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Physicochemical and Sensory Properties of Sugar Cane Candies with Roasted Peanut and Extruded Rice Bran

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Abstract The aim of this study was to evaluate the physicochemical characteristics of sugar cane candies, which were prepared with different concentrations of sugar cane juice, roasted peanuts and extruded rice bran, and to monitor the microbiological contamination and the acceptance of sugar cane candies selected as having a greater physicochemical desirability. Simplex design was used to evaluate the concentration effect of these ingredients in the color, hardness and proximate composition of sugar cane candies enriched with rice bran and peanuts. Sugar cane candy formulated with 20% extruded rice bran, 5% roasted peanuts and 75% sugar cane juice was considered desirable with respect to physicochemical characteristics and it was accepted in sensory analysis. The final formulation showed an increase in constituents concentration when it was compared with the original candy, such as protein (from 0.28 to 7.2 g $100g^{-1}$), total dietary fiber (from zero to 2.30 g $100g^{-1}$) and lipids (from zero to 9 g $100g^{-1}$). Therefore, the sugar cane candy formulated in this work had an improving in the nutritional characteristics, when compared with traditional sugar cane candy, and a good evaluation in sensory analysis, demonstrating the commercial viability of the product.

Keywords: *Oryza sativa L., byproduct, Arachis hypogaea L., texture, nutrients*

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1. Introduction

Sugar cane candy is an unrefined crumbly sweet, with pleasant and characteristic flavor and odor, produced from sugarcane juice that is concentrated until reach around 92ºBrix [1]. This product is consumed in over thirty countries, where India accounts for 67% of the total world production, and Colombia is the world's largest consumer, with about 32 kg ha^{-1} yr^{-1}. Brazil is the seventh largest producer of sugar cane candy, with 80 thousand tons per year and consumption of 1.4 kg ha^{-1} yr^{-1} [2].

In Brazil, the production of sugar cane candy is common in the Ceará, Pernambuco, Paraíba, Piauí, Bahia and Alagoas states [3], which are located in the Northeastern region, where the mortality rate is the highest of the country due to malnutrition [4]. Mortality due to malnutrition is the result of several factors such as poor level of information and education of the mother, poverty, poor living conditions, lack of health assistance, unemployment and inadequate eating habits [5].

Although the sugar cane candy is rich in carbohydrates and minerals, it is considered an unbalanced food due to the high content of sugars and minerals and low levels of other nutrients [2]. In this context, the enrichment of this product is recommended, since in the traditional processing of sugar cane candy the addition of fruit or grains are include, mainly to diversify the flavor and to offer different options for the consumers.

Peanut (Arachishypogaea L.), which was used extensively by the indigenous population before colonization, is rich in lipids, proteins and vitamins that makes it an important source of energy and amino acids. Currently, peanut is a product known and appreciated in almost all countries by its unique flavor and versatility of use in savory and sweet dishes, and in the industry [6].

Brazil is the main producer of rice (Oryza sativa L.) in Latin America, and it is estimated that the growing season in 2012 produced 730 million tons of paddy rice worldwide [7], and the estimate for the 2014/2015 crop in Brazil is around 12.2 million tons of grain [8], representing 2% of world production. Bran is one of the byproducts from rice polishing, which represents 8% to 11% of the total grain weight and is a source of many nutrients such as protein, lipids and dietary fiber [9], which are the lacking components in sugar cane candy. However, rice bran has unpleasant flavor, which could be minimized by the pronounced flavor of peanuts. Furthermore, rice bran naturally has enzymes that hydrolyze triglycerides, increasing the content of free fatty acids, mono- and diglycerides, which promote the formation of rancid odor and flavor. Thermal treatment of rice bran by extrusion reduces the production of free fatty acids, compared to the crude product [10].

There are not studies with addition of these agroindustrial byproducts in sugar cane candies. The rice brain is rich in fiber, minerals and vitamins and has a low cost. The use of rice bran and peanut in the enrichment of sugar cane candy would be an option for the use of this by-product of rice processing, besides it agregate nutritional value to sugar cane candy. The enriched sugar cane candy with rice bran and peanut can be introduced into feed of more poor population, by its addition in the basic consumer basket and school meals.Thereby, the aim of this study was to evaluate the color, hardness, proximate composition and the microbiological contamination of sugar cane candy prepared with different concentrations of sugar cane juice, roasted peanuts and extruded rice bran and to determine the acceptance of the formulation with greater desirability.

2. Materials and Methods

2.1. Preparation of Raw Materials

Sugarcane juice (SJ), from cultivar RB855536, 2011 harvest, was provided by Farm Santa Rita (Vianópolis, Goiás, Brazil). The stems were harvested without burning and immediately transported to the mill to be pressed, yielding SJ with 17°Brix. Extruded rice bran (ERB), cultivar IRGA-417, was provided by Cristal Foods (Aparecida de Goiânia, Goiás, Brazil), and processed in a single screw thermoplastic extruder (Inbramq, PQ30, Ribeirão Preto, Brazil). The parameters used in extrusion were moisture of 8.10 g 100 g^{-1}, temperature in the first, second and third zones of 40, 60 and 90°C respectively, opening of the circular die of 4 mm diameter, screw 300 mm long, and compression ratio of 3:1, and screw speed of 100 Hz. At the end of processing, extruded rice bran (ERB) showed a moisture content of 4.92 g 100 g^{-1}, then it was dried at 80°C in an air circulation oven, to reduce the moisture in less than 2.00 g 100 g^{-1}. Peanut was purchased from the retail market of Goiânia, Goiás, Brazil. It was roasted at 140°C for 30 min in an air circulation oven, hand peeled and crushed in domestic multiprocessor (Faet, Multipractic MC-5, São Paulo, Brazil), producing the crushed roasted peanuts (RP).

2.2. Formulation and Sugar Cane Candies Processing

The ingredients proportions of the mixture, in order to prepare the experimental sugar cane candy, were defined with the aid of the software Statistica (MicroStat, Statistica 7.0, Tulsa, USA). Simplex experimental design was used, with five runs and two replicates at the central point, with the ERB content ranging from 10.00 to 20.00 g 100 g^{-1}, the RP content from 5.00 to 10.00 g 100 g^{-1} and the SJ from 75.00 to 85.00 g 100 g^{-1} (Table 1). Experimental sugar cane candies were processed at the site of Farm Santa Rita. The SJ was finely sieved to remove coarse impurities, and then processed in copper container on direct fire.

Table 1. Simplex design with the concentrations of extruded rice bran (ERB), roasted peanuts (RP) and sugarcane juice (SJ) used in the preparation of sugar cane candy, and values of pseudocomponents

Run	Real concentration (g 100 g^{-1})			Pseudocomponent		
	ERB	RP	SJ	ERB	RP	SJ
R1	10	5	85	0	0	1
R2	20	5	75	1	0	0
R3	10	10	80	0	0.5	0.5
R4	15	10	75	0.5	0.5	0
$R5_{(1)}$	13.75	7.5	78.75	0.37	0.25	0.37
$R5_{(2)}$	13.75	7.5	78.75	0.37	0.25	0.37
$R5_{(3)}$	13.75	7.5	78.75	0.37	0.25	0.37

ERB + RP + SJ = 100 ou 1.

Emerging impurities were removed with a ladle during the concentration of SJ, and when it reached 80°C, it was vigorously stirred for incorporation of air and texture development. The heating continued with constant stirring until reaching 120°C, when it was transferred to another vessel where RP and ERB were added, mixed and then distributed into molds of 25 g. After cooled, sugar cane candy was unmolded and immediately packed in low density polyethylene film. The sugar cane candies were stored in cool boxes at room temperature, it were kept in these conditions until analysis, approximately 60 days.

2.3. Physicochemical Characteristics

Particles size (mm) of ERB and RP were assessed in vibrating equipment (Produtest, T, São Paulo, Brazil), according to the methodology described by Dias and Leonel [11]. Color parameters (L*, a* and b*) of sugar cane candies were determined with a colorimeter (ColorQuest II, HunterLab, Reston, Canada), and hardness (N) was determined with texturometer (TA, XT2, Halesmere, England), with test speed of 2 mm s^{-1}, distance of 18 mm, force of 0.98 N and probe type knife HDP/BSK. Contents of ash, protein, lipids, total dietary fiber, soluble dietary fiber, and insoluble dietary fiber (g 100 g^{-1}) of the raw materials and sugar cane candies were determined according to the methods recommended by AOAC [12]. Carbohydrate content (g 100 g^{-1}) of the sugar cane candies was obtained by difference and the total energy value calculated with the Atwater conversion factors [13].

The microbiological analyses and acceptance sensory were carried out in the formulation of sugar cane candy indicated by the desirability test.

2.4. Microbiological Analysis

Samples were collected and analyzed according to National Health Surveillance Agency (ANVISA) Resolution RDC No. 12 of January 2, 2001 [14].

Dilutions from 10^{-1} to 10^{-6} and the inoculations were carried out according to methodology proposed by Vanderzant and Splittstoesser [15], in order to perform the counting of molds and yeasts, determination of the most probable number per gram of total and thermotolerant coliforms, counting of *Staphylococcus aureus* and determination of the *Bacillus cereus*, which were investigated according to techniques described by the Food and Drug Administration.

2.5. Acceptance Sensory

The appearance, texture, flavor and odor were evaluated in laboratory scale using a nine point hedonic scale 9 = like extremely, 5 = not liked nor disliked and 1 = disliked extremely) according to design of randomized blocks, and positive, maybe or negative purchase intent [16]. Acceptance sensory was performed in individual cabins with 50 homogeneous testers (16 men and 34 women), aged between 18 and 37, with high educational level and previous experience with sensory analysis (94%). According Dutcosky [17] the homogeneity of the sampling taster is much more important than the number of tasters. For each segment of tasters, from 45 to 50 tasters are sufficient (Dutcosky, 2013; Mirim, 2013) [17,18].

The sample, cut into 3 cm × 3 cm pieces, was served on plastic plates and in a sequential monadic manner with a completely randomized design. The acceptance test was conducted after approval by the Ethics Committee (number 113/11).

2.6. Analyses of Results

The fitted polynomial models were subjected to analysis of variance, and with the help of the function "Response Desirability Profiling" (MicroStat, Statistica 7.0, Tulsa, USA), of the significant fitted models, the most desirable formulation was determined, considering as such the one with the highest values of luminosity, hardness, ash, protein, lipids and total dietary fiber (more balanced in relation to the nutritional value). All data were evaluated using the Statistica 7.0 software, including the analysis of variance (ANOVA) and average comparison using Tukey test ($p \leq 0.05$). All experiments were carried out in triplicate.

3. Results and Discussion

3.1. Physical and Chemical Properties

ERB had 80.00 g 100 $g^{-1}$of the particles retained in the 2.83 mm sieve, 8.90 g 100 g^{-1}on the bottom and 11.10 g 100 g^{-1} distributed among the sieves 2.19, 1.68, 1.19 and 0.54 mm, while for the RP, 32.90 g 100 $g^{-1}$of particles were retained on the 2.83 mm sieve, 30.10 g 100 g^{-1}on the 2.19 mm sieve, 13.00 g 100 g^{-1} on the 0.54 mm sieve and 24.00 g 100 g^{-1}on the other sieves, so both presented coarse particle size, but ERB was the more irregular.

Contents of ash, protein, lipids, carbohydrates, dietary soluble, insoluble and total fiber, and total energy were lower, of SJ were lower than in the other ingredients (Table 2).

Table 2. Proximate composition (dry matter basis) and total energy value of extruded rice bran (ERB), roasted peanuts (RP) and sugarcane juice (SJ)

Parameter	ERB	RP	SJ
Ash[1]	9.79 ± 0.04^{a}	2.31 ± 0.03^{b}	0.34 ± 0.06^{c}
Protein[1]	15.80 ± 0.13^{b}	35.75 ± 0.38^{a}	0.06 ± 0.01^{c}
Lipids[1]	17.69 ± 0.07^{b}	47.70 ± 0.36^{a}	0.00 ± 0.00^{c}
Carbohydrates[1]	56.71 ± 0.17^{b}	14.20 ± 0.59^{c}	99.6 ± 0.05^{a}
Total dietary fiber[1]	12.69 ± 0.06^{a}	11.27 ± 0.02^{b}	0.00 ± 0.00
Soluble dietary fiber[1]	2.28 ± 0.28^{a}	0.64 ± 0.03^{b}	0.00 ± 0.00^{c}
Insoluble dietary fiber[1]	10.41 ± 0.22^{a}	10.63 ± 0.09^{a}	0.00 ± 0.00^{b}
Total energy value[2]	1879.79 ± 0.25^{b}	2632.82 ± 1.91^{a}	1726.44 ± 0.25^{c}

* Means followed by standard deviations; 1 g 100 g-1; 2 kJ100 g-1.

The content of ash, soluble dietary fiber and carbohydrate of ERB were respectively 3.2, 3 and 2.5 times higher than in RP. On the other hand, the content of proteins, lipids and total energy value of RP were respectively 126%, 170% and 40% higher than those of ERB. The instrumental color parameters obtained for the standard sugar cane candy (SJ only as raw material) and for those made with SJ, RP and ERB (experimental), as well as hardness, proximate composition, total energy value are listed in Table 3. Models for L*, hardness, ash, protein, lipids and total dietary fiber were significant, explaining 96 to 99% of the responses and the lack of fit was not significant (Table 4).

Models for chroma a* and b*, soluble and insoluble dietary fiber were not significant and are not shown. Chroma a* and b*ranged from 5.01 to 7.64 and 12.92 to 20.4, respectively, and the candies had tendency to an orange color (Table 3).

The highest values of L* were obtained between points A, B and the experimental point 2 (Figure 1A), thus, lighter experimental mixtures were those with higher content of ERB, between 18.3 and 20 g 100 g^{-1} and lower content of RP (about 5.00 - 6.70 g 100 g^{-1}) and of SJ (between 75.00 and 75.50 g 100 g^{-1}).

The heating of sucrose and reducing sugars promotes the reactions involved in caramelization and darkening [19], so in the sugar cane candy the SJ (rich in sugars) was responsible for those reactions and for the typical aroma and flavor of sugar cane candy. However, the inclusion of solids components (RB and RP) lightens the color of the candy in comparison with the control candy and the formulations with higher concentrations of SJ (SCC1, SCC3 and central point). In Figure 1B, the area between points A, B and 2 contained the higher values of hardness (above 50 N), higher than those found in the standard sugar cane candy (Table 3). Therefore, the hardest experimental sugar cane candy was the one formulated with higher amounts of ERB (between 18.60 and 20.00 g 100 g^{-1}) and lower of RP (between 5.00 and 5.50 g 100 g^{-1}) and of SJ (between 75.00 and 76.40 g 100 g^{-1}).

Table 3. Physicochemical characteristics of the standard sugar cane candy (SCS pure) and the experimental made with different levels of extruded rice bran, roasted peanuts and sugarcane juice

Paramenter	Standard	SCC1	SCC2	SCC3	SCC 4	SCC $5_{(1)}$	$SCC5_{(2)}$	$SCC5_{(3)}$
Luminosity	47.57 ± 3.00^{ef}	51.18 ± 1.00^{cd}	66.95 ± 0.90^{a}	52.91 ± 1.00^{c}	59.67 ± 1.10^{b}	45.82 ± 2.30^{f}	52.51 ± 1.20^{c}	48.85 ± 1.70^{de}
Chroma a*	6.30 ± 0.20^{abc}	5.01 ± 0.90^{cd}	6.04 ± 0.2^{bcd}	6.43 ± 1.00^{ab}	7.64 ± 0.70^{a}	4.78 ± 0.80^{d}	7.43 ± 0.20^{a}	6.39 ± 0.40^{ab}
Chroma b*	15.40 ± 1.20^{bc}	12.92 ± 1.90^{c}	20.40 ± 0.4^{a}	13.21 ± 1.7^{c}	20.05 ± 2.200^{a}	9.60 ± 1.30^{d}	16.98 ± 0.60^{b}	13.78 ± 1.30^{c}
Hardness[1]	19.81 ± 3.00^{d}	28.25 ± 4.90^{c}	54.70 ± 3.7^{a}	30.33 ± 3.30^{bc}	29.22 ± 3.80^{bc}	32.87 ± 2.80^{bc}	33.22 ± 3.10^{b}	30.67 ± 2.90^{bc}
Ash[2]	1.56 ± 0.10^{d}	2.47 ± 0.10^{c}	3.35 ± 0.1^{a}	2.43 ± 0.10^{c}	2.76 ± 0.10^{b}	2.72 ± 0.10^{b}	2.77 ± 0.10^{b}	2.66 ± 0.01^{b}
Protein[2]	0.28 ± 0.01^{d}	4.37 ± 0.10^{c}	6.09 ± 0.2^{b}	6.36 ± 0.30^{b}	7.17 ± 0.10^{a}	6.29 ± 0.20^{b}	6.06 ± 0.10^{b}	5.99 ± 0.3^{b}
Lipids[2]	0.00 ± 0.00^{f}	4.91 ± 0.10^{e}	6.69 ± 0.1^{d}	7.65 ± 0.30^{b}	9.00 ± 0.40^{a}	6.90 ± 0.10^{d}	7.43 ± 0.20^{bc}	6.97 ± 0.20^{cd}
Carbohydrates[2]	98.16 ± 0.10^{a}	88.25 ± 0.20^{b}	83.88 ± 0.2^{cd}	83.55 ± 0.40^{d}	81.07 ± 0.40^{e}	84.39 ± 0.30^{c}	83.74 ± 0.30^{cd}	84.38 ± 0.40^{c}
Total dietary fiber[2]	0.00 ± 0.00^{f}	1.14 ± 0.03^{e}	2.30 ± 0.10^{a}	1.48 ± 0.10^{d}	1.99 ± 0.10^{b}	1.81 ± 0.10^{c}	1.82 ± 0.10^{bc}	1.88 ± 0.10^{bc}
Soluble dietary fiber[2]	0.00 ± 0.00^{e}	0.25 ± 0.04^{cd}	0.40 ± 0.04^{a}	0.23 ± 0.01^{d}	0.34 ± 0.02^{ab}	0.30 ± 0.01^{bc}	0.28 ± 0.02^{bcd}	0.29 ± 0.01^{bc}
Insoluble dietary fiber[2]	0.00 ± 0.00^{e}	0.89 ± 0.02^{d}	1.91 ± 0.04^{a}	1.25 ± 0.10^{c}	1.65 ± 0.08^{b}	1.51 ± 0.10^{b}	1.54 ± 0.03^{b}	1.59 ± 0.04^{b}
Total energy value[3]	393.76 ± 0.23^{f}	414.67 ± 0.87^{e}	420.05 ± 0.04^{d}	428.54 ± 1.45^{b}	433.96 ± 0.98^{a}	424.80 ± 0.85^{c}	426.04 ± 1.03^{bc}	424.19 ± 0.77^{c}

1Newtons; 2g 100g-1; 3kJ 100g-1.

Table 4. Fitted polynomial models, with significance level (p), lack of fit (LF) and coefficient of determination (R^2) for L*, hardness, ash, protein, lipids and total dietary fibre as a function of the coded levels of extruded rice bran (x_1), roasted peanuts (x_2) and sugarcane juice (x_3)

Parameter	Model*	p	LF	R^2
Luminosity (L*)	y_1=66.6x_1+53.6x_2+51.4x_3-46.9x_1x_3	0.013	0.78	0.96
Hardness	y_2=54.3x_1+32.5x_2+27.6x_3-63.7x_1x_2	0.002	0.38	0.98
Ash	y_3=3.3x_1+2.4x_2+2.5x$_3$-0.5x_1x_2	0.002	0.64	0.99
Protein	y_4=6.1x_1+8.4x_2+4.4x_3	0.003	0.67	0.98
Lipids	y_5=6.8x_1+10.9x_2+4.83x_3	0.001	0.66	0.97
Total dietary fiber	y_6=2.3x_1+1.8x_2+1.2x_3	0.001	0.11	0.97

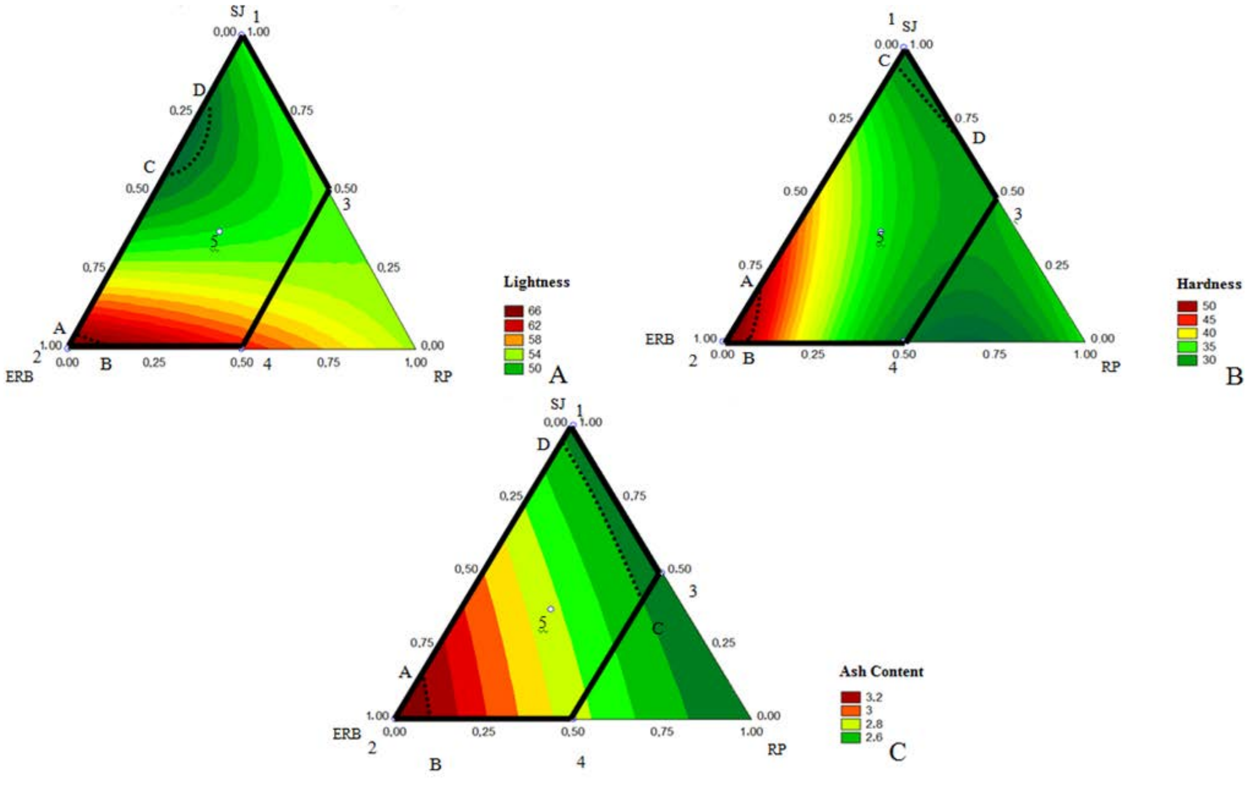

Figure 1. Lightness (A), hardness (B) and ash content (C) of the experimental sugar cane candy according to the levels of sugarcane juice, extruded rice bran and roasted peanuts

The greater the amount of RP, the easier the product was broken during the compression test, probably because the RP consisted of large particles, which negatively interfered in the structural arrangement and in the cohesiveness. RP particle allowed the formation of voids within the product, where the breaks were observed during the analysis. The amount of ERB interfered in the maximum strength of the compression required during testing, since the higher its concentration in the mixture the greater the strength necessary to break it. The ERB, especially the most crumbled fraction, probably helped to form a more cohesive internal structure, which hampered its break during compression.

A trend was shown about the ash content, which the higher the ash content the greater the amount of ERB and the lower the SJ. The highest ash content (3.20 g 100 g^{-1}) was obtained in the delimited area between points A, B and 2 (Figure 1C), in sugar cane candy formulated with 18.30 to 20.00 g 100 g^{-1} of ERB, 5.00 to 6.00 g 100 g^{-1} of RP, and 75.00 to 76.70 g 100 g^{-1} of SJ. The lowest ash content (2.6%), represented in the area formed by points C and D and the experimental points 1 and 3, was found in the sugar cane candy with formulations with 10.00 to 15.30 g 100 $g^{-1}$of ERB, 5.00 to 10.00 g 100 g^{-1} of RP, and 79.60 to 85.00 g 100 g^{-1} of SJ.

Comparing the ash content in the experimental sugar cane candy found in this study (Table 2) with the content found in other studies related to the composition of pure sugar cane candy, which was between 1.70 and 1.54 g 100 g^{-1} [3 and 9 respectively], there was an increase of ashes in the formulated candies, ranging between 34.92 and 63.37% which reiterates the importance of including ERB and RP.

The maximum amount of ash permitted by the Brazilian legislation for sugar cane candy is 6.00 g 100 g^{-1} [2]. The ash content indicates the amount of minerals present in the food, which are essential to the functioning of the organism, but high concentrations of ash can also indicate the presence of impurities, from fraud or contamination during the manufacturing process.

In relation to the protein content, the highest value was found in the sample SCC4 with the highest amounts of RP and ERB and the lowest of SJ (Figure 2A), area delimited by points A, B and 4, in formulations with 15.00 to 17 g 100 g^{-1} of ERB, 9.70 to 10.00 g 100 g^{-1} of RP, and 75.00 to 79.00 g 100 g^{-1} of SJ. RP was the component with the highest protein content. Freitas and Naves [20], in studies on the chemical composition of nuts and edible grains, stated that in general, edible grains, such as peanuts, meet much of the essential amino acids required for children and adults, with the exception of lysine, methionine and cysteine, compared to the most recent standards of the World Health Organization [21]. The sugar cane candy enriched with ERB and RP would be a major contributor to meet those needs, especially if included in school meals, since the RP could meet part of the essential amino acids required for school children.

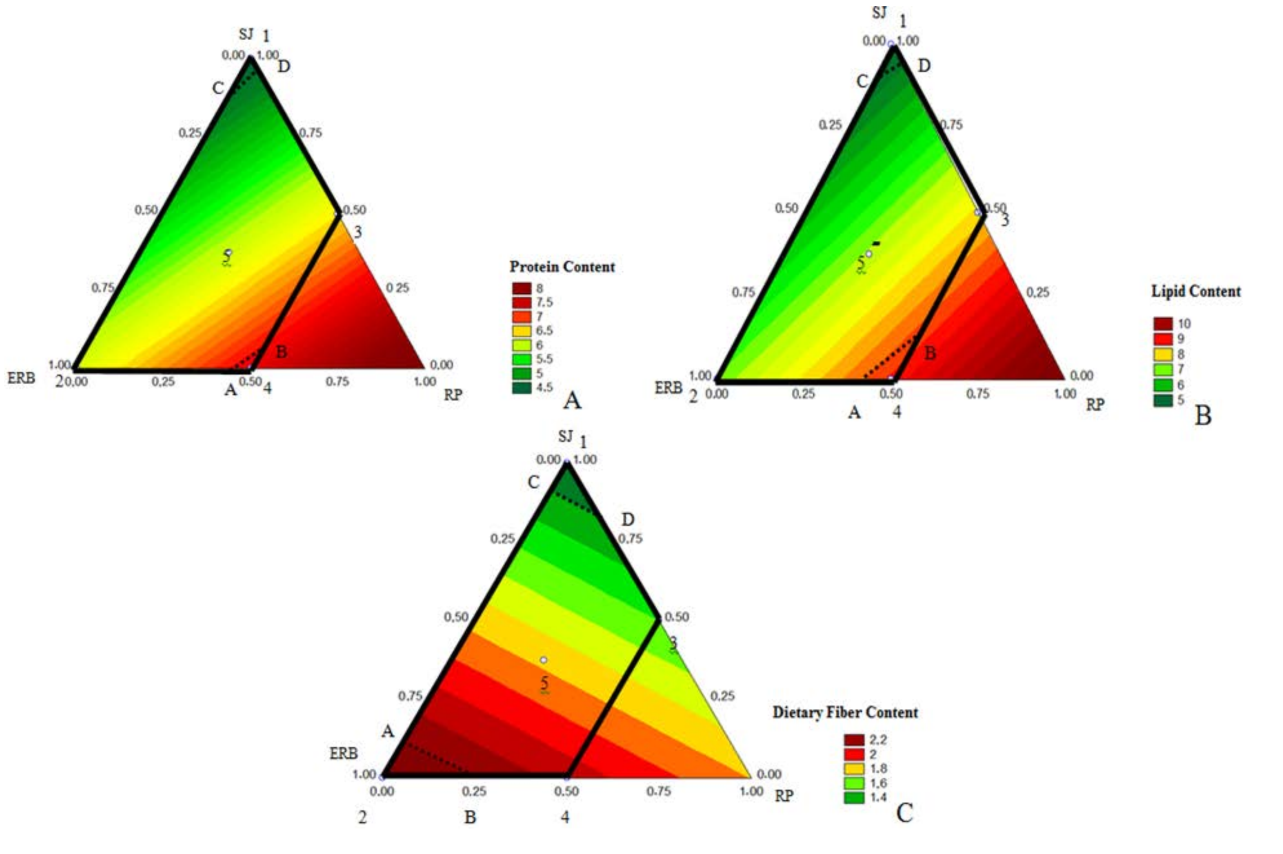

Figure 2. Protein, lipid and total dietary fiber of the experimental sugar cane candy according to the contents of sugarcane juice, extruded rice bran and roasted peanuts

The lowest protein content (4.5 g 100 g^{-1}), which is represented in the area of the graph inside the area delimited by points C, D and 1 (Figure 2A), in sugar cane candy with formulations from 10.00 to 10.50 g 100 g^{-1} of ERB, 5.00 to 5.30 g 100 g^{-1} of RP, and 84.50 to 85.00 g 100 g^{-1} of SJ.As the standard sugar cane candy exhibits low content of protein, the values of this nutrient found in sugar cane candy formulated are from the ERB and the RP and has a better nutritional balance than the standard.

The highest level of lipids were observed in the higher concentrations of RP and ERB and lower of SJ, sample SCC4. In the area delimited by points A, B and4 (Figure 2B), were observed the highest contents of lipids (7.67 g 100 g^{-1}), corresponding to formulations with 15.00 to 17.00 g 100 g^{-1} of ERB, 9.30 to 11.00 g 100 g^{-1} of RP, 75.00 to 79.00 g 100 g^{-1} SJ. The lowest content of lipids were verified in the area delimited by points C, D and 1, with 10 to 10.50 g 100 g^{-1}, 5.00 to 5.20 g 100 g^{-1} of RP, and 84.50 to 85 g 100 g^{-1} of SJ. The amount of lipids in formulated sugar cane candy was from RP, which contains high amounts of lipids (Table 2), while the standard sugar cane candy did not contain lipid.

Studies conducted by Fernandes [22] demonstrated that high content of mono and polyunsaturated fatty acids in peanuts resulted in an elevated relationship between omega 6 and omega 3. Lipids play an important role in the quality of food, since they contribute with attributes such as texture, flavor, nutrition and caloric density. The use of lipids has had special emphasis on research and development of food [19]. Lipid is among the main sources of energy used by man and provide more calories than carbohydrates and proteins [23]. The presence of lipids in the candy is important because it contributes in the balance of calories provided by the sucrose of the sugar cane.

The highest amount of total dietary fiber (2.20 g 100 g^{-1}) was found in the area delimited by points A, B and 2 (Figure 2C), with 17.70 to 20.00 g 100 g^{-1} of ERB, 5.00 to 7.30 g 100 g^{-1} of RP, and 75.00 to 76.2 g 100 g^{-1} SJ, because higher amounts of ERB, found in these formulations, that has the highest content of dietary fiber (Table 2). In the area between the points C, D and 1, the lowest contents of total dietary fiber were found (less than 1.4 g 100 g^{-1}) in formulations with 10 to 10.9 g 100 g^{-1} of ERB, 5 to 6.6 g 100 g-1 of RP, and 84.1 to 85 g 100 g^{-1} of SJ. As the standard sugar cane candy has insignificant amounts of total dietary fiber, that amount is from the combination with ERB and RP (12.69 and 11.27 g 100 g^{-1}).

Solid foods, which are considered sources of dietary fiber, have at least 3 g fibers 100 g^{-1} of solids. Among the formulations of sugar cane candy, the SCC4 had the highest fiber content (2.30 g 100 g^{-1}), 76.7% of the value considered important by the legislation and although it did not reach the value of 3 g 100 g^{-1}, there was a significant increase of up to 2.3 times in this constituent in compared with standard sugar cane candy. This increase can supply 2.28% of the daily requirement of a child that consume 25 g sugar cane candy formulated per day [13].

After the analyses of physicochemical characteristics of sugar cane candy, the desirability test was applied, in which the desirable sample was the one with maximum values of hardness and L*, since the most striking characteristic of sugar cane candy is its high hardness and lighter color. The high values found in the chemical characteristic of sugar cane candy (protein, lipids, total dietary fiber) make it a more nutritious food.

To determine the most desired formulation, scores were assigned to each parameter, 0 (zero) for the least desirable and 1 (one) for the most desirable. The result of the desirability test for obtaining sugar cane candy formulated, with high values of hardness, lightness, ash, protein, lipids and total dietary fiber, indicated as parameters coded as pseudocomponents, the amount of ERB, RP and SJ in 1, 0, 0 (SCC2 treatment), respectively, corresponding to 20.00 g 100 g^{-1} ERB, 5.00 g 100 g^{-1} RP and 75.00 g 100 g^{-1} SJ. This treatment is among those with the lowest amount of SJ, greater amount of ERB and lesser amount of RP, the latter two being responsible for the increase of most nutrients presented in formulated sugar cane candy.

3.2. Microbiological Parameters

The formulation of sugar cane candy indicated by the desirability test presented low count of total coliforms, thermotolerant coliforms, molds and yeasts, *Staphylococcus aureus*, *Bacillus ceereus* (10^2 NMPg^{-1}, < 10 NMPg^{-1} , <100 CFU g^{-1} e < 100 CFU g^{-1}, respectively) and absence of *Salmonella* spp (Table 5).

Table 5. Microbiological parameters of the sugar cane candy formulation indicated by the desirability test

Microbiological Parameter	Sugar cane candy	MAV*
Total coliforms (MPNg^{-1})	10^2	NE
Thermotolerant coliforms 45°C (MNPg^{-1})	< 10	1.0 x 10^1
Molds and yeasts (CFU g-1)	< 100	NE
Staphylococcus aureus (CFU g^{-1})	<100	1.0 x 10^3
Bacillus cereus g^{-1}	< 100	5.0 x 103
Salmonella ssp	absence in 25 g	absence in 25 g

*MAV: maximum allowed value by National Health Surveillance Agency (ANVISA) Resolution RDC No. 12 of January 2, 2001 [14].
NE: limits not established by Anvisa.
CFU: colony forming units
MPN: most probable number.

All microbiological parameters, which are required by the Brazilian legislation, showed values below the limit established by legislation [14]. These results indicated that the raw materials used for the production of sugar cane candy had low microbial counts and the processing of sugar cane candy was made in suitable hygienic-sanitary conditions.

Presence of total coliforms, thermotolerant coliforms, molds and yeasts, *Staphylococcus aureus* and *Salmonella* ssp in food is considered an indication of contamination due hygiene and sanitation inadequate during the processing, production or storage of food [25].

Bacillus cereus is a microrganism widely distributed in nature, and the soil is its natural reservoir. For this reason, food such as vegetables, cereals and tubers can be easy contaminated by this microrganism. Ingestion of food contaminated with pathogenic strains can lead to occurrence of disease [26].

Therefore, these results showed that the sugar cane candy formulation presented microbiological standards within the established by Brazilian legislation, without risk of contamination for human consumption.

3.3. Sensory Analysis

The sensory analysis of the enriched sugar cane candy, indicated by the desirability test, evaluated flavor, odor, texture and appearance, indicating how much the judges liked or disliked the product, as well as the purchase intent. The sample received an average score for the attribute flavor of 7.62, 7.46 for aroma, 7.44 for texture and 7.30 for appearance, which match to the classification between 'like moderately' and 'like very much'. These results were above the acceptance rate set by Dutcosky [17], who considered 7.0 the minimum score for the acceptance of a product. In relation to the purchase intent, 54% said they would definitely buy the formulated product, 26% probably would buy, 12% maybe would buy, 6% possibly would not buy and 2% certainly would not buy. Most of the judges (92%) expressed some interest in buying the product, which shows its great acceptance, proving that it would be a good option in the market, because besides being familiar and pleasant, it also has better nutritional characteristics compared to the standard sugar cane candy.

4. Conclusion

The inclusion of components such as extruded rice bran and roasted peanuts in sugar cane candy increased nutrient availability, not common in the original formulation, such as protein, dietary fiber and lipids, improving the nutritional properties of the traditional sugar cane candy. The sugar cane candy formulated with 20 g 100 g^{-1} extruded rice bran, 5g 100 g^{-1} roasted peanuts and 75 g 100 g^{-1} sugar cane juice, was more desirable with respect to physicochemical characteristics and it accepted by the sensory judges, evidencing the commercial viability of the product.

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