Brazilian Journal of Biology
ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

https://doi.org/10.1590/1519-6984.186435
Original Article

Rubus sellowii Cham. & Schlitdl. (Rosaceae) fruit nutritional potential characterization

M. Teixeira[a], T. Altmayer[a], F. Bruxel[a], C. R. Orlandi[a], N. F. de Moura[b], C. N. Afonso[c], E. M. Ethur[a,d], L. Hoehne[a] and E. M. de Freitas[a,d,e]*

[a]Programa de Pós-graduação em Biotecnologia, Universidade do Vale do Taquari – Univates, Av. Avelino Talini, 171, CEP 95900-000, Universitário, Lajedo, RS, Brasil

[b]Escola de Química e Alimentos, Universidade Federal do Rio Grande – FURG, Rua Barão do Caí, Bairro Cidade Alta, 125, CEP 95500-000, Santo Antônio da Patrulha, RS, Brasil

[c]Marine and Environmental Sciences Centre – MARE, Instituto Politécnico de Leiria – ESTM, Santuário Nossa Senhora dos Remédios, Apartado, 126, 2520-641, Peniche, Portugal

[d]Programa de Pós-graduação em Ambiente e Desenvolvimento, Universidade do Vale do Taquari – Univates, Av. Avelino Talini, 171, CEP 95900-000, Universitário, Lajedo, RS, Brasil

[e]Programa de Pós-graduação em Sistemas Ambientais Sustentáveis, Universidade do Vale do Taquari – Univates, Av. Avelino Talini, 171, CEP 95900-000, Universitário, Lajedo, RS, Brasil

*e-mail: luceliah@univates.br

Received: October 11, 2017 – Accepted: January 10, 2018 – Distributed: August 31, 2019

Abstract

The aim of this study was to know the physical, chemical and nutritional characteristics of *Rubus sellowii* (Rosaceae) fruits, known as blackberry, native plant mainly to Rio Grande do Sul State (RS), Brazil. For this, three different populations of this plant were selected and the fruits were analyzed through moisture, ash, titratable acidity, pH, lipids, fibers, carbohydrates, proteins, carotenoids, lycopene, ascorbic acid, aminogram and *in vitro* digestibility. Fruits showed high acidity (3.28 percent), ash and protein (1.02 and 0.93 percent) and higher ascorbic acid (38.43 mg per 100 g) if compared to *Rubus* cultivars. Due to *Rubus sellowii* nutritional properties, they provide benefits to human health.

Keywords: functional food, blackberry, healthy food consumption.

Rubus sellowii Cham. & Schlitdl. (Rosaceae) caracterização do potencial nutricional de frutas

Resumo

O objetivo deste estudo foi conhecer as características físicas, químicas e nutricionais de frutos de *Rubus sellowii* (Rosáceas), conhecida como amora-preta, planta nativa principalmente do Rio Grande do Sul (RS), Brasil. Para isso, foram selecionadas três populações diferentes desta planta e frutas foram analisadas por meio de umidade, cinza, acidez titulável, pH, lipídios, fibras, carboidratos, proteínas, carotenóides, licopeno, ácido ascórbico, aminograma e digestibilidade in vitro. As frutas apresentaram alta acidez (3,28 g por cento), cinzas e proteínas (1,02 e 0,93 g por cento) e maior ácido ascórbico (38,43 mg por 100 g) em comparação com as cultivares *Rubus*. Devido às propriedades nutricionais de *Rubus sellowii*, elas proporcionam benefícios para a saúde humana.

Palavras-chave: alimentos funcionais, amora, consumo saudável de alimentos.

1. Introduction

The demand for natural products with differentiated characteristics and properties that benefit consumers' health has grown, not only for finished products, but also for ingredients to be included in more elaborated foods (Lima et al., 2003) and products (Alho, 2008; Pinto et al., 2016). And this is also a consequence of the incentive that has been given to the consumption of healthy foods (Levy-Costa et al., 2005; Castro Neto et al., 2010) and that favor nutrient ingestion (Vizeu et al., 2005). In this context, fruits are important for providing vitamins, minerals, carbohydrates, fibers, proteins and lipid (Gomes et al., 2012). Fruit and other plant structures have vitamins and minerals that are essential for health maintenance, besides having protective effect against several serious diseases (Temple and Gladwin, 2003).

However, much of the information regarding popular and traditional use is not enough to determine fruit efficacy and safety (Souza-Moreira et al., 2010). Thus, there is the

need to research the species' nutritional characteristics and find beneficial health effects (Maihara et al., 2006). The Rosaceae family has been widely used for the treatment of various disorders and has several of its species included in the Brazilian folk medicine plants list. Pharmacological studies show that *Rubus* genus (blackberry) species may be the source of important active principles, thus, it is essential to carry out studies on their species (Nogueira et al., 1998). In addition, the species are included in the List of Non-Conventional Plant Foods (NCPF) (Kinupp and Lorenzi, 2014). Therefore, the aim of the present study was to know the nutritional potential and physical and chemical characteristics of *Rubus sellowii* Cham. & Schlitdl. (Rosaceae), popularly known as blackberry.

2. Material and Methods

2.2. Fruit collection

Rubus sellowii (blackberry) is a scandent shrub native to Brazil, occurring from the States of Minas Gerais to Rio Grande do Sul and aggregate fruits of red to black coloration when ripe (Lorenzi et al., 2006).

For the tests, fruits of *Rubus sellowii* were collected from three populations located in municipalities from the central region of RS State, Brazil, and were named Population 1 (CV) (29°19'52.57" S and 52°16'08.27" W), Population 2 (PR) (29°15'09.94" S and 52°22'34.39" W) and Population 3 (SE) (29°23'19.68" S and 52°17'28.61" W). Fertile material of the populations was inserted in the HVAT Herbarium of the Universidade do Vale do Taquari - Univates under registers 5206 (Population 1 - CV); 2440, 2441 and 2462 (Population 2 - PR); and 5359 (Population 3 – SE). In order to avoid collecting contaminated fruits, the selected populations were located in distant areas from housing, roads and crops. Fruits were collected in the morning, between February and April 2016 and, at each collection, were duly identified and transferred to the Botanic Laboratory of Univates, where they were washed and frozen for further analysis.

2.3. Physical and chemical analysis

Ash, moisture, titratable acidity, protein and carbohydrates analysis, as proposed by Instituto Adolfo Lutz (2008), and *in vitro* digestibility analysis, as described by Schmidt (2008). As there were fewer fruits from two of the populations selected for the study, amino acid, lipid, fiber, ascorbic acid and carotenoid analysis were performed with a single sample. The sample consisted of a fruit pulp mixture of the three populations, in equal proportions.

2.4. Fibers

Total dietary fiber contents were obtained at the Eurofins Group Laboratory, following the method proposed by the Association of Official Analysis Chemists (AOAC, 1995).

2.5. Amino acids

For amino acid analysis, blackberry fruit pulp samples were sent to the Food Research and Production Technology Center (CTPPA), Univates Science and Technology Park, TECNOVATES. Amino acids were determined through the methodology proposed by Shimadzu High-Performance Liquid Chromatograph (Shimadzu Corporation, 2008).

2.6. Ascorbic acid content

In order to determine the ascorbic acid content, the analysis followed the established methodology in accordance with MAPA (2013).

2.7. Carotenoids

In order to determine carotenoids content, the analysis followed the methodology described by Rodriguez-Amaya and Kimura (2004).

2.8. Lipids

Lipids quantification was obtained through analysis performed at the Laboratory of Analysis and Service Provision, *UNIANÁLISES*, Univates, following the Association of Official Analytical Chemists (AOAC, 2012).

2.9. Statistical analysis

The results of parameters evaluated in *Rubus sellowii* fruits were expressed by mean and standard deviation, and submitted to analysis of variance (ANOVA), followed by Tukey's test ($p < 0.05$ significance level), using InfoStat software.

3. Results

Average pH values found in the fruits of the three studied populations ranged from 3.06 (SE) to 3.11 (CV), with a significant difference of population 3 (SE) in relation to the others (Table 1).

Fruit titratable acidity was high, ranging from 2.99 for population 3 (SE) to 3.28 for population 1 (CV).

Mineral salts content, determined by ash analysis, ranged from 0.63 (SE) to 1.02 percent (PR), showing a significant difference between population 2 (PR) and the other two populations. Differing from other studies with blackberry varieties, fruits of these populations showed higher carbohydrate amounts (PR = 15.10 and SE = 15.31 percent), without significant differences between populations (Table 1). In a total of carbohydrate, 5 percent is of fiber in a pulp total. Values found for protein content ranged from 0.90 (PR) to 0.93 percent (SE), without significant difference between populations.

Fruit pulp analysis also showed high ascorbic acid content (38.43 mg per 100 g) when compared to other fruits of the same genus. Jacques et al. (2010), while studying *Rubus fruticosus* fruit bioactive and volatile compounds, registered 0.9 mg per 100g of ascorbic acid. Similarly, Barcia et al. (2010) recorded 0.75 mg per 100 g of ascorbic acid for Tupy Cultivar's blackberry fruits. However, when compared to other fruits, ascorbic acid content was relatively low. In kiwifruit, the amount ranged from 84.6 to 116.6 mg per 100g (Gomes et al., 2012), in acerola it was 183 mg per 100g (Araujo et al., 2007), in mango it was 89 mg per 100 g, and in papaya it was 86 mg per 100 g (Hernandéz et al., 2006). Ascorbic acid

Table 1. Average and standard deviation of fruit pulp physicochemical parameters of three *Rubus sellowii* Cham. & Schltdl. (Rosaceae) populations.

Parameters (in percentage)	CV	PR	SE
pH	3.11 ± 0.01[(a)]	3.10 ± 0.01[(a)]	3.06 ± 0.005[(b)]
Titratable acidity	3.28 ± 0.04[(a)]	3.20 ± 0.04[(a)]	2.99 ± 0.03[(b)]
Humidity	83.01 ± 0.72[(a)]	82.56 ± 0.11[(a)]	83.02 ± 0.40[(a)]
Ashes	0.73 ± 0.13[(b)]	1.02 ± 0.06[(a)]	0.63 ± 0.08[(b)]
Carbohydrates	15.30 ± 0.35[(a)]	15.10 ± 0.11[(a)]	15.31 ± 0.65[(a)]
Proteins	0.92 ± 0.09[(a)]	0.90 ± 0.08[(a)]	0.93 ± 0.05[(a)]
Digestibility	79.84 ± 4.18[(a)]	83.31 ± 1.29[(a)]	78.81 ± 6.25[(a)]

Different letters on the same line show significant differences between populations ($p < 0.05$). CV - population 1; PR - population 2 and SE - population 3.

amount difference in natural products can be influenced by climatic conditions, soil type, storage and cultivation forms (Silva et al., 2004).

The lipid content found in the blackberry pulp was 0.12 g per 100g, a low value when compared to other fruits. According to the Brazilian Food Composition Table (TACO), *in natura* strawberry, also of the Rosaceae family, contains 0.3 percent of lipids. Guimarães and Silva (2008) evaluated the chemical, physical and microbiological composition of murici fruits and the *in natura* lipids content was 3.02 g per 100g. Oliveira et al. (2012), in a study with pineapple concentrated pulp, registered 0.29 percent lipids. Fruits and vegetables have low lipid amounts and highly energetic molecules containing unsaturated fatty acids that are beneficial to the health (Somerville et al., 2000). In addition, they are necessary for liposoluble vitamins absorption, since they act as substances and nutrients carriers and constitute the cell membranes (Pinheiro et al., 2005).

The total carotenoids content found in the blackberry pulp was 0.056 mg per g and the only identified carotenoid was lycopene, with value of 9.09 µg per g.

4. Discussion

Considering the pH scale, ranging from 1.0 to 14 according to Mardini and Mardini (2000) where 7.0 corresponds to neutral acidity, whereas below and above 7.0 correspond to acidic and alkaline pH, respectively, *Rubus* spp. fruits had high acidity, what was already expected due to their acid to sweet-acid flavor (Hirsch et al., 2012). Ripe fruits of the evaluated populations are favorable for industrialization, once pH values between 3.0 and 3.2 are considered optimal for gel formation (Lopes, 2007).

About fruit titratable acidity, the results confirming the acid taste, once *Rubus* spp., according to Aroucha et al. (2010), has a higher titratable acidity value than fruits with low acidity, which range from 0.2 to 0.3 percent (Bonetti et al., 2011). Values obtained for the three populations studied were higher than those reported by Hirsch et al. (2012) for blackberry (*Rubus* spp.) cultivars spread in Brazil's southern region (1.30 to 1.58). This favors sustainable exploitation of the native species in the present study, since high acidity content provides high dilution and, consequently, higher yield in the final product for the juice industry (Andrade et al., 1993). In addition to high titratable acidity value, moisture determination results showed that fruits had high water content (PR - 82.56 to SE 83.02%), and there were no significant difference among the three populations (Table 1). Higher values were found by Mota (2006) for Tupy and Guarani blackberry cultivars (91.7 and 90.47 percent, respectively), which were found in the municipality of Caldas, Minas Gerais, Brazil, and by Hirsch et al. (2012) for Guarani, Tupy and Cherokee cultivars (86.1, 89.0 and 90.3 percent, respectively) in Pelotas, RS State. Variations show that fruit characteristics may differ when they come from different climatic regions (Hassimotto et al., 2008). In the present study, population locations did not interfere in water amount, probably because the populations are in municipalities of the same region, and with little climatic variation between them.

In spite of ashes, where there are minerals, the results were compared with Hirsch et al. (2012) recorded lower values (0.38 to 0.49 percent) for blackberry cultivars. Lower values were also recorded by Oliveira et al. (2012) for *Annanas comosus* (pineapple) (0.31 percent). Moreover, Storck et al. (2013) described lower values in *Citrus aurantium* (orange) (0.3 percent), *Cucumis melo* (melon) (0.5 percent), *Mangifera indica* (mango) (0.4 percent) and *Carica papaya* (papaya) (0.4 percent). According to Antunes (2002), blackberry fruits have considerable mineral amounts, which play an important role in human health development and maintenance (Ercisli and Orhan, 2008).

Therefore, they are considered important mineral sources (Hardisson et al., 2001). Ash in a higher level than that registered for fruits of cultivars of the same genus reinforces the importance of stimulating the consumption of fruits obtained from *Rubus* native species.

In relation of carbohydrate amounts, Antunes (2002) stated that blackberry fruits contain about 10 percent carbohydrates, corroborating with Jacques and Zambiazi (2011) who obtained values of 6 to 13 percent for blackberry (*Rubus* spp.).This amount is also higher than values recorded for *Fragaria vesca* L. (strawberry) (6.8 percent), *Averrhoa carambola* L. (starfruit) (7.5 percent) and *Cucumis melo* L. (melon) (7.5 Percent) (NEPA, 2011). As carbohydrates perform important cellular functions, especially regarding the nutrition of central nervous system

cells and energy supply, the higher amounts of carbohydrates makes this fruit attractive for consumption, and it could be part of everyday food (Pinheiro et al., 2005).

About fiber in a total pulp, a value similar to that reported by Hirsch et al. (2012) (5.5 to 5.8 percent) when studying blackberry varieties, and by Souza et al. (2015), while characterizing blackberry fruits and jelly (4.12 to 9.13 percent) was found in this study". Fibers ingestion has innumerable benefits, such as reducing the risk of arterial hypertension and stroke, improving glycemic control in patients with diabetes mellitus, favoring the proper functioning of the immune system and helping in weight reduction (Bernaud and Rodrigues, 2013). Considering all the benefits that fiber ingestion provides, and that its daily intake should be of at least 30 g, *Rubus sellowii* fruits consumption should be stimulated.

Hirsch et al. (2012) reported lower protein values (0.09 to 0.14 percent) for blackberry cultivars. According to the Brazilian Food Composition Table (TACO), protein amount variation in fruits and by-products is 0.2 to 3.2 percent, corroborating with Tirapegui et al. (2016), who mentioned that fruits and vegetables are low in protein, with these representing only 1 to 2 percent of their total weight. As a comparison parameter, Oliveira et al. (2012) reported that pineapple protein content is 0.72 percent, reinforcing the low protein amount recorded for fruits of the three populations studied. However, the values found in this study were higher than those indicated in studies on cultivars of the same plant group.

In addition to the low protein content, most foods of plant origin have specific essential amino acids deficiency. However, their consumption must be stimulated, since feed must be diversified, so that nutritional needs are met (Tirapegui et al., 2016). Amino acids found in the *Rubus selowii* populations studied were glutamic acid (Glu) and histidine (His), which only represented 3.75 and 0.89 μMol per mL, respectively. Amino acids composition or presence and digestibility are related to the protein nutritive value (Pires et al., 2006). Digestibility corresponds to the protein part that will be hydrolyzed by digestive enzymes and made available as amino acids to the organism (Gerhardt et al., 2014). In the *in vitro* digestibility evaluation of *Rubus sellowii* fruits, values expressed were high (78.81 for SE, 79.84 for CV and 83.31 percent for PR), demonstrating that *Rubus sellowii* fruits are easily digested, since, according to Toledo et al. (2007) plant proteins have digestibility of 80 percent.

Carotenoids results showed the presence in the fruit, and are one of the most important pigment groups in nature (Oliver and Palou, 2000), responsible for fruit colors from yellow to red (Uenojo et al., 2007), and for performance of various functions, having structural diversity and wide distribution (Oliver and Palou, 2000). The value found in the fruit pulp was low in the present study compared to that recorded by Jacques and Zambiazi (2011). who obtained 0.877 mg per g of total carotenoids in blackberry fruits (*Rubus* spp.).

Lycopene was low when compared to tomato (31 μg per g), papaya pulp (26 μg per g), red guava (53 μg per g) and surinam cherry pulp (73 μg per g) (Shami and Moreira, 2004). Lycopene synthesized by plants has been attracting attention because it may provide protection against cancer and other degenerative diseases influenced by free radical reactions (Pelissari et al., 2008; Ellinger et al., 2006).

In conclusion, *Rubus sellowii* fruits are beneficial to human health for their nutritional properties. Thus, the importance of *Rubus sellowii* fruits and their by-products in the diet is emphasized, contributing to the valorization of regional foods in human feed. As it has high acidity, it is an important mineral and protein source when compared to same genus cultivars. In addition, it is a source of ascorbic acid and carotenoids, even though in small amounts, complementing the diet and contributing to protect cells from oxidative damage, reducing the risk of developing some diseases. Thus, this study contributes to the improvement of scientific knowledge on the native plants of the region.

Acknowledgement

Thanks to CNPq for the Prosup scholarship and to the scholarship holders of Univates Botany Laboratory, for helping in all activities. Thanks to the owners who allowed access to their properties for fruit collection. Clélia Neves Afonso has the support of the Science and Technology Foundation (FCT), through the strategic project UID by MAR, 04292, 2013, granted to MARE.

References

ALHO, C.J.R., 2008. The value of biodiversity. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 68, no. 4, suppl., pp. 1115-1118. http://dx.doi.org/10.1590/S1519-69842008000500018. PMid:19197481.

ANDRADE, J.S., ARAGÃO, C.G. and FERREIRA, S.A.N., 1993. Physical and chemical characteristics of Araça-pera (Psidium acutanguium D.C.). *Acta Amazonica*, vol. 23, no. 2-3, pp. 213-217. http://dx.doi.org/10.1590/1809-43921993233217.

ANTUNES, L.E.C., 2002. Blackberry: a new crop option to Brazil. *Ciência Rural*, vol. 32, no. 1, pp. 151-158. http://dx.doi.org/10.1590/S0103-84782002000100026.

ARAÚJO, P.G.L., FIGUEIREDO, R.W., ALVES, R.E., MAIA, G.A. and PAIVA, J.R., 2007. B-carotene, ascorbic acid and total antocyanins in fruit pulp of the acerola tree conserved by the cold for 12 months. *Food Science and Technology*, vol. 27, no. 1, pp. 104-107.

AROUCHA, E.M.M., GOIS, V.A., LEITE, R.H.L., SANTOS, M.C.A. and SOUZA, M.S., 2010. Acidity in vegetable and fruits. *Revista Verde.*, vol. 5, no. 2, pp. 1-4.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS – AOAC, 1995. *Official method 991.43: total, soluble, and insoluble dietary fiber in foods*. Rockville: AOAC International.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS – AOAC, 2012. *Official method 920.177*. Rockville: AOAC International.

BARCIA, M.T., JACQUES, A.C., PERTUZATTI, P.B. and ZAMBIASI, R.C., 2010. Determination by HPLC of ascorbic acid and tocopherols in fruits. *Semina: Ciências Agrárias*, vol. 31, no. 2, pp. 381-390. http://dx.doi.org/10.5433/1679-0359.2010v31n2p381.

BERNAUD, F.S.R. and RODRIGUES, T.C., 2013. Dietary fiber – adequate intake and effects on metabolism health. *Arquivos Brasileiros de Endocrinologia & Metabologia*, vol. 57, no. 6, pp. 397-405. http://dx.doi.org/10.1590/S0004-27302013000600001. PMid:24030179.

BONETTI, J.A., ZANUZO, M.R., MACHADO, R.A.F., CONSTANTINO, E.J., CACHO, R.C. and RIEGER, F.A., 2011. Influência do Parcelamento de Potássio (K) nas características do melão utilizando sistema tutorado em Sinop-MT. *Revista Uniara*, vol. 14, no. 1, pp. 110-117.

CASTRO NETO, N., DENUZI, V.S.S., RINALDI, R.N. and STADUTO, J.A.R., 2010. Organic food production: a strategic potentiality for family agriculture. *Revista Percurso*, vol. 2, no. 2, pp. 73-95.

ELLINGER, S., ELLINGER, J. and STEHLE, P., 2006. Tomatoes, tomato products and lycopene in the prevention and treatment of prostate cancer: do we have the evidence from intervention studies? *Current Opinion in Clinical Nutrition and Metabolic Care*, vol. 9, no. 6, pp. 722-727. http://dx.doi.org/10.1097/01.mco.0000247470.64532.34. PMid:17053426.

ERCISLI, S. and ORHAN, E., 2008. Some physico-chemical characteristics of black mulberry (Morus nigra L.) genotypes from Northeast Anatolia region of Turkey. *Scientia Horticulturae*, vol. 116, no. 1, pp. 41-46. http://dx.doi.org/10.1016/j.scienta.2007.10.021.

GERHARDT, A., VINCENZI, A., SILVA, B.P., SOUZA, C.F.V., LIMA, C.V.S., ETHUR, E.M., WILDNER, G.R., HOEHNE, L., RODRIGUES, M. and MACIEL, M.J., 2014. Produção e análise de bioprodutos. In: R.A. Sperotto, org. *Protocolos e métodos de análise em laboratórios de biotecnologia agroalimentar e de saúde humana*. Lajeado: Editora da Univates.

GOMES, A.P.E., SILVA, K.E., RADEKE, S.M. and OSHIRO, A.M., 2012. Physical and chemical characterization of kiwi in natura and pulp from the marketing of Dourados - MS. *Revista de Ciências Exatas e da Terra UNIGRAN*, vol. 1, no. 1, pp. 1-8.

GUIMARÃES, M.M. and SILVA, M.S., 2008. Nutritional value and chemical and physical chacacteristics of dried murici fruits (Byrsonima verbascifolia). *Food Science and Technology*, vol. 28, pp. 817-821.

HARDISSON, A., RUBIO, C., BAEZ, A., MARTIN, M., ALVAREZ, R. and DIAZ, E., 2001. Mineral composition of the banana (Musa acuminata) from the island of Tenerife. *Food Chemistry*, vol. 73, no. 2, pp. 153-161. http://dx.doi.org/10.1016/S0308-8146(00)00252-1.

HASSIMOTTO, N.M.A., MOTA, R.V., CORDENUNSI, B.R. and LAJOLO, F.M., 2008. Physico-chemical characterization and bioactive compounds of blackberry fruits (*Rubus* sp.) grown in Brazil. *Food Science and Technology*, vol. 28, no. 3, pp. 702-708. http://dx.doi.org/10.1590/S0101-20612008000300029.

HERNANDÉZ, Y., LOBO, M.G. and GONZÁLES, M., 2006. Determination of vitamin C in tropical fruits: a comparative evaluation of methods. *Food Chemistry*, vol. 96, no. 4, pp. 654-664. http://dx.doi.org/10.1016/j.foodchem.2005.04.012.

HIRSCH, G.E., FACCO, E.M.P., RODRIGUES, D.B., VIZZOTTO, M. and EMANUELLI, T., 2012. Physicochemical characterization of blackberry from the Southern Region of Brazil. *Ciência Rural*, vol. 42, no. 5, pp. 942-947. http://dx.doi.org/10.1590/S0103-84782012005000021.

INSTITUTO ADOLFO LUTZ, 2008. *Métodos físico-químicos para análise de alimentos*. 8. ed. São Paulo: Instituto Adolfo Lutz. 1020p.

JACQUES, A.C. and ZAMBIAZI, R.C., 2011. Fitoquímicos em amora-preta (*Rubus* spp.) Phytochemicals in blackberry. *Semina: Ciências Agrárias*, vol. 32, no. 1, pp. 245-260. http://dx.doi.org/10.5433/1679-0359.2011v32n1p245.

JACQUES, A.C., PERTUZATTI, P.B., BARCIA, M.T., ZAMBIAZI, R.C. and CHIM, J.F., 2010. Stability of bioactive compounds in frozen pulp of blackberry (*Rubus* fruticosus) cv. Tupy. *Química Nova*, vol. 33, no. 8, pp. 1720-1725. http://dx.doi.org/10.1590/S0100-40422010000800019.

KINUPP, V.F. and LORENZI, H., 2014. *Plantas Alimentícias Não Convencionais (PANC) no Brasil: guia de identificação, aspectos nutricionais e receitas ilustradas*. São Paulo: Instituto Plantarum de Estudos da Flora.

LEVY-COSTA, R.B., SICHIERI, R., PONTES, N.S. and MONTEIRO, C.A., 2005. Household food availability in Brazil: distribution and trends (1974-2003). *Revista de Saude Publica*, vol. 39, no. 4, pp. 530-540. http://dx.doi.org/10.1590/S0034-89102005000400003. PMid:16113900.

LIMA, V.L.A.G., MÉLO, E.A., MACIEL, M.I.S. and LIMA, D.E.S., 2003. Evaluation of total anthocyanins in frozen acerola pulp from fruits of 12 different acerola trees (Malpighia emarginata D.C.). *Food Science and Technology*, vol. 23, no. 1, pp. 101-103. http://dx.doi.org/10.1590/S0101-20612003000100021.

LOPES, R.L.T., 2007. *Dossiê técnico: fabricação de geléias*. Minas Gerais: CETEC.

LORENZI, H., BACHER, L., LACERDA, M. and SARTORI, S., 2006. *Frutas brasileiras e exóticas cultivadas: de consumo in natura*. São Paulo: Instituto Plantarum de Estudos de Flora.

MAIHARA, V.A., SILVA, M.G., BALDINI, V.L.S., MIGUEL, A.M.R. and FÁVARO, D.I.T., 2006. Nutritional evaluation of proteins, lipids, carbohydrates, fiber and vitamins in industry worker's diets. *Food Science and Technology*, vol. 26, no. 3, pp. 672-677. http://dx.doi.org/10.1590/S0101-20612006000300029.

MARDINI, C.V. and MARDINI, L.B.L.F., 2000. *Cultivo de peixes e seus segredos*. Canoas: Editora ULBRA.

MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO – MAPA. SECRETARIA DE DEFESA AGROPECUÁRIA – SDA. COORDENAÇÃO-GERAL DE APOIO LABORATORIAL – CGAL, 2013 [viewed 26 November 2016]. *Análises físico-químicas de bebidas e vinagres (BEB): método para determinação de ácido ascórbico* [online]. Available from: http://physicsweb.org/articles/news/11/6/16/1

MOTA, R.V., 2006. Characterisation of black-berry juice prepared in a domestic extractor. *Food Science and Technology*, vol. 26, no. 2, pp. 303-308. http://dx.doi.org/10.1590/S0101-20612006000200012.

NOGUEIRA, E., ROSA, G.J.M., HARAGUCHI, M. and VASSILIEFF, V.S., 1998. Anxiolytic effect of *Rubus brasiliensis* in rats and mice. *Journal of Ethnopharmacology*, vol. 61, no. 2, pp. 111-117. http://dx.doi.org/10.1016/S0378-8741(98)00022-1. PMid:9683341.

NÚCLEO DE ESTUDOS E PESQUISAS EM ALIMENTAÇÃO – NEPA, 2011. *Tabela brasileira de composição dos alimentos*. Campinas: UNICAMP. 161 p.

OLIVEIRA, J.A.R., CARVALHO, A.V., MARTINS, L.H.S. and MOREIRA, D.K.T., 2012. Elaboração e caracterização físico-química e sensorial de estruturados de polpa concentrada de abacaxi. *Alimentos e Nutrição*, vol. 23, no. 1, pp. 23-31.

OLIVER, J. and PALOU, A., 2000. Chromatographic determination of carotenoids in foods. *Journal of Chromatography. A*, vol. 881, no. 1-2, pp. 543-555. http://dx.doi.org/10.1016/S0021-9673(00)00329-0. PMid:10905734.

PELISSARI, F.M., RONA, M.S.S. and MATIOLI, G., 2008. O Licopeno e suas contribuições na prevenção de doenças. *Arquivos do Museu Dinâmico Interdisciplinar*, vol. 12, no. 1, pp. 5-11.

PINHEIRO, D.M., PORTO, K.R.A. and MENEZES, M.Ê.S., 2005. *A química dos alimentos: carboidratos, lipídios, proteínas e minerais*. Maceió: EDUFAL.

PINTO, L.C., MORAIS, L.M., GUIMARÃES, A.Q., ALMADA, E.D., BARBOSA, P.M. and DRUMOND, M.A., 2016. Traditional knowledge and uses of the Caryocar brasiliense Cambess. (Pequi) by "quilombolas" of Minas Gerais, Brazil: subsidies for sustainable management. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 76, no. 2, pp. 511-519. http://dx.doi.org/10.1590/1519-6984.22914. PMid:27058602.

PIRES, C.V., OLIVEIRA, M.G.A., ROSA, J.C. and COSTA, N.M.B., 2006. Nutritional quality and chemical score of amino acids from different protein sources. *Food Science and Technology*, vol. 26, no. 1, pp. 179-187. http://dx.doi.org/10.1590/S0101-20612006000100029.

RODRIGUEZ-AMAYA, D.B. and KIMURA, M., 2004. *HarvestPlus handbook for carotenoid analysis*. Washington: International Food Policy Research Institute – IFPRI; Cali: International Center for Tropical Agriculture – CIAT. (HarvestPlus Technical Monograph; 2).

SCHMIDT C.G., 2008 [viewed 26 November 2016]. *Hidrólise enzimática das proteínas de carne de frango* [online]. Porto Alegre: Universidade Federal do Rio Grande, 143 p. Dissertação de Mestrado. Available from: http://repositorio.furg.br/handle/1/2538

SHAMI, N.J.I.E. and MOREIRA, E.A.M., 2004. Lycopene as an antioxidant aget. *Revista de Nutrição*, vol. 17, no. 2, pp. 221-236. http://dx.doi.org/10.1590/S1415-52732004000200009.

SHIMADZU CORPORATION, 2008. *Shimadzu high-performance liquid chromatograph prominence: amino acid analysis system supplementary manual*. Kyoto: Shimadzu Corporation.

SILVA, M.R., SILVA, M.S. and OLIVEIRA, J.S., 2004. Stability of ascorbic acid in refrigerated and frozen cerrado cashew apple. *Pesquisa Agropecuária Tropical*, vol. 34, no. 1, pp. 9-14.

SOMERVILLE, C., BROWSE, J., JAWORSKI, J. and OHROLOGGE, J.B., 2000. Lipids. In: B.B. Buchanan, W. Gruissem, R. Jones, eds. *Biochemistry and molecular biology of plants*. Rockville: American Society of Plant Biologists.

SOUZA, A.V.D., RODRIGUES, R.J., GOMES, E.P., GOMES, G.P. and VIEITES, R.L., 2015. Bromatological characterization of blackberry fruits and jellies. *Revista Brasileira de Fruticultura*, vol. 37, no. 1, pp. 13-19. http://dx.doi.org/10.1590/0100-2945-037/14.

SOUZA-MOREIRA, T.M., SALGADO, H.R.N. and PIETRO, R.C.L.R., 2010. Brazil in the context of plants and derivates quality control. *Revista Brasileira de Farmacognosia*, vol. 20, no. 3, pp. 435-440. http://dx.doi.org/10.1590/S0102-695X2010000300023.

STORCK, C.R., NUNES, G.L., OLIVEIRA, B.B. and BASSO, C., 2013. Leaves, stalk, pell and seeds of vegetables: nutritional composition, utilization and sensory analysis in food preparations. *Ciência Rural*, vol. 43, no. 3, pp. 537-543. http://dx.doi.org/10.1590/S0103-84782013000300027.

TEMPLE, N.J. and GLADWIN, K.K., 2003. Fruit, vegetables and the prevention of cancer: research challenges. *Nutrition*, vol. 19, no. 5, pp. 467-470. http://dx.doi.org/10.1016/S0899-9007(02)01037-7. PMid:12714102.

TIRAPEGUI, J., CASTRO, I.A. and ROSSI, L., 2016. Biodisponibilidade de proteínas. In: S.M.F. Cozzolino, ed. *Biodisponibilidade de nutrientes*. São Paulo: Editora Manole.

TOLEDO, T.C.F., BRAZACA, S.G.C., ARTHUR, V. and PIEDADE, S.M.S., 2007. Composition, protein digestibility and deamidation in Brazilian soy cultivars subjected to gamma radiation. *Food Science and Technology*, vol. 27, no. 4, pp. 812-815. http://dx.doi.org/10.1590/S0101-20612007000400022.

UENOJO, M., MARÓSTICA JUNIOR, M.R. and PASTORE, G.M., 2007. Carotenoids: properties, applications and biotransformation in flavor compounds. *Quimica Nova*, vol. 30, no. 3, pp. 616-622. http://dx.doi.org/10.1590/S0100-40422007000300022.

VIZEU, V.E., FEIJÓ, M.B.S. and CAMPOS, R.C., 2005. Measurement of the mineral composition of various "multimistura" formulations. *Food Science and Technology*, vol. 25, no. 2, pp. 254-258. http://dx.doi.org/10.1590/S0101-20612005000200012.