

## Production and characterization of mixed water-soluble plant extracts

### ABSTRACT

The use of plant-based products as a substitute for cow's milk has increased in recent years, with emphasis on plant extracts. Cashew nuts and baru nuts have excellent nutritional characteristics for the production of water-soluble plant extracts. Thus, this study aimed to produce and characterize mixed water-soluble plant extracts based on cashew nuts and baru nuts. Preliminary tests were carried out to determine the best nut to water ratio, and the type and concentration of gum to be used in the formulation. Nut: water ratios of 1:6 and 1:8 (w/w) were selected for the production of water-soluble extracts of baru nuts (EBN) and cashew nuts (ECN), respectively. Subsequently, tests were performed with the gums, and xanthan gum at 0.25% was selected for both extracts. From the results of preliminary tests, three mixed extracts were prepared in the following proportions: 60% EBN + 40% ECN; 50% EBN + 50% ECN; and 40% EBN + 60% ECN. No significant difference was observed between the three mixed extracts for protein, lipid, and ash contents, with a significant difference for moisture and carbohydrates contents.

**KEYWORDS:** plant extracts, allergy, nuts, plant-based.

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## INTRODUCTION

Consumers' behavior has been changing over the past few years, as they are increasingly concerned about the health and the environment, thus increasing the search for a healthy and sustainable lifestyle Ventura (2010). These changes in the consumer profile have encouraged the food industry to invest in research and new technologies to meet the demand for novel products with unaltered sensory characteristics, extended shelf life, high nutritional value, as well as products with specific characteristics, including gluten-free and lactose-free products for medical, religious, and other reasons Rodrigues *et al.* (2013); Bragante (2014).

An increase in the demand for plant-based products in the diet of consumers has been observed in the last decade Sig Combibloc Magazine (2015). In Brazil, according to Vegan Business magazine (2021), the revenue generated with plant-based products as an alternative to cow's milk is around U\$56 million. A study on the consumption of cow's milk has shown that people consume milk out of habit or taste preference. In turn, some individuals have reported some reasons for not consuming dairy products, including concern for animal welfare, environmental damage, and/or physiological problems (lactose intolerance and casein allergy). These consumers consider that cow's milk can be substituted by alternative sources provided that it gives a pleasant flavor Cuinãs, Vailati and Lazzati (2020). People with food restrictions have great difficulties in choosing food, especially concerning industrialized products, since the industry has focused on the manufacture of mass-produced products, thus leaving these groups of consumers in the background. Thus, consumers who are lactose intolerant, allergic to cow's milk proteins, or adept at vegetarianism and/or veganism, have difficulties in consuming specific foods, due to little variety in the market and the higher prices when compared to the conventional products Da Silva Estrela *et al.* (2017). Therefore, in recent years, food industries have sought food alternatives to meet these demands, with emphasis on plant extracts, popularly known as vegetable "milk" Norberto *et al.* (2018).

According to Resolution 268 of September 22/2005, of the National Health Surveillance Agency (ANVISA), vegetable products are those obtained from the edible parts of vegetables traditionally consumed as food, including oilseeds, submitted to drying and/or dehydration, and/or cooking and/or salting, and/or fermentation, and/or lamination, and/or flocculation, and/or extrusion, and/or freezing, as well as other technological processes considered safe for food production. They may be presented with a liquid covering and may contain salt, sugar, seasoning, or spice, and/or other ingredient provided that there is no significant change in the product Brasil (2005).

Plant extracts have been a viable and promising alternative to replace cow's milk, as well as for the preparation of dairy products such as yogurt, cheese, sweets, among others. In addition, plant extracts have a good nutritional profile, which is essential for replacing milk Da Silva Estrela *et al.* (2017). Plant-based beverages come from different sources, including cereals (oats, wheat, rice, and corn), pulses (soybeans, peanuts, peas, and beans), oilseeds (almonds, coconut, hazelnut, pistachio, and walnuts), seeds (sesame, linseed, and sunflower), and pseudo-cereals (quinoa, amaranth, and teff) Cuinãs, Vailati and Lazzati (2020).

The soy-based extract, popularly known as "soy milk", was the pioneer in the market to replace cow's milk, as it is considered a source of proteins and has a low

cost Norberto *et al.* (2018). However, in recent years, soy extract has not been the first choice alternative product, due to problems of allergy and intolerance to soy and low sensory acceptance of the product. Therefore, there is an increasing demand for alternative beverages based on other oilseeds, seeds, almonds, and fruits Sig Combibloc Magazine (2015).

The baru nut almond is obtained from the baru tree, native to the Cerrado, and is highly appreciated by the local population, who use the nuts in various culinary preparations, such as bread, cakes, cookies, liqueurs, oil extraction, etc. It also has excellent nutritional characteristics, especially the high content of lipids, proteins, soluble fiber, potassium, magnesium, and calcium Vera *et al.* (2009). The cashew nut almond, in turn, comes from the cashew tree, a tree with a tropical climate, and is highly appreciated by consumers, mainly for its pleasant taste. Cashew nuts also have excellent nutritional properties and are considered a source of proteins, polyunsaturated fatty acids, carbohydrates, and have high minerals levels (calcium, iron, phosphorus, manganese, copper, arsenic, and selenium) Soares *et al.* (2012).

Thus, the knowledge about the addition of baru nuts and cashew nuts to food products as a water-soluble plant extract may be an interesting alternative for the production of differentiated products to attend consumers who do not consume animal products, due to dietary restrictions, and/or adherents of veganism. Given the above, this study aimed to determine the feasibility of the use of baru nuts and cashew nuts in the manufacture of mixed water-soluble extracts.

## MATERIALS AND METHODS

### PRELIMINARY TESTS

Preliminary tests were carried out with baru and cashew nuts to select the best methodology and the nut: water ratios for the production of the extracts. In addition, tests were performed to determine the type and amount of gum to be used in the water-soluble extracts.

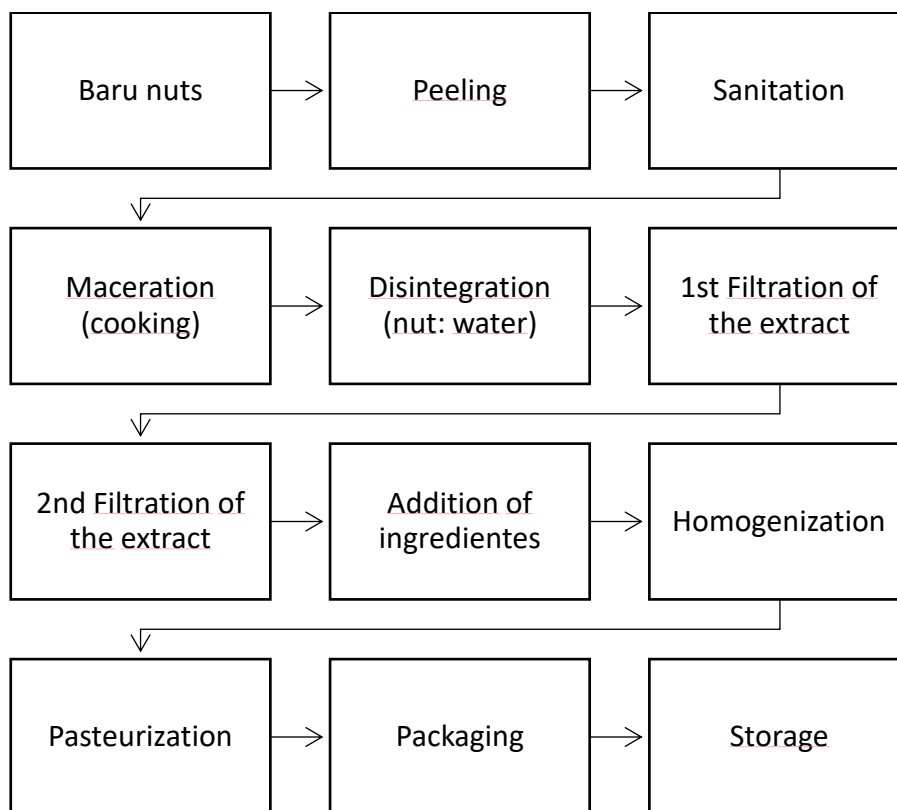
Initially, the experiments were carried out with nuts (baru and cashew) and water in proportions of 1:4, 1:5, 1:6, and 1:8 (w/w). The gums studied (alone and combined) were xanthan gum, carboxymethylcellulose (CMC), and iota carrageenan in concentrations ranging from 0.5% to 0.2% of the extract.

### PREPARATION OF WATER-SOLUBLE EXTRACT OF BARU NUTS (EBN)

The EBN was produced according to the methodology proposed by Felberg *et al.* (2005) with modifications. The processing steps are described below (Figure 1).

First, the baru nuts were peeled, sanitized with 200 ppm sodium hypochlorite for 15 minutes, washed with running water, and subjected to thermal treatment at 95°C for 5 minutes at a ratio of 1:6 w/w (nut: water). Then, the nuts were milled in an industrial blender for 3 minutes, and the extract was filtered twice with the aid of a 1 mm sieve and filter cloth to remove the remaining residues. Subsequently, the other ingredients were added, as follows: 0.5% inulin, 0.2% xanthan gum, 0.1% salt, and 0.03% potassium sorbate. The mixture was

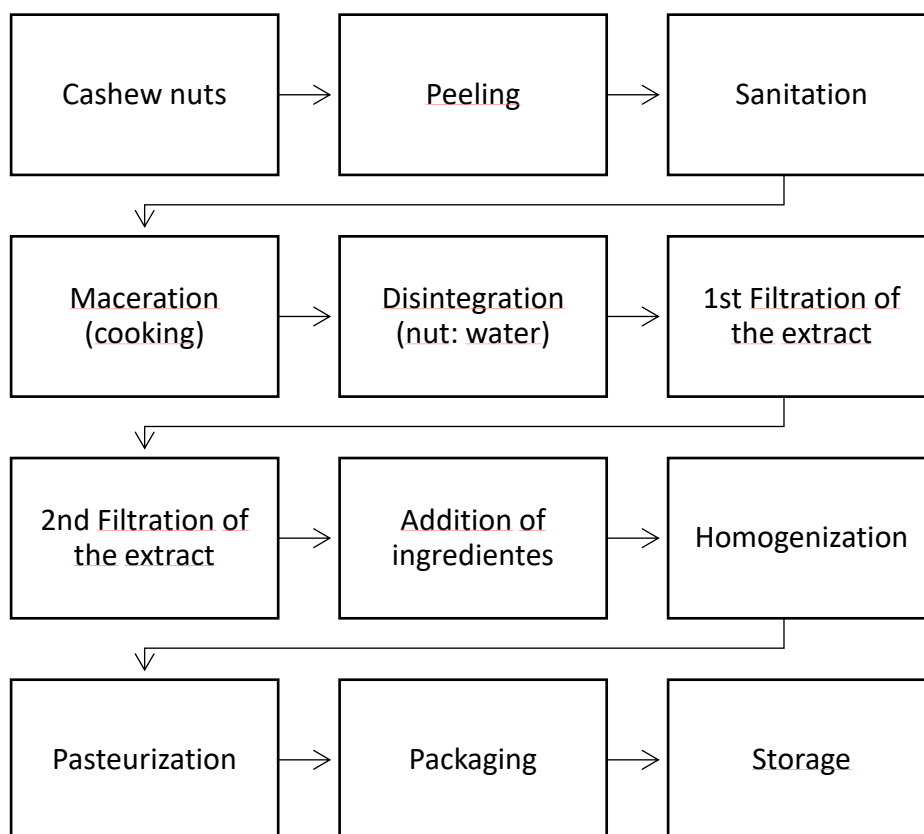
pasteurized at  $93 \pm 2$  °C for 3 minutes under agitation, packaged at 70 °C, and stored under refrigeration ( $7 \pm 1$  °C).



**Figure 1.** Production of water-soluble extract of baru nuts (EBN).

#### PREPARATION OF WATER-SOLUBLE EXTRACT OF CASHEW NUTS (ECN)

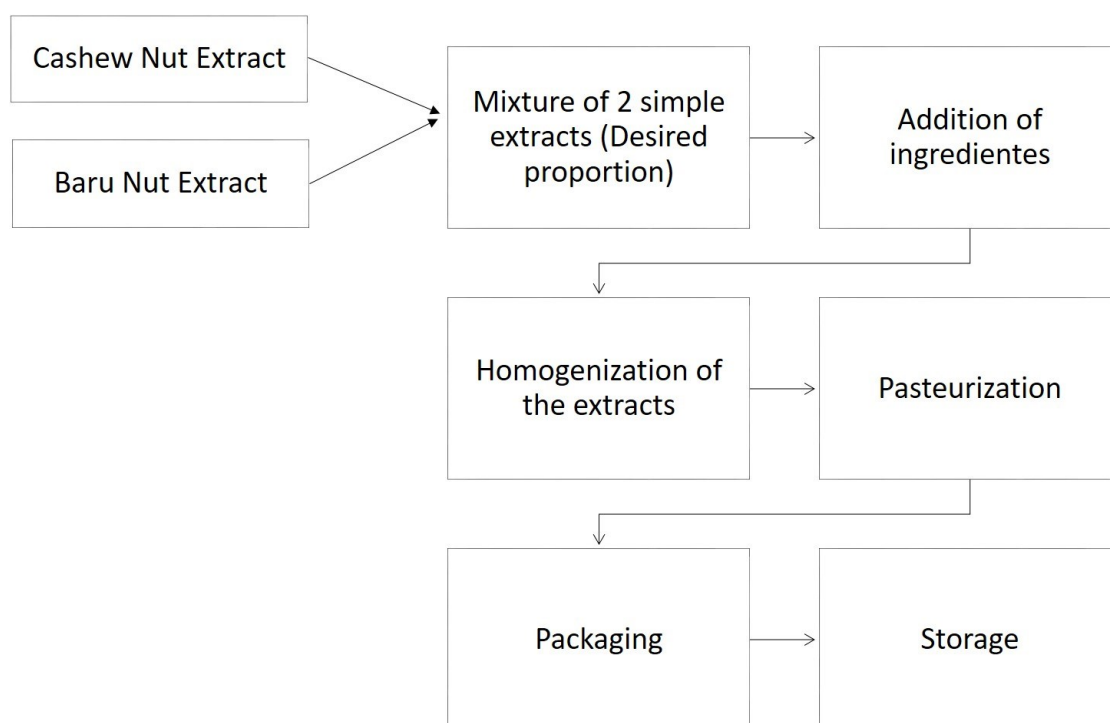
The ECN was produced according to the production of EHCN, and the processing steps are shown in Figure 2. The cashew nuts were sanitized with 200 ppm sodium hypochlorite for 15 minutes and washed with running water. Then, they were left to soak in water at room temperature (nut: water ratio of 1:2) for 24 hours and macerated at 95 °C for 5 minutes. After the maceration process, the nuts were milled in an industrial blender for 3 minutes using a nut to water ratio of 1:8. The extract was filtered twice with the aid of a 1mm sieve and filter cloth to remove the remaining residues. Then, the other ingredients were added, as follows: 0.05% xanthan gum, 2% sucrose, 0.1% salt, 0.03% sorbate, and 0.25% inulin. The mixture was homogenized, pasteurized at 93 °C for 3 minutes, and packaged at 70 °C.



**Figure 2.** Production of water-soluble extract of cashew nuts (ECN).

#### PREPARATION OF THE MIXED WATER-SOLUBLE EXTRACT OF BARU NUTS AND CASHEW NUTS (MEBCN)

The mixed extracts (Figure 3) were produced using three different proportions of the EBN and ECN extracts (60:40; 50:50, and 40:60 v/v). After mixing the pure extracts (without addition of the ingredients), 0.25% xanthan gum, 2% sucrose, 0.1% salt, 0.03% potassium sorbate, and 0.75% inulin were added.



**Figure 3.** Production of mixed plant extract of baru nuts and cashew nuts (MEBCN).

### PROXIMATE COMPOSITION

The proximate characterization (n=4) of the mixed extracts was performed according to the methodologies proposed by Instituto Adolf Lutz (2008), namely: moisture (method 012/IV), ash (method 018/IV), total lipids (method 321/IV, with adaptations), crude protein (method 036/IV, with adaptations). The total carbohydrates contents were calculated by difference (Equation 1) Zenebon, Pascuet and Tigela (2008).

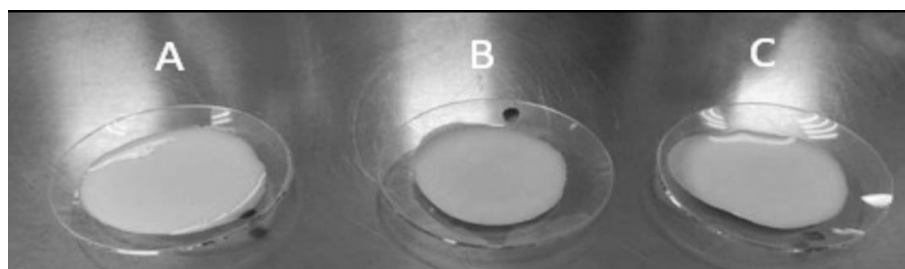
$$\text{Carbohydrates content (g/100g)} = 100 - (\text{moisture} + \text{lipids} + \text{crude protein} + \text{ash}) \quad (\text{Equation 1})$$

### RESULTS AND DISCUSSION

In the first step, preliminary tests were carried out to determine the best nut to water ratio (baru and cashew) for the production of the pure extracts, as well as the type and concentration of gum. The best nut to water ratio was 1:6 and 1:8 (w/w) for baru nuts and cashew nuts, respectively, which presented a higher yield, characteristic nut flavor, and low watery taste. Lima *et al.* (2017) prepared a water-soluble extract of cashew nut using a nut to water ratio of 1:10 (w/w), while Vieira, Zuñiga and Ogawa (2020) studied a baru nut extract in a ratio of 1 :3 (w/w) (almond: water).

Concerning the type and concentration of gum, tests were carried out aimed to provide viscosity and stability in the extracts, with characteristics closer to those found on the market. Hydrocolloids are necessary for the stabilization of beverages, even in small concentrations, to keep the pulp in suspension without significantly altering the sensory quality Godoy, Antunes and Zonta (1998). In this study, phase separation was observed when using CMC (alone or combined) after 48 hours, for both extracts. According to Vesterinen *et al.* (2002), the stability of CMC can be affected by temperature, pH, concentration, and some biological agents. The xanthan gum and iota carrageenan presented the best results; however, iota carrageenan has a higher cost and limited availability, thus xanthan gum was selected for the study.

After determining the nut to water ratio, and the type and concentration of gum, the mixed extracts of baru nuts and cashew nuts were produced in different proportions (40:60, 50:50, and 60:40). The resulting extracts were homogeneous and stable, as shown in Figure 4.



**Figure 4.** Mixed extracts of water-soluble extract of cashew nuts (ECN) and water-soluble extract of baru nuts (EBN) in the proportions 40:60 (A), 50:50 (B), and 60:40 (C).

The characterization of the mixed extracts (MEBCN) is shown in Table 1. The moisture contents ranged from 87.96 to 88.05%, proteins from 1.51 to 1.59%, lipids from 5.35 to 6.28%, ash from 0.30 to 0.34, and carbohydrates from 3.74 to 5.03%.

**Table 1.** Physicochemical characterization of mixed extracts of baru nuts and cashew nuts.

Parameters (%)	Mixed extract of baru nuts and cashew nuts (MEBCN)		
	Proportion (v/v)		
	40:60	50:50	60:40
Moisture	87.70 ± 0.01 <sup>c</sup>	88.05 ± 0.02 <sup>a</sup>	87.96 ± 0.01 <sup>b</sup>
Proteins	1.57 ± 0.00 <sup>a</sup>	1.59 ± 0.00 <sup>a</sup>	1.51 ± 0.00 <sup>a</sup>
Lipids	5.35 ± 0.02 <sup>a</sup>	6.28 ± 0.01 <sup>a</sup>	6.22 ± 0.01 <sup>a</sup>
Ash	0.34 ± 0.00 <sup>a</sup>	0.34 ± 0.00 <sup>a</sup>	0.30 ± 0.00 <sup>a</sup>
Carbohydrates	5.04 ± 0.50 <sup>b</sup>	3.74 ± 0.30 <sup>a</sup>	3.94 ± 0.60 <sup>a</sup>

NOTE: \* Results expressed as mean ± standard deviation. Means with equal lowercase letters, in the same column, do not differ at the level of  $p > 0.05$  by Tukey's test at 95% confidence.

Due to the No significant difference was observed among all mixed extracts for the protein, lipids, and ash contents. Schmitz (2018) studied pure cashew and baru extracts and reported protein contents of 2.28 and 2.82%, lipids of 4.10 and 4.86%, and ash of 0.32 and 1.03%, respectively. The protein contents found by those authors were higher than the findings of the present study, while lower fat and ash contents were observed when compared to the composite extract. In contrast, Diniz, Jesus and Bertan (2020) reported 1.87 and 1.39% protein, 8.03 and 5.02% lipids, and 0.27 and 0.43% ash for pure cashew nuts and baru nuts extracts, respectively. The values reported by Diniz, Jesus and Bertan (2020) in the pure extracts were similar to the mixed extracts of this study for protein contents, and higher for fat and ash contents. This difference was probably due to the difference in raw materials and ingredients used in the production of the extract as well as the processing conditions.

Concerning the moisture contents of the mixed extracts, the extract 50:50 had the higher moisture content (88.05%), followed by the extracts 60:40 (87.96%) and 40:60 (87.70%). Diniz, Jesus and Bertan (2020) produced a pure extract of baru nuts and cashew nuts using the same proportions and ingredients of the present study and reported moisture contents of 88.65 and 87.58% for the pure baru nut extract and cashew nut extract, respectively. The mean moisture contents of the two pure extracts (87.58 + 88.65%) studied by Diniz, Jesus and Bertan (2020) was 88.12%, which is similar to that of the mixed extract in the proportion of 50:50 (v/v). Schmitz (2018) reported moisture contents of 87.11% and 80.97% for pure cashew nuts extract and baru nuts extract, respectively, similar to those found for the mixed extracts made in this study.

Regarding the carbohydrate contents, the extract 40:60 presented a higher value (5.04%). This result is due to the carbohydrate contents were determined by difference, and the mixed extract at a ratio of 40:60 exhibited a lower lipid content (5.35%) when compared to the other extracts, thus presenting the higher carbohydrate content.

Carvalho *et al.* (2011) studied broken rice extract, brown rice extract, and soybean extract and reported higher moisture and ash contents, and lower protein, lipids, and carbohydrate contents for all extracts when compared to extracts from the present study. This difference may be due to the difference in the raw material used. When comparing the extracts of this study with the soybean extract reported by the authors, which is the most produced worldwide Sig Combibloc Magazine (2015), they showed higher proteins, lipids, and carbohydrates contents. Tamuno and Monday (2019) produced water-soluble extracts of cashew nuts and reported lower moisture and lipid contents, and higher ash, protein, and carbohydrate contents. The authors concluded that the water-soluble extract of cashew nuts can be used as a substitute for cow's milk due to its high nutrient content. The difference between the results of this study and the literature may be due to the varieties of fruits used, the genetic variability, cultivation period, location, climate, processing conditions, among others.

According to RDC 268, of September 22/2005, to be considered as a protein aceous product, the plant-based products must have a minimum of 3.0% protein, thus the water-soluble soybean extract is within the requirements of the Brazilian law Brasil (2005). In turn, all mixed extracts cannot be considered a protein product, once the protein contents ranged from 1.51% to 1.59%. However, these extracts presented interesting protein levels since they had higher protein



contents when compared to broken rice (0.73%), brown rice (0.84%), and soybean (2.5%) extracts reported by Carvalho *et al.* (2011).

### **CONCLUSIONS**

The methodology used in this study has proven to be effective to produce water-soluble plant extracts from cashew nuts and baru nuts, both in pure and combined forms. The physicochemical characterization of the extracts showed that they are interesting from a nutritional point of view, as they presented considerable levels of lipids, proteins, and minerals, although they cannot be characterized as proteinaceous products.

Therefore, the water-soluble plant extracts can be considered as a good source of macronutrients for individuals intolerant to lactose, allergic to milk protein, as well as for the vegan public and/or those who enjoy the consumption of such products.

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## Título em português

### RESUMO

Resumo em português.

**PALAVRAS-CHAVE:** todas em letra minúscula, separadas por ponto e vírgula.

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