Research, Society and Development, v. 9, n. 9, e437997228, 2020
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i9.7228

Composição físico-química e parâmetros de qualidade da amêndoa e do óleo da amêndoa da macaúba (Acrocomia aculeata (jacq.) lodd)

Physicochemical composition and quality parameters of almond and macauba almond oil (Acrocomia aculeata (jacq.) lodd)

Composición fisicoquímica y parámetros de calidad del aceite de almendras y almendras macauba (Acrocomia aculeata (jacq.) lodd)

Received: 01/08/2020 | Reviewed: 14/08/2020 | Accept: 19/08/2020 | Published: 23/08/2020

Marina Leopoldina Lamounier Campidelli
ORCID: https://orcid.org/0000-0002-0127-2943
Federal University of Lavras, Brazil
E-mail: marina.lamounier@yahoo.com.br
Rafael Alexandre Rodrigues
ORCID: https://orcid.org/0000-0002-5858-0066
Federal University of Lavras, Brazil
E-mail: rafaelalexandremoraes@yahoo.com.br
Maísa Lamounier Magalhães
ORCID: https://orcid.org/0000-0001-8006-2487
Federal University of Lavras, Brazil
E-mail: maisa.lamounier@yahoo.com.br
Renata Abadia Reis Rocha
ORCID: https://orcid.org/0000-0002-2854-6772
Federal University of Lavras, Brazil
E-mail: renata.ufvcrp@gmail.com
João Pedro Marinho Guimarães
ORCID: https://orcid.org/0000-0002-9326-9783
Federal University of Lavras, Brazil
E-mail: joao.guimaraes5@estudante.ufla.br

Resumo

A amêndoa da macaúba (Acrocomia aculeata) tem despertado grande interesse econômico e nutricional por ser uma fonte promissora de compostos químicos e óleos com estabilidade oxidativa elevada. Esse estudo propôs realizar a caracterização da composição físico-química

e avaliar os parâmetros de qualidade da amêndoa da macaúba, bem como verificar as quantidades de ácidos graxos, peróxidos e selênio presentes no óleo da mesma. Trata-se de uma pesquisa de campo e pesquisa de laboratório, de natureza qualitativa. Dentre os principais resultados, foram encontrados na amêndoa elevados níveis de cinzas (1.37 g/100g-1), proteínas (12.12 g/100g-1) e fibras (11.31g/100g-1) colocando-a à frente de outras oleaginosas devido a superioridade desses nutrientes. No óleo, foi detectado baixa presença de ácidos graxos livres (2.30 % m/m) e peróxidos (0.56 meq Kg óleo-1) indicando que este alimento possui estabilidade oxidativa elevada. Quanto ao teor de selênio, não foi identificada presença significativa desse mineral em ambos os alimentos. Com o resultado, conclui-se que a amêndoa e o óleo da amêndoa da macaúba por apresentarem características físico-químicas e parâmetros de qualidade satisfatórios, podem ser inseridos no mercado de alimentos como uma estratégia viável voltada para pessoas que desejam modificar positivamente sua alimentação.
Palavras-chave: Oleaginosas; Composição nutricional; Bioma cerrado.

Abstract

The macauba almonds (*Acrocomia aculeata*) have aroused great economic and nutritional interest as they are a promising source of chemical compounds and oils with high oxidative stability. This study proposed to carry out the characterization of the physicochemical composition and to evaluate the quality parameters of the macauba almond, as well as to verify the amounts of fatty acids, peroxides and selenium present in the macauba's oil. This is a field and laboratory research of qualitative nature. Among the main results, high levels of ash (1.37 $g/100g^{-1}$), proteins (12.12 $g/100g^{-1}$) and fibers (11.31$g/100g^{-1}$) were found in the almond, placing it in front of other oilseeds due to superiority of these nutrients. In the oil, a low presence of free fatty acids (2.30% w/w) and peroxides (0.56 meq Kg oil^{-1}) was detected, indicating that this food has high oxidative stability. As for the selenium content, no significant presence of this mineral was identified in both foods. As a result, it is concluded that the almond and the oil of the macauba almond can be inserted in the market as a viable strategy aimed at people who wish to positively modify their diet, as they present satisfactory physicochemical characteristics and quality parameters.
Keywords: Oilseeds; Nutritional composition; Savanna biome.

Resumen

Los granos de guacamayo (*Acrocomia aculeata*) han despertado un gran interés económico y nutricional, ya que son una fuente prometedora de compuestos químicos y aceites con alta estabilidad oxidativa. Este estudio propuso caracterizar la composición físico-química y evaluar los parámetros de calidad del grano de macauba, así como verificar las cantidades de ácidos grasos, peróxidos y selenio presentes en el aceite de macauba. Es una investigación de campo y de laboratorio, de carácter cualitativo. Entre los resultados principales, se encontraron altos niveles de cenizas (1.37 $g/100g^{-1}$), proteínas (12.12 $g/100g^{-1}$) y fibras (11.31$g/100g^{-1}$) en las almendras, colocándolas frente a otras semillas oleaginosas debido a La superioridad de estos nutrientes. En el aceite, se detectó una baja presencia de ácidos grasos libres (2.30% p/p) y peróxidos (0.56 meq Kg $aceite^{-1}$), lo que indica que este alimento tiene una alta estabilidad oxidativa. En cuanto al contenido de selenio, no se identificó una presencia significativa de este mineral en ambos alimentos. Como resultado, se concluye que la almendra y el aceite de la almendra macauba, ya que presentan características físico-químicas satisfactorias y parámetros de calidad, pueden insertarse en el mercado como una estrategia viable dirigida a personas que desean modificar positivamente su dieta.

Palabras-clave: Oleaginosas; Composición nutricional; Bioma de sabana.

1. Introduction

The diet of the Brazilian population can often indicate the origin of health problems due to poor nutritional quality. Incomplete dietary patterns occur in different regions. However, Brazil, which is recognized worldwide for the plant biodiversity of its forests, has natural resources and agricultural alternatives that can meet and/or supplement these nutritionally deficient diets. Nevertheless, there is still a wide variety of foods that remain little explored, especially those of plant origin. These must be scientifically investigated since they are expressive sources not only of macro and micronutrients, but also bioactive compounds (Coimbra & Jorge, 2011). In this context, macauba (*Acrocomia aculeata* (Jacq.) Lodd.) .) (Hiane et al., 2006) is cited.

Macauba is a species found in the Cerrado biome and belongs to the Arecaceae family. The plant is popularly known as "bocaiúva", "coco-de-catarro" or "coco-de-macauba " and its fruiting occurs mainly from September to January (Almeida, 1998). It has high productivity per planted area and is a promising source of oil for the food and non-food sectors (Prates-Valério, 2019).

The fruits, which are formed by peel (20%), the pulp (40%), endocarp (33%), and almond (7%), have high levels of nutritional compounds such as lipids, sugars, fibers, proteins, and minerals. Such elements contribute to the energy and nutrient supplies necessary to keep the organism alive. They also have bioactive compounds such as carotenoids, tocopherols, and monounsaturated fatty acids, which are capable of triggering metabolic and physiological effects beneficial to human health. Among these effects are the antioxidant, anti-inflammatory, and chemopreventive action, which are fundamental for the reduction of chronic non-communicable degenerative diseases (Teixeira et al., 2019; De Almeida et al., 2019).

It is known that the macauba almond is one of the main parts of the fruit and, due to the chemical superiority that oilseed generally present, it is becoming a food with great socio-economic interest. However, research on its nutritional properties is still limited, requiring further studies to identify and characterize the maximum number of present compounds (De Almeida et al., 2019; Schex et al., 2018; Coimbra & Jorge, 2011).

In this context, this study aimed at characterizing the physicochemical composition and quality parameters of the macauba almond, as well as to verify the amounts of fatty acids, peroxides and selenium present in the macauba oil.

2. Material and Methods

The experiment was carried out at the Federal Institute of Minas Gerais *campus* Bambuí (IFMG-Bambuí). The analyses were performed in triplicates at the Physical Chemistry Laboratory with samples collected on the countryside of Córrego Danta – Minas Gerais (MG). This is a field and laboratory research of qualitative nature (Pereira et al., 2018).

2.1 Sample selection and preparation

Approximately 20kg of nearly ripe fruits were collected and underwent a dehydration process in which they were previously dried at room temperature (28ºC) for seven days. Then manually pulped using a stainless-steel knife. The almonds were sent to a processing industry in Dores do Indaiá – MG for oil extraction. At this stage, the almonds went through a continuous screw press for the cold extraction of the oil, followed by the decanting and filling processes.

2.2 Analytical determinations

2.2.1 Physical-chemical composition (almond)

Proximate composition analysis was performed according to AOAC (2005). The moisture content was analyzed through forced-air circulation kiln-drying at 85ºC until constant weight. The ash content, or fixed mineral residue, was determined by incinerating organic matter in a muffle at 550ºC. The ether extract (EE) was obtained by hot solvent extraction (petroleum ether) and acid hydrolysis using the Soxhlet extractor. The carbohydrate content was determined by a glycidic fraction (difference in weight). Crude protein was studied by determining the total nitrogen content, by distillation, in a Micro Kjedahl apparatus using the factor 5.75 to calculate the protein concentration. The methodology to detect crude fiber was carried out by the method of Weende (1864), which is based on the successive dissolution of the sample in acidic, basic, and acetone solutions.

2.2.2 Quality parameters (almond)

The pH analysis was performed by the electrometric method employing a digital pHmeter. The total soluble solids (TSS) content was analyzed by direct reading in a refractometer (Atago n.1 0~32 ºBrix), and the values were expressed in ºBrix (). Total titratable acidity (TTA) analysis was determined by titrating with a standardized NaOH 0,01N solution and expressed as % oleic acid (AOAC, 2005).

2.2.3 Peroxide content (almond oil)

The selected method for peroxide determination is based on the reaction of organic peroxides in potassium iodide, in which the released iodine was titrated in sodium thiosulfate in starch with an indicator (Moretto, 1998).

2.2.4 Free fatty acids (almond oil)

This analysis was performed by diluting the samples in ether and alcohol (2+1) and titrating with KOH and phenolphthalein (Moretto, 1998).
According to the equation (1):

(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i9.7228

$$\% \ oleic \ acid = \frac{V \times N \times 28.2}{P} \quad (1)$$

Where:

V = volume (mL) of KOH solution used in the titration;

N = normality of the KOH solution;

P = grams of sample;

28,8 = oleic acid factor;

2.2.5 Selenium content (almond and almond oil)

One gram of the sample of almond and its oil was used to determine the selenium content. It was placed in a 20 mm diameter polyethylene sample holder that was covered with a 6 µm thick polypropylene film. The samples were vacuum irradiated in triplicates for 300 seconds using a dispersive energy x-ray spectrophotometer (EDXRF Shimadzu), according to Tezotto et al. (2013).

2.2.6 Statistical analyses

The average calculation and standard deviation of the sample repetitions were performed.

3 Results and discussion

3.1 Physical-chemical composition (almond)

The analyses of moisture, ash, total carbohydrates, ether extract, crude fiber and protein of the almond are shown in Table 1. The moisture content was 11.63g/100g^{-1} and this value did not meet what had been previously reported (12.08g/100g) by Dessimoni-Pinto et al (2010) in macauba almond. This difference is related to the different ripening stages at which the fruits were harvested and also to the drying method, since the authors promoted the dehydration of the fruits under the sun and in this study it was performed in the laboratory, therefore resulting in a higher moisture content. Furthermore, the methodology used to measure the moisture content uses lower temperatures (more specifically 85 ºC up to constant weight).

Table 1. Average contents of chemical composition of macauba almond (1)

Moisture ($g/100g^{-1}$)	Ash ($g/100g^{-1}$)	Carbohydrates (2) ($g/100g^{-1}$)	Ether extract ($g/100g^{-1}$)	Fiber ($g/100g^{-1}$)	Protein ($g/100g^{-1}$)
11.63±0.15	1.37±0.19	25.07±0.17	39.47±0.31	11.31±0.23	11.15±0.12

(1) Means ± standard deviation. Source: Authors.

The ash content is directly related to the mineral content. Its importance is due to the contributions of these minerals to the healthy maintenance of the body (Stuart, 2010). This study found a result of $1.37g/100g^{-1}$, which is higher than that found by Lira (2013) who analyzed the macauba almond and reported an ash content of $0.63g/100g^{-1}$.

The carbohydrate content was $25.07g/100g^{-1}$ and this value is below the one reported by Dessimoni-Pinto et al. (2010), which was $51.65g/100g^{-1}$. Some chemical compounds can be influenced by many factors such as ripening, species, cultivation practices, geographical origin, growing stage, harvest conditions and storage process, which may explain the different results (Dessimoni-Pinto et al., 2010). (et al., 2010).

Regarding the ether extract, this study had a result of 39.47g/100g and this value is attributed to the chemical constitution of the macauba almond. This element is highly present in grains, seeds, and cereals and generally present a good fat that contributes to decreasing diseases. Due to the fact that this oil is unsaturated and practically composed of a double bonded chain, it is easily digested and helps to reduce sedimentation in the arteries (Aprile, 2008). Furthermore, the obtained value is similar to the oilseed vegetable sources such as pequi fruit, soy and olives, which according to Lima (2007) and Oliveira (2009) have 33.4%, 20% and 18.5% of lipids respectively.

Fibers are important agents which influence in humans' gastrointestinal tract. Fibers are carbohydrates undigested by enzymes in the human body, so they do not affect sugar / glucose levels or sugar levels related to hormones like insulin. This study found a content of 11.31g/100g in the macauba almond. A food must have at least 3g of fibers per portion in its composition to be considered a source of fiber, whereas a content of 6g per portion is required to allege that it is a high fiber content food, which is the case of the macauba almond (Brazil, 2012). According to the legislation, the reference daily intake of fibers is 25g (Brazil, 2012).

(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i9.7228

In this way, one would need to ingest 221g of macauba almond to meet such intake. The ingestion of 100g of this food would represent 45.24% of the reference daily intake. Oliveira et al. (2009) and Dessimoni-Pinto et al. (2010) reported a lower fiber content in macauba almond (4.41%).

The protein content was 11.15%. This is an important result since proteins strongly contribute to the development of the organism's structure aiding in human and animal nutrition and, thus, makes this food a viable option to the consumer. The protein value of macauba almonds according to Dessimoni-Pinto et al. (2010) was 12.28%, being close to this work.

In a research carried out by Hiane et al. (2006), a nutritional assessment of the macauba almond protein was performed by determining the nitrogen balance, true digestibility, biological value, protein efficiency ratio, and amino acids composition. It was concluded these almonds can be used to supplement diets especially when preparation steps that improve its digestibility have been adopted. The authors justified its use as an alternative source of proteins to school meals and populations without access to proteins of animal origin.

When comparing the results obtained with those found by other authors, in general, small nutritional variations can be attributed to sample differences regarding species and cultivation conditions such as temperature, light, soil type and nutrition conditions, which strongly influence the nutritional quality (Ayerza,, 2009). Due to the ability to translocate nutrients to the fruit, the chemical composition is also associated with the location where it is inserted.

3.2 Quality parameters (almond)

To evaluate the quality parameters of the macauba almond, the pH, SST and ATT contents were analyzed (Table 2).

Table 2. Values of pH, total soluble solids (TSS) and total titratable acidity (TA) present in the macauba almond [(1)]

pH	TSS[(2)]	ATT[(3)]
6.80±0.23	2.00±0.13	0.83±0.27

[(1)] Means ± standard deviation; [(2)] Data presented in ° brix; Expressed as % oleic acid Source: Authors.

The macauba almond had an average pH of 6.80. This characteristic is inherent to the fruits of this group since Faria (2010) described a pH of 6.94 for the same fruit and that Almeida (1998) reported a pH of 6.11 for the baru nut. A higher pH value was observed, which is compatible with the other quality parameters of the macauba oil (peroxide and fatty acid indexes) since the macauba almond is not an acid raw material, maintaining a quality profile of its oil.

The result of TSS, which expresses the amount of sugar present in the food, was 2.0 ºBrix. This value meets what was reported by Dessimoni-Pinto et al. (2010), 2.50 ºBrix. In terms of acidity, the result was 0.83g/100g. The macauba almond can be classified, therefore, as a low acidity fruit. It is worth mentioning that there may be a change in acidity due to the ripening stage or storage process.

High values of acidity indicate the development of hydrolytic reactions with the release of free fatty acids and, consequently, of diglycerides, which occurs due to the presence of water, temperature, and enzymes. For the food and pharmaceutical industries, high values of acidity compromise not only processing but also the final quality of the oil. It causes deep modifications in the lipid fraction, leading to sensory changes (Paucar-Menacho et al., 2007; Cella, Regitano-D'arce & Spoto, 2002).

3.3 Peroxide and free fatty acids (almond oil)

The results of peroxides and free fatty acids present in the macauba almonds oil are shown in Table 3.

Table 3. Values of peroxide and free fatty acids of macauba almonds oil [(1)]

Peroxides (mEq Kg oil $^{-1}$)	Free fatty acids (% m/m)
0.56±0.33	2.30±0.39

[(1)] Means ± standard deviation. Source: Authors.

The peroxide and fatty acid contents were 0.56 and 2.30 (% w/w), respectively. These results, when compared with those of Faria (2010) in macauba almond oil, which obtained values of 3.94 (meq Kg oil $^{-1}$) of free fatty acids and 12.1 (% w/w) of peroxide, show that the analyzed oil has high oxidative stability, as it is known that the lower these values are, the lower the degradation of the compounds and, consequently, the lower the degree of deterioration of the food. It is important to emphasize that the harvesting, extraction and storage processes are well conducted, as they directly influence the quality of the final product. Furthermore, the peroxide index for oils must be below 20 mEq/kg according to Normative Instruction 270 (, 2005). Therefore, macauba almonds oil is within the permitted limit regarding the presence of oxidative degradation compounds (AOAC, 2005).

3.3.1 Selenium content (almond and almond oil)

Selenium levels were not quantified in the almond and in the macauba almond oil. Probably, the concentrations of this mineral were below the detection rate of the equipment. A viable alternative would be to use another methodology that is more sensitive and, in this way, can quantify this element, since it is known that macauba is a source of minerals, including selenium (Lira,2013).

4 Conclusion

In the experimental conditions of the present research, the results obtained allowed to conclude that the macauba almond has high levels of ash, proteins, fiber (receiving functional claim), however, it presents absence of selenium. Regarding its oil, it has low levels of free fatty acids, peroxides and absence of selenium. In general, as they present satisfactory physical-chemical characteristics and quality parameters, both foods can be placed on the market as a viable strategy aimed at people who wish to positively modify their diet.

However, future studies must be developed to evaluate the oxidative stability of oil, as well as its thermal and structural parameters. In addition, research is needed to carry out the nutritional characterization of the macauba, mapping the vitamins and minerals present in the fruit. Furthermore, the development of products added with macauba pulp is of great importance, as it has also shown to be rich in proteins, carbohydrates and fibers, proving to be a great functional food.

Acknowledgments

We acknowledge and thank the National Council for Scientific and Technological Development (CNPq), the Research Foundation of Minas Gerais (FAPEMIG) and the

Coordination of Improvement of Higher Education (CAPES) for the support in the execution of the research.

Conflict of interest

The authors declare no conflict of interest.

References

Almeida, S. P. (1998). *Frutas nativas do Cerrado: caracterização físico-química e fonte potencial de nutrientes.* In: Sano, S. M., & Almeida, S. P. Cerrado: ambiente e flora**.** Planaltina: EMBRAPA.

AOAC. (2005). *Official and tentative methods, American Oil Chemists' Society*. USA: Champaign, AOCS.

Aprile J. (2008). *Óleos vegetais gorduras do bem*. Revista Online. São Paulo: Editora Escala.

Aune, D., Giovannucci, E., Boffertta, P., Farnes, L. T,, Keum, N., Norat, T., Greenwood, D. C., Rioboli, E., Vatten, L. J., & Tonstad, S. (2017). Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality – a systematic review and dose response Meta-analysis of prospective studies. *International Journal of Epidemiology*, 46 (3), 1-2.

Ayerza, R. (2009). The seed's protein and oil content, fatty acid composition and growing cycle length of a single genotype of Chia (*Salvia hispanica L.*) as affected by environmental factors. *Journal of Oleo Science*, 58 (7), 347 – 354.

Brazil. (2014). *Foods with claims of functional and / or health properties, new foods / ingredients, bioactive substances and probiotics*. Brasília, 2014.

Brazil. (2012). Resolution of the collegiate board - RDC nº 54, of November 12, 2012. *Provides for the Technical Regulation on Complementary Nutritional Information*. Official Gazette of the Federative Republic of Brazil, Brasília - DF, November 12, 2012.

Brazil. (2005). Resolution RDC / ANVISA / MS nº 270, of September 22, 2005. *Technical regulation for vegetable oils, vegetable fats and vegetable cream.* Official Gazette of the Federative Republic of Brazil, Brasília - DF, September 23, 2005.

Cella, R. C. F., Regitano-D‟arce, M. A. B., & Spoto, M. H. F. (2002). Comportamento do óleo de soja refinado utilizado em fritura por imersão com alimentos de origem vegetal. *Ciência e Tecnologia de Alimentos,* 22, 111-116.

Coimbra, M. N., & Jorge, N. (2011). Proximate composition of guariroba (*Syagrus oleracea*), jerivá (*Syagrus romanzoffiana*) and macauba (*Acrocomia aculeata*) palm fruits. *Food Research International,* 44, 2139–2142.

De Almeida, A. B., Silva, A. K. C., Lodete, A. R., & Egea, M. B. Assessment of chemical and bioactive properties of native fruits from the Brazilian Cerrado. *Nutrition & Food Science*, 49, 3, 381-392, 2019.

Dessimoni-Pinto, N. A. V., *et al.* (2010). Características Físico-Químicas Da Amêndoa De Macauba E Seu Aproveitamento Na Elaboração De Barras De Cereais. *Revista de Alimentos e Nutrição Araraquara*., 21 (1), 79-86.

Faria, L. de F. (2010). *Hydrolysis of macauba almond oil with extracellular lipase from Colletotrichum gloesporioides produced by fermentation in liquid substrate. Dissertation (Master's), Food Science, Faculty of Pharmacy, Federal University of Minas Gerais.*

Hiane, P. A., Baldasso, P. A., Marangoni, S., & Macedo, M. L. R. (2006). Chemical and nutritional evaluation of kernels of bocaiuva, *Acrocomia aculeata* (Jacq.) Lodd. *Food Science and Technology*, 26 (3), 683-689.

Lima, A., Silva, A. M. O., Trindade, R. A., Torres, R. P., & Mancini-Filho, J. (2007). Composição química e compostos bioativos presentes na polpa e na amêndoa do pequi (*Caryocar brasiliense*, Camb. *Revista Brasileira de Fruticultura*, 29, 3.

Lira, F. F., Machado, W., Dos Santos, J. V. F., Takahashi, L. S. A., Guimarães, M. F., & Leal, A. C. (2013). Avaliação da Composição Centesimal de Frutos de Macauba. *III Simpósio de Bioquímica e Biotecnologia*, 17-20.

Moretto, E., & Fett, R. (1998). *Vegetable oils and fats technology in the food industry*. São Paulo: Ed. UFSC.

Paucar-Menacho, L. M., Silva, L. H., Sant‟ana, A. de S., & Gonçalves, L. A. G. (2007). Refino de óleo de farelo de arroz (*Oriza sativa L.)* em condições brandas para preservação do γ-orizanol. *Ciência e Tecnologia de Alimentos,* 27, 45-53.

Pereira, A. S., et al. (2018). Scientific research methodology. [eBook]. Santa Maria. Ed. UAB / NTE / UFSM. Retrieved from https://repositorio.ufsm.br/bitstream/handle/1/15824/Lic_Computacao_Metodologia-Pesquisa-Cientifica.pdf?sequence=1.

Prates-Valério, P., Celayeta, J. M. F., & Cren, E. C. (2019). Quality parameters of mechanically extracted edible macauba oils (*Acrocomia aculeata*) for potential food and alternative industrial feedstock application. *European Journal of Lipid Science and Technology*, 121 (5), 1800329.

Schex, R., Lieb, V. M.; Jiménez, V. M.; Esquivel, P.; Schweiggert, R. M.; Carle, R., & Steingass, C. B. (2018). HPLC-DAD-APCI/ESI-MSn analysis of carotenoids and α-tocopherol in Costa Rican *Acrocomia aculeata* fruits of varying maturity stages. *Food Research International*, 105, 645–653.

Slavin, J. L., & Lloyd, B. (2012). Health benefits of fruits and vegetables. *Advances in Nutrition (Bethesda, Md.)*, 3 (4), 506-516.

Teixeira, N., Melo, J. C. S., Batista, L. F., Paula-Souza, J.; Fronza, P., & Brandão, M. G. L. (2019). Edible fruits from Brazilian biodiversity: A review on their sensorial characteristics versus bioactivity as tool to select research. *Food Research International*, 119, 325–348.

Tezotto, T., Ffavarin, J. L., Neto, A. P., Gratão, P. L., Azevedo, R. A., & Mazzafera, P. Simple procedure for nutrient analysis of coffee plant with energy dispersive X-ray fluorescence spectrometry (EDXRF). (2013). *Scientia Agricola*,70 (4), 263-267.

Percentage of contribution of each author in the manuscript

Marina Leopoldina Lamounier Campidelli – 20,00%

Rafael Alexandre Rodrigues–20, 00%

Maísa Lamounier Magalhães – 20,00%

Renata Abadia Reis Rocha–20, 00%

João Pedro Marinho Guimarães–20, 00%