

Comparative Analysis of Organic Components in Extracted and Commercial Clove Oil Using GCMS

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Abstract: Aromatic plants are those species whose leaves, flowers, roots or other parts produce and release pleasant smells. Essential oils are plant extracts which are highly concentrated and are obtained from different parts of plants. The present study aims to analyze the organic components present in clove essential oil extracted from clove flower buds and to compare them with commercially available clove oil. Clove oil was extracted using steam distillation and analyzed using GCMS. The analysis revealed that eugenol is the predominant compound in both extracted and commercial clove oil, although the concentration varies significantly. This comparative study highlights the differences in chemical composition, emphasizing the impact of extraction methods on the purity and efficacy of clove oil.

Keywords: Clove oil, GCMS, steam distillation, eugenol, essential oils

1. Introduction

Aromatic plants are those plant species whose leaves, flowers, roots¹⁻² or other parts release pleasant smells. These plants are highly appreciated because of their odorous extracts which can be utilized in a range of sectors such as the fragrance industry, personal care products, cooking and even aromatherapy. They contain volatile essential oils which are responsible for characteristic odours and therapeutic & medicinal³⁻⁴ properties.

Clove (*Syzygium aromaticum*)⁵ is a highly aromatic plant species that has been widely used in all over the world for their culinary uses due to its intense flavour and medicinal properties. They are the aromatic flowering buds of a tree in Myrtaceae family native to Maluku islands, Indonesia⁶. Clove tree is an evergreen tree cultivated preferably in tropical regions. The tree measures up to 8 - 12 metres tall and has oval or long shaped leaves (refer Img.1) and clove buds (refer Img.2) are closely packed in clusters of small crimson flowers. Clove buds can be harvested manually or mechanically and then dried. The ancient Chinese Han dynasty⁷ gives us our first clue to the use of fragrant clove. Cloves were introduced to Indians by East India Company in its spice garden at Courtallam, Tamilnadu.

Eugenol is the major component of clove oil. It has a variety of applications. Clove oil has remarkable uses, possessing antioxidant⁸, anti-inflammatory and cardiovascular^{3, 9}, antimicrobial¹⁰ properties. In addition, it is also used as an analgesic and anesthetic¹¹⁻¹² for amphibians. It is also used to cure gastro-intestinal disorders and has a wide application in the field of dentistry¹³ as a remedy for toothache (refer Img.3). Moreover, a mixture of zinc oxide and eugenol is used to fill dental cavities. Cloves are also used as an insect repellent due to their strong aroma used as a pesticide and fungicide¹⁴ in drugs and cosmetics¹⁵.

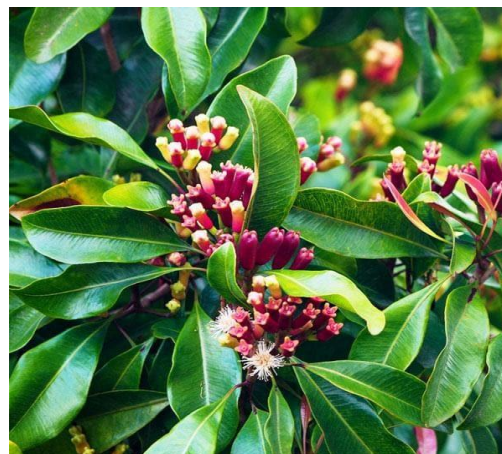


Image 1: Clove tree



Image 2: Clove buds



Image 3: Commercial clove oil

Volume 13 Issue 8, August 2024

Fully Refereed | Open Access | Double Blind Peer Reviewed Journal

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2. Methods & Materials

Sample collection - The sampling of clove buds was done from the local spice market of the Kanpur city. About 200 grams of sample was taken. The clove buds were grinded into smaller fragments for oil extraction.

Extraction of oil - There are variety of techniques used in extraction of clove oil from aromatic plants. Some widely used methods include steam distillation, solvent extraction and cold pressing method. Out of these the most widely used method is steam distillation¹⁶. The apparatus used for oil extraction is Clevenger apparatus (refer Img.4). The apparatus usually consists of a round bottom flask, a heating mantle with temperature regulation, water cooled condenser, water supply and a collection tube which has a knob fitted on it. 200 grams of clove buds were taken in a R. B. flask and 1200ml of water is poured, then the apparatus is turned on and temperature is increased accordingly. After few hours, accumulation of clove oil on the collection tube of apparatus was observed (refer Img.5).



Image 4: Clevenger apparatus



Image 5: Clove oil accumulation in collection tube

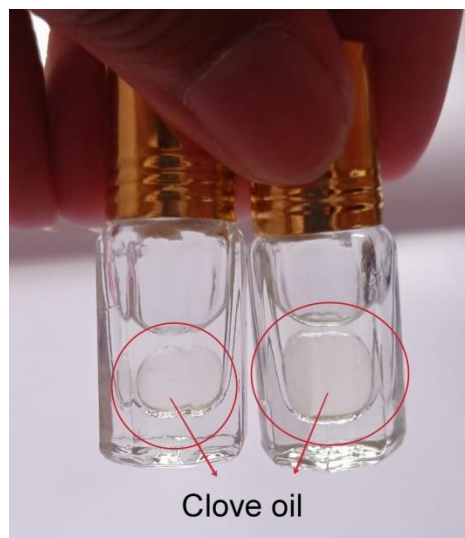


Image 6: Clove oil sample

GC - MS analysis of clove oil - The instrumentation used in GC - MS analysis of extracted clove oil is Agilent 8890/5977B. The compound identification was carried out using Masshunter GC - MS acquisition software by comparing the Wiley library data.

3. Results & Discussion

Extracted clove oil

A variety of organic compounds were discovered in the GC - MS analysis of clove essential oil. The major & minor constituents present in clove oil sample are shown in the table below.

Observed organic compounds	RT	Area %
Eugenol	30.128	41.6
Acetyl eugenol	33.767	1.89
Isoeugenyl acetate	35.072	1.29
β - Caryophyllene	22.249	0.17
Caryophyllene oxide	34.3	0.25
Eucalyptol	8.058	0.23
Cadinene	15.182	0.45
Coniferyl aldehyde	44.885	1.78
Benzyl benzoate	37.71	3.95
Methyl salicylate (Vanillin)	36.76	1.78
2, 3, 4 - Trimethoxyacetophenone	36.331	5.77
N- Ethyl- N- methyl- nitrosobenzeneamine	34.46	4.96
Glycopyrrolate	35.724	0.18

The chromatogram obtained from the GC - MS analysis of the sample clove oil is -

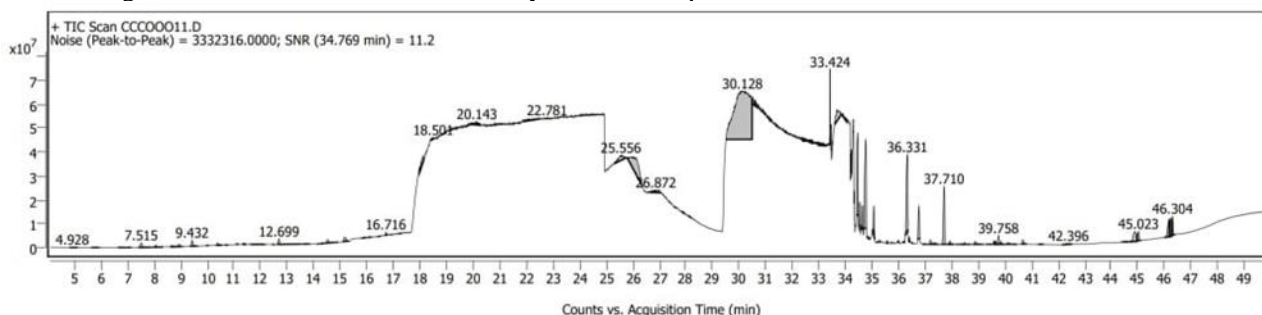


Image 7: GC - MS chromatogram of extracted clove oil

On interpreting the following data, it was observed that the major component of clove oil is Eugenol which is obtained at a retention time of 30.128 and its chemical constitution is

about 41.60%. The observed chromatogram and the observed and library spectra of eugenol are given below (refer Img.8).

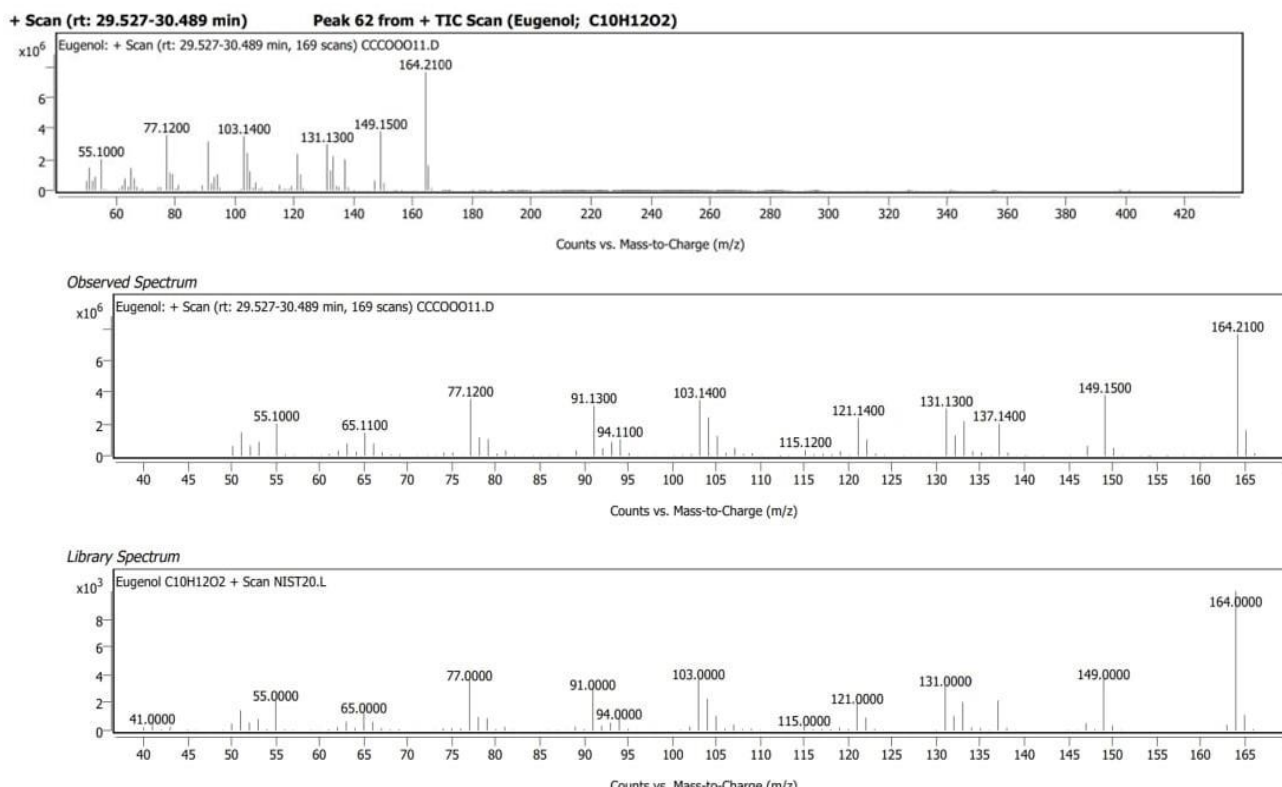


Image 8: Observed peaks & observed and library spectra of Eugenol

Commercial clove oil

The GC - MS analysis data of commercial clove oil and major components present in commercial clove oil are as follows,

Observed Organic Compound	RT	Area %
2 - Heptanone	8.89	0.04
α - Pinene	9.21	0.01
Limonene	10.29	0.01
2 - Heptyl Acetate	10.46	0.04
(E) - β - Ocimene	10.51	0.33
2 - Nonanone	10.92	0.02
Linalol	10.98	0.01
Methyl Salicylate*	11.89	0.07
p - Allyl phenol	12.6	0.19
Eugenol*	13.61	87
α - Copaene	13.72	0.1
β - Caryophyllene*	14.12	3.56
α - Humulene	14.46	0.4
Cadinene*	15.18	0.04
Eugenyl Acetate*	15.26	6.01
Caryophyllene oxide*	15.73	2.1

*Marked compounds are common in both samples

The GC - MS chromatogram of commercial clove oil:

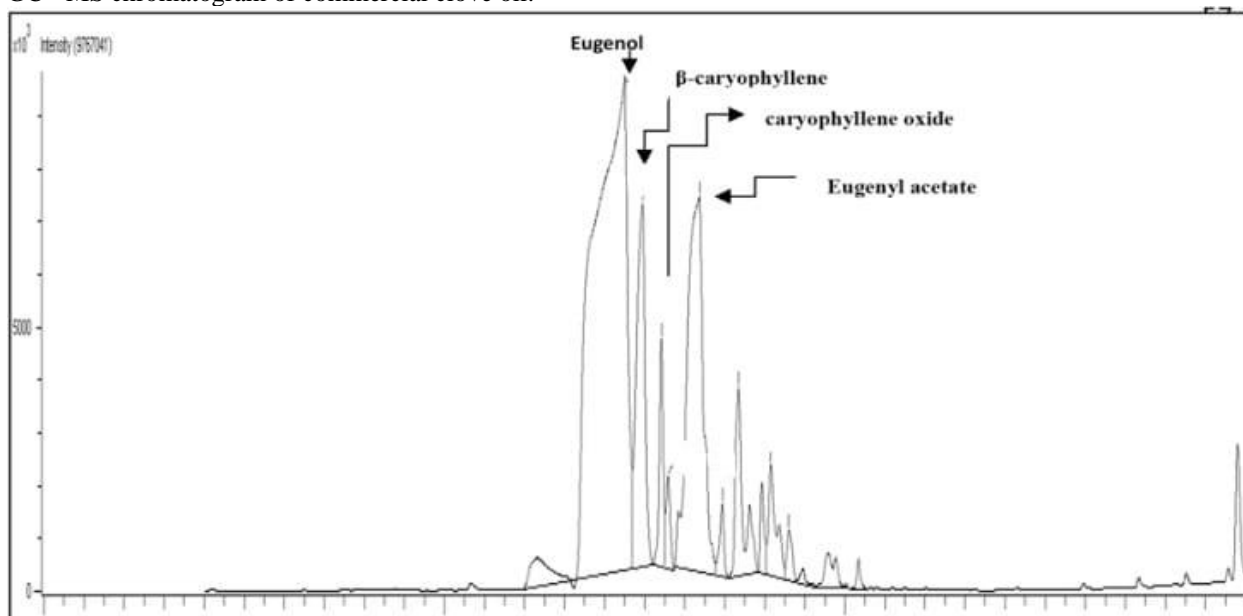


Image 9: GC - MS chromatogram of commercial clove oil

Comparison with commercial clove oil

The GC - MS data of commercial clove oil was studied and it was found that the GC - MS chromatogram of the commercially available clove oil possesses very sharp and clear peaks. This is due to the fact that the commercially available clove oils are treated through various purification processes and there are very less or no impure substances. The compound with the greatest abundance in the GC - MS data is eugenol which comprises up to 87% of the total chemical composition of the commercial clove oil.

The compounds which are common in both the samples of clove oil (extracted clove oil and the commercial clove oil) are Eugenol, Eugenyl acetate, Methyl Salicylate, Caryophyllene oxide, β - Caryophyllene, Cadinene. The eugenol composition in commercial clove oil is comparatively higher than that of the extracted clove oil.

The table of comparison between extracted clove oil and the commercial clove oil is given below,

Observed compounds	Extracted clove oil	Commercial clove oil
Eugenol	41.60	87
Eugenyl acetate	1.29	8.01
Cadinene	0.45	0.04
β - Caryophyllene	0.17	3.56
Caryophyllene oxide	0.25	0.10
Methyl salicylate	1.78	0.07

Significance & Purpose

This study aims to analyze and compare the chemical composition of clove oil extracted from clove buds with that of commercially available clove oil, using GCMS to determine the concentration of key components such as eugenol.

Understanding the chemical composition differences between extracted and commercial clove oil is essential for determining the efficacy and applications of these oils in medicinal, pharmacological, and industrial contexts.

4. Conclusion

This study provides a detailed quantitative analysis of clove oil extracted from clove buds using steam distillation, compared with commercially available clove oil. The results indicate that the eugenol concentration is significantly higher in commercial clove oil. This difference may be attributed to various factors, including extraction methods and purification processes, highlighting the importance of method selection in essential oil production. The eugenol content of the commercially available clove oil is about 87% while the eugenol content of extracted clove oil sample is 41.60%. Some other studies^{17 - 22} conclude that the eugenol concentration of clove essential oil ranges from 50 - 90%. The concentration of eugenol depends on various factors, including variety, purity, adulteration, climate, soil conditions and species.

Acknowledgement

The authors are grateful to Mr. Manoj Kumar Jaiswal, CRF Staff, Central Research Facility, Synthesis lab, Indian Institute of Technology, Delhi for providing assistance with GC - MS analysis.

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