The Chemistry of Ginger: From Root to Spice

GC-MS Profiling and Comparative Analysis of Key Compounds in Fresh, Paste, and Powdered Ginger

Favour Ogheneoruese Onoharigho, Intasar Ul Haq, Sireethorn Poomborplab
Department Of Chemistry – BMC, Analytical Chemistry, Uppsala University, Uppsala, Sweden

Introduction

Ginger (*Zingiber officinale Roscoe*) is widely valued for its flavor and medicinal properties, largely due to bioactive compounds and essential oils. Fresh ginger has high moisture content which makes it susceptible to microbial proliferation, meanwhile drying of ginger inhibits microbial growth but improper drying can degrade its nutritional and aromatic qualities. Therefore, ginger paste serves as an alternative with extended freshness but deteriorates over time. One of the commonly used method for extraction of essential oil is hydro-distillation and to carry out the analysis of ginger samples, Gas chromatography-mass spectrometry (GC-MS) was used.

Aim: This research aims to compare the chemical composition of fresh, powdered, and pasted ginger and analyze the impact of different forms of ginger on key compound levels with GC-MS and statistical analysis.

Method

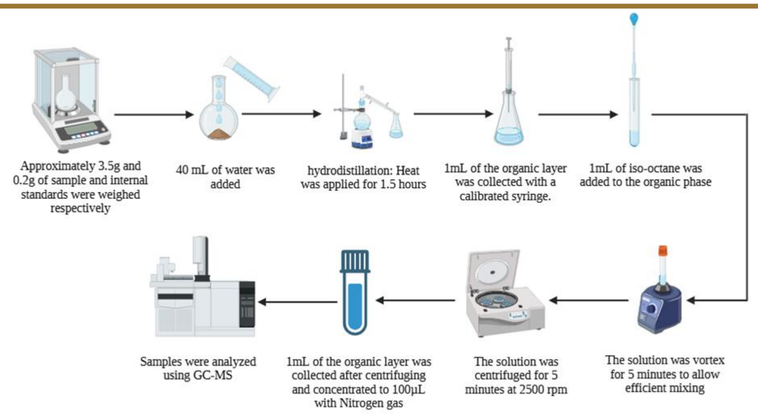
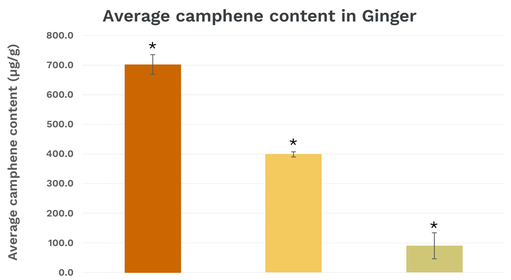


Figure 1. General overview of the experimental procedure, consisting of Distillation, extraction, and GC-MS analysis

Quantitative analysis



Sample	Powder	Paste	Fresh
Average (µg/g)	702.39	398.64	89.97
%RSD	4.73 %	2.19%	48.79%

*Figure 2. Camphene content (µg/g) in Fresh, Paste, and Powdered Ginger. The standard deviation is shown as error bars. * The average camphene content between all groups is statistically different (p < 0.05).*

Method validation

- Method validation was performed. This method has a matrix effect of 65.16% and Recovery of 63.73%, resulting in an Extraction efficiency of 41.53%.
- The calibration curve against concentration ratio and area ratio between camphene can carvone gives satisfaction linearity with R^2 = 0.9970, and no trend was observed in the residual plot

Does Ginger Form Affect Camphene Levels?

- The One-way ANOVA analysis and Tukey's post hoc analysis were performed, suggesting that the average camphene content between all groups is statistically different. Ranging from Powder (highest) to Fresh (lowest). (Figure 2)

Acknowledgment

We would like to express our heartfelt gratitude to Varun Sharma and Lucie Davidová for their invaluable support and guidance throughout this project. We also want to thank Ingela Lanekoff and Per Sjöberg for the knowledge and insights they shared with us during the Applied Analysis of Complex Samples course. Your expertise and encouragement were instrumental in the success of this project.

Qualitative analysis

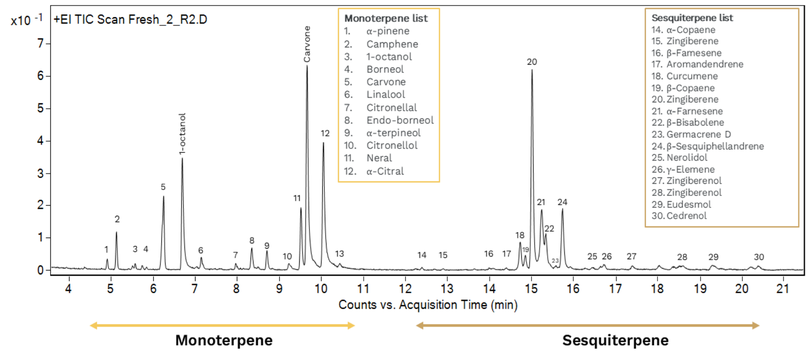


Figure 3. Total Ion Current (TIC) Chromatograms of Fresh ginger sample with the key active compound list. Two major groups of compounds are monoterpene and sesquiterpene.

- Thirty compounds present in ginger extract were identified. The two main groups of key compounds are monoterpene and sesquiterpene.

Health benefit of Key Compounds in ginger

Monoterpene

Antibacterial

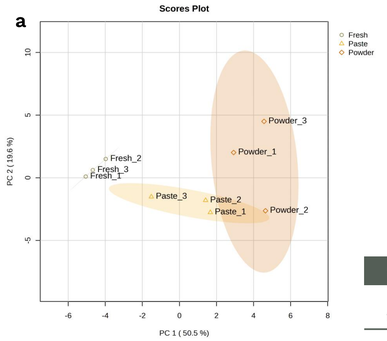
Analgesic

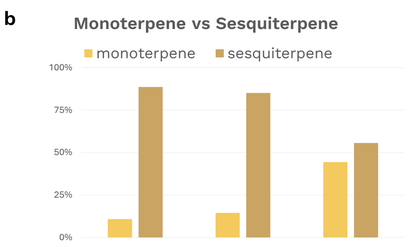
Sesquiterpene

Hepatocurative

Anti-inflammatory

Does Ginger Form Affect Ginger Profile?



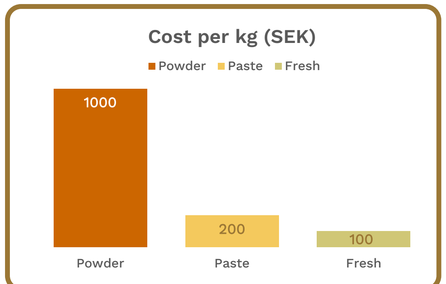


Sample	Powder	Paste	Fresh
Mono terpene	10.75%	14.45%	44.37%
Sesqui terpene	88.62%	85.11%	55.60%

Figure 4. a) The PCA analysis of the compound profiles b) The ratio between monoterpene and sesquiterpene

- The multivariable PCA analysis observed the separation pattern, suggesting strong differences in the compound profiles between fresh to paste and powdered ginger, while paste and powdered ginger are more similar.
- The same profile was observed in the total area ratio between monoterpene and sesquiterpene. Suggesting that fresh ginger contains a higher proportion of volatile compounds.

Ginger Price Spectrum



Conclusion

- ❖ Fresh ginger boasts a higher concentration of volatile monoterpenes, while processed ginger contains more non-volatile sesquiterpenes.
- ❖ The manufacturing process of ginger leads to a significant loss of volatile compounds.
- ❖ Fresh ginger exhibits a balanced monoterpene and sesquiterpene profile, potentially offering balanced health benefits.
- ❖ Fresh ginger is a more economical choice, providing both cost and health advantages.

Reference

1. N.A. Zahid, H.Z.E. Jaafar, M. Hakiman, Micropropagation of ginger (Zingiber officinale Roscoe) 'Bentong'and evaluation of its secondary metabolites and antioxidant activities compared with the conventionally propagated plant. Plants. 10, 630 (2021). https://doi.org/10.3390/plants10040630
2. Jeyaratnam, N., Nour, A. H., Kanthasamy, R., Nour, A. H., Yuvaraj, A., & Akindoyo, J. O. (2016). Essential oil from Cinnamomum cassia bark through hydrodistillation and advanced microwave assisted hydrodistillation. Industrial Crops and Products, 92, 57–66. https://doi.org/10.1016/j.indcrop.2016.07.049
3. Fortuna, A. M., Juárez, Z. N., Bach, H., Nematallah, A., Av-Gay, Y., Sánchez-Arreola, E., Catalán, C., Turbay, S., & Hernández, L. R. (2011). Antimicrobial activities of sesquiterpene lactones and inositol derivatives from Hymenoxys robusta. Phytochemistry, 72(18), 2413–2418. https://doi.org/10.1016/j.phytochem.2011.09.001