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Chemical Composition and Antioxidant Activity of Genipa Americana L. (Jenipapo) of the Brazilian Cerrado

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Abstract

Brazil has the largest biodiversity of any country in the world, which includes a large number of fruit species. Cerrado, a Brazilian biome that has a large number of underexploited native and exotic fruit species, is of potential interest to the agroindustry and a possible future source of income for the local population. This paper presents the centesimal composition, phenolic contents, anthocyanin, flavonoids, and antioxidant activity of *Genipa americana* L. fruit. The results indicated the following composition: moisture (75.00%), lipids (1.60%), proteins (0.67%), carbohydrates (20.50%), and ash (2.20%). The *Genipa americana* fruit contained considerable amounts of phenolic compounds (857.10 mgGAE.100^{-1} g) and flavonoids (728.00 mg.100^{-1} g), which contribute to its high antioxidant activity. This study highlights the potential of this fruit as an important source of both nutritional and bioactive compounds available in the native Brazilian flora.

Keywords: *Genipa americana* L. (jenipapo), food chemistry, phenolic compounds, antioxidant capacity

1. Introduction

Brazil has the largest biodiversity of any country in the world, which includes a large number of fruit species (Leterme et al., 2006).

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Many fruit species in Brazil are unknown and relatively few are commercially available (Mattietto, Lopes, and Menezes, 2010). The Cerrado, a Brazilian biome that has a large number of underexploited native and exotic fruit species,is of potential interest to the agroindustry and a possible future source of income for the local population (Almeida et al., 2011).

Among the compounds present in food with functional properties, substances with antioxidant activities have received significant attention because they protect the human body against oxidative stress, preventing a number of chronic degenerative disorders (Canuto et al., 2010). Natural antioxidants present in foods have attracted interest because of their safety and potential nutritional and therapeutic effects (Rufino et al., 2009). Fruits are a source of antioxidant compounds, such as phenolics, vitamins, carotenoids, and minerals, which contribute to their chemopreventive effects (Almeida et al., 2011).

The fruit of *Genipa americana* L. belongs to the Rubiaceae family and is a soft brown berry with a subglobosa of 8-10 cm long and 6-7 cm in diameter, and yellowish-brown, thin membranous, and wrinkled bark. The pulp has brown coloration and is juicy, sweet and soft and includes numerous fibrous, dark brown, and flattened seed albumins of 6-10 mm long (Figueiredo et al., 1991).

In previous research performed by Moreira-Araújo et al. (2010). a high content of phenolic compounds in fruits of the Brazilian Cerrado, including *Genipa americana* L., was determined; therefore, it is of paramount importance to analyze these fruits because of the potential benefits of these compounds to human health. The aim of this study was to determine the centesimal composition, total phenolic content, flavonoids and anthocyanins, and assess their antioxidant capacity.

2. Materials and Methods

2.1. Samples

The ripe fruit of *Genipa Americana* L., was collected in Empresa Brasileira de Pesquisa Agropecuária (Embrapa Middle-North), located in the city of Teresina, Piauí (05° 05 ' South latitude, 42° 48 ' West longitude). Located at an elevation of, 72 m above sea level, the climate was classified as tropical hot sub-humid, between the months of February and March, 2011.

The fruits harvested were carefully selected to obtain a uniform batch over the size range and degree of maturity, determined by the intensity of the yellowish-brown color. After selection, the fruits were sanitized, peeled, devitalized and stored in plastic containers at a temperature of -20° C until the time of examination. For preparation of extracts, the fruits were thawed in the refrigerator at 4° C and, cut into strips with the aid of a steel baking dish. Samples, were then vented and dried using a model TE-3942 klin set to 50° C, for 12 hours. After this process, samples were crushed using a semi-automatic knife mill to create a powder.

2.2. Chemicals

The 1,1-diphenyl-2-picrylhydrazyl (DPPH) reagent was obtained from Sigma-Aldrich (St. Louis, MO, USA). The Folin-Ciocalteu reagent, methanol, ethanol, and acetone were provided by Merck. All reagents were of analytical grade.

2.3. Methods

2.3.1. Centesimal composition

Moisture, ash, protein (N × 6.25) and total lipid content were determined according to AOAC (1998). Total carbohydrate content was determined by the difference between 100 and the sum of the moisture, protein, total lipids, and ash content percentages. The energy value was calculated from the protein, and total lipid and carbohydrate content was calculated using an Atwater system (Merrill and Watt, 1973). Each determination was performed in triplicate and repeated at least three times.

2.3.2 Extract Preparation

The extracts were prepared with dry sample, in mass/solvent ratio of 1:12 according to Rufino et al. (2010). Four solvents were used, including the following: methanol, ethanol, acetone, and water. The extraction was conducted with an ultrasound device (USC-1400-Original ®) for a period of 60 min, followed by centrifugation at 4000 rpm. Subsequently, the supernatant was used to determine the total phenolic and antioxidant activity.

2.3.3 Determination of Total Phenolics

For this analysis, 2 mL of deionised water was added to a 10 mL flask, 100 µL of sample (extract) was pipetted with an automatic pipette, and the sample was transferred to a 10 mL volumetric flask. Next, 0.5 mL of the Folin-Ciocalteu reagent was added, followed by vigorous agitation. After 5 min, 1.5 mL of sodium carbonate at 20 % m/v was added, and the mixture was well agitated and diluted with deionised water to a volume of 10 mL. After a 2 hour rest at room temperature, the absorbance was measured at 765 nm in a 10 mm cuvette (Singleton e Rossi, 1965).

2.3.4 Determination of Total Flavonoids

The extraction was performed in an ethanol solution with 1.5N HCl (85:15 v/v) and determination held in a spectrophotometer according to the methodology of Francis (1982). Quantification of flavonoids was accomplished by means of the formula: Absorbance × dilution factor/ 98.2. The wavelength used was 374 nm.

2.3.5 Determination of Total Anthocyanins

Total anthocyanins were determined using a pH differential method (Guisti and Wrolstad, 2001). The extracts were dissolved separately in a potassium chloride buffer (KCL, 0.025 M, pH 1.0) and sodium acetate (CH_3COONa. 3 H_20, 0.4 M, pH 4.5), according to a predetermined dilution factor. Sample measurement absorptions were read at 510 and 700 nm against a blank cell containing distilled water. The absorption (A) of the diluted sample was then calculated as follows:

$$A = (A_{510} - A_{700})_{pH\ 1.0} - (A_{510} - A_{700})_{pH\ 4.5}$$

The monomeric anthocyanin pigment concentration in the original sample was calculated according to the following formula: Anthocyanin content (mg/100 g of dry fruit) = A × MW × DF × 100/ (ε ×1).

This equation was applied where cyanidin-3-glucoside molecular weight (MW = 449.2 g mol^{-1}) and the molar absorption of cyanidin-3-glucoside (ε=26,900 M) constants were used. The anthocyanin content was expressed as mg of cyanidin-3-glucoside (cy-3-glu) equivalent per 100 g of dry fruit. Each determination was performed in triplicate and was repeated at least three times.

2.3.6 Evaluation of the Antioxidant Activity (DPPH Method)

For this analysis, 0.0394 g of the radical was weighted and dissolved in 10 mL of methanol. After this procedure, the solution was diluted 1:100 in 80 % methanol v/v, adjusting the initial absorption to 0.800. Once the solution was prepared, 2.9 mL of the radical was pipetted into a 10 mm cuvette. The initial absorption was then measured. A 100 μL sample of extract was added, and a reaction time of 30 min was allowed, with the sample kept in the dark. The results were expressed in EC_{50}. The method was conducted according to Kim et al. (2002).

2.3.7 Statistical Analysis

All of the analyses using different extraction systems were carried out in triplicate, and the results were presented as averages and standard deviations. To compare the averages, a variance analysis (ANOVA) was carried out (univariate) as well as the Tukey test, using Statistica® 6.0 software, version 2001. The statistical significance level for the differences between averages was accepted at 5% ($p < 0.05$).

3 Results and Discussion

3.1 Chemical Composition

The chemical composition of the *Genipa americana* L. (jenipapo) fruit is described in Table 1.

Table 1: Centesimal Composition (g/100 g) and Caloric Value of the Genipa Americana L. (Jenipapo) Fruit.[a]

Properties	Values
Moisture 105°C	75.00 ± 0.249
Protein[b]	0.67 ± 0.02
Lipids	1.60 ± 0.17
Ashes	2.20 ±0.26
Carbohydrates[c]	20.53
Caloric value (kcal/kJ)[d]	99 kcal/415 kJ

a Results presented as the mean ± SD, n=3.

b N x 6.25.

c Calculated by the difference of: 100 – (% total lipids + % proteins + % moisture + % ashes).

d Calculated by the sum of the percentages of proteins and carbohydrates multiplied by a factor of 4 (Kcal/g) and total lipids multiplied by a factor of 9 (Kcal/g).

The moisture level of the fruit was approximately 75%, which lies within the class of fleshy and succulent fruits (a common characteristic in tropical fruits). Souza (2007) previously obtained a moisture value of 74.34%, while Figueiredo et al. (1986) obtained 74.81%. The protein level was 0.67%, a value similar to that (0.68%) achieved by Figueiredo et al. (1986). With respect to total lipids, the value determined was 1.60%, higher than that obtained by the same author (0.35%). For determination of ash, we obtained a value of 2.20%. The carbohydrate level (20.53%) is the largest contributor of calories because the content of lipids and proteins determined did not substantially influence the calculation of the energy value (99 kcal/100 g). It is noteworthy that the scarcity of data in the literature on the chemical characteristics of the *Genipa americana* L. Fruit makes difficult to discuss and compare certain values.

3.2 Phenolic Compounds

Table 2 shows the bioactive compounds content and antioxidant capacity of the different extraction systems obtained from the *Genipa americana* fruit.

Table 2: Bioactive Componds and Antioxidant Activity of the Genipa Americana L. (Jenipapo) Fruit Extracts.[1]

Extracts	Total phenolic (mgGAE.100^{-1} g)[2]	DPPH EC_{50} (μg.mL^{-1})
Methanolic/Acetonic	857.10 ± 0.05[a]	606.7[a]
Aqueous	410.00 ± 59.40[b]	5747.1[b]
Ethanolic	406.00 ± 0.00[b]	1092.5[c]
	Anthocyanins (mgcy-3-glu.100 g^{-1})	**Flavonoids (mg.100^{-1}g)**
	4.6 ± 0,05	728.00 ± 0,10

1 Data was expressed as average ± SD, n=3.

2 Equivalent to gallic acid (GAE).

For the different letters (superscripts a, b, and c) the (ANOVA) showed significant differences between the averages. The same letter indicates no significant differences between medium, according to the Tukey test ($p<0.05$).

The Methanolic/Acetonic extract presented the highest level of total phenolic compounds, 857.10 mgGAE.100^{-1} g, and the difference was statistically significant ($p < 0.05$). There was no difference between the aqueous and ethanolic extracts, at 410.00 and 406.00 mgGAE.100^{-1} g, respectively.

This result was superior to that found in most fruit pulps consumed in Brazil. According to Kuskoski et al. (2006), açaí berry (*Euterpe oleracea,* Mart) has a phenolic content of 136.8 mgGAE.100^{-1} g, guava a content of 83.1 mgGAE.100^{-1} g, strawberry a content of 132.1 mg GAE.100^{-1} g, pine apple a content of 21.7 mgGAE.100^{-1} g, soursop a content of 84.3 mgGAE.100^{-1} g, and passion fruit a content of 20.2 mgGAE.100^{-1} g. Tiburski et al. (2011), who carried out research using the pulp of yellow mombin pulp, obtained a content of 260.21 mgGAE.100^{-1} g. In comparison with other exotic fruits, the *Genipa americana* (jenipapo) has a higher total phenolic content than acerola *(Malpighia emarginata)* (580.1 mgGAE/100 g), camarinha (*Gaylussacia brasiliensis*) (492.87 mgGAE.100^{-1} g) and mango (544 mgGAE.100^{-1} g) (Bramorski et al., 2011; Kuskoski et al., 2006).

Barbosa (2008) analyzed the phenolic content in the *Genipa americana* (jenipapo) fruit and obtained a value of 1178 mgGAE.100^{-1} g. In this study, compared to the values obtained by Barreto, Benassi and Mercadante (2009) in other typical Brazilian Cerrado fruit, the *Genipa americana* L. fruit has more total phenolic content then that of *Platonia insignis M.* (bacuri) (266.8 mgGAE.100^{-1} g), *Mauritia flexuosa* (buriti) (108.1 mgGAE.100^{-1} g) and *Byrsonima crassifolia* L. (murici) (384.5 mgGAE.100^{-1} g) and less than *Caryocar brasiliense* C. (pequi) (4623.4 mgGAE.100^{-1} g).

We obtained a high content of flavonoids (728.00 mg.100^{-1} g) from analysis of *Genipa americana* L. No information was available in the literature on the content of flavonoids in *Genipa americana* L. therefore, reference data from other fruits grown in Brazil was used. Barreto, Benassi and Mercadante (2009) obtained a flavonoid concentration of 73.3 mg.100^{-1} g for buriti, 103.8 mg.100^{-1} g for bacuri, 319.4 mg.100^{-1} g for murici and 741.2 mg.100^{-1} g for pequi. Only the pequi approached the figure obtained in this study, while the other fruits had values well below those recorded in this survey.

For total anthocyanins, the results obtained express a low concentration of these compounds (4.6 mg cy-3-glu.100^{-1} g). This value was lower compared with data from other exotic fruits available in the literature such as blackberries (152.8 mg cy-3-glu.100^{-1} g), blueberries (113.3 mg cy-3-glu.100^{-1} g), strawberries (20.1 mg cy-3-glu.100^{-1} g) and grapes (107.6 mg cy-3-glu.100^{-1} g) (Khanal, Howard Prior, 2012; Sellappan, Akon Krewer, 2002; Zheng et al., 2007).

Anthocyanins are intensely colored pigments, responsible for most of the blue, violet and all red shades of colors that appear in flowers, fruits and some leaves, stems and roots of plants. It is noteworthy that the blue color present on the *Genipa americana* L. fruit before complete maturity is due to the presence of a class of dye iridóids belonging to terpene compounds.

3.3 Antioxidant Activity

The DPPH method is one of the most widely used chemical methods to determine antioxidant capacity because it is considered to be practical, fast, and stable. The antioxidant activity of the methanolic/acetonic, aqueous and ethanolic extracts of the *Genipa americana* fruits obtained using the DPPH radical scavenging method is shown in Table 3. The results were expressed as EC_{50} (the quantity of antioxidant in the extracts that is capable of reacting with 50% of the radical in the DPPH solution). Therefore, the lower the EC_{50} value, the greater the antioxidant activity of the extract analyzed.

Table 3: Antioxidant Activity, % Reduction and EC_{50} of the Dry Extract of Genipa Americana L. (Jenipapo).[1]

Concentrations (μg.mL^{-1})	Methanolic/Acetonic			
	100	**400**	**700**	**1000**
% reduction DPPH	44^{a}	44^{a}	54^{b}	58^{b}
EC_{50} (μg.mL^{-1})		**606.7^{a}**		
Concentrations (μg.mL^{-1})	**Aqueous**			
	200	**400**	**600**	**1000**
% reduction DPPH	3.57^{a}	3.57^{a}	3.57^{a}	7.14^{b}
EC_{50} (μg.mL^{-1})		**5747.1^{b}**		
Concentrations (μg.mL^{-1})	**Ethanolic**			
	200	**400**	**600**	**1000**
% reduction DPPH	8.54^{a}	13.41^{b}	30.49^{c}	35.37^{d}
EC_{50} (μg.mL^{-1})		**1092.5^{c}**		

1 Data were expressed as average ± SD, n=3.
Different lowercase letters in the same column and different uppercase letters on the same line represent significant differences (Tukey test $p < 0.05$).

We used four concentrations for each extract as presented in Table 3.

The methanolic/acetonic combined extract showed better antioxidant activity, especially if the concentration was 700 $\mu g.mL^{-1}$ (which reduced the radical 54%) and showed no significant difference to the value obtained when using a concentration of 1000 $\mu g.mL^{-1}$ (58%). The ethanolic extract presented relevant values, especially at the concentration of 1000 $\mu g.mL^{-1}$, whose percentage of reduction was 35.37%. The aqueous extract showed no significant antioxidant activity in any of the tested concentrations. As for the EC_{50}, the best value obtained was for the methanolic/acetonic combination, with a value of 606.7 $\mu g.mL^{-1}$ (amount needed to reduce the initial concentration of 50% DPPH), showing a good antioxidant capacity, followed by the ethanolic extract (1092.5 $\mu g.mL^{-1}$). Roesler et al. (2007), examined other fruits in the Brazilian Cerrado, and obtained an EC_{50} of 387.47 µg/mL for cagaita (*Eugenia dysenterica*), 298.75 µg/mL for pequi (*Caryocar brasiliense*), and 148.82 µg/mL for araticum (*Annona classiflora*). Marques et al. (2012), in a study with the *Terminalia catappa* L. (castanhola), obtained an EC_{50} of 0.70 and 85.99 $\mu g.mL^{-1}$ in aqueous and alcoholic extract, respectively. Bramorski et al. (2011), obtained a value of 1399.95 µMol/100 g for the camarinha fruit.

Compared with Brazilian Cerrado fruits, extracts of the jenipapo are less effective antioxidants. Roesler et al. (2007), in their study on pequi, araticum, cagaita, and lobeira pulps, obtained EC_{50} values in alcoholic extracts of 298.75 ± 3.80 $\mu g.mL^{-1}$, 148.82 ± 0.98 $mg.mL^{-1}$, 387.47 ± 8.70 $mg.mL^{-1}$ and 162.97 ± 2.05 $\mu g.mL^{-1}$, respectively.

4 Conclusions

In terms of nutritional composition, the *Genipa americana* (jenipapo) fruit showed high levels of carbohydrates. The total polyphenol content was dependent on the solvent used, demonstrating its positive correlation to the antioxidant capacity of the different jenipapo extracts. A combination of methanol and acetone, was the most efficient solvent for total polyphenol extraction, which is associated with the highest levels of antioxidant activity, verified by the DPPH method. In addressing the lack of research on *Genipa americana*, this study highlights the potential of this fruit as an important source of nutritional and bioactive compounds available in native Brazilian flora.

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References

Almeida, M. M. B., Souza, P. H. M., Arriaga, A. M. C., Prado, G. M. P., Magalhães, C. E. C., Mais, G. A. M. (2011). Bioactive compounds and antioxidant activity of fresh exotic fruits from northeastern Brazil. Food Research International, 44, 2155–2159.

AOAC (1998). Officials methods of analysis (6thed). Arlington, VA, USA: Association of Official Analytical Chemist.

Barbosa, D. A. (2008) Avaliação fitoquímica e farmacológica de Genipa americana L. (Rubiaceae). 115f. Dissertação de Mestrado. Faculdade de Farmácia – Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Barreto, G. P. De M., Benassi, M. T., Mercadante, A. Z. (2009). Bioactive compounds from several tropical fruits and correlation by multivariate analysis to free radical scavenger activity. Journal of the Brazilian Chemical Society (Online), 20, 1856 - 1861.

Bramorski, A., Cherem, A. R., Mezadri, T., Melo, S. S., Deschamps, F. C., Gonzaga, L. V., Rockenbach, I. I., Fett, R. (2011). Chemical composition and antioxidant activity of Gaylussacia brasiliensis (camarinha) grown in Brazil. Food Research International, 44, 2134-2138.

Canuto, G. A., Xavier, A. A. O., Neves, L. C., & Benassi, M. T. (2010). Caracterização físico química de polpas de frutos da Amazônia e sua correlação com a atividade anti-radical livre. Revista Brasileira de Fruticultura, 32, 1196–1205.

Figueiredo, R. W. de; Maia, G. A.; Monteiro J. C. S.; Figueiredo, E. A. T. (1991). Composição de ácidos graxos na fração lipídica da polpa e sementes do jenipapo (Genipa americana L.). Boletim do Centro de Pesquisa e Processamento de Alimentos, 9 (2), 149-154.

Figueiredo, R. W. de; Maia, G. A.; Holanda, L. F. F. de; Monteiro, J. C. S. (1986). Processamento e estabilidade de néctares de jenipapo submetidos a diferentes métodos de conservação. Pesquisa Agropecuária Brasileira, 21(10), 1077-1084.

Francis, F. J. (1982). Analysis of anthocyanins. In: Markakis, P. (ed.) Anthocyanins as food colors. New York: Academic Press, 181-207.

Guisti, M. M., e Wrolstad, R. E. (2001). In R. E. Wrolstad (Ed.), Anthocyanins: Characterization and measurement with UV-visible spectroscopy. Current Protocols In food Analytical Chemistry. (pp.1−13) New York: J. Wiley, & and Sons.

Khanal, R. C., Howard, L. R., & Prior, R. L. (2010). Effect of heating on the stability of grape and blueberry pomace procyanidins and total anthocyanins. Food Research International, 43, 1464−1469.

Kim, D. O., Lee, K. W., Lee, H. J., Lee, C. Y. (2002). Vitamin C equivalent antioxidant capacity (VCEAC) of phenolics phytochemicals. Journal of Agricultural Food and Chemistry, 50, 3713-3717.

Kuskoski, E. M., Asuero, A. G., Morales, M. T., & Fett, R. (2006). Frutos tropicais silvestres e polpas de frutas congeladas: atividade antioxidante, polifenóis e antocianinas. Ciência Rural, 36(4), 1283 - 1287.

Leterme, P., Buldgen, A., Estrada, F., and Londoño, A. M. (2006). Mineral content of tropical fruits and unconventional foods of the Andes and the rain forest of Colombia. Food Chemistry, 95, 644–652.

Marques, M. R., Paz, D. D., Batista, L. P., Barbosa, C de O., Araújo, M. A. M., Moreira-Araújo, R. S. dos R. (2012). An in vitro analysis of the total phenolic content, antioxidant power, physical, physicochemical, and chemical composition of Terminalia Catappa Linn fruits. Ciência e Tecnologia de Alimentos, 32(1), 564-569.

Mattietto, R. A., Lopes, A. S., & Menezes, H. C. (2010). Caracterização física e físico-química dos frutos da cajazeira (Spondias mombin L.) e de duas polpas obtidas por dois tipos de extrator. Brazilian Journal of Food Tchnolology, 13, 156–164.

Merrill, A. L., e Watt, B. K. (1973). Energy Value of Foods: Basis and Derivation, Revised U.S. Department of Agriculture, Retrieved November, 15, 2008 from the Department of Agriculture. Agriculture Handbook, 74, 1973. Home page: www.nal.usda.gov/fnic/foodcomp/Data/Classics/index.html.

Moreira-Araújo, R. S. dos R., Souza, V. A. B. de, Araújo, M. A. da M., Barbosa,C. de O., Cardoso, B. V. S., Rocha, M. S., Marques, M. R. (2010). Relatório Técnico: Determinação de Fenólicos e Atividade Antioxidante de Frutos do Cerrado Brasileiro. UFPI/CNPQ.

Roesler, R., Malta, L. G., Carrasco, L. C., Holanda, R. B., Sousa, C. A. S., Pastore, G. M. (2007). Atioxidant activity of cerrado fruits. Ciência e Tecnologia de Alimentos, 27(1), 53-60.

Rufino, M. S. M., Fernandes, F. A. N., Alves, R. E., and Brito, E. S. (2009). Free radical-scavenging behavior of some North-east Brazilian fruits in DPPH system. Food Chemistry, 114 , 693–695.

Rufino, M. S. M., Alves, R. E., Pérez--Jiménez, J., Saura Calixto, F., Brito, E. S., Mancini-Filho, J. (2010). Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. Food Chemistry, 121(4), 996–1002.

Sellappan, S., Akoh,C. C., e Krewer, G. (2002). Phenolic compounds and antioxidant capacity of Georgia-grown blueberries and blackberries. Journal of Agricultural and Food Chemistry, 50, 2432 - 2438.

Singleton, V. L. & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents. American Journal Enology and Viticulture, 16, 144-168.

Souza, C. N. (2007) Características físicas, físico-químicas e químicas de três tipos de Jenipapos (Genipa americana L.). 58p. Dissertação de mestrado. Universidade Estadual de Santa Cruz – Ilhéus, BA.

Tiburski, J. H., Rosenthal, A., Deliza, R., Godoy, R. L. De O., Pacheco, S. (2011). Nutritional properties of yellow mombin (Spondias mombin L.) pulp. Food Research International, 44, 2326 – 2331.

Zheng, Y., Wang, S. Y., Wang, C. H., & Zheng, W. (2007). Changes in strawberry phenolics, anthocyanins, and antioxidant capacity in response to high oxygen treatments. Food Science and Technology, 40, 49 - 57.