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Correlation between antioxidant activity and total phenolic content with physicochemical parameters of blended extracts of *Camellia sinensis*

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ABSTRACT. This paper evaluated the total antioxidant activity (TAA) and the correlation with parameters such as total phenols (FT), total acidity, pH, redox potential (ORP) and conductivity (EC), of commercial teas of *Camellia sinensis*, single or blended with other plants. The extracts tested were: *Camellia sinensis* fermented and unfermented, *Camellia sinensis* with *Citrus limonium*, *Camellia sinensis* with *Mentha piperita*, *Camellia sinensis* with *Prunus persica*, *Camellia sinensis* with *Citrus sinensis*. All extracts showed high percentages of TAA and were not significantly different by Tukey's test. The correlation matrices indicated that except for the extract of *Camellia sinensis* with *Prunus persica,* all the other extracts had statistically significant correlations. Strong correlations were found between TAA and FT, and between pH and FT. The extract of *Camellia sinensis* with *Mentha piperita* presented the highest correlation between TAA and FT. The same compounds that influence the pH and ORP may also influence the EC, for almost all teas. For the fermented and unfermented extracts of *Camellia sinensis* all parameters had been strongly correlated ($r > 0.7$).

Keywords: *Camellia sinensis*, antioxidant activity, green tea.

Correlação da atividade antioxidante e teor de fenos totais com parâmetros físico-químicos de extratos mistos de *Camellia sinensis*

RESUMO. Este trabalho apresenta os resultados da avaliação da atividade antioxidante total (AAT) e a correlação com parâmetros como teor de fenóis totais (FT), acidez titulável, pH, potencial redox (ORP) e condutividade elétrica (CE), de chás comerciais puros e mistos de *Camellia sinensis*. Os extratos testados foram *Camellia sinensis* fermentado e não-fermentado, *Camellia sinensis* com *Citrus limonium*, *Camellia sinensis* com *Mentha piperita*, *Camellia sinensis* com *Prunus pérsica* e *Camellia sinensis* com *Citrus sinensis*. Todos os extratos mostraram altos valores percentuais de AAT e não diferiram estatisticamente entre si, pelo Teste de Tukey. As matrizes de correlação obtidas mostraram que, com exceção do extrato de *Camellia sinensis* com *Prunus persica*, todos os demais extratos apresentaram correlações estatisticamente significantes. Foram observadas fortes correlações entre a AAT e FT e entre o pH e FT. O extrato de *Camellia sinensis* com *Mentha piperita* foi o que apresentou a melhor correlação entre AAT e FT. Os mesmos compostos que influenciam o pH e o ORP também podem influenciar o parâmetro de CE para quase todos os chás. Para os extratos de *Camellia sinensis* fermentado e não-fermentado todos os parâmetros apresentaram fortes correlações entre si ($r > 0,7$).

Palavras-chave: *camellia sinensis*, atividade antioxidante, chá verde.

Introduction

Numerous therapeutic effects of infusions of leaves of *Camellia sinensis* are currently well recognized. In vitro and in vivo studies have shown the modulating function of these extracts in anti-inflammatory (SUR et al., 2001) and anti-bacterial processes (HAMILTON-MILLER, 1995). It was also proved hepatoprotective and diuretic activities (SENGOTTUVELU et al., 2008; SHARANGI, 2009), besides the protective effect against various cancers (ZAVERI, 2006), cardiovascular (NAKACHI et al., 2000) and degenerative diseases (PAN et al., 2003; WEINREB et al., 2004).

Teas prepared from leaves of *Camellis sinensis* L.O. Kuntze are classified into three categories according to the degree of inactivation of leaf enzymes during the processing: the green tea is prepared from fresh leaves, which undergoes the bleaching process to inactivate the polyphenol oxidase, through steaming and drying. This process allows the composition of polyphenols of the product to be very close to the fresh leaf, obtaining thus a tea more rich in catechins. The oolong tea is a semi-fermented tea (or partially oxidized) obtained after the leaves having remained at rest for 2-4 hours, being then heated to interrupt the oxidation process. The black tea derives from aged leaves through aerobic

oxidation of catechins, enzymatically catalyzed (HARA et al., 1995a). The three types of tea comprise the most consumed nonalcoholic beverage worldwide after the water. The popularity of the plant is partially due to the several possibilities of marketing the products based on green or black tea, either for food or pharmaceutical and cosmetics industries. The consumption of tea has increased nowadays owing the commercial availability of these three types of tea, in blended versions with parts of different plants.

The beverage consumed as infusion contributes for extracting phenolic compounds, important antioxidant substances. Extracts of teas, such as of *Camellia sinensis*, are important sources of phenolic acids, e.g. hydroxycinnamic acid and flavonoid derivatives especially the subclass of catechins (HARA et al., 1995b). The major catechins present in the plant are (-) epigallocatechin gallate (EGCG), (-) epigallocatechin (EGC), (-) epicatechin gallate (ECG), epicatechin (EC) and catechin (C) (GRAHAM, 1992). The antioxidant activity of these chemical components basically depends on some intrinsic properties, such as: the reduction potential, the property to chelate metals and to work as singlet oxygen scavengers, and the possibility to capture or scavenge free radicals. These properties make the phenolic compounds to act as antioxidant in both steps of initiation and propagation of the oxidation process (SHAIDI et al., 1992). Given the significant presence of these bioactive compounds and the potential capacity to promote health benefits, the literature has considered the green tea as a functional food (KAO et al., 2000; LAMARÃO; FIALHO, 2009).

Several characteristics of aqueous and organic extracts of *Camellia sinensis* have been evaluated, primarily considering the ratio between the phenolic fraction and the antioxidant activity. However, few studies have examined blended teas with *Camellia sinensis* commercially available, produced in Brazil.

Regarding the economic importance of this product to the domestic and world markets, this study added technical information, by means of chemical studies, to the commercial presentations of blended teas with *Camellia sinensis*. The present study evaluated the relationship between the total phenolic content and in vitro antioxidant activity with other physicochemical parameters, such as titratable acidity, pH, redox potential, and electric conductivity.

Material and methods

Preparing the extracts

The extracts were prepared from commercial samples of green and black teas, green tea blended with lemon (*Camellia sinensis* with *Citrus limonium*), green tea blended with mint (*Camellia sinensis* with *Mentha piperita*), green tea blended with peach (*Camellia sinensis* with *Prunus persica*) and green tea blended with orange (*Camellia sinensis* with *Citrus sinensis*). Initially, for each type of tea, all the content of the individual tea bags within a commercial package were mixed. Then, the extracts were prepared by solid-liquid extraction in deionized water as recommended in the package at known concentrations (10 - 50 mg mL^{-1}). The packages did not list the proportion of each plant type in the blended tea, but that ground parts of the plant like stems, buds and leaves, were mixed to the powder of *Camellia sinensis*.

Determination of total phenols

The concentration of phenols in the extracts was determined by spectrophotometry according to the standard procedure of Folin-Ciocalteau (SINGLETON et al., 1999). In this assay, an aliquot of 50 μL of the extract was mixed to 250 μL of Folin-Ciocalteau reagent and 750 μL of 20% sodium carbonate. The final volume was adjusted with distilled water. After 2 hours at room temperature the color was read at 735 nm, in a spectrophotometer UV/Vis Bioespectro model SP-220. The calibration curve was obtained using chlorogenic acid as standard. The total phenols (FT) was expressed in mmol L^{-1} g^{-1} sample.

Determination of the antioxidant activity by the DPPH• method

The antioxidant activity of the extracts was evaluated using the radical 1,1-diphenyl-2-picrylhydrazyl (DPPH•) (BRAND-WILLIAMS et al., 1995; MOLYNEUX, 2004). For this, extracts aliquots with known volume were added to an ethanolic solution with 0.1 mmol L^{-1} of DPPH•. In the radical form, the DPPH• has a maximum absorption at 517nm, but under a reduction by an antioxidant, the stable form (non-radical) of the DPPH• is not absorbed. The decrease in absorbance of the radical solution after 15 minutes was monitored in a spectrophotometer UV/Vis Bioespectro model SP-220. The 97% Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylicacid) was used as standard. The absorbance values were related to the percentage of antioxidant activity (AA) through the equation:

$$\% = \frac{Abs_{control} - (Abs_{sample} - Abs_{blank})}{Abs_{control}} X\,100$$

where:

$Abs_{control}$ is the initial absorbance of the ethanolic solution of DPPH; Abs_{sample} is the absorbance of the reaction mixture (DPPH + sample) and Abs_{blank} is the absorbance of the blank.

It was also calculated the IC_{50} (half maximal inhibitory concentration) defined as the extract concentration required to reduce by 50% the initial concentration of DPPH of the reaction. The values of IC_{50} were calculated through a linear regression of graphs, where the abscissa axis represented the extract concentration in mg mL^{-1}, and the ordinate axis the antioxidant activity (%). For the calculation, the y value was replaced by 50 in the equation, in order to obtain the concentration of the sample relative to the value of IC_{50}.

Physicochemical determinations

The pH and the redox potential (Oxidation Reduction Potential, ORP) were read with a digital pHmeter (Digimed model DM-22), with the values of ORP expressed in mV.

The electric conductivity (EC) was measured using a conductivimeter (Gehaka model CG 1800), being the measures expressed in miliSiemens cm^{-1} (mS cm^{-1}).

The total titratable acidity (TTA) was determined by titration with a standard solution of NaOH at 0.01 N, and the results expressed in mEq Kg^{-1}.

Statistical Analysis

All the determinations were performed in triplicate, and the results presented as mean ± standard deviation (SD). The data were subjected to an analysis of variance and F-test. When the F value was significant, the data were treated with a Tukey's test. Differences between the means were significant when $p \leq 0.05$. The statistical analyses were carried out using the software Microcal Origin 6.0.

Results and discussion

Determination of total phenols (FT)

The determination of the amount of total phenols (FT) in the extracts was performed by the Folin-Ciocalteau method and the results listed in Table 1. This method is based on the oxide-reducing and chelating properties of the phenolic compounds. In the reaction with the Folin Ciocalteau reagent (a mixture of phosphotungstic acid, $H_3PW_{12}O_{40}$ and phosphomolybdic acid, $H_3PWMo_{12}O_{40}$), the phenol derivatives are oxidized to phenolates in alkaline medium. The resulting products consist of a mixture of tungsten and molybdenum blue oxides (W_8O_{23} and Mo_8O_{23}), which allows the quantification of the fraction of total phenols by measuring the absorption of these products in the visible spectrum.

Table 1. Percentage of total antioxidant activity (AAT) and values of IC_{50} for the extracts of *Camellia sinensis*.

Sample / Parameter	FT ⋆ (mmol L^{-1} g^{-1})	$AAT_{maximum}$ (%)⋆	IC_{50} (mg mL^{-1})
Camellia sinensis	3.54 ± 0.40^{a}	92.50 ± 2.02^{a}	37.80
Fermented *Camellia sinensis*	$4.96 \pm 0.44^{b,c}$	$90.70 \pm 1.50^{b,c}$	50.63
Camellia sinensis + *Citrus limonium*	$1.04 \pm 0.02^{b,c,d}$	$86.30 \pm 2.6^{b,c,d}$	19.42
Camellia sinensis + *Mentha piperita*	$1.90 \pm 0.11^{b,c,d}$	81.70 ± 1.92^{d}	7.31
Camellia sinensis + *Prunus persica*	$0.27 \pm 0.01^{b,c,d}$	78.72 ± 3.07^{e}	73.74
Camellia sinensis + *Citrus sinensis*	0.33 ± 0.01^{c}	$69.70 \pm 2.82^{a,b}$	17.03

⋆Mean values ± standard deviation followed by the same letter in the column are not significantly different by Tukey's test ($p < 0.05$).

The content of poliphenols in plants is quite variable in distribution and concentration even in the same plant. This is primarily due to environmental and genetic factors, cropping system, harvest period and conditions of extraction the plant is submitted to (ESCARPA; GONZÁLEZ, 2001). No significant variation was found for the samples, according to the Tukey's test, despite a variation in the quantification of total phenols, especially because of the different composition of the tested plants. The content of total phenols (FT) was significantly different ($p < 0.05$) between the extracts of *Camellia sinensis* and some blended extracts. The fermented extract of *Camellia sinensis* was only different from the extract of *Camellia sinensis* with *Citrus sinensis*. The other extracts did not present significant difference regarding the content of total phenols.

The difference in the content of total phenols between fermented and unfermented extracts can be assigned to the manufacturing process. During the fermentation process of the extracts of *Camellia sinensis*, occur oxidation and dimerization of polyphenols, especially catechins, with formation of more complex structures, such as theaflavins, theasinensins, and dimerized structures forming the thearubigins (HARBOWY; BALENTINE, 1997; LEUNG et al., 2001). For the other extracts, the mixture of different plants did not change the phenolic composition of the beverage.

Determination of the antioxidant activity - DPPH• method

The method is based on the reaction between an antioxidant (AH) with a solution of the relatively stable free radical DPPH•, commercially available. The DPPH• is considered a stable radical by the relocation of the pair of electrons on the molecule as a whole, preventing the dimerization, which is very common in structures of free radicals. Owing this characteristic, the test is particularly suitable in determining antioxidant compounds

capable of reducing this radical, according to the equation

$$DPPH^{\bullet} + AH \longrightarrow DPPH{-}H + A^{\bullet}$$
$$DPPH^{\bullet} + R^{\bullet} \longrightarrow DPPH{-}R$$

where:

AH = antioxidant

R = radical species

In the tested extracts, the significant fraction of phenolic compounds is the most responsible for the antioxidant activity, primarily the catechins. Most of the polyphenols have a low standard potential, making them thermodynamically capable to effectively reduce free radicals, by donating a hydrogen atom. During this process, the intermediate formed, the phenolic free radical aroxila, reacts with the second radical resulting in a relatively stable structure, the quinone (RICE-EVANS; MILLER, 1996).

The Table 1 presents the variation of the antioxidant activity for the different extracts of *Camellia sinensis*. Almost all the extracts showed high antioxidant activity against the radical $DPPH^{\bullet}$. These results obtained even with blended extracts may be associated with the recognized biological activity of the extracts of *Camellia sinensis*. The antioxidant activity presented by the extracts followed the order: *Camellia sinensis* > fermented *Camellia sinensis* > *Camellia sinensis* with *Citrus limonium* > *Camellia sinensis* with *Mentha piperita* > *Camellia sinensis* with *Prunus persica* > *Camellia sinensis* with *Citrus sinensis*.

In order to display biological functions, such as the antioxidant activity of the phenolic fraction, the bioactive compounds, even at low levels, have to prevent or delay the self-oxidation or oxidation mediated by free radicals, and the product formed needs to be stable after the reaction. The value of the IC_{50} parameter being low, better is the antioxidant activity of the sample. In this sense, the values of IC_{50} were estimated by a polynomial regression and the data are shown in the Table 1. The lowest antioxidant activity was observed for the extract of *Camellia sinensis* with *Prunus persica*, with IC_{50} of 73.74 mg mL^{-1}. Lower concentrations of IC_{50} were obtained for the blended extracts of *Camellia sinensis* with *Mentha piperita, Camellia sinensis* with *Citrus sinensis* and *Camellia sinensis* with *Citrus limonium,* with values of 7.31 mg mL^{-1}, 17.03 mg mL^{-1} and 19.42 mg mL^{-1} respectively. These results suggest that different parts of these plants when mixed during the processing of the blended tea of *Camellia sinensis* may improve the biological characteristics in relation to the antioxidant property of this tea, compared to the extract of pure *Camellia sinensis*. The blended extract *Camellia sinensis* with *Mentha piperita* had a IC_{50} much lower when compared with pure extracts of *Camellia sinensis*, this blended infusion was not significantly different when expressed in percentage of inhibition.

According to Kulisic et al. (2006), this difference can be attributed to differences in the phenolic concentration during the dilution of the plant extracts. Diluted infusions of teas may have different and complex phenolic profiles, and may present compounds with different kinetic and reduction behaviors. Associated to this, previous studies with extracts of *Camellia sinensis* (ASTILL et al., 2001; RUSAK et al., 2008) pointed out that the method of preparation, infusion time, way of packaging the herb, temperature, and the proportion between dry weight of herb and the amount of water used, influence the final quantity of phenolic compounds in the antioxidant activity measured.

Physicochemical determinations

Table 2 shows the results of pH and ORP, whose values were significantly different for the different extracts, according to ANOVA and Tukey's test.

The two methods most used to measure the acidity are the total titratable acidity (ATT) and pH. The first represents all acid groups found in the sample, in the present study, the free organic acids, in the form of salts and phenolic compounds. The ATT and conductivity (CE) were not significantly different for all extracts tested (ANOVA; $F < F_{critical}$). The values of ATT and CE were, respectively: *Camellia sinensis*, 70 mEg kg^{-1} and 351 mS cm^{-1}; *Camellia sinensis* fermentado, 11 mEq kg^{-1} and 336 mS cm^{-1}; *Camellia sinensis* with *Citrus limonium*, 19 mEq kg^{-1} and 296 mS cm^{-1}; *Camellia sinensis* with *Mentha piperita*, 55 mEq kg^{-1} and 441 mS cm^{-1}; *Camellia sinensis* with *Prunus persica*, 61 mEq kg^{-1} and 335 mS cm^{-1}; *Camellia sinensis* with *Citrus sinensis*, 66 mEq kg^{-1} and 332 mS cm^{-1}.

The pH determines the hydrogen ion concentration of solutions. It indicates if the sample is acidic, neutral, or alkaline. In the case of the tested extracts, the pH reflects the composition with acidic character of these plants, with predominance of weak acids such as tannic and phenolic acids, especially those derived from hydroxybenzoic and hydroxycinnamic acids. The pH for all the extracts was higher than 5.0, indicating a low acidity. Statistically, only the values found for the extracts of *Camellia sinensis*, *Camellia sinensis* with *Citrus limonium*, and *Camellia sinensis* with *Prunus persica* were not significantly different ($p < 0.05$).

Table 2. Physicochemical parameters of pH and ORP for the extracts of *Camellia sinensis*.

Sample / Parameter	pH	ORP (mV)
Camellia sinensis	6.10 ± 0.03^{a}	$164 \pm 1.0^{a,c,d}$
Fermented *Camellia sinensis*	$5.80 \pm 0.03^{b,d,f}$	$205 \pm 3.0^{b,d,e}$
Camellia sinensis + *Citrus limonium*	5.75 ± 0.03^{c}	$139 \pm 2.6^{a,c,e}$
Camellia sinensis + *Mentha piperita*	$6.20 \pm 0.01^{b,d,f}$	$154 \pm 3.6^{a,b,d}$
Camellia sinensis + *Prunus persica*	5.83 ± 0.01^{e}	$127 \pm 4.6^{b,c,e}$
Camellia sinensis + *Citrus sinensis*	$5.50 \pm 0.13^{b,d,f}$	142 ± 1.6^{f}

*Mean values ± standard deviation followed by the same letter in the column are not significantly different by Tukey's test ($p < 0.05$).

The redox potential (ORP) is a measure of spontaneity (or trend) of a chemical species to acquire electrons and to be reduced. It pointed the status of oxidation and reduction of a sample, and the lower this value the greater the reduction character of the sample. High values of ORP, between 350 and 500 mV, as commonly registered, for example, in samples of wine in contact with the air, indicate that the beverage weakly reducer or with low antioxidant effect.

The ORP values for the extracts of teas ranged from 127 to 205 mV, confirming that are samples with reducer character or constituted of good antioxidants. In agreement with the Table 2, only the values of ORP for the extract of fermented *Camellia sinensis* presented a significant difference compared with the other extracts. These results are in accordance with those reported for extracts of *Camellia sinensis* subjected to different manufacturing processes (CHEN et al., 2007). In this study, the ORP values obtained for the extracts of unfermented and completely fermented *Camellia sinensis* varied between 120 and 240 mV.

Linear correlation between the content of FT, AAT and physicochemical parameters

In the Tables 3 to 8 are presented the matrices of linear correlation between the total antioxidant activity (AAT), the content of total phenols (FT) and the physical and chemical determinations with different concentrations (10, 20, 30, 40, 50 mg mL^{-1}) of the extracts of *Camellia sinensis*. Except for the extract of *Camellia sinensis* with *Prunus persica* ($r = 0.494$), all the other extracts had strong correlation ($r > 0.7$) between AAT and the content of FT, and between the pH and the content of total phenols. Satisfactory correlations have been reported between the parameters of antioxidant activity and content of total phenols in different *in vitro* models, with different extracts of plants, fruit and wine (BERNARDI et al., 2008; EL-HAITUM et al., 2008; JAGDISH et al., 2009; SANCHEZ et al., 2007). Specifically for tea infusions these results are in agreement with previous studies where similar results were verified of a high correlation between AAT and FT for pure extracts of *Camellia sinensis* (ANESINI et al., 2008; EROL et al., 2009; SOUZA et al., 2008). In relation to the correlation matrices the extract of *Camellia sinensis* with *Mentha piperita* presented the highest correlation, was obtained a strong positive correlation ($r = 0.965$) between these two determinations. These results indicate that phenolic compounds are the major contributors to antioxidant activity, also significantly contributing to pH of the extracts of *Camellia sinensis* with other plants.

Furthermore, the same compounds influencing pH and ORP may also influence the conductivity (CE) for almost all extracts. The exception was observed for the extract of *Camellia sinensis* with *Citrus sinensis*, pH and ORP, $r = -0.51$; pH and CE, $r = -0.57$; ORP and CE, $r = 0.31$. For the extract of *Camellia sinensis* with *Prunus persica* it was observed a lack of correlation between pH and ORP, $r = 0.02$, and a weak correlation between ORP and CE, $r = 0.24$. For the pure extracts of unfermented and fermented *Camellia sinensis*, all the parameters had strong correlations ($r > 0.7$). These results suggest that the plants *Camellia sinensis* and *Prunus persica,* when blended, result in a tea with poor biochemical and physicochemical characteristics, probably due to an antagonistic effect of the major bioactive compounds in these plants.

Table 3. Correlation matrix of the variables for the extract of *Camellia sinensis*.

	AAT	FT	ATT	pH	ORP	CE
AAT	1					
FT	-0.879	1				
ATT	-0.825	0.737	1			
pH	0.912	-0.966	-0.824	1		
ORP	0.817	-0.973	-0.777	0.949	1	
CE	-0.939	0.976	0.684	-0.940	-0.902	1

Table 4. Correlation matrix of the variables for the extract of fermented *Camellia sinensis.*

	AAT	FT	ATT	pH	ORP	CE
AAT	1					
FT	-0.892	1				
ATT	-0.953	0.867	1			
pH	0.990	-0.944	-0.952	1		
ORP	0.829	-0.966	-0.833	0.888	1	
CE	-0.981	0.891	0.993	-0.979	-0.846	1

Table 5. Correlation matrix of the variables for the extract of *Camellia sinensis* with *Mentha piperita*.

	AAT	FT	ATT	pH	ORP	CE
AAT	1					
FT	0.965	1				
ATT	0.966	0.922	1			
pH	-0.717	-0.763	-0.566	1		
ORP	-0.726	-0.793	-0.554	0.978	1	
CE	0.935	0.977	0.857	-0.881	-0.893	1

Table 6. Correlation matrix of the variables for the extract of *Camellia sinensis* with *Citrus sinensis*.

	AAT	FT	ATT	pH	ORP	CE
AAT	1					
FT	0.734	1				
ATT	0.688	0.378	1			
pH	-0.728	-0.944	-0.197	1		
ORP	0.269	0.477	0.282	-0.511	1	
CE	0.916	0.704	0.898	-0.578	0.316	1

Table 7. Correlation matrix of the variables for the extract of *Camellia sinensis* with *Citrus limonium*.

	AAT	FT	ATT	pH	ORP	CE
AAT	1					
FT	0.752	1				
ATT	0.184	0.575	1			
pH	-0.372	-0.800	-0.770	1		
ORP	-0.541	-0.879	-0.772	0.979	1	
CE	0.627	0.950	0.796	-0.899	-0.955	1

Table 8 Correlation matrix of the variables for the extract of *Camellia sinensis* with *Prunus persica*.

	AAT	FT	ATT	pH	ORP	CE
AAT	1					
FT	0.494	1				
ATT	0.828	0.820	1			
pH	-0.936	-0.372	-0.810	1		
ORP	-0.208	0.473	0.329	0.025	1	
CE	0.876	0.819	0.987	-0.835	0.246	1

Conclusion

Our results can contribute for the evaluation of *in vitro* antioxidant effects of these extracts largely consumed as teas. With except for the extract blended with *Prunus persica*, the other results suggested the extracts of *Camellia sinensis* pure or blended with other plants did not suffer significant changes in the studied physical and chemical characteristics. Among the extracts, the content of total phenols was significantly different ($p < 0.05$) in the extracts of unfermented and fermented *Camellia sinensis,* and blended extract of *Camellia sinensis* with *Citrus sinensis*. The other extracts did not have significant difference in the analysis of AAT. For almost all infusions, the content of total phenols may directly influence this biological property, once the samples more rich in these compounds also presented the best percentages of antioxidant activity. The results indicated that pH and ORP can also be affected by the content of phenols.

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