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Chemical Composition and Traditional Applications of *Citrus limetta* Peel Essential Oil Identified by GC-MS

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Abstract

The constituents of essential oil isolated by hydro-distillation of *Citrus limetta* peel from Bharatpur, Rajasthan was examined by Gas chromatography and Mass spectroscopy. A total 28 components were identified out of 100 % of total essential oil. The most abundant were D-Limonene (88.01%), Myrcene (3.35%), and Linalool (1.07%). Most of the identified compounds are biologically and traditionally important.

Keywords: *Citrus limetta*; Rutaceae; Gas chromatography; Mass spectroscopy; D-Limonene; Myrcene; Linalool

1. Introduction

Citrus limetta, commonly known as sweet lime or "Mosambi", is a member of the Rutaceae family widely cultivated in tropical and subtropical regions. The fruit is consumed fresh or juiced, and its peel is often discarded despite being a rich source of essential oils with potential therapeutic and industrial applications "[1]''. The peel contains a variety of bioactive compounds, particularly monoterpenes, which contribute to the aroma and biological activities of the oil "[2]".

EOs from citrus peels, are characterized by possessing a strong and pleasant aroma with a refreshing sensation. They are used as flavouring in various foods, beverages and pharmaceuticals "[3]". They are rich in flavonoids, alkaloids, coumarins, limonoids, carotenoids, phenolic acids and antioxidants "[4–6]".

Essential oils derived from citrus peels have attracted significant interest due to their antimicrobial, antioxidant, anti-inflammatory, and anticancer properties "[7]". Among the various Citrus species, *C. limetta* remains relatively less explored, especially in terms of its complete phytochemical and volatile composition. Gas chromatography–Mass spectrometry (GC–MS) is a highly sensitive and widely used technique for the qualitative and quantitative analysis of essential oils. It enables the identification of volatile constituents based on their retention times and mass spectral fragmentation patterns, often compared with standard databases such as NIST or Wiley "[8]".

Previous GC–MS analyses of *C. limetta* peel essential oil have consistently reported d-limonene as the major constituent, accounting for up to 96% of the total oil content, along with minor components such as α-pinene, β-myrcene, γ-terpinene, and α-terpineol "[9,10]".These compounds are associated with strong antioxidant and antimicrobial activity, making the oil a potential candidate for use in food preservation, pharmaceuticals, and natural health products.

This study aims to extract and analyse the essential oil of *C. limetta* peel using GC–MS, identify its major and minor constituents, and evaluate its relevance in biological and industrial applications.

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2. Material and Methodology

2.1. Oil Extraction

Hydro-distillation employing Clevenger's equipment at room temperature was used to extract Essential Oil from the peel of *C. limetta***.** The crushed peel was placed in a separate flask, together with distilled water (1 L). After 5-6 hours, oil was collected from the apparatus, anhydrous with sodium sulphate from removal of water traces, then this 100% pure essential oil were dispended into dark bottle and stored at 4°C until used.

2.2. GC Analysis

Quantitative analysis of the essential oil of *Citrus limetta* was carried out using a Shimadzu GC- 2010. Nitrogen was used as carrier gas at 10 psi inlet pressure with FID and Omega SPTm column (30.0 m x 0.25 mm ID, film thickness 0.25 um). Injector and detector temperatures were 270°C and 280°C respectively. Column temperature programmed from 80°C (2 mins hold), 80°C to 180°C at 4°C/min and 180°C to 230°C at 6°C/min withhold time of 6 min and 19 min. respectively. The flow rate of carrier gas was 1.21 ml/min and split ratio was 1:80. The data were processed on GC solutions software for oil composition.

2.3. GC-MS Analysis

GC-MS data was obtained on a Shimadzu GCMS-QP-2010 plus system using Omega SPTm column (30.0 m x 0.25 mm ID. film thickness 0.25 um). Helium was used as carrier gas. Injector, Mass detector and Ion source temperatures were 270°C, 280°C and 250°C respectively. Column temperature programmed from 80°C (2 mins hold), 80°C to 180°C at 4°C/min and 180°C to 230°C at 6°C/min withhold time of 6 min and 19 min. respectively. The flow rate of carrier gas was 1.21 ml/min and split ratio was 1:80. EI source and mass range were 70 eV and 40850 amu respectively. Compounds were identified by using Willey, NIST and Perfumery libraries.

2.4. Traditional Applications of Citrus limetta Peel Essential Oil

- **Nutritional and Deficiency-Related Uses-** Mosambi juice has traditionally been consumed to prevent and manage scurvy, a condition associated with vitamin C deficiency. Its regular intake is believed to help maintain healthy gums, improve resistance to infections, and support overall nutritional status.
- **Gastrointestinal Uses-** In traditional practice, Mosambi juice is commonly used as a digestive aid. Its pleasant aroma is thought to stimulate salivation, while its natural acids and flavonoids may support the secretion of digestive juices and bile. The juice is frequently consumed to relieve indigestion, nausea, dizziness, constipation, diarrhoea, and dysentery, including amoebic dysentery. Its potassium content is considered helpful in restoring electrolyte balance during gastro-intestinal disturbances, and its mild, palatable nature is believed to reduce vomiting and nausea.
- **Traditional Use in Diabetes-** Mosambi juice is traditionally regarded as beneficial for individuals with diabetes. Folk remedies often combine it with amla (*Emblica officinalis*) juice and honey, taken orally on an empty stomach. This practice is believed to support blood glucose regulation, although scientific evidence remains limited.
- **Anti-ulcer and Oral Health Uses-** Traditional use suggests that mosambi juice may help relieve symptoms of peptic ulcers by reducing gastric acidity, possibly through a mild alkalizing effect. A mixture of mosambi and lemon juices is often recommended. Diluted Mosambi juice taken in warm water is also used for the management of mouth ulcers and halitosis.
- **Immune and Cardiovascular Support-** Regular consumption of Mosambi juice is believed to improve blood circulation and support heart function, which may contribute to enhanced immune response and general wellbeing.
- **Use in Weight Management-** Due to its low calorie and fat content, Mosambi juice is commonly included in traditional dietary practices aimed at weight control. When combined with honey, it is believed to aid metabolism and promote calorie utilization.
- **Use During Pregnancy-**In traditional dietary advice, Mosambi juice is often recommended for pregnant women because of its mineral content, particularly calcium, which is believed to support both maternal health and fetal development.
- **Urinary Tract Disorders-** Mosambi juice is traditionally used in the management of urinary disorders such as cystitis. The juice is sometimes boiled and consumed after cooling, a practice believed to help cleanse the kidneys and urinary bladder. Its potassium content is thought to contribute to reduced inflammation and prevention of recurrent urinary tract infections.

- **Ophthalmic Uses-**In folk medicine, Mosambi juice is used to support eye health due to its perceived antioxidant and antimicrobial properties. Diluted juice is occasionally applied externally as an eye wash for mild infections such as conjunctivitis.
- **Respiratory Uses-**Because of its high vitamin C content, Mosambi juice is traditionally consumed during episodes of the common cold to help relieve symptoms and improve resistance to respiratory infections.
- **Lipid-Lowering and Blood Pressure Regulation-**Traditional knowledge suggests that regular intake of mosambi juice may help reduce cholesterol levels and support the regulation of blood pressure.
- **Traditional Dermatological Uses-** Mosambi juice is widely used in traditional skincare practices. Its antioxidant and antimicrobial properties are believed to help maintain healthy skin. Fresh Mosambi juice is applied topically to manage hyperpigmentation, acne, spots, and blemishes. It is also thought to cleanse the blood and protect the skin from infections. Bathing with diluted Mosambi juice is traditionally practiced to control excessive sweating and body Odor. For cracked lips, repeated application of Mosambi juice is believed to promote healing and improve lip appearance. In addition, a traditional topical preparation combining mosambi juice with castor oil is used to reduce localized swelling, inflammation, and pain.

3. Results

The *Citrus limetta* Essential oil was pale yellow in colour with a typical citrus Odor. Hydro distillation is one of the most common methods for the extraction of essential oils and allows the use of environmentally friendly solvents [11]. The GC–MS analysis identified 28 volatile compounds that represented 100% of the total composition. The chromatogram (Graph 1) produced major peaks for the different monoterpenes and oxygenated compounds. The major compound found was d-limonene, which accounted for 88.01% of the oil. Other major constituents were β-myrcene (3.35%), linalool (1.07%), α-pinene (0.92%), Sabinene (0.83%), n-octanol (0.81%), Delta-3-carene (0.70%) trace quantities of Geranial (0.47%) and α-terpineol (0.43%). The full list of compounds, with their retention times, molecular weights, and relative percentages, is shown in Table 1.

Table 1 Chemical composition of essential oil of *Citrus limetta* by GC/GC-MS

PEAK	R. TIME	AREA	AREA%	NAME OF COMPOUND
1	5.513	475263	0.05	Alpha-thujene
2	5.729	8399576	0.92	Alpha-pinene
3	7.069	7560926	0.83	Sabinene
4	7.739	30577329	3.35	Myrcene
5	8.197	7378765	0.81	n-octanal
6	8.455	6401726	0.70	Delta-3-carene
7	9.613	802476303	88.01	Limonene
8	10.491	1861553	0.20	Gamma-terpinene
9	11.073	2742638	0.30	1-Octanol
10	11.720	2064800	0.23	Terpinolene
11	12.302	9773593	1.07	Linalool
12	13.908	137783	0.02	Trans-limonene oxide
13	14.237	197730	0.02	Beta-terpineol
14	14.433	177120	0.02	Cis-verbenol
15	14.639	895061	0.10	Citronellal
16	15.686	5443673	0.60	Terpinen-4-ol
17	16.321	3887082	0.43	Alpha-terpineol
18	17.018	1964139	0.22	Decanal

19	17.630	941947	0.10	Trans-carveol
20	18.104	2825087	0.31	Citronellol
21	18.601	1591818	0.17	Citral b
22	19.280	514157	0.06	Geraniol
23	19.944	4272201	0.47	Geranial
24	21.858	706463	0.08	Para-viny lguaiacol
25	23.730	3068482	0.34	Eugenol
26	26.182	1134775	0.12	Trans-caryophyllene
27	29.009	864493	0.09	2-Hydroxypiperitone
28	33.411	3466254	0.38	Cedrol
		911800737	100.00	

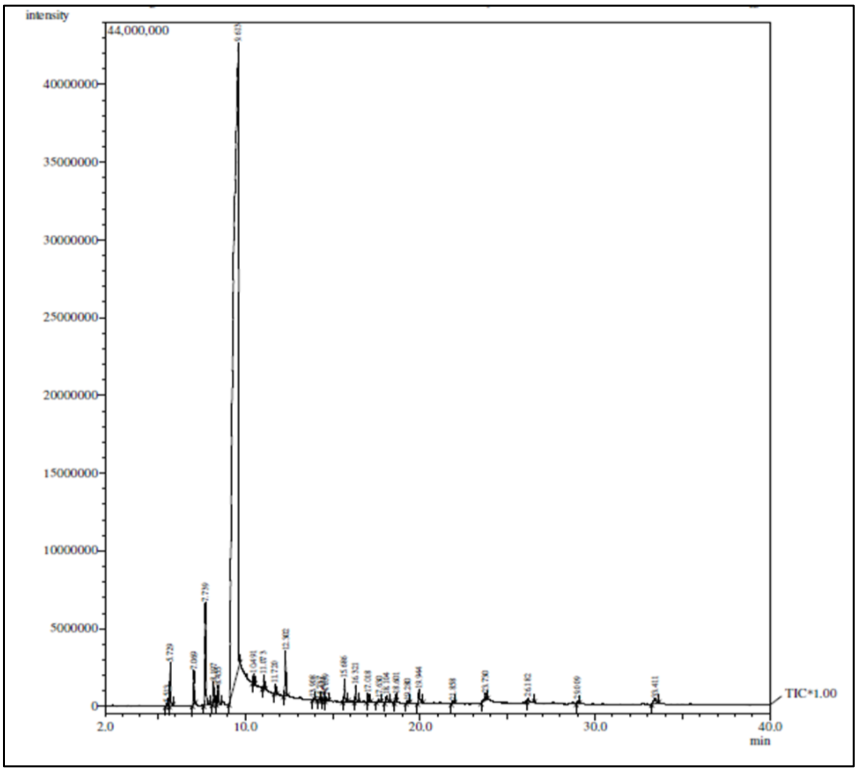

Figure 1 Gas chromatogram of *Citrus limetta*

4. Discussion

GC–MS analysis verifies that Citrus limetta peel essential oil is characterized by monoterpene hydrocarbons, predominantly d-limonene, in agreement with earlier research "[2,9]". The preponderance of d-limonene accounts for the intense citrus scent of the oil and is responsible for many of its documented biological activities, such as antioxidant, antimicrobial, and anti-inflammatory properties "[7]''.

Presence of β-myrcene, γ-terpinene, and α-pinene adds synergistically to the bioactivity of the oil. Minor constituents with free radical scavenging activity and possible roles in antimicrobial and anticancer pathways include these compounds "[10]". The oxygenated monoterpenes α-terpineol and linalool are especially important for their fragrance-enhancing activity and medicinal properties.

The comparatively high d-limonene content (against other Citrus species) indicates potential for the peel of *C. limetta* as a cost-effective source of this monoterpene with various applications in the cosmetic, food, and pharmaceutical industries.

5. Conclusion

The current research proves that *Citrus limetta* peel essential oil is abundant in bioactive monoterpenes, with d-limonene being the main constituent. GC–MS analysis detected 28 volatile compounds, offering a comprehensive chemical profile of the oil. The most abundant were D-Limonene (88.01%), Myrcene (3.35%), and Linalool (1.07%). These compounds are associated with strong antioxidant and antimicrobial activity, making the oil a potential candidate for use in food preservation, pharmaceuticals, and natural health products. The fruit juice is the most commonly used part and is valued for both its nutritional and therapeutic properties. Many of its traditional applications are linked to the presence of vitamin C, flavonoids, organic acids, and minerals such as potassium.

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