Organic acid adaptations in sugarcane juice

Rodrigo Rodrigues Petrus
ABSTRACT

Acidification is a usual procedure performed by the juice industry that targets either the standardization or microbiological and enzymic stabilization of the end product. This study was primarily undertaken to investigate sensorial adaptation of organic acids in sugarcane juice. Trans-aconitic, malic and citric acids were separately added into freshly extracted whole juice (pH ~ 5.0) until pH 4.4. Nine-point hedonic scale, difference-from-control and rank preference tests were carried out. Also physicochemical, microbiological, enzymic assays and measurement of color parameters were conducted. Although trans-aconitic is the predominant organic acid found in sugarcane juice, it is not the best option for the juice acidification. Conversely, citric and malic acids were more compatible with cane juice based on the sensory analysis, and citric acid best matched cane juice. Citric acid is also much more affordable compared to trans-aconitic and malic acids.

Keywords: Plant-Based Product, Trans-Aconitic Acid, Malic Acid, Citric Acid.
INTRODUCTION

Sugarcane juice is a highly energetic drink (~73 kcal/100 g). Its pH and soluble solids content may widely range between 4.7 and 5.8, and from 10 to 25 °Brix. The juice’s color also varies from green to brown. As with all plant-based products, cane juice composition highly depends on the raw material cultivar, climate, soil, cultivation site, maturity and agricultural practices (Panigrahi et al., 2020; Adulvitayakorn et al., 2019; Oliveira et al., 2007). Cane juice is great for recharging energy because it is rich in carbohydrates and iron. Green-typed tropical cane is sweetest and juiciest. Sugar cane juice is a nutritious product containing natural sugars, minerals and organic acids, and it has many medicinal properties. It strengthens the stomach, kidneys, heart, eyes, and brain (Yasmin et al., 2010). Fresh cane juice is popular in countries such as India and Brazil, where it is a cheap and sweet beverage (Panigrahi et al., 2020).

Nevertheless, cane juice ($a_w$ 0.99) deteriorates rapidly, and preservation technologies must be implemented to avoid spoilage, growth pathogenic microorganisms, and enzymic activity as well. These events jeopardize both the sensory and nutritional quality of the juice and shorten its shelf life (Graumilich; Marcy; Adams, 1986). Panigrahi et al. (2020) holds that fresh cane juice has a short shelf life due to browning and fermentation in presence of oxidative enzymes, yeasts and bacteria. Development of effective treatments or procedures to keep the fresh quality of juice would allow it to be more widely marketed, and would maintain its quality and safety as well (Mao et al., 2007).

To enhance the palatability of cane juice and standardize its flavor, either citric fruit juice or organic acid may be added to juice. This intervention significantly changes the ratio soluble solids/titratable acidity (Matsura et al., 2004; Oliveira et al., 2007). Additionally, as the pH is decreased below 4.6, the microbiological and enzymic stability is favored (Vera et al., 2003). As an alternative to fruit juice addition, organic acids can be incorporated into cane juice to extend its shelf life. Acidification is a method of food preservation, which inhibits the activity of enzymes and microorganisms. Nevertheless, the combination of acidification and mild heat treatments are more effective targeting the juice’s quality preservation. Singh and Shalini (2016) highlight that the preservation of almost all foods is based on combined application of several preservative methods, including acidification. Hurdle technology represents the application of technologies in reduced “doses” to interact synergistically to control safety and retain sensory quality and nutritional values. When applied to cane juice, this consists of acidification to a pH of approximately 4.4, pasteurization, ultra clean filling and refrigeration. Usaga et al. (2014) reported that thermal pasteurization is not sufficient for destroying heat-resistant spores, and therefore, acidification has been commonly applied by the food
industry as a pretreatment to pasteurization to inhibit spore germination and to allow milder time and temperature conditions during heat treatments.

Food grade acids, known as acidulants, are used in food industry for purposes such as: 1) to prevent or delay enzymatic and microbiological deterioration; 2) to act as buffering agents; 3) to control and/or standardized the pH of the food. Acidulants have very different taste profiles; taste profiles of acids refer to their perception, intensity and duration in foods. The acidulating power of acids is related to its dissociation and interaction with the components of the food matrix. To choose the best acidulant, one needs to take into account the chemical profile of the acid, as well as the chemical elements of the food and the way in which they interact with each other (Food Ingredients Brazil, 2016); therefore, the sensory acceptance is frequently the ultimate criterion to guide the acidification. Organic acids represent a significant percentage of non-sugars in cane and are account for the titratable acidity of the juice. Trans-aconitic acid is the main acid produced by sugarcane, but cis-aconitic, oxalic and citric acids are also found in its raw material (Zapata, 2007). Gutierrez, Ferrari and Orelli Jr (1989) determined the levels of organic acids in cane juice extracted from different varieties of raw material. Trans-aconitic acid accounted for 84% of the total organic acids, followed by malic acid with 14%. Other organic acids, such as citric, were found at levels below 1%. Trans-aconitic (1-propene-1,2,3-tricarboxylic acid/C_6H_6O_6) is a tricarboxylic acid. Citric acid (2-hydroxypropane-1,2,3-tricarboxylic/C_6H_8O_7) is also tricarboxylic. Malic acid (2-hydroxybutanedioic acid/C_4H_6O_5) is dicarboxylic (PubChem Compound Database).

This study was primarily undertaken to search for the organic acid that best matches the cane juice. Trans-aconitic, malic and citric acids were tested. The findings herein reported may guide cane juice processors to choose the organic acid in an acidification procedure. To the best of our knowledge, no studies are available on the comparison among organic acids aiming the acidification of cane juice, thus paving way for the application of this simple but outstanding hurdle in a scale industry.

■ MATERIAL AND METHODS

Juice extraction

Sugarcane (Saccharum spp.) cultivar RB867515 was locally procured in the city of Pirassununga – Sao Paulo/Brazil. The raw material was cut, sorted, scraped and dipped into a 0.1% (v/v) peracetic acid solution for 30 min at a temperature of approximately 25 ºC. The juice was extracted and pre-filtered (28 mesh) in a stainless steel electric cylinder mill, manufactured by Maqtron (Joaçaba – Santa Catarina/Brazil). Subsequently, it was filtered (35 mesh). A volume of approximately 35 L of juice was extracted. The freshly extracted juice
was collected into 4-L polyethylene containers which were partially dipped into a water bath kept at 0 °C to preserve the juice during acidification. The juice was then acidified by adding trans-aconitic, citric and malic acids, separately, until achieving a pH of 4.4.

**Measurement of pH and soluble solids**

The pH and soluble solids content (expressed in °Brix) of the freshly extracted juice were measured in a pHmeter (Tecnopon model MPA-2010) and a digital refractometer (model Reichert AR-200).

**Microbiological assays**

Counts of mesophiles, psychrotrophs, and molds and yeasts were carried out following the protocol described in the Compendium of Methods for the Microbiological Examination of Foods (Downes, 2001).

**Enzymic tests**

The protocols adapted from Campos et al. (1996) were used to determine the polyphenol oxidase (PPO) and peroxidase (POD) activities.

**Polyphenol oxidase**

Five and half milliliters of 0.2 M phosphate buffer solution (pH 6.0) and 1.5 mL of 0.2 M catechol were added into a test tube and maintained at 25 °C for 10 min. Then 1.0 mL of the diluted sample in deionized water (1:10) was added. The tube was stirred for 15 s and returned to the water bath at 25 °C for 30 min. The absorbance was read in a spectrophotometer at 425 nm. The blank was prepared by diluting the sample in deionized water.

**Peroxidase**

Seven milliliters of 0.2 M phosphate buffer solution (pH 5.5) and 1.0 mL of the diluted sample (juice) in deionized water (1:10) were added to a test tube and maintained in a heat bath at 35 °C for 10 min. Then 1.5 mL of 0.05% guaiacol and 0.5 mL of 0.1% hydrogen peroxide were added. The tube was magnetically stirred for 15 s and returned to the bath at 35 °C for 15 min. Finally, the absorbance was read in a spectrophotometer at 470 nm.

One (1) unit of enzyme activity (U) was defined as the amount of enzymic extract capable of increasing absorbance at 425 and 470 nm for PPO and POD, respectively, at rates of 0.001 units per minute.
**Instrumental color analysis**

The color parameters ($L^*$, $a^*$ and $b^*$) of whole and acidified juice samples were measured in a Hunterlab Ultra-Scan colorimeter (Hunter Associates Laboratory, Model SN7877 Reston, VA/USA). The illuminant D65 and observation angle at $10^\circ$ were set up. The parameters $a^*$ and $b^*$ were used to determine chroma ($C$) and hue angle ($\text{hue}$) (Equations 1 and 2). In order to compare the acidified juice to the regular one (control), total color difference (TCD) was calculated by Equation 3. Also $L^*$, $a^*$ and $b^*$ were inserted in the EasyRGB to convert them into color image (EasyRGB, 2020).

\[
C = \left( a^{*2} + b^{*2} \right)^{1/2} \quad \text{(Eq.1)}
\]

\[
\text{hue} = \arctan\left( b^*/a^* \right) \quad \text{(Eq.2)}
\]

\[
\text{TCD} = \left( \Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2} \right)^{1/2} \quad \text{(Eq.3)}
\]

**Sensory evaluation**

This study was validated by the Ethics in Research Committee from College of Animal Science and Food Engineering of the University of São Paulo (CAAE 13436919.2.0000.5422 / report 3.401.445). Tests were performed in individual booths acclimatized at 24 ºC and lighted with white fluorescent lamp. Samples of cane juice were served at a temperature of approximately 6 ºC in 50 mL plastic cups labeled with a 3-digit code. Mineral water was provided to cleanse the palate. The panel consisted of untrained habitual consumers of cane juice averaging 22 years old. Sensory evaluation was carried out based on protocols described by Meilgaard, Civille, and Carr (2015).

**Hedonic scale test**

Four juice samples (regular juice, and juice acidified with trans-aconitic, citric and malic acids) were individually served to a panel of 100 assessors. The panelists were asked to evaluate the appearance, flavor and overall impression by assigning a liking score on a 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely).

**Rank preference test**

The four samples were served simultaneously to a panel of 100 assessors who were asked to rank the samples based on their preference.
Difference-from-control test

This test was conducted to determine whether the acidified samples differed from control, and to estimate the “size” of such any difference. Five juice samples were simultaneously served to a panel of fifty assessors. Control sample was coded as “C” and served with four samples labeled with a 3-digit code. The panelist was asked to compare the 3-digit coded samples to control and point out the size of the difference using a five-point scale (0 = no difference, 2 = moderate difference, 4 = very large difference). One blind control sample (3-digit coded) was served among the 3-acidified juice samples.

Data statistical analysis

Data from enzymic, instrumental color assays, and hedonic scale tests were subjected to analysis of variance (ANOVA) and Tukey’s test at 5% significance level. Friedman and Dunnet tests were performed to analyze data from rank-preference and difference-from-control tests, respectively. To this end, the statistical analysis system (SAS 9.3) was used. Principal components analysis (PCA) was carried out to simultaneously analyze the parameters of samples, through software Statistica 13. PCA is a useful statistical technique to “compress” data into an image which captures the essence of the original data set.

RESULTS AND DISCUSSION

Total soluble solids and pH of whole regular juice

The soluble solids content and pH of regular and freshly extracted cane juice determined in this study were 5.0 and 23.5 ºBrix. Bomdespacho (2018) reported mean values of 5.1 and 21.2 ºBrix, in cane juice extracted from different cultivars. Weerawatanakorn (2020) reported a pH range of 5.2 – 5.4 and soluble solids between 19 and 21 ºBrix. Panigrahi et al. (2020) reported total soluble solids of 13.3 Brix. Adulvitayakorn et al. (2019) reported a pH of 5.8, and soluble solids of 10.8 ºBrix. The latter was meaningfully lower than that determined in this study. Martini et al. (2010) evaluated cane juice extracted from the same cultivar (RB867515) herein used, and reported a pH of 5.6 and soluble solids of 19.81 ºBrix.

Microbial counts and enzymic activities
Table 1. Microbial counts (log CFU/mL) and enzymic activities (U) in regular (control) and acidified (pH 4.4) sugarcane juice.

<table>
<thead>
<tr>
<th></th>
<th>Mesophiles</th>
<th>Yeasts and molds</th>
<th>Psychrotrophs</th>
<th>PPO</th>
<th>POD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>6.5</td>
<td>3.0</td>
<td>3.0</td>
<td>11.8</td>
<td>62.5</td>
</tr>
<tr>
<td>Trans-aconitic</td>
<td>5.7</td>
<td>3.9</td>
<td>3.2</td>
<td>10.9</td>
<td>55.6</td>
</tr>
<tr>
<td>Citric</td>
<td>4.6</td>
<td>2.7</td>
<td>4.4</td>
<td>10.7</td>
<td>71.2</td>
</tr>
<tr>
<td>Malic</td>
<td>4.3</td>
<td>3.2</td>
<td>4.8</td>
<td>8.7</td>
<td>74.2</td>
</tr>
</tbody>
</table>

PPO - polyphenol oxidase. POD - peroxidase.

As for mesophiles, counts in acidified juice were notably lower than in control. Regarding yeasts and molds, counts in juice acidified with trans-aconitic acid achieved the highest level. With respect to psychrotrophs, interestingly, counts in acidified juice were meaningfully greater than that in control. One expected that the acidification invariably inhibited microbial growth in cane juice. The interaction among food matrix, organic acid and group of microorganism is the more likely hypothesis to explain the data herein presented. Panigrahi et al. (2020) reported that fresh cane juice had a bacterial count of 6.6 log CFU/mL; yeasts and molds count in raw cane juice was 4.8 log CFU/mL. Yasmin et al. (2010) reported that the total plate count, and yeasts and molds counts in fresh raw juice were 3.5 and 4.0 log CFU/mL, respectively. Adulvitayakorn et al. (2019) reported that the total aerobic mesophilics, and molds and yeasts counts were 6.8 and 6.1 log UFC/mL, respectively. Chauhan et al. (2002) pasteurized cane juice after addition of 0.04%(w/v) citric acid and 0.015%(w/v) of potassium metabisulphite. The citric acid gave a preservative action and inhibited the growth of micro-organism during storage. Food Safety and Standards Regulations (Revised Microbiological Standards for Fruits and Vegetables and their products, 2018) states that the upper limit of acceptability for juice for total plate count is 7 log CFU/mL, and 4 log CFU/mL for yeasts and molds. Counts obtained in this study were lower than those limits.

Notably, the activity of POD was significantly greater the PPO; however, the latter plays a more important role on cane juice browning. In regard to PPO, juice acidified with malic acid exhibited the lowest activity. As for POD activity the lowest activity was observed in trans-aconitic-acidified juice. Interestingly, the POD activity in juice acidified with malic acid was significantly greater than control. Silva et al. (2006) reported POD e PPO activities of 44 and 25 U, respectively, in raw (regular) cane juice. Bomdespacho et al. (2018) obtained PPO and POD activities of 12 and 30, respectively. Bucheli and Robinson (1994) reported that POD activity was 36 fold greater than PPO in cane juice, and there is a correlation between juice´s color and phenolic content but not between juice´s color and PPO activity. Nevertheless, the same authors held that enzymic browning contributes significantly to color formation in cane juice, and PPO is the major enzyme involved. To control the enzyme activity, application of chemicals that lower the pH of the juice can be used. In addition, different acids have variable effects on the enzyme activity; for example, citric acid, ascorbic acid,
malic acid, and sodium metabisulfite were found to be more effective for inhibition of enzyme activity (Kaavya et al., 2019).

**Color parameters**

The parameters L*, a* and b* were used to calculate chroma and hue (Table 2). Chroma describes the saturation or intensity, and hue classifies color in red, yellow, green, blue and their variations. Color is a mixture of three attributes: lightness (L*), hue and saturation.

Table 2. Color parameters determined in regular (control) and acidified (pH 4.4) cane juice.

<table>
<thead>
<tr>
<th></th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>Chroma</th>
<th>hue</th>
<th>EasyRGB image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>32.6</td>
<td>8.0</td>
<td>28.9</td>
<td>30.0</td>
<td>74.5</td>
<td></td>
</tr>
<tr>
<td>Trans-aconitic</td>
<td>35.1</td>
<td>9.4</td>
<td>24.5</td>
<td>26.2</td>
<td>69.0</td>
<td></td>
</tr>
<tr>
<td>Citric</td>
<td>36.1</td>
<td>7.9</td>
<td>25.9</td>
<td>27.1</td>
<td>73.1</td>
<td></td>
</tr>
<tr>
<td>Malic</td>
<td>35.0</td>
<td>8.4</td>
<td>25.8</td>
<td>27.2</td>
<td>72.0</td>
<td></td>
</tr>
</tbody>
</table>

L* (lightness) = 0 (black), 100 (white), -a* = green, +a* = red, -b* = blue, +b* = yellow.

The parameter L* ranged from 32.1 to 36.1; samples exhibited low lightness. Regarding the parameter a* (-60: green, +60: red) of regular and acidified juice, a slight trend towards red was observed, with values varying between 7.9 and 9.4. As for b* (-60: blue; +60: yellow), values were between 24.5 and 28.9, tending to yellowish color. Apparently, juice turns a little brighter by the acidification; a mild variation in color was observed in images from acidified samples (Table 2). The total color differences between control and juice acidified with trans-aconitic, citric and malic acids were 5.2, 4.6 and 3.9, respectively. The values found by Adulvitayakorn et al. (2019) for L*, a* and b* were 72, 5 and 50, respectively, for raw juice. Yusof, Shian and Osman (2000) reported darker colors than those herein observed, which is more likely due to the variation intrinsic to raw material cultivar and stage of maturation just to name a few.

**SENSORY EVALUATION**

**Hedonic scale test**

Table 3. Gathers the findings from hedonic scale, rank preference and difference-from-control tests.
Table 3. Sensory evaluation of regular (control) and acidified (pH 4.4) cane juice.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Trans-aconitic</th>
<th>Citric</th>
<th>Malic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>6.8 ± 1.6/78</td>
<td>6.8 ± 1.7/76</td>
<td>7.3 ± 1.4/91</td>
<td>6.9 ± 1.6/79</td>
</tr>
<tr>
<td>Flavor</td>
<td>7.3 ± 1.4/91</td>
<td>7.0 ± 1.7/84</td>
<td>7.3 ± 1.5/87</td>
<td>7.1 ± 1.4/86</td>
</tr>
<tr>
<td>Overall impression</td>
<td>7.2 ± 1.3/89</td>
<td>6.8 ± 1.5/85</td>
<td>7.3 ± 1.3/89</td>
<td>7.1 ± 1.3/86</td>
</tr>
</tbody>
</table>

Mean scores and percentages of acceptance assigned in nine-point hedonic scale
Mean scores/percentage of assessors who assigned scores greater than or equal to 6.0. Means followed by the same exponent in the same column are not different (p > 0.05).

<table>
<thead>
<tr>
<th>Assessor</th>
<th>1</th>
<th>4</th>
<th>4</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Σ</td>
<td>247</td>
<td>230</td>
<td>267</td>
<td>258</td>
<td></td>
</tr>
</tbody>
</table>

Rank preference test
1 - least preferred, 4 - most preferred. Critical difference between the total of rank sums (Σ) according to Newel-MacFarlane table at 5% significance: 47.

<table>
<thead>
<tr>
<th>Mean</th>
<th>1.32 ± 0.89</th>
<th>2.04 ± 0.99</th>
<th>1.62 ± 1.12</th>
<th>1.66 ± 1.12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference between means</td>
<td>0.72</td>
<td>0.30</td>
<td>0.34</td>
<td></td>
</tr>
</tbody>
</table>

Clearly, the mean scores assigned to all attributes were good (> 6.5). In terms of appearance, the citric acid-acidified juice achieved the highest score (7.3). As for flavor, there was no difference (p > 0.05) among samples. In regard to overall impression, there was no difference (p > 0.05) among control, citric and malic. The percentages of acceptance were greater than 75%. Dutcosky (2013) states that rates of approval above 70% show a good acceptance, as was found in this study. The juice acidified with citric acid achieved the highest rates for all attributes, when compared to trans-aconitic and malic. Data presented in Table 4 indicates that citric acid best matched cane juice. Chauhan at al. (2002) added citric acid (40 mg/100 mL) to cane juice. Addition of citric acid or ascorbic acid gave a pleasant dull orange color to juice. Trials were conducted by adding 20, 40, 60 and 80 mg citric acid per 100 mL of cane juice to improve the appearance, flavor and overall acceptability. The panelists awarded highest scores to juice with 40 mg citric acid/100 mL. Higher concentrations of citric acid made the juice much too sour. The scores assigned to control (regular juice) in the nine point-hedonic scale for appearance, flavor and overall acceptability were 8, 8 and 7.6, respectively. The scores assigned to citric acid added cane juice for appearance, flavor and overall acceptability were 8.3, 8.5 and 8.1, respectively. Yasmin et al. (2010) reported the addition of citric acid to pasteurized (90 ºC/5 min) cane juice to achieve a pH of 4.3. The scores assigned to appearance, taste and overall acceptability were 9, 8 and 8, respectively.

In terms of preference, no difference (p > 0.05) was observed among juice samples, demonstrated as follows.

\[ | \Sigma A - \Sigma B | = | 247 - 267 | = 20 < 47 \text{ (no difference)} \]
| ΣA - ΣC | = | 247 - 258 | = 11 < 47 (no difference)
| ΣA - ΣD | = | 247 - 230 | = 17 < 47 (no difference)
| ΣB - ΣC | = | 267 - 258 | = 9 < 47 (no difference)
| ΣB - ΣD | = | 267 - 230 | = 37 < 47 (no difference)
| ΣC - ΣD | = | 258 - 230 | = 28 < 47 (no difference)

Table 3 shows that neither citric nor malic acidified juice differed from control. In this way, both of acids might be used in cane juice acidification. An issue worth highlighting is the cost of the organic acids; over the course of this study (in 2019), 100 g of trans-aconitic, citric and malic acids were US$ (26.49, 0.05 and 0.23), respectively. Ginslov (2000) patented a method of producing a stabilized sugarcane juice product. The extracted juice is acidified immediately upon extraction by feeding it into a solution comprising ascorbic acid for preventing discoloration and also by feeding it simultaneously into an acidic solution of citric, malic, tartaric, phosphoric acids and a mixture thereof, for adjusting the pH below 5.0.

**Principal components analysis**

Figures 1 depicts the projection of samples (1a) and variables (1b) on the plane. Sensory attributes and parameters of instrumental color were grouped to perform the multivariate/exploratory analysis.
**Figure 1.** Projection of samples (Fig 1a) and variables (Fig 1b) in the multiple factor analysis carried out for regular (control) and acidified (pH 4.4) sugarcane juice.

Figures 1a and 1b illustrate the distribution of juice samples and variables, respectively, on the map. Principal components (PC) 1 and 2 explained 98.91% (65.55 + 33.36) of the total variation among samples, and validated the two-dimensional representation of the components to describe the samples’ characteristics. The position of the four samples in different quadrants (Figure 1a) indicates that they are not similar in relation to the parameters
evaluated. Control is mainly represented by chroma and \( ^\circ \)hue; malic is characterized mainly by \( L^* \); citric is well represented by appearance, flavor and overall acceptance. The parameters \( ^\circ \)hue and flavor are the main contributors in PC1, while \( L^* \) in PC2 (Figure 1b). Vectors close to each other indicate that the parameters may have a high positive correlation, such as flavor and \( ^\circ \)hue. Chroma and \( L^* \) vectors formed an angle close to 180\(^\circ\), suggesting a negative correlation between them. However, analysis of linear correlations did not exhibit correlation among variables (\( p > 0.05 \)).

**Overall evaluation**

Table 4 summarizes the findings of this study. Signal “+” represents the advantage of using the respective acid based on a specific parameter. For example, positive signal assigned to a specific acid in terms of microbiological and enzymic parameters means that the lowest counting and activity was found.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Trans-aconitic</th>
<th>Citric</th>
<th>Malic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microbiological</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Enzymic</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Instrumental color</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sensory</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cost</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Overall score</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

1 In relation to regular cane juice (control).

Under the conditions of this research work, as exhibited in Table 4, citric acid was the best option to acidify sugarcane juice. This conclusion may be useful from the perspective of the emerging ready-to-drink cane juice processing.

**CONCLUSION**

Although trans-aconitic is the predominant organic acid found in sugarcane juice, it is not the best option for the juice’s acidification. Conversely, citric and malic acids were more compatible with cane juice based on the sensory assays herein conducted. Of the organic acids studied, citric acid proved to be the overall best adapted to cane juice. Additionally, it is much more affordable when compared to trans-aconitic and malic acids.
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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest for this research work.

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