Food and Nutrition Sciences, 2015, 6, 869-874
Published Online July 2015 in SciRes. http://www.scirp.org/journal/fns
http://dx.doi.org/10.4236/fns.2015.610091

Antioxidants, Chemical Composition and Minerals in Freeze-Dried Camu-Camu (*Myrciaria dubia* (H.B.K.) Mc Vaugh) Pulp

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Received 3 June 2015; accepted 19 July 2015; published 22 July 2015

Abstract

Camu-camu (*Myrciaria dubia* (H.B.K.) Mc Vaugh) is a fruit native to the Amazon region and is considered the greatest natural source of vitamin C worldwide. It is also a promising source of many phenolic compounds, including flavonoids and anthocyanins. Given the growing rates of chronic non-communicable diseases such as dyslipidemia, obesity and diabetesworldwide, freeze-dried camu-camu can be used for its functional properties, which can reduce the incidence of these diseases. Hence, the objective of this study was to produce freeze-dried camu-camu pulp and present it as an alternative functional food because of its high production and use potential, adding value to this fruit in particular, not very demanded by the food industry. Freeze-dried camu-camu pulp is a pink, homogeneous powder with great antioxidant capacity, 52,000 μmol TE/g, six times greater than freeze-dried acai powder. It is also very rich in vitamin C (20.31 g/100g), potassium (796.99 mg/100g), carbohydrates (47.00 g/100g), dietary fiber (19.23 g/100 g), many amino acids, other vitamins, and anthocyanins (0.739 mg/g). The camu-camu freeze-drying process is an effective alternative way to preserve the fruit, preserving its macronutrient and vitamin C contents. Camu-camu is also an excellent source of other bioactive compounds, such as minerals and other phenolic compounds. In conclusion, camu-camu can be used to introduce bioactive compounds into food products and to delay or prevent many human diseases.

Keywords

Functional Foods, Ascorbic Acid, Freeze Drying, Antioxidant Capacity

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How to cite this paper: Aguiar, J.P.L. and Souza, F.C.A. (2015) Antioxidants, Chemical Composition and Minerals in Freeze-Dried Camu-Camu (*Myrciaria dubia* (H.B.K.) Mc Vaugh) Pulp. *Food and Nutrition Sciences*, **6**, 869-874.
http://dx.doi.org/10.4236/fns.2015.610091

1. Introduction

The Amazon has numerous potentially lucrative plant species, and camu-camu (*Myrciaria dubia* (H.B.K.) Mc Vaugh) stands out among them. Camu-camu is a wild fruit from the family Myrtaceae. It occurs in the margins of Amazonian rivers and lakes, but it is not well known in the rest of Brazil [1]. However, great volumes of camu-camu have been exported to Japan and the United States of America (USA). Camu-camu is a round fruit with a diameter of 2 to 4 centimeters, and smooth and shiny skin. Its mean weight is 8.4 grams. The color varies from dark red to purplish-black when ripe. Each fruit has one to four, more commonly two to three, kidney-shaped, ellipsoid seeds covered with fibril filaments [2]. Interest in camu-camu has grown because of its notable vitamin C content, varying from 1600 to 2994 mg/100g of pulp [3] Even higher concentrations were found by in three camu-camu batches from east Roraima, 3571 to 6112 mg/100g of pulp, making it the fruit with the highest vitamin C content in the world [4].

Despite the discovery and dissemination of the high ascorbic acid content of camu-camu and its adaptability to solid ground, this fruit is not yet widely consumed by the general population, and its demand by the food industry is low. One of the factors that hinder its consumption is the extreme acidity of the pulp and bitterness of the skin, so studies are necessary to increase camu-camu use. It is important to develop new products that preserve camu-camu's nutritional quality and simultaneously have a reasonable shelflife without the need of adding considerable amounts of preservatives. Thus, the present study produced freeze-dried camu-camu pulp and presents it as a new functional food with high production and use potentials, adding value to a fruit that is lowly demanded by the food industry.

2. Material and Methods

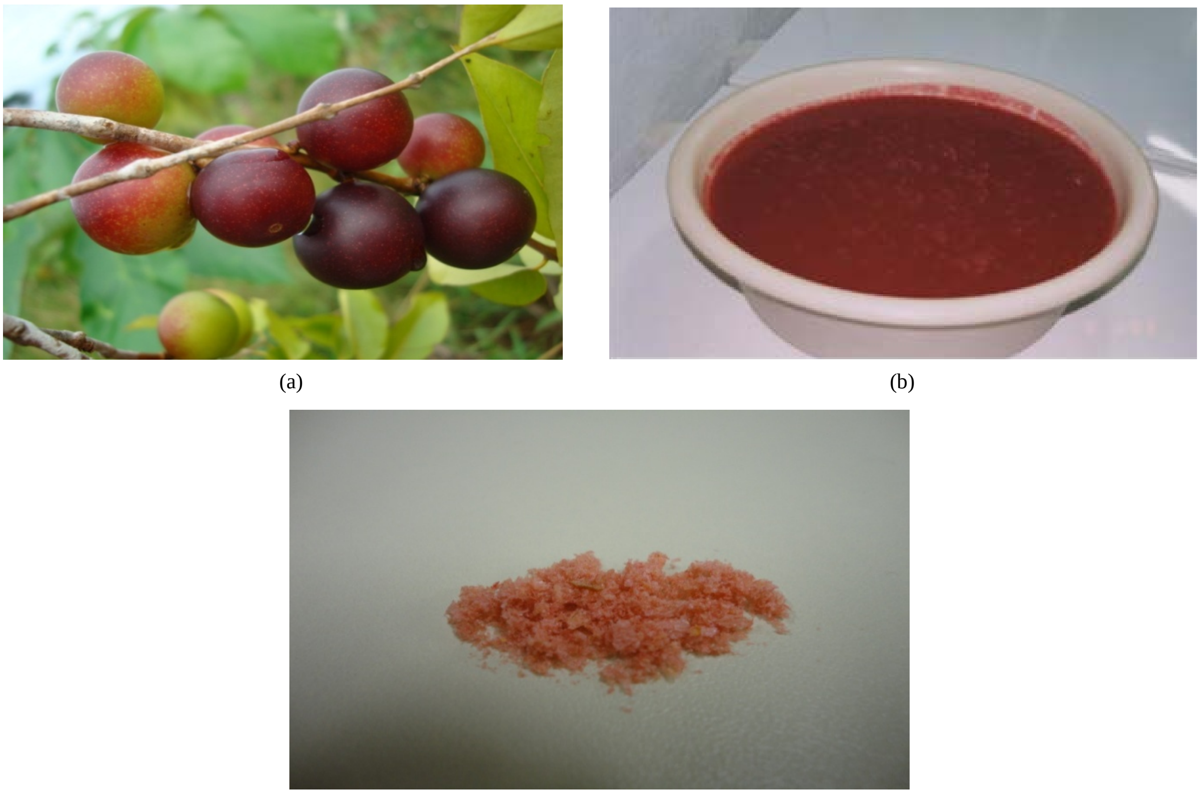
2.1. Samples

The study camu-camu was collected manually during the commercial ripening stage in Rio Branco, Roraima (RR), in a region called Santa Izabel de Boiaçú, municipality of Rorainópolis, RR, with the following geographic coordinates: 0˚23'27.3"S to 61˚48'22.5"W. The fruits were placed in sterile plastic bags and transported to the Physical and Chemical Food Laboratory (LFQA) of the Society, Environment, and Health Coordination (CSAS) of the National Research Institute of Amazônia (INPA).

The excessively ripe fruits and those with sanitary or mechanical injuries were discarded. The remainder were rinsed with running water, immersed in 10% sodium hypochlorite for 30 minutes, and then rinsed again with potable water. The pulps were extracted by an automatic pulp ejector (Itametal, mesh of 1.5 mm). The extracted pulps were immediately placed on stainless steel trays, frozen to −80˚C, and dried by the lyophilizer SP Scientific model 25 L GENESIS, at a working temperature of −70˚C to produce freeze-dried camu-camu pulp powder (**Figure 1**). All freeze-dried samples were homogenized in a blender before the physical and chemical analyses to quantify minerals, amino acids, lipids, some vitamins, and antioxidants.

2.2. Sample Preparation

The moisture, ash, protein, lipid, and carbohydrate contents of the freeze-dried powder were analyzed three times as recommended by Instituto Adolfo Lutz [5], and amino acids also three times as recommended by Schuster [6]. Moisture was determined by drying the sample in an incubator at 105˚C until the weight of the sample became constant; ash content was determined by incineration; lipids were analyzed by Soxhlet extraction; protein content was determined by the Kjeldahl's method; soluble and insoluble fiber contents were determined by the method proposed by Asp *et al*. [7] and carbohydrate content was given by subtracting all other weights from the total weight. Energy content was calculating by multiplying the carbohydrate, protein, and lipid contents in grams by 4, 4, and 9 kcal/g, respectively [8]. Ph was measured by a digital potentiometer (Micronal, model B474). Vitamin C content was measured three times by high-performance liquid chromatography (HPLC) following the method proposed by Maeda *et al*. [3]. Anthocyanins and vitamin B_{12} were determined as recommended by the American Organization of Analytical Chemists [9]. Calcium, sodium, potassium, magnesium, manganese, iron, zinc, and copper contents were determined by digesting the sample (CEM Coorporation, model MD-2591) and reading the solution with an atomic absorption spectrometer (Variam Spectra AA, model 220 FS).



(c)

Figure 1. Camu-camu fruits on the plant for processing (a); extracted pulp for freeze-drying (b); and freeze-dried camu-camu powder (c).

2.3. Antioxidant Capacity

Antioxidant capacity was determined as recommended by Brand-Williams, Cubelier, and Berset [10] using 2,2-dyphenyl-picrylhydrazil (DPPH). Ten grams were extracted with 100 ml of 60% ethanol under constant stirring at 30˚C for 24 hours. The extracts were filted by filter paper number one and the fluid portions were analyzed for antioxidant content. The absorbance was read three times at 515 nm, and the antioxidant capacity was calculated as µmol of Trolox equivalents (TE) per gram. The results were described descriptively and the contents were expressed as mean ± standard deviation (SD).

3. Results and Discussion

Table 1 shows that freeze-dried camu-camu has a high concentration of vitamin C, approximately 20.31 g/100g, naturally much higher than that in fresh pulp (between 2.0 and 6.5 g/100g). Vitamin C content in camu-camu was also higher than in other traditional Brazilian fruits, such as acerola (1357.0 ± 9.5 mg/100g of fresh fruit) and acai (84.0 ± 10 mg/100g of fresh fruit) [11]. Soluble and insoluble fiber contents are also very high, making camu-camu a good natural source of these nutrients. Studies have shown that high-fiber diets have great therapeutic potential against dyslipidemia, cardiovascular diseases, and some types of cancer [12]. Fibers also decrease intestinal transit time and glucose absorption, with consequent lowering of glycemia and blood cholesterol. Potassium was the most abundant mineral in freeze-dried camu-camu, with a concentration of 796.99 mg/100g. Calcium is usually low in Amazonian diets. Freeze-dried camu-camu can help Amazonians to achieve their recommended calcium intake.

In addition to these components, camu-camu has high levels of phenolic compounds, such as flavonoids and anthocyanins. Freeze-dried camu-camu has an anthocyanin content of 0.739 mg/g and flavonoids of 16.93 mg/100g. However, Reynertoson *et al.* [13] found that the total anthocyanin content of freeze-dried camu-camu powder was very low (0.01 mg/g of dry weight), varying greatly. This variation may be attributed to the fact that

Table 1. Nutritional composition of freeze-dried camu-camu pulp.

Moisture (g/100g)	94.1 ± 0.1
Protein (g/100g)	6.65 ± 0.14
Ash (g/100g)	3.67 ± 0.21
Crude fiber (g/100g)	19.23 ± 0.00
Soluble fiber (g/100g)	11.11 ± 0.00
Insoluble fiber (g/100g)	8.12 ± 0.00
Lipids (g/100g)	0.98 ± 0.07
Carbohydrates (g/100g)	47.00 ± 0.00
Vitamin C (g/100g)	20.31 ±0.04
Sodium (mg/100g)	Tr*
Potassium (mg/100g)	796.99 ± 43.94
Calcium (mg/100g)	22.12 ± 2.54
Magnesium (mg/100g)	33.47 ± 1.30
Iron (mg/100g)	2.23 ± 0.12
Manganese (mg/100g)	1.29 ± 0.08
Zinc (mg/100g)	1.26 ± 0.07
Copper (mg/100g)	0.84 ± 0.03
pH	2.61 ± 0.02
Antioxidant capacity (µmol TE/g)	52.000
Vitamin B 12 (µg/g)	0.0034
Anthocyanins (µg/g)	0.739
Flavonoids (mg/100g)	16.93

*Traces.

camu-camu is a deciduous fruit, that is, the pigments are predominantly found in the skin, hence removing the skin results in smaller extractions. The degree of ripeness is another variable that affects anthocyanin levels. Macheix *et al*. [14] found a higher concentration of phenolic compounds in the skin than in the pulp.

Table 1 shows that freeze-dried camu-camu has extremely high antioxidant activity, 52,000 µmol TE/g, six times more than freeze-dried acai. The ripening process is a critical variable in camu-camu bioactive properties, especially with respect to its reduction potential. These results agree with the antioxidant activity measured during ripening. The antioxidant potential may be related to the phenolic composition of the extracts, but other components may also make an important contribution.

4. Amino Acid Profile

Table 2 shows the amino acid contents of freeze-dried camu-camu expressed as g/100g of sample. **Table 2** lists some essential amino acids. The most abundant amino acids in camu-camu are arginine (0.692 g/100g) and glutamic acid (0.619 g/100g). The lysine content (0.196 g/100g) in camu-camu is similar to that of wheat flour (0.11%), one of the most important plant sources of this amino acid. Despite the great variety of amino acids found in camu-camu, it is not possible to consider it a good protein source because its total protein content of 3.86% is similar to that of other dried fruits amendoim (3.1%), nozes (2.3%).

5. Conclusion

Camu-camu fruits are excellent sources of different bioactive compounds, such as vitamin C, fibers, minerals,

Table 2. Amino acids present in freeze-dried camu-camu expressed as g/100g of sample.

Amino acid	Content	Amino acid	Content
Aspartic acid	0.375	**Leucine**	0.219
Threonine	0.124	**Tyrosine**	0.141
Serine	0.228	**Phenylalanine**	0.128
Glutamic	0.619	**Lysine**	0.196
Proline	0.168	**Histidine**	0.110
Glycine	0.229	**Arginine**	0.692
Alanine	0.180	**Cystine**	0.101
Valine	0.176	**Methionine**	0.058
Isoleucine	0.124	**Total**	3.868

and phenolic compounds. Camu-camu fruits show high antioxidant capacity as compared to other fruits. In conclusion, camu-camu fruits can be used to increase the amount of bioactive compounds in food products and to delay or prevent many human diseases.

Acknowledgements

The authors thank the financial support of Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, Brazil) and Fundação de Amparo à Pesquisa do Estado do Amazonas (FAPEAM, Brazil) processo 062.01725/2014/PAPAC.

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