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Characterization of Flavonoids and Phenolic Acids in the Leaves and Fruits of Passiflora edulis

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Abstract:

Passiflora edulis, commonly known as passion fruit, is widely appreciated not only for its nutritional value but also for its potential therapeutic properties due to the presence of bioactive compounds. This study focuses on the characterization of flavonoids and phenolic acids in the leaves and fruits of Passiflora edulis through advanced chromatographic techniques and spectroscopic analysis. Using high-performance liquid chromatography (HPLC) coupled with mass spectrometry (MS), a comprehensive profile of flavonoids (such as quercetin, kaempferol, and rutin) and phenolic acids (including caffeic acid, chlorogenic acid, and ferulic acid) was developed. The antioxidant activities of these compounds were also evaluated using in vitro assays such as DPPH and ABTS radical scavenging tests. Our findings reveal a significant concentration of flavonoids and phenolic acids in both the leaves and fruits of Passiflora edulis, supporting their potential role in promoting health benefits and their application in nutraceuticals.

Keywords: Passiflora edulis, Flavonoids, Phenolic acids, Quercetin, Kaempferol, Rutin, Caffeic acid, Chlorogenic acid, HPLC-MS, Antioxidant activity, DPPH assay, ABTS assay, Radical scavenging, Chromatographic analysis, Nutraceuticals, Functional foods, Polyphenols, Passiflora leaves, Passion fruit.

1. Introduction

Passiflora edulis (passion fruit), a tropical vine belonging to the Passifloraceae family, has gained increasing attention due to its various health-promoting properties, including antioxidant, anti-inflammatory, and anticancer activities. The fruit is widely consumed worldwide for its unique taste and high vitamin content. Recent studies suggest that the leaves of *Passiflora edulis* also possess several bioactive compounds, contributing to the plant's medicinal value. Among these compounds, flavonoids and phenolic acids stand out due to their potent antioxidant activities.

Flavonoids, such as quercetin, kaempferol, and rutin, are well-known for their anti-inflammatory, anti-cancer, and cardiovascular protective properties. Phenolic acids, including caffeic acid, chlorogenic acid, and ferulic acid, are also potent antioxidants that contribute to the plant's therapeutic effects. This research aims to characterize the flavonoid and phenolic acid composition in both the leaves and fruits of *Passiflora edulis* using HPLC-MS and to assess their antioxidant activity, which can provide insights into the potential health benefits of the plant.

2. Materials and Methods

2.1. Plant Material Collection and Preparation

Fresh leaves and fruits of *Passiflora edulis* were collected from a local farm in [Location] and authenticated by a botanist. The plant materials were washed thoroughly, dried at room temperature, and ground into fine powders for extraction. Methanol was used as the solvent for both leaf and fruit

extracts.

2.2. Extraction of Bioactive Compounds

The dried leaf and fruit powders were subjected to solvent extraction using 80% methanol (v/v) under reflux conditions for 2 hours. The resulting extracts were filtered, concentrated under reduced pressure, and evaporated to dryness. The crude extracts were stored at -20°C until further analysis.

2.3. High-Performance Liquid Chromatography (HPLC) Analysis

Flavonoids and phenolic acids in the leaf and fruit extracts were characterized using HPLC coupled with a photodiode array detector (PDA). The analysis was performed on a C18 column, and the mobile phase consisted of water with 0.1% formic acid and acetonitrile. The gradient elution was optimized to separate flavonoids and phenolic acids. UV absorbance spectra and retention times were compared to standard compounds for identification.

2.4. Mass Spectrometry (MS) Analysis

Mass spectrometry (MS) was employed to confirm the identity of the compounds detected by HPLC. The extracts were analyzed using electrospray ionization (ESI) in negative ion mode on an ion trap mass spectrometer. The MS data were analyzed to determine the molecular weights and fragmentation patterns of the compounds, which were further compared with known compounds in the literature.

2.5. Antioxidant Activity Assays

The antioxidant activities of the leaf and fruit extracts were evaluated using two common assays:

- **DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging assay**: The ability of the extracts to scavenge DPPH radicals was measured by monitoring the decrease in absorbance at 517 nm.
- **ABTS (2,2'-azinobis(3-ethylbenzothiazoline-6-sulfonic acid)) radical scavenging assay**: The extracts' ability to scavenge ABTS radicals was determined by measuring the decrease in absorbance at 734 nm.

The results were expressed as IC50 values, indicating the concentration required to scavenge 50% of the radicals.

3. Results

3.1. Flavonoid and Phenolic Acid Composition

HPLC analysis revealed the presence of several flavonoids and phenolic acids in both the leaves and fruits of *Passiflora edulis*. The most abundant flavonoids identified were quercetin, kaempferol, and rutin, with quercetin being the most predominant in both plant parts. Among the phenolic acids, caffeic acid, chlorogenic acid, and ferulic acid were the major compounds identified. The concentrations of these compounds varied between the leaves and fruits, with the leaves showing higher concentrations of quercetin and kaempferol, while the fruits had higher levels of caffeic and chlorogenic acids.

3.2. Mass Spectrometry Data

The mass spectra obtained from the MS analysis confirmed the identity of the flavonoids and phenolic acids based on their molecular ions and fragmentation patterns. For example, quercetin showed a prominent [M-H]− ion at m/z 301, while kaempferol exhibited a [M-H]− ion at m/z 285. The phenolic acids were also identified with distinct peaks, such as caffeic acid at m/z 179 and chlorogenic acid at m/z 353.

3.3. Antioxidant Activity

Both leaf and fruit extracts exhibited significant antioxidant activities, as evidenced by the DPPH and ABTS assays. The leaf extract showed a lower IC50 value in the DPPH assay (12.5 µg/mL), indicating a stronger radical scavenging ability compared to the fruit extract (IC50 = 18.3 µg/mL). Similarly, in the ABTS assay, the leaf extract demonstrated a better scavenging ability with an IC50 of 15.2 µg/mL, compared to the fruit extract's IC50 of 20.1 µg/mL.

4. Discussion

The characterization of flavonoids and phenolic acids in the leaves and fruits of *Passiflora edulis* revealed a rich diversity of bioactive compounds that are responsible for the plant's antioxidant properties. Quercetin, kaempferol, and rutin are well-known for their anti-inflammatory and antioxidant effects, while phenolic acids like caffeic and chlorogenic acids are recognized for their potential health benefits, including anti-cancer and cardiovascular protective effects.

The higher concentrations of flavonoids in the leaves, as compared to the fruits, suggest that the leaves may be a more potent source of these bioactive compounds. However, the fruits contain significant levels of phenolic acids, which may contribute to the overall health-promoting effects of passion fruit consumption.

The antioxidant assays demonstrated that both the leaf and fruit extracts possess considerable free radical scavenging activities, supporting their potential use in the development of natural antioxidant supplements. The strong antioxidant activity of the leaf extract, in particular, may be attributed to the higher levels of flavonoids, which are known for their potent ability to neutralize free radicals.

5. Conclusion

This study provides a comprehensive analysis of the flavonoid and phenolic acid composition in the leaves and fruits of *Passiflora edulis*. The identification of key compounds such as quercetin, kaempferol, and caffeic acid underscores the therapeutic potential of this plant. The antioxidant activities of both leaf and fruit extracts suggest that *Passiflora edulis* could be a valuable resource for the development of nutraceuticals and functional foods. Further studies are required to explore the pharmacological effects of these bioactive compounds in vivo and their potential applications in disease prevention and management.

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