Antioxidant activity and phenolic content of leaf infusions of Myrtaceae species from Cerrado (Brazilian Savanna)

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Abstract

There is considerable interest in identifying new antioxidants from plant materials. Several studies have emphasized the antioxidant activity of species belonging to the Myrtaceae family. However, there are few reports on these species from the Cerrado (Brazilian savanna). In this study, the antioxidant activity and phenolic content of 12 native Myrtaceae species from the Cerrado were evaluated (*Blepharocalyx salicifolius*, *Eugenia bimarginata*, *Eugenia dysenterica*, *Eugenia klotzschiana*, *Hexachlamys edulis*, *Myrcia bella*, *Myrcia lingua*, *Myrcia splendens*, *Myrcia tomentosa*, *Psidium australe*, *Psidium cinereum*, and *Psidium laruotteanum*). Antioxidant potential was assessed using the antioxidant activity index (AAI) by the DPPH method and total phenolic content (TPC) by the Folin–Ciocalteu assay. There was a high correlation between TPC and AAI values. *Psidium laruotteanum* showed the highest TPC (576.56 mg GAE/g extract) and was the most potent antioxidant (AAI = 7.97, IC_{50} = 3.86 μg·mL^{-1}), with activity close to that of pure quercetin (IC_{50} = 2.99 μg·mL^{-1}). The extracts of nine species showed IC_{50} of 6.24–8.75 μg·mL^{-1}. Most species showed TPC and AAI values similar to or higher than those for *Camellia sinensis*, a commonly consumed tea with strong antioxidant properties. The results reveal that the analyzed Myrtaceae species from the Cerrado possess high phenolic contents and antioxidant activities. Thus, they are a potential source of new natural antioxidants.

Keywords: free radical scavenging.

Atividade antioxidante e conteúdo fenólico de infusões foliares de espécies de Myrtaceae do Cerrado (Savana Brasileira)

Resumo

Há um considerável interesse na descoberta de novos antioxidantes de origem vegetal. Muitos estudos enfatizaram a atividade antioxidante de espécies pertencentes à família Myrtaceae. No entanto, há poucos relatos sobre espécies do Cerrado. Neste estudo, a atividade antioxidante e o conteúdo fenólico de 12 espécies nativas de Myrtaceae do Cerrado foram avaliados (*Blepharocalyx salicifolius*, *Eugenia bimarginata*, *Eugenia dysenterica*, *Eugenia klotzschiana*, *Hexachlamys edulis*, *Myrcia bella*, *Myrcia lingua*, *Myrcia splendens*, *Myrcia tomentosa*, *Psidium australe*, *Psidium cinereum* e *Psidium laruotteanum*). O potencial antioxidante foi estimado através do índice de atividade antioxidante (AAI) pelo método do DPPH e o conteúdo fenólico total (TPC) pelo ensaio de Folin-Ciocaulteu. Houve uma alta correlação entre os valores de TPC e AAI. *P. laruotteanum* teve o maior TPC (576,56 mg de equivalente em ácido gálico por g de extrato) e foi o antioxidante mais potente (AAI = 7,97, IC_{50} = 3,86 μg.mL^{-1}), com atividade próxima da quercetina pura (IC_{50} = 2,99 μg.mL^{-1}). Os extratos de nove espécies apresentaram IC_{50} de 6,24 a 8,75 μg.mL^{-1}. Além disso, a maioria das espécies teve valores de TPC e AAI similares ou maiores que *Camellia sinensis*, cujo chá é comumente consumido e apresenta fortes propriedades antioxidantes. Os resultados mostraram que as espécies de Myrtaceae do Cerrado analisadas apresentam conteúdos fenólicos e atividades antioxidantes elevadas. Dessa forma, elas são uma fonte potencial de novos antioxidantes.

Palavras-chave: sequestro de radical livre.

1. Introduction

Free radicals and other small reactive molecules have emerged as important regulators of many physiological and pathological processes (Nathan and Ding, 2010). Increased levels of these short-lived reactive molecules can cause oxidative damage to biological macromolecules and disrupt the cellular reduction–oxidation (redox) balance (Dowling and Simmons, 2009). Oxidative stress caused by the accumulation of free radicals in the body is involved in various pathological processes including cardiovascular diseases, cancer, neurodegenerative disorders, and aging (Yoshihara et al., 2010).

An antioxidant is a compound that can delay or inhibit the oxidation of lipids or other molecules by blocking the initiation or propagation of oxidative chain reactions, which prevents or repairs the damage done to the cells by oxygen (Tachakittirungrod et al., 2007). The consumption of natural antioxidants presents potential health benefits (Yoshihara et al., 2010). Thus, there is considerable interest in finding new antioxidants from plant materials. Antioxidant compounds from plants, particularly polyphenols, can inhibit the propagation of free radical reactions and protect the human body from diseases (Perron and Brumaghim, 2009; Lizcano et al., 2010).

Several studies have emphasized the antioxidant activity of species belonging to the Myrtaceae family such as *Feijoa sellowiana* (Weston, 2010), *Psidium guajava* (Tachakittirungrod et al., 2007), and *Eucalyptus rostrata* (Okamura et al., 1993). Furthermore, many members of this family are used in folk medicine, mainly as antidiarrheal, antimicrobial, cleansing, antirheumatic, anti-inflammatory, and cholesterol-lowering agents (Stefanello et al., 2011). However, there are few reports on the antioxidant activity of Myrtaceae species from the Cerrado (Brazilian savanna), although phytochemical studies reveal the presence of quercetin and kaempferol, which are compounds considered to be potent antioxidants (Imatomi et al., 2013). Therefore, in the present study, we aimed to evaluate the antioxidant activity and quantify polyphenols in leaf infusions of 12 Myrtaceae species from the Cerrado.

2. Material and Methods

2.1. Plant materials

Leaves of 12 Myrtaceae species with no signs of herbivory or disease (from at least three individuals per species) were collected in a cerrado sensu stricto area of the Universidade Federal de São Carlos (21° 58′ 5″ S and 47° 53′ 12″ W), São Carlos, São Paulo, Brazil, on July 15, 2013.

Voucher specimens were deposited at the Herbarium of the Universidade Federal de São Carlos. The 12 species included *Blepharocalyx salicifolius* (Kunth) O. Berg (8308), *Eugenia bimarginata* O. Berg (8310), *Eugenia dysenterica* DC. (8545), *Eugenia klotzschiana* O. Berg (8311), *Hexachlamys edulis* (O. Berg) Kausel & D. Legrand (8546), *Myrcia bella* Cambess. (8314), *Myrcia lingua* (O. Berg) Mattos (8315), *Myrcia splendens* DC. (8317), *Myrcia tomentosa* DC. (8318), *Psidium australe* Cambess. (8319), *Psidium cinereum* Mart. (8320), and *Psidium laruotteanum* Cambess. (8321). After collection, the leaves were dried at 40 °C for 48 h and ground in an electric mill.

Green tea is commonly used for its antioxidant properties (Senanayake, 2013). Thus, a commercial green tea (dry leaves and stalks of *Camellia sinensis* (L.) Kuntze) was used for comparison with Myrtaceae species, Yamamatoyama (Midori Indústria de Chá Ltda., lot number: 242).

2.2. Chemicals

The reagents used in the experiment were DPPH (2,2-diphenyl-1-picrylhydrazyl) and quercetin from Sigma Aldrich, Folin–Ciocalteu reagent from Haloquímica, gallic acid from Vetec, anhydrous sodium carbonate, and methanol from Synth.

2.3. Infusion extraction

The extraction was performed with 20 g of powdered dry leaves of Myrtaceae or green tea and 200 mL of distilled water for 10 min in a thermostatic water bath at 95 °C. The extracts were filtered through a filter paper (pore size = 3 μm) in a Büchner funnel and lyophilized (Terroni Enterprise I lyophilizer). The yields were calculated on dry weight basis of the plant material.

2.4. Total phenolics determination assay

The total phenolic content (TPC) in the extracts was determined by a modified Folin-Ciocalteu method (George et al., 2005). Extracts were diluted in distilled water (0.4 mg/5 mL) and 0.5 mL of the diluted solutions or distilled water (blank) were each mixed with 2.5 mL of Folin-Ciocalteu reagent (1/10, pre-diluted with distilled water). After allowing the diluted extracts to stand for 2 min at room temperature, 2 mL of aqueous Na_2CO_3 solution (75 g/L) was added to each of them. The mixture was vortexed, incubated for 15 min at 50 °C, and cooled in an ice water bath. Sample absorbances were measured at 760 nm. A calibration curve was prepared with gallic acid (1-8 $\mu g \cdot mL^{-1}$). TPC was expressed as milligrams of gallic acid equivalents (GAE) per gram of dry extract according to the calibration curve, $y = 0.133x + 0.001$ ($r^2 = 0.999$), where y denotes absorbance and x denotes gallic acid concentration in mg/L.

2.5. Antioxidant activity assay

The antioxidant properties of the samples were assessed by the DPPH method (Scherer and Godoy, 2009). Methanolic solutions of the extracts (0.05 mL) at six different concentrations were added to 1.95 mL of DPPH methanolic solution at 0.08 mM. Methanol PA and 2 commercial antioxidants, gallic acid and quercetin, were used as negative and positive controls, respectively. After 90 min of incubation in the dark at room temperature, the absorbances of the samples were measured at 517 nm (Femto spectrophotometer, model

800XI). Antioxidant activity index (AAI) was calculated as follows: AAI = (final concentration of DPPH in the reaction)/IC_{50}, where the final concentration of the reaction was 30.75 $\mu g \cdot mL^{-1}$. The concentration for 50% inhibition (IC_{50}) was calculated by the linear regression equation between the extract concentration and the corresponding scavenging effect. The scavenging effect was calculated as follows: $I\% = [(Abs_0 - Abs_1)/Abs_0] \times 100$, where Abs_0 indicates absorbance of the negative control, and Abs_1 is the absorbance with the tested extract at different concentrations. Scherer and Godoy (2009) established the following criteria of AAI values for plant extracts: poor activity < 0.05 < moderate < 1.0 < strong < 2.0 < very strong.

2.6. Data analysis

Assays were performed in triplicates. The data were compared by ANOVA and Tukey test ($\alpha = 0.05$). Correlations between TPC and AAI values were calculated. Statistical analyses were performed with PAST software, version 2.5 (Hammer et al., 2001).

3. Results

Extraction yields between 10.4% and 29.2% were obtained after the infusion of powdered dry leaves in distilled water and lyophilization (Table 1). There was a high correlation between phenolic contents and antioxidant activities of these extracts. The determination coefficient (r^2) between them was 0.767 (Figure 1).

The phenolic contents of these extracts were in the range of 287.98-576.56 mg GAE/g extract (Table 1). *P. laruotteanum*, *B. salicifolius*, *E. klotzschiana*, *E. dysenterica*, *H. edulis*, and *M. tomentosa* showed a significantly higher TPC than that found in green tea. TPC of these species ranged from 412.10 to 576.56 mg GAE/g extract, whereas the value of green tea was 259.53 mg GAE/g extract. The highest TPC was found in *P. laruotteanum*, which was more than twice the amount obtained for green tea. Phenolics also represented at least one fourth of the extract weights from the remaining five species (287.98-324.72 mg GAE/g extract).

In addition, all infusion extracts presented very strong AAIs (>2) according to the criteria established by Scherer and Godoy (2009) for plant extracts (Table 1). The IC_{50}

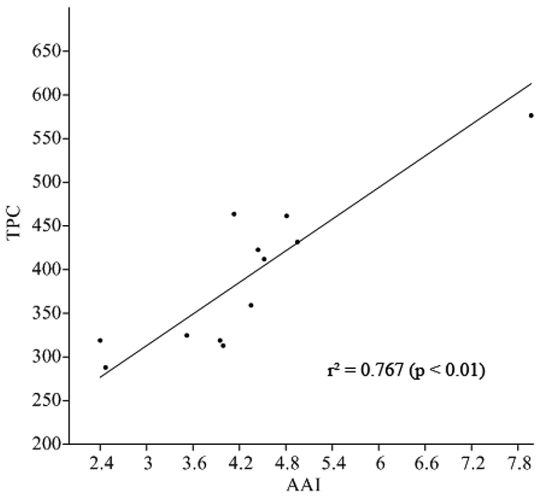

Figure 1. Linear correlation between total phenolic content (TPC in mg of gallic acid equivalents/g dry extract) and antioxidant activity indexes (AAI) of leaf infusions from 12 Myrtaceae species.

Table 1. Antioxidant activity index (AAI) and total phenolic content (TPC) of leaf infusions from 12 Myrtaceae species.

DPPH: 30.75 $\mu g \cdot mL^{-1}$	r^2			Mean IC_{50} ($\mu g \cdot mL^{-1}$)	Mean AAI ± SD		Mean TPC ± SD		Extraction
	I	II	III				(mg GAE/g dry extract)	yield (%)*	
Gallic acid	0.996	0.998	0.997	1.33	23.23 ± 1.14	a	-		-
Quercetin	0.994	0.998	0.993	2.99	10.35 ± 0.92	b	-		-
Psidium laruotteanum	0.997	0.997	0.998	3.86	7.97 ± 0.36	c	576.56 ± 21.82	a	22.6
Blepharocalyx salicifolius	0.998	0.995	0.997	6.24	4.95 ± 0.39	d	431.70 ± 10.63	bc	23.2
Eugenia klotzschiana	0.996	0.996	0.961	6.40	4.81 ± 0.26	de	461.50 ± 12.38	b	25.3
Eugenia dysenterica	0.990	0.991	0.996	6.83	4.52 ± 0.37	de	412.10 ± 17.20	b	25.6
Hexachlamys edulis	0.991	0.989	0.997	6.93	4.44 ± 0.23	de	422.10 ± 44.16	bcd	10.4
Psidium australe	0.987	0.990	0.994	7.10	4.35 ± 0.30	de	359.26 ± 11.91	bcdef	29.2
Green tea	0.984	0.982	0.982	7.45	4.13 ± 0.01	de	259.53 ± 4.30	f	16.2
Myrcia tomentosa	0.988	0.993	0.999	7.46	4.13 ± 0.17	de	463.69 ± 54.42	b	18.0
Myrcia bella	0.995	0.988	0.998	7.73	3.99 ± 0.24	de	312.99 ± 8.60	ef	19.4
Myrcia lingua	0.984	0.971	0.988	7.80	3.95 ± 0.16	de	318.93 ± 47.69	def	25.8
Psidium cinereum	0.993	0.970	0.993	8.75	3.52 ± 0.21	ef	324.72 ± 3.28	def	22.6
Myrcia splendens	0.996	0.994	0.995	12.48	2.47 ± 0.14	f	287.98 ± 55.66	f	19.4
Eugenia bimarginata	0.945	0.992	0.996	12.83	2.40 ± 0.05	f	318.93 ± 57.43	def	24.3

Gallic acid and quercetin: reference antioxidants. Green tea: reference antioxidant infusion. r^2: determination coefficient of free radical scavenging effect on the concentration of the substance/extract I, II, and III (three repetitions). IC_{50}: concentration for 50% inhibition. SD: standard deviation. Different letters: significant difference ($p < 0.05$). GAE: gallic acid equivalents. -: not evaluated. *: dry weight basis.

values were lower than 13 $\mu g \cdot mL^{-1}$, considering a final concentration of DPPH in the reaction of 30.75 $\mu g \cdot mL^{-1}$. P. laruotteanum was also the most potent antioxidant (AAI = 7.97) with activity close to that of quercetin (AAI = 10.35), corresponding to one third of that of pure gallic acid (AAI = 23.23). Nine species statistically displayed the same antioxidant potential as that of green tea (AAI = 4.13), which was equivalent to half the activity of quercetin.

4. Discussion

Extract´s yield and chemical composition are determined by the extraction method (Dai and Mumper, 2010). Water infusion is a simple, fast, cheap, and non-toxic procedure to extract phenolic compounds efficiently because of their water polarity. Therefore, this method was used in our study, resulting in high extraction yields of phenolics.

Phenolics are the most abundant secondary metabolites in plants (Dai and Mumper, 2010). Myrtaceae species have the ability to accumulate phenolics (Salvador et al., 2011). These organic compounds are important defense antioxidants (Pietta, 2000), which are more potent than Vitamin C and E and carotenoids (Rice-Evans et al., 1996). Some authors reported phenolic contents in leaves of other Myrtaceae species. Coutinho et al. (2008) found a TPC of 7.2-21.2 mg GAE/g extract in *Campomanesia adamantium*. Salvador et al. (2011) reported high values for *Eugenia chlorophylla*, *Eugenia pyriformis*, *Myrcia laruotteana*, and *Myrcia obtecta* (343.7-429.3 mg GAE/g extract). In these studies, the extraction methods were different. They used organic solvents such as hexane, chloroform, methanol, and ethanol. However, some of our TPC values were still higher than these results.

Phenolic content and antioxidant activity are parameters of quality for tea pertaining to its biological properties (Anesini et al., 2008). For this reason, several studies have been performed to evaluate these parameters and their functional properties (e.g., anti-inflammatory or anticarcinogenic activity) (Yao et al., 2006; Chan et al., 2007; Anesini et al., 2008; Nishiyama et al., 2010; Senger et al., 2010). In our study, green tea was used as another reference (in addition to the pure substances, quercetin, and gallic acid) due to its abundance of flavonoids, including catechins and their derivatives, which may constitute up to 30% of its dry weight (Lorenzo et al., 2013). In our study, leaf infusions of Myrtaceae species showed phenolic concentrations similar to or even higher than those of green tea.

AAI by the DPPH method was used because it is considered appropriate for comparing extracts and pure compounds. There is no difference in AAI values when different solutions of DPPH and concentrations of the compounds/extracts are used (Scherer and Godoy, 2009).

The relation of extraction yield, TPC and antioxidant activity must be taken into account in the analysis of results. One species can display high TPC and AAI values but low yield. Others may display lower antioxidant activity but higher extraction yield. The understanding of the balance between these factors is necessary for further studies and their application. Despite this variation, the studied species displayed high antioxidant activities and can be considered as promising for future studies. *Psidium laruotteanum* was the most potent, possessing the highest phenolic content and antioxidant activity.

To the best of our knowledge, this is the first comparative survey on the antioxidant potential of Myrtaceae leaf infusions from the Cerrado. The focus of antioxidant studies in the Myrtaceae family from Brazil has been on edible fruits (Marin et al., 2008; Rufino et al., 2009, 2010; Pereira et al., 2012) with few reports on leaves (Coutinho et al., 2008; Salvador et al., 2011). Thus, our results contribute valuable knowledge about the bioactive properties of native Myrtaceae species.

Further studies should be conducted to isolate, characterize, and understand the mode of action of these phenolic compounds. Likewise, evaluation of the effect of environmental abiotic factors, such as temperature and humidity, on the production and concentration of these compounds is desirable.

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References

ANESINI, C., FERRARO, G.E. and FILIP, R., 2008. Total polyphenol content and antioxidant capacity of commercially available tea (*Camellia sinensis*) in Argentina. *Journal of Agricultural and Food Chemistry*, vol. 56, no. 19, pp. 9225-9229. http://dx.doi.org/10.1021/jf8022782. PMid:18778031.

CHAN, E.W.C., LIM, Y.Y. and CHEW, Y.L., 2007. Antioxidant activity of *Camellia sinensis* leaves and tea from a lowland plantation in Malaysia. *Food Chemistry*, vol. 102, no. 4, pp. 1214-1222. http://dx.doi.org/10.1016/j.foodchem.2006.07.009.

COUTINHO, I.D., COELHO, R.G., KATAOKA, V.M.F., HONDA, N.K., SILVA, J.R.M., VILEGAS, W. and CARDOSO, C.A.L., 2008. Determination of phenolic compounds and evaluation of antioxidant capacity of *Campomanesia adamantium* leaves. *Eclética Química*, vol. 33, pp. 53-60.

DAI, J. and MUMPER, R.J., 2010. Plant phenolics: extraction, analysis and their antioxidant and anticancer properties. *Molecules (Basel, Switzerland)*, vol. 15, no. 10, pp. 7313-7352. http://dx.doi.org/10.3390/molecules15107313. PMid:20966876.

DOWLING, D.K. and SIMMONS, L.W., 2009. Reactive oxygen species as universal constraints in life-history evolution. *Proceedings. Biological Sciences*, vol. 276, no. 1663, pp. 1737-1745. http://dx.doi.org/10.1098/rspb.2008.1791. PMid:19324792.

GEORGÉ, S., BRAT, P., ALTER, P. and AMIOT, M.J., 2005. Rapid determination of polyphenols and vitamin C in plant-derived products. *Journal of Agricultural and Food Chemistry*, vol. 53, no. 5, pp. 1370-1373. http://dx.doi.org/10.1021/jf048396b. PMid:15740008.

HAMMER, Ø., HARPER, D.A.T. and RYAN, P.D., 2001. *PAST: Paleontological Statistics Software Package for Education and Data Analysis*. Version 2.5 [software]. Palaeontologia Eletronica.

IMATOMI, M., NOVAES, P., MATOS, A.P., GUALTIERI, S.C.J., MOLINILLO, J.M.G., LACRET, R., VARELA, R.M. and MACÍAS, F.A., 2013. Phytotoxic effect of bioactive compounds isolated from *Myrcia tomentosa* (Myrtaceae) leaves. *Biochemical Systematics and Ecology*, vol. 46, pp. 29-35. http://dx.doi.org/10.1016/j.bse.2012.09.005.

LIZCANO, L.J., BAKKALI, F., RUIZ-LARREA, M.B. and RUIZ-SANZ, J.I., 2010. Antioxidant activity and polyphenol content of aqueous extracts from Colombian Amazonian plants with medicinal use. *Food Chemistry*, vol. 119, no. 4, pp. 1566-1570. http://dx.doi.org/10.1016/j.foodchem.2009.09.043.

LORENZO, C., DELL'AGLI, M., SANGIOVANNI, E., SANTOS, A., UBERTI, F., MORO, E., BOSISIO, E. and RESTANI, P., 2013. Correlation between catechin content and NF-κB inhibition by Infusions of green and black tea. *Plant Foods for Human Nutrition (Dordrecht, Netherlands)*, vol. 68, no. 2, pp. 149-154. http://dx.doi.org/10.1007/s11130-013-0354-0. PMid:23636906.

MARIN, R., APEL, M.A., LIMBERGER, R.P., RASEIRA, M.C.B., PEREIRA, J.F.M., ZUANAZZI, J.Â.S. and HENRIQUES, A.T., 2008. Volatile components and antioxidant activity from some Myrtaceous fruits cultivated in Southern Brazil. *Latin American Journal of Pharmacy*, vol. 27, no. 2, pp. 172-177.

SENANAYAKE, S.P.J.N., 2013. Green tea extract: chemistry, antioxidant properties and food applications - a review. *Journal of Functional Foods*, vol. 5, no. 4, pp. 1529-1541. http://dx.doi.org/10.1016/j.jff.2013.08.011.

NATHAN, C. and DING, A., 2010. SnapShot: Reactive Oxygen Intermediates (ROI). *Cell*, vol. 140, no. 6, pp. 951-951. http://dx.doi.org/10.1016/j.cell.2010.03.008. PMid:20303882.

NISHIYAMA, M.F., COSTA, M.A.F., COSTA, A.M.D., SOUZA, C.G.M.D., BÔER, C.G., BRACHT, C.K. and PERALTA, R.M., 2010. Chá verde brasileiro (*Camellia sinensis* var assamica): efeitos do tempo de infusão, acondicionamento da erva e forma de preparo sobre a eficiência de extração dos bioativos e sobre a estabilidade da bebida. *Food Science and Technology*, vol. 30, pp. 191-196. http://dx.doi.org/10.1590/S0101-20612010000500029.

OKAMURA, H., MIMURA, A., YAKOU, Y., NIWANO, M. and TAKAHARA, Y., 1993. Antioxidant activity of tannins and flavonoids in *Eucalyptus rostrata. Phytochemistry*, vol. 33, no. 3, pp. 557-561. http://dx.doi.org/10.1016/0031-9422(93)85448-Z.

PEREIRA, M.C., STEFFENS, R.S., JABLONSKI, A., HERTZ, P.F., RIOS, A.O., VIZZOTTO, M. and FLORES, S.H., 2012. Characterization and antioxidant potential of Brazilian fruits from the Myrtaceae family. *Journal of Agricultural and Food Chemistry*, vol. 60, no. 12, pp. 3061-3067. http://dx.doi.org/10.1021/jf205263f. PMid:22397467.

PERRON, N.R. and BRUMAGHIM, J.L., 2009. A review of the antioxidant mechanisms of polyphenol compounds related to iron binding. *Cell Biochemistry and Biophysics*, vol. 53, no. 2, pp. 75-100. http://dx.doi.org/10.1007/s12013-009-9043-x. PMid:19184542.

PIETTA, P.-G., 2000. Flavonoids as antioxidants. *Journal of Natural Products*, vol. 63, no. 7, pp. 1035-1042. http://dx.doi.org/10.1021/np9904509. PMid:10924197.

RICE-EVANS, C.A., MILLER, N.J. and PAGANGA, G., 1996. Structure-antioxidant activity relationships of flavonoids and phenolic acids. *Free Radical Biology & Medicine*, vol. 20, no. 7, pp. 933-956. http://dx.doi.org/10.1016/0891-5849(95)02227-9. PMid:8743980.

RUFINO, M.D.S.M., ALVES, R.E., BRITO, E.S., PÉREZ-JIMÉNEZ, J., SAURA-CALIXTO, F. and MANCINI-FILHO, J., 2010. Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. *Food Chemistry*, vol. 121, no. 4, pp. 996-1002. http://dx.doi.org/10.1016/j.foodchem.2010.01.037.

RUFINO, M.S.M., FERNANDES, F.A.N., ALVES, R.E. and BRITO, E.S., 2009. Free radical-scavenging behaviour of some north-east Brazilian fruits in a DPPH system. *Food Chemistry*, vol. 114, no. 2, pp. 693-695. http://dx.doi.org/10.1016/j.foodchem.2008.09.098.

SALVADOR, M.J., LOURENÇO, C.C., ANDREAZZA, N.L., PASCOAL, A.C.R.F. and STEFANELLO, E.A., 2011. Antioxidant capacity and phenolic content of four Myrtaceae plants of the south of Brazil. *Natural Product Communications*, vol. 6, no. 7, pp. 977-982. PMid:21834237.

SCHERER, R. and GODOY, H.T., 2009. Antioxidant activity index (AAI) by the 2,2-diphenyl-1-picrylhydrazyl method. *Food Chemistry*, vol. 112, no. 3, pp. 654-658. http://dx.doi.org/10.1016/j.foodchem.2008.06.026.

SENGER, A.E.V., SCHWANKE, C.H.A. and GOTTLIEB, M.G.V., 2010. Chá verde (*Camellia sinensis*) e suas propriedades funcionais nas doenças crônicas não transmissíveis. *Scientia Medica*, vol. 20, no. 4, pp. 292-300.

STEFANELLO, M.É.A., PASCOAL, A.C.R.F. and SALVADOR, M.J., 2011. Essential oils from Neotropical Myrtaceae: chemical diversity and biological properties. *Chemistry & Biodiversity*, vol. 8, no. 1, pp. 73-94. http://dx.doi.org/10.1002/cbdv.201000098. PMid:21259421.

TACHAKITTIRUNGROD, S., OKONOGI, S. and CHOWWANAPOONPOHN, S., 2007. Study on antioxidant activity of certain plants in Thailand: mechanism of antioxidant action of guava leaf extract. *Food Chemistry*, vol. 103, no. 2, pp. 381-388. http://dx.doi.org/10.1016/j.foodchem.2006.07.034.

WESTON, R.J., 2010. Bioactive products from fruit of the feijoa (*Feijoa sellowiana*, Myrtaceae): a review. *Food Chemistry*, vol. 121, no. 4, pp. 923-926. http://dx.doi.org/10.1016/j.foodchem.2010.01.047.

YAO, L.H., JIANG, Y.M., CAFFIN, N., D'ARCY, B., DATTA, N., LIU, X., SINGANUSONG, R. and XU, Y., 2006. Phenolic compounds in tea from Australian supermarkets. *Food Chemistry*, vol. 96, no. 4, pp. 614-620. http://dx.doi.org/10.1016/j.foodchem.2005.03.009.

YOSHIHARA, D., FUJIWARA, N. and SUZUKI, K., 2010. Antioxidants: benefits and risks for long-term health. *Maturitas*, vol. 67, no. 2, pp. 103-107. http://dx.doi.org/10.1016/j.maturitas.2010.05.001. PMid:20627629.