



Proximate composition of guariroba (*Syagrus oleracea*), jervivá (*Syagrus romanzoffiana*) and macaúba (*Acrocomia aculeata*) palm fruits

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ABSTRACT

This study aimed to characterize the pulp and kernel of guariroba (*Syagrus oleracea*), jervivá (*Syagrus romanzoffiana*) and macaúba (*Acrocomia aculeata*) palm fruits, through their proximate composition, carotenoids contents and tocopherol composition. The three kernels showed to be composed mainly of lipids and proteins, as the three pulps, of carbohydrate and fiber. In the kernels the levels of lipids ranged from 45.17 to 56.37% and proteins from 15.46 to 28.61%. In the pulps the total fiber content ranged from 20.26 to 26.98%. The pulps also presented a significant amount of ash, which represents a significant mineral content, especially in the guariroba (5.16%). Moreover, the pulp oils showed higher carotenoids and tocopherol contents. The jervivá pulp oil contained carotenoid and tocopherol on average 1219 µg/g and 323.50 mg/kg, respectively. The consumption of the whole fruit, pulp, and kernel supplies important quantities of many necessary nutrients for human diet, including vitamins A and E.

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1. Introduction

Nutritional composition knowledge of food consumed in Brazil is essential to assess nutrient availability, and develop researches in agricultural and food industry planning, among others. However, there still exists a great variety of little consumed and studied foods, mainly of vegetable origin, which should be better characterized, as they may be a rich source of macro- and micronutrients, or bioactive compounds (Center for Studies and Research in Food, 2004).

The palms represent the major symbols of tropical forests. This is because most of the existing species occur exclusively in the tropics, representing one of the largest families of plants, both in wealth and abundance, occupying almost all habitats. In Brazil, 119 species are distributed, belonging to 39 genres (Donatti, 2004).

The guariroba is a palm distributed in the states of Minas Gerais, Goiás, Mato Grosso and São Paulo. Its palm heart, known for its bitter taste, is quite appreciated. Its commercial exploitation has intensified in recent years, with the advent of commercial plantations for fresh and industrial consumption (Carneiro, Rolim, & Fernandes, 2003). The fruit occurs in greenish-yellow clusters, with a white edible oleaginous

kernel. The oil extracted from this nut can also be used in the soap production, due to its high lipid content (Bora & Moreira, 2003).

The jervivá palm belongs to the *Palmae* family and it is distributed in Brazil from the south of Bahia, Espírito Santo, Minas Gerais and São Paulo to Rio Grande do Sul and Mato Grosso do Sul (Lorenzi, 2000). The oval yellow fruit has only 3 cm in its widest part. The outer part, fleshy, is composed of sweet mucilage really appreciated by some animals such as parrots, or even by humans. Internally, it has a small kernel which is very similar to that of coconut.

The macaúba is a common species of palm tree found from Pará to São Paulo and Mato Grosso do Sul. It presents an edible kernel that can be consumed fresh or as sweet, in the form of crushed peanut candy and coconut candy. From kernels, it is also possible to obtain a clear and colorless oil, used in cooking instead of olive oil. The pulp can also be eaten fresh, cooked, in ice creams or in recipes such as biscuits and cakes.

Few studies are related to the characterization of fruits of these three species of palms. Bora and Moreira (2003) studied the fatty and amino acids composition of guariroba palm, but no information about carotenoids and tocopherols composition. Vallilo, Tavares, Aued-Pimentel, Garbelotti, & Campos (2001) reported the centesimal composition, fatty acids profile and the minerals of four tropical palms, including jervivá, but just the fruit kernels were analyzed. Ramos, Ramos Filho, Hiane, Braga Neto, and Siqueira (2008) determined the centesimal composition and main carotenoids of the pulp of macaúba, but they have not studied the macaúba kernels.

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Thus, the detailed study of the proximate composition of the pulp and kernel of guariroba, jervá and macaúba fruits will contribute to the generation of data that can be used in tables of chemical composition of foods, as well as a better dietary guidance. In this sense, the aim of the present study was to evaluate the proximal composition of guariroba (*Syagrus oleracea*), jervá (*Syagrus romanzoffiana*) and macaúba (*Acrocomia aculeata*) pulps and kernels.

2. Materials and methods

2.1. Materials

The guariroba, jervá and macaúba fruits were from the Southeast and Midwest regions. Three batches of each fruit were collected from the 2008/2009 harvest. The three batches of guariroba fruits were from São José do Rio Preto and Santa Fé do Sul cities, in São José state, and from Frutal city, in Minas Gerais state, and they were collected between October 2008 and January 2009. The three batches of jervá fruits were collected in São José do Rio Preto, José Bonifácio and Santa Fé do Sul cities, in São Paulo state, between September 2008 and January 2009. The three batches of macaúba fruits were purchased in São José do Rio Preto, Meridiano and José Bonifácio cities, in São Paulo state, between November 2008 and January 2009.

All fruits were collected directly from the ground, and they were ripe, firm and had no injuries. Afterwards, the selected fruits were slightly washed with distilled water to remove the waste. Whole fruits were immediately dried in a forced air circulation oven at 40 °C for 3 h. After this previous drying, the pulp was separated from the stone of the fruits using a stainless steel knife. Then, the pulp and stone were again dried in a forced air circulation oven at 40 °C until they reached a less than 10% moisture percentage, which is recommended for the oil extraction and better raw material conservation (Schwartzberg, 1987). The kernel was not separated from the stone, which was removed only at the time of the analysis, with the aid of a vise. For all pulps and kernels, the three batches were homogenized and stored in sealed recipients.

2.2. Methods

The pulp and kernel fruits were analyzed separately. The moisture was measured in a vacuum oven at 70 °C to a constant weight, according to Ca 2d-25 AOCS (1993). The protein level was determined by the Kjeldahl method, according to AOAC 984.13 (1995). The ash was determined by calcination at 550 °C, according to the method Ba 5a-49 AOCS (1993). Lipids were extracted in Soxhlet apparatus with petroleum ether at 40–60 °C, according to the method 3 75 Ai AOCS (1993). Total fibers were determined according to the method of Prosky et al. (1985) proposed by AOAC 991.43 (1995) and carbohydrates, by difference.

The oils used in the analysis were obtained from the pulps and kernels, separately, by extraction with petroleum ether at 40–60 °C in Soxhlet apparatus. The levels of total carotenoids was measured spectrophotometrically, using the method described by Rodríguez-Amaya (1999) for the extraction of carotenoids, quantification was calculated using the absorption in the wavelength of maximum absorption and A value (specific absorbance coefficient) of 2592 in petroleum ether.

Tocopherols composition was determined according to AOCS Ce 8-86 (1998). The analysis was performed in the Varian high-performance liquid chromatography (HPLC), model 210, with fluorescence detection, silica column 250 × 4.6 mm with pore of 5 µm, a flow of 1.2 mL/min, an excitation wave length of 290 nm, an emission wave length of 330 nm, and as mobile phase the mixture of 99.5% of n-hexan and 0.5% of isopropanol.

2.3. Statistical analysis

The results of the analytical determinations, in triplicate, were subjected to analysis of variance and differences between means were tested at 5% probability by Tukey's test, through the ESTAT program, version 2.0.

3. Results and discussion

Table 1 shows the mean and standard deviation for the data of proximate composition of the pulp and kernel fruits.

Among the oil sources, the pulps moisture was significantly higher than that of kernel. Among kernels, macaúba had the highest moisture content, followed by guariroba and jervá. For pulps, the one with the highest moisture content was the guariroba.

The protein content present in kernels was significantly higher than in the pulps, showing that the kernels of all species are rich sources of protein and the highest content was found in macaúba kernel. The pulps showed lower amount of this nutrient and the lowest result was obtained by the jervá pulp. However, the guariroba pulp deserves further attention, with a relatively high protein percentage, especially when compared to the other pulps examined.

Souza and Menezes (2004) analyzed the quality parameters of Brazil nut and found a protein content of 14.29% in this kernel. In a study on the proximate composition of pequi pulp and kernel, Lima, Silva, Trindade, Torres, and Mancini-Filho (2007) found protein content of 3.00% in the pulp and 25.27% in kernel. Just as in the present study, the pequi showed the highest concentration of protein in the kernel rather than in the fruit pulp.

Regarding the ash content, once again there was a significant difference between the amounts found in the pulp and kernels. In this case, the ash content was significantly higher in pulps than in kernels. Among species, there was also a significant difference. The guariroba pulp showed the greatest percentage of ash. Nevertheless, its kernel has the lowest percentage among the samples. As the ash content indicates the amount of minerals that the sample has, then, it is

Table 1
Proximate composition of pulps and kernels from guariroba, jervá and macaúba fruits (%).

Sources	Species		
	Guariroba	Jervá	Macaúba
<i>Moisture</i>			
Pulp	8.71 ± 0.07 ^{aA}	7.75 ± 0.13 ^{bA}	5.98 ± 0.15 ^{cA}
Kernel	4.83 ± 0.03 ^{bB}	3.94 ± 0.06 ^{cB}	4.97 ± 0.07 ^{aB}
<i>Proteins</i>			
Pulp	11.59 ± 0.39 ^{aB}	5.41 ± 0.10 ^{cB}	6.72 ± 0.45 ^{bB}
Kernel	15.46 ± 0.30 ^{cA}	23.98 ± 0.51 ^{bA}	28.61 ± 0.27 ^{aA}
<i>Ash</i>			
Pulp	5.16 ± 0.06 ^{aA}	3.21 ± 0.02 ^{bA}	2.17 ± 0.02 ^{cA}
Kernel	1.52 ± 0.06 ^{cB}	1.72 ± 0.05 ^{bB}	2.08 ± 0.03 ^{aB}
<i>Lipids</i>			
Pulp	13.60 ± 0.19 ^{bB}	7.48 ± 0.36 ^{cB}	28.94 ± 0.83 ^{aB}
Kernel	45.17 ± 0.49 ^{bA}	56.37 ± 0.34 ^{aA}	46.06 ± 0.54 ^{bA}
<i>Total fibers</i>			
Pulp	20.64 ± 0.02 ^{bA}	26.98 ± 0.00 ^{aA}	20.26 ± 0.28 ^{cA}
Kernel	12.46 ± 0.28 ^{aB}	10.99 ± 0.46 ^{bB}	12.49 ± 0.11 ^{aB}
<i>Carbohydrates</i>			
Pulp	40.32 ± 0.15	49.20 ± 0.12	36.22 ± 0.35
Kernel	20.60 ± 0.23	3.01 ± 0.28	5.81 ± 0.20

The results represent the mean ± standard deviation of the analysis performed in triplicate.

a, b... (line)—means followed by the same letter do not differ by Tukey test ($p < 0.05$). A, B... (column)—means followed by the same capital letter do not differ by Tukey test ($p < 0.05$).

possible to suggest that the pulp fruits in the present study are important sources of these micronutrients.

It can be inferred that the quantity of lipids differs in each species of fruit. Considering the sources of oil, kernels had lipid content significantly higher than that of pulps. All kernels studied showed important sources of lipids for food with more than 45% of this macronutrient. The jervá kernel should be highlighted due to the highest lipid content. However, although lower than the value obtained by kernels, macaúba pulp also displayed a significant amount of lipids, 28.94%, the largest of the analyzed pulps.

In a study on pequi (*Caryocar brasiliense*, Camb.), Lima et al. (2007) found lipid content of 33.40% in the pulp and 51.51% in kernel, indicating that, as well as the present work, the fruit kernels are richer in lipid content than pulps.

Table 1 shows that both the fruit pulps and kernels proved to be important total dietary fiber source and the fruit pulps have fiber content higher than that of kernels. Among the pulps, which obtained the highest percentage of fibers was jervá, followed by guariroba and macaúba, both with around 20%. For the kernels, the highest fiber content was obtained by guariroba and macaúba kernels, with about 12% each, followed by jervá kernel, with 10.99%.

The consumption of 100 g of jervá pulp offers the total amount of fiber consumption indicated per day, which is about 25 g (Brazil, 2003). The guariroba and macaúba pulps account for approximately 80%, while the consumption of 100 g of each kernel is around 45% of daily needs. This shows that the consumption of the analyzed fruit's pulps and kernels may benefit people's health, since the regular consumption of dietary fiber in the diet is related to a reduced risk of several pathologies (Michels et al., 2005). The lower intake of fiber and fiber-containing foods has refocused the food industry on the benefits of incorporating different fibers in the foodstuff (Rosell, Santos, & Collar, 2009).

Pulps presented much higher carbohydrate contents than kernels, being important suppliers of this macronutrient when included in the diet. Among the pulps, which obtained the highest total carbohydrate content was jervá, and the one with lower content was macaúba. Among the kernels, the carbohydrate content was higher in guariroba, while the lowest in jervá kernel.

Both the studied fruits pulps and kernels may be important when it comes to energy intake, once included in the diet. Using a conversion factor of 4 kcal/g for protein and carbohydrate and 9 kcal/g for lipids, it was possible to estimate the caloric value of the pulps and kernels. Thus, the calorie amount was higher in jervá, macaúba and guariroba kernels, which had about 615, 552 and 550 kcal/100 g, respectively. In macaúba guariroba and jervá pulps, the amount of calories was 432, 330 and 285 kcal/100 g, respectively.

The consumption of the whole fruit, pulp and kernel, supplies a significant amount of all necessary nutrients for human diet, and a high amount of calories. Clearly, further studies should be conducted with this potential food source, especially regarding toxic and antinutritional factors.

The mean and standard deviations for the data of carotenoids and tocopherols present in oils extracted from the fruits are presented in Table 2.

The amount of total carotenoids, expressed as β -carotene, was significantly higher in the pulp oils than in the kernels. Among the pulps, jervá had an amount four times greater than the macaúba pulp oil and seven times higher than the guariroba. Visually, the jervá pulp oil presented a dark orange color, while the macaúba and guariroba oils showed a yellow shade. Among the kernels, jervá oil also had the highest carotenoid level, followed by macaúba kernel oil and guariroba. Visually, the three kernel oils showed no difference in coloring.

By comparison, other studies have found a β -carotene content of 62 $\mu\text{g/g}$ in carrots (Niizu & Rodriguez-Amaya, 2005), 40 $\mu\text{g/g}$ in melons (Casagrande & Kimura, 2006) and 57 $\mu\text{g/g}$ in pumpkins

Table 2

Carotenoid and tocopherol content in pulps and kernels from guariroba, jervá and macaúba fruits.

Oil source	Species		
	Guariroba	Jervá	Macaúba
<i>Total carotenoids ($\mu\text{g/g}$)</i>			
Pulp	158.44 \pm 4.69 ^{CA}	1219.01 \pm 16.21 ^{AA}	300.01 \pm 2.29 ^{BA}
Kernel	0.81 \pm 0.02 ^{CB}	2.16 \pm 0.01 ^{AB}	1.82 \pm 0.04 ^{BB}
<i>Total tocopherols (mg/kg)</i>			
Pulp	45.13 \pm 2.65 ^{CA}	323.50 \pm 7.85 ^{AA}	212.95 \pm 0.64 ^{BA}
Kernel	19.70 \pm 0.42 ^{BB}	19.75 \pm 1.06 ^{BB}	23.10 \pm 0.01 ^{AB}
<i>α-tocopherol (mg/kg)</i>			
Pulp	36.33 \pm 2.45 ^{CA}	273.53 \pm 4.79 ^{AA}	143.70 \pm 1.13 ^{BA}
Kernel	11.90 \pm 0.28 ^{BB}	11.05 \pm 1.20 ^{BB}	14.35 \pm 0.07 ^{AB}
<i>β-tocopherol (mg/kg)</i>			
Pulp	0.97 \pm 0.21 ^{CA}	36.43 \pm 3.30 ^{AA}	3.25 \pm 0.21 ^{BA}
Kernel	nd	0.95 \pm 0.07 ^{AB}	0.85 \pm 0.07 ^{BB}
<i>γ-tocopherol (mg/kg)</i>			
Pulp	nd	5.47 \pm 0.40 ^b	57.85 \pm 0.35 ^a
Kernel	nd	nd	nd
<i>δ-tocopherol (mg/kg)</i>			
Pulp	7.83 \pm 0.06 ^{BA}	8.07 \pm 0.31 ^{AA}	8.15 \pm 0.07 ^{AA}
Kernel	7.80 \pm 0.14 ^{AA}	7.75 \pm 0.07 ^{AA}	7.90 \pm 0.00 ^{AA}

The results represent the mean \pm standard deviation of the analysis performed in triplicate.

a, b... (line)—means followed by the same letter do not differ by Tukey test ($p < 0.05$). A, B... (column)—means followed by the same capital letter do not differ by Tukey test ($p < 0.05$).

nd—not detected ($< 0.10\%$).

(Azevedo-Meleiro & Rodriguez-Amaya, 2005), values close to the levels of β -carotene found in macaúba.

Important health benefits have been attributed to the carotenoids. Some carotenoids, such as β -carotene, are capable of being converted to vitamin A, thereby they play an important nutritional role. Research shows that consumption of foods rich in pro-vitamin A carotenoids can supply significant vitamin A amounts in animals and humans (Siqueira, Arruda, Vargas, & Souza, 2007). Moreover, both the pro- and non-pro-vitamin A carotenoids can act as antioxidants against cardiovascular conditions, certain cancers, neurological disorders, strengthen the immune system, macular degeneration related to age and cataracts, in gene activation and inflammatory processes, by modulating the lipoygenase (Gama & Sylos, 2007).

It must be considered not only in bioactive compounds concentration in food, but also its bioavailability. Researches show that the β -carotene from the macaúba pulp is highly bioavailable, when compared to pure β -carotene, and in the case of oil consumption, this further increases bioavailability (Ramos, Siqueira, Isomura, Barbosa, & Arruda, 2007).

In addition to carotenoids, tocopherols also have an antioxidant activity, which was verified both in vivo and in vitro. In vegetable oils, tocopherols act protecting the unsaturated fatty acids from lipid oxidation. Besides, in the human body they exhibit biological activity of vitamin E (Ching & Mohamed, 2001).

The oils extracted from three pulps showed the total tocopherol amount significantly higher than the oils from kernels. The pulp oil with the highest tocopherol content was the jervá (323.50 mg/kg), followed by macaúba (212.95 mg/kg) and guariroba (45.13 mg/kg). As for the kernels, macaúba oil had the highest total tocopherol content (23.10 mg/kg), followed by jervá and guariroba, both with about 19 mg/kg.

The α -tocopherol was predominant in all oils analyzed, representing in the jervá and guariroba pulp oils about 80% of total tocopherols and in macaúba pulp oil about 67%. In the kernel oils, the α -tocopherol accounted for approximately 60% of total tocopherols. α -tocopherol is

the most common form of vitamin E, presenting the highest activity (100%). Besides α -tocopherol, δ -tocopherol was also present in all oils tested, at concentrations of about 8 mg/kg. For all kernel oils and for guariroba pulp oil, this was the second predominant isomer, representing about 35% of the total tocopherols in the kernels and 17% in the guariroba pulp. While α -tocopherol presented the highest vitamin E activity, γ - and δ -tocopherol have higher antioxidant activity (Schmidt & Pokorný, 2005).

4. Conclusions

The pulps and kernels of guariroba, jervá and macaúba were quite different in their proximate composition. The high fiber content indicates that the studied pulps and kernels have the potential to be used in the formulation of bakery products to enrich their texture, flavor and nutritional value.

Concerning the bioactive compounds, pulp oils showed to be richer in carotenoids and tocopherols. Jervá and macaúba pulp oils showed considerable carotenoid and tocopherol amounts, especially α -tocopherol, thus representing an important source of vitamins A and E. Since analyzed fruits are still little used for consumption, tests on toxicity and antinutritional factors should be provided in future studies.

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References

- AOAC (1995). Official and Tentative Methods of the AOAC International. Maryland.
- AOCS (1993). Official Methods and Recommended Practices of the American Oil Chemists Society. Champaign.
- Azevedo-Meleiro, C. H., & Rodriguez-Amaya, D. B. (2005). Carotenoid composition of kale as influenced by maturity, season and minimal processing. *Journal of the Science of Food and Agriculture*, 85, 591–597.
- Bora, P. S., & Moreira, R. V. R. (2003). Catolé palm (*Syagrus oleracea* Mart) fruits: Fatty and amino acids composition. *Grasas y Aceites*, 54, 145–150.
- Brazil (2003). Dispõe regulamento técnico sobre a rotulagem de alimentos embalados, tornando obrigatória a rotulagem nutricional. Brasília: Diário Oficial da União.
- Carneiro, C. E. A., Rolim, H. V. M., & Fernandes, K. F. (2003). Procedimento eficiente na inibição do escurecimento de guariroba (*Syagrus oleracea*, Becc) durante processamento e armazenamento. *Acta Scientiarum. Agronomy*, 25, 253–258.
- Casagrande, M. C. R., & Kimura, M. (2006). *Carotenoid composition of melon*. World Congress of Food Science and technology-IUFoST. Nantes: França.
- Center for Studies and Research in Food (2004). Tabela brasileira de composição de alimentos. Campinas: NEPA/ UNICAMP.
- Ching, L. S., & Mohamed, S. (2001). Alpha-tocopherol content in 62 edible tropical plants. *Journal of Agricultural and Food Chemistry*, 49, 3101–3105.
- C. I. Donatti, (2004). Consequências da defaunação na dispersão de sementes e no recrutamento de plântulas da palmeira brejaúva (*Astrocaryum aculeatissimum*) na Mata Atlântica. Dissertação de Mestrado. Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo.
- Gama, J. J. T., & Sylos, C. M. (2007). Effect of thermal pasteurization and concentration on carotenoid composition of Brazilian Valencia orange juice. *Food Chemistry*, 100, 1686–1690.
- Lima, A., Silva, A. M. O., Trindade, R. A., Torres, R. P., & Mancini-Filho, J. (2007). Composição química e compostos bioativos presentes na polpa e amêndoa do pequi (*Caryocar brasiliense*, Camb.). *Revista Brasileira de Fruticultura*, 29, 695–698.
- Lorenzi, H. (2000). *Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil*. Instituto Plantarum. São Paulo: Nova Odessa.
- Michels, K. B., Fuchs, C. S., Giovannucci, E., Colditz, G. A., Hunter, D. J., Stampfer, M. J., et al. (2005). Fiber intake and incidence of colorectal cancer among 76,947 women and 47,279 men. *Cancer Epidemiology, Biomarkers & Prevention*, 14, 842–849.
- Niizu, P. Y., & Rodriguez-Amaya, D. B. (2005). New data on the carotenoid composition of raw salad vegetables. *Journal of Food Composition and Analysis*, 18, 739–749.
- Prosky, L., Asp, N. G., Furda, I., De Vries, J. W., Schweizer, T. F., & Harland, B. (1985). The determination of total dietary fiber in foods, food products: Collaboratory study. *Journal - Association of Official Analytical Chemists*, 68, 677–679.
- Ramos, M. I., Ramos Filho, M. M., Hiane, P. A., Braga Neto, J. A., & Siqueira, E. M. A. (2008). Qualidade nutricional da polpa de bocaiúva *Acrocomia aculeata* (Jacq.) Lodd. *Ciência e Tecnologia de Alimentos*, 28, 1–5.
- Ramos, M. I., Siqueira, E. M. A., Isomura, C. C., Barbosa, A. M. J., & Arruda, S. F. (2007). Bocaiuva (*Acrocomia aculeata* (Jacq.) Lodd) improved vitamin A status in rats. *Journal of Agricultural and Food Chemistry*, 55, 3186–3190.
- Rodriguez-Amaya, D. B. (1999). A guide to carotenoids analysis in food. Washington: ILSI Press.
- Rosell, C. M., Santos, E., & Collar, C. (2009). Physico-chemical properties of commercial fibers from different sources: A comparative approach. *Food Research International*, 42, 176–184.
- Schmidt, S., & Pokorný, J. (2005). Potential application of oilseeds as sources of antioxidants for food lipids—a review. *Czech Journal of Food Science*, 23, 93–102.
- Schwartzberg, H. G. (1987). Leaching-organic material. In R. Rosseau (Ed.), *Handbook of Separation Process Technology* (pp. 540–577). New York: J. Wiley.
- Siqueira, E. M. A., Arruda, S. F., Vargas, R. M., & Souza, E. M. (2007). β -Carotene from cassava (*Manihot esculenta* Crantz) leaves improves vitamin A status in rats. *Comparative Biochemistry and Physiology. C: Toxicology & Pharmacology*, 146, 235–240.
- Souza, M. L., & Menezes, H. C. (2004). Processamentos de amêndoa e torta de castanha-do-Brasil e farinha de mandioca: parâmetros de qualidade. *Ciência e Tecnologia de Alimentos*, 24, 120–128.
- Vallilo, M. I., Tavares, M., Aued-Pimentel, S., Garbelotti, M. L., & Campos, N. C. (2001). Composição química e o perfil de ácidos graxos das sementes de quatro espécies de palmeiras cultivadas no estado de São Paulo. *Revista do Instituto Florestal*, 13, 147–154.