



Nutritional characterization of *Vasconcellea quercifolia* A.St-Hil.: potential for the development of functional food

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Abstract

Vasconcellea quercifolia A.St-Hil. (Caricaceae) is a non-conventional food plant (PANC) of Brazil. The aim of this study was to investigate the physical, chemical, and nutritional properties of green and ripe fruits and medullary parenchyma of *V. quercifolia* A.St-Hil., in order to develop functional foods. We determined humidity, pH, ash content, protein content, carbohydrate content, fibre content, carotenoid content, ascorbic acid content, and aminograms of green and ripe fruits and of medullary parenchyma from three specimens, following existing methodologies. Green fruits had higher protein and fibre contents, and ripe fruits had higher ash, carbohydrate, and carotenoid contents, higher than other most consumed fruits. On the other hand, medullary parenchyma had higher ash content and humidity. Glutamic acid, aspartic acid, and lysine were the amino acids with the highest contents, mainly in green fruits. Aside from medullary parenchyma, used as food in the past, both green and ripe fruits can be used for the development of new food products with functional properties and potential for new alternatives for consumption.

Keywords: Caricaceae; functional food; fibres; PANC; proteins; sustainable use of biodiversity.

Practical Application: Species with high nutritional potential and for the development of new food products.

1 Introduction

Brazil houses 15 to 20% of all species of global terrestrial biodiversity, but is also responsible for the deforestation of large forest extensions, which might be causing the extinction of many species even before they are known to Science, thus hampering the discovery of new products or substances that might be beneficial for human kind (Brasil, 2000). In addition, agricultural activities generally exploit few species. This paradox brings forth the need for increasing research to broaden knowledge and lead to a better use of Brazilian biodiversity (Garcia, 1995). Additionally, human kind is heading towards reduced food diversity, with consequent cessation of certain foods that were once consumed, and adopting calorie-rich diets with low contents of essential micronutrients which are crucial to a good quality of life (Moratoya et al., 2013).

Vasconcellea quercifolia A.St-Hil. (Caricaceae), popularly known as papaya of the woods or jacaratiá, occurs from the south of Bahia to Rio Grande do Sul (RS) and is considered a Non-Conventional Food Plant (PANC) (Kinupp et al., 2011; Kinupp & Lorenzi, 2014), however, its nutritional characteristics are poorly known. In addition, it is included in the list of the Brazilian flora, considered part of its sociobiodiversity, with

feeding value that justifies its marketing *in natura* or that of its derivatives (Brasil, 2016).

Grated medullary parenchyma was used instead of coconut in the preparation of sweets in the past. However, its popular use had been gradually forgotten (Kinupp et al., 2011; Kinupp & Lorenzi, 2014) and was recently resumed with the broad dissemination of PANC's (Kinupp & Lorenzi, 2014) which describe the potentialities of this species (Kinupp & Lorenzi, 2014; Caetano et al., 2008). In light of that, the aim of the present study was to investigate the physical, chemical, and nutritional properties of *V. quercifolia* to encourage its use in the development of new food products.

2 Materials and methods

2.1 Sample collection

Medullary parenchyma and green and ripe fruits were collected from three individuals located in the central region of Rio Grande do Sul (coordinates 29°23.426'; 29°19'49"; 29°19'82" S and 52°04'63"; 52°13'45"; 52°17'40" W) identified as Sample 1, Sample 2 and Sample 3, respectively. Fertile material

Received 15 June, 2018

Accepted 26 Nov., 2018

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of the specimens was placed at the HVAT Herbarium of the Universidade do Vale do Taquari - Univates, under voucher numbers 491, 482 and 4114.

2.2 Physical and chemical analyses

Percentage of total proteins (TP) was estimated by determining the total nitrogen with the Kjeldahl method using Digestion Blocks (Marconi, Brazil) and a Kjeldahl Distiller (Tecnal, Brazil). In order to determine ash (Ash), samples were weighed on porcelain crucibles and incinerated in a muffle furnace (Marconi, Brazil), with temperature programmed to reach 550 °C. For humidity (H), fresh samples were placed in an oven at 105 °C and the difference in dry mass was calculated. Carbohydrates were calculated using the difference in all parameters = 100 – % (humidity + protein + fat + ash + fibre). Titratable acidity (TA) was determined by titration with 0.1 N NaOH solution and expressed as percentage. The pH values of the samples were determined using a digital pHmeter (Digimed, Brazil) through direct measurement. All parameters were determined in triplicates for each sample of green fruit, ripe fruit, and medullary parenchyma, following the methodology described by Instituto Adolf Lutz (2008). TA and pH were not defined for stem samples due to their difficult homogenization. Total contents of dietary fibre and amino acids were determined at the laboratory of the Eurofins Group using the AOAC 991.43 method (Association of Official Analytical Chemists, 1991) and high-efficiency chromatography (EU 152/2009 (F), Standards EN ISO 13904, ISO 13903:2005), respectively (European Union, 2009; International Organization for Standardization, 2005a, b). The ascorbic acid in the fruit was determined by 2,6-dichloroindophenol following the methodology proposed by the Instituto de Tecnologia de Alimentos (1990).

Carotenoids, β -carotene, and lycopene were determined following the methodology proposed by Rodriguez-Amaya & Kimura (2004), aliquots of fruit (2.5 g) were ground in a mixer with 10 mL of extracting solvent (acetone:hexane 4:6) under constant agitation and protected from light for 30 min. The supernatant was centrifuged at 10,000 rpm for 5 min. The reading was performed at wavelengths of 453, 505, 645, and 663. The results were expressed in mg of β -carotene and lycopene per 100 g of medullary parenchyma and green fruits. Semi-mature and ripe fruits from sample 1 were not analysed due to the lack of material. All data were submitted to an analysis of variance (ANOVA) and Tukey's test using the BioEstat 5.3 program.

3 Results

Fruits (green and ripe) differed from each other in all parameters (humidity, proteins, carbohydrates, and fibres) except for ashes. Green fruits had higher protein and fibre contents, and ripe fruits had higher ash and carbohydrate contents (Table 1). On the other hand, the medulla had higher ash content and humidity. There was no significant difference between the physical and chemical parameters of the samples of the three individuals, showing uniformity in the contents of each nutritional component in the species, regardless of the site collected.

Protein contents significantly differed ($p < 0.01$) among the three structures evaluated, with the lowest value in the medullary parenchyma. On the other hand, medullary parenchyma was the structure with the highest ash content, significantly differing only from green fruit samples ($p < 0.05$). Ripe fruits showed intermediate values and did not differ from green fruits.

Table 1. Mean values and standard deviation (SD) of total proteins (TP), ashes (Ash), humidity (H), titratable acidity (TA), pH, carbohydrates (CH), and fibres (F) of green fruits (GF), ripe fruits (RF), and medullary parenchyma (MV), considering three analytical replicates, in g per 100 g of each sample (1, 2, and 3).

Sample	TP	Ash	H	TA	pH	CH	F
GF Sample 1	2.09 ± 0.55 ^A	1.00 ± 0.07 ^B	89.75 ± 0.16 ^A	0.62 ± 0.07	5.45 ± 0.06	7.16 ± 0.05 ^B	3.67 ± 0.03 ^A
GF Sample 2	2.01 ± 0.07 ^A	1.22 ± 0.04 ^B	89.26 ± 0.22 ^A	0.83 ± 0.09	5.46 ± 0.08	7.50 ± 0.07 ^B	3.66 ± 0.06 ^A
GF Sample 3	2.02 ± 0.21 ^A	1.30 ± 0.05 ^B	88.26 ± 0.53 ^A	0.89 ± 0.14	5.26 ± 0.01	8.42 ± 0.01 ^B	3.67 ± 0.04 ^A
RF Sample 1	1.75 ± 0.17 ^B	1.48 ± 0.09 ^{AB}	85.13 ± 0.52 ^B	0.92 ± 0.42	5.32 ± 0.07	10.43 ± 0.01 ^A	3.47 ± 0.05 ^B
RF Sample 2	1.73 ± 0.56 ^B	1.44 ± 0.07 ^{AB}	84.29 ± 0.19 ^B	0.97 ± 0.07	5.20 ± 0.08	12.54 ± 0.02 ^A	3.48 ± 0.03 ^B
RF Sample 3	1.78 ± 0.21 ^B	1.48 ± 0.01 ^{AB}	82.87 ± 0.50 ^B	0.96 ± 0.01	5.32 ± 0.08	13.87 ± 0.04 ^A	3.48 ± 0.05 ^B
MC Sample 1	0.58 ± 0.03 ^A	1.66 ± 0.07 ^A	90.78 ± 0.06 ^A	-	-	6.89 ± 0.07 ^B	2.18 ± 0.03 ^A
MC Sample 2	0.58 ± 0.05 ^A	1.40 ± 0.08 ^A	90.49 ± 0.04 ^A	-	-	7.53 ± 0.05 ^B	2.17 ± 0.02 ^A
MC Sample 3	0.66 ± 0.01 ^A	1.91 ± 0.01 ^A	90.45 ± 0.41 ^A	-	-	6.98 ± 0.03 ^B	2.16 ± 0.03 ^A

Statistical analysis was not applied for TA and pH. Different letters on the same column indicate significant differences ($p < 0.05$ for ashes and $p < 0.01$ for the other variables). Fibres are included in carbohydrate values.

Medullary parenchyma and green fruits had the lowest humidity contents, significantly differing ($p < 0.01$) from ripe fruits, whereas the opposite occurred with carbohydrates, which were higher in ripe fruits, significantly differing ($p < 0.01$) from the other two structures evaluated. Fibre determination showed that fibres do not follow carbohydrate proportion. Fibre content recorded in green fruits (3.67 g for every 100 g) corresponded to 47% of total carbohydrates while the lowest value recorded for medullary parenchyma (2.17 g) corresponded to 30.43% of carbohydrates, with significant differences among the three parts of the studied plants ($p < 0.01$). Ripe fruits had the lowest proportion of fibres in relation to total carbohydrates (28%), showing reduced fibre content with fruit ripening.

Titratable acidity, analysed only in fruits, had citric acid indices between 0.62% (green fruit) and 0.97% (ripe fruit). On the

other hand, pH values were close to neutrality with a slight acidic flavour (5.20 and 5.46 for green and ripe fruits, respectively).

Aminogram analysis showed that green and ripe fruits and stem medulla of *V. quercifolia* had higher glutamic acid, aspartic acid, and lysine (essential amino acid) contents than other amino acids (Table 2). In a 100-gram sample, the highest concentrations of the three amino acids were observed in green fruits, followed by ripe fruits, and medullary parenchyma, which was similar to total protein values.

Ascorbic acid (vitamin C) content progressively increased from green to ripe fruits (Table 3). The same occurred with β -carotene and lycopene contents, with values three times higher in ripe fruits. For the three parameters evaluated (ascorbic acid, β -carotene, and lycopene), medullary parenchyma had much lower contents than fruits.

Table 2. Mean amino acid values (g in 100 g of sample) present in green fruits, ripe fruits, and medullary parenchyma of *Vasconcellea quercifolia*.

Amino acids	Green fruits	Ripe fruits	Medullary parenchyma
Glutamic acid	0.388	0.345	0.035
Aspartic acid	0.292	0.277	0.056
Lysine	0.262	0.206	0.036
Proline	0.220	0.167	<0.02
Tyrosine	0.219	0.161	<0,023
Arginine	0.154	0.164	<0,042
Leucine*	0.126	0.122	0.021
Serine	0.118	0.115	0.018
Valine*	0.112	0.11	0.028
Glycine	0.106	0.108	0.022
Alanine	0.095	0.098	0.02
Isoleucine*	0.092	0.089	<0,035
Phenylalanine	0.083	0.103	<0,031
Threonine	0.079	0.081	0.018
Histidine	0.071	0.066	<0.02
Cysteine + cystine	0.046	0.045	0.023
Tryptophan*	0.039	0.035	<0.01
Methionine*	0.025	0.024	<0,024

< = lower than the quantification limit (DL) of the technique; *essential amino acids.

Table 3. Mean values and standard deviation of ascorbic acid, β -carotene, and lycopene in green fruits (GF), semi-mature fruits (SMF), ripe fruits (RF), and medullary parenchyma (MP) of three *Vasconcellea quercifolia* individuals.

Sample	Ascorbic acid (mg/100 g)	β -carotene (μ g/g)	Lycopene (μ g/g)
GF	3.9 \pm 0.3	76.7 \pm 11.1	41.0 \pm 9.79
SMF	7.0 \pm 0.28	114.2 \pm 41.4	73.7 \pm 22.3
RF	12.15 \pm 0.0	238.04 \pm 52.6	134.8 \pm 38.2
MP	0.84 \pm 0.0	31.7 \pm 29.9	5.2 \pm 2.6

4 Discussion

The homogeneity of the parameters observed in each structure of different individuals was also observed by Kinupp & Barros (2008) who studied the same species. Additionally, the protein content observed in fruits by the same author was similar to that observed in the present study, indicating a pattern in protein content, which encourages its exploitation as it ensures the quality of the product to be produced. However, when considering the same parameters in different structures (green fruits, ripe fruits, and medullary parenchyma), there was variation in chemical composition between individuals. Green fruits had higher protein and fibre contents, ripe fruits had higher ash content, carbohydrate content, and titratable acidity, whereas medullary parenchyma had higher ash content. This indicates a second advantage to this species, as it allows for the plant to be exploited in several ways and for different purposes, including the development of new dietary products, which includes functional foods.

The high protein contents observed in green and ripe fruits were confirmed when compared to the content observed in 'Papaya' papaya (0.5%) and 'Formosa' papaya (0.8%) (Universidade Estadual de Campinas, 2011). Both papaya varieties are among the most consumed and exported fruits in Brazil (Bueno & Baccarin, 2012), although they are not native. On the other hand, other native species of Brazil, such as *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. (macaúba) and *Passiflora* sp. (passion fruit), have similar protein contents (2.1% and 2.0%, respectively) (Universidade Estadual de Campinas, 2011) to those recorded for *V. quercifolia* fruits in the present study. Other species have been considered PANC by Kinupp & Lorenzi (2014) e.g. *Ananas bracteatus* (Lindl.) Schult. & Schult.f. (pineapple), and *Portulaca oleracea* L. (purslane) (2.93%, 2.1%, and 1.6%, respectively) both native of Brazil (Kinupp & Lorenzi, 2014). The use of these types of species favours dietary diversification, and contributes to a healthier, nutrient-rich diet.

Medullary parenchyma, the most frequently used as food, especially as a replacement for coconut (*Cocos nucifera* L.) in the preparation of sweets, contains a much lower protein content than fruits and coconut, whose protein content is 0.83% (Santana, 2012). Their contents, however, are similar to those recorded for *Amaranthus viridis* L. (caruru) (0.6%) (Bredariol, 2015), also considered PANC by Kinupp & Lorenzi (2014).

As it is rich in proteins, *V. quercifolia* also constitutes an important source of amino acids. Among the ten amino acids with the highest contents found in *V. quercifolia*, three are essential amino acids. Of those, lysine was the third highest both in green and ripe fruits (0.26% and 0.21%, respectively). Lysine-rich foods comprise a healthy diet, as they reduce the recurrence, severity, and incidence time of lip infections caused by herpes simplex and promote higher calcium absorption and lower calcium excretion in diets supplemented with calcium, which suggests their potential to prevent and treat osteoporosis with a daily dose of 400-800 mg/day of lysine (Bruno, 2013). This daily amount indicated for people with osteoporosis, for instance, can be easily reached, considering that there is 0.262 g of lysine in 100 g of green fruit.

Green and ripe fruits of this species were rich in fibres, with a higher content than that recorded for papaya (1.0%) and 'Formosa' papaya (1.8%); this emphasizes its potential for developing new food products. On the other hand, it was similar to loquat (3.0 g), pear (*Pyrus communis* L.) (3.0 g), and pitanga (*Eugenia uniflora* L.) (3.2 g); the latter is considered PANC (Kinupp & Lorenzi, 2014). Despite the low fibre content observed in the medullary parenchyma, these values are similar to those recorded in other fruits (*Annona cherimola* Mill. (cherimóia), *Annona squamosa* L. (atemoia), *Musa* spp. (banana), *Theobroma cacao* L. (cocoa), and *Mangifera indica* (mango) (Universidade Estadual de Campinas, 2011). *Cocos nucifera*, for instance, had much higher contents than in the grated medullary parenchyma of the study species (10.15 g); however, the analysis was performed with freeze-dried pulp, whereas the analysis in the present study was performed with *in natura* medulla.

Regarding carbohydrates, the results for ripe fruits are in accordance with the values recorded for 'Papaya' papaya and 'Formosa' papaya, which are 10.4% and 11.6%, respectively. The same occurs with other fruits consumed worldwide, such as *Mangifera indica* L. (mango, 'Tommy Atkins cultivar') and *Vitis vinifera* L. (grapes, 'Rubi cultivar'). Carbohydrate contents in stem and in green fruits, on the other hand, are lower and similar to those recorded in *Cucumis melo* L. (melon), *Fragaria vesca* L. (strawberry), and *Ananas comosus* L. Merrill (pineapple) pulp (Universidade Estadual de Campinas, 2011). However, this carbohydrate content includes fibres, which favours its consumption by people who need to control sugar uptake. When considering fibre to total carbohydrate ratio, green fruits had a higher ratio (47%), which a sharp decrease in ripe fruits (28%). Medullary parenchyma, on the other hand, showed an intermediate percentage of fibres (30.43%).

The data recorded also show that green fruits and medullary parenchyma of *Vasconcellea quercifolia* A.St-Hil. (Caricaceae) promote a fibre-rich diet, with daily indication of 20 to 35 g/d (Pilch, 1987). Therefore, they might constitute functional foods and meet the expectation of researchers who have investigated new sources of fibres (Ou et al., 2002), as they improve intestinal functioning and decrease absorption of carbohydrates and fats (Schneeman & Tietzen, 1994). As they control the absorption of some diet components, they reduce obesity and risks of cardiovascular diseases; especially stroke (Bazzano et al., 2003).

Aside from representing an important source of fibres, medullary parenchyma is also rich in mineral salts, corroborating the findings by Kinupp & Barros (2008) for this species. It also confirms that the medullary parenchyma of *Vasconcellea quercifolia* A.St-Hil. (Caricaceae) is richer in minerals than other foods, such as *Cocos nucifera* pulp, which, according to Santana (2012), has only 0.75 g of ashes when it is grated, and this indicates the advantage of replacing it with grated medullary parenchyma of *V. quercifolia*. Ripe fruits, and even green fruits, which had the lowest mineral salt content among the three structures evaluated in this study, are also rich in minerals and have twice the value recorded by Universidade Estadual de Campinas (2011) for both papaya varieties.

Values of pH were similar to those recorded for 'Papaya' papaya (5.71) (Fagundes & Yamanishi, 2003; Albertini et al.,

2016), which was expected, but with lower acidity level compared to ripe papaya fruits of 'Formosa' cultivar (4.1) (Souza et al., 2005). Acidity values influence the decision as to how the fruit shall be used since acidity helps reduce the development of pathogenic micro-organisms (Hansen et al., 2008); low acidic fruits are more indicated for consumption *in natura* and those with higher acidity, for the food industry (Botrel, 1994). Therefore, *V. quercifolia* fruits might be indicated for consumption *in natura* and for the preparation of other foods.

Titrate acidity (TA) was higher in ripe fruits, indicating a relationship between TA and ripening stage; according to Caldas et al. (2010) citric acid content decreases with fruit ripening. Moura et al. (2003) also observed reduced TA in ripe acerola fruits and indicated as potential cause the decrease in organic acids that occurs during ripening.

Ascorbic acid and carotenoids (β -carotene and lycopene) increase with decreased CA in ripe *V. quercifolia* fruits, as much as three times the amount recorded for green fruits, which in turn, was a little lower than that recorded for semi-mature fruits. These results corroborate the findings of Leong & Shui (2002), according to whom the content of these phytochemicals with antioxidant action changes according to the type of fruit, variety, ripening degree, and edaphic and climatic conditions of the cultivation site. Despite the sharp increase in ascorbic acid in ripe fruits, this species falls in the category Low (50 mg 100g⁻¹) according to the classification by Ramful et al. (2011), whereas the papaya varieties ('Formosa' and 'Papaya') studied by Reis et al. (2015), who evaluated ascorbic acid content in 'Formosa' papaya fruits (70.09 mg 100g⁻¹) and 'Papaya' papaya fruits (114.52 mg 100g⁻¹), fall into category High (> 50 mg 100g⁻¹). On the other hand, *V. quercifolia* fruits have more ascorbic acid than that recorded by Universidade Estadual de Campinas (2011) in other fruits such as avocado (8.7 mg 100g⁻¹), watermelon (6.37 mg 100g⁻¹), and pineapple (5.77 mg 100g⁻¹), and with a similar amount to that found for Valencia orange (47.8 mg 100g⁻¹) and tangerine (48.8 mg 100g⁻¹). The opposite occurs with β -carotene and lycopene contents; both were higher in ripe fruits, more than three times the values recorded for carrot (23.8 mg 100g⁻¹), for instance.

Lycopene contents recorded for green and semi-mature fruits were similar to those recorded for guava (53.00 μ g g⁻¹) and watermelon (36.00 μ g g⁻¹). On the other hand, ripe fruits had a higher value compared to the samples analyzed, reaching 134.8 μ g g⁻¹, which is similar to that of tomato; 174 μ g g⁻¹ (Rodrigues-Amaya et al., 2008). B-carotene is the most important precursor of vitamin-A (retinol), which plays a role in several physiological processes, such as improved sight, growth, teeth formation, collagen formation, and is related to the functioning of the immune system (Rodrigues-Amaya et al., 2008; Queiroz et al., 2013). B-carotene content in RF was, on average, 238 μ g g⁻¹; this corresponds to 23,800 μ g 100 g⁻¹. This value is much higher than that found by Reis et al. (2015) for the two most consumed papaya varieties worldwide ('Formosa' papaya and 'Papaya' papaya), which have mean b-carotene values of 41.11 μ g g⁻¹ and 42.84 μ g g⁻¹, respectively.

Considering that the conversion rate from b-carotene to vitamin-A is 12:1 (Campos & Rosado, 2005), 23,800 μ g of b-carotene contained in 100 grams of ripe fruit shall comprise 1,983 μ g of vitamin-A or retinol (ER). This value is higher than

that found in boiled carrot, which generates 1,326 μ g of ER, and in raw pumpkin, which is 1,108 μ g of ER (Universidade Estadual de Campinas, 2011).

In addition to the previously explained nutritional characteristics of *V. quercifolia*, its carotenoid content emphasizes its potential as food. Several carotenoids, especially β -carotene, work as sequesters of free radicals and prevent singlet oxygen from being formed (Podsedek, 2007). Among natural carotenoids, lycopene is one of the most powerful absorbents of singlet oxygen and have an antioxidant activity, capable of preventing DNA lesions and chromosomal changes (break and loss), having a chemopreventive activity in case of mutations (Scolastici et al., 2007). For these reasons, carotenoids are antioxidants that help delay aging and reduce risks of diseases such as cancer, cataract, and atherosclerosis (Damodaran et al. 2017). According to Kruger & Mann (2003), carotenoids are among the compounds that provide benefits to health and that comprise functional ingredients.

According to Resolution n° 19, of April 30, 1999, of the Agência Nacional de Vigilância Sanitária (Brasil, 1999), food with functional properties has metabolic or physiological activity, promoting growth, development, and maintenance of the organism. For Hasler (1998), these food items have potential to mitigate diseases, promote health, and reduce costs to the healthcare system. Thus, the high fibre content associated to high contents of proteins, amino acids (including essential amino acids), ashes, and carotenoids place *V. quercifolia* in the category of functional food. These food items, as part of a diet, provide basic nutrients and benefits to metabolic and physiological functioning of the organisms, thus contributing to physical and mental health, as well as preventing chronic degenerative diseases (Angelis, 2001).

The search for new food options with functional properties is of great importance. For Kinupp & Barros (2008) low income populations strive to keep a balanced diet regarding nutrients, and therefore, the discovery of species with easy access and cultivation, and with high nutritious value is quite important. Other food options indicated by the same authors are ripe fruits of *Ananas bracteatus* (Lindl.) Schult. & Schult. (pineapple), *Psidium cattleianum* (araça-rosa) and *Vitex megapotamica* (Spreng.) Moldenke (tarumã), or even the medullar parenchyma of *Jacaratia spinosa* (Aubl.) DC. (jacaratiá), all of which are native of Brazil and have high protein content. These species are considered non-conventional food species, very similar to our study species, and their nutritious content is still poorly known and exploited (Kinupp & Barros, 2008). These species, as is the case of *V. quercifolia*, might be exploited as food, for safety, nutrition, agricultural development, economic improvement, and also as rotation crops. *V. quercifolia* can also contribute with the global production of foods due to its adaptation to several environmental conditions, high resistance to diseases, pests and rapid growth (Sridhar & Seena, 2006) and to its potential to produce functional food.

5 Conclusions

V. quercifolia has high dietary potential. Its fruits, either green or ripe, and its medullary parenchyma have high contents of ashes, proteins, carbohydrates, fibres, and carotenoids,

sometimes similar to or higher than those recorded in several plants consumed worldwide. Therefore, edible structures of the plant might be used for the development of new foods that have functional properties, meeting the demand for new food items which are more nutritious, combined with the possibility of contributing with good health.

Acknowledgements

We are grateful to the scholarship owners from the laboratories of Botanic and Chemistry of Unives, for their help in the activities carried out. We also thank the property owners who provided access to their properties for plant sampling.

References

- Albertini, S., Lai Reyes, A. E., Trigo, J. M., Sarriés, G. A., & Spoto, M. H. F. (2016). Effects of chemical treatments on fresh-cut papaya. *Food Chemistry*, 190, 1182-1189. <http://dx.doi.org/10.1016/j.foodchem.2015.06.038>. PMID:26213093.
- Angelis, R. C. (2001). *Importância de alimentos vegetais na proteção da saúde: fisiologia da nutrição protetora e preventiva de enfermidades degenerativas*. São Paulo: Atheneu.
- Association of Official Analytical Chemists – AOAC. (1991). *Total, soluble and insoluble dietary fiber in foods* (Method 991.43). Arlington: AOAC.
- Bazzano, L. A., Serdula, M. K., & Liu, S. (2003). Dietary intake of fruits and vegetables and risk of cardiovascular disease. *Current Atherosclerosis Reports*, 5(6), 492-499. <http://dx.doi.org/10.1007/s11883-003-0040-z>. PMID:14525683.
- Botrel, N. (1994). Manga: variedades, qualidade e tecnologia pós-colheita. *Informe Agropecuário*, 17(179), 55-60.
- Brasil, Agência Nacional de Vigilância Sanitária – ANVISA. (1999, May 3). Aprova o Regulamento Técnico de procedimentos para registro de alimento com alegação de propriedades funcionais e ou de saúde em sua rotulagem (Resolução nº 19, de 30 de abril de 1999). *Diário Oficial da União*. Retrieved from http://portal.anvisa.gov.br/documents/33916/394219/RESOLUCAO_19_1999.pdf/f33ae19c-1f69-4994-8fb3-82fd5b8024b9
- Brasil, Ministério do Meio Ambiente. (2000). *Convenção sobre Diversidade Biológica (CDB)*. Brasília: Centro de informação e Documentação Luís Eduardo Magalhães.
- Brasil, Ministério do Meio Ambiente. (2016, May 18). Portaria Interministerial nº 163, de 11 de maio de 2016. *Diário Oficial [da] República Federativa do Brasil*, seção 1.
- Bredariol, L. R. (2015). *Levantamento e caracterização das Plantas Alimentícias Não Convencionais (PANC'S) espontâneas presentes em um sistema agroflorestal no Município de Rio Claro-SP* (Monografia). Universidade Estadual Paulista, Rio Claro.
- Bruno, G. (2013). The benefits of individual amino. *Vitamin Retailer Magazine*, 10. Retrieved from <https://vitaminretailer.com/supplement-science-the-benefits-of-individual-amino-acids/>
- Bueno, G., & Baccarin, J. G. (2012). Participação das principais frutas brasileiras no comércio internacional: 1997 a 2008. *Revista Brasileira de Fruticultura*, 34(2), 424-434. <http://dx.doi.org/10.1590/S0100-29452012000200015>.
- Caetano, L. C. S., Burbano, T. C. L., Sierra, C. L. S., Tique, C. A. P., & Nunes, D. G. C. (2008). Cytogenetic of *Vasconcellea* species (Caricaceae). *Acta Agronomica*, 57(4), 241-245.
- Caldas, Z. T. C., Araújo, F. M. M. C., Machado, A. V., Almeida, A. K. L., & Alves, F. M. S. (2010). Investigação de qualidade das polpas de frutas congeladas comercializadas nos estados da Paraíba e Rio Grande do Norte. *Revista Verde*, 5(4), 156-163.
- Campos, F. M., & Rosado, G. P. (2005). Novos fatores de conversão de carotenóides provitamínicos A. *Food Science and Technology*, 25(3), 571-578. <http://dx.doi.org/10.1590/S0101-20612005000300029>.
- Damodaran, S., Parkin, K., & Fennema, O. R. (2017). *Fennema's food chemistry* (5th ed.). Flórida: CRC Press.
- European Union. (2009). *Regulations nº 152/2009. Official Journal of the European Union*.
- Fagundes, G. R., & Yamanishi, O. K. (2003). Physical and chemical characteristics of fruits of papaya tree from 'Solo' group commercialized in 4 establishments in Brasília-DF. *Revista Brasileira de Fruticultura*, 23(3), 541-545. <http://dx.doi.org/10.1590/S0100-29452001000300018>.
- Garcia, E. S. (1995). Biodiversidade, biotecnologia e saúde. *Cadernos de Saúde Pública*, 11(3), 495-500. PMID:12973629.
- Hansen, D. S., Silva, S. A., Fonseca, A. A. O., Hansen, O. A. S., & França, N. O. (2008). Chemical characterization of native jenipapo fruits from the Recôncavo Baiano region aiming *in natura* fruit consumption and industrialization. *Revista Brasileira de Fruticultura*, 30(4), 964-969. <http://dx.doi.org/10.1590/S0100-29452008000400021>.
- Hasler, C. M. (1998). Functional foods: their role in disease in: developing new food products for a changing prevention and health promotion. *Food Technology*, 52(11), 63-70.
- Instituto Adolf Lutz – IAL. (2008). *Métodos físico-químicos para análise de alimentos*. São Paulo: IAL.
- Instituto de Tecnologia de Alimentos – ITAL. (1990). *Manual técnico de análise química de alimentos*. São Paulo: IAL.
- International Organization for Standardization – ISO. (2005a). *ISO 13904: animal feeding stuffs: determination of tryptophan content* (1st ed). Genebra: ISO.
- International Organization for Standardization – ISO. (2005b). *ISO 13903:2005: animal feeding stuffs: determination of amino acids content*. Genebra: ISO.
- Kinupp, V. F., & Barros, I. B. I. (2008). Teores de proteína e minerais de espécies nativas, potenciais hortaliças e frutas. *Food Science and Technology*, 28(4), 846-857. <http://dx.doi.org/10.1590/S0101-20612008000400013>.
- Kinupp, V. F., & Lorenzi, H. (2014). *Plantas Alimentícias Não Convencionais (PANC) no Brasil*. Nova Odessa: Instituto Plantarum.
- Kinupp, V. F., Lisbôa, G. N., & Barros, B. I. B. (2011). *Vasconcellea quercifolia*: Jaracatiá. In L. Coradin, A. Siminski & A. Reis (Eds.), *Espécies nativas da flora brasileira de valor econômico atual ou potencial: plantas para o futuro: região sul* (cap. 5, pp. 209-2014). Brasília: Ministério do Meio Ambiente.
- Kruger, C. L., & Mann, S. W. (2003). Safety evaluation of functional ingredients. *Food and Chemical Toxicology*, 41(6), 793-805. [http://dx.doi.org/10.1016/S0278-6915\(03\)00018-8](http://dx.doi.org/10.1016/S0278-6915(03)00018-8). PMID:12738185.
- Leong, L. P., & Shui, G. (2002). An investigation of antioxidant capacity of fruit in Singapore markets. *Food Chemistry*, 76(1), 69-75. [http://dx.doi.org/10.1016/S0308-8146\(01\)00251-5](http://dx.doi.org/10.1016/S0308-8146(01)00251-5).
- Moratoya, E. E., Carvalhaes, G. C., Wander, A. E., & Almeida, L. M. M. C. (2013). Changes in food consumption pattern in Brazil and around the world. *Revista de Política Agrícola*, 22(1), 72-84.
- Moura, C. F., Alaves, R. E., Paiva, J. R., Almeida, A. S., & Figueiredo, R. W. (2003). Características físico-químicas de frutos verdes e maduros de clones de aceroleira (*Malpighia emarginata*). *Proceedings of the Interamerican Society for Tropical Horticulture*, 47, 96-98.

- Ou, B., Huang, D., Hampsch-Woodill, M., Flanagan, J. A., & Deemer, E. K. (2002). Analysis of antioxidant activities of common vegetables employing Oxygen Radical Absorbance Capacity (ORAC) and Ferric Reducing Antioxidant Power (FRAP) assays: a comparative study. *Journal of Agricultural and Food Chemistry*, 50(11), 3122-3128. <http://dx.doi.org/10.1021/jf0116606>. PMID:12009973.
- Pilch, S. M. (1987). *Physiological effects and health consequences of dietary fiber*. Rome: FAO. Retrieved from <http://agris.fao.org/agris-search/search.do?recordID=US9001285>
- Podsedek, A. (2007). Natural antioxidants and antioxidant capacity of Brassica vegetables: a review. *Lebensmittel-Wissenschaft + Technologie*, 40(1), 1-11. <http://dx.doi.org/10.1016/j.lwt.2005.07.023>.
- Queiroz, D., Paiva, A. A., Pedraza, D. F., Cunha, M. A. L., Esteves, G. H., Luna, J. G., & Diniz, A. S. (2013). Vitamin A deficiency and associated factors in children in urban areas. *Revista de Saúde Pública*, 47(2), 248-256. <http://dx.doi.org/10.1590/S0034-8910.2013047002906>. PMID:24037351.
- Ramful, D., Tarnus, E., Aruoma, O. I., Bourdon, E., & Bahorun, T. (2011). Polyphenol composition, vitamin C content and antioxidant capacity of Mauritian citrus fruit pulps. *Food Research International*, 44(7), 2088-2099. <http://dx.doi.org/10.1016/j.foodres.2011.03.056>.
- Reis, C. R., Viana, E. S., Jesus, J. L., Neves, T. T., & Conceição, E. A. (2015). Ompostos bioativos e atividade antioxidante de variedades melhoradas de mamão. *Ciência Rural*, 45(11), 2076-2081. <http://dx.doi.org/10.1590/0103-8478cr20140776>.
- Rodrigues-Amaya, D. B., Kimura, M., & Amaya-Farfan, J. (2008). *Fontes brasileiras de carotenoides: tabela brasileira de composição de carotenoides*. Brasília: Ministério do Meio Ambiente.
- Rodriguez-Amaya, D. B., & Kimura, M. (2004). *HarvestPlus handbook for carotenoid analysis*. Washington: International Food Policy Research Institute.
- Santana, I. A. (2012). *Avaliação química e funcional da polpa de coco verde e aplicação em gelado comestível* (Dissertação de mestrado). Instituto Mauá de Tecnologia, São Caetano do Sul.
- Schneeman, B. O., & Tietyen, J. (1994). Dietary fiber. In M. E. Shils, J. A. Olson & M. Shike (Eds.), *Modern nutrition in health and disease* (pp. 89-100). Philadelphia: Lea & Febiger.
- Scolastici, C., Lima, R. O. A., Barbisan, L. F., Ferreira, A. L., Ribeiro, D. A., & Salvadori, D. M. F. (2007). Lycopene activity against chemically induced DNA damage in Chinese hamster ovary cells. *Toxicology In Vitro*, 21(5), 840-845. <http://dx.doi.org/10.1016/j.tiv.2007.01.020>. PMID:17350795.
- Souza, B. S., Durigan, J. F., Donadon, J. R., & Teixeira, G. H. A. (2005). Preservation of fresh cut 'Formosa' papaya store under refrigeration. *Revista Brasileira de Fruticultura*, 27(2), 273-276. <http://dx.doi.org/10.1590/S0100-29452005000200021>.
- Sridhar, K. R., & Seena, S. (2006). Nutritional and antinutritional significance of four unconventional legumes of the genus *Canavalia*: a comparative study. *Food Chemistry*, 99(2), 267-288. <http://dx.doi.org/10.1016/j.foodchem.2005.07.049>.
- Universidade Estadual de Campinas – UNICAMP. (2011). *Tabela Brasileira de Composição de Alimentos (TACO)* (4. ed. rev. e ampl.). Campinas: UNICAMP/NEPA.