Soy and Brazil nut beverage: processing, composition, sensory, and color evaluation

Bebida de soja e castanha do Brasil: processamento, composição, avaliação sensorial e de cor

Ilana FELBERG[1]*, Rosemar ANTONIASSI[1], Rosires DELIZA[1],
Sidinea Cordeiro de FREITAS[1], Regina Celia Della MODESTA[1]

Abstract

Despite its high nutritional value, soymilk consumption in Western countries is limited mainly due to undesirable flavors developed during the traditional elaboration process. Brazil nut (*Bertholletia excelsa*) has pleasant flavor and recognized nutritional value. Thus, the aim of this work was to elaborate a soy and Brazil nut beverage exploring the use of two national products of high nutritional quality. The process for manufacturing a soy and Brazil nut beverage consisted of elaboration, formulation, and homogenization of soymilk and Brazil nut milk. The addition of five levels (10, 20, 30, 40, and 50%) of Brazil nut milk to soy beverages was investigated. Although no significant differences in consumer average preference ($p > 0.05$) were observed among the beverages, analyzing both the consumer preference frequency distribution of the products and the Internal Preference Mapping (IPM), it was possible to conclude that the beverage with 30% of Brazil nut milk reached the most adequate performance demonstrating the sensory benefits Brazil nuts brought to the product. Regarding proximate composition, it did not present a better performance in terms of nutritional value, except for the oil content. The soy and Brazil nut beverage presented visual stability and no phase separation despite the non-stability shown by Brazil nut beverage itself. When Brazil nut milk was added to soy beverage, the final product became whiter than soy beverage, which is appealing to consumers who normally search for a clearer soymilk. The soy and Brazil nut beverage processing can be considered an alternative to increase the use of Brazil nuts in the Brazilian diet.
Keywords: *soymilk; Brazil nut; beverages; processing; evaluation.*

Resumo

Apesar do alto valor nutricional do extrato de soja, seu consumo nos países do ocidente ainda é limitado principalmente devido às características sensoriais desagradáveis resultantes do seu tradicional processo de obtenção. A castanha do Brasil (*Bertholletia excelsa*) apresenta sabor agradável e é reconhecida por seu valor nutricional. Para promover a incorporação da castanha do Brasil na dieta do brasileiro é necessário estabelecer melhor exploração industrial. Portanto, o objetivo deste trabalho foi elaborar uma bebida de soja e castanha do Brasil explorando os benefícios de dois importantes produtos nacionais de alto valor nutritivo. O processo de obtenção da bebida constituiu-se de elaboração, formulação e homogeneização dos extratos de soja e de castanha do Brasil. Foram estudados cinco níveis (10, 20, 30, 40 e 50%) de extrato de castanha adicionados à bebida de soja. A bebida de soja contendo 30% de extrato de castanha foi a preferida entre os consumidores que participaram deste estudo, demonstrando o benefício sensorial promovido pela castanha do Brasil. No entanto, ela não apresentou um melhor desempenho em termos de valor nutricional, exceto pelo teor de óleo. Bebidas à base de soja e castanha do Brasil apresentaram estabilidade visual (sem separação de fases), apesar da não estabilidade demonstrada pela bebida de castanha do Brasil isoladamente. Quando o extrato de castanha do Brasil foi acrescentado à bebida de soja, o produto final foi mais branco do que a bebida de soja. Isto é interessante do ponto de vista do consumidor que procura por um extrato de soja mais claro. O processamento da bebida de soja e de castanha do Brasil pode ser uma alternativa para o aumento do uso de castanha do Brasil na dieta dos brasileiros.
Palavras-chave: *leite de soja; castanha do Brasil; bebidas; processamento; avaliação.*

1 Introduction

Soybean is one of the most important agricultural commodities in Brazil. Soybean national production reached 58 million tons in 2007 (IBGE, 2008). However, this highly nutritional food is still very limitedly used in Brazilian diet. The search for more nutritional and healthier foods is increasing due to a significant number of individuals who are motivated to consume low calorie food with less fat and without cholesterol. Soy food has been reported to reduce the risk of several diseases including breast and prostate cancer, osteoporosis, and heart diseases (MESSINA; MCCASKILL-STEVENS; LAMPE, 2006). Among the soy derivatives, soymilk has been distinguished as a highly nutritional value ready-to-drink product which has relatively low cost and is easy to obtain. Unfortunately, soymilk is yet not well accepted in Western countries on account of its beany flavor and adstringency (AL MAHFUZ et al., 2004). The traditional soymilk production method consists basically of soaking the beans, wet grinding (cold water grinding), filtering and cooking, which results in a final product appreciated by the Eastern population. Soymilk resembles cow milk in appearance and can be commercialized either in sterilized or pasteurized form, with or without flavoring addition (BENEDETTI; FALCÃO, 2003).

Recebido para publicação em 12/12/2007
Aceito para publicação em 28/10/2008 (003086)
[1] *Embrapa Agroindústria de Alimentos, Av. das Américas, 29501, Guaratiba, CEP 23020-470, Rio de Janeiro - RJ, Brasil, E-mail: ilana@ctaa.embrapa.br*
**A quem a correspondência deve ser enviada*

Its typical sensory properties are the main reasons that prevent soy from being incorporated into the Brazilian diet. Since the introduction of soy beverages in the Brazilian market in 1997, their consumption has been growing as a consequence of consumers' search for more ready-to-drink and healthy products (MORAIS; SILVA; DAMÁSIO, 2000). Many studies have been carried out to improve product characteristics including alterations in the traditional process (WILKENS; MATTICK; HAND, 1967; BADENHOP; HACKLER, 1970; NELSON; STEINBERG; WEI, 1976), the use of low fat flour, protein isolate and concentrates (RODRIGUES; GOZZO; MORETTI, 2003), as well as the use of varieties without lipoxygenases (SHAOHONG; KOW-CHING-CHANG, 2007). However, factors that impact on the bitter taste and adstringency still remain and their control has demanded great efforts from industries (AL MAHFUZ et al., 2004). The development of soymilk formulations by adding adequate types and amounts of sweeteners, flavorings, and other products according to local market preferences is a way of increasing its acceptance. On the other hand, beverages made from oleaginous and nuts aiming to replace milk in infant foods and supplements were developed in Asia a long time ago. Brazil nut (*Bertholletia excelsa*) is the seed of Brazil nut tree, which is found mainly in the Amazon region, and it is very popular in local culinary. Its consumption is still restricted in other areas of the country, and most of the production is exported to Europe and North America where it is consumed as a delicacy. Brazil nut nutritional value is recognized for its oil composition and high biological value proteins, vitamins, and considerable amounts of minerals (SOUZA; MENEZES, 2004; SOUZA; MENEZES, 2008). The amount of selenium differs widely in Brazil nut with results varying from 0.18 to 32.08 mg.100 g^{-1} (FREITAS et al., 2008). Souza and Menezes (2004) presented the results of proximate analysis of Brazil nut with oil, protein, and dietary fiber content of 67.3; 14.3 and 8.02 g.100 g^{-1}, respectively. Sulfur amino acids content is high in Brazil nut; probably due to the richest food source in these essential amino acids (SUN; LEUNG; TOMIC, 1987; FELBERG et al., 2004), mainly for methionine. On the other hand, the limiting amino acid of Brazil nut is lysine, whose deficiency can be supplied by products rich in this amino acid, soybean for example. Due to its pleasant flavor and recognized nutritional value, an increase in Brazil nut consumption through its incorporation in the Brazilian diet is highly recommended. This work aimed to develop a soybean and Brazil nut beverage with adequate sensory characteristics according to the preference of Brazilian consumers who look for more nutritious and healthier products.

2 Material and methods

2.1 Material

The beverages were prepared with soybean (*Glycine max* (L.) Merr.), var. *IAS-5*, and Brazil nut (*Bertholletia excelsa, H.B.K*).

2.2 Methods

Production of soymilk and Brazil nut milk

Brazil nut milk was prepared as follows: Brazil nuts were ground in water at 75 °C using a Waring Blender in the ratio 7:1 (water: Brazil nuts) for three minutes. Non-soluble particles were separated using an IEC centrifuge model K7165 at 4000 rpm (~2500 g) with a 150 µm nylon filter.

The basic process for soymilk elaboration involved dehulling of the grains, cooking of the dehulled grains for 10 minutes in boiling sodium bicarbonate solution (0.25%) in the ratio 1:3 (soy: solution), cleaning, and draining and grinding with boiling water using Waring Blender in the ratio 1:8 (water: dehulled soybeans) for two minutes followed by centrifugation using an IEC centrifuge model K7165 at 4000 rpm (~2500 g) with a 150 µm nylon filter.

Development of soy and Brazil nut beverages

Soy and Brazil nut beverages were formulated by adding 3% of sugar and 0.2% of salt to soy and Brazil nut milks, respectively. The amount of added sugar and salt was defined in previous tests (FELBERG et al., 2004).

Brazil nut milk with approximately 10% of total solids was added to soy milk with 7% of total solids at proportions varying from 10 to 50% (related to the final beverage) followed by addition of 3% of sugar and 0.2% of salt. The beverage was homogenized at 4000 psi (APV Gaulin model 15 MR). The effect of different proportions of added Brazil nut milk was evaluated in order to establish consumer preference. The most preferred beverage was then submitted to proximate and mineral composition analyses. The processing of the soy and Brazil nut beverage is shown in Figure 1.

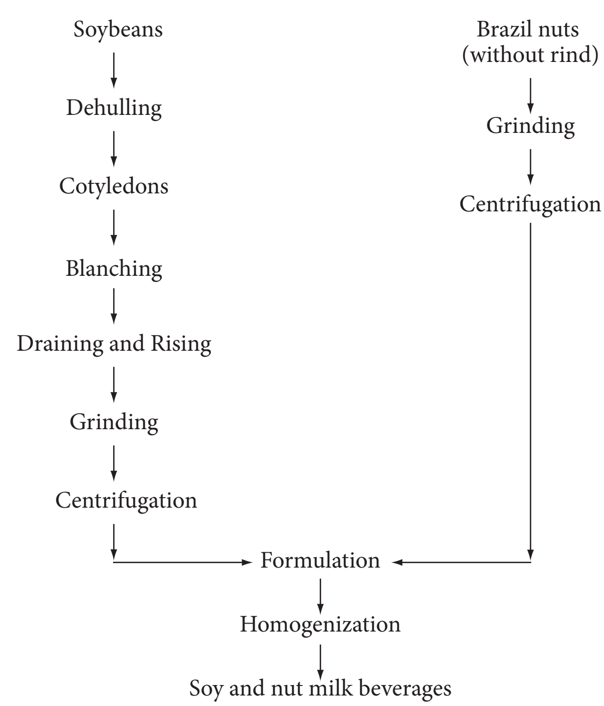

Figure 1. Processing of soy and Brazil nut beverages.

Proximate composition of raw materials and beverages

The proximate composition of raw materials and beverages was carried out according to AOAC (2005). The mineral analysis of samples was conducted in sealed PTFE (Teflon® polytetrafluoroethylene) cups using a microwave oven (Millestone), and the measurements were performed at ICP OES (Inductively Coupled Plasma) according to AOAC (2005). Oligosaccharides were determined by High Performance Liquid Chromatography using sugar Pak column (Waters) and a detector of refractive index with external standardization.

The soybean and Brazil nuts were analyzed with three and nine replicates, and F-Snedecor, and the standard deviation was calculated using STATGRAPHICS (MANUGISTICS, 1993).

Three batches of the beverages were elaborated and analyzed in triplicate. ANOVA was performed to check the differences among samples, and data were analyzed using SAS (2004).

Beverages stability

The beverage stability was evaluated according to Priepke et al. (1980) with modification: 300 mL of each sample was poured into a 400 mL long shape glass Beaker and kept in the refrigerator for seven days, and after this procedure phase separation was verified.

Preference evaluation

Beverages were given to 80 consumers (47 women and 33 men, aged between 18 and 65 years) who were used to drink soy beverages. Before starting the test, the participants were told that the objective of the study was to investigate how much they liked the samples. They read an Explanation and Consent Form, in which it was written that any information collected would be kept strictly confidential and their names would not appear in any analyses or published reports. They signed the referred Consent Form. They also were told that they could withdraw from the study at any time without explanations. All participants volunteered for the study and did not receive any monetary incentive for their participation. Samples were served at 7 ± 1 °C in 50 mL in plastic cups coded with three digit numbers. A nine-point hedonic scale was used to evaluate the beverages, where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely. The order of the sample presentation was balanced and followed a complete block design according to MacFie et al. (1989).

Samples were presented monadically. Participants were supplied with mineral water and were instructed to rinse their mouths between samples' evaluation. Tests were carried out at Embrapa Food Technology Sensory Evaluation Laboratory (Embrapa Agroindústria de Alimentos) between 10:00 am and 4:30 pm. Sensory evaluation data were analyzed using ANOVA, and Tukey test was used to check differences between means. Data were also analyzed using the Internal Preference Mapping (IPM), a principal component analysis (PCA) of the covariance matrix of consumers by products (GREENHOFF; MacFIE, 1994), which clusters consumer groups with similar preferences using the SAS (2004).

Color instrumental analysis

The color instrumental analysis was carried out by measuring the reflectance in S & M Color Computer model SM-4-CH Suga in the Hunter system. The color parameters measured were: L = lightness (0 = black, 100 = white); a = redness (–80 to zero = green, from zero to 100 = red); and b = yellowness (–100 to zero = blue; from zero to +70 = yellow), and WI = whiteness (perfect white is a perfect reflecting diffuser, which has a value of 100). Calibration readings for reference were done with the white plate: L = 90.21; a = –2.38, b = 1.40. The total color difference (ΔE) may also be calculated $(\Delta E) = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$. The samples were placed in a 5 cm wide and 2 cm high Petri plate, and four readings were done for each sample. The ANOVA was carried out on data, and the Tukey and t-Student ($p < 0.05$) tests were performed for mean comparisons.

3 Results and discussion

3.1 Proximate composition of Brazil nuts and dehulled soybeans

Proximate data for dehulled soybeans and Brazil nuts are shown in Table 1. Dehulled soybeans presented higher levels of protein, carbohydrates and ash than Brazil nuts. On the other hand, Brazil nuts had tree times more oil than the dehulled soybeans ($p < 0.05$). The results obtained for the soybeans are similar to those found by Felberg et al. (2004) for the same variety harvested in São Paulo, Brazil, and proximate analysis results of Brazil nuts were similar to those found by Souza and Menezes (2004).

Mineral composition results are shown in Table 2. Brazil nuts presented higher content of P, Mg, Cu, Se, Zn, and Cr compared to dehulled soybeans ($p < 0.05$). On the other hand, dehulled soybeans presented higher values for Fe, K, and Mn. In general, mineral contents can vary due to several factors such as soil composition, variety, and harvesting period, among others (VIEIRA; CABRAL; PAULA, 1999). The variation in Brazil nut selenium content reported in the literature is enormous and Freitas et al. (2008) showed results varying from 0.18 to 32.08 mg.100 g^{-1} due to the content of selenium in soils, varieties

Table 1. Proximate composition (g.100 g^{-1}) of Brazil nut and dehulled soybeans (dry weight).

Sample	Components (g.100 g^{-1})[a]				
	Protein	Total carbohydrates[b]	Ash	Oil	Crude fiber
Brazil nut	14.35	11.61	3.42	70.62	2.45
Dehulled soybean	42.62	32.43	5.09	19.87	-
F-Snedecor	27653*	28219*	633*	33573*	-
Standard deviation	0.36	0.29	0.44	0.59	-

*significant difference $p < 0.05$; [a]each value is an average of nine determinations; and [b]Carbohydrates by difference (100 – protein – ash – oil).

of nut trees that absorb selenium more efficiently, and region and environmental conditions.

Stachyose, raffinose, sucrose, glucose, and fructose ($g.100\ g^{-1}$) in Brazil nuts and dehulled soybeans are shown in Table 3. Dehulled soybeans presented higher levels of sucrose, glucose, and fructose in comparison to Brazil nuts ($p < 0.05$). Stachyose and raffinose are oligosaccharides present in soybeans. These results are similar to those reported by Trugo, Farah and Cabral (1995) for the same soy variety. Holland, Unwins and Buss (1992) and the USDA (2008) reported respectively, 2.4 and 2.33 $mg.100\ g^{-1}$ for sucrose while fructose and glucose were not detected in Brazil nuts.

3.2 Preference evaluation

Means and standard errors of the sample preference scores are presented in Table 4. The ANOVA results showed no significant differences for the preference ($p > 0.05$) among the studied beverages.

Despite the low means achieved by samples, analyzing the consumer score frequency distribution histograms for each beverage (Figure 2), it was verified that some consumers liked them while others rated the products with low scores. Sample 4 (30% of Brazil nut milk) and sample 5 (40% of Brazil nut milk) were the least rejected. These results were achieved by applying univariate analysis, in which it is assumed that all participants have the same behavior and the mean value is representative of the entire population tested (MacFIE; THOMSON, 1988). IPM (GREENHOFF; MacFIE, 1994), which incorporates data from each individual subject, is a tool which was used to overcome this problem. IPM of the beverages is presented in Figure 3. The first two dimensions of the IPM of the six beverages accounted for 55.2% of the variance (dimension 1: 31.6%; dimension 2: 23.6%). Results showed a consumer preference segmentation for the evaluated samples because participants were spread into the four quadrants of the graphic. This particular distribution indicated that there was a preference of specific products for specific consumers in terms of appreciation clearly showing that averaged hedonic ratings did not provide a complete and accurate account of consumer preferences. However, analyzing the dimension 1 of both the consumer plots (Figure 3a) and product maps (Figure 3b), it is possible to see that consumer preferences were oriented towards the beverage with 30% of Brazil nut, as the majority of fitted consumers were located close to it followed by the product with 40% of Brazil nut. Moving left to right on the first dimension, beverages prepared with 100% soy, 50%, and 10% of Brazil nut were the least preferred. Despite being liked by some participants, they do not represent the consumer preference trend for this kind of product. The same results, i.e., consumer preference segmentation of specific products, was observed by Felberg et al. (2004) in evaluation of soy Brazil nut beverage made with whole soy milk.

IPM has been applied to consumer data of several kinds of products aiming to investigate consumer preference (YACKINOUS; WEE; GUINARD, 1999; GUINARD; UOTANI; SCHLICH, 2001; PAGLIARINI; MONTELEONE; RATTI, 2001). Traditional statistical techniques applied to consumer data which examine means (e.g. ANOVA) provide some information about consumer preference; however, they are limited. IPM is a useful tool which has to be used in combination with such techniques to investigate individual preferences as well as population trends.

3.3 Beverages proximate composition

The soy and Brazil nut beverage (with 30% of Brazil nut milk), soy beverage, and Brazil nut beverage proximate composition are presented in Table 5. The soy and Brazil nut beverage (with 30% of Brazil nut milk) was chosen to be analyzed because of the IPM results. This beverage, with total solid levels around 11.40 $g.100\ g^{-1}$ and 2.63 of protein and 3.77 $g.100\ g^{-1}$ of oil, respectively, was considered a product of high nutritional value.

The proximate composition of soy and Brazil nut beverage (30% of nut milk), soy beverage, and Brazil nut beverage were compared and significant differences ($p < 0.05$) in protein, oil, ash, and carbohydrate contents were observed among them. The soy beverage presented higher levels of protein, carbohydrates and ash, and lower levels on oil content compared to the soy

Table 3. Concentration of stachyose, raffinose, sucrose, fructose, and glucose (dry weight) of Brazil nut and dehulled soybeans.

Samples	Sugars ($g.100\ g^{-1}$)[a]				
	Stachyose	Raffinose	Sucrose	Glucose	Fructose
Brazil nuts	nd	nd	2.82	0.04	0.04
Dehulled soybeans	4.77	0.76	6.64	0.37	0.09
F–Snedecor	–	–	1604*	555*	9*
Standard deviation	–	–	0.20	0.03	0.03

*Significant difference $p < 0.05$; [a]each value is an average of nine determinations; and nd = not detected

Table 2. Mineral composition (dry weight) of Brazil nuts and dehulled soybeans.

Sample	Minerals ($mg.100g^{-1}$)[a]														
	P	Ca	Na	Mg	Mn	Fe	K	Al	Co	Cr	Cu	Mo	Pb	Se[b]	Zn
Brazil nut	721.25	159.04	0.14	381.90	1.34	2.82	717.25	0.81	0.10	0.052	2.22	nd	nd	3.44	4.72
Dehulled soybean	613.05	164.88	nd	215.95	2.51	5.05	1830.00	0.84	nd	0.037	1.17	0.12	nd	0.08	3.54
F-Snedecor	83*	2	–	534*	402*	732*	1112*	0	–	17.7*	313*	–	–	104*	141*
Standard deviation	14.52	13.15	–	8.79	0.07	0.10	40.86	0.13	–	0.005	0.07	–	–	0.49	0.12

*Significant difference $p < 0.05$; [a]each value is an average of three determinations; and [b]each value is an average of nine determinations nd < 0,1 $mg.100\ g^{-1}$.

Table 4. Consumer preference for beverages.

Preference	Soy beverage	Soy and Brazil nut beverage (10% Brazil nut milk)	Soy and Brazil nut beverage (20% Brazil nut milk)	Soy and Brazil nut beverage (30% Brazil nut milk)	Soy and Brazil nut beverage (40% Brazil nut milk)	Soy and Brazil nut beverage (50% Brazil nut milk)
Mean scores	4.8	5.0	4.5	5.2	5.1	4.7
Standard error	0.25	0.24	0.25	0.24	0.25	0.27

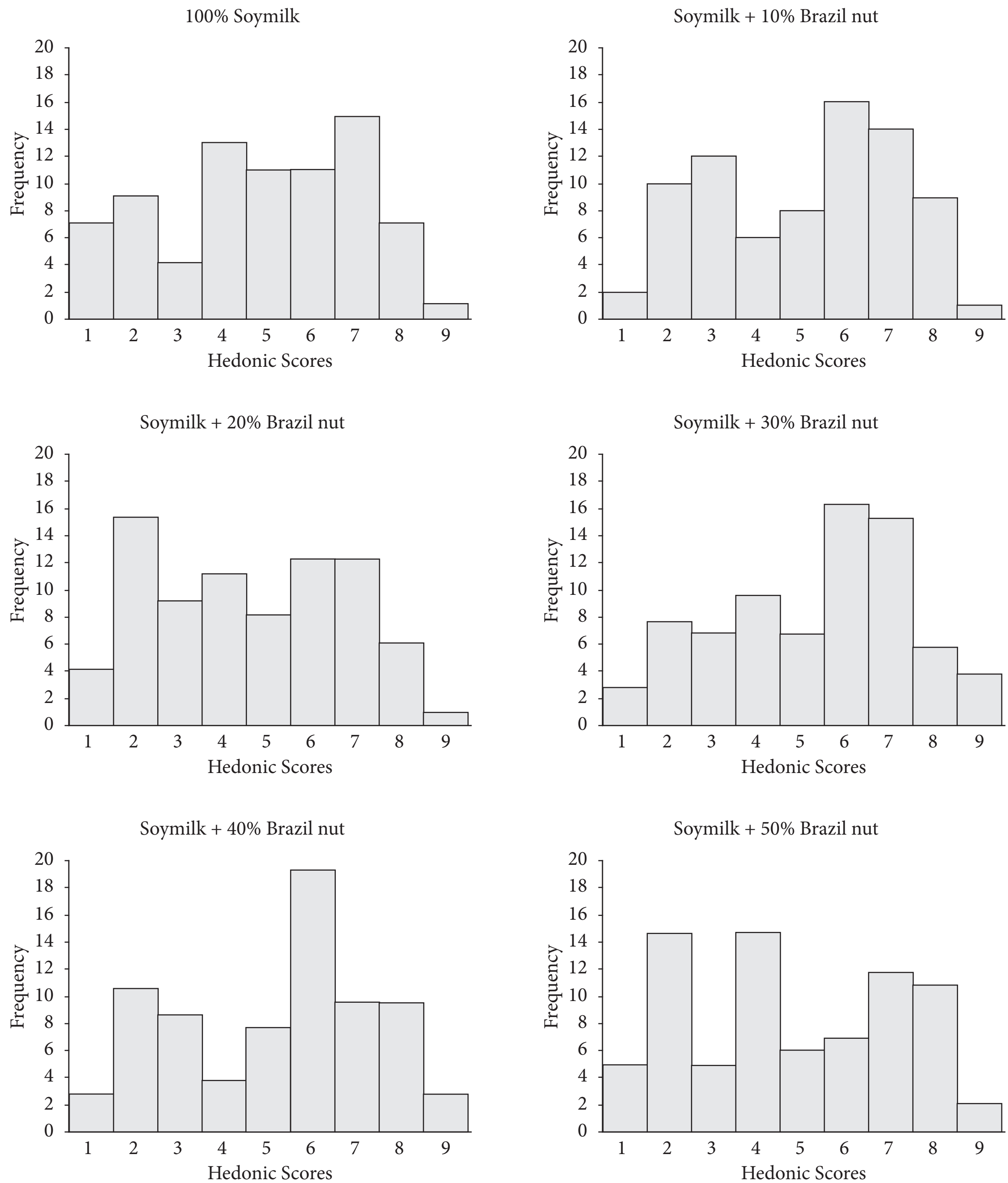

Figure 2. Frequency distribution histograms of consumer scores for the evaluated beverages (scale raging from 1 = disliked extremely, to 9 = liked extremely).

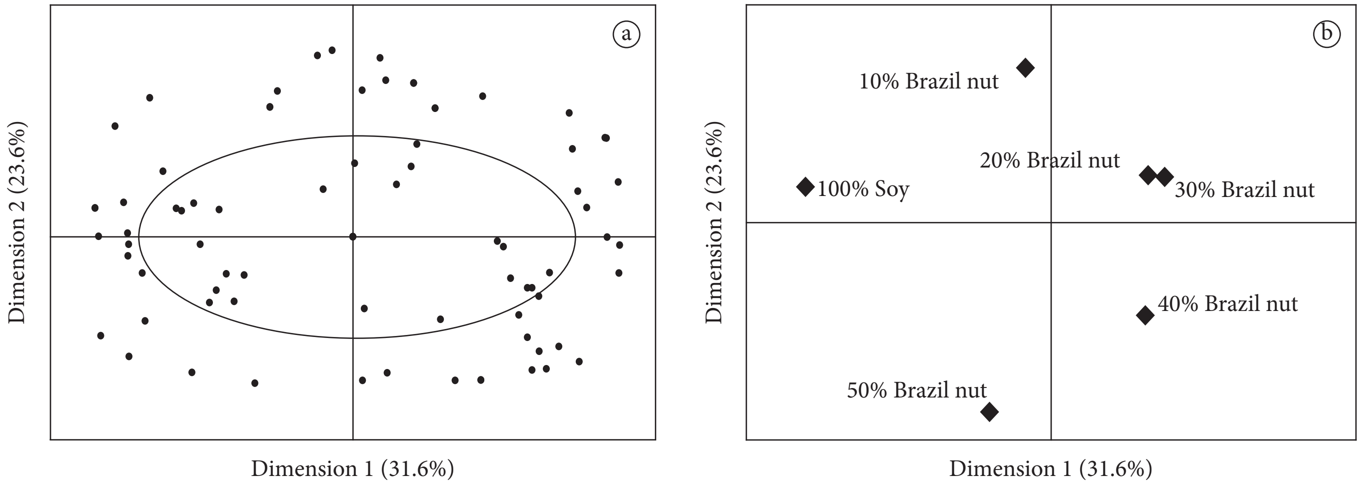

Figure 3. Internal Preference Mapping of soy and Brazil nut beverage: a) position of consumers; and b) position of beverages.

Table 5. Proximate composition of the beverages (g.100 g^{-1})*.

Beverages	Protein		Oil		Ash		Carbohydrates**		Total solids	
	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight
Soy and Brazil nut beverage[§]	2.63	23.05[b]	3.77	33.07[b]	0.53	4.61[b]	4.48	39.27[b]	11.40	–
Soy beverage	3.00	28.78[c]	2.31	22.18[a]	0.57	5.44[c]	4.54	43.60[c]	10.41	–
Brazil nut beverage	1.75	12.91[a]	7.20	52.95[c]	0.52	3.83[a]	4.13	30.31[a]	13.60	–
Standard deviation	–	1.31	–	1.62	–	0.21	–	2.26	–	–

Values in the same column with different following letters are significantly different at 5%; *each value is an average of nine determinations; [§]soy and Brazil nut beverage with 30% Brazil nut milk; and **carbohydrates by difference (100 – protein – ash – oil).

Table 6. Mineral content of the beverages (mg.100 g^{-1})*.

Beverages	P		Ca		Na		Mg		Mn		Fe		K	
	Wet Basis	Dry weight	Wet Basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight
Soy and Brazil nut beverage[§]	58.47	512.76[c]	9.44	82.81[b]	84.70	742.83[a]	21.24	186.26[b]	0.13	1.18[b]	0.26	2.30[b]	113.52	995.42[b]
Soy beverage	47.88	460.03[b]	7.89	75.80[a]	91.84	882.74[b]	17.31	166.22[a]	0.16	1.49[c]	0.28	2.68[c]	135.04	1297.38[c]
Brazil nut beverage	58.57	431.09[a]	12.46	91.64[c]	79.66	586.09[c]	29.97	220.45[c]	0.11	0.78[a]	0.25	1.83[a]	65.64	482.82[a]
Standard Deviation	–	18.46	–	3.10	–	12.13	–	5.63	–	0.07	–	0.122	–	18.93

*Each value is an average of three determinations; values in the same column with different following letters are significantly different at 5%; and [§]soy and Brazil nut beverage with 30% Brazil nut milk.

and Brazil nut milk (30%) and the Brazil nut beverage. As a consequence of Brazil nut milk addition, the latter contained less protein and more oil than the soy beverage, but on the other hand, it contained more protein and less oil than the Brazil nut beverage. Beverages were compared according to dry weight because they presented distinct solid levels.

The mineral composition of the beverages is shown in Table 6. The mineral content was significantly different among them ($p < 0.05$).

The soy beverage presented higher levels of Na, Mn, Fe, and K compared to the Brazil nut beverage that presented more Ca and Mg ($p < 0.05$). In a way, Brazil nut addition did not contribute to the nutritional improvement of the formulation since the referred mineral contents were lower than those of the soy beverage.

The visual separation stability of the beverages is shown in Table 7. Soymilk, soy beverage and soy and Brazil nut beverages (with 10 to 50% of nut milk) did not present visual phase separation; therefore, they could be considered stable. The same did not occur for Brazil nut milk and for Brazil nut beverage, in which a separation of oil layer occurred. The elaboration of soy and Brazil nut beverages by adding the mentioned Brazil nut milk levels did not allow phase separation in the studied beverages.

The sugar composition results of the beverages are shown in Table 8. The soy and Brazil nut beverage presented significantly lower levels of stachyose, raffinose, and sucrose ($p < 0.05$). These results were expected, as stachyose and raffinose were not detected in Brazil nut, as reported in Table 3. The high values of sucrose were due to the addition of sugar to the beverage formulations. In Table 8, it can be observed that there was significant difference ($p < 0.05$) between the soy beverage and soy and Brazil nut beverage in relation to all investigated sugars, except for sucrose that presented high levels due to its addition to the formulation. No glucose and fructose were detected in the beverages (wet basis).

Table 7. Evaluation of the visual separation stability of the beverages.

Samples	Stability by visual separation
Brazil nut milk	separated
Brazil nut beverage	separated
Soy milk	not separated
Soy beverage	not separated
Soy and Brazil nut beverage (10% Brazil nut milk)	not separated
Soy and Brazil nut beverage (20% Brazil nut milk)	not separated
Soy and Brazil nut beverage (30% Brazil nut milk)	not separated
Soy and Brazil nut beverage (40% Brazil nut milk)	not separated
Soy and Brazil nut beverage (50% Brazil nut milk)	not separated

3.4 Color evaluation

The instrumental color analysis of the beverages is shown in Table 9. There were significant differences at 5% level among all investigated attributes. The soy beverage presented the lowest value for luminosity (L = 82.47). The soy and Brazil nut beverage luminosity varied from 84.45 to 87.64 (with 10% and 50% of Brazil nut milk, respectively). Soy beverage presented the highest values for green color ($p < 0.05$) (a = –1.77) and yellow intensities (b = 17.61). The green intensity of the soy and Brazil nut beverage varied from –1.62 to –1.32 and the yellow intensity from 16.47 to 11.52.

The total color difference (ΔE) is the difference between luminosity, green and yellow color intensities, product luminosity, and green and yellow intensities of the white plate used as standard. The soy beverage presented the highest total color difference, and the addition of Brazil nut milk decreased the total color difference.

As expected, the index of whiteness (WI) presented results similar to those obtained for luminosity. When the Brazil nut milk was added to the soy beverage, the final product was whiter than the soy beverage. This result can be very appealing

Table 8. Concentrations of stachyose, raffinose, sucrose, glucose, and fructose of the beverages (mg.100 g^{-1})*.

Beverages	Stachyose		Raffinose		Sucrose		Glucose		Fructose	
	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight	Wet basis	Dry weight
Brazil nut beverage	nd	nd	nd	nd	3.34	24.54ᵃ	nd	nd	nd	nd
Soy beverage	0.42	4.07ᵇ	0.08	0.81ᵇ	3.46	33.27ᶜ	nd	nd	nd	nd
Soy and Brazil nut beverage§	0.29	2.53ᵃ	0.06	0.53ᵃ	3.02	29.96ᵇ	nd	nd	nd	nd
Standard deviation	–	0.09	–	0.03	–	0.87	–	–	–	–

*Each value is an average of nine determinations; values in the same column with different following letters are significantly different at 5%; nd = not detected; §soy and Brazil nut beverage with 30% Brazil nut milk.

Table 9. Instrumental color evaluations[1].

Sample	L	a	b	ΔE	WI
Soy beverage	82.47ᶠ	–1.77ᵉ	17.61ᵃ	17.98ᵃ	75.09ᶠ
Soy and Brazil nut beverage (10% Brazil nut milk)	84.45ᵉ	–1.62ᵈ	16.47ᵇ	16.16ᵇ	77.29ᵉ
Soy and Brazil nut beverage (20% Brazil nut milk)	85.18ᵈ	–1.55ᶜ	15.01ᶜ	14.54ᶜ	78.85ᵈ
Soy and Brazil nut beverage (30% Brazil nut milk)	86.41ᶜ	–1.38ᵃᵇ	13.90ᵈ	13.10ᵈ	80.52ᶜ
Soy and Brazil nut beverage (40% Brazil nut milk)	87.13ᵇ	–1.41ᵇ	12.68ᵉ	11.74ᵉ	81.88ᵇ
Soy and Brazil nut beverage (50% Brazil nut milk)	87.64ᵃ	–1.32ᵃ	11.52ᶠ	10.50ᶠ	83.05ᵃ
F_{sample}	1249.82*	104.84*	4223.60*	1.5×10^{4}*	2.0×10^{4}*

[1]Each value is an average of four determinations; *significantly at 5%; values in the same column with different following letters are significantly different at 5%; L = lightness (0 = black, 100 = white); a = redness (–80 to zero = green, from zero to 100 = red); b = yellowness (–100 to zero = blue; from zero to +70 = yellow) ΔE = total color difference = $\sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$; and WI = whiteness index.

to consumers who search for a clearer soymilk (DELLA MODESTA et al., 2001). In a study on processed soymilk using eleven varieties of grains, Tango et al. (1984) reported luminosity, redness, and yellowness variations from L = 76.73 to 81.73; a = –0.17 to 3.20 and b = 13.83 to 20.23, respectively. The results achieved in the present study were different from those reported by Tango et al. (1984), probably due to the use of different variety and processing method to prepare soymilk.

4 Conclusions

Although no significant differences in the consumer average preference ($p > 0.05$) were observed among the beverages, analyzing both the consumer preference frequency distribution of the products and the IPM, it was possible to conclude that the beverage with 30% of Brazil nut milk reached the most adequate performance. Regarding proximate composition, the soy and Brazil nut beverage with 30% of Brazil nut milk did not present a better performance in terms of nutritional value when compared to soy beverage.

Nonetheless, the addition of Brazil nut contributed positively to consumer preference implying that the production of beverages with soy and Brazil nut may favor its consumption by the population. It was possible to elaborate soy and Brazil nut beverage that presented visual stability and, therefore, no phase separation, despite the non stability shown by Brazil nut milk and Brazil nut beverage.

In relation to color parameters, the addition of Brazil nut milk to the soy beverage yielded a significantly whiter product and decreased the yellow color intensity. Further studies on consumer evaluation of viscosity and appearance are recommended. The soy and Brazil nut beverage processing can be considered an alternative to increase the use of Brazil nuts, a national raw material which is not very frequently used in the Brazilian diet.

References

AL-MAHFUZ, A. et al. Chances of adstringent sensation of soy milk during tofu curd formation. **Journal of Agricultural and Food Chemistry,** v. 52, n. 23, p. 7070-7074, 2004.

Association of Official Analytical Chemists – AOAC. **Official Methods of Analysis.** 18 ed. Washington, DC, 2005

BADENHOP, A. F.; HACKLER, L. R. Effect of soaking soybeans in sodium hydroxide solution as pretreatment for soymilk production. **Cereal Science Today**, v. 15, n. 3, p. 84-88, 1970.

BENEDETTI, A. C. E. P.; FALCÃO, D. P. Monitoramento da qualidade higiênico-sanitária no processamento do “leite” de soja na unisoja. **Ciência Tecnologia de Alimentos**, v. 23, n. supl., p. 200-205, 2003.

DELLA MODESTA, R. C. Avaliação da influência da adição de “leite” de castanha-do-brasil na cor de “leites” de soja integral e hidrossolúvel. In: SIMPÓSIO LATINO AMERICANO DE CIÊNCIA E TECNOLOGIA DE ALIMENTOS, 4, 2001, Campinas. **Anais...** Campinas: UNICAMP, 2001.

FELBERG, I. et al. Bebida mista de extrato de soja integral e castanha-do-brasil: caracterização físico-química, nutricional e aceitabilidade do consumidor. **Alimentos & Nutrição,** v. 15, n. 2, p. 163-174, 2004.

FREITAS, S. C. et al. Meta-análise do teor de selênio em castanha-do-brasil. **Brazilian Journal of Food Tecnhology.** v. 11, n. 1, p. 54-62, 2008.

GREENHOFF, K. **Measurement of Food Preferences**. London: Blackie Academic and Professional, 1994. p. 137-165.

GUINARD, J. X.; UOTANI, B.; SCHLICH, P. Internal and external mapping of preferences for commercial lager beers: comparison of hedonic ratings by consumers blind versus with knowledge of brand and price. **Food Quality and Preference**, v. 12, n. 4, p. 243-255, 2001.

HOLLAND, B.; UNWIN, I. D.; BUSS, D. H. Fruit and Nuts. In: MCCANCE & WIDDOWSON’S (Ed.). **The composition of foods.** 5 ed. Cambridge: The Royal Society of Chemistry, 1992.

Instituto Brasileiro de Geografia e Estatística - IBGE. **Levantamento Sistemático da Produção Agrícola.** 2008. Disponível em: <http://www.ibge.gov.br>. Acesso em: Junho 2008.

MACFIE, H. J. H.; THOMSON, D. M. H. Preference mapping and multidimensional scaling. In: PIGGOT, J. R. (Ed.). **Sensory analysis of foods.** London: Elsevier Applied Science, 1988. p. 380-409.

MACFIE, H. J. H. et al. Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. **Journal of Sensory Studies**, v. 4, n. 2, p. 129-148, 1989.

MANUGISTICS. **Statgraphics reference manual.** Rockville: Manugistics, 1993. p. 11-1 – 11-64, A1-A12.

MESSINA, M.; MCCASKILL-STEVENS, W.; LAMPE, J. W. Addressing the soy and breast cancer relationship: Review, commentary, and workshop proceedings. **Journal of the National Cancer Institute**, v. 98, n. 18, p. 1275-1284, 2006.

MORAIS, A. A. C.; SILVA, A. L. S.; DAMÁSIO, A. B. F. Otimização do uso da soja. **Revista Brasileira de Nutrição Clínica**, v. 15, n. 2, p. 350-357, 2000.

NELSON, A. I.; STEINBERG, M. P.; WEI, L. S. Illinois process for preparation the soymilk. **Journal of Food Science**, v. 41, n. 1, p. 57-61, 1976.

PAGLIARINI, E.; MONTELEONE, E.; RATTI, S. Sensory profile of eight tomato cultivars (*Lycopersicon esculentum*) and its relationship to consumer preference. **Italian Journal of Food Science**, v. 13, n. 3, p. 285-296, 2001.

PRIEPKE, P. E. et al. Suspension stability of Illinois soybean beverage. **Journal of Food Science**, v. 45, n. 2, p. 242-245, 1980.

RODRIGUES, R. S.; GOZZO, A. M.; MORETTI, R. H. Comportamento reológico de extratos de grãos, farinha integral e isolado protéico de soja. **Boletim do CEPPA**, v. 21, n. 2, p. 367-378, 2003.

SAS. **SAS User’s Guide:** Statistics. Version 8. Cary, North Carolina: SAS Institute Inc., 2004. 956 p.

SHAOHONG, Y.; KOW-CHING-CHANG, S. Selected odor compounds in soymilk as affected by chemical composition and lipoxygenases in five soybean materials. **Journal of Agricultural and Food Chemistry**, v. 55, n. 2, p. 426-431, 2007.

SUN, S. S. M.; LEUNG, F. W.; TOMIC, J. C. Brazil Nut (*Bertholletia excelsa* H. B. K.) proteins: fractionation, composition, and identification of a sulfur-rich protein. **Journal of Agricultural and Food Chemistry**, v. 35, n. 2, p. 232-235, 1987.

SOUZA, M. L.; MENEZES, H. C. Processamentos de amêndoa e torta de castanha-do-Brasil e farinha de mandioca: parâmetros de qualidade. **Ciência e Tecnologia de Alimentos**, v. 24, n. 1, p. 120-128, 2004.

SOUZA, M. L.; MENEZES, H. C. Extrusão de misturas de castanha do Brasil com mandioca. **Ciência e Tecnologia de Alimentos**, v. 28, n. 2, p. 451-462, 2008.

TANGO, J. S. et al. Caracterização de algumas cultivares de soja para produção de extrato protéico. **Boletim do Instituto Tecnologia de Alimentos**, v. 21, p. 157-182, 1984.

TRUGO, L. C.; FARAH, A.; CABRAL, L. C. Oligosaccharide distribution in brazilian soybean cultivars. **Food Chemistry**, v. 52, n. 4, p. 385-387, 1995.

United States Department of Agriculture - USDA. **Agricultural Research Service**. Nutrient data laboratory. Disponível em: <http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl>. Acesso em: Maio 2007.

United States Department of Agriculture - USDA. **Nutrient Data Laboratory**. Nutrient database for standard. Disponível em: <http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl>. Acesso em: Abril 2008.

WILKENS, W. F.; MATTICK, L. R.; HAND, D. B. Effect of processing method on oxidative off-flavor soybean milk. **Food Technology**, v. 21, n. 12, p. 1630-1633, 1967.

YACKINOUS, C.; WEE, C.; GUINARD, J. X. Internal preference mapping of hedonic ratings for Ranch salad dressing varying in fat and garlic flavor. **Food Quality and Preference**, v. 10, n. 4-5, p. 401-409, 1999.

VIEIRA, C. R.; CABRAL, L. C.; PAULA, A. C. O. Composição centesimal e conteúdo de aminoácidos, ácidos graxos e minerais de seis cultivares de soja destinadas à alimentação humana. **Pesquisa da Agropecuária Brasileira**, v. 34, n. 7, p. 1277-1283, 1999.