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Characterization and Sensory Properties of the Condensed Milk from the Brazil Nut

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Abstract

The Brazil nut is a native seed from the Amazon region with a high nutritional value. Products of this seed can meet the demands of consumers who are looking for a healthy diet. This commercial potential has stimulated the development of a water-soluble condensate from the Brazil nut, which was characterized and compared to the commercial soy product. The product proved to have lower fat (5.87%) and higher protein (3.29%) than soy product with 6.68% and 2.39%, respectively. In the sensory test, approximately 90% of the participants stated that they liked the commercial soy condensate equally well as the Brazil nut formula. After 60 days of shelf life, the Brazil nut formula presented an acceptable appearance, which makes it a possible alternative for consumers in search of healthy nutrition.

Keywords: *Bertholletia excelsa* H.B.K.; *Shelf-life*; selenium; acidity, viscosity

[1] Prof. Ariane Kluczkovski is expert in by-products from Amazon forest such as Brazil nut and toxicology. Relevant publications: 1) De Oliveira, T.S; Freitas-Silva, O; Freitas-Sá, D., **Kluczkovski, A. M.,** Furtado, M., Campelo, P. 2020. Application of Brazil nut oil microparticles in a brownie recipe. Europ. Acad. Research 3(2)905-920; 2) **Kluczkovski, A. M.**; Lima, N. P. C.; Oliveira, M. K. S. 2016. Brazil nut powdered milk properties. J. of Food Proc. and Preservation 40:1-6, 2016. Corresponding author: mendonca-ariane@hotmail.com

1. INTRODUCTION

The Brazil nut (*Bertholletia excelsa* H. B. K.) harvested in tropical regions is well known by nutritional and antioxidant properties (Hughenin et al., 2015). Besides being an export product, it is an ingredient for the development of new products in the food industry. Its composition includes fibers, selenium (Se) and a high nutritional value containing oils and protein (Dos Santos et al., 2017). After being harvested in the jungle, the Brazil nut is improved through various dehydration stages, and at the end of the process it is sold with or without peel. The nuts of irregular format or which do not meet the export standards can be used to produce by-products. The “plant-based milk” sector is still expanding, especially their functionality may be to addresses different needs and lifestyles, to boost energy, fight ageing, fatigue and stress, target specific diseases (Sethi et al., 2016). Some studies have used tree nuts as raw material to produce new products for specific groups of consumers, such as almonds and hazelnuts (Lipan et al, 2020; Silva et al., 2020; Aydar et al, 2020). Brazil nut, for example, has been studied to produce flour/cake and oil (Zanqui et al., 2020; Gomes et al., 2019). The “defatted cake” fraction from the Brazil nut flour has protein, fiber and mineral (mainly Se) values that exceed those of the nut itself (Souza & Menezes, 2004). On the other hand, the Brazil nut “milk” is another product and intended for use in cooking and as ingredient in beverages (Silva et al., 2019) Among the vegetable raw materials for the preparation of "plant-based milks", soybean (*Glycina max*) also have applications in the preparation of "milk" by-prodcuts to expand market options to diversify the diet (Kohli et al., 2017). In the sensory analysis, this product gets lower acceptance grades when compared to the commercial condensed milk, from bovine, but it still obtains an intermediate acceptance score from consumers. In the context of the increasing demand for highly nutritious foods, the aim of this study was to produce a Brazil nut condensed “milk”, through the development of a water-soluble extract and evaluate the proximate composition, properties and sensorial aspects.

2. MATERIAL AND METHODS

2.1 Ingredients

The commercial condensed soy milk (Soymilke®) ingredients were the basis for developing the Brazil nut product. The ingredients were: dehydrated Brazil nuts (extract and protein isolates), sugar, corn glucose and vegetable fat. Different lots of Brazil nuts were used in two different formulas according to table 1, with a difference of 5% in the Brazil nut content. In both formulas were used the following additives: Sodium citrate (0.03%), titanium dioxide (0.05%), Guar gum (0.25%), carrageenan gum (0.03%), Sodium bicarbonate (0.04%), Vanilla (0.50%), refined salt (0.10%), pectin (1.00%) and citric acid (*qsp* pH3.2)

Table 1. Formulas of water-soluble extracts of Brazil nut

Ingredients	Formulas (%)	
	1	2
Brazil nut extract	35.8	30.8
Protein Isolate	4.0	4.0
Syrup 64º Brix	39.5	44.5
Corn Glucose	4.0	4.0
Vegetable fat	4.0	4.0
Water	12.7	12.7

% mass/mass

2.2 Preparation of the Raw material

Brazil nuts were acquired from a wholesale located in the city of Manaus-AM-Brazil and peeled according to Ferberg et al. (2002). For each formula, different batches of raw material were used. The nuts were immersed in a boiling NaOH 2% solution for 1 min. (proportion 1:2 nut: NaOH). They were drained in cold water for 2 min. in the proportion 1:5 (nut: water). The skin was removed manually, and the nuts were immersed in cold water for 10 min. to eliminate the NaOH residues.

2.2.1 Preparation of the "cake" and the water-soluble extract

According procedures adapted from Cardarelli and Oliveira (2000). The nuts were crushed in a Walita® 600w blender and then mechanically pressed to extract the oil and separate the "cake". The "cake" was diluted in drinking water at 75º C in the ratio 1:2 (nut: water) and 0.2% of carboxymethylcellulose (CMC) was added with blending for 2 min, followed by citric acid 0.05%+sorbate 0.2%. The material was pasteurized at 75 °C/20 min, after which the extract was freeze dried.

2.2.3 Protein Isolate

The defatted “cake” was dispersed in the ratio of 1:15 with NaOH 2% solution (pH>9) according to Gloria & Regitano D'Arce (2000). The suspension was kept under magnetic stirring for 2 h/60 rpm. The precipitate was subjected to two consecutive washes in the same type of solution. It was added to the supernatant HCl 0.3 N with a pH of up to 4. The suspension was stirred for 30 min and then centrifuged at 1500 rpm/20 min. The precipitate was washed twice in an acid solution and dried in a forced air circulation oven at 40 °C/4 h.

2.3 Preparation of the Water Soluble Extract

Formulas were carried out with: 60% sugar+ 40% water, heated to 64° Brix. Additives were added, and homogenized with corn glucose, refined salt, vegetable fat, protein isolate and extract. Sodium bicarbonate (pH> 4.3) was added and stirred for 5 min. and sodium citrate, guar and carrageenan gum. Vanilla aroma and white dye were added under stirring for 1 min. and the extract was cooled for 8h.

2.4 Characterization of the Water-Soluble Extract of Condensed Brazil Nut

2.4.1 Proximal and physical-chemical composition

Brazil nut and condensed commercial soy formulas were analyzed in triplicate, according to A.O.A.C. (2016) regarding their moisture content (*mc*), ashes, proteins, lipids and crude fibers. The Se and Sodium contents were determined by the method of Olson et al. (1975) and by the 985.35 and 984.27 methods from Horwitz (2005), respectively. Physical-chemical analysis were carried out to acidity, pH, and total soluble solids (°Brix) after 0, 15, 30, 45 and 60 d. of storage, according to A.O.A.C (2016). The viscosity was assessed with a Brooksfield® viscometer uswith ing spindles 62, 63 and 64, rotating at 0.3 to 100 rpm at 25 °C.

2.4.2 Sensory Analysis

The sensory tests were carried out with 120 university students and faculty members, of both sexes, between 18-50 years of age, with approval of the Ethics Committee from the Federal University of Amazonas-UFAM NºCAAE 19623813.8.0000.5020. The samples were randomly served to assessors, at room temperature, at the same time in transparent plastic cups with standardized amounts (10 g) and encoded with 3 (three) digits obtained from a table of random numbers. The untrained assessors signed the Free and Informed Consent Term (FICT), and, during the evaluation, the assessor remained alone in a closed booth with artificial lighting with white light. The Brazil nut and commercial soy formulas were submitted to the acceptability test (Dutcosky, 2011). The acceptability index (%) was calculated by the equation: the average sum of the results of the assessors/number of points used in the range of evaluation x 100 (Oliveira et al., 2014). In this test, the participant assessed in a nine-point hedonic scale. The anchors point of the scale were the expressions: (a) superior point: "enjoyed extremely" and (b) inferior point: "disliked extremely". Only formula 2 was tested according to their color, flavor, sweetness, aroma, and overall appearance attributes, because it showed less Se content, in a safe level to the assessors.

2.5 Statistical Analysis

To test the hypothesis that the products had the same physical-chemical composition, we used ANOVA (*Analysis of Variances*) and, if the assumptions of normality and homogeneity of variances were not met, we used Kruskal-Wallis ANOVA. The post-hoc test for multiple mean comparison was performed by means of Tukey HSD. To compare the acidity index, pH and Brix of shelf time, we first tested the assumptions of normality and homoscedasticity, or homogeneity of variances, of the data sets. To check the normality of the frequency distributions, we used the Shapiro-Wilk test, and for the homoscedasticity between two data sets, we used Bartlett's conventional tests and the Fligner-Killeen test (Conover et al., 1981). In the cases where the data met the assumptions for the application of parametric statistics, we used the Student t test to compare two means, and classical ANOVA to compare more than two means. In all other cases, the Wilcoxon-Mann-Whitney U tests and the Kruskal-Wallis H test were chosen. The sensory tests were analyzed with the Wilcoxon T-test and the Kruskal-Wallis H test.

3. RESULTS AND DISCUSSION

3.1 Yield and characterization of extracts

Each kilo of Brazil nut yielded 715 g of "cake", producing 1 liter of extract in the proportion 1:2 (nut:water). Each liter of extract resulted on average in 277.25 g of freeze-dried extract, producing: *formula 1*: 774. 44 g, and *formula 2*: 900.16 g. Regarding the proximal composition of the Brazil nut and condensed commercial soy formulas, all parameters showed statistically significant differences between the three products ($p<0.0183$), as can be seen in Table 2. The two products prepared from the Brazil nut showed a similar *mc* ($p>0.2454$), higher than that found for the soybean product. Formula 1 presented higher ash, protein, and fiber contents than formula 2, with a smaller proportion of extract/nut. The soybean product, however, showed higher carbohydrate content.

Table 2. Composition of Brazil nut and soy formulas.

Variables	Formulas			P[3]
	Formula 1[1]	Formula 2[2]	Commercial Soy	
pH	6.59 (0.01)^a	6.88 (0,05)^b	6.52 (0.03)^a	0.0177
Acidity	2.91 (0.11)^c	0.75 (0.10)^a	1.06 (0.11)^b	0.0182
Brix°	46.67 (0.58)^c	50.31 (0.24)^b	64.83 (0.29)^a	0.0168
mc (%)	37.03 (0.54)^b	38.18 (1.13)^b	29.95 (0.93)^a	0.0001
Ashes (%)	1.43 (0.01)^c	0.96 (0.05)^b	0.57 (0.02)^a	0.0001
Lipids (%)	7.57 (0.04)^c	5.87 (0.56)^a	6.68 (0.10)^b	0.0006
Protein (%)	4.69 (0.14)^a	3.29 (0.15)^b	2.39 (0.07)^c	0.0182
Carbohydrates (%)[4]	49.29 (0.43)^c	51.68 (0.93)^b	60.34 (0.99)^a	0.0001
Fibers (%)	0.18 (0.01)^a	0.13 (0.02)^b	0.00^c	0.0164

Values in parenthesis are standard deviation. [1] Formula with 35.8% of extract; [2] Formula with 30.8% of extract; [3] p-value by ANOVA between the products; [4] calculated by differences

Fleitas et al. (2001) prepared soy-based sweetened condensed milk with: 6.8% of proteins, 5.0% of lipids, 0.3% of ash, 48.2% of carbohydrates, with 60.3° Brix and pH of 6.8. Olaoye (2015) quality parameters and shelf stability of sweetened condensed vegetable milks produced from four varieties of soybeans (Glycine max). The author found during storage period, were within 6.5 to 7.0 while crude fiber (%) varied between 1.34 and 2.14. The highest contents of 2.44 % and 19.82% were recorded for ash and protein, respectively. In their samples the lipids ranged in average of 7.82-8.43% at the beginning of storage. In our study, the lipid content (7.57%) was like their results. According to table 3, the two Brazil nut formulas presented values for crude fibers, while these were not detected in the commercial soy condensate sample. The pH of the Brazil nut formulas was like commercial soy product but had lower acidity. It can be explained by the addition of sodium bicarbonate to adjust the acidity. On the other hand, the Brazil nut formulas revealed a higher protein content and lower values for sugars than the commercial soybean condensate. The brix levels of the Brazil nut formulas were lower than commercial condensed soymilk sample. In table 4, significant differences can be seen in the levels of sodium and Se of the three products ($p<0.0063$). Formula 2 showed the lowest sodium content ($p<0.0062$). Se was not detected in the soy condensate. Formula 1 showed an average value of 500 µg%, and formula 2 of 150 µg%. The value obtained for both formulas was greater than that observed in the commercial soy product, which is not an acknowledged source of Se as Brazil nut. The nuts used in the formulas were obtained from a wholesaler, but without a description of the specific geographical locality of the Amazon to provide an indication of Se levels. Because the Institute of Medicine (2000) considers 400 µg/day to be the maximum recommended intake of Se, formula 1 was considered "not safe" for consumption and not offered in the sensory tests. Formula 2, on the other hand, was considered as a suitable food to be tested. Each 100 g of formula 1 contained 81.5 mg of sodium, and the condensate of formula 2 contained 63.7 mg, corresponding to 5.43% and 4.2% of the maximum recommended daily intake for adults, respectively.

Table 3. Sodium and Selenium levels in the formulas

Mineral	Formulas[1]			P[2]
	Formula 1	Formula 2	Commercial Soy	
Sodium (mg/100g)	81.5 (0.29)^c	63.7 (1.01)^a	71.4 (0.32)^b	0.0080
Se (µg /100g)	500.0 (0.04)^a	150.0 (0.01)^b	0.0^c	<0.0001

[1] Values in the parenthesis are standard deviation; different legends in the same line mean the values are statistically different; [2] p value

Regarding the physical-chemical characteristics of the products, differences were observed for acidity, pH, and Brix measurements of the formulas throughout their shelf life, as shown in table 4. The acidity level differed between the formulas in the measurements taken after 30 and 45 days (p< 5.98). pH values were only similar between the formulas after 30 d. Brix values differed between the formulas throughout the shelf life (p=0.0080).

Table 4. Physical-chemical variables of Brazil nut formulas over 60 d. of storage

Variables	Shelf-life	Brazil nut formulas		p
		1	2	
Acidity	15	1.06 (0.23)[a]	0.80 (0.00)[a]	0.7000
	30 *	0.79 (0.00)[a]	0.40 (0.00)[b]	<0.0001
	45 *	0.80 (0.00)[a]	0.39 (0.00)[b]	<0.0001
	60	0.66 (0.23)[a]	0.40 (0.01)[a]	0.4000
pH	15 *	6.61 (0.02)[b]	6.84 (0.02)[a]	0.0002
	30	6.65 (0.04)[a]	6.69 (0.06)[a]	0.4127
	45 *	6.43 (0.11)[b]	6.90 (0.02)[a]	0.0170
	60 *	6.61 (0.03)[b]	6.88 (0.07)[a]	0.0043
Brix	15 *	45.33 (0.38)[a]	48.42 (0.38)[b]	0.0006
	30 *	45.33 (0.38)[a]	48.42 (0.38)[b]	0.0006
	45 *	44.58 (0.52)[a]	46.42 (0.38)[b]	0.0079
	60 *	43.42 (0.38)[a]	45.33 (0.38)[b]	0.0036

Values in the parenthesis are standard deviation; Same legends in the same line mean the values are statistically similar; "*" beside the shelf-life means statistical differences between the formulas

After 15 and 60 d. of shelf life, the acidity level of the formula 1 showed an asymmetrical distribution (p<0.0343) and high variability in relation to formula 2 (p<0.0028). Figure 1 reveals that the oscillation of the pH in formula 1 of the Brazil nut was not statistically significant (p=0.0589) throughout the 60 d. of storage, possibly due to the dispersion of the data measured after 45 d. The oscillation of the pH in formula 2 (p=0.0023) occurred between days 15 and 30 (p=0.0174) and between days 30 and 45 on the shelf life (p=0.0250), with the pH remaining stable between 45 and 60 d. (p=0.9281). Figure 1 also shows the statistically significant oscillation in the Brix of both formulas (p< 5.98), over the course of 60 d.

The Brazil nut formula 1, which was prepared with more nuts and less sugar, presented the lowest acidity index, pH and Brix, and may be considered more stable. The acidity index and Brix scale presented a pattern of reduction over the 60 d. The combination of relative humidity (RH) from the storage location (>80 %) and the glass packaging of the product may have caused this instability. The pH showed no reduction or increase pattern.

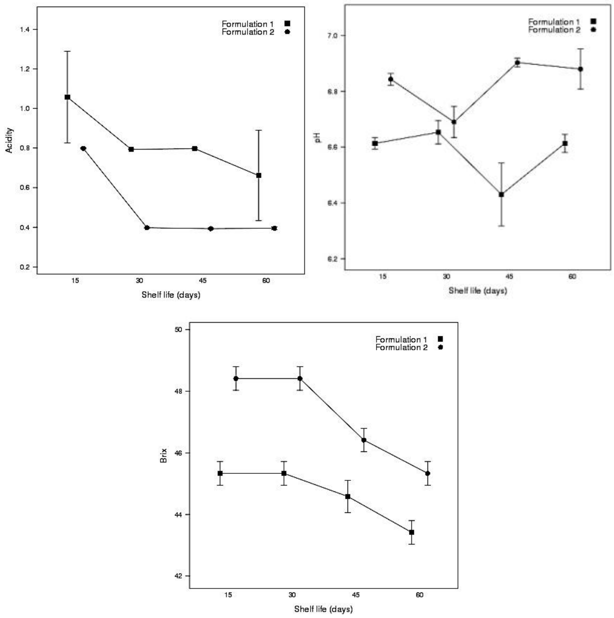

Figure 1. Oscillation of its acidity, pH and Brix of two formulas Brazil nut over 60 days.

Concerning viscosity, figure 3 shows that the three samples were similar. Formula 1 had a slightly lower value because of the lower proportion of sugar in its formulation. All the samples showed a reduction according to rotations per minute, presenting pseudoplastic behavior. This could be explained by the high concentration of solids. The two Brazil nut formulas contained thickeners and have viscosity values that approach that of the commercial soy condensate.

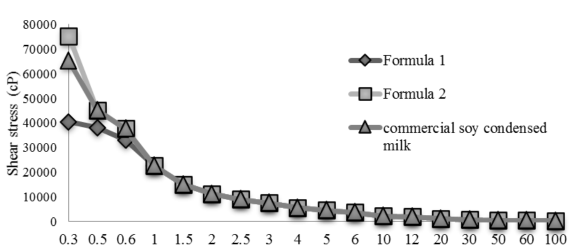

Figure 3. Viscosity in shelf life from plant-based condensed samples

3.2 Sensory Analysis

For the sensory analysis, a panel of 120 non-trained assessors was assembled, of which 85% were female and 15% male, with a mean age of 26.23±6.95 y. Dividing the group of consumers based on frequency of sweet consumption, the panel of assessors showed that 35.00% rarely consumed sweets, 19.17% twice a month, 14.17% once a week and 31.67% always or almost every day. Dividing the group into three age classes, the panel of assessors consisted of 15.83% of young individuals (<20 y.), 55.83 % of young adults (≥20 and ≤30 y.), 21.67 % of adults (≥30 and ≤40 y.), and 6.67% of adults between 40 and 50 y. The statistical analysis shown in table 5 revealed significant differences in the evaluation of the tested products. The commercial soy condensate had the best acceptance regarding color, aroma and flavor (p<0.0486). The Brazil nut formula resembled the soy concentrate in the items sweetness and overall evaluation (p>0.4200). The purchase intention of both products did not differ statistically (p=0. 3968), and the indicators for acceptance and intention of consumption were also similar (p>0.2119).

Table 5. Results of sensory tests, general acceptability and consumption intention of the Brazil nut and commercial soy formulas.

	Formulas Acceptability %		
Properties	Brazil nut	Commercial Soy	p
Color	88.33[a]	95.00[a]	0.6225
Aroma	72.50[a]	88.33[a]	0.2119
Flavor	82.50[a]	86.67[a]	0.7487
Sweetness	84.17[a]	86.67[a]	0.8483
General acceptability	89.17[a]	90.83[a]	0.9011
Consumption Intention	68.33[a]	77.50[a]	0.4478

Same legends in the same line mean statistical similar values.

McClements et al., (2019) reported many consumers, are reluctant to adopt plant-based milks because they do not like the flavor or they do not behave in the same way as bovine milk, for example, when added to hot beverages or used in cooking. In this sense the Brazil nut formula seems to be an alternative with good acceptability at least comparing to the soy formula.

4. CONCLUSIONS

Each kilo of dehydrated Brazil nut yielded a different amount of the proposed formulas. Formula 1 was considered more stable in storage than formula 2. However, the product should be tested with different storage temperatures in order to extend the *shelf-life* of 60 d. It is important to emphasize that in the preparation of products with Brazil nut, a prior assessment of the Se content is essential in order to meet the daily intake parameters and to avoid toxicity. In the sensory analysis, the commercial soy product showed better acceptance of color, aroma and flavor. The product prepared with Brazil nut had a similar acceptance as those based on soybeans regarding sweetness, general evaluation and purchase intention. In this sense, we suggest the addition of coloring and flavoring agents to make the Brazil nut product more attractive to the consumer.

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