EVALUATION OF PEEL EXTRACT OF MANGOSTEEN AS A DYE NATURAL AND ANTIOXIDANT AND ITS USE AS AN ADDITIVE IN A FRUIT BEVERAGE

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ABSTRACT

This research was aimed to evaluate the antioxidant capacity, the phenolic content, the dye stability, the yield of extracts of different polarities obtained from the peel of mangosteen (*Garcinia Mangostana*), and finally, their potential use as an additive in mangosteen fruit beverage. Water, ethanol, and different mixtures were used to obtain the dye extracts. Physicochemical and microbiological stability was measured according to Colombian Resolution 3929 of 2013 to determine whether the beverage complies with current regulations. CIE L*a*b* scale measured the color stability of the beverage for 30 days, the sensorial acceptance with a hedonic scale. The best extraction performance was achieved with the mixture of water and ethanol in a 1:1 ratio, yielding 23.07 ±0.12% of total biomass extracted from the peel, and the phenolic content was 368.7 mg GAE 100 mL^{-1}, IC_{50} values of 184 mg mL^{-1}, and 146 mg mL^{-1} by the ABTS and DPPH respectively. The beverage prepared from mangosteen pulp and dye extract reached the microbiological requirements by Resolution 3929 of 2013 for fruit drinks. The sensorial test showed that formulated mangosteen beverage dye extract is hedonically the same at treatment with ascorbic acid.

Key words: Mangosteen pulp, phenolic compounds, fruit juices, antioxidant capacity

تقييم مستخلص قشور المانجوستين (*Garcinia mangostana*) كصبغة طبيعية ومضادات للأكسدة واستعمالها كمضاف في مشروبات الفاكهة

ماكادو ماريلو هنسي
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المستخلص

يهدف البحث إلى تقييم القدرة المضادة للأكسدة ، والمحتوى الفينولي، واستقرار الصبغة، وإنتاجية المستخلصات ذات الأقطاب المختلفة التي تم الحصول عليها من قشر المانجوستين (*Garcinia Mangostana*)، وأخيرًا، إمكانية استخدامها كمادة مضافة في مشروب فاكهة المانجوستين تم استعمال الماء والإيثانول ومخاليط مختلفة للحصول على مستخلصات الصبغة .تم قياس الاستقرار الفيزيائي والكيميائي والميكروبيولوجي وفقًا للقرار الكولومبي 3929 لعام 2013 لتحديد ما إذا كان المشروب يتوافق مع اللوائح الحالية .يقيس مقياس CIEL*a*b* ثبات لون المشروبات لمدة 30 يومًا ، والقبول الحسي بمقياس المتعة .تم تحقيق أفضل أداء استخلاص بخليط الماء والإيثانول بنسبة 1 :1 ، ينتج0.12 ± 23.07 ٪ من إجمالي الكتلة الحيوية المستخرجة من القشر ، وكان المحتوى الفينولي 368.7 ملجم GAE / 100 مل ، قيم IC_{50} قدرها 184 ملجم / مل ، و 146 مجم / مل بواسطة ABTS و DPPH على التوالي .وصل المشروب المحضر من لب المانجوستين ومستخلص الصبغة إلى المتطلبات الميكروبيولوجية بموجب القرار 3929 لعام 2013 لمشروبات الفاكهة.

الكلمات المفتاحية: لب مانغوستين، مركبات الفينول، عصائر الفاكهة، القدرة المضادة للأكسدة

Received:22/3/2021, Accepted:13/6/2021

INTRODUCTION

During 2020 Colombia produced 1500 tons of mangosteen (22), and around 50% of the total production is for export. Mangosteen is considered a good fruit in Colombia's export plan, and it is committed to increasing production in the coming years. However, one of the purposes of this agro chain is not to offer a commodity but to generate added value to the product (28). Although the fruit does not actively participate in the Colombia agroindustry, some companies have bet on its industrialization. Waste generated during processing is 70% because the non-edible part is very high in peels and seeds (34). Therefore, the above becomes an opportunity to generate added value due to its varied chemical composition. The waste generated in the food industry has recently attracted attention as a means of sustainable management. It could simultaneously increase the benefits for economies by valorizing this waste (10). Therefore, collective efforts have been made in recent years to exploit this biomass as a resource for the generation of value-added products, bio-energy, chemicals, pharmaceuticals, cosmetics, and food (26). The epicarp of mangosteen has been used in medicine and pharmacology to treat diseases like antidiabetic, antimicrobial, anticarcinogenic, appetite suppressant, and others due to the presence of metabolites such as anthocyanins, xanthones, terpenoids, flavonoids, lactones (4, 32). The use of peel extract with bioactive properties like antioxidants and natural dye in the food industry can lead to the development of new products (1, 37). For example, the mangosteen peel extract has been incorporated into food and cosmetics matrices as juices, edible oils, and face cream (8, 25, 36). In this article, we analyze for the first time the coloring and antioxidant potential of mangosteen peel extract and their effect on the physicochemical, microbiological, and organoleptic properties when incorporated into beverages formulated with mangosteen pulp. In this way, we explore other alternatives for the integral use of the mangosteen fruit in the food beverage sector that lead to the generation of the added value of waste.

MATERIALS AND METHODS

Dye extraction and evaluation of solvents

Fresh mangosteen was selected in the red-violet ripening stage and purchased from the market (Ibague, Tolima). The peel was separated and dried in an oven at 40 °C for 24 hours. The mangosteen's flesh was stored at -18 °C until used. The dried peel was milled in a hammer mill to 1 mm diameter mesh. For the extraction, water (E1), a combination of 50:50 water and ethanol at 96% (E2), and ethanol at 96% (E3) were used. A ratio of 1:10 p/v of ground material was added to each solvent. Each sample with its solution was kept to constant agitation on a magnetic table with 1000 RPM rotation for 24 hours at 26 °C. Then, it was vacuum filtered with a Büchner funnel and 110 mm diameter filter paper. The filtration has repeated three times to exhaust the substrate, and the dye solutions were measured in CIE coordinates L*a*b*. The dye extraction yields were expressed in the initial biomass of mangosteen peel (w/w); on the other hand, the one with the highest performance will be chosen to incorporate into the drink.

Determination of antioxidant capacity by DPPH and ABTS methods

The antioxidant activity was carried out using the DPPH method applied by Brand-Williams, which is based on the reduction of the absorbance of the DPPH radical 1,1-diphenyl-2-picrylhydrazyl, measured at 515 nm (6). The antioxidant activity was performed by mixing 150 µL from the extraction sample and 850 µL of the DPPH- 0.1 mM.

The percentages of inhibitions are expressed in Equation 1:

Equation 1. Percentage of antioxidant inhibition

$$\%\,\boldsymbol{Inhibition} = \frac{\boldsymbol{A - A_1}}{\boldsymbol{A}} . \mathbf{100}$$

Where:

A = Blank absorbance

A_1 = Sample absorbance

The antioxidant capacity of ABTS was also determined by the modified method proposed by Kuskosky 2005 (17). First, a mixture is prepared with ABTS radical (7 mM) and ammonium persulphate (4.9 mM) in a ratio of 1:1. This mixture was kept at rest for 16 hours in the dark, after which it was diluted with

20% ethanol until an absorbance of 0.7 ± 0.02 at 734 nm was reached; then, aliquots were added at different concentrations. Next, 150 µL of extract prepared were added to 850 µL of the ABTS solution, and the change in optical density at 734 nm was measured after the first 6 minutes of reaction. Finally, the median inhibitory concentration (IC_{50}) values of DPPH and ABTS were calculated. Trolox calibration curves were prepared for the DPPH at a concentration range between 0.1562 and 10 µg mL^{-1} and the ABTS at a concentration range between 0.0781 and 5 µg mL^{-1}.

The stabilizing activity of ABTS was determined by Equation 2:

Equation 2 Percentage of ABTS stabilizing activity

$$\boldsymbol{AE\ ABTS} = \left(\frac{\boldsymbol{A_{ABTS} - A_{6\ min}}}{\boldsymbol{A_{ABTS}}}\right).\mathbf{100}$$

Where:

AE ABTS: Stabilizing activity of the ABTS radical, expressed as a percentage

A_{ABTS}: Absorbance of the ABTS before adding the sample

A_{6min}: Absorbance of the reaction mixture after 6 minutes

The antioxidant activity of the dye solutions obtained was evaluated at different pHs in DPPH and ABTS: water extract pH 4.13 (T1), water extract pH 3.70 (T2), water-ethanol extract pH 4.75 (T3), water-ethanol extract pH 3.70 (T4), ethanol extract pH 4.70 (T5), and ethanol extract pH 3.70 (T6). In addition, samples were acidified at two points to determine the influence of pH on antioxidant activity. In addition, resolution 3939 of 2013 in Colombia establishes that this type of fruit beverage must have a pH below 4.0.

Determination of phenolic content

Total phenols were quantified using the Folin-Ciocalteu reagent (31). A calibration curve with gallic acid was prepared at concentrations between 1.5 and 10 µg mL^{-1} and 760 nm. The absorbance was read at 760 nm and in a Multiskan Go microplate reader. The results are expressed as mg equivalents of gallic acid per 100 ml of extract (mg GAE 100 mL^{-1}).

Mangosteen beverage preparation

The mangosteen beverage production was formulated by blending the mangosteen pulp, refined sugar, and water, balancing the mixture to meet the physical requirements demanded by Colombian regulations (*23*). Finally, the beverage must have at least 8% pulp and 6% soluble solids. The beverages were pasteurized at 70℃ for 30 min.Three treatments were tested on the beverage for 30 days: (I) with 1% of mangosteen extract), (II) 0.1% ascorbic acid, and (III) a control without the addition of preservatives to determine the effect of the mangosteen peel extract on the inhibition of microorganisms in the beverage under the parameters evaluated. The beverages were packed in glass bottles and stored at 4°C.

Physicochemical and microbiological characterization of formulated beverage

Soluble solids were determined in mangosteen beverages by optical refractometry in a Brixco refractometer ATC3040 (0 - 32 °Bx). The pH was measured with the SD300 Lovibond potentiometer. The content of acid present in the beverage was determined by titration with sodium hydroxide at 0.1 N concentration; the method was applied in the digital burette until the sample reached a pH of 8.3. Subsequently, it was expressed as a percentage of citric acid, as indicated in NTC 440 (16). The microbiological parameters were evaluated as required by resolution 3929 of 2013 (*23*). It was evaluated for 60 days with sampling on days 0, 30, and 60, using sowing in dilutions of 100 and 10-1 in Petri dish with Chloramphenicol Glucose (YGC) agar, was taken to Memmert incubator at 27 ºC for 72 hours performed for molds and yeasts, acceptable limit in fruit beverages is below 300 CFU mL^{-1} (*14, 23*). For the determination of mesophiles, plate count agar was used and incubated at 37 ºC for 48 h, the acceptable limit in fruit beverages is below 100 CFU mL^{-1} (15, 23).

Colorimetric analysis

The colorimetric analysis of the extracts was measured in CIELab space coordinates (L*, a*, and b*) on a Konica Minolta Cr-5 colorimeter. To establish the color difference between the samples, ΔE is calculated using the following equation 3 (13).

Equation 3 Color variation expressed in ΔE

$$\boldsymbol{\Delta E} = \sqrt{(\boldsymbol{L_0 - L_1})^2 + (\boldsymbol{a_0 - a_1})^2 + (\boldsymbol{b_0 - b_1})^2}$$

Where:

Δ*E*: Variation or alteration of color
Δ*a*: Variation from green to red between measurements
Δ*b*: Variation from blue to yellow between measurements
ΔL: Variation in brightness between measurements

Sensory evaluation of formulated mangosteen beverage

A sensory evaluation was realized with 30 untrained judges, measuring the attributes of color, smell, taste, and overall acceptability using a 9-point hedonic scale (1: extremely dislike, 2: very dislike, 3: dislike, 4: slightly dislike, 5: neither like nor dislike, 6: slightly like, 7: very like, 8. like, and 9: extremely like (*9, 33*). The above scale was used to evaluate the formulations' color, odor, flavor, and general acceptability. The test was carried out in 3 moments: on the first day, after 15 days, and after 30 days; at each moment, ten untrained judges participated.

Statistical analysis

The statistical program Statgraphics (Centurion version) was applied to perform a unidirectional analysis of variance in the biomass yield, and a simple linear regression was used to predict the solvents' IC_{50} of antioxidant inhibition at different concentrations of mangosteen extract. In addition, Tukey's multiple comparison test was analyzed using Minitab 16 (Minitab Inc, State College, PA) for the hedonic test.

RESULTS AND DISCUSSION

Extraction yields

The extraction yields of mangosteen peel under the treatments with water-ethanol mixture 1:1 v/v (E2), treatment with ethanol concentrated at 96% (E3), and treatment with water (E1) expressed in biomass were 23.07 ±0.1%, 17.03 ±1.15%, and 9.23 ±1.33% respectively. The above shows a significant difference ($p<0.05$), highlighting that the water-ethanol treatment had the best performance. This effect is due to use phytochemical compounds present in the peel can synergic ally extract the mixture of solvents with different polarities; in this case, water drags the polar biocomposites and ethanol the less polar ones (18). The water acts as a swelling agent for plant tissue, increasing the contact surface. At the same time, ethanol induces the rupture of the link between the solutes and the matrix, considerably increasing extraction yields (21). However, the subsequent filtrations observed that the yield decreased considerably, as showesin **Figure 1**. The solids retained through the filtrations decrease significantly as each filtrate passes, emphasizing that the binary mixture of the solvents generated in the first filtration has the highest retention of phytochemical material. For example, filtration 2 yields below 5%, and filtration 3 approaches to 0% with no significant difference among E1, E2, and E3 treatments.The colour results measured in CIE coordinates L*a*b*, recorded the following; (T3) water-ethanol: L*=62.53, a*=17.23 and b*=56.86; (T5) ethanol: L*=88.79, a*=-7.54 and b* = 81.95 and (T1) water: L* = 3.14, a* = 15.45 and b* = 4.94. **Table 1** shows the difference in color with different treatments. The less intense color of the extracts diminishes after each filtering because most of the biomass is dragged in the first filtrate. The biomass retained through the filtrations decreases significantly as each filtrate passes, emphasizing that the binary mixture of the solvents generated in the first filtration has the highest retention of phytochemical material; filtration 2 yields below 5%, and filtration 3 approaches 0%. Therefore, we chose to work with the water-ethanol extract (T3) and only with the first filtrate.

Antioxidant activity

The best antioxidant activity was in the hydroalcoholic treatments T3 and T4; however, T3 showed an IC_{50} in DPPH of 145.83 ppm, significantly differences ($p<0.05$) from the T4 extract pH 4.75 of 167.20 ppm (A low IC_{50} indicates a higher antioxidant capacity). On the other hand, the aqueous treatments T1 and T2 showed the lowest antioxidant capacity since, at a pH of 3.7, they presented an IC_{50} of 816.09 ppm; finally, the ethanolic treatments T5 and T6 were much better than the aqueous treatments. The results suggest that the hydroalcoholic solvent at 50% ethanol is an excellent mixture to extract compounds with

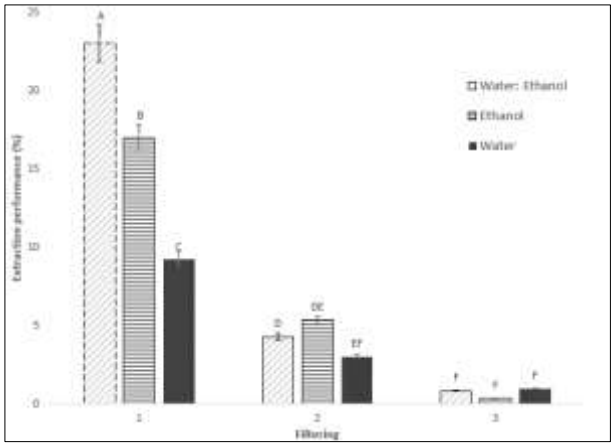

Figure 1 Extraction yields of mangosteen peel dye using different solvents

antioxidant activity, reflecting the DPPH and ABTS methodologies (Table 2). Furthermore, binary extracts of water and ethanol show a better antiradical and reducing power than when they work independently (11). Also, the primary antioxidants in mangosteen peels have polarity between water and ethanol under experimental conditions (35). By the ABTS method, it's evident that the hydroalcoholic treatments T3 and T4 are the best; however, T3 stands out with IC_{50} of 183.70 ppm, significantly different ($p<0.05$) from the extract T4 pH 3.70 of 216.87 ug mL^{-1}. The aqueous treatments T1 and T2 showed the lowest antioxidant capacity since, at a pH of 3.7, they presented an IC_{50} of 562.00 ppm; finally, the ethanolic treatments T5 and T6 were much better than the aqueous treatments.

Table 1. Colorimetric parameters in peel mangosteen extracts*

Treatment	Filtered 1	Filtered 2	Filtered 3
Water: ethanol	L*62.53 *a**17.23 b*56.86	L*86.31 a*-5.24 b*48.28	L*87.91 a*-5 b*35.03
Ethanol	L*88.79 *a**-7.54 b*81.95	L*96.85 a*-12.9 b*41.58	L*99.04 a*-5.42 b*14.1
Water	L*3.14 *a**15.45 b*4.94	L*60.75 a*8.05 b*40.57	L*68.83 a*3.19 b*31.38

***Color reference according to:** http://www.workwithcolor.com

Manasathien and Khanema (19) reported that for ethanolic and aqueous mangosteen peel extracts, IC_{50} for DPPH- of 1199.85 ±47.16 and 2435.71 ±273.74 µg/mL, respectively, found that the ethanolic fraction has expressed in IC_{50} and antiradical activity twice higher than the aqueous extracts. In the present study, values of 406.74 ±29.21 µg mL^{-1} and 777.23 ±5.49 µg mL^{-1} were obtained for the ethanolic and aqueous fractions; respectively, besides for the hydroalcoholic extract IC_{50} of 145.83 ±1.96 µg mL^{-1}, the results were better than those reported by Manasathien (19). However, this type of antioxidant activity measured through this methodology is affected according to the ripening of the fruit since the peel of young fruit could be result from higher phenolic contents and total tannins (27).

Therefore, the results obtained could be vary from other studies because IC_{50} in mangosteen is affected according to the maturity of the fruit, the growth sites, harvest time, and extraction method (29). The antioxidant properties obtained from plants potentially increase the value of agro-industrial waste, taking advantage of attributes such as the decrease in cancer incidence attributed to phenolic compounds that remove reactive oxygen species (24). These results guarantee the excellent use of this by-product as an antioxidant additive in a food matrix.

Phenolic content

In the present study, the yields of the phenolic content against the extraction capacity of the solvents behave in the following order T3> T5 > T4 (see Table 3). Water-ethanol pH 4.75 presented 322 ± 9.14 mg GAE 100 mL^{-1} extract (T3), which is significantly different ($p<0.05$) from water-ethanol at pH 3.7 (T4) and ethanol pH 4.70 (T5). The ethanol extract pH 3.7 showed 212.46 ±0.87 GAE 100 mL^{-1} extract. Finally, water extract pH 4.13 (T1) and water pH 3.7 (T2) treatments showed the lowest content of phenolic compounds, where 100.04 ±8.97 and 102.9 ±2.73 mg GAE 100 mL^{-1} extract respectively reported; no significant difference was reported ($p>0.05$). It is important to note that the polar nature of the phenolic compounds present in fruits is highly soluble in alcoholic and hydroalcoholic

solvents (20), as observed in T3 and T5 since hydroalcoholic solvent mixtures prove to be effective during extractions, managing to attract compounds of a wide range of polarity (5).

Table 2. IC_{50} values of different mangosteen peel extract analyzed by DPPH• and ABTS• radical stabilization methods.

Treatment	IC_{50} DPPH µg mL^{-1}	Limit of prediction 95%		Confidence limit 95%		R^2
		Lower	Superior	Lower	Superior	
Ascorbic acid standard	2.19	32.41	67.56	43.05	56.92	97.78
T1: Water extract; pH 4.13	777.23	27.12	72.88	37.16	62.84	90.04
T2: Water extract; pH 3.70	816.09	28.47	76.52	39.01	65.98	94.54
T3: Water: ethanol Extract; pH 4.75	145.83	20.15	102.15	28.71	71.29	88.45
T4: Water: ethanol Extract; pH 3.70	167.20	24.19	75.82	39.34	60.67	95.99
T5: Ethanol extract; pH 4.70	406.74	26.02	73.98	39.56	60.44	92.62
T6 Ethanol extract; pH 3.70	220.70	34.81	65.17	43.00	56.98	98.69
Treatment	IC_{50} ABTS µg mL^{-1}	Lower	Superior	Lower	Superior	
Ascorbic Acid Standard	2.17	39.43	60.56	45.94	54.04	98.95
T1: Water extract; pH 4.13	467.68	12.59	87.41	33.33	66.67	93.77
T2: Water extract; pH 3.70	562.00	35.10	64.94	43.38	56.66	98.43
T3: Water: ethanol Extract; pH 4.75	183.70	28.03	71.97	40.68	59.32	97.01
T4: Water: ethanol Extract; pH 3.70	216.87	39.96	60.04	45.42	54.58	99.33
T5: Ethanol extract; pH 4.70	343.59	28.45	71.55	41.35	58.65	96.85
T6 Ethanol extract; pH 3.70	349.27	20.92	79.08	37.84	62.16	93.11

Table 3. Extraction performance of phenolic compounds by Tukey method and 95 % confidence

Treatment	Media mg GAE 100 mL^{-1} extract
T3: Water-ethanol at pH 4.75	322.00 ± 9.14a
T5: Ethanol at pH 4.70	248.88± 1.03b
T4: Water-ethanol at pH 3.70	239.88 ±1.58b
T6: Ethanol at pH 3.70	212.46 ±0.87c
T2: Water at pH 3.70	102.90 ±2.73d
T1: Water at pH 4.13	100.04 ±8.97d

*** Averages that do not share a letter *are significantly different***

Physicochemical characteristics of mangosteen beverage

Three different beverages were formulated, I) added ascorbic acid (0.1%), II) a control without additives, and III) mangosteen dye extract water: ethanol (1%). The last one was chosen because this treatment shows the highest yield in biomass and the best phenolic compound content. Table 4 shows the physicochemical results of the beverages compared to what is required by the standard. This beverage was formulated with 46% less than the maximum sugar limit allowed by the rules. However, adding coloring-type extract instead of ascorbic acid reflected an increase in pH and decrease and Titratable acidity out of standard. Therefore, alternatives should be studied to meet the minimum requirements of titratable acidity and pH parameters, enhancing the extract evaluated and thus being viable in the food industry. Microbiological counting of mangosteen beverage on the shelf for 60 days showed results for mesophiles, molds, and yeasts measured in CFU mL^{-1} below the parameters allowed by resolution 3929 of 2013. The control beverage had the highest mesophilic microorganisms count at 270 CFU mL^{-1}, followed by ascorbic acid treatment at 52 CFU mL^{-1}, and the best was the beverage with the mangosteen dye extract at 20 CFU mL^{-1} (see Figure 2). Different studies corroborate that raw and ethanolic extracts generate bacteriostatic effects due to the Xanthone α-mangosteen in the mangosteen's peel (3). The best treatment was the one that incorporated mangosteen dye extract (see Figure 1). The one treated with ascorbic acid and the control recorded 18 CFU mL^{-1} and 13 CFU mL^{-1}, respectively. For mold and yeast counts, 100 CFU mL^{-1} is

permissible. (See Figure 3). The treatments with ascorbic acid and the control do not present fungicidal action alone; however, the mangosteen peel extract in the beverage achieved effectiveness, obtaining the lowest count during the study. This fungistatic action is attributed to the presence of phenolic compounds from the mangosteen's peel when used as a bio preservative in food (2).

Table 2. Physicochemical characteristics of mangosteen beverage

Requirements	Parameters (*23*)		Beverages		
	Min	Max	Ascorbic Acid	Dye extract	Control
Soluble solids by refractometric reading at 20°C (°Brix)	-	13.0	6.0	6.0	6.0
pH at 20°C	-	4.0	4.0	4.5	5.0
Titratable acidity expressed as % citric acid	0.2	-	0.03	0.01	0.01

Color stability

The color change (ΔE) was measured in three-dimensional space by the CIE L*a*b* scale and, after one month of storage, was quantified at 0.25 for the ascorbic acid treatment and 0.72 for the coloring extract and 2.75 for the control, showing week-by-week changes in Figure 2. The control may show a more significant color change (ΔE) than the treatments applied, generating significant changes (30). The treatments with ascorbic acid and with the coloring extract show that during a month of refrigerated storage, the mangosteen beverage is not possible to perceive a difference in color according to the CIE L*a*b* scale; on the contrary, the control shows a more significant color changes, reflected mainly in the darkening of the product. In Figure 4, the points located on the Y-axis from 0 to 1.5 are considered slight differences; from 1.5 to 5 is a difference that can be distinguished, and greater than 5 are evident color differences (12). It is essential to highlight the color stability of the extract Water: ethanol in the beverage since the maximum ΔE in time was 0.82, even lower than the maximum ΔE of 0.90 of the treatment with ascorbic acid. The above indicates that the by-product extract positively affected the color of the food, being viable for use in the food industry. In this way, an alternative is generated for agro-industrial waste such as mangosteen peel, taking advantage of its antioxidant properties conferred by these by-products, replacing chemical additives currently used in food, as demonstrated in this study.

Sensory evaluation of formulated mangosteen beverage

After one day of storage (see Table 5), the treatment with mangosteen dye extract obtained the highest average rating in odor and general acceptability, the treatment with ascorbic acid the highest rating for taste, and the control the best rating in color. However, a specific analysis of the attributes evaluated in the treatments didn't show significant color differences (p=0.719), odor (p=0.769), taste (p= 0.825), and general acceptability (p= 0.874).

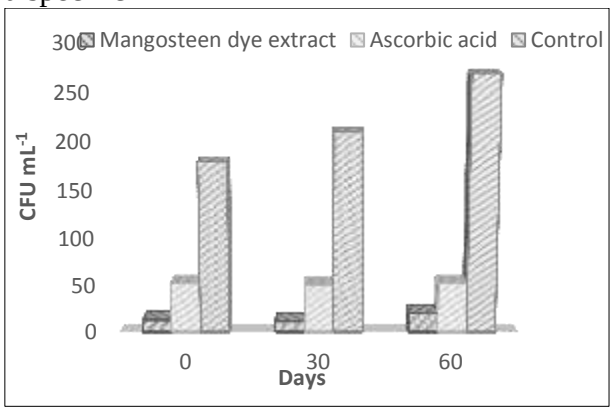

Figure 2. Results of mesophilic aerobic count in the samples analyzed

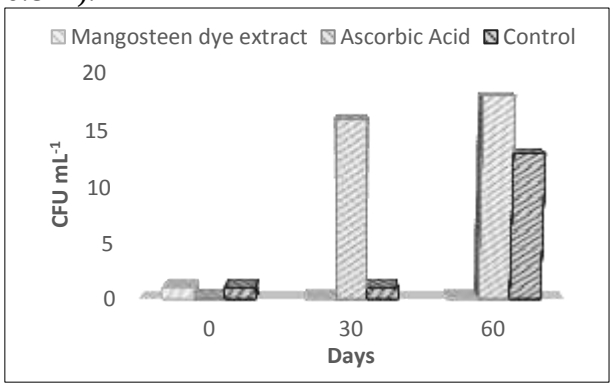

Figure 3. Results of molds and yeasts count in the samples analyzed

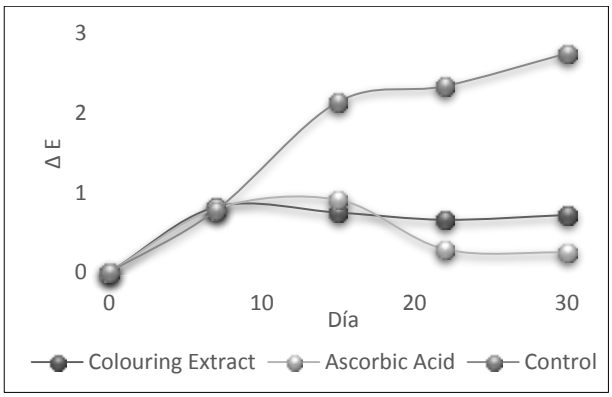

Figure 4. Total color difference (ΔE) of Mangosteen beverage for one month

After 15 days of storage, as showes in Table 6, the treatment with ascorbic acid recorded the best average rating for flavor. This preference for ascorbic acid over other treatments is explained by the fact that this organic acid is traditionally used in beverage manufacturing as an antioxidant, preservative, sequestrant, and reducing agent (7). Finally, after 30 days of storage (Table 7), there were no significant differences where color has a (p=0.884), odor (p=0.183), taste (p=0.914), and general acceptability (p=0.816). Overall the test showed that the behavior is hedonically the same for all three sensory evaluations performed on days 1, 15, and 30 of storing the three mangosteen beverage.

Table 3. Hedonic scale sensory evaluation day 1

Treatment (Day 1 Evaluation)	Color	Odor	Flavor	General acceptability
Ascorbic Acid	6.2 ±1.03	5.8 ±1.13	6.5 ±1.51	6.4 ±1.43
Dye Extract	6.1 ± 1.10	6.1 ±1.59	6.1 ±1.92	6.5 ±0.97
Control	6.5 ±1.26	5.7 ±0.94	6.0 ±2.16	6.2 ±1.47
p value (5%)	0.719	0.769	0.825	0.874

Table 4. Hedonic scale sensory evaluation day 15

Treatment (Day 15 Evaluation)	Color	Odor	Flavor	General acceptability
Ascorbic Acid	5.5 ±1.78	5.3 ±1.05	6.9 ±1.79	6.7 ±1.33
Dye Extract	5.8 ±1.68	5.5 ±2.32	5.2 ±1.75	5.5 ±1.26
Control	5.0 ±0.94	6.6 ±1.57	5.9 ±1.28	6.3 ±1.05
p value (5%)	0.501	0.214	0.081	0.103

Table 5 Hedonic scale sensory evaluation day 30

Treatment (Day 30 Evaluation)	Color	Odor	Flavor	General acceptability
Ascorbic Acid	6.5 ±1.35	6.2 ±0.91	7.1 ±1.85	6.8 ±1.31
Dye Extract	6.6 ±1.43	6.8 ±1.61	7.1 ±1.79	6.9 ±1.66
Control	6.3 ±1.33	5.7 ±1.25	6.8 ±1.81	6.5 ±1.35
p value (5%)	0.884	0.183	0.914	0.816

CONCLUSIONS

Of the extraction methods evaluated for mangosteen peel, higher yields were achieved with the binary mixture of the solvents water and ethanol, improving the biomass yield, antioxidant activity, and phenolic content. Furthermore, incorporating the best extract within the mangosteen beverage allowed the development of color; according to the CIE L*a*b* scale, it is within the range of the "Brown" also, it replaced the antioxidant effect that would have as an additive on the matrix the ascorbic acid. The sensory evaluation did not show significant differences between the treatments applied to the beverages, for which a high-cost antioxidant agent such as ascorbic acid can be replaced by mangosteen extract, increasing the potential of the agro-industrial residue as a source for obtaining an antioxidant compound for the food industry. It is necessary to continue studies that improve the solubility of the dye extracted from the peel into the beverage. The microbiological analysis of the beverage showed that the mangosteen extract performed well as a preservative agent.

ACKNOWLEDGEMENTS

We thank José Giovanni Tovar Guayabo for his support in the statistical design.

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