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ANALYSIS OF VOLATILE COMPOUNDS FROM PSIDIUM GUAJAVA, PASSIFLORA EDULIS, AND LITCHI CHINENSIS IN VIET NAM

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Abstract

This study investigated the volatile components of Psidium guajava, Passiflora edulis, and Litchi chinensis, with a focus on utilizing by-products from the fruit juice industry for potential raw material applications that enhance fruit value. Beyond identifying volatiles from waste materials such as peels and seeds, the chemical composition of the fruit flesh was also examined to inform optimization in juice production processes. A multi-solvent extraction approach was applied to peels and seeds, while a combined method employing Natuzyme enzyme treatment and Porapak Q chromatography was used for fruit flesh. Gas chromatography–mass spectrometry (GC–MS) was employed to analyze the extracted compounds. Results showed that in Passiflora edulis, benzaldehyde (23.86%) and hexadecanoic acid (11.19%) dominated peel extracts, while hexyl hexanoate (19.44%) and hexyl butanoate (13.25%) were most abundant in the flesh. In Psidium guajava, alcohols were the principal volatiles, with (Z)-3-hexen-1-ol comprising 47.71% in the peel and 16.80% in the pulp. For Litchi chinensis, terpenes and derivatives such as β-caryophyllene (20.64%) and β-bisabolene (17.74%) were abundant in the peel, whereas hexadecanoic acid methyl ester (23.08%) and acetoin (19.19%) dominated the pulp. These findings provide valuable insights for valorizing fruit-processing by-products and highlight their potential use in flavor and fragrance production, ultimately contributing to sustainable industry practices.

Keywords: Volatile compounds, Psidium guajava, Litchi chinensis, Passiflora edulis, GC–MS

Introduction

Vietnam, with its tropical climate, provides favorable conditions for the cultivation of a wide variety of tropical fruits such as Psidium guajava (guava), Passiflora edulis (passion fruit), and Litchi chinensis (litchi). These fruits are widely consumed both locally and internationally, not only for their nutritional value but also for their health-promoting properties. Despite their abundance and high yields, the economic value of these fruits in Vietnam remains relatively modest due to limited processing and underutilization of by-products. Much of the fruit peel, rind, and seeds generated from the juice industry is discarded as waste, representing a missed opportunity for value addition.

This study was designed to address this challenge by investigating the volatile components present in guava, passion fruit, and litchi, with a focus on utilizing by-products as raw materials for flavoring and fragrance production. By characterizing volatile compounds, the research aims to support the development of applications that can enhance the economic value of these fruits and contribute to more sustainable industry practices. In addition, the study examined the chemical composition of volatiles in the fruit flesh itself, which can provide valuable insights for optimizing fruit juice production processes.

To achieve these objectives, a multi-solvent extraction technique was applied to the fruit peels, while a combined extraction method employing Natuzyme enzyme treatment and Porapak Q chromatography was used for the flesh. The resulting aromatic substances were analyzed using gas chromatography–mass spectrometry (GC–MS), a highly sensitive method for identifying and quantifying volatile organic compounds.

Aromatic compounds in plant materials generally exist either in free form—where they are mixtures of organic molecules responsible for distinctive odors—or bound form, where they are conjugated with glucosides or other molecules. Essential oils, a key class of volatile compounds, are typically liquid at room temperature and can evaporate without decomposition, thereby releasing strong aromas. These oils are usually extracted by distillation, while aromatic resins and other complex volatiles are often obtained through solvent extraction methods.

The perception of aroma is largely attributed to the volatility of these compounds and their ability to stimulate olfactory nerve cells. The evaporation rate of a volatile substance can be quantitatively measured by the mass of material evaporated over a given surface area at a specific temperature and time. By analyzing the volatile constituents of guava, passion fruit, and litchi, this research contributes both to understanding their aromatic potential and to identifying pathways for industrial utilization of fruit-processing by-products.

Materials and Methods

2.1. Materials, chemicals and equipment

Litchi fruits grown at litchi garden in Thanh Ha (Hai Duong,Vietnam), Passion fruits (purple), Guajava fruits grown at Dong Du – Thanh Tri – Ha Noi were purchased at the southern market of Ha Noi and immediately cleaned, stripped into their different parts: peel, seed and flesh (edible part). They were stored in the refrigerator of Sanaky VH365A2 at a temperature of 4-6 o C, and research was conducted the following day. Chemical and equipments: The solvent used has a purity of 98-99%, produced by Merck:

n - hexane, diethyl ether, ethyl acetate, n - pentane, dichloromethane, methanol, activated carbon, sodium sulfate. Column chromatography: using Porapak Q resin (50/80 mesh) was obtained commercially from Supelco (Japan). Natuzyme Enzyme. Clevenger Essential Oil Distillation Kit. Buchi Rotavapor R-14 rotary evaporator. Ultrasonic tank equipment ultrasonic LC 60H.

GC – MS QP 2010 analyzer from Shimadzu Japan. Blender: Miyako BL-152GF

Measuring cup, measuring cylinder, roughened conical flask, filter funnel, filter paper, etc…

2.2 Methods

All experiments were performed at laboratory C10 - Institute of Research and Development of Natural Compounds, laboratory C4 - Institute of Biotechnology and Food Technology, Hanoi University of Science and Technology. Method of extraction and collection of volatile components in fruit.

Process Description

The fruit flesh/pulp from passion fruit/guajava/litchi was collected. 100 grams of minced fruit flesh/pulp was placed in a 500 ml conical bottle, and Natuzyme enzyme (0.00176% of fruit flesh/pulp) was added before sealing tightly.

The solution was stirred for 90 minutes at 30°C. Then, 5g of NaCl was added, and the mixture was stirred for 30 minutes.

The mixture was centrifuged at 9000 rpm for 10 minutes, yielding extract liquid and dregs.

The extract liquid was processed through column chromatography. Sugars, acids, and other water-soluble compounds were washed out with 200 ml of purified water. The eluate was dehydrated using anhydrous sodium sulfate, filtered, and the solvent was evaporated at 39.5°C under atmospheric pressure to obtain the aroma concentrate. The volatile concentrate was transferred into a glass bottle, sealed tightly, and stored at 0°C to 4°C before GC-MS analysis.

The dregs were immersed in MeOH for 24 hours. The resulting extract was centrifuged at 9000 rpm for 10 minutes, filtered, and adjusted to a 5% methanol aqueous solution with purified water, then filtered again.

The column was used 3cm in diameter and 60cm high, washed, dried and mounted in a clamp. The Porapak adsorbent was soaked in methanol and gaven in to ¼ of the column height. The packing was kept stable by soaking in methanol.

1. Method for determining chemical composition

GC – MS QP 2010 analyzer from Shimazu

The stationary phase of GC is a DB-5 capillary column with a diameter of 0.25mm and a length of 30m.

The thickness of the column coating film is 0.25µm Helium mobile phase

Analysis mode: the amount of sample injected into the detector is 0.1µl with analysis conditions: □ GC conditions:

- Evaporation start temperature: 60 o C

- Final temperature of vaporization process (injection temperature): 230 o C

- Split mode 1:10

- Carrier gas flow rate is: 1.5ml/min

- Running process: when starting to pump the sample, keep the oven temperature at 60 o C for 4 minutes to evaporate all the solvent to mix the sample before pumping into the machine. Next, increase the oven temperature by 3 o C/minute, when the temperature increases to 230 o C, keep the heat for 15 minutes and then slowly lower the temperature to end the process.

MS Condition:
Ionization source temperature: 200 o C

Ionize the sample at 70eV ionization potential

Results and Discussion
3.1 Analysis of volatile components from passion

a. Peel

Selection of extraction solvent
Using two solvents dichloromethane and ethyl acetate to extract volatile components from passion fruit peel. - With Dichloromethane,

The main components of passion fruit peel extracted by ethyl acetate are benzaldehyde (23.86%), hexadecanoic acid (11.19%); in addition, there are some esters, aldehydes, organic acids and alcohols.

Using the ethyl acetate solvent extraction method for 24 hours combined with ultrasound gives good results. Through this study, it was found that passion fruit peel contains mostly alcohol and organic acids. b. Flesh/pulp fruit

To analyze the aromatic components in the juice and pulp of passion fruit : After the initial sample centrifugation process, we obtain 2 components: fruit juice and fruit pulp. The fruit juice sample is run on a packed column chromatography called the liquid sample. The pulp sample is soaked in MeOH (24 hours), then centrifuged to collect the liquid and used to run the packed column chromatography similar to the liquid sample.

Conclusion
The study successfully extracted and analyzed the volatile components from three tropical fruits Psidium guajava, Passiflora edulis, and Litchi chinensis highlighting the potential of utilizing by-products from the fruit juice industry in Vietnam. The findings demonstrated that significant aromatic compounds such as benzaldehyde and hexadecanoic acid were predominantly present in Passiflora edulis, while Psidium guajava exhibited a variety of alcohols. Additionally, Litchi chinensis revealed notable terpenes in its peel and distinct compounds in its pulp, including hexadecanoic acid methyl ester and acetoin.

These results underscore the viability of leveraging waste materials from fruit processing to develop flavoring agents, thereby augmenting the economic value of these fruits and supporting sustainable practices within the fruit juice industry. This study not only contributes valuable insights into the chemical composition of these fruits but also fosters the advancement of technologies aimed at optimizing fruit juice production.

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