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ORIGINAL ARTICLE

Nutritional and consumer acceptance evaluation of soymilk from specialty and conventional soybean cultivars

Avaliação nutricional e aceitação pelo consumidor de extrato de soja de cultivares especiais e convencionais

Ilana Felberg[1], Mercedes Concórdia Carrão-Panizzi[2], Rosires Deliza[1], Sidinéa Cordeiro de Freitas[1], Elizabeth Borges Gonçalves[1], Sidney Pacheco[1], Manuela Cristina Pessanha de Araujo Santiago[1], Rosemar Antoniassi[1*]

[1]Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Rio de Janeiro/RJ - Brasil
[2]Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Passo Fundo/RS - Brasil

***Corresponding Author:** Rosemar Antoniassi, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Laboratório de Óleos Graxos, Av. das Américas, 29501, CEP: 23020-470, Rio de Janeiro/RJ - Brasil, e-mail: rosemar.antoniassi@embrapa.br.

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Abstract

The soymilk is a ready-to-eat, nutritious and naturally cholesterol-free product. Several soybean specialty cultivars were developed in Brazil in order to increase the human consumption of soybean products. The aim of this work was to evaluate the nutritional composition and consumer acceptance of soymilk from three soybean cultivars with special features such as high-protein and isoflavone contents, mild flavor and lipoxygenase-free compared to three conventional ones. The soymilk was obtained after blanching with a bicarbonate solution, grinding, centrifugation and pasteurization. The physicochemical and nutritional evaluation data were analyzed using Analysis of Variance (ANOVA) and Tukey's test to check differences among means, and the consumer data through cluster analysis and internal preference mapping. The lipoxygenases were inactivated after thermal processing. There were significant differences among soybean cultivars and soymilks related to the protein, isoflavones, oil, and sugar contents and soymilk yield ($p < 0.05$). The BRS 133 and BRS 284 cultivars and soymilks presented the highest total isoflavone content ($p < 0.05$). Regarding the overall consumer acceptance, there were significant differences among cultivars ($p < 0.05$) with means ranging from 5.9 to 6.7 and the lower score was obtained by BRS 267. However, the cluster analysis identified three consumer segments according to preference similarity. The cultivars BRS 284 and BRS 267 reached the highest mean among the consumers of segment 1 (6.8 and 6.7 respectively). The consumers of segment 2 preferred the cultivar without lipoxygenases, BRS 213 (mean of 7.5) while segment 3 preferred the BRS 133 (mean of 7.4). The process of blanching of soybean with bicarbonate solution, grinding with boiling water and pasteurization mitigated the differences between conventional and specialty cultivars and the six cultivars evaluated were suitable for soymilk production.

Keywords: (Glycine max (L.) Merrill; Consumer acceptance; Isoflavones; Lipoxygenases; Cluster analysis; Internal preference mapping.

Resumo

O extrato de soja é um produto pronto para o consumo, nutritivo e naturalmente livre de colesterol. Diversas cultivares especiais de soja foram desenvolvidas no Brasil com o objetivo de aumentar o consumo humano de produtos derivados da soja. O objetivo deste trabalho foi avaliar a composição nutricional e a aceitação pelo consumidor do extrato de soja de três cultivares de soja com características especiais, como alto teor de proteínas e isoflavonas, sabor suave e livre de lipoxigenases, em relação a três cultivares convencionais. O extrato de soja foi obtido após branqueamento com solução de bicarbonato, trituração, centrifugação e pasteurização. Os resultados foram analisados por meio do teste de Anova e Tukey, para verificar diferenças entre as médias, e os dados do consumidor, por meio de análise de agrupamento e mapa de preferência interno. As lipoxigenases foram inativadas após o processamento térmico. Houve diferenças significativas entre as cultivares de soja e os extratos obtidos em relação aos teores de proteína, isoflavonas, lipídios e açúcares, e para o rendimento de extrato ($p < 0,05$). As cultivares BRS 133 e BRS 284 apresentaram o maior teor de isoflavonas totais ($p < 0,05$). Em relação à aceitação geral pelo consumidor, houve diferenças significativas entre as cultivares ($p < 0,05$), sendo que a menor média foi obtida por BRS 267. No entanto, a análise de cluster identificou três segmentos de consumidores de acordo com a similaridade de preferência. As cultivares BRS 284 e BRS 267 alcançaram a maior média entre os consumidores do segmento 1 (6,8 e 6,7, respectivamente). Os consumidores do segmento 2 preferiram a cultivar sem lipoxigenases, BRS 213 (média de 7,5), enquanto o segmento 3 preferiu a BRS 133 (média de 7,4). O processo de branqueamento da soja com solução de bicarbonato, trituração com água quente e pasteurização atenuou as diferenças entre as cultivares convencionais e especiais, e as seis cultivares avaliadas foram adequadas para a produção de extrato de soja.

Palavras-chave: (Glycine max (L.) Merrill; Análise sensorial; Isoflavonas; Lipoxigenases; Análise de cluster; Mapa interno de preferência.

Highlights

- The specialty and conventional cultivars were suitable for soymilk production
- The processing promoted lipoxygenase inactivation and reduced the differences among cultivars
- The cluster analysis identified three consumer segments due to preference similarity

1 Introduction

Efforts to increase soybean consumption are significant as scientific studies continue to demonstrate that soybean intake contributes to maintaining health and, possibly, is related to the reduction of chronic diseases such as breast and prostate cancer, osteoporosis, and heart diseases (Messina, 2016; Nachvak et al., 2019; Li et al., 2020; Sansai et al., 2020; Dietary Guidelines for Americans, 2020; Cai et al., 2021).

The soymilk stands out among soybean products as a ready-to-eat, nutritious, and naturally cholesterol-free product. However, sensory barriers must yet be overcome. In the traditional processing to obtain the soymilk, the cold-water grain soaking step favors the development of a beany flavor due to reactions catalyzed by the lipoxygenase enzymes, which result in different compounds with undesirable sensory characteristics (Nelson et al., 1976; Han et al., 2021). Such compounds limited the soymilk acceptance among western consumers for many years (Al Mahfuz et al., 2004). Lipoxygenases (LOX) are present in soybean as three isozymes: LOX1, LOX2, and LOX3 with different characteristics (optimal pH and formation of compounds) (Kumar et al., 2003). In that regard, technological alternatives have been employed for soybean processing resulting in products with a more pleasant aroma and flavor (Nelson et al., 1976; Felberg et al., 2009).

The research focused on specialty soybean cultivars for human consumption in Brazil has been developed by the breeding program at Embrapa (Empresa Brasileira de Pesquisa Agropecuária – in English Brazilian

Agricultural Research Corporation) (Carrão-Panizzi et al., 2001). The cultivars BRS 213 and BRS 257 are genetically free of the lipoxygenase enzymes (Oliveira et al., 2010). Specialty cultivars also include BRS 216 which shows a high protein content (Silva et al., 2009). The cultivar BRS 267 is not a lipoxygenase free but has a pleasant flavor, possibly due to its particular sugar profile (Oliveira et al., 2010). Some cultivars such as BRS 232 are considered conventional and have no specific characteristics for human consumption, but show a light hilum color.

Some specialty and conventional soybean cultivars were evaluated regarding the nutritional composition (proteins, fatty acids, sugars) and presence of bioactive compounds such as isoflavones in which Silva et al. (2009) and Ciabotti et al. (2019) showed the differences among them. However, consumer acceptance of soymilk was not performed. On the other hand, the acceptability of the beverage obtained with powdered soymilk from BRS 213 (lipoxygenase free) was higher than the commercial products for consumers of different cities in Brazil (Silva et al., 2007), showing the relevance of consumer acceptance evaluation.

There are few results regarding the sensory evaluation of soymilk using these specialty cultivars in Brazil. This study aimed to investigate the performance of different soybean cultivars, specialty and conventional to produce soymilk regarding the soymilk yield, nutritional characteristics, presence of isoflavones and consumer acceptance.

2 Material and methods

2.1 Material

The soybean cultivars were selected based on previous studies that investigated their nutritional characteristics and absence of LOX. The cultivars were provided by Embrapa Soybean (Londrina, PR, Brazil), and their characteristics are described in Table 1.

Table 1. Soybean cultivars from the genetic breeding program at Embrapa Soybean.

Cultivars	Characteristics
BRS 216*	Specialty type for soybean sprouts, small grains, high protein and isoflavone contents
BRS 267*	Specialty type with pleasant flavor, large grains
BRS 133*	Conventional type with high isoflavone contents
BRS 213*	Specialty type with absence of lipoxygenases (LOX1, LOX2, LOX3)
BRS 232	Conventional type and mild flavor
BRS 284	Conventional type and mild flavor

*Silva et al. (2009).

2.2 Processing

Soymilk processing was based on Felberg et al. (2009) and Antoniassi et al. (2008) and consisted of dehulling, cooking for 10 minutes in sodium bicarbonate solution (0.25%) at a ratio of 1:3 (dehulled soybean: solution), draining, grinding with boiling water using a Waring® heavy-duty blender at a ratio of 1:8 (blanched soybeans: water) for two minutes, and centrifugation using an IEC® K7165 centrifuge with a 150 µm nylon filter at 4000 rpm (~2500 g). After the centrifugation step, the soymilk was pasteurized at 95-98 °C for 10 minutes. The process was carried out five times for each cultivar. The soymilk yield was measured as liters of soymilk resulting from 1 kg of dehulled soybean grains. The soymilk had about 7% of total solids and was formulated by adding 3% sugar and 0.2% salt (w/w).

2.3 Physicochemical analysis of soybean and soymilk

2.3.1 Proximate analysis

The proximate analysis of soybean and soymilk was performed in six replicates according to the Official Methods of Analysis of AOAC International (Association of Official Analytical Chemists, 2010). Moisture

analysis was performed by oven-drying to constant weight at 105 °C (AOAC 925.45B). The ash content was measured at 550 °C in a muffle furnace (AOAC 923.03/32.1.05). The protein content was calculated based on the nitrogen content obtained by the Kjeldahl method (AOAC 4.2.11) using a 6.25 factor. Oil extraction was performed by acid hydrolysis followed by ethyl ether and petroleum ether extraction according to AOAC method 922.06.

2.3.2 Lipoxygenase analysis

Lipoxygenase activity in soymilk (after pasteurization) was determined by spectrophotometry according to Axelrod et al. (1981) and Kumar et al. (2003), using six replicates. The soymilk was lyophilized (LIOBRAS K120) and defatted with petroleum ether (30 ºC to 60 ºC) in a Soxhlet apparatus for 16 h before extraction. Enzyme extraction was performed by stirring for one hour at 0 ºC to 4 ºC with 0.2M phosphate buffer (pH 6.8), followed by centrifugation at 10,000 rpm for 10 minutes (4 ºC) (Thermo Scientific Sorvall Legend XTR). LOX1 activity was measured at pH 9 (borate buffer), whereas LOX2+3 activity was measured at pH 6.8 using sodium linoleate as substrate. The absorbance of LOX1 and LOX2+3 was read at 234 and 238 nm, respectively, and was measured for 3 min at 30-second intervals using an Agilent 8453 UV-visible spectrophotometer. The slope of the linear part of the curve corresponded to the enzymatic activity (Ludikhuyze et al., 1998; Wang et al., 2008).

2.3.3 Chromatographic analysis

Sugar analysis was performed with six replicates according to the method proposed by Macrae (1998), based on the chromatographic separation of the sample into an amino column using a High Performance Liquid Chromatography (HPLC) system (Waters™, Waltham, MA, USA), with quantification by external standardization. The chromatographic conditions used in the determinations were a Zorbax carbohydrate column (4.6 x 250 mm; 5mm – Agilent™) at 30 °C, isocratic elution mode with acetonitrile: water (75:25, v/v), refractive index detector mode W2410 (Waters™) at an internal temperature of 45 ºC, and a 20 µL injection volume. Sample extraction was conducted with 1 g of sample weighed in a 25 mL volumetric flask containing 10 mL of ultrapure water, followed by an ultrasonic bath for 10 min. Subsequently, 5 mL of acetonitrile was added, and the volume was completed with ultrapure water. Finally, the extract obtained after this process was filtered directly into the autosampler vial.

The isoflavone analysis of soybean and soymilk was carried out according to AOAC method 2001.10 (Association of Official Analytical Chemists, 2010) using six and twelve replicates, respectively. The extractions were performed with methanol/water (80:20, v/v), followed by hydrolysis with NaOH solution, acidification, and filtration with Whatman filter paper No. 1. The analyses were carried out by HPLC-Photodiode Array detector (Alliance™ 2695 and 2996, Waters, Waltham, MA, USA) using a YMC-Pack Pro C18 column (5 µm, 4.6 mm × 250 mm, YMC, Kyoto, Japan) and a gradient with acetic acid solution and methanol running at 1.3 mL/min. The data were acquired at 260 nm. The identification and quantification of isoflavones were performed by comparing the peak retention time under investigation with those of the respective standards injected as a pool. The peak identities were confirmed by UV spectra to avoid coelutions. The conversion of the isoflavone concentrations (genistin, glycitin, and daidzin) into aglycon equivalents was calculated by multiplying the mass of each isoflavone form by the ratio of its aglycone molecular weight to the molecular weight of the individual form (Song et al., 1998). The total isoflavones as aglycon equivalents were determined by summing the concentrations of daidzein, glycitein, and genistein to the aglycon equivalent concentrations of daidzin, glycitin, and genistin.

2.4 Evaluation of soymilk consumer acceptance

The soymilk from the specialty and conventional cultivars (Table 1) were evaluated for the consumer. In total, 102 consumers (64 women and 38 men) aged 18 to 66 years took part in the study. The subjects were

recruited at a supermarket in the West Zone of Rio de Janeiro, in the state of Rio de Janeiro (RJ). The samples were presented individually in white 50 mL disposable plastic cups codified with three-digit numbers and served at 8 ± 2 ºC. The samples were evaluated using a 9-point hedonic scale (1: dislike it extremely and 9: like it extremely). The presentation order was balanced according to MacFie et al. (1989). The data were analyzed by Analysis of Variance (ANOVA) ($p \leq 0.05$), Tukey's test to assess differences between means, Internal Preference Mapping, and cluster analysis. In addition to the acceptance, participants also recorded what they liked most and least about each product. The study was submitted to and approved by the Research Ethics Committee of the Federal University of Rio de Janeiro (UNIRIO) - (TTDD:232/2011).

2.5 Statistical analysis

The one-way ANOVA was performed using SAS/Stat 9.2 (Statistical Analysis System Institute, 2008) and Base SAS 9.2 (Statistical Analysis System Institute, 2009). The mean values of each parameter were further compared by Tukey's test to check the difference among means. The significance level for all tests was set at 5%. The soybean and soymilk results were compared on a dry and wet basis. However, the comparison shown in the tables was performed on a wet basis.

3 Results and discussion

3.1 Physicochemical analysis of soybean and soymilk

The cultivars showed significant differences with regard to the proximate composition and sugar content ($p < 0.05$) (Table 2). The cultivar BRS 216 showed the highest protein content (46.8 g 100 g^{-1}) and the lowest oil content (22.2 g 100 g^{-1}). On the other hand, BRS 284 showed the lowest protein content (38.3 g 100 g^{-1}) and the highest lipid content (28.0 g 100 g^{-1}). These results confirmed the inverse relationship between the protein and oil contents in soybean (Carrão-Panizzi et al., 2021). The ash content ranged from 5.2 to 6.4 g 100 g^{-1}, and the highest and lowest ash contents found in BRS 267 and BRS 216 were attributed to large and small grains, respectively. The levels of protein, oil and ash contents were higher than those reported by Silva et al. (2009), Ciabotti et al. (2019) and Carrão-Panizzi et al. (2021). The sucrose content ranged from 3.1 to 5.3 g 100 g^{-1} and was higher in BRS 216 and BRS 133 ($p < 0.05$), whereas the raffinose content ranged from 0.9 to 1.8 g 100 g^{-1}, with BRS 267 showing the highest values ($p < 0.05$). No significant differences were observed among cultivars for stachyose (2.9 to 4.8 g 100 g^{-1}), except for the lower content observed in BRS 267 ($p < 0.05$). Silva et al. (2009) evaluated five Brazilian soybean cultivars as well as BRS 213, BRS 216, BRS 267 and BRS 133 and the ranges observed for sucrose, raffinose and stachyose were 3.4 to 4.3; 0.4 to 1.0 and 2 to 3.5 g 100 g^{-1}, respectively. However, the results of this work were higher for raffinose and stachyose than those reported by Silva et al. (2009) while the sucrose content was higher or lower depending on the cultivar evaluated. In another study, Oliveira et al. (2010) evaluated 28 Brazilian and foreign genotypes/cultivars and observed very wide ranges of values for sucrose (2.4 to 5.9 g 100 g^{-1}), stachyose (from 2.7 to 4.4 g 100 g^{-1}) and raffinose (from 0.4 to 1.2 g 100 g^{-1}). These features pointed out the influence of edaphoclimatic conditions and different years on the composition of soybeans.

Table 2. Proximate composition and sugar content of six soybean varieties (g 100 g^{-1}) (wet basis)*.

Cultivar	Chemical composition				Sugars		
	Protein	Oil	Ash	Moisture	Sucrose	Raffinose	Stachyose
BRS 216	46.8^{a}	22.2^{d}	5.2^{c}	9.2^{cd}	5.28^{a}	1.33^{bc}	4.54^{a}
BRS 267	44.5^{b}	23.0^{c}	6.4^{a}	10.0^{b}	3.70^{b}	1.80^{a}	2.91^{b}
BRS 133	42.4^{c}	24.0^{c}	5.6^{b}	11.0^{a}	5.33^{a}	0.90^{d}	4.24^{a}
BRS 213	41.8^{c}	24.3^{b}	5.8^{b}	9.4^{cd}	3.82^{b}	1.49^{b}	4.47^{a}
BRS 232	41.6^{c}	24.4^{b}	5.9^{b}	10.1^{b}	3.42^{b}	0.92^{d}	4.37^{a}
BRS 284	38.3^{d}	28.0^{a}	5.7^{b}	9.0^{d}	3.11^{b}	1.22^{c}	4.79^{a}

*Results expressed as the average of six replicates. Means with different lowercase letters in the same column are significantly different ($P < 0.05$) by Tukey's test.

The soymilk samples showed significant differences with regard to nutritional characteristics ($p < 0.05$) (Table 3). The total solids content of the soymilk samples differed significantly, and the statistical evaluation was performed on a wet and dry basis, with similar results. The results in the tables are shown on a wet basis. The soymilk from the cultivar BRS 232 showed the highest protein content (3.37 g 100 g^{-1}) and the lowest lipid content (2.05 g 100 g^{-1}) ($p < 0.05$). However, its grain protein content was one of the lowest. BRS 284 soymilk showed the lowest protein content (2.85 g 100g^{-1}) and the highest lipid content (3.15 g 100 g^{-1}). On the other hand, the extracts from cultivars BRS 133, 232, and 267 showed no significant differences with regard to the protein content. It should be noted that cultivar BRS 267 showed the highest ash contents agreeing with the result obtained for the soymilk. There was a significant difference in the yield of soymilk ($p < 0.05$) and BRS 133 showed the lowest figure (2.8 L/kg). Although no significant difference was observed for the others cultivars evaluated, there is a trend toward higher yield for the conventional cultivars BRS 232 and BRS 284, indicating a more favorable extraction of proteins from soybean grains. This characteristic was related to grain softening during blanching, enhancing the grinding efficiency.

Table 3. Proximate composition (g 100 g^{-1})* and yield** of soymilk obtained from six soybean cultivars (wet basis).

Cultivar	Protein	Oil	Ash	Moisture	Soymilk yield **
BRS 216	3.20^{b}	2.26^{b}	0.66^{b}	89.1^{bc}	3.1^{ab}
BRS 267	3.13^{bc}	2.20^{bc}	0.73^{a}	89.7^{a}	3.2^{ab}
BRS 133	3.11^{c}	2.94^{a}	0.55^{c}	88.8^{cd}	2.8^{b}
BRS 213	3.11^{c}	2.41^{b}	0.57^{c}	88.3^{d}	3.3^{ab}
BRS 232	3.37^{a}	2.05^{c}	0.63^{b}	89.9^{a}	3.7^{a}
BRS 284	2.85^{d}	3.15^{a}	0.52^{d}	89.3^{b}	3.45^{a}

*Results expressed as the average of six replicates. **Average soymilk yield obtained from five processes (Liters of soymilk without formulation/kg of dehulled soybeans). Means with different lowercase letters in the same column are significantly different ($p < 0.05$) by Tukey's test.

The soymilk samples showed no residual LOX1 activity. However, the cultivar BRS 284 showed residual LOX2+3 activity, indicating that the blanching conditions (boiling sodium bicarbonate 0.25% solution for 10 minutes), grinding with boiling water and pasteurization inactivated the lipoxygenases in most soybean cultivars. These blanching and grinding conditions were similar to those reported by Felberg et al. (2004, 2009). The effect of the blanching conditions on lipoxygenase activity was evaluated by Antoniassi et al. (2008), with different bicarbonate solution concentrations (0.25 to 0.5%) and 10 to 12 minutes of blanching resulting in the highest lipoxygenase inactivation.

The total average content of isoflavones of the samples evaluated expressed as aglycone equivalents (wet basis) are shown in Table 4. The isoflavone contents showed significant differences among the soybean and soymilk samples evaluated ($p < 0.05$). The main isoflavones were genistin, daidzin, and genistein, followed by lower amounts of daidzein. Glycitein was not detected in any of the soymilk and soybean samples evaluated. In contrast, glycitin was quantified in the soybean samples of cultivars BRS 267, BRS 133, and BRS 284 (up to 6 mg 100 g^{-1}), and in the soymilk of BRS 133 (up to 0.19 mg 100 g^{-1})(data not shown). Cultivar BRS 133 showed the highest total isoflavone content (183 mg 100 g^{-1}) agreeing with Silva et al. (2009). On the other hand, BRS267 showed the lowest content of this component (44.70 mg 100 g^{-1}). The USDA isoflavone database (Bhagwat et al., 2015) showed significant differences in the isoflavone content of soybean samples around the world. Mature and raw soybeans (from different countries and cultivars) showed daidzein contents ranging from 2.64 to 191.43 mg.100 g^{-1}, genistein contents ranging from 5.56 to 276.21 mg 100 g^{-1}, and glycitein contents ranging from 0 to 121.69 mg.100 g^{-1}. The total isoflavones ranged from 10.04 to 440.72 mg 100 g^{-1}. The isoflavone contents in soybean vary due to genetic differences, geographic location, soil, year, and environmental conditions during growth (Wang & Murphy, 1994; Carrão-Panizzi et al., 2009). The isoflavone profile obtained was within the range observed for other soybean cultivars grown in Brazil and around the world.

Table 4. Isoflavone content (mg 100 g^{-1}, wet basis) of soybean and soymilk from different Brazilian soybean cultivars.

Cultivars	Soybean					Soymilk				
	Daidzein	Genistein	Daidzin*	Genistin*	Total isoflavone*	Daidzein	Genistein	Daidzin*	Genistin*	Total isoflavone*
BRS 216	1.78^{d}	4.20^{e}	33.96^{c}	65.44^{d}	105.38^{d}	0.13^{d}	0.22^{d}	2.08^{c}	5.64^{e}	8.07^{d}
BRS 267	2.14^{c}	7.27^{c}	8.67^{e}	25.30^{e}	44.69^{f}	0.12^{de}	0.32^{b}	0.55^{e}	2.25^{f}	3.26^{e}
BRS 133	5.66^{b}	8.78^{b}	69.10^{a}	94.01^{b}	183.10^{a}	0.21^{b}	0.30^{bc}	4.94^{a}	10.21^{b}	15.84^{a}
BRS 213	8.49^{a}	20.25^{a}	38.71^{b}	76.67^{c}	144.12^{c}	0.47^{a}	1.09^{a}	2.54^{b}	7.23^{c}	11.33^{c}
BRS 232	0.55^{f}	2.15^{f}	27.52^{d}	68.69^{d}	98.92^{e}	0.18^{c}	0.16^{e}	1.84^{d}	6.47^{d}	8.64^{d}
BRS 284	0.72^{e}	5.15^{d}	26.95^{d}	112.58^{a}	151.01^{b}	0.10^{e}	0.27^{cd}	1.93^{cd}	11.02^{a}	13.32^{b}

*Individual isoflavone glycosides were normalized for their molecular weight differences into aglycone forms and summed to obtain the total content. Means with different lowercase letters in the same column are significantly different ($p < 0.05$) by Tukey's test. Results expressed as the average of six soybean replicates and twelve soymilk replicates .

The total isoflavone content of soymilk ranged from 8.07 to 15.84 mg 100 g^{-1} (wet basis) (Table 4), with the isoflavone profile showing a similar pattern to that of soybean. However, from the total isoflavone contents of soybean and soymilk (on a dry basis), it was possible to observe (Figure 1) different transference ratios of isoflavone from soybean to soymilk. The highest ratio between soymilk and soybean isoflavones was observed for conventional cultivars BRS 232 and BRS 284, which showed the highest soymilk yield (Table 3). Grain softening during processing favored the extraction of both proteins and isoflavones into soymilk.

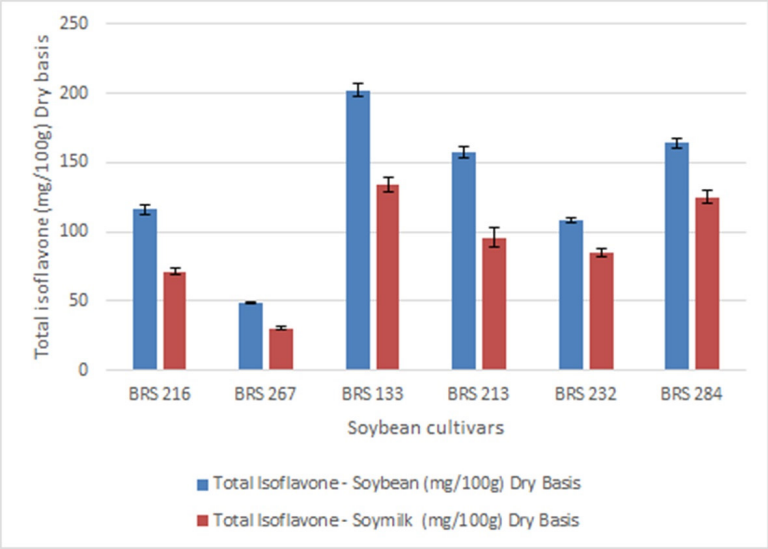

Figure 1. Total isoflavone content of soybean and soymilk (mg.100 g^{-1}, dry basis).

3.2 Consumer acceptance of soymilk

There were significant differences ($p < 0.05$) with regard to the overall consumer acceptance (n = 102) among soybean cultivars (Table 5), which ranged from 5.9 to 6.7, and, therefore, in the "like" portion of the 9-point hedonic scale (1:disliked it extremely and 9:liked it extremely). The cultivar BRS 232 showed the highest acceptance, which did not differ from the BRS 284. The conventional cultivars BRS 284 and BRS 133 did not differ from the special BRS 216 and BRS 213, the latter of which had no lipoxygenases. This result suggests that the process used to obtain the soymilk, with blanching and grinding, inactivated the lipoxygenase enzymes and contributed to mitigating the differences between cultivars.

The cluster analysis identified three consumer segments according to preference similarity. The acceptance means are shown in Table 5. The results of the internal preference mapping, a tool that considers the individual

perception of participants, are shown in Figures 2A and 2B. The first two dimensions explained 52.3% of the variance, which is expected taking into account that the study was carried out by untrained people (consumers). Dimension 1 separated the cultivar BRS 267 from the others. In contrast, dimension 2 separated the soymilk prepared with cultivars BRS 284 and BRS 133. The soymilk prepared with BRS 267 was the least appreciated by most participants of this study (segments 2 and 3), differing from the conclusion reported by Silva et al. (2009) in which this cultivar was the best cultivar for soymilk preparation among the same cultivars evaluated in this work based on its chemical composition. However, this cultivar reached the highest mean among the consumers of segment 1 as well as BRS 284. BRS 267 is a vegetable-type cultivar with a more appropriate flavor to be consumed as edamame (Carrão-Panizzi et al., 2018; Felberg et al., 2020).

Table 5. Average consumer acceptance[#]: overall and the identified segments' results.

Cultivars	Acceptance			
	Overall (n = 102)	Cluster 1 (n = 28)	Cluster 2 (n = 32)	Cluster 3 (n = 35)
BRS 213	6.3^{b}	5.4^{dC}	7.5^{aA}	5.8^{dB}
BRS 232	6.7^{a}	6.3^{bB}	6.6^{bA}	7.0^{bA}
BRS 284	6.5^{ab}	6.8^{aA}	6.1^{cC}	6.4^{cB}
BRS 133	6.4^{b}	4.9^{cC}	6.4^{bB}	7.4^{aA}
BRS 216	6.3^{b}	5.6^{dB}	6.6^{bA}	6.3^{cA}
BRS 267	5.9^{c}	6.7^{aA}	6.2^{cB}	4.7^{eC}

[#]Evaluated on a 9-point hedonic scale (1: disliked it extremely and 9: liked it extremely). Means followed by lowercase letters in the columns and uppercase letters in the rows do not differ by Tukey's test ($p \leq 0.05$).

The consumers of segment 2 preferred the cultivar without lipoxygenases, BRS 213 (acceptance mean of 7.5). On the other hand, the consumers of segment 3 preferred the cultivar BRS 133 (acceptance mean of 7.4) which showed the highest total isoflavone content. These results highlight the effect of processing over the intrinsic characteristics of the cultivars, reducing the effect of the specialty cultivars in the soymilk. On the other hand, the internal preference mapping and cluster analysis showed the segmentation of different consumer groups which are useful tools to select among cultivars and products.

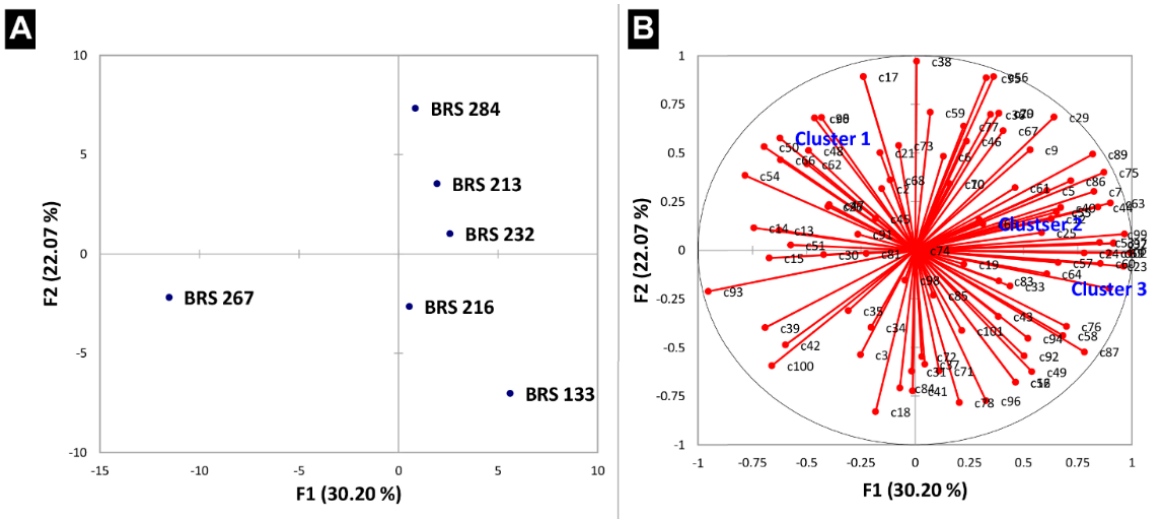

Figure 2. Internal preference map showing (A): the position of the samples and (B): the position of the consumers in the three clusters.

4 Conclusions

The studied cultivars differed with regard to nutrients and bioactive compounds, remaining within the ranges expected for soybean. There was a difference among the cultivars related to the transference rates of protein and isoflavones from soybean to soymilk as well as the soymilk yield. Thermal treatment applied to soybean grains and soymilk inactivated the enzymes when these were present, and the soymilks did not differ from the one obtained of the cultivar without lipoxygenase. The results indicated that the conventional cultivars and specialty cultivars are promising for preparing the soymilk from the perspective of consumer acceptance since the technological process and thermal treatment attenuated the differences among cultivars.

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