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Addition of toasted baru nut (*Dypteryx alata* Vog.) and extruded rice bran to sugar cane candy ("rapadura")

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Abstract

Different proportions of sugar cane juice, toasted baru nut and extruded rice bran were used in the formulation of sugar cane candies ("rapaduras"), and the effect on color, hardness and proximate composition determined. The best formulation was selected on the basis of composition, hardness and luminosity, and evaluated for sensory acceptance and purchase intent. Simplex design was used to plan the experiment and the limits of the different ingredients. Sugar cane juice has lower values for ash, protein, lipids and total fiber compared to the other ingredients, but it is the ingredient that characterizes the product. The added ingredients affect the physical and chemical characteristics of the "rapaduras". The hardness of the experimental "rapaduras" varied between 20 and 26.1 N, similar to the traditional product, while protein (from 3.28 to 5.9 g 100 g^{-1}), lipids (from 3.87 to 7.67 g 100 g^{-1}), and total dietary fiber (1.47 to 2.67 g 100 g^{-1}), were above the values of the traditional product. Addition of 15 g 100 $g^{-1}$of extruded rice bran and 10 g 100 $g^{-1}$of toasted baru nut to 75 g 100 g^{-1} of sugar cane juice delivered a product with low microbiological risk and good sensory acceptance. The developed product with extruded rice bran and toasted baru nut has good technological potential, allied with sensory and nutritional advantages, and it can be an alternative to add value to rice by-product and nuts from areas of forest conservation.

Keywords: *Saccharum officinale*; *Oryza sativa* L.; by-product; acceptance; nutrients.

Practical Application: Increasing the nutritional value of sugar cane candy with the addition of extruded rice bran and toasted baru nuts.

1 Introduction

The sugar cane candy "rapadura" is a natural sweetener made of unrefined dehydrated sugar cane juice, which is patterned in the form of a brick (Silva et al., 2011). "Rapadura" is produced in Latin America, the Caribbean, Asia and Africa, and the composition depends on cane varieties, as well as on agronomical and processing conditions (Maria, 2013). In Brazil this foodstuff production is the main source of income for farming families, especially in the northeast of the country (Rodriguez et al., 2007).

"Rapadura" contain mainly sucrose and other components in small quantities, such as water, ashes and insoluble proteins. The high energetic value and the presence of minerals and vitamins explain the nutritional benefits of the product (Guerra & Mujica, 2010). In this context, the enrichment of the "rapadura" with grain by-products and nuts is a very interesting method of increasing the nutritional value and diversifying the flavor for consumers.

The baru tree (*Dypterix alata* Vog.) is a plant from the Brazilian savanna, and baru nuts have regional importance because of their nutritional content. The baru nut contains high values of unsaturated fatty acids (ώ-6, ώ-3), vitamin E, zinc, tannin and phytate (Sousa et al., 2011; Marin et al., 2009; Maranhão et al., 2011; Siqueira et al., 2012). Bento et al. (2014) reported the beneficial effects of these bioactive components in combating to the oxidative stress and contributing to reducing the risk of cardiovascular diseases. Considering the nutritional properties and healthy claims, the consumption of nuts and seeds should be stimulated (Freitas & Naves, 2010).

Rice bran is one of the by-products of rice milling, which represents about 8% of the rice grain. It has gained increasing attention worldwide due to its beneficial nutritional and biological effects. The addition of rice bran high in dietary fiber that has a therapeutic potential for the health of the consumers, can contribute to the development of value-added foods or functional foods that are currently in high demand (Friedman, 2013; Gul et al., 2015). However, rice bran is presently underused due to its poor flavor and solubility (Liu et al., 2017). The disagreeable savor could be reduced by the strong taste of baru nut. Furthermore, rice bran has natural enzymes that hydrolyze triglycerides to free fatty acids, which produces a rancid flavor. Thus, the extrusion of rice bran minimized the production of free fatty acids (Lacerda et al., 2013). This agro-industrial by-product is of low cost and could be an option for the rice industry to aggregate

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value to "rapadura" and to feed poor populations through its addition to basic-needs care package (Silva et al., 2016).

The aim of this study was to evaluate the effect of ingredient content (sugar cane juice, toasted baru nut and extruded rice bran) on color, hardness and chemical composition of the sugar cane candies "rapaduras" to determine the higher desirable formulation, and to evaluate sensory acceptance and purchase intent of the selected candy.

2 Materials and methods

The sugar cane juice (SJ) was obtained by milling stems, which were mechanically harvested. The cane used was from the RB855536 cultivar, donated by Santa Rita Farm, situated in the municipality of Vianópolis, Goiás State, Brazil, with 17 °Brix. The rice bran, from the IRGA-417 cultivar, was donated by Cristal Foods, situated in municipality of Aparecida de Goiânia, Goiás State, Brazil. Toasted baru nut (TBN) was acquired in Goiânia city, Goiás State, Brazil. They were peeled manually and powdered in a multiprocessor (Faet, Multipractic MC-5, São Paulo, Brazil). The standard "rapadura" was processed with the same technique as the experimental "rapaduras".

2.1 Formulation and processing of sugar cane candies "rapadura"

The rice bran with 8.1 g 100 g^{-1} of moisture was extruded in a single screw equipament (Inbramaq, PQ30, Ribeirão Preto, Brazil), with temperature in the first zone of 40 °C, in the second zone of 60 °C and in the third zone of 90 °C. A screw of 300 mm long, compression ratio of 3:1, and speed of 100 Hz were used. Besides a die of 4 mm diameter. After extrusion the extruded rice bran (ERB) presented 4.92 g 100 g^{-1} of moisture. To reduce moisture to 2 g 100 g^{-1}, the ERB was oven dried at 80 °C.

The simplex design was employee (Barros et al., 2001), with five runs and two replications at the central point. The tree ingredients and their variations were ERB (10-20 g 100 g^{-1}), TBN (5-10 g 100 g^{-1}) and SJ (75-85 g 100 g^{-1}) (Table 1). The mixtures to prepare the "rapaduras" were calculates by Statistica software (MicroStat, Statistica 7.0, Tulsa, USA).

Table 1. Simplex design used to prepared the sugar cane candies ("rapaduras") with sugar cane juice (SJ), extruded rice bran (ERB) and toasted baru nut (TBN), real concentrations and pseudo-components values.

Run	Real concentration (g 100 g^{-1})			Pseudo-component		
	ERB	TBN	SJ	ERB	TBN	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	7.50	78.75	0.375	0.25	0.375
R5 (2)	13.75	7.50	78.75	0.375	0.25	0.375
R5 (3)	13.75	7.50	78.75	0.375	0.25	0.375

ERB + TBN + SJ = 100 or 1.

Experimental sugar cane candies were processed on Santa Rita Farm. The SJ was sieved to separate impurities, and concentrated in a copper recipient on direct fire. The impurities that floated were collected with a ladle throughout this processing step. When SJ attained 80 °C, it was vigorously shaken for air incorporation and texture improvement. The concentration process with constant shaking continued up to 120 °C, when the concentrated sugar cane juice was moved to another recipient, and ERB and TBN were incorporated, blended, placed in into molds of 25 g, cooled, and packed in plastic film until the analysis days.

2.2 Physical and chemical characteristics

The particles size was determined in granulometer (Produtest, T, São Paulo, Brazil), according to the recommended method by Dias & Leonel (2006). The luminosity, chroma a* and chroma b* of the "rapaduras" were read by a colorimeter (ColorQuest II, HunterLab, Reston, Canada). Hardness was read by a texturometer (TA, XT2, Halesmere, United Kingdom), with distance of 18 mm, test speed of 2 mm s^{-1}, 0.98 N of force and HDP/BSK knife. The lipids, protein, ash, soluble, insoluble and total dietary fiber contents of the raw materials and "rapaduras" were obtained by methods of Association of Official Analytical Chemists (2012). The total carbohydrate was determined by difference method (Equation 1). The total energy was estimated with the conversion factors of Atwater (Brasil, 2003). The microbiological and sensory analysis were carried out on the "rapadura" choosed by the result of the desirability test.

$$\textit{Total carbohydrate} = 100 - \left(\textit{mass in g}\left[\textit{protein} + \textit{fat} + \textit{water} + \textit{ash}\right] \textit{in } 100 \textit{ g of food}\right) \quad (1)$$

2.3 Microbiological analysis and sensory acceptance

The *Staphylococcus aureus*, thermotolerant and total *Coliforms*, *Bacillus cereus*, molds & yeasts counts and the presence or absence of *Salmonella* spp were determined by methods recommended by Food and Drug Administration (2001). Texture, appearance, odor and flavor were analyzed on a sensory laboratory by a nine point hedonic scale (1: dislike extremely, 5: neither like nor dislike and 9: like extremely), using design of randomized blocks. Negative, maybe or positive purchase intent was determined too (Dutcosky, 2015). Sensory acceptance was carry-out by fifty tasters, 34 women and 16 men, with high educational formation and sensory analysis experience (94%), in individual cabins. The samples, cut into 30 mm × 30 mm pieces, were offered on disposable plastic dishes in a sequential monadic form and completely randomized design. The acceptance test was approved by the Ethics Committee.

2.4 Statistical analyses

The adjusted models were evaluated by variance analysis ($p \leq 0.10$), and with "Response Desirability Profiling" function (MicroStat, Statistica 7.0, Tulsa, USA). For the choice of the best formulation was considered the highest values of luminosity (lighter), protein, ash, total dietary fiber and lipids (with more balanced nutritional value), and lowest value of hardness (closer to the value obtained for traditional sugar cane). The means of the sensorial attributes were compared by the Tukey test ($p \leq 0.05$).

3 Results and discussion

3.1 Particle sizes and proximal composition of raw material

The ERB presented 80.02% of the particles retained in the 2.83 mm sieve, 8.91% on the background plate, and 11.07% distributed between 2.19, 1.68, 1.19 and 0.54 mm sieves, whilst for the TBN, 44.01% of particles stopped on the 2.83 mm sieve, 17.97% on the 2.91 mm sieve, 10.29% on the bottom plate, and the rest on the other sieves (Figure 1).

SJ did not present in its composition lipids, dietary soluble and insoluble fiber. Protein and ash contents, and total energy value of SJ were lower than in the other ingredients (Table 2). The ash content of ERB was 3.2 times higher than in TBN. In contrast, the protein and lipids contents and total energy value of TBN were 85%, 120% and 30% higher than ERB. Carbohydrates were higher in SJ then in the other components (ERB and TBN).

Lacerda et al. (2009) reported for 100 g of ERB values of 7.63 g ash, 13.46 g protein, 27.72 g lipid, 38.84 g carbohydrates and 16.35 g TDF. Sousa et al. (2011) reported for 100 g of baru nut on wet basis 3.18 g ash, 29.92 g protein, 41.95 g lipids, 12.25 g carbohydrates and 9.21 g TDF, values similar to those of this research, except in relation to total dietary fiber. One hundred grams of sugar cane juice (wet basis) had 0.3 g ash, 0.3 g protein, 0.1 g lipid and 20.5 g carbohydrates, and 82 kcal (Instituto Brasileiro de Geografia e Estatística, 1999). Variations in the composition of the raw materials can be justified by differences among cultivars, seasons and harvesting site (Carvalho & Bassinello, 2006).

3.2 Characterization of sugar cane candies

Luminosity, hardness, chemical composition and total energy value for the standard sugar cane candy and for those made with SJ, TBN and ERB are presented in Table 3. Statistical differences for ash, protein, lipids and total dietary fiber were significant ($p < 0.05$), while luminosity (L*) and hardness were significant ($p \leq 0.10$), and explained 89-99% of the responses, and lack of fit was not significant (Table 4). Differences were not calculated for total carbohydrates and total energy because the values were only estimated.

There was a trend of higher luminosity values (62) is in the area of the graph which includes points A, B and 4 (Figure 2A). Lower values of luminosity L* (41) includes formulations with

Table 2. Total energy value and proximal composition (dry matter basis) of the sugar cane juice (SJ), toasted baru nuts (TBN) and extruded rice bran (ERB).

Parameter	ERB	TBN	SJ
Ash(1)	9.79 ± 0.04^a	3.03 ± 0.04^b	0.34 ± 0.01^c
Protein(1)	15.80 ± 0.13^b	29.18 ± 0.39^a	0.06 ± 0.00^c
Lipids(1)	17.69 ± 0.07^b	39.08 ± 1.81^a	0.00^c
Total carbohydrate(1)	56.71 ± 0.17^b	28.70 ± 1.43^c	99.6 ± 0.01^a
Total dietary fiber(1)	12.69 ± 0.06^b	16.37 ± 0.28^a	0.00^c
Soluble dietary fiber(1)	2.28 ± 0.28^b	2.72 ± 0.14^a	0.00^c
Insoluble dietary fiber(1)	10.41 ± 0.22^b	13.65 ± 0.14^a	0.00^c
Total energy value(2)	449.28 ± 0.25^b	583.30 ± 9.12^a	398.62 ± 0.05^c

Means in the same line with different letters differ significantly (Tukey Test; $p \leq 0.05$); means followed by standard deviations; (1)g 100 g^{-1}; (2)kcal g^{-1}.

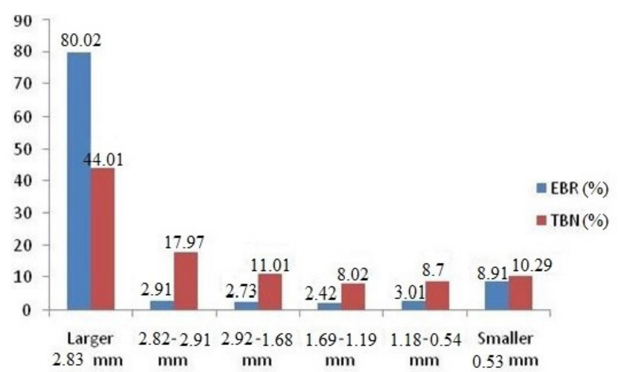

Figure 1. Particle size distribution of extruded rice bran (EBR) and toasted baru nut (TBN) (*Dypteryx alata Vog.*).

Table 3. Physicochemical characteristics of sugar cane candies “rapaduras” (R) formulated with sugar cane juice (SJ), extruded rice bran (ERB) and toasted baru nuts (TBN).

Parameter	Standard(7)	R1	R2	R3	R4	$R5_{(1)}$	$R5_{(2)}$	$R5_{(3)}$
Luminosity	47.57 ± 3.00^d	48.33 ± 0.40^d	41.25 ± 0.60^e	53.96 ± 1.30^c	63.47 ± 0.70^a	53.22 ± 1.50^c	59.79 ± 0.60^b	55.79 ± 1.70^c
Hardness(1)	19.81 ± 3.00^d	26.10 ± 2.60^a	24.45 ± 3.70^b	26.15 ± 4.90^a	20.35 ± 2.20^d	22.53 ± 2.10^c	21.06 ± 2.50^{cd}	21.09 ± 1.70^{cd}
Ash(2)	1.56 ± 0.04^e	2.26 ± 0.10^d	3.27 ± 0.06^a	2.62 ± 0.02^c	2.93 ± 0.04^b	2.71 ± 0.02^{bc}	2.89 ± 0.02^{bc}	2.84 ± 0.10^{bc}
Protein(2)	0.28 ± 0.01^d	3.28 ± 0.10^c	5.47 ± 0.02^b	5.85 ± 0.03^a	5.90 ± 0.10^a	5.19 ± 0.24^b	5.39 ± 0.20^b	5.25 ± 0.10^b
Lipids(2)	0.00 ± 0.00^e	3.87 ± 0.00^d	5.80 ± 0.04^c	7.11 ± 0.30^b	7.67 ± 0.40^a	6.21 ± 0.30^c	6.80 ± 0.30^b	5.99 ± 0.10^c
Carbohydrates(2)	98.16	90.67	85.46	84.42	83.50	85.90	84.91	85.92
TDF(2,3)	0.00 ± 0.00^f	1.47 ± 0.00^e	2.67 ± 0.10^a	2.01 ± 0.10^d	2.58 ± 0.00^b	2.40 ± 0.10^c	2.44 ± 0.00^c	2.45 ± 0.10^c
SDF(2,4)	0.00 ± 0.00^d	0.29 ± 0.00^c	0.50 ± 0.03^a	0.36 ± 0.10^b	0.43 ± 0.00^a	0.36 ± 0.04^b	0.38 ± 0.00^b	0.37 ± 0.00^b
IDF(2,5)	0.00 ± 0.00^e	1.18 ± 0.00^d	2.17 ± 0.10^a	1.65 ± 0.05^c	2.15 ± 0.00^a	2.04 ± 0.00^b	2.06 ± 0.00^b	2.07 ± 0.00^b
Total energy value(6)	393.76	409.02	415.94	425.05	426.62	420.22	422.47	418.61

Means in the same line with different letters differ significantly (Tukey Test; $p \leq 0.05$); means followed by standard deviations; (1)Newtons; (2)g 100 g^{-1}; (3)TDF = Total dietary fiber; (4)SDF = Soluble dietary fiber; (5)IDF = Insoluble dietary fiber; (6)kcal g^{-1}; (7)“Rapadura” standart formulated only with sugar cane juice.

Table 4. Fitted polynomial models for luminosity, hardness, lipids, protein, total dietary fiber and ashes (y_n) in function of the extruded rice brain (x_1), toasted baru nuts (x_2) and sugar cane juice (x_3) (coded levels), coefficient of determination (R^2), significance level (p) and lack of fit (LF).

Parameter	Model	p	LF	R^2
Luminosity	y_1=42.1 x_1 + 59.3 x_2 + 49.8 x_3 + 58.0 x_1x_2	0.059	0.38	0.89
Hardness	y_2=24.5 x_1 + 26.2 x_2 + 26.1 x_3 – 19.9 x_1x_2 -14.8 x_1x_3	0.076	1.00	0.96
Ashes	y_3=3.3 x_1 + 2.8 x_2 + 2.3 x_3	0.04	0.48	0.94
Protein	y_4=5.6 x_1 + 8.4 x_2 + 3.4 x_3 – 3.6 x_1x_2	0.010	0.08	0.97
Lipids	y_5=5.8 x_1 + 10.1 x_2 + 4.01 x_3	0.003	0.70	0.94
Total dietary fiber	y_6=2.6 x_1 + 2.5 x_2 + 1.5 x_3 + 1.8 x_1x_3	0.000	0.55	0.99

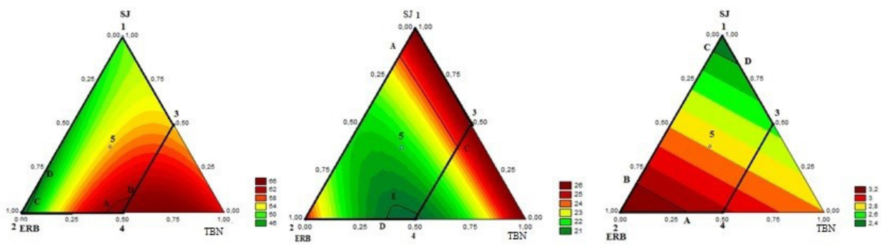

Figure 2. Luminosity (A), hardness (B) and ash content (C) of sugar cane candies "rapaduras" (R) as function of the toasted baru nut (TBN), extruded rice bran (ERB) and sugar cane juice (SJ) level.

TBN between 5 and 6 g 100 g^{-1}, SJ between 75 and 77 g 100 g^{-1}, and ERB between 18 and 20 g 100 g^{-1}.

SJ is responsible for the caramelization (the reaction that happens with the heating of the sucrose), flavor and dark color of the "rapaduras". Therefore, the addition of solids components (TBN and ERB) lightens the color of the candy in comparison with the control candy (Damodaran et al., 2010), and the formulations with higher concentrations of SJ.

The area included between the points A, C, 1 and 3 (Figure 2B) had values of hardness (above 25 N), higher than those found in the standard "rapadura" (Table 3). Thus, the hardest "rapaduras" were formulated with 10-15 g 100 g^{-1} of ERB and 75-80 g 100 g^{-1} of SJ. In study conducted by Silva et al. (2016) that evaluated the physicochemical characteristics of "rapaduras" formulated with different concentrations of extruded rice bran, sugar cane and juice roasted peanuts, a crunch grain with a texture similar to baru, the hardest sugar cane candies were the ones that contained 18.6-20 g 100 g^{-1} of extruded rice bran, 5.0-5.5 g 100 g^{-1} of roasted peanuts, and 75-76.4 g 100 g^{-1} of SJ, probably due to differences in texture between the nuts.

During the hardness tests it was possible to note that when the probe reached a nut it required higher compression force, but when it reached an area with mostly ERB less compression power was required. As the mass of "rapaduras" was not structured in these areas, it was as if there were empty of spaces between the solidified SJ (hard) and the ERB, enabling easer rupture of the sample.

The highest ash level (3.2 g 100 g^{-1}) was determined in the area formed by points A, B and 2 (Figure 2C) and the lowest ash content (2.4 g 100 g^{-1}) was represented in the area between the points C, D and 1. Therefore, the largest amount of ash was in "rapadura" with the maximum amounts of ERB and minimal SJ. In their experimental sugar cane candy, Silva et al. (2016) obtained higher ash content with higher amounts of the extruded rice bran and a lower roasted peanut content. An increase in ashes was observed in formulated "rapaduras", which reiterates the importance of including ERB, TBN or roasted peanut, as possible source of minerals. In their papers on the composition of pure sugar cane sweetener, Maria (2013) and Guerra & Mujica (2010) found the ash content to be between 0.6-2.5 g 100 g^{-1} and 1.15-2.63 g 100 g^{-1}, respectively. The ashes contents in this study (Table 2) were between 2.26-3.27 g 100 g^{-1}.

The highest protein content was found in the formulations R3 and R4, which had the highest values of TBN (Table 3), as demonstrated in Figure 3A through the area limited by points A, B, 3 and 4. TBN was the component with the highest protein content (Table 2), Silva et al. (2016) also obtained the largest amount of protein with higher contents of extruded rice bran and a higher amount of roasted peanut.

The highest level of lipid was verified in the lower concentrations of SJ, and higher of TBN and ERB and, formulation R4, in the area delimited by 3, 4, A and B points (Figure 3B).

The lowest content of lipid was determined in the area limited by 1,.C and D points. The lipids in the "rapaduras" were from TBN, which contains high amounts of lipids (Table 2), while the standard "rapadura" did not contain lipids. Silva et al. (2016) also obtained the highest level of lipids with the formulation with the highest amount of roasted peanut.

Baru nuts are rich in high-quality protein (23.9-29.9 g 100 g^{-1}), and in lipid (38.2-41.9 g 100 g^{-1}) that are predominantly unsaturated fatty acids (approximately 81.2 g 100 g^{-1} of lipid); they also have high concentrations of phytate and tannins

(1073.6 ± 114.9 and 72.2 ± 12.5 mg 100 g^{-1}, respectively). Consumption of baru nut protects biological tissues against iron-induced oxidative stress, and the phytic acid may be partially responsible for this protective effect (Sousa et al., 2011; Siqueira et al., 2012).

Dietary supplementation of mildly hypercholesterolemic subjects with baru nuts improved serum lipid parameters, so this product might be included in diets for reducing the risk of cardiovascular diseases (Bento et al., 2014).

The highest level of total dietary fiber was observed with the higher concentrations of TBN and ERB and lower of SJ, formulation R2 (Table 3), and visualized in Figure 3C, between the A, B and 2 points. The same result was obtained by Silva et al. (2016), since the highest level of total dietary fiber in “rapadura” was the one with the maximum amount of extruded rice bran and roasted peanut, and minimum amounts of SJ.

Solid foods having at least 3 g 100 g^{-1} of total dietary fiber are classified as source of dietary fiber (Brasil, 2003). The formulation R2 had the highest total dietary fiber content (2.67 g 100 g^{-1}), 89% of the amount considered a standard by the legislation. The highest values of total dietary fiber, protein, lipids and ash obtained in the “rapaduras” are due to the maximum addition of ERB and TBN.

The result of the desirability profile graphic for selecting the formulated “rapadura” with high values of luminosity (lighter), protein, ash, total dietary fiber and lipids (with more balanced nutritional value), and lowest value of hardness (closer to the value obtained for traditional sugar cane), indicated the pseudo-components of ERB, TBN and SJ as 0.5, 0.5, 0 (sample R4) (Figure 4), respectively, corresponding to 75 g 100 g^{-1} SJ, 15 g 100 g^{-1} ERB and 10 g 100 g^{-1} TBN. This formulation is among those with the lowest amount of SJ and higher amounts of TBN, which is responsible for the increase in nutrients present in the formulated “rapadura”.

3.3 Microbiological risk

The selected “rapadura” had low count of *Staphylococcus aureus*, *Bacillus cereus*, total coliforms, thermotolerant coliforms, molds and yeasts (Table 5). All parameters showed values below

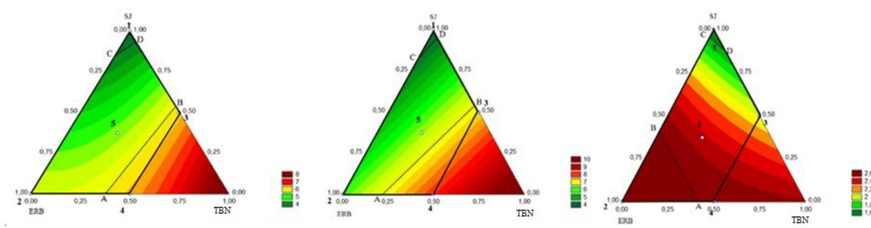

Figure 3. Protein (A), lipid (B) and total dietary fiber (C) of sugar cane candies “rapaduras” (R) as function of the toasted baru nut (TBN), extruded rice bran (ERB) and sugar cane juice (SJ) level.

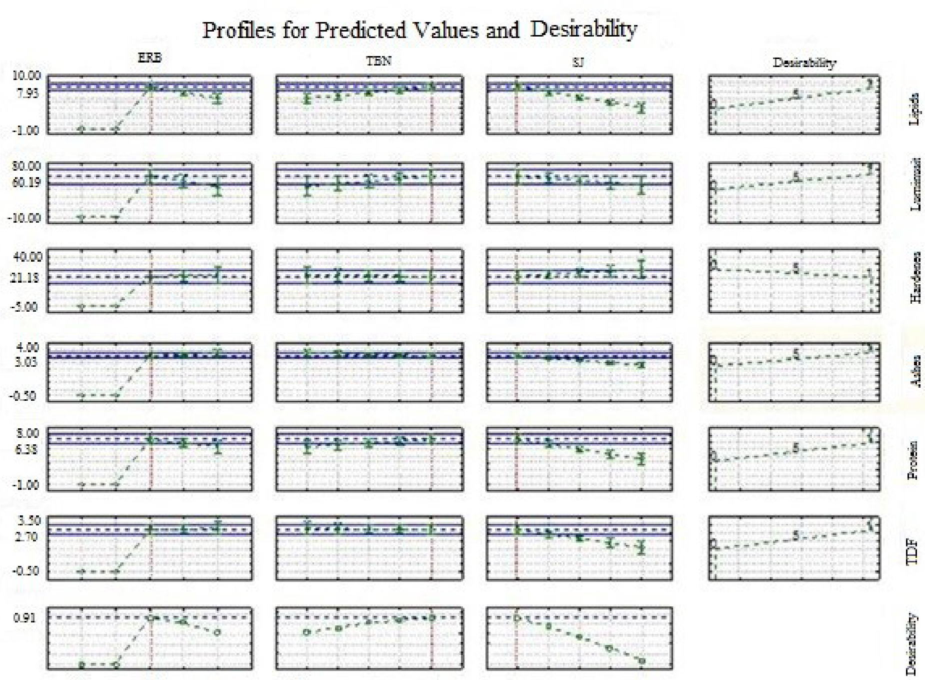

Figure 4. Profiles for predicted values of desirability.

Table 5. Results of microbiological analysis of the sugar cane candy "rapadura" chosen by the desirability test.

Parameter	Sugar cane candy	MAV*
Total coliforms (MPN g^{-1})	10^2	NE
Thermotolerant coliforms 45 °C (MNP g^{-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 10^3
Salmonella sp g^{-1}	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 (Brasil, 2001); NE = limits not established by Anvisa; CFU = colony forming units; MPN = more probable number.

the limit stablished by Brazilian legislation and do not present risk to the consumers (Brasil, 2001).

The raw materials used for the production of "rapaduras" had low microbial count and that the processing occurred in suitable hygienic-sanitary conditions. Wojtczak et al. (2012) reported that the presence of microorganisms in raw cane sugar may be caused by microbiological contamination both during cane processing and during transport and storage.

3.4 Sensory analysis

The selected "rapadura" received an average score of 7.74 for appearance, 7.68 for flavor, 7.56 for aroma, and 7.66 for texture, with classification between 'like very much' and 'like moderately'. The results stayed above the acceptance rate set indicated by Dutcosky (2015), that recommended to take into consideration 7.0 as the minimum score for the acceptance of a product.

Of the tasters, 58% said that would definitely buy the selected "rapadura", 24% would probably buy, 16% maybe would buy, 2% possibly would not buy and no one said that they certainly would not buy. Most of the judges (98%) expressed some interest in buying the "rapadura", which shows its high acceptance level, allowed that it would be a great option for market, because it has better nutritional features than the traditional standard "rapadura".

4 Conclusion

Ash, protein, lipids, dietary soluble, insoluble and total dietary fiber contents, and total energy value of sugar cane juice were lower than in the other ingredients. The hardness values of the experimental sugar cane candies were close to the traditional product, while protein, lipids, and total dietary fiber were above the values of the traditional product. The selected formulation of sugar cane candy combining extruded rice bran, toasted baru nut and the sugar cane juice had low microbiological risk and good sensory acceptance. The product has technological potential, with sensory and nutritional advantages, and can be an alternative to add value to rice by-product and nuts from areas of forest conservation.

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