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Development of Molasses Syrup from Rapadura with Added Cashew and Mango Industrial Co-products

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Abstract: The state of Ceará is one of the largest producers of cashew and mango, and the processing industries generate a high volume of residues of these fruits which are sources of nutrients and can be used in food formulations. This work proposes developing molasses from rapadura added cashew and mango waste in the proportions 10%, 15% and 20% and evaluate their quality. The molasses syrup were developed from the previously grated brown sugar melt and mixed with cashew and mango waste in these proportions. Seven molasses formulations were developed and the control formulation. The proximate composition was performed, caloric value, reducing sugars and non-reducing, acidity, pH, fluidity and sensory analysis. To evaluate the stability, the molasses were studied with regard to acidity, pH and fluidity for 15, 30, 45 and 60 days. It has been found that the incorporation of waste improved nutritional quality, increasing the content of protein, ash, fat and carbohydrates, reduced the levels of non-reducing sugars and fluidity, as well as promoted increased acidity and pH reduction. Molasses formulations obtained average hedonic score above 6.0 and higher acceptance rate of 70%. For stability, there was an increase in the fluidity and acidification of molasses. The addition of cashew and mango processing co-products in molasses produced from rapadura constitutes a viable source of use of this raw material because it improves the nutritional quality and has no sensory rejection.

Keywords: Reutilization, Sensory Evaluation, Quality, Waste

1. Introduction

According to the [1], molasses syrup is a coproduct in the sugar cane industry, whose main products are sugar and alcohol. After going through a cleansing process, the sugar cane is crushed, the juice extracted is sifted, and the impurities are removed and heated to the point of syrup. It is paradoxical that almost all nutrients are removed during production, until the resulting white sugar. Is a liquid obtained by evaporating the cane juice or molasses. It is also called treacle and corresponds to the sugarcane juice filtered, decanted and clean, then evaporated and concentrated to a crystallizable syrup consistency.

The State of Ceará has a tourist route on the East Coast called "Route of the Mills of Rapadura", where this derivative of sugarcane is widely produced, a source of employment and income for the country of the state population.

The derivatives of cane are considered pure foods, because they are produced without chemical additives. Also, they preserve the nutrients, and are nutritional better than the refined sugar [2].

The molasses syrup is popularly mentioned as a source of iron. According to Brazilian Food Composition Table (TACO) the iron content in molasses syrup is 5.4 mg/100 g of product, which corresponds to 39% of the recommended amount, according to [3]. According to the Regulation Identity and Quality Technician for sugar and products to sweeten through [4], the molasses syrup may be the product obtained from melted brown sugar.

The molasses syrup is presented as a product of good acceptance by consumers and can be consumed in various ways. In some states in the Northeast, it is used in a mixture with grated cheese or flour. In the state of Minas Gerais, it is appreciated when consumed with polenta corn meal; elsewhere in the country is consumed pure, with cookies, cakes, with yam or cassava [5].

The use of coproducts in the processing of new foods has been an important follow-up to the industry, particularly with regard to demand for products for special diets [6].

The main waste generated in the processing of fruit pulps are, peel, core, seeds or pulp. These wastes have in their composition, vitamins, minerals, fiber and antioxidants important to physiological functions. However, most of the industries are wasted [7].

The bagasse, which is the byproduct of cashew apple juice extraction, since the nut is considered the fruit may be dehydrated and ground to processing into flour and used in food fortification.

According to the National Supply Company [7], the cashew cultivation is one of the main options for economic and social development of rural areas in the Northeast. The State of Ceará is one of the main cashew producers in Brazil, especially for the production of cashew nut, with the apple being used for the production of juices and waste generation. Although the cashew apple beneficiation is less significant than the nuts (around 10 to 15% of total production), in the juice industry, jams, jellies, fermented etc. [8], it generates a huge amount of waste. It is assumed that approximately 40% of the cashew apple is processed in this type of industrialization, resulting in large residues after the extraction of juice. [9] focusing on the characteristics of the composition of byproduct of cashew apple highlighted the protein content present in the stalk and in the pomace and recommended that the inclusion of the byproduct to improve the quantity of fiber ingested.

As the use of waste parts of cashew have nutritional advantages, recent studies have pointed out the use of mango peel as a source of phenolic compounds. It contains an extensive listing of glycosides, xanthone and flavonols [10]. The major phenolic compounds present in the peels are gallic acid, ellagic acid, gallates, gallotannins, condensed tannins, mangiferin, catechin, epicatechin and benzoic acid. The seeds contain mangiferin and quercetin in the form of aglycone and deglycosídies in the shell, showing a higher antioxidant potential in relation to the seed [11].

After the manufacturing process of the mango juice, considerable amounts of the product are discarded as waste, which amounts to 40 to 60% of raw material, which is composed of 12 to 15% hulls and 15 to 20% seed [12].

This product may have different applications, such as jellies substitute; use in school lunch the Northeast, especially the state of Ceará, or raw material for various food products. The development of molasses syrup from molasses with added waste from cashew and mango processing can promote the reduction of product production cost and provide nutritional benefits by including fibers.

The work aimed to develop molasses syrup from molasses added cashew waste and mango in the proportions of 10, 15 and 20% and evaluate their physical, physicochemical and sensory parameters and stability during 60 days.

2. Materials and Methods

For the development of molasses syrup formulations added residues of cashew and mango agro it was used completely randomized design (CRD), varying the concentrations of coproducts in the 10% proportion, 15% and 20% in relation to the amount of rapadura used.

The fruits and rapadura were purchased in local shops and through donation companies located in Fortaleza, Ceará. For the preparation of the samples, rapadura were scraped using a stainless steel grater with a hole of 0.5 cm. The coproducts was obtained from cashew and mangos properly sanitized, immersed in chlorinated water for 15 minutes in a concentration of chlorine of 200 mg/L of water.

The fruits were cut and processed in a conventional blender for the removal of juice and obtaining and residue through sieves. The juice was passed for consumption, while the residue was dried in a forced air circulation oven at 70 ° C for 6 hours to reduce the moisture content to minimal levels, and was subsequently crushed to obtain a flour.

Table 1 presents the molasses formulations developed with cashew and mango coproducts.

Table 1. *Molasses formulation with cashew and mango coproducts.*

Formulations	Rapadura (g)	Cashew Coproduct (%)	Mango Coproduct (%)
Control	300	-	-
C1	300	10	-
C2	300	15	-
C3	300	20	-
M1	300	-	10
M2	300	-	15
M3	300	-	20
CM	300	10	10

*C1= Molasse added of 10% cashew coproduct; C2 = Molasse added of 15% cashew coproduct; C3 = Molasse added of 20% cashew coproduct; M1 = Molasse added of 10% mango coproduct; M2 = Molasse added of 15% mango coproduct; M3 = Molasse added of 20% mango coproduct; CM = Molasse added of 10% mango and cashew coproduct.

The molasses syrup were produced from the melting of rapadura over high heat, in the average temperature of 110°C, cashew and mango coproduct were added manually by mechanical agitation to promote homogenization. The molasses syrup were cooled at room temperature (T = 28°C) and placed in glass bottles previously sterilized at 120°C in a thermostatic bath for 30 minutes.

The determinations of values of moisture (method n° 44-15.02), protein (n° 46-09.01), fat (30-25.01), ash (n° 08-01.01) were carried out by the methods of the [13]. The carbohydrate content was determined by difference and the total caloric value through Atwater coefficients, according to the methodology described by [14].

The pH determination, total soluble solids, reducing sugars and non-reducing and acidity were based on the methods of the [15]. The fluidity was determined using the method described by [16].

Sensory analysis was performed at the Laboratory of Sensory Analysis Department of the Federal University of Ceará Food Engineering by 60 non-trained panelists, who received about 25 g of molasses, previously weighed in analytical balance. The molasses syrup were presented in plastic cups, where the tasters with the aid of a plastic spatula were able to taste the product.

The molasses syrup were subjected to sensory evaluation by hedonic scale of 09 points, which evaluated the appearance attributes, scent, flavor, texture and overall impression. Buying attitude was assessed by a scale of 05 points, as suggested by [17]. The sample consisted of 64 tasters. To calculate the Acceptability Product Index was adopted AI expression (%) = A x 100 / B, where A = average grade obtained for the product in the overall impression and B = maximum score given to the product, according to the methodology adopted by [18].

To study the life of molasses syrup were performed pH, acidity and fluidity over 60 days of storage. The analyzes were applied at 0, 15, 30, 45 and 60 days.

The molasses syrup statistical analysis was performed by analysis of variance (ANOVA) and Tukey mean comparison test to determine significant differences at 5% significance between formulations and storage time, by using the Statistica 9.0 program.

3. Results & Discussion

Table 2 and 3 presents the results of chemical composition of the molasses produced.

Table 2. *Chemical composition of molasses added cashew and mango coproduct.*

Molasses	Moisture (%)	Protein (%)	Fat (%)
Control	21.37^{a}±0.02	0.54^{d}±0.03	0.21^{d}±0.03
C1	19.38^{b}±0.03	0.69^{c}±0.03	0.26^{c}±0.04
C2	18.49^{c}±0.02	0.75^{b}±0.02	0.31^{b}±0.03
C3	17.59^{e}±0,03	0.84^{ab}±0.03	0.34^{ab}±0.06
M1	20.03^{ab}±0,04	0.59^{cd}±0.03	0.24^{c}±0.03
M2	19.15^{b}±0,02	0.64^{c}±0.04	0.33^{ab}±0.02
M3	18.27^{c}±0,02	0.78^{b}±0.02	0.37^{ab}±0.03
CM	17.93^{d}±0,03	1.05^{a}±0.02	0.42^{a}±0.03

¹Lowercase letters in the same column do not differ significantly by Tukey test ($p \leq 0.05$); ± = Standard deviation.

It was found that the moisture content of the molasses syrup vary significantly. The values ranged from 21.37% for the control sample to 17.93% for CM sample. This behavior may be related to temperature variations during the cooking step molasses, causing shorter boiling and evaporating a minor amount of water, causing the syrup has a higher moisture content.

Table 3. *Chemical composition of molasses added cashew and mango sticky coproduct.*

Molasses	Ash (%)	Carbohydrates (%)	Calorific Value (cal)
Control	0.55^{g}±0.01	77.33^{c}±0.03	313.37^{e}±0,23
C1	0.73^{e}±0.03	78.94^{b}±0.02	320.26^{d}±0,31
C2	0.99^{d}±0.02	79.46^{ab}±0.01	323.65^{bc}±0,29
C3	1.15^{ab}±0.03	80.08^{a}±0.02	326.74^{a}±0,12
M1	0.69^{f}±0.03	78.45^{b}±0.02	319.30^{d}±0,15
M2	0.83^{de}±0.01	79.05^{ab}±0.03	321.73^{c}±0,22
M3	1.09^{c}±0.03	79.49^{ab}±0.01	324.41^{b}±0,19
CM	1.33^{a}±0.04	79.27^{ab}±0.04	325.06^{ab}±0,21

¹Lowercase letters in the same column do not differ significantly by Tukey test ($p \leq 0.05$); ± = Standard deviation.

The incorporation of dehydrated coproduct cashew and mango apparently influenced in reducing the final moisture content of the molasses syrup. It was found that the smaller the addition of these residues, the higher the moisture provided by the molasses syrup, this result was expected given that by adding up products in powder form, a low moisture content, the water present in molasses they tend to migrate to the added ingredient being immobilized in this matrix, which lowers the total moisture content.

[19] analyzed molasses syrup produced in the state of Santa Catarina found average humidity values of 16.05%, 20.82% and

22.30%, showing that the addition of cashew and mango waste not mischaracterize the product on the moisture content.

The molasses syrup had low protein content, ranging between 0.54% (CM) to 1.05% when there was incorporation of cashew and mango waste in the proportion of 10% each. It was found that cashew and mango coproduct raised this parameter significantly at 5% significance when compared to the control.

[20] found 1.16% protein content byproduct of cashew, almost twice that found for the control molasses syrup, and can therefore be stated that occurs enriching the protein content of the product by incorporating the coproduct.

In turn, [21] mention that the crude protein content of the by-product of the cashew peduncle is close to 10%, is an important source of this nutrient for adding in various food matrix.

A similar effect was caused by the coproduct fat from developed molasses syrup. The fat content varying from 0.21% for the control sample to 0.42% for sample CM not being a source of lipids.

The ashes content increased significantly ($p = 0.05$) due to the addition of cashew processing waste and sleeve. Upon a comparison of samples C1, C2, C3 to the control, there was an increase from 0.55% to 0.73%, 0.99% and 1.15% respectively. This increase is due to the ash content in this waste is approximately 1.78%, as [20].

For molasses syrup added of mango coproducts ash values were 0.69% (M1), 0.83% (M2) and 1.09% (M3). According to [22] the mango coproduct presents mineral content of 2.08%, proving that raw materials can enrich the nutritional value with respect to the mineral content of molasses syrup.

In the study by [23], the mineral content of molasses syrup produced in the state of São Paulo varied from 0.84% to 1.94%. The difference between these values and obtained from the control sample may be explained by the genetic variability of sugar cane, the raw material for the production of molasses, as well as extrinsic factors of the cultivation.

The carbohydrate content was significantly influenced by the addition of cashew and mango waste, especially the high fiber content, according to the results of [23] and [24] and [20], influencing directly on the sticky carbohydrate content. It has been found that the addition of the waste increased this parameter, which was 77.33% for the control sample to 80.08% in the sample C3, 20% of cashew residue. [23] found carbohydrates values ranging from 68.10% to 96.4% for molasses, molasses being added cashew waste and sleeve within this range.

The total caloric value of molasses syrup was significantly influenced by the addition of cashew and mango waste, particularly by increasing the carbohydrate content. The lower caloric value was presented by the sample control with 313.37 calories per 100 grams of molasses, followed by M1 samples with 319.30 calories and C1, which had 320.26. The higher caloric value was obtained by the sample CM (325.06 calories/100 g of molasse).

Table 4 shows the results of analysis of reducing sugars and non-reducing of molasses syrup.

Table 4. *Levels of reducing sugars and non-reducing of molasses added cashew and mango coproduct.*

Molasses	Reducing Sugars	Non-Reducing Sugar
Control	52.03^{e}±0.03	25.30^{a}±0.03
C1	52.38^{d}±0.03	24.56^{b}±0.02
C2	54.77^{c}±0.02	24.69^{b}±0.03
C3	56.94^{a}±0.01	23.14^{c}±0.02
M1	53.15^{cd}±0.01	24.92^{ab}±0.02
M2	55.21^{bc}±0.01	23.84^{bc}±0.02
M3	56.37^{ab}±0.02	23.12^{c}±0.02
CM	55.89^{b}±0.02	24.38^{b}±0.03

[1]Lowercase letters in the same column do not differ significantly by Tukey test (p ≤ 0.05); ± = Standard deviation.

The reducing sugar content consists of the amounts of glucose and fructose in the samples. The levels varied significantly with the incorporation of cashew and mango waste, because the levels of these sugars in this raw material. The control sample had the lowest value to 52.03%, while the sample C3, added with 20% of cashew residue showed 56.94%.

According to [23], the higher the content of reducing sugars was higher mean inversion of sucrose, and there is a less possibility of crystallizing the syrup being beneficial the qualily during storage. Therefore, the inclusion of waste can bring improvements, indirectly, in reducing the treacle of crystallization.

Regarding the non-reducing sugar content, the control sample had the highest content (25.30%), while the remaining samples had values less than 24.92%, obtaining less likely to crystallization due to the lower amount of sucrose.

[19] to analyze different types of molasses syrup found that reducing sugar content ranged from 19.30% to 71.11% and non-reducers 10.86% to 50.46%, values within the range of obtained in molasses added cashew processing waste and mango.

According to [23] molasses production process is designed to make the most acidic broth, so that the sucrose is hydrolyzed in reducing sugars and decrease the incidence of crystallization of the sugar during storage, therefore, it is customary to add the broth acid composition. However, it was found that the produced molasses from rapadura and adding coproduct already has a high content of reducing sugars, making its quality during storage.

Table 5 presents the results of the acidity analysis, pH, total soluble solids and fluidity of developed molasses.

Table 5. *Values of Acidity, pH, total soluble solids (SST) and fluidity of molasses.*

Molasses	Acidity (%)	pH	SST (°Brix)	Fluidity (cm)
Control	5.03^{e}±0.01	5.51^{a}±0.01	72.39^{d}±0.05	$6,05^{a}$±0.02
C1	7.12^{c}±0.04	5.32^{ab}±0.01	73.44^{bc}±0.04	$4,54^{c}$±0.02
C2	8.42^{b}±0.02	5.15^{bc}±0.02	74.32^{b}±0.03	$3,55^{d}$±0.02
C3	9.03^{ab}±0.03	4.95^{cd}±0.01	75.11^{a}±0.02	$3,18^{d}$±0.02
M1	6.33^{d}±0.01	5.35^{ab}±0.02	72.99±0.02	$5,23^{b}$±0.04
M2	7.03^{c}±0.05	5.24^{b}±0.04	73.28^{c}±0.03	$4,85^{bc}$±0.01
M3	7.95^{bc}±0.02	5.08^{c}±0.03	74.51^{ab}±0.02	$3,12^{d}$±0.03
CM	9.42^{a}±0.02	4.87^{cd}±0.02	74.31^{b}±0.03	$3,62^{cd}$±0.02

[1]Lowercase letters in the same column do not differ significantly by Tukey test (p ≤ 0.05); ± = Standard deviation.

There was a significant influence of the coproduct of cashew processing and mango on the acidity of molasses syrup compared to the control. There was a sticky acidification process, since the control showed acidity of 5.03%, while that added cashew residue obtained acid 7.12%, 8.42% and 9.03% for C1, C2 and C3 respectively.

A similar effect was provided by the incorporation of residues sleeve which molasses syrup had acidity of 6.33%, 7.03% and 7.95% for M1, M2 and M3 respectively. The highest acidity was presented by the sample CM, 9.42% due to the addition of 10% of cashew and mango coproduct.

The acidification process is provided due to the fruit organic acids present and, consequently, in the waste. This process may contribute to the hydrolysis of sucrose into glucose and fructose present, favoring the storage as well as hindering the growth of bacteria due to the reduction in pH.

The pH varied from 4.87 to 5.51 CM sample to a control sample, with a significant difference. The pH values are directly related to the acidity levels, therefore, the acidification of molasses syrup is to reduce the pH. The results showed that lowering the pH is inversely correlated with the acidity (R^2 = - 0.8733), indicating that lower pH samples were also higher acidity.

[23] found pH values ranging from 3.60 to 5.50 and acidity of 4.10% to 10.30% for different molasses syrup produced in the state of São Paulo, corroborating the results obtained for molasses syrup processed coproducts cashew and mango.

According to [24], the higher this level, the product is more viscous and more difficult is its deterioration. SST values ranged from 72.39 °Brix for the control sample to 75.11 for sample C3, added to 20% of cashew coproduct.

The total soluble solids content may be related to the fluidity of molasses syrup. It was found that the higher the solids content, the lower the fluidity of molasses syrup by the flat surface, which implies a higher viscosity, because the setting of this property is the resistance of a given fluid to fluidity.

The control sample showed the highest fluidity, with 6.05 cm, while the lowest value was presented by the samples C3 (3.18 cm) and M3 (3.12 cm), with no significant differences at the level of 5% significance between them. Therefore, it can be stated that the addition of the coproducts, and increase the SST content promotes an increase in viscosity, by reducing the fluidity of molasses.

The Table 6 and 7 presents the results concerning the sensorial analysis of molasses syrup developed.

Table 6. *Sensory Analysis of developed molasses.*

Molasses	Appearence	Color	Flavor
Control	6.84^{ab}±0.10	6.33^{a}±0.13	7.28^{b}±0.12
C1	6.99^{a}±0.12	6.29^{a}±0.13	7.33^{b}±0.13
C2	7.12^{a}±0.10	6.42^{a}±0.09	7.41^{ab}±0.10
C3	6.33^{c}±0.09	6.21^{a}±0.11	7.22^{bc}±0.15
M1	6.58^{b}±0.14	6.22^{a}±0.15	7.49^{a}±0.12
M2	6.69^{ab}±0.18	6.31^{a}±0.11	7.38^{ab}±0.11
M3	6.10^{d}±0.14	6.29^{a}±0.12	7.12^{c}±0.11
CM	7.25^{a}±0.13	6.32^{a}±0.12	7.69^{a}±0.12

[1]Lowercase letters in the same column do not differ significantly by Tukey test ($p \leq 0.05$); ± = Standard deviation.

The appearance of molasses syrup was significantly affected by the addition of cashew and mango coproduct. The control sample had an average of 6.84, with the C3 and M3 samples below this threshold, with 6.33 and 6.10 respectively, however, within the zone of acceptability of this sensory attribute. The highest averages were obtained by the CM samples (7.25), C2 (7.12) and C1 (6.99), there were no significant differences between them.

Table 7. *Sensory Analysis of developed molasses.*

Molasses	Texture	Overall Impression	Buying attitude
Control	6.39^{c}±0.09	6.44^{a}±0.09	4.25^{a}±0.07
C1	6.93^{bc}±0.12	6.49^{a}±0.12	4.23^{a}±0.03
C2	7.28^{b}±0.08	6.38^{a}±0.08	4.31^{a}±0.08
C3	7.55^{a}±0.15	6.35^{a}±0.09	4.28^{a}±0.05
M1	6.44^{c}±0.19	6.47^{a}±0.06	4.31^{a}±0.12
M2	6.82^{bc}±0.13	6.42^{a}±0.07	4.28^{a}±0.10
M3	7.39^{ab}±0.08	6.39^{a}±0.09	4.21^{a}±0.09
CM	7.44^{a}±0.15	6.46^{a}±0.12	4.33^{a}±0.12

[1]Lowercase letters in the same column do not differ significantly by Tukey test ($p \leq 0.05$); ± = Standard deviation.

When the addition of the coproduct was 20% was found to reduce the hedonic value of the appearance, which may be related to the presence of flour, promoting printing fragments present in molasses syrup.

To the obtained color attribute was not significant difference between all samples, values ranged from 6.42 (C2) 6.21 (C3) within the acceptance zone. This result reinforces the little influence of by-products in the color of molasses syrup, it is from the burning of sugar during the preparation of the syrup.

The flavor attribute averaged ranging from 7.69 (CM) to 7.12 (M3) with a significant difference between the samples. The control sample and C1; CM and M1; C2 and M2 showed no significant differences. It has been found that when incorporating the waste and cashew sleeve was close to 15% an improvement in the molasses syrup taste, probably due to the fruit flavor transfer to the syrup.

The texture was influenced by the inclusion of waste of cashew and mango processing. The values ranged from 7.55 for the sample C3 to 6.39 for the control sample, with a significant difference. The residue promoted viscosity increase of molasses syrup, which had a firmer texture, similar to that of jellies, which may have favored acceptability.

For the overall impression of molasses syrup there was no significant difference between samples, so the addition of waste did not damage the syrups regarding their acceptability, regardless of the degree of incorporation. The averages ranged from 6.38 (C2) 6.49 to (C1).

The buying attitude and the overall impression was not influenced by the different amounts of cashew waste and incorporated sleeve. The values ranged from 4.23 (C2) to 4.33 (CM), and the product is within the range likely to buy therefore the potential to be marketed.

From the average of the overall impression, it was possible to calculate the Acceptability Index of samples: control (71.55%), C1 (72.11%), C2 (70.88%), C3 (70.55%), M1 (71.88%), M2 (71.33%), M3 (71.00%) and CM (71.77%), all being considered with good effect, since it had values above 70%, as recommendation [18]

[25] to develop gabiroba jelly lack satisfactory acceptability and the sample added with 1.5% citric acid 6.16 acceptability obtaining average, lower than the values obtained by the developed molasses syrup.

4. Conclusions

The addition of cashew and mango coproduct improves the nutritional quality of molasses syrup by promoting increased protein content and ash.

Waste reduction provide the content of non-reducing sugars and pH, as well as increased acidity levels, factors that contribute to prevent crystallization of sucrose during the storage period. The fluidity of molasses syrup decrease as increasing the amount of coproduct added.

Developed molasses syrup showed sensory results within the acceptability range for all attributes, as well as marketing potential through the results of the buying attitude.

During the storage period molasses syrup showed increased acidity and flow due to the reduction of the pH, where the waste contributed to the accentuation of these behaviors.

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