then vacuum-filtered (Whatman No.1001-125). Infusions were freeze-dried and preserved at -20°C, until further use.

Trolox equivalent antioxidant capacity (TEAC) (ORAC-fluorescein): Trolox equivalent antioxidant capacity of the plant infusions was evaluated according to the method of ORAC-Fluorescein[8] using the oxygen radical absorbance capacity with fluorescein as probe (ORAC-FL) assay. Peroxyl radicals were generated by 2, 2'-azobis (2-amidinopropane) dihydrochloride and fluorescent loss was monitored in a Synergy microplate reader (Dynergy TM HT Multidetection, BioTek, Inc, Winoosgki, VT, USA). The excitation and emission absorbance were set at 485 and 538 nm, respectively. The antioxidant capacities were expressed as micromoles of Trolox Equivalents (μmol TE) per gram of dry weight (dw) Plant Infusions (PI).

Angiotensin-Converting Enzyme Inhibitory (ACE-I) activity: Angiotensin-converting enzyme inhibitory activity of plant infusions was determined according to Miguel *et al.*[4] with modifications. The plant infusion was added to 0.1 M borate buffer (pH 8.3) containing 0.3 M NaCl and 5 mM

Table 1: Plants used in traditional medicine

Botanical name	Common names	Nomenclature	Part used	Therapeutic uses
Camellia sinensis (L.) Kuntze	White, Green, Oolong and Black tea	CsW, CsG, CsO and CsB	Leaves	Antihypertensive, antioxidant, antiaging[6]
Paullinia cupana	Guarana	Pc	Seeds	Stimulating, aphrodisiac[20]
Rhododendron simsii	Azalea	Rs	Flowers	Anti-inflammatory, anti-diarrheal[21]
Cochlospermum vitifolium (Willd.) Spreng.	Silk-cotton tree (Rosa Maria)	Cv	Bark	Anti-hypertensive, anti-diabetic[24]

hippuryl-histidyl-leucine. The ACE (2 mU) was added and the reaction mixture was incubated at 37°C for 30 min. The reaction was stopped by adding 1 M HCl. The hippuric acid formed was extracted with ethyl acetate and the organic phase was evaporated. The residue was dissolved in distilled water and measured spectrophotometrically at 228 nm. Captopril, one of the main drugs used in the treatment of hypertension and epigallocatechin gallate (EGCG) were used as positive controls. In order to determinate the IC_{50} (concentration of the extract required to inhibit 50% of the enzymes activity, mg mL^{-1}) of each PI, data were adjusted to a nonlinear regression model using Hill's equation.

Anti-aging potential

Anti-collagenase, anti-elastase and anti-hyaluronidase activities: *In vitro* collagenase inhibitory (Col-I) activity of plant infusion was determined according to Chompoo *et al.*[9] with modifications. The reaction mixture contained tricine buffer 0.05 M, N-[3-(2-Furyl)acryloyl]–Leu–Gly–Pro-Ala (FALGPA) 0.46 mg mL^{-1}, collagenase 0.1 U and different concentrations of PI. Absorbance at 345 nm was determined at t = 0, after this, the reactions were incubated at 25°C for 20 min and finally, absorbance at t = 20 was registered.

In vitro elastase inhibitory (Ela-I) activity of the plant infusion was assessed as reported by Kim *et al.*[10] with modifications. The reaction mixture was composed by 0.2 mM Tris-HCl buffer (pH 8.0), 0.36 mg mL^{-1} N-Succinyl-Ala-Ala-Ala-p-nitroanilide (Suc-Ala), elastase 3.9 mU and plant infusions dilutions. Absorbance at 410 nm was determined at t = 0, after this, the reactions were incubated at 21°C for 20 min and finally, absorbance at t = 20 was registered.

Percentage of Inhibition Activity (IA) for both anti-collagenase and anti-elastase assays was calculated using the following equation:

$$IA\,(\%) = \left[1 - \frac{C - D}{A - B}\right] \times 100$$

Where:

A = Absorbance of the control reaction at t = 20 min
B = Absorbance of the control reaction at t = 0 min
C = Absorbance of the sample at t = 20 min
D = Absorbance of the sample at t = 0 min

In vitro hyaluronidase inhibitory (Hya-I) activity of the plant infusions was determined according to a procedure previously described by Chompoo *et al.*[9]. The reaction mixture contained 0.02 M phosphate buffer (pH 7.0), 0.15 mg mL^{-1} hyaluronic acid, hyaluronidase 0.37 U and dilutions of PI. The reactions were incubated at 37°C, 45 min and then, absorbance (600 nm) was determined. Percentage of Inhibition Activity (IA) was calculated using the following formula:

$$IA = \left(\frac{\text{Abs sample}}{\text{Abs control}}\right) \times 100$$

In order to determinate the IC_{50} of PI, the IA values were adjusted to a nonlinear regression model using Hill's equation, by Graph-Pad Prism 5 software (San Diego, California, USA).

Phytochemical characterization

Total phenolic content: Total Phenolic Control (TPC) of plant infusions was determined according to the method described by Singleton *et al.*[11] 20 µL of plant infusions dilutions were oxidized with 180 mL of folin-ciocalteu reagent. After 20 min, absorbance (750 nm) was measured using a Microplate Reader (Synergy™ HT Multi-Detection, Bio-Tek Inc, Winooski, VT, USA). Gallic acid was used as standard and TPC was expressed as milligrams of gallic acid equivalents (mg GAE)/g sample dry weight.

Total flavonoid content: Total Flavonoid Control (TFC) of the plant infusions were determined according to Xu and Chang[12]. The results were expressed as milligrams of catechin equivalents (mg CE)/g sample, using (+)-catechin as standard. Linearity range of the calibration curve was 10-1000 mg mL^{-1} (r = 0.99) and the extracts were diluted to fit in the linear range for the assay.

Condensed tannins content: Condensed Tannins Content (CTC) was analyzed using the acidified vanillin reagent[12]. The results were expressed as mg CE/g sample and (+)-catechin was used as standard for the calibration curve. Linearity range of the calibration curve was 50-1000 mg mL^{-1} (r = 0.99).

Statistical analysis: Data were analyzed using one-way analysis of variance followed by Tukey test for comparisons among means with a significance level of 5%. Pearson correlation coefficient was used to determine correlations among means. Statistical analysis was performed using Statgraphics Centurion XV software (Statpoint Technologies, Inc., Warrenton, Virginia, USA).

RESULTS AND DISCUSSION

Antioxidant capacity: Trolox equivalent antioxidant capacity of the plant infusions are shown in Fig. 1. All extracts showed antioxidant capacity, with values ranged from 227.74 (Cv) to

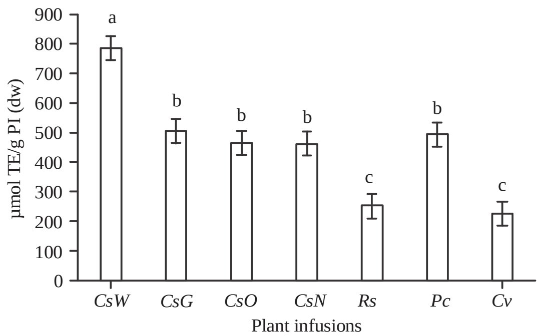

Fig. 1: Antioxidant capacity of seven plant infusions used in traditional medicine by ORAC-FL method. HSD = 614.86 µm TE/g of pi, α = 0.05

788.04 (CsW) µmol TE/g PI (dw), the species of plants had a significant effect on the antioxidant capacity ($p<0.00001$).

In general, the plant infusions resulting from *Camellia sinensis* (CsW, CsG, CsO and CsB) showed high antioxidant capacities. White tea is an infusion made from young leaves and buds, green tea corresponds to the infusion of fully grown and developed leaves; whereas oolong and black tea are the result of different levels of oxidation of these leaves[13]. It has been reported that phenolic compounds from tea leaves possess antioxidant activity, mainly those belonging to the flavan-3-ol family[14,15]. During leaf oxidation, monomeric flavan-3-ols [i.e., epigallocatechin (EGC), epicatechin (EC) and epigallocatechin gallate (EGCG)] undergo an oxidative polymerization becoming in the aflavins and thearubigins[13]. Studies reports have revealed that the decrease in flavan-3-ols due to its conversion into theaflavins and thearubigins is also related to a significant drop in antioxidant capacity of black and oolong teas in comparison with white and green teas[14,15]. This is consistent with the results of this study, in which it was found that, as the oxidation of compounds of plant infusions increases, their antioxidant capacity decreases ($p<0.00001$).

Regarding to Pc, Kuskoski *et al.*[16] evaluated the antioxidant capacity of several products, including seed powder (sp), finding trolox equivalent antioxidant capacity values of 987.3 µmol TE/g of seed powder and were correlated with their procyanidin, catechin and tannin contents. In the present study, Pc showed, values of TEAC (495.57 µmol TE/g sp) was lower than the values (4765.18 µmol TE/g PI) obtained by Kuskoski *et al.*[16], probably due to the extraction method, since they used methanol as solvent. The plant infusions of Rs also presented high TEAC values (253.44 µmol TE/g), characterization reports of this plant have shown the presence of phenolic compounds with antioxidant activity, such as flavanone glycosides, benzoic acid and matteucinol[17], which might be present in the Rs-PI. The Cv plant infusions showed the lowest TEAC value (253.44 µmol TE/g PI), this could be explained by their minor concentration of phenolic compounds.

Table 2: Ace-I activity of PI

Samples	IC_{50} (µg mL^{-1})
CsO	0.0000492^{b}
CsB	0.0000113^{b}
CsW	0.0001090^{b}
CsG	0.0052500^{b}
Pc	0.0245000^{b}
Cv	0.1900000^{b}
Rs	4.3333300^{a}
EGCG	0.0000694^{b}
Captopril	0.0000887^{b}

*Different letters indicate significant difference among PI (HSD = 0.108 µg mL^{-1}, α = 0.05)

Angiotensin-Converting Enzyme Inhibitory (ACE-I) activity: ACE-I potential of the plant infusions is presented in Table 2. The statistical analysis showed that the plant species affected significantly the antihypertensive capacity of the plant infusions ($p<0.01$). The plant infusions of Rs showed the highest IC_{50} value, indicating a lower ACE-I activity than the rest of the plant infusions, which exhibited higher antihypertensive potential.

The IC_{50} values of EGCG and captopril were 6.94E-05 and 8.871E-05 µg μL^{-1}, respectively, these results were similar to those shown by CsO and CsB (4.92E-05 and 1.13E-05 µg μL^{-1}), however, they were not significantly different from CsW, CsG, Pc and Cv, which also showed high ACE-I activity. In infusions of *C. sinensis*, the main components are flavan-3-ols, such as catechin, EC, EGC and EGCG, some of which have showed ACE-I activity[18,19], which could explain the high antihypertensive potential of this infusion.

Herbal extracts are generally rich in phytochemicals, mainly polyphenols, which can be found in plants as flavonoids, condensed tannins, among others. These compounds have been considered as cardioprotective phytochemicals, in terms of their effect on ACE activity[18-21]. Infusions evaluated in this study were prepared from different parts of plants, therefore, it is very likely that they present numerous phytochemical compounds, which may exert synergistic effects for the inhibition of ACE, resulting in a high antihypertensive potential.

Antiaging potential of the plant infusions

Anti-collagenase, anti-elastase and anti-hyaluronidase activities: The Col-I, Ela-I and Hya-I activities of the plant infusions were assessed and the results are shown in Table 3.

Table 3: Inhibitory activity of plant infusions over aging-related enzymes

PI	Collagenase (IC_{50} µg mL^{-1})	Elastase (IC_{50} µg mL^{-1})	Hyaluronidase (IC_{50} µg mL^{-1})
CsW	ND**	5.61^{d*}	ND
CsG	ND	232^{b}	ND
CsO	ND	127^{bc}	0.358^{a}
CsB	ND	65.2^{cd}	0.153^{b}
Rs	ND	34.8^{cd}	0.224^{b}
Pc	643^{b}	1210^{a}	ND
Cv	708^{a}	5.3^{d}	0.0429^{c}
EGCG	48.8	61.1	863
Quercetin	ND	412	1086

*Different letters throughout columns indicate significant difference among treatments, $HSD_{Collagenase}$ = 0.0468 µg mL^{-1}, $HSD_{Elastase}$ = 0.6596 µg mL^{-1}, $HSD_{Hyaluronidase}$ = 0.1063 µg mL^{-1}, **ND: Not detected values

Some of the plant infusions exhibited percent inhibition of collagenase activity from 6-97%, however, only the extracts from Pc and Cv inhibited more than 50% of the enzymes activity and the IC_{50} values for Pc and Cv were 643 and 708 µg mL^{-1}, respectively. These values are lower than those obtained by Chompoo *et al.*[9], who evaluated the Col-I activity of several parts of the plant *Alpinia zerumbet* (shell ginger), finding the higher Col-I potential in the fruit pericarp with an IC_{50} value of 45.67 µg mL^{-1}.

The Pc extracts have been reported as a source of caffeine-like compounds, tannins, fiber, starch, pectins, mucilages and other polysaccharides, which altogether could be potentiating the Col-I activity of guarana[19]. On the other hand, there are previous reports that have considered Cv bark extract as a source of compounds with biological activity (hepatoprotective, antihypertensive and hypoglycemic) such as naringenin[22], a flavanone isolated from citrus-fruits and grape juice, also an analysis of methanolic extracts of *C. tinctorium* revealed the presence of flavonoids, tannins, alkaloids, polysaccharides, among other compounds[23], which can be found in plant infusions and can also be participating on Col-I activity of Cv.

Thring *et al.*[5] reported Col-I activity for green and white tea, they reported that an aqueous extract from white tea was able to inhibit 87% of collagenase activity, whereas green tea glycerol extract only exhibited 9.9% of inhibition against this enzyme. In the present study CsW and CsG showed a Col-I activity of 33.3 and 13.09 %, respectively, at a concentration of 300 µg mL^{-1}. Differences among the researchers mentioned above and presented in this study, may be explained by the different extraction techniques used in the studies, in the case of white tea were able to extract a greater amount of inhibitory-associated compounds; however, the main objective of this study was to determine potential beneficial capacities of plant extracts prepared as infusions, which is the most common way of consumption of these plants.

Regarding the Ela-I activity, all plant infusions inhibited this enzyme activity in more than 50% and the IC_{50} values ranged from 5.3-1210 µg mL^{-1}, corresponding to Cv and Pc, respectively. According to statistical analysis, Cv, Rs and CsW presented the lowest numerical IC_{50} values ($p<0.05$), even lower than EGCG and Quercetin (61.1 and 412 µg mL^{-1}, respectively) used as positive controls, which indicates that these plant infusions showed the highest Ela-I capacities, whereas Pc was the plant infusions with the lowest Ela-I potential ($p<0.05$).

The Ela-I activity has been reported for different plant materials, for example, *Areca catechu* ethanolic extract has showed IC_{50} values of 64.1 µg mL^{-1} [24], furthermore, Piwowarski *et al.*[25] determined the Ela-I activity of several tannin-rich plants, from which, *Aesculus hippocastanum* L. aqueous bark extract showed the highest potential with 62.0% of inhibition of elastase activity, at a concentration of 10 µg mL^{-1}, Chompoo *et al.*[9] determined the IC_{50} value for the Ela-I activity of different parts of the plant *Alpinia zerumbet* and they found that the rhizome extract showed the highest inhibitory potential with an IC_{50} value of 57 µg mL^{-1}; however, all these potentials were lower than those exhibited in this study by the extracts of Cv and CsW.

As it was mentioned before, the presence of diverse compounds in Cv extracts has been reported, among which flavonoids, particularly naringenin emerges as a potential bioactive metabolite[22,26], which could possibly be involved in the Ela-I activity of the Cv aqueous extract.

On the other hand, CsW also showed a high inhibitory potential against elastase; as discussed above, this plant contains high levels of flavanols, mainly monomers and oligomers of catechins and their derivatives, which present Ela-I activity[15] and it is very likely that these compounds are present in aqueous extracts.

Respecting Hya-I activity, only four of the 7 plant infusions presented inhibition over 50% of hyaluronidase activity. The IC_{50} values ranged from 4.29E-02-3.58 E-01 µg mL^{-1}, for Cv and CsO, respectively. The statistical analysis showed that the Cv extract showed the highest Hya-I potential ($p \leq 0.05$), this potential was much higher than those reported for a fraction of *Areca catechu* hydro-ethanolic seed extract (IC_{50} = 210 µg mL^{-1}) and could be attributed to the biologically active constituents of the extract such as flavonoids and tannins[23]. Furthermore, the Hya-I activities of these four plant infusions were higher than Quercetin and EGCG (1086 and 863 µg mL^{-1}, respectively) used as positive controls, as well as for the reported for the rhizome aqueous extract of *Alpinia zerumbet* (0.035 µg $µL^{-1}$)[18] and a *Cucumis* *sativus* lyophilized fruit juice (0.021 µg µL^{-1})[27]. These high Hya-I activities could be due to numerous natural hyaluronidase inhibitors, which among others include, proteins, glycosaminoglycans (GAG's), polyphenols, tannins and polysaccharides as lignins and pectins[27,28], compounds that are very likely to be present in the plant infusions and they can be exhorting a synergistic role for hyaluronidase inhibition, thus posing the highest Hya-I activity of all the plant infusions evaluated in this study.

Phytochemical quantification

Total phenolic content: Figure 2a shows the TPC of the seven aqueous extracts. As it was expected, all of the extracts analyzed contained phenolic compounds, with values that ranged from 269.52-499.43 mg GAE/g PI (dw) for CsG and Pc, respectively. The highest TPC was exhibited by Pc and CsW extracts. According to Khoddami *et al.*[28] this high TPC in *Pc* could be due to the presence of phenolic acids such as benzoic, gallic, syringic, isovanillic, protocatechuic and flavonoids including catechin, epicatechin and quercetin, which were identified by gas chromatography coupled to a mass spectrometry. Li *et al.*[29] assayed over 200 medicinal plants for its TPC, finding that *S. miltiorrhiza* showed the higher amount (101.33 mg GAE/g) of these compounds; however, these values were much lower than the observed in the present study, in which even the plant infusions with the lowest TPC (259.52 mg GAE/g for CsG extract) was higher.

Total Flavonoid content: Figure 2b shows the TFC of the seven plant infusions analyzed. The values ranged from 20.42-131.24 mg CE/g, for Cv and Pc, respectively.

The Pc presented the highest TFC, coincidently with the TPC, which it was also the highest for this extract. As mentioned above, some reports indicate the presence of flavonoids in Pc including flavanols and flavonons, such as catechin-related compounds and glycosides (i.e., quercetin), compounds with known therapeutic activities[16,28].

Previous studies in Rs have proven the presence of flavonoids including catechin, quercetin, myricetin, afzelin, kaempferol, gossypetin as well as glycosylated and acetylated flavonoids[30].

Nowadays, there are a few reports of TFC of *Cochlospermum vitifolium*, however, Sánchez-Salgado *et al.*[22] identified naringenin as the major flavonoid present in *C. vitifolium* bark.

Condensed tannins content: Figure 2c presents the results corresponding to condensed tannins content, the range of

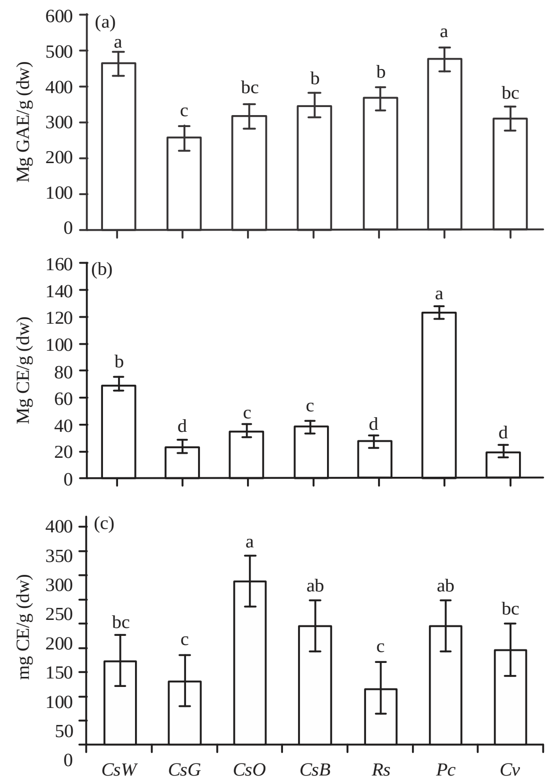

Fig. 2(a-c): Phytochemical content of plant infusions, (a) TPC (HSD = 17.92 mg GAE/g pi, α = 0.05), (b) TFC (HSD = 4.06 mg CE/g pi, α = 0.05) and (c) CTC (HSD = 82.24 mg CE/g pi, α = 0.05)

values was between 101.60 and 300.71 mg CE/g PI (dw), for Rs and CsO, respectively. The statistical analysis showed that CsO and CsB presented the highest condensed tannins content (300.71 and 247.64 mg CE/g PI (dw), respectively) and were significantly different from the other *C. sinensis* plant infusions, which presented the lowest condensed tannins content (116.07 and 153.63 mg CE/g PI (dw), for CsG and CsW, respectively). These results are consistent with previous reports which indicate that oxidized *C. sinensis* infusions present a higher condensed tannins content, as a result of the fermentation of tea leaves, oxidation of flavan-3-ols is induced and this leads to the formation of the two major pigments in black tea, theaflavins and thearubigins[14,15].

The Pc and Cv also presented high condensed tannins content (218.32 and 173.14 mg CE/g PI, respectively). Kuskoski *et al.*[16] reported that tannins comprise up to 16% of the Pc seed's dry weight, also there are reports that indicate the presence of a bioactive compound formed by caffeine and a tannin, known as "Guaranine", which could be present in the plant infusions of Pc. About Cv, this has been described as a good source of tannins containing up to 10% of dry weight.

Table 4: Pearson correlation values for the nutraceutical, antiaging and phytochemical response variables

Evaluations	Pearson's correlation coefficient (r)	p-value
ACE-I and TPC	-0.031	0.894
ACE-I and TFC	-0.173	0.452
ACE-I and CTC	-0.363	0.106
ACE-I and TEAC	-0.225	0.327
Col-I and TPC	-0.863	0.027
Col-I and TFC	-0.894	0.016
Col-I and CTC	-0.953	0.003
Col-I and TEAC	-0.885	0.019
Ela-I and TPC	0.322	0.155
Ela-I and TFC	0.807	0.000
Ela-I and CTC	0.217	0.346
Ela-I and TEAC	-0.003	0.991
Hya-I and TPC	0.090	0.780
Hya-I and TFC	0.591	0.043
Hya-I and CTC	0.434	0.158
Hya-I and TEAC	0.689	0.013
TEAC and TPC	0.654	0.001
TEAC and TFC	0.407	0.067
TEAC and CTC	-0.054	0.815

For all enzymatic assays the correlations were carried out with the IC_{50} values

Pearson's correlation test: The TPC, TFC and CTC were correlated to every one of the response variables. Results of Person's correlation test are shown in Table 4.

As it can be observed, ACE-I activity data did not seem to correlate with any of the co-variables not being as well for Col-I activity, for which high negative correlations were found between the inhibitory activity and TPC, TFC, CTC or TEAC. These results may mean that as the phytochemical content increases, the IC_{50} values for the inhibition of Collagenase decrease, hence a greater Col-I potential. Ela-I activity only showed negative correlation with TEAC, which indicate that when TEAC values increases, the IC_{50} values decreases (indicating a greater Ela-I potential). On the other hand, for Hya-I activity was found that as TFC and TEAC increases, plant infusions present less inhibitory activity for hyaluronidase.

The TEAC values resulted only correlated to TPC (r = 0.654), which has been seen in several reports[5,25] where antioxidant activity has been associated to the content, type and structure of phenolic compounds[31]. It is well reported that flavonoids and tannins have strong inhibitory capacity over several enzymes[25], in this sense many authors suggest that the abundance of such compounds is a determinant factor on the biological activity of plant extracts[32].

CONCLUSION

The present study reveals that plant infusions used in traditional medicine showed good scavenging activity, also some of them exhibited high antihypertensive activities, even similar to captopril, which is one of the main drugs used in hypertension treatment. Among evaluated extracts, it is suggested that *C. vitifolium* is the most interesting, due to its high inhibition of aging-related enzyme and relatively high inhibition of ACE. Overall, it is possible to state that the evaluated extracts can be added to food matrices or cosmetic products as plant-based materials with nutraceutical and antiaging effects on human skin and health.

SIGNIFICANCE STATEMENT

The results of this study demonstrate the antioxidant, antihypertensive and antiaging potential of seven plant infusions commonly used in traditional medicine and their beneficial effects appear to be related to their bioactive compounds. Therefore, this study will help the researchers to uncover the critical areas of food science, specifically, plant extracts characterization and generate useful evidence for the development of new products with beneficial effects on health.

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