Application and sensory evaluation of a hydroalcoholic extract of nasturtium (*Tropaeolum majus* L.) in a beverage from tropical fruits and vegetables

Camila Andrea Avila-Ortiz1*, Andrés Giraldo-Toro2, Valentina Guzmán2, and María Soledad Hernández1

**ABSTRACT**

The nasturtium is diverse in bioactive compounds such as carotenoids, anthocyanins, and glucosinolates. Due to these attributes, it is important to apply them to novel foods, such as drinks. The objective of this study was to carry out a sensory evaluation for the viability of the addition of nasturtium extract to a beverage. Solvent extraction was performed at a solute-solvent ratio of 1:10 – 1:15 and ethanol purity of 45%, 70%, or 96%; antioxidant capacity was analyzed by the FRAP method and total phenolic compounds content by the Folin-Ciocalteu method. Additionally, three samples of the beverage that included nasturtium extract (extract content of 1000, 2500, or 5000 mg kg\(^{-1}\)) were evaluated through a 5-point hedonic test and a preference test for the attributes of flavor, aroma, consistency, and the product as a whole. The samples with the highest solute-solvent ratio presented the highest antioxidant capacity, while the samples with ethanol purity of 45% and 70% obtained the highest content of total phenolic compounds. The sample with 1000 mg kg\(^{-1}\) of the extract was the best qualified in all the sensory attributes evaluated.

**Key words:** phenolic compounds, fruit juices, hedonic scale, antioxidant capacity.

**Introduction**

Nasturtium (*Tropaeolum majus* L.) is a climbing plant of South American origin belonging to the Tropaeolaceae family (Brondani *et al*., 2016), characterized by its round, peltate leaves and orange, yellow, and red flowers (Hegnauer, 1973). Its application is mainly ornamental, although it has also been used in traditional oral medicine for treatment of respiratory and skin infections (Alonso & Desmarchelier, 2015). These applications are attributed to bioactive compounds found in the plant, such as carotenoids, anthocyanins, glucosinolates and phenolic compounds (quercitrin, flavanols, gallic acid, caffeic acid, coumaric acid, chlorogenic acid) (Martínez-Navarrete *et al*., 2008; Jakubczyk *et al*., 2018; Demasi *et al*., 2021). Due to the nasturtium attributes, the extraction of its bioactive compounds has been carried out through different methods, using solvents such as methanol (Navarro-González *et al*., 2015; Demasi *et al*., 2021) or acetone (Amiri, 2012), the Soxhlet method (Fernandes *et al*., 2017) and new technologies such as ultrasound-assisted extraction (Jha Kumar & Sit, 2022); the extraction of phenolic and antioxidant compounds has been carried out using ABTS, DPPH methods (Garzón & Wrolstad, 2009; Arellano *et al*., 2015), FRAP methods...
Antioxidant Capacity - TEAC (µmol Trolox/g extract). The content of total phenolic compounds was analyzed by the Folin-Ciocalteu method (Navarro-González et al., 2015), and the results were expressed in mg gallic acid equivalents / g extract. Each of the six treatments was analyzed in triplicate.

**Beverage development**

A nectar-type drink of tropical fruits and vegetables was made: 25% w/w ‘Valencia’ orange juice (*Citrus sinensis* [L.] Osbeck), 23% w/w yacon pulp (*Smallanthus sonchifolius* [Pöpp. & Endl.] H. Rob.), 16% w/w ‘Granny Smith’ apple pulp (*Malus domestica* Borkh.), 10% w/w chayote pulp (*Sechium edule* [Jacq.] Swartz), 12% w/w of an infusion of mint (*Mentha spicata* L.) at 5% w/w and 11% w/w cucumber pulp (*Cucumis sativus* L.). A known concentration of the extract was added to this drink (see the sensory analysis method), together with additives such as xanthan gum (0.2%), maltodextrin (1%) and 1% of a commercial sweetener, Best4u (https://fitmarketbogota.co/products/endulzante-natural-250gr-best4u), which is a mixture of erythritol and stevia.

**Sensory analysis**

Three beverages were prepared with different extract content: 1000, 2500, or 5000 mg extract/kg beverage (the extract used in this experiment was obtained with ethanol with 70% of purity and relation solute-solvent 1:10; this extract had one of the highest total phenolic compounds compared to the other extracts evaluated). The beverages were analyzed through an affective test (hedonic scale of 5 points: 1: I dislike it very much, 2: I dislike it a little, 3; I neither like nor dislike it, 4: I like it a little, 5: I like it a lot) with 60 untrained consumers, evaluating three attributes (aroma, flavor, consistency) and the product in general. Each consumer was given 20 ml of each sample in glasses coded with 3 random digits, at a temperature of 10°C. In addition, a preference test was conducted, in which the evaluator was asked to place the sample code in front of the phrase that most identified it: “the one that I like the most – the one that follows me in taste – the one that I like the least.”

For statistical analysis, an analysis of variance (ANOVA) was performed. When the results did not present normality, a non-parametric Kruskal-Wallis analysis was performed, with a confidence level of 95%.
Results and discussion

Antioxidant capacity and total phenolic compounds

Table 1 presents the six experimental samples and their antioxidant capacity and total phenolic compounds.

The experiments obtained values higher than those reported by others, with 12.95 mg gallic acid equivalent/g for the content of phenolic compounds reported by Navarro-González et al. (2015) and 9.51 TEAC and 14.2 TEAC for the antioxidant capacity reported by Navarro-González et al. (2015) and Demasi et al. (2021), respectively. Both studies carried out extractions with methanol-water, a solvent mostly used for the extraction of bioactive compounds; however, due to its toxicity when ingested (Alcalá Pedrajas, 2002), it is necessary to review other solvents with equal or better yields to be used in edible products. Therefore, extraction with food-grade ethanol is a good replacement for methanol.

Extracts 4 and 5 had higher antioxidant capacity (Tab. 1), both with the highest solute-solvent ratio evaluated (1:15). Similar results were obtained by Yang and Li (2022), in which a ratio of 1:20 (the largest evaluated in the study) was the one with the highest antioxidant capacity in an extraction with 80% methanol solvent from the Angelica dahurica (Fisch.) Benth. & Hook plant. Sample 1, with a ratio of 1:10 and 96% ethanol, obtained the lowest value for total phenolic compounds, while samples 2 (70% ethanol - ratio 1:10) and 6 (45% ethanol - ratio 1:15) obtained the highest value for phenolic compounds. Both samples had solvent mixtures (ethanol-water); this indicates that for optimal extraction of phenolic compounds it is necessary to consider solvent mixtures, taking advantage of the affinities of the compounds with different solvents used. In the review by Jha Kumar and Sit (2022), different solvents were used to extract polyphenols from different plants, and the authors mentioned that, to extract compounds flavonols and phenolic acids, it is necessary to use ethanol in concentrations of 10%-90%. In addition, various studies obtained results similar to the present study, obtaining extracts with higher contents of total phenolic compounds with the ethanol concentration of up to 80% (Celant et al., 2016; Medina-Medrano et al., 2018; Martínez-Patiño et al., 2019). Samples with the highest antioxidant capacity were not the ones with the highest phenolic content (samples 4 and 5), which would indicate the extraction of other compounds with antioxidant capacity found in nasturtium leaves, such as carotenoids and glucosinolates (Brondani et al., 2016; Hernández-Rodriguez et al., 2020; Demasi et al., 2021).

Sensory evaluation

The mean aroma for all samples was similar, this attribute being a non-determining factor for the evaluators (Fig. 1). Sample 3 was the one with the lowest rating for all the attributes, its means being significantly different from the others (ANOVA P ≤ 0.05), showing a clear rejection by consumers. On the other hand, the 1000 mg kg⁻¹ sample and the one with 2500 mg kg⁻¹ had similar means in the attributes of taste, consistency, and the product in general, but for the attribute of consistency, the difference is greater compared to the others (Fig. 1).

Regarding the preference test, the sample with 1000 mg kg⁻¹ was the highest qualified, followed by the sample with 2500 mg kg⁻¹ and, finally, the sample with 5000 mg kg⁻¹ (Fig. 2). Similar behavior was observed in the hedonic test, confirming that the drink with 1000 mg kg⁻¹ of the extract was the most preferred by the evaluators. Also, the consumers had no adverse effects due to the intake of the samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Relation solute-solvent (w/w)</th>
<th>Purity of ethanol (% v/v)</th>
<th>Antioxidant capacity mean ± PSD ¹,³</th>
<th>Total phenolic compounds mean ± PSD ²,³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1:10</td>
<td>96</td>
<td>19.86±0.35</td>
<td>2.60±0.50</td>
</tr>
<tr>
<td>2</td>
<td>1:10</td>
<td>70</td>
<td>24.49±0.35</td>
<td>39.58±0.50</td>
</tr>
<tr>
<td>3</td>
<td>1:10</td>
<td>45</td>
<td>17.76±0.35</td>
<td>16.91±0.50</td>
</tr>
<tr>
<td>4</td>
<td>1:15</td>
<td>96</td>
<td>36.30±0.35</td>
<td>21.87±0.50</td>
</tr>
<tr>
<td>5</td>
<td>1:15</td>
<td>70</td>
<td>32.21±0.35</td>
<td>33.75±0.50</td>
</tr>
<tr>
<td>6</td>
<td>1:15</td>
<td>45</td>
<td>30.17±0.35</td>
<td>40.75±0.50</td>
</tr>
</tbody>
</table>

¹TEAC, ²mg gallic acid equivalent/g extract, ³PSD - Pooled Standard Deviation.
A promising application of nasturtium leaf extract in food products, more specifically in nectar-type drinks, with good reception by potential consumers.

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Conflict of interest statement
The authors declare that there is no conflict of interests regarding the publication of this article.

Author’s contributions
All authors conceptualized the study, CAAO developed the methodology, conducted the research, and wrote the manuscript. MSH administered the project, supervised the whole research, and reviewed the manuscript. AGT supervised the research. All authors reviewed the final version of the manuscript.
from tropical fruits and vegetables

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