Physicochemical characterization of seeds and aril of *Renealmia aromatica* (*Aubl.*) Griseb

Caracterização físico-química de sementes e arilo de *Renealmia aromata* (*Aubl.*) Griseb

Caracterización fisicoquímica de semillas y arilo de *Renealmia aromática* (*Aubl.*) Griseb

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ABSTRACT
The Amazon has great biodiversity, being inhabited by indigenous peoples since time immemorial, as well as being home to traditional farmers, settlers, riverine dwellers, people responsible, in large part, for the conservation of biodiversity through the cultivation and storage of grains, tubers, roots and seeds. Among the numerous species cultivated and managed by the Amazonian peoples, we approach, in this work, the species *Renealmia aromatica* (Aubl.) Griseb., belonging to the Zingiberaceae family. The objective of this article is to present physicochemical aspects of the fruits of *Renealmia aromatica* (Aubl.) Griseb. aiming to emphasize its alimentary potential and nutritional value.This work consisted of harvesting the fruits of mother plants located in the experimental garden of the Universidade Federal do Acre – UFAC. The analyzes were carried out at the Unidade de Tecnologia de Alimentos – Utal of UFAC – Campus Rio Branco. The variables analyzed were protein, ascorbic acid (vitamin C), titratable acidity, moisture and ash (fixed mineral residue) according to the methods for physicochemical analysis of foods from the Instituto Adolfo Lutz. In the aril and in the seed, protein contents of 7.97% and 6.67% were found, respectively. As for lipids, the highest concentration was observed in the seeds, with a content of 6.76%. The aril showed a satisfactory level of vitamin C (182,81 mg/100g). With a high concentration of lipid, the seeds had a total caloric value of 335,56 kcal/100g. Thus, the seeds and arils of *R. aromatica* have alimentary and nutritional potential, being the seeds used for the production of edible oil or condiment, and the aril, rich in vitamin C, used in alimentation. This, although already used in food, is still restricted to indigenous peoples and traditional communities.

Keywords: food plant, medicinal plant, condiment, zingiberaceae.

RESUMO
A Amazônia detém grande biodiversidade, sendo povoada por indígenas desde tempos imemoriais, assim como abriga agricultores tradicionais, colonos, ribeirinhos, povos responsáveis, em grande parte, pela conservação da biodiversidade através do cultivo e guarda de grãos, tubérculos, raízes e sementes. Dentre as inúmeras espécies cultivadas e manejadas pelos povos Amazônicos, abordamos, neste trabalho, a espécie *Renealmia aromatica* (Aubl.) Griseb., pertencente à família das zingiberáceas. O objetivo deste artigo é avaliar os caracteres físico-químicos das sementes e arilo de *R. aromatica* visando consolidar o potencial alimentício e o valor nutricional. Este trabalho consistiu na colheita dos frutos de plantas matrizes localizadas na horta experimental da Universidade Federal do Acre – UFAC. As análises foram realizadas na Unidade de Tecnologia de Alimentos – Utal da UFAC - Campus Rio Branco. As variáveis analisadas foram proteína, ácido ascórbico (vitamina C), acidez titulável, umidade e cinzas (resíduo mineral fixo) conforme os métodos para análise físico-química de alimentos do Instituto Adolfo Lutz. No arilo e na semente, foram encontrados teores de proteína de 7,97% e 6,67% respectivamente. Quanto aos lipídeos, a maior concentração foi observada nas sementes, apresentando teor de 6,76%. O arilo apresentou índice satisfatório de vitamina C (182,81 mg/100g). Com alta concentração de lipídeo, as sementes apresentaram valor calórico total de 335,56 kcal/100g. Desta forma, as sementes e os arilos de *R. aromatica* apresentam potencial alimentício e nutricional, podendo ser as sementes utilizadas para produção de óleo comestível ou condimento, e o arilo, rico em vitamina C, utilizado na alimentação. Este, embora já utilizado na alimentação, ainda restringe-se aos povos indígenas e comunidades tradicionais.

Palavras-chave: planta alimentícia, planta medicinal, condimento, zingiberáceas.

RESUMEN
La Amazonia posee una gran biodiversidad, siendo habitada por pueblos indígenas desde tiempos inmemoriales, además de ser hogar de agricultores tradicionales, colonos, ribereños, personas responsables, en gran parte, de la conservación de la biodiversidad a través del cultivo y almacenamiento de granos, tubérculos. , raíces y semillas. Entre las numerosas especies cultivadas y manejadas por los pueblos amazónicos, abordamos en este trabajo la especie Renealmia aromatica (Aubl.) Griseb., perteneciente a la familia Zingiberaceae. El objetivo de este artículo es presentar aspectos fisicoquímicos de los frutos de Renealmia aromatica (Aubl.) Griseb. con el objetivo de resaltar su potencial alimentario y valor nutricional. Este trabajo consistió en la cosecha de frutos de plantas madre ubicadas en el jardín experimental de la Universidade Federal do Acre – UFAC. Los análisis fueron realizados en la Unidad de Tecnología de Alimentos – Utal de la UFAC – Campus Rio Branco. Las variables analizadas fueron proteína, ácido ascórbico (vitamina C), acidez titulable, humedad y cenizas (residuo mineral fijado) según los métodos de análisis fisicoquímicos de alimentos del Instituto Adolfo Lutz. En el arilo y en la semilla se encontraron contenidos de proteína de 7,97% y 6,67%, respectivamente. En cuanto a los lípidos, la mayor concentración se observó en las semillas, con un contenido de 6,76%. El arilo presentó un nivel satisfactorio de vitamina C (182,81 mg/100g). Con una alta concentración de lípidos, las semillas tenían un valor calórico

total de 335,56 kcal/100g. Así, las semillas y arilos de R. aromática tienen potencial alimentario y nutricional, siendo las semillas utilizadas para la producción de aceite o condimento comestible, y el arilo, rico en vitamina C, utilizado en la alimentación. Este, aunque ya se utiliza en la alimentación, todavía está restringido a los pueblos indígenas y comunidades tradicionales.

Palabras clave: planta alimenticia, planta medicinal, condimento, zingiberáceas.

1 INTRODUCTION

Brazil has great biodiversity, the Amazon being inhabited by indigenous peoples since time immemorial and who have always used the resources of the forest for their survival. Traditional peoples are a fundamental link for the protection of natural resources, with knowledge passed from generation to generation (Pereira; Diegues, 2010). Living together in the midst of nature provides them with a greater awareness of biodiversity conservation (Enríquez, 2008), since this knowledge is also part of their culture (Bevilaqua *et al.*, 2014).

In the Amazon, traditional peoples do not dissociate man from nature, strengthening this relationship and ethno-knowledge (Lira; Chaves, 2016). As described by Lanza *et al.* (2017), in their studies on the food of a certain indigenous land located in Acre, indigenous peoples ensure their village sovereignty and food security through the diversified consumption of food species present in their lands.

Traditional, indigenous and non-indigenous farmers are responsible for the natural management of cultivars, natural selection and domestication of wild resources. And it is in this scenario of vast agrobiodiversity imposed by these traditional populations that new sources of molecules and new plant genes are possible to be found, reinforcing the importance of these peoples for the conservation of biomes and ecosystems (Santilli, 2009).

Despite the great biodiversity in Brazil, the diet of the general population is monotonous, with only a few species that have been part of our daily lives since colonial times (Kinupp; Lorenzi, 2014). This includes condiments, aromatic herbs, exotic species, the same ones used by our ancestors, such as black pepper, turmeric, cloves, among others, even with great potential for the use of native species, such as those belonging to the genus *Piper* sp. (Tomchinsky, 2017).

As outlined by Kinnup and Barros (2008) unconventional species have a greater supply of nutrients and minerals compared to conventional species that are commonly included in the population's diet. As can be seen in the species *Bidens Pilosa*, where the aerial part has around 21.82% of crude protein, 1.1% of calcium and 0.71% of phosphorus. In nutritional terms, Oliveira *et al.* (2013) highlight the species taioba (*Xanthosoma taioba* E.G. Gonç.) with 3.82 g/100 grams of potassium, ora-pro-nóbis (*Pereskia aculeata* Mill.) with 2.16 g/100 grams of calcium, bertalha (*Basella alba* L.) 3.87 g/100 grams of potassium and beldroega (*Portulaca oleracea* L.) having in its composition about 2.39 g/100 grams of calcium. They are species consumed and cultivated in remote times that have become neglected.

The spice herbs present the production of secondary compounds, which are influenced by factors ranging from climate to the age of the plant maturation. Among the commonly used spice herbs, oregano is cited, with a high antioxidant activity (Gonçalves *et al.*, 2015). Pereira *et al.* (2017) accentuate that some aromatic plants used as a condiment, such as rosemary, basil and coriander, contain significant levels of polyunsaturated fatty acids, especially linoleic and α-linolenic acids.

Tomchinsky (2017) cites that the Brazilian market for spice plants is, for the most part, dominated by exotic and/or produced outside of Brazil species. Of the 923 spice species, 499 are native to the country. Vasquez *et al.* (2014), in research in an Amazon region, describe that one of the roles of women farmers is the cultivation of medicinal and spice species around their homes. Among the species cited by the authors, three belong to the Zingiberaceae family, they are: vim-di-ca (*Alpinia zerumbet* (Pers.) B.L.Burtt & R.M.Sm.), turmeric (*Curcuma longa* L.) and mangarataia (*Zingiber officinale* Roscoe), mainly used for medicinal purposes. Gómez-Betancur; Benjumea (2014) reports that plants belonging to this botanical family are known for their uses as spice and medicinal.

Included in this family is the genus *Renealmia*, represented by about 87 species, of which 21 are located in Brazil. Amid the purposes of each species, the food and medicinal use, encompassing all parts of the plants, stand out. In the chemical composition of the species, the most common compounds found are β-pyrene and diterpenoid labdanes (Negrelle, 2015). Indigenous people from South America have been using the species *Renealmia alpinia* for medicinal purposes (Gómez-Betancur; Benjumea, 2014).

The species *Renealmia aromatica* (Aubl.) Griseb. is native to Brazil, having a phytogeographic domain in the Amazon region (Negrelle, 2015). Popularly called pacová or amazonian-cardamom, it is commonly found in dense forests and dry land. It grows spontaneously, but it is also cultivated by the local indigenous people who use its fruits as food, dye and in the medicine of their people. From the seeds, the aril is used to dye the beiju (a dish of indigenous origin) and the seeds can be crushed and have a similar use as cardamom (Kinupp; Lorenzi, 2014). Widely used in Indian cuisine, in the Middle East it is considered an aphrodisiac, cardamom has great versatility from use as flavoring, seasoning even for medicinal use (Korikanthimathm *et al.*, 2001).

According to the work carried out by Mesa *et al.* (2017), artisans located in the municipality of Puerto Gaitán, Colombia, during the processing of the species *Mauritia flexuosa*, popularly known as buriti, for the production of handicrafts, use the species *R. aromatica* to impart a violet color, a pigment from the fruit rinds, in the dyeing of *M. flexuosa* Lf. fibers.

The objective of this article is to present physicochemical aspects of the fruits of *Renealmia aromatica* (Aubl.) Griseb. aiming to emphasize its alimentary potential and nutritional value.

2 MATERIAL AND METHODS

The species studied was the *Renealmia aromatica* (Aubl.) Griseb. The plant is cultivated in the experimental garden of the Universidade Federal do Acre – UFAC. A total of 84 fruits were collected, which were analyzed at the Unidade de Tecnologia de

Alimentos – Utal of the Universidade Federal do Acre – Campus Rio Branco, which followed the methods described by the Instituto de Análise Físico-Química para Alimentos of the Instituto Adolfo Lutz (2008).

The harvest of 84 fruits that already had a completely dark purple skin, which is an indication that they were already ripe and ready for use, was carried out. From the collected fruits a selection was performed, where only 72 were used for analysis, they measured between 40 and 50 mm, the other fruits already had an aspect of rancidity and an unpleasant odor that showed that they were already in the state of degradation of the aril.

Figure 1: A) ripe fruits surrounded by the rind already in the opening stage for later seed dispersal; B) rind and aril surrounding the seeds; C) washed seeds; D) fruit devoid of the rind, with exposed aril and seeds.

Source: A,B,C and D - PANC/UFAC Group photographic archive.

The chemical analyzes of seeds and aril were performed in a completely randomized design (DIC) in triplicate.

The fruits were opened and the seeds were separated from the aril, the weights of the aril and seeds were obtained on an analytical balance, after being separated, totaling 28.4318g and 81.1790g respectively. The ready-to-use samples, separated from seeds and arils, were stored in 100 ml glass beakers, sealed with plastic film and stored, during the analyzes, in a refrigerator for common/domestic use at a temperature between 5 and 10 ºC, to avoid oxidation and subsequent degradation of the material.

The seeds were crushed in the multiprocessor to homogenize the samples and facilitate the processes resulting from the analyzes. All analyzes were performed on a wet basis, except for ash (fixed mineral residue).

The protein was quantified using the Kjeldahl method, in which the total organic nitrogen content was estimated. After weighing 0.25 grams of each treatment and repetition, the seed and aril samples, the first process was the degradation with catalytic mixture and P.A sulfuric acid, followed by nitrogen distillation and, finally, the titration. The values obtained, after the distillation of N and stipulated by the titration with 0.1 hydrochloric acid, were submitted to the formula for converting nitrogen into vegetable protein using the factor 5.75, according to Resolution - RDC ANVISA/MS nº 360, of December 23, 2003 (ANVISA, 2003).

For the verification of lipids, the samples were weighed and placed in envelopes made with filter paper and sealed with cotton. Subsequently, the envelopes containing the samples were placed in cartridges, which were coupled to the Soxleht extractor and in flat-bottomed glass flasks. For approximately 36 hours, the samples were 'washed' with ether to remove fat, which, in turn, was deposited at the bottom of the flasks.

At the end of the process, the flasks containing the lipids from the samples were submitted to an oven at 105º C so that all the ether evaporates, leaving only the material to be evaluated. All values obtained were submitted to the formula for measuring lipids:

$$\frac{\text{Balloon with fat} - \text{Fat free starter balloon x 100}}{\text{Sample weight}} = \text{\% of lipid}$$

As for the verification of the presence and quantification of ascorbic acid (vitamin C), the process occurred through the degradation of the sample with 20% sulfuric acid, followed by titration with 0.1 M potassium iodate until the sample obtained an orange/brown color. The values of weight and volume spent during the titration with potassium iodate were applied to the formula to verify how many mg/100g of vitamin C was in the material.

To perform the carbohydrate calculations by difference and to measure the total caloric value, only the seeds were used because they were in greater quantity in relation to the aril.

The analysis of ash, or fixed mineral residue, consisted of the incineration of organic matter in steel plates until the moment when the smoke output of the samples was no longer visible, then submitted to a muffle furnace at 550 °C for 3 hours, leaving only the mineral matter, which was weighed together with the porcelain cadins and the initial and final weighing values entered in the ash measurement formula, as shown below:

$$\frac{\text{(Final weight - Initial weight) x 100}}{\text{Sample weight}} = \text{Outcome} = \text{\% of fixed mineral residue.}$$

Moisture analysis was performed by sample weight difference, when submitted to an oven at 105 ºC for 24 hours. Then, placed in a desiccator in order not to let the moisture in the medium come into contact with the analyzes and interfere with the results.

3 RESULTS AND DISCUSSION

Regarding the physicochemical analyzes, there was a significant difference ($p<0.05$) for the variables protein, ash (mineral matter) and vitamin C (Table 1).

Table 1. Average contents of crude protein, lipid and vitamin C evaluated, on a wet basis, of seeds and aril of the plant *Renealmia aromatica* (Aubl.) Griseb.

Treatments	**Protein (%)**	**Lipid (%)**	**Vitamin C (mg/100g)**
Aril	7,97 a	1,26 b	182,81 a
Seed	6,14 b	6,76 a	73,18 b
CV (%)	3,65%	29,1%	1,56%

Means followed by different letters on the line differ from each other by Tukey's test ($p<0.05$).
Source: Authors

As observed in the results of the analyzes, the aril has a higher amount of vitamin C and protein in relation to the seeds. However, the seeds have a high lipid content.

The high content of vitamin C present in the aril can probably be explained by the presence of carotenoids, as described by Guevara *et al.* (2018) in their research with *Renealmia alpinia* (Rottb.) Maas., noting the large amount of this compound in the aril of the seeds. According to the author, the aril of *R. alpinia* contains around 28.30 mg/100g of vitamin C and, therefore, it can be affirmed that the samples of *Renealmia aromatica* analyzed in this work are richer, containing larger amounts of this antioxidant both in the aril and in the seeds, with values of 182.81 mg/100g and 73.18 mg/100g respectively.

According to the TACO table (2011), conventional fruits commonly consumed by the population, such as bitter orange and rangpur lime, present in their composition, on a raw basis, 44.3 mg/100g and 32.8 mg/100g of vitamin C. Castro *et al.* (2012) found 17.3 mg/100g of vitamin C in rose pepper fruits, a species used as a spice.

The use of spices is an excellent source of natural antioxidants, in addition to becoming a food and pharmaceutical supplement option (Del Ré; Jorge, 2012). The use of black pepper (*Piper nigrum L.*), for example, used as a condiment since ancient times, gives the body, in addition to antioxidant action, anti-inflammatory action and provides minerals and vitamins (Carvenalli; Araujo, 2013). As verified, the seeds of *Renealmia aromatica* can also replace synthetic sources of antioxidants, as well as being used as a condiment during several preparations, as well as the black pepper, commonly spread and commercialized.

According to Resolution RDC nº 269, of September 22, 2005, a minimum daily intake of 45 mg of vitamin C is recommended for adults (ANVISA, 2005) so that there are no symptoms of vitamin C deficiency, therefore, the fruits of *R. aromatica*, both the seeds and the aril, supply the daily need for the vitamin, provided that they are consumed in the amount of 45 mg/day, superior even to that found in conventional species of fruits, vegetables and spices, such as raw bitter orange with 34.7 mg/100g of vitamin C, raw Haden mango, 17 mg/100g, raw watercress, 60.1 mg/100g, and raw carrots, 5.1 mg/100g (TACO, 2011), foods frequently consumed by the population.

Foods that contain amounts of vitamin C above the recommended daily intake become more attractive. Moraes *et al.* (2010) report the losses of vitamin C that vegetables present during the process from reception to distribution in restaurants, which is one of the components most susceptible to losses within a food.

The protein contents found in the aril and in the seeds of *R. aromatica* obtained significant differences ($p<0.05$), being found in greater quantity in the aril. As we can see in the TACO table (2011), conventional fruits and vegetables tend to have low amounts of protein in their composition, for example, raw apple, with 0.2 g/100g, and raw iceberg lettuce, with 0.6 g/100g, foods commonly used and made available to the population. According to Resolution RDC nº 269, of September 22, 2005, the recommendation of 50 g of protein per day is suggested.

Guevara *et al.* (2018), when analyzing the species *R. alpinia*, found levels of 4.20% of protein in the fruits, which makes it lower than the species *R. aromatica*, with 7.97% of protein in the aril and 6.14% in the seeds. Ramirez *et al.* (2017), when performing analyzes of crushed cardamom seeds (*Elletaria cardamomum*), a very widespread spice in cooking and used for oil extraction, belonging to the same botanical family as *R. aromatica*, found 7.8% of protein.

According to the physicochemical analyzes of fresh ginger rhizomes, Torres (2009) found 1.74% of protein in 100g of sample, a value statistically similar to that found by Silva *et al.* (2020), 1.85% (± 0.03) in ginger pulp, both of which used the value 6.25 to calculate proteins in general.

It is known that unconventional food plants tend to have nutritional values higher than conventional species, such as the ripe fruits of *Ananas bracteatus* (2.93% protein), *Eugenia myrcianthes* (8.05%) and *Rubus rosifolius* (6.9%) (Kinupp; Barros, 2008). In this way, as well as some unconventional species, the fruits of *R. aromatica* also present satisfactory concentration of protein, being able to contribute to the nutrition and feeding of the population.

Some oilseeds, such as soybeans, are sources of vegetable protein, however, they may have anti-nutritional factors in their composition, such as tannins. Although vegetable proteins do not have all essential amino acids, they provide greater digestibility, as the body tends to absorb and metabolize them faster (Grande; Cren, 2016).

As shown in table 1, the amount of lipid present in the seed was higher than that found in the aril, with a significant difference ($p<0.05$). Guevara *et al*. (2018) observed 8.60% of fat in the pulp (aril) of *R. alpinia*, similar to the value found in the aril of *R. aromatica* in this work. Lucio *et al.* (2010) reported, in the chemical composition of ginger (*Zingiber officinale* Roscoe) inflorescence, intended for food, the presence of 3.80% of lipid in the green inflorescence and 3.81% when it was already pink in color. As can be seen, the lipid levels found in the arils of the fruits of the species studied here are higher than the levels found in the ginger inflorescences in both stages of maturation.

According to the work carried out by Oliveira (2018) with ginger (*Zingiber officinale*) on a dry basis from conventional and organic producers, the highest value obtained in terms of lipid was 2.54% (± 0.43) in gingers from conventional cultivation. Therefore, even though it belongs to the same botanical family as *R. aromatica*, it has a higher lipid content, even though its growth is spontaneous and without conventional and more elaborate management practices, such as periodic fertilization.

Silva *et al.* (2020) found lipid contents of 0.23% (± 0.13) in ginger pulp, lower than the values found in this work for *R. aromatica* and by Oliveira (2018) in conventional ginger.

In this work, the only method used in the seeds to carry out the analyzes was the crushing in a multiprocessor. As described by Dourado (2012), when analyzing the yield of oil extracted from rose pepper (*Schinus terebinthifolius* Raddi), the extraction method influences the amount of oil that will be released. The greater the maceration of the grains, the higher the oil yield. That is, through the method of macerating the grains or seeds, higher amounts of oil can be obtained or not. The method used in this work was in order to facilitate the analyzes and to extract the maximum of components present in the seeds and in the aril. Thus, if the maceration method were performed in another way, it would probably imply greater oil removal at the time of processing. However, despite using a multiprocessor, the lipid results were satisfactory, both in the aril and in the seeds.

For the seeds, the values of moisture (23.07%) and ash or mineral matter (1.58%) were also measured in order to determine the total caloric value, reaching the result of 335.56 kcal/100g. As we can note, in the seeds, there are minerals, as well as a high caloric value, which may come from the amount of oil present in them.

Silva *et al.* (2020), on the physicochemical composition of ginger on a wet basis, determined, through the analysis of protein, lipid and carbohydrate by difference, a total caloric value of 79.68 kcal/100g, considered low compared to that found in the seeds of *R. aromatica*. This is mainly due to the high lipid content found in the seeds, which makes the fruit more caloric.

Guevara *et al.* (2018), in their studies on the fruits of *Renealmia alpinia* (Rottb.) Maas, detected high levels of carotenoids in the aril, commonly called pulp, which gives the strong yellow/orange pigmentation found in them. In addition, he found that the fruits have high antioxidant potential due to the high presence of flavonoids and carotenoids in the aril (pulp) and anthocyanins and phenolic compounds in the rind.

Among the edible parts of the fruit, Kinupp; Lorenzi (2014) highlights the aril, the fleshy portion that surrounds the seeds, the seeds as a condiment and the dry rinds for use in the form of tea. Negrelle (2015) reports that the fruits of *R. petasites* and *R. alpinia* are edible due to the presence of aril in their seeds.

4 CONCLUSIONS

The seeds and aril of Renealmia aromatica have nutritional potential, being rich in vitamin C, in addition to having satisfactory amounts of lipid and protein.

The lipid extracted from both parts showed satisfactory results, which makes it a viable option to add value, both for food and cosmetic purposes.

The seeds of the fruits showed higher lipid yields in relation to the aril and, thus, with the processing, they can be useful for culinary uses such as condiment, spice and food oil production. The seeds are highly aromatic and slightly spicy.

The fruit is a great source of vitamin C and can contribute to the supply of this important nutrient in diets.

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