UR Uningá Review

Uningá Review, v. 36, eURJ3953, 2021
doi.org/10.46311/2178-2571.36.eURJ3953

ISSN 2178-2571

Agrarian Sciences and Environment

COMPARISON OF PHENOLIC AND FLAVONOIDS CONCENTRATIONS AND THE PRICE OF NATIVE AND EXOTIC FRUITS FROM THE NORTHEAST OF BRAZIL

COMPARAÇÃO ENTRE A CONCENTRAÇÃO DE COMPOSTOS FENÓLICOS E FLAVONOIDES COM O PREÇO DE FRUTAS NATIVAS E EXÓTICAS DO NORDESTE BRASILEIRO

Daywison Silva Rodrigues **Gamboa**, João Ricardhis Saturnino de **Oliveira**, Vera Lucia de Menezes **Lima***

Universidade Federal de Pernambuco, Recife, PE, Brasil.
*lima.vera.ufpe@gmail.com

ABSTRACT

Brazilian flora has great diversity, and the fruit market represents an activity of great economic importance for the country. Ingestion of phenolic compounds, derived from fruits, is associated with various types of benefits, and pathological prevention. In this sense, the present study made the price survey and the literature review on the phenolic and flavonoids content in six native fruits (cashew, seriguela, umbu, juá, cajá and pitomba) and in eight exotic fruits (acerola, star fruit, coconut, breadfruit, soursop, custard apple, sapodilla, tamarind) to the Brazilian Northeast. The survey was based on the evaluation of prices published on digital platforms of Northeastern Food Centers and the concentrations of total phenols and flavonoids were obtained through literature review. No statistical difference was observed between the mean concentration values of total phenolic compounds and flavonoids in native and exotic fruits, but a difference close to R$ 2.00 was observed between the average price of native and exotic fruits, being natives the cheapest ones. Thus, native fruits are a source of lower cost and have the same nutritional value of flavonoids and total phenols of exotic fruits. However, there is a market and buyer preference for exotic fruits for production and taste reasons.

Keywords: Flavonoids. Native fruits. Phenolic species.

RESUMO

A flora brasileira apresenta uma grande diversidade, e o mercado de frutas representa uma atividade de grande importância econômica para o país. A ingestão de compostos fenólicos, oriundos de frutas, está associada a vários efeitos benéficos e prevenção de condições patológicas. O presente estudo consiste em uma revisão crítica sobre o teor de compostos fenólicos totais e flavonoides em relação ao preço de mercado de seis frutas nativas (caju, seriguela, umbu, juá, cajá e pitomba) e em oito frutas exóticas (acerola, carambola, coco, fruta-pão, graviola, pinha, sapoti, tamarindo) ao Nordeste brasileiro. O levantamento foi realizado a partir de avaliação dos preços divulgados nas plataformas digitais dos Centros de Abastecimento de Alimentos dos estados nordestinos e as concentrações de fenóis totais e flavonoides foram obtidas através de levantamento bibliográfico em bases de dados. Diferenças significativas não foram observadas entre as concentrações médias de compostos fenólicos em frutas nativas e exóticas. Da mesma forma, o teor de flavonoides não apresentou diferença significativa entre os dois grupos. Contudo, foi observado a diferença de aproximadamente R$2,00 entre o preço médio das frutas nativas e exóticas, sendo atribuído menor preço às frutas nativas. Desse modo, as frutas nativas se mostram como fonte de menor custo e com o mesmo valor nutricional em flavonoides e fenóis totais das frutas exóticas avaliadas. No entanto, embora mais dispendiosas, há uma preferência do mercado pela aquisição de frutas exóticas por questões de produção e sabor.

Palavras-chave: Compostos fenólicos. Flavonoides. Frutas nativas.

INTRODUCTION

The Brazilian flora is characterized by a great biodiversity, allowing for several possibilities of exploring its resources, such as the search for new agents with therapeutic potential and the trade of fruit-growing products. An activity of great economic importance in Brazil is the fruit market, having been considered the world's largest producer of fruit in the last decade, with an average production of 43.6 million tons (NEGRI; BERNI; BRAZACA, 2017).

The Northeast region has a good performance for fruit production, in 2014 it accounted for 27% of all national fruit production, in addition to generating 25,191 employment contracts in 2015. About 60% of the Northeastern production is consumed in the Brazilian domestic market and the rest is exported, which favored the generation of an area of 2 million hectares cultivated for this purpose (VIDAL; XIMENES, 2016).

With a large territorial extension and different climatic conditions, the Northeast has the potential for the development of a diversified fruit culture, as it has exotic species, introduced by human actions (voluntary or involuntary) and native species, which are still being produced on a large scale (LEÃO, 2011; VIDAL; XIMENES, 2016).

Despite having a vast native flora, tropical fruits originating in the Antilles or the Caribbean, such as acerola and mango, occupy a prominent position in the Brazilian market when compared to native fruits (SOUZA *et al.*, 2015). Native fruits such as pitanga and cashew nut present, respectively, an annual production of 1,500 and 35 thousand tons, contrasting with the annual production of mango and banana with, respectively, 133 and 130 thousand tons (LOPES; OLIVEIRA; SILVA, 2009; NEGRI; BERNI; BRAZACA, 2017).

It is recommended, both by the Food Guide for the Brazilian population, and by the World Health Organization (WHO), the daily consumption of 400g of fruits and vegetables (WHO, 2002; BRASIL, 2014; NEGRI; BERNI; BRAZACA, 2017). Problems with nutritional deficiency still exist in the Brazilian population, having as main cause the misuse or deficiency of food, in which the consumption of fruits is one of the ways to prevent this condition (MINISTÉRIO DA SAÚDE, 2002). In addition to the presence of nutrients and fiber, fruit consumption is also beneficial due to the presence of compounds from the secondary metabolism of plants, such as phenolic compounds (RUFINO, 2008; MAQSOOD *et al.*, 2020).

Produced by practically all higher plants via shikimic acid, the phenolic compounds are characterized by structurally having one or more hydroxyls directly linked to an aromatic ring, and may vary from simple molecules to polymers (SINGH *et al.*, 2017). Within the phenolic compounds there are flavonoids, which are groups of polyphenols characterized by their structure, being subdivided into flavonols, flavones, flavanones, flavan-3-ols, anthocyanidins and isoflavones (GANDHI *et al.*, 2018). These metabolites have several biological activities, such as antioxidante (RUFINO, 2008), imunomodulatory (TALHAOUI *et al.*, 2016; JARGER; PARYLAK; GAGE, 2018), antiinflamatory (OTEIZA *et al.*, 2018), gastroprotector (YOUSEFIAN *et al.*, 2018) and antimicrobial (SANTOS *et al.*, 2015; SILVA *et al.*, 2016).

The intake of phenolic compounds in the diet is also associated with the prevention of high blood pressure due to the reduction of reactive oxygen species (SPAGNUOLO; MOCCIA; RUSSO, 2018), improvement of cognition and prevention of neurodegenerative disorders (YANG *et al.*, 2018), cancer prevention through interaction with cell receptors (WANG; LI; BI, 2018) is associated with an improvement in the lipid profile (GANDHI *et al.*, 2018; DINDA *et al.*, 2019) and protection against Alzheimer disease (COSTA *et al.*, 2016). In this sense, the work aimed to survey the price and critically review the amount of total phenolic compounds and flavonoids of native and exotic fruits from the Brazilian Northeast.

MATERIAL AND METHODS

Study design and fruit selection

This is a cross-sectional study on the price of native and exotic fruits from Northeastern Brazil, and a critical analysis of the content of phenolic compounds and flavonoids reported in the scientific literature. The selected fruits are the most found in the supply centers of the Brazilian states, and were divided into native and exotic according to the literature. *Spondias purpurea* (seriguela) (NEGRI; BERNI; BRAZACA, 2017; *Ziziphus joazeiro* (juá) (NEGRI; BERNI; BRAZACA, 2017); *Anacardium occidentale* (caju) (RUFINO, 2008); *Talisia esculenta* (pitomba) (FLORA DO BRASIL, 2020); *Spondias tuberosa* (umbu) (MENDES, 2015) and *Spondias mombin* (cajá) (FLORA DO BRASIL, 2020) have been reported as natives. *Malpighia emarginata* (acerola) (NEGRI; BERNI; BRAZACA, 2017); *Averrhoa carambola* (carambola) (MINISTÉRIO DA SAÚDE, 2002); *Annona muricata* (graviola) (MINISTÉRIO DA SAÚDE, 2002); *Manilkara zapota* (sapoti) (RUFINO, 2008); *Tamarindus indica* (tamarindo) (FLORA DO BRASIL, 2020); *Annona squamosa* (pinha) (FLORA DO BRASIL, 2020); *Cocos nucifera* (coco) (FLORA DO BRASIL, 2020) and *Artocarpus altilis* (fruta-pão) (SOARES *et al.*, 2015) have been reported as exotics.

Fruit price analysis

The price per kilo of fruit was obtained from the variation of values during the two semesters of 2019 (January to June and July to December). For a list of values, the websites of the Food Supply Centers (CEASA) of the northeastern states of Brazil were consulted: Alagoas, Bahia, Paraíba, Pernambuco, Rio Grande do Norte e Sergipe (CEASA-BA, 2020; CEASA-PE, 2020; CEASA-RN, 2020; EMDAGR-SE, 2020; EMPASA, 2020; IDERAL, 2020).

Literature review

A bibliographic review of the levels of total phenolic compounds and flavonoids in the databases PubMed, Scielo, ScienceDirect, Bireme and Google Scholar was carried out to search for works that report concentrations of total phenols and flavonoids in the selected fruits for this study. Key words: flavonoids, total phenols, extract, fruit, pulp and fruit peel, in addition to the popular and scientific names of each fruit species. Complete articles were included, in any language, indicating the phenolic and/or flavonoid content of the fruit of the listed species. Papers showing the concentration of these secondary metabolites in tree trunk, leaves and roots were excluded. There was no restriction by year of publication.

Statistical analysis

Price, phenol content and flavonoid concentration data were compared, based on the mean and standard deviation of native and exotic groups, and analyzed by unpaired t-test in Prism 8.0 software (GraphPad, USA). Results with $p<0.05$ or 95% confidence interval were considered statistically significant.

RESULTS AND DISCUSSION

The highest concentrations of phenolic compounds in native fruits were observed for umbu, followed by cashew and seriguela, while seriguela and pitomba had the highest flavonoid values among the fruits of this group. Among the exotic fruits, acerola, carambola and coconut showed the highest proportion of total phenols, while carambola and coconut had the highest concentrations of flavonoids. The values of the contents of total phenolic compounds and flavonoids are shown in Table 1.

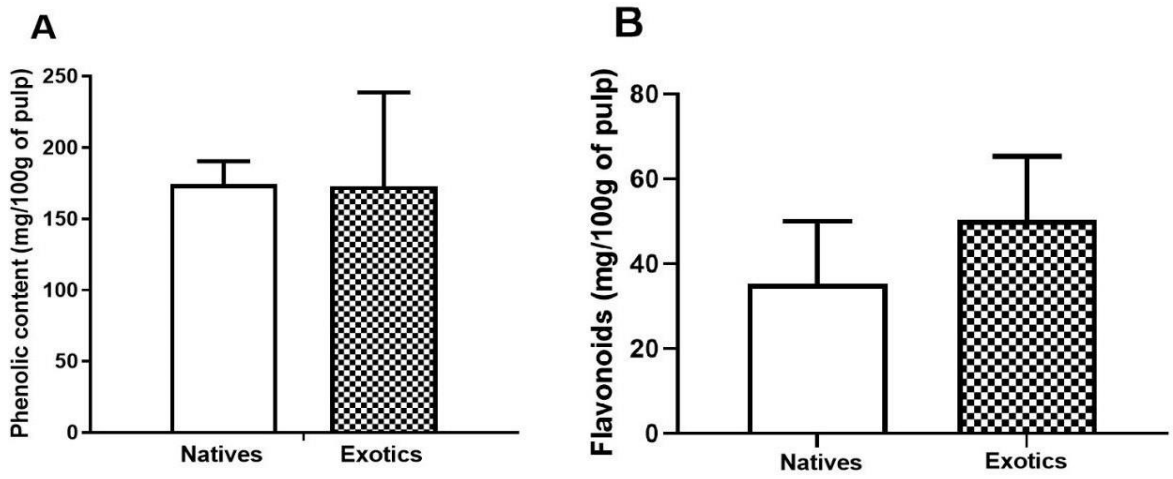
Table 1 - Concentrations of total phenolic compounds and flavonoids in native and exotic fruits in Northeastern Brazil

Popular Name	Scientific Name	Totat Phenols (mg/100g)	Total Flavonoids (mg/100g)	References
Natives				
Caja	*Spondias mombin*	134.22 ± 3.23 [a]	14.94 ± 0.25 [b]	(STAFUSSA *et al*., 2018)
Cashew	*Anacardium occidentale*	205.52 ± 2.95[a]	6.93 ± 0.13 [b]	(STAFUSSA *et al*., 2018)
Jua	*Ziziphus joazeiro*	126.60 ± 2.70 [a]	4.2 ± 0.6 [a]	(SOUZA *et al*., 2016)
Pitomba	*Talisia esculenta*	158.50 ± 3.81 [a]	95.78 ± 2.23 [b]	(STAFUSSA *et al.*, 2018)
Seriguela	*Spondias purpurea*	204.11 ± 6.36 [a]	61.74 ± 2.75 [b]	(STAFUSSA *et al.*, 2018)
Umbu	*Spondias tuberosa*	216.74 ± 2.30 [a]	27.64 ± 1.10 [b]	(STAFUSSA *et al.*, 2018)
Exotics				
Acerola	*Malpighia emarginata*	593.77 ± 10.16 [a]	29.09 ± 0.34 [b]	(STAFUSSA *et al*., 2018)
Carambola	*Averrhoa carambola*	220.78 ± 4.18 [a]	122.17 ± 2.00 [b]	(STAFUSSA *et al*., 2018)
Coconut	*Cocos nucifera*	171.10 ± 1.506 [a]	98.15 ± 7.48 [b]	(ZIELINSKI *et al.*, 2014)
Fruta-pão	*Artocarpus altilis*	3.71 [a]	NR	(BOAKYE; WIREKO; AGBENORHEV, 2014)
Soursop	*Annona muricata*	147.61 ± 3.71 [a]	46.10 ± 0.29 [b]	(STAFUSSA *et al.*, 2018)
Sugar apple	*Annona squamosa*	81.70 ± 4.00 [a]	88.00 [b]	(ALMEIDA *et al*., 2011; BHARDWAJ *et al*., 2014)
Sapoti	*Manilkara zapota*	15.35 ± 0.73 [a]	0.18 ± 0.14 [b]	(MOO-HUCHIN *et al*., 2014
Tamarindo	*Tamarindus indica*	148.77 ± 2.49 [a]	39.99 ± 0.82 [b]	(STAFUSSA *et al.*, 2018)

Notes: a: Gallic acid is the standard; b: Quercetin is the standard; NR: not reported.
Source: authors.

Comparing acerola with umbu, the fruits with the highest concentration of total phenols in each group, it is observed that the phenol content of acerola is about 174% higher than that of umbu. Although some exotic fruits, such as acerola, have high levels of total phenols, other fruits in this group have minimal amounts of phenolic compounds, such as sapodilla and breadfruit. The comparison between the mean concentration values of total phenolic compounds and total flavonoids in native and exotic fruits in Northeastern Brazil is shown in Figure 1. When the unpaired t-test was applied, native and exotic plants showed no significant difference. regarding the content of phenols and flavonoids. This shows the possibility of mixing native and exotic fruits at the table, without losing nutritional benefits.

Figure 1 - Comparison of the amount of total phenols and flavonoids in native and exotic fruits from Northeastern Brazil

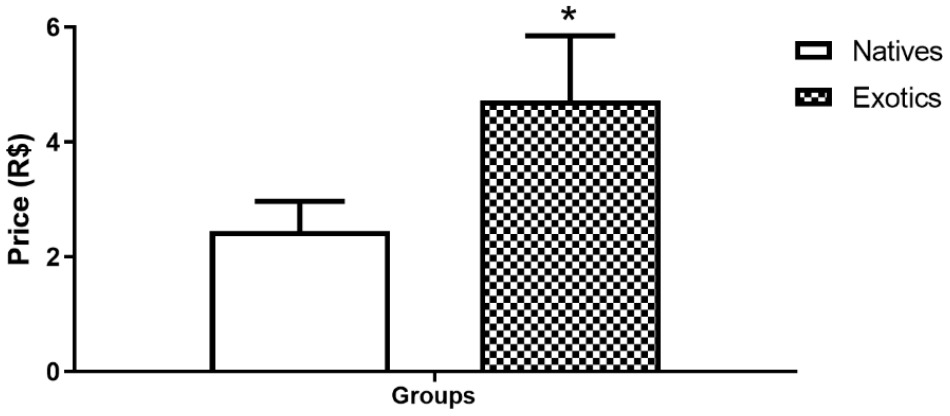


Notes: A: comparison between phenols concentrations; B: comparison between flavonoids concentrations. No statistical difference in non-parametric t-test ($p>0.05$).
Source: authors.

Although the groups do not differ significantly regarding the concentrations of total phenolic compounds and flavonoids, native fruits are cheaper than exotic fruits (Figure 2), around two reais. Thus, native fruits make it possible to consume the same amount of these metabolites, associated with several beneficial effects such as anti-inflammatory action (OTEIZA *et al.*, 2018); imunomodulatory (TALHAOUI *et al.*, 2016; JARGER; PARYLAK; GAGE, 2018); neuroprotector (SPAGNUOLO; MOCCIA; RUSSO, 2018) and preventor for cancer (WANG; LI; BI, 2018) and hypertension (YOUSEFIAN *et al.*, 2018), for a lesser price. Despite this, native fruits have low representation in the trade market (SOUZA *et al.*, 2015).

This difference between the consumption of native and exotic fruits can occur due to factors such as flavor, since fruits such as cajarana have been having a growing participation in agribusiness due to its exotic flavor, and soursop, which has great acceptance in the agribusiness due to to its pleasant flavor and aroma. Culinary preference is another factor, where exotic fruits such as pitanga and avocado, for example, are widely used as ingredients in numerous recipes (BRASIL, 2014).

Figure 2 - Price comparison between native and exotic fruits in Northeast Brazil



Notes: *$p<0.05$, non-parametric t-test.
Source: authors.

Other factors that can benefit exotic fruits are logistical issues, such as bananas, which can be found throughout the year and ripen slowly after being picked, which facilitates harvesting, transport

and increases the fruit's use; and adaptation, in which soursop, for example, finds ideal conditions for development in the climate and soil of coastal regions and in the semiarid region of the Northeast (BRASIL, 2014).

Few native fruits managed to stand out in the national market (SOUZA FILHO *et al.*, 2000). Some fruits native to the Brazilian Northeast (such as seriguela and cajá) have a pleasant texture, aroma and flavor, as well as could receive greater prominence if they were more studied and disseminated (SOUZA FILHO *et al.*, 2000). In addition, the low number of tropical species cultivated in Northeast Brazil that are available on the market may be related to the lack of knowledge about production and conservation systems (ALMEIDA, 2009).

CONCLUSION

Native fruits to the Brazilian Northeast have nutritional value of flavonoids and total phenols similar to exotic fruits, although the price and quantity of production are different. This is possibly due to a cultural, culinary and market preference for exotic fruits. Nutritional plans could include these fruits, for nutritional optimization and valorization of Brazilian products, with a reduction in the acquisition costs of these products.

ACKNOWLEDGEMENT

We acknowledge CAPES, CNPq and FACEPE.

REFERENCES

ALMEIDA, M. M. B. Avaliação de macro e microminerais em frutas tropicais cultivadas no nordeste brasileiro. **Ciência e Tecnologia de Alimentos**, v. 29, n. 3, p. 581-586, 2009.

ALMEIDA, M. M. B. *et al.* Bioactive compounds and antioxidant activity of fresh exotic fruits from northeastern Brazil. **Food Research International**, p. 44, n. 7, p. 2155-2159, 2011.

BHARDWAJ, A. *et al*. Preliminary screening of nutraceutical potential of *Annona squamosa*, an underutilized exotic fruit of India and its use as a valuable source in functional foods. **Journal of Pharmacognosy and Phytochemistry**, v. 3, n. 2, p. 172-180, 2014.

BOAKYE, A. A.; WIREKO, M. F. D.; AGBENORHEVI, J. K. Antioxidant activity, total phenols and phytochemical constituents of four underutilised tropical fruits. **International Food Research Journal**, v. 22, n. 1, p. 262-268, 2014.

BRASIL. Ministério da Saúde. Brasil **Guia alimentar para a população brasileira**. Brasília: Ministério da saúde. 2 ed., 2014.

CENTRO DE ABASTECIMENTO DE ALIMENTOS DO ESTADO DA BAHIA. **Ceasa Preços**. CEASA-BA, 2020.

CENTRO DE ABASTECIMENTO DE ALIMENTOS DO ESTADO DE PERNAMBUCO. **Cotações de Preços**. CEASA-PE, 2020.

CENTRO DE ABASTECIMENTO DE ALIMENTOS DO ESTADO DE RIO GRANDE DO NORTE. **Cotação de Preço**. CEASA-RN, 2020.

COORDENAÇÃO GERAL DE POLÍTICAS DE ALIMENTAÇÃO E NUTRIÇÃO. Secretaria de Políticas de Saúde, Ministério da Saúde. **Alimentos regionais brasileiros**. Brasília: Ministério da Saúde, 2002.

COORDENAÇÃO GERAL DE POLÍTICAS DE ALIMENTAÇÃO E NUTRIÇÃO. Secretaria de Políticas de Saúde, Ministério da Saúde. **Alimentos regionais brasileiros.** 2. ed. Brasília: Ministério da Saúde, 2015.

COSTA, S. L. *et al.* Impact of plant-derived flavonoids on neurodegenerative diseases. **Neurotoxicity research**, v. 30, n. 1, p. 41-52, 2016.

DINDA, B. *et al.* Dietary plant flavonoids in prevention of obesity and diabetes. **Advances in Protein Chemistry and Structural Biology**, v. 120, p. 1-77, 2019.

EMPRESA DE DESENVOLVIMENTO AGROPECUÁRIO DE SERGIPE. **Cotação**. EMDAGR, 2020.

EMPRESA PARAIBANA ABASTECIMENTO SERVICOS. **Cotações.** EMPASA, 2020.

GANDHI, G. R. *et al*. Flavonoids as Th1/Th2 cytokines immunomodulators: A systematic review of studies on animal models. **Phytomedicine**, v. 44, p. 74-84, 2018.

INSTITUTO DE DESENVOLVIMENTO RURAL E ABASTECIMENTO DE ALAGOAS. **Cotação de Preços**. IDERAL, 2021.

JARGER, B. N.; PARYLAK, S. L.; GAGE, F. H. Mechanisms of dietary flavonoid action in neuronal function and neuroinflammation. **Molecular Aspects of Medicine**, v. 61, p. 50-62, 2018.

LEÃO, T. C. C. *et al.* **Espécies exóticas invasoras no Nordeste do Brasil: contextualização, manejo e políticas públicas**. Centro de Pesquisas Ambientais do Nordeste e Instituto Hórus de Desenvolvimento e Conservação Ambiental. Recife: Cepan., 2011. 99 p.

LOPES, P. R. C.; OLIVEIRA, I. V. M.; SILVA, R. R. S. Avaliação do potencial de produção de frutas de clima temperado no Nordeste Brasileiro. In: **Embrapa Semiárido-Artigo em anais de congresso**. Semana internacional da fruticultura, floricultura e agroindústria; Instituto Frutal, 2009.

MAQSOOD, S. *et al.* Bioactive compounds from date fruit and seed as potential nutraceutical and functional food ingredients. **Food Chemistry**, v. 308, n. 5, p. 1-18, 2020.

MENDES, R. J. S. **Biodiversidade e composição de alimentos: dados nutricionais de frutas nativas subutilizadas da flora brasileira**. 2015. 111p. Dissertação (Mestrado em Ciências) - Universidade de São Paulo, São Paulo, 2015.

MOO-HUCHIN, V. M. *et al*. Determination of some physicochemical characteristics, bioactive compounds and antioxidant activity of tropical fruits from Yucatan, Mexico. **Food Chemistry**, v. 152, p. 508-515, 2014.

NEGRI, T. C.; BERNI, P.; BRAZACA, S. Valor nutricional de frutas nativas e exóticas do Brasil. **Biosaúde**, v. 18, n. 2, p. 82-96, 2017.

OTEIZA, P. I. *et al*. Flavonoids and the gastrointestinal tract: local and systemic effects. **Molecular Aspects of Medicine**. v. 61, p. 41-49, 2018.

REFLORA - FLORA DO BRASIL. ***Annona squamosa* L.**, 2020.

REFLORA - FLORA DO BRASIL. ***Cocos nucifera* L**., 2020.

REFLORA - FLORA DO BRASIL. ***Spondias mombin* L**., 2020.

REFLORA - FLORA DO BRASIL. ***Talisia esculenta***, 2020.

REFLORA - FLORA DO BRASIL. ***Tamarindus indica* L**., 2020.

RUFINO, M. S. M. **Propriedades funcionais de frutas tropicais brasileiras não tradicionais**. 2008. 237f. Tese (Doutorado em Agronomia) - Universidade Federal Rural do Semi-Árido, Mossoró, 2008.

SANTOS, A. T. B. *et al.* Organic extracts from *Indigofera suffruticosa* leaves have antimicrobial and synergic actions with erythromycin against *Staphylococcus aureus*. **Frontiers in Microbiology**, v. 6, p. 1-7, 2015.

SILVA, A. P. S. A. *et al*. Antimicrobial activity and phytochemical analysis of organic extracts from *Cleome spinosa* Jaqc. **Frontiers in microbiology**, v. 7, p. 1-10, 2016.

SINGH, B. *et al*. Phenolic composition and antioxidant potential of grain legume seeds: a review. **Food Research International**, v. 101, p. 1-6, 2017.

SOARES, E. F. *et al*. Potencial do latex da fruta pão (*Artocarpus altilis*) como agente coagulante do leite. **Ciência Rural**, v. 45, n. 1, p. 149-154, 2015.

SOUSA, D. S. *et al*. Diversidade de frutas nativas e exóticas comercializadas na central de abastecimento de Campina Grande, PB. **Embrapa Tabuleiros Costeiros-Artigo em anais de congresso (ALICE)**. Simpósio da rede de recursos genéticos vegetais do Nordeste, 2015.

SOUSA, J. M. *et al.* Polyphenolic profile and antioxidant and antibacterial activities of monofloral honeys produced by Meliponini in the Brazilian semiarid region. **Food Research International**. v. 84, p. 61-68, 2016.

SOUZA FILHO, M. S. M. *et al*. Formulações de néctares de frutas nativas das regiões norte e nordeste do Brasil. **Boletim do Centro de Pesquisa de Processamento de Alimentos**, v. 18, n 2, p. 275-283, 2000.

SPAGNUOLO, C.; MOCCIA, S.; RUSSO, G. L. Anti-inflammatory effects of flavonoids in neurodegenerative disorders. **European Journal of Medicinal Chemistry**, v. 153, p. 105-115, 2018.

STAFUSSA, A. P. *et al*. Bioactive compounds of 44 traditional and exotic Brazilian fruit pulps: phenolic compounds and antioxidant activity. **International Journal of Food Properties**, v. 21, n. 1, p. 106-118, 2018.

TALHAOUI, N. *et al*. Phenolic compounds and *in vitro* immunomodulatory properties of three *Andalusian olive* leaf extracts. **Journal of Functional Foods**, v. 22, p. 270-277, 2016.

VIDAL, M. F.; XIMENES, L. J. F. Comportamento recente da fruticultura nordestina: área, valor da produção e comercialização. **Caderno Setorial ETENE**, v. 1, n. 2, p. 18-26, 2016.

WANG, T.; LI, Q.; BI, K. Bioactive flavonoids in medicinal plants: Structure, activity and biological fate. **Asian Journal of Pharmaceutical Sciences**, v. 13, n. 1, p. 12-23, 2018.

WORLD HEALTH ORGANIZATION. **Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation**. WHO, 2002.

YANG, B. *et al.* New insights on bioactivities and biosynthesis of flavonoid glycosides. **Trends in Food Science & Technology**, v. 78, p. 116-124, 2018.

YOUSEFIAN, M. *et al.* The natural phenolic compounds as modulators of NADPH oxidases in hypertension. **Phytomedicine**, v. 55, p. 200-2013, 2018.

ZIELINSKI, A. A. F. *et al.* The association between chromaticity, phenolics, carotenoids, and *in vitro* antioxidant activity of frozen fruit pulp in Brazil: an application of chemometrics. **Journal of Food Science**. v. 79, n. 4, p. c510-c516, 2014.