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Development of mixed nectar of cashew apple, mango and acerola

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Abstract

Currently, there is an increasing health concern, which has resulted in greater consumption of fruits, considered as rich sources of vitamins, minerals and antioxidants compounds. The tropical fruit nectars are well accepted by consumers due to their high acidity, different colors and flavors, especially those cashew apple, mango and acerola pulps. The chemical and physico-chemical evaluation of mixed nectars of tropical fruits is still scarce. In this way, the purpose of this study was to develop a mixed nectar based on cashew apple (*Anacardium occidentale* L.), mango (*Mangifera indica* L.) and acerola (*Malpighia emarginata* D.C.) pulps. Ten formulations were elaborated using a simplex centroid design. The formulations were evaluated concerning their chemical attributes. The formulations with higher contents of acerola and cashew apple pulps showed higher levels of vitamin C and total extractable polyphenols. Increasing mango pulp content in the formulations resulted in an increase of total carotenoids and a decrease of vitamin C, total extractable polyphenols and anthocyanins. These data will be useful in food industries as a guide for setting parameters in the storage and processing steps, as well as to report the nutritional value of the products obtained. Another important consideration is the use of nacional raw materials can make possible the reduction of regional economic disparities, since the raw materials selected are extremely important and represents economic value for the Northeast region of Brazil.

Introduction

Consumer interest in health issues has increased the demand for healthy foods such as fresh fruit and fruit juices (Maia *et al*., 2007; Caswell, 2009; Barnard, 2010), which are important sources of minerals, vitamins and other compounds, with a positive influence on human health (Kim *et al*., 2010). These compounds are involved in reducing oxidative stress, bringing overall benefits to health (Maia *et al*., 2007).

Cashew apple (*Anacardium occidentalle* L.) belongs to the Anacardiaceae family. It is native from tropical America (Michodjehoun-Masters *et al*., 2009). It is an important source of nutrients due to its high contents of vitamin C (Andrade *et al*., 2008), carotenoids (Zepka and Mercadante, 2009), flavonoids (Hoffmann-Ribani *et al*., 2009) and phenolic compounds, which make cashew apple one of the most important tropical fruits used in juice production (Melo *et al*., 2008).

Mango (*Mangifera indica* L.) also belongs to the Anacardiaceae family and it is native from Southeast Asia and India (Dak *et al*., 2006). It is a good source of amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins, vitamins (Bon *et al*., 2010), fiber (Kikuchi *et al*., 2010), and it contains several bioactive compounds that inhibit cancer cells proliferation (Daud *et al*., 2010; Noratto *et al*., 2010), such as polyphenols and carotenoids, which have a negative effect on oxidative stress (Pourahmad *et al*., 2010).

Acerola (*Malpighia emarginata* D.C.) belongs to the Malpighiaceae family. It is originally from the West Indies and it was introduced in Brazil about 50 years ago (Mezadri *et al*., 2008; Rosso *et al*., 2008). Acerola pulp has been used to increase vitamin C in fruit nectars. In addition to vitamin C, acerola is also an excellent source of flavonoids (Hoffmann-Ribani *et al*., 2009) which show an antioxidant activity (Mezadri *et al*., 2008). Developing mixed nectar based on cashew apple, mango, and acerola may bring benefits to industries and to consumers by offering a natural, healthy and pleasant product. Thus, this study aimed to develop formulations of mixed nectar of cashew apple, mango and acerola, with good acceptability and high contents of functional compounds.

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Table 1. Simplex centroid design for 10 treatments for formulations of mixed nectar of cashew apple, mango and acerola

Treatments (Formulation)	Pseudo components (%)			Original components (%)		
	Cashew apple	Mango	Acerola	Cashew apple	Mango	Acerola
1	90	5	5	31.5	1.8	1.8
2	5	90	5	1.8	31.5	1.8
3	5	5	90	1.8	1.8	31.5
4	47.5	47.5	5	16.6	16.6	1.8
5	47.5	5	47.5	16.6	1.8	16.6
6	5	47.5	47.5	1.8	16.6	16.6
7	33.3	33.3	33.3	11.7	11.7	11.7
8	61.67	19.17	19.17	21.6	6.7	6.7
9	19.17	61.67	19.17	6.7	21.6	6.7
10	19.17	19.17	61.67	6.7	6.7	21.6

Materials and Methods

Raw material

Frozen pasteurized pulps of cashew apple, mango and acerola obtained from a fruit-processing industry located in Pacajús / Ceara, Brazil were used in this work.

Beverages formulations

Ten formulations with different concentrations of cashew apple, mango and acerola pulps, were prepared in triplicate. The overall proportion of pulp, in all cases were of 35% of the total composition of the nectar, the other 65% were related to water and sucrose. The concentration of soluble solids was fixed by mass balance at 12 ºBrix, as recommended by the brazilian legislation for tropical fruit nectars (MAPA, 2003). After homogenization, formulations were subjected to pasteurization at 90°C for 1 minute; then 500 mL glass bottles were filled, closed with plastic caps, cooled in running water and stored at room temperature (28ºC ± 2ºC) in the absence of light until the time of analysis. The proportions of cashew apple, mango and acerola pulps in each formulation were employed as it is shown in Table 1, giving a total of 10 treatments. The proportions of each formulation amounted to 100% (for a total of 35% of fruit pulp).

Chemical characterization

For the characterization of thev samples, chemical analyses were performed in three replicates for all formulations. The pH was determined by direct reading in pHmeter (WTW brand, model 330i/SET), calibrated at each use with buffer solutions of pH 4.0 and 7.0 according to IAL (2008). The content of soluble solids by refractometry was performed by measuring oBrix (refractometer Atago), with a scale ranging from 0 to 90 ° Brix, according to IAL (2008). The reducing and total sugars were determined according to Miller (1959). For the determination of total acidity by titration, it was used 1 mL of sample, and a 0.1 M NaOH solution, according the technique described by IAL (2008), and 1% phenolphthalein as indicator, the results were expressed as mg citric acid /100 mL sample.

For the determination of carotenoids, the extraction was done using an extracting solution of isopropyl alcohol: hexane (3:1) followed by direct reading from spectrophotometer (Shimadzu, model UV – 1800) at wavelength of 450 nm (Higby, 1962).

The anthocyanin content was determined by using a method described by Francis (1982), in which 1 mL of sample was homogenized with 1.5 M HCl solution and ethanol 85% V / V. The homogenized was kept overnight under refrigerated conditions and in absence of light. The extract was filtered and the results were obtained by their detection at 535 nm, expressed as mg/100 mL. The yellow flavonoid content was determined by the same methodology described for the analysis of anthocyanins, at 374 nm. The vitamin C content was determined by using the titration method based on the reduction of 2,6-dichlorophenolindophenol indicator by ascorbic acid (IAL, 2008). The results were expressed as mg ascorbic acid /100 mL sample. The total extractable polyphenols were determined according to the methodology described by Reicher *et al.* (1981), by using the Folin-Ciocalteu, and tannic acid as standard. The reading was made using a spectrophotometer (Shimadzu, model UV-1800) at 760 nm.

Statistics

The composition of the different nectar formulations were determined according to a mixture design using the program SAS (2006), version 8.1. The linear (1), quadratic (2) and cubic (3) models obtained for the experimental responses were assessed in terms of its significance ($p \leq 0.05$) and its correlation coefficients (R^2). The contour lines were

Table 2. Results of pH, total titratable acidity, total sugar and reducing sugar of mixed nectar of cashew apple. mango and acerola

Nectar	Original componentes (%)			Analysis*			
	Cashew Apple	Mango	Acerola	pH	TTA (%)	TS (%)	RS (%)
1	31.5	1.8	1.8	4.51±0.04	0.27±0.32	13.10±1.24	11.62±0.35
2	1.8	31.5	1.8	4.53±0.04	0.27±0.37	12.02±0.43	4.44±0.38
3	1.8	1.8	31.5	4.08±0.24	0.29±0.24	11.87±0.35	3.73±1.00
4	16.6	16.6	1.8	4.48±0.24	0.26±0.31	13.48±1.82	10.42±1.88
5	16.6	1.8	16.6	4.27±0.27	0.27±0.32	12.18±0.53	8.50±2.05
6	1.8	16.6	16.6	4.44±0.10	0.29±0.36	11.86±0.77	4.50±0.45
7	11.7	11.7	11.7	4.43±0.10	0.27±0.34	11.49±1.57	7.23±1.59
8	21.6	6.7	6.7	4.46±0.12	0.26±0.25	12.34±1.12	10.28±0.29
9	6.7	21.6	6.7	4.42±0.09	0.26±0.33	11.97±0.94	5.71±0.64
10	6.7	6.7	21.6	4.37±0.12	0.29±0.21	12.08±0.56	6.38±1.78

TTA: total titratable acidity. TS: total sugar; RS: reducing sugar.
* Values are the averages of triplicates ± standard deviation

used to analyze the behavior of each attribute under consideration depending on the proportions of the different pulps used.

$$Y = b_1'X_1' + b_2'X_2' + b_3'X_3' \quad (1)$$

$$Y = b_1'X_1' + b_2'X_2' + b_3'X_3' + b_1'b_2'X_1'X_2' + b_1'b_3'X_1'X_3' + b_2'b_3'X_2'X_3' \quad (2)$$

$$Y = b_1'X_1' + b_2'X_2' + b_3'X_3' + b_1'b_2'X_1'X_2' + b_1'b_3'X_1'X_3' + b_2'b_3'X_2'X_3' + b_1'b_2'b_3'X_1'X_2'X_3' \quad (3)$$

In which:

Y = estimate of the response of these parameters for each model;

b '= coefficients of the equation;

X 'amount of pseudo = (cashew apple - X'_1, mango - X'_2 and acerola - X'_3).

Results

Chemical characterization

The contour lines related to the results obtained for pH, total titratable and reducing sugar tests are shown in Figure 1. The formulations had pH ranging from 4.08 to 4.53 (Table 2). The interaction between the cashew apple and mango pulps and pulps from acerola and cashew apple contributed to the decrease in pH of the nectars (Figure 1).

No significant adjustments ($p \leq 0.05$) were found for soluble content solids to the linear, quadratic and cubic models. The levels of titratable acidity were fitted to the linear model (Figure 1). For the analysis of reducing sugars, the data showed significant adjustments ($p \leq 0.05$) for the three models used (Figure 1). The lack of adjustments was not significant. The cubic model was chosen for analysis of this parameter as it provided the highest correlation (R^2). Formulations with high levels of mango pulp and acerola showed lower levels of reducing sugars.

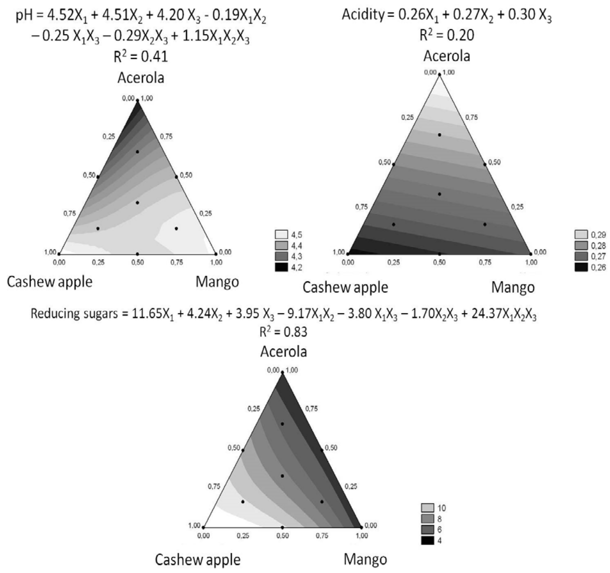

Figure 1. Surface diagram for pH, acidity and reducing sugars

As the cashew pulp proportion increased, an increase in the content of sugar was observed. (Table 2 and Figure 1). With regard to reducing sugar content, the interaction between the three pulps contributed to reduce this parameter while the other interactions between the pulps contributed to increase the sugar content (Figure 1).

The vitamin C contents ranged from 31.58 to 229.94 mg ascorbic acid/100g (Table 3). The formulations with higher levels of cashew apple and mango pulps showed lower levels of total extractable polyphenols. Therefore, the higher the proportion of mango and cashew apple in the formulation, the lower the total extractable polyphenol content. For the anthocyanins analysis, the data obtained showed significant adjustments ($p \leq 0.05$) for the linear,

Table 3. Results of analysis of vitamin C, polyphenols, anthocyanins and carotenoids mixed nectar of cashew apple, mango and acerola

Néctar	Original components(%)			Analyses*			
	Cashew Apple	Mango	Acerola	Vitamin C	Polyphenols	Anthocyanins	Carotenoids
1	31.5	1.8	1.8	64.33±8.62	206.56±41.67	0.98±0.65	0.143±0.02
2	1.8	31.5	1.8	31.58±1.78	99.50±18.12	0.42±0.21	0.60±0.02
3	1.8	1.8	31.5	209.66±49.60	628.87±133.20	3.24±0.67	0.368±0.03
4	16.6	16.6	1.8	45.09±13.14	150.62±37.98	0.19±0.22	0.540±0.01
5	16.6	1.8	16.6	178.03±20.90	377.24±30.69	1.21±1.18	0.355±0.05
6	1.8	16.6	16.6	167.46±22.50	323.19±60.73	1.77±0.96	0.333±0.09
7	11.7	11.7	11.7	133.90±32.05	285.96±39.66	1.34±0.61	0.488±0.12
8	21.6	6.7	6.7	101.71±11.00	257.21±44.81	0.83±0.31	0.499±0.15
9	6.7	21.6	6.7	76.48±15.97	187.69±35.58	0.73±0.29	0.683±0.06
10	6.7	6.7	21.6	229.94±23.80	442.82±27.53	1.67±0.18	0.568±0.11

* Values are the averages of triplicates (mg/100g) ± standard deviation.

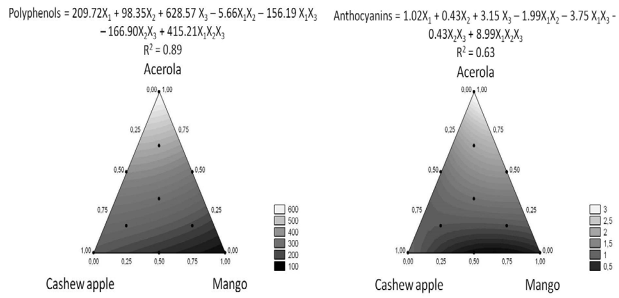

Figure 2. Surface diagram for polyphenols and anthocyanins

quadratic and cubic models. The cubic model was chosen for analysis of this parameter for providing highest correlation (R^2) (Figure 2). The anthocyanin content obtained for the mixed nectar of cashew apple, mango and acerola ranged from 0.42 to 3.24 mg/100 g of nectar. The higher proportion of the acerola pulp in the formulation, the higher the anthocyanin content, since acerola is a fruit rich in this substance. (Figure 2).

The interaction between the three pulps used contributed to increase the content of total extractable polyphenols and anthocyanins while other interactions between the pulps (cashew apple and mango, cashew apple and acerola, mango and acerola) contributed to reduce the levels of such substances in the mixture (Figure 2). The total carotenoid obtained for the mixed nectar ranged from 0.143 to 0.683 mg/100 g. The formulations that contained higher levels of mango and acerola pulps showed higher levels of carotenoids, except for formulation 4, consisting of higher levels of cashew apple and mango pulp.

Discussion

Significant adjustments in the pH data ($p \leq 0.05$) were obtained for the linear, quadratic and cubic models. The cubic model was chosen for analysis of this parameter as it provided the highest correlation (R^2). The increasing proportion of the acerola pulp in the mixed nectar decreased the pH. The low value of correlation coefficient shows that despite the statistical significance for the analysis of variance, the equation is not statistically significant, but a trend indicator.

In the analysis of variance, the linear model was significant and the lack of fit was not significant. The formulations that showed higher levels of the acerola pulp showed better results for acidity, compared to formulations that showed higher levels of cashew apple and mango pulp. With increasing proportion of cashew apple pulp in the mix, a decrease in acidity was observed. Pereira *et al.* (2009) developed a blended beverage based on coconut water, pineapple juice and acerola juice obtaining values of total acidity in the range from 0.24 to 0.52%.

Sousa *et al.* (2010) developed a nectar mixture using cashew apple, mango and acerola. The proportions of each pulps were as follows: 21% mango pulp, 12.25% of cashew apple pulp and 1.75% of acerola pulp. This nectar had 9, 4 and 10.1% of reducing sugars, respectively. The results for total sugars were similar for all formulations analyzed and no significant adjustments were found ($p \leq 0.05$) for the linear, quadratic and cubic models.

This heterogeneity among the formulations for the levels of vitamin C can be explained by the varying levels of different pulps in each formulation.

No significant adjustments were observed for the content of vitamin C ($p \geq 0.05$) for the linear, quadratic and cubic models. Relating to the analysis of total extractable polyphenols, the data showed significant adjustments ($p \leq 0.05$) for the linear, quadratic and cubic models. The cubic model was chosen for analysis of this parameter as it provided the highest correlation (R^2) (Figure 2). Formulations 3 and 10, consisting of the highest levels of the acerola pulp showed the highest levels of total extractable polyphenols (Table 3 and Figure 2A).

Conclusions

Mixed nectars of cashew apple, mango and acerola presented good amounts of functional compounds, varying from the type and concentration of fruit pulps in each formulation. Those that had higher levels of acerola and cashew apple pulps presented higher levels of vitamin C and total extractable polyphenols. By increasing the mango pulp concentrations, an increase in total carotenoids and reduced levels of vitamin C, total extractable polyphenols and anthocyanins were observed. The results can provide guidance to the industrial sector in the determination of the storage and processing, but also revealing the nutritional value of the obtained products. The selected raw material presents extremely economic value for the Northeast region of Brazil. Therefore, this research could reduce the economic disparities in the region mentioned.

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