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ORIGINAL ARTICLE

# DOCUMENTATION OF FEW VOLATILE ORGANIC COMPOUNDS (VOCS) IN THE TRADITIONAL MANGO (*MANGIFERA INDICA* L.) VARIETY, CHAMPA, OF MURSHIDABAD DISTRICT OF WEST BENGAL

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## ABSTRACT

Volatile organic compounds (VOCs) are central to the sensory identity of mangoes: they create the aroma bouquet that consumers perceive as "mango-ness" and strongly influence preference and willingness to pay. Traditional mango varieties grown in the Malda and Murshidabad districts of West Bengal form an important regional germplasm pool whose flavours and aromas are central to local cuisine, markets and cultural identity. This investigation is an initial attempt to find unique Volatile organic compounds (VOCs) in the traditional mango variety, Champa of Murshidabad district of West Bengal. The traditional variety Champa was chosen because of its unique aroma. The mature fruit has the aroma of the champaka flower, *Michelia champaca* L. Beyond flavour and processing, VOC profiles are powerful tools for authentication, traceability and value-addition. Chemical fingerprints derived from HS-SPME–GC–MS or related platforms allow differentiation among cultivars and can support geographic-indication branding or premium marketing for regionally prized varieties.

**Keywords:** *Mangifera indica* L., Volatile organic compounds (VOCs), Champa mango variety.

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## INTRODUCTION

The mango (*Mangifera indica* L.) is prized worldwide for its complex, highly evocative aroma, a trait created by a rich mixture of volatile organic compounds (VOCs). Volatile organic compounds (VOCs) are central to the sensory identity of mangoes: they create the aroma bouquet that consumers perceive as "mango-ness" and strongly influence preference and willingness to pay. Headspace solid-phase microextraction combined with gas chromatography/mass spectrometry is one of the strongest tools for comprehensive analysis of volatile compounds and has been used to analyze aromatic components of mango and investigate its varietal characteristics (Shimizu *et al.*, 2021).

Traditional mango varieties grown in the Malda and Murshidabad districts of West Bengal form an important regional germplasm pool whose flavours and aromas are central to local cuisine, markets and cultural identity. Malda and Murshidabad are centres of high mango diversity (De *et al.*, 2014). Sometimes the same variety has more than two names in different parts of these two districts. These traditional mango varieties differ markedly in harvest season (De *et al.*, 2021a), pulp quality (De & Dey, 2021) and traditional uses (fresh consumption vs. processing) traits. These varieties are distinct from one another in taste and aroma; so, these differences are expected to be reflected in differing volatile profiles and total VOC yield while chemical profiling of these varieties. Documenting and understanding the volatile composition of these traditional varieties is important for conservation, breeding, processing and value-addition.

**Mango aroma:** Mango aroma is not produced by a single molecule but by hundreds of compounds belonging mainly to these chemical classes:

**Terpenes and terpene hydrocarbons (monoterpenes, sesquiterpenes):** often the most abundant class in mango aroma and major contributors to the “fresh, resinous, citrusy” top notes. Common terpenes include α-pinene, myrcene, limonene, and δ-3-carene.

**Esters:** provide fruity, “pineapple/banana-like” characteristics; important in ripe fruit aroma.

**Lactones:** give creamy, peachy, coconut-like nuances and are especially important for the characteristic mango “roundness”.

**Aldehydes and alcohols:** contribute green, herbaceous, and fresh notes (for example hexenal-type “green” notes) and are often more prominent at earlier ripening stages.

**Ketones and apocarotenoids:** apocarotenoids (breakdown products of carotenoids) can give floral and sweet notes even at low concentrations.

**Sulfur-containing volatiles:** present at trace levels but can impart distinctive, sometimes powerful notes in select cultivars.

Together these classes and their relative ratios create the cultivar-specific bouquet that differentiates one mango variety from another. Traditional varieties from Malda and Murshidabad (e.g., Anaras, Champa, Fazli, Himsagar, Laxmanbhog, Ranipasand and many farmer landraces) are prized locally precisely because of distinctive VOC profiles high levels and characteristic ratios of terpene hydrocarbons (δ-3-carene, myrcene, limonene), esters and lactones produce cultivar-specific top notes, fruity sweetness and creamy roundness that differentiate one landrace from another (Pino, 2005; Maldonado-Celis *et al.*, 2019).

## Importance of volatile organic compounds (VOCs) in mango varieties

### 1. Sensory quality, consumer preference and market value

Aroma is a primary driver of consumer liking for mango. Traditional varieties from Malda and Murshidabad are often prized locally for their particular aromatic profiles (e.g., Fazli’s pungent ripeness, Himsagar's fibreless sweetness). Distinctive VOC profiles translate into product differentiation and can command premium prices in fresh markets and for processed products (pickles, pulps, jams, confectionery). Knowledge of the volatile fingerprint helps growers and traders highlight cultivar-specific selling points.

**2. Post-harvest handling and processing**

Volatile composition changes with maturity, storage and processing. Understanding which compounds drive desirable fresh-fruit aroma versus which survive processing is critical for industrial uses (juice, pulp, wine, dried mango). For example, esters and lactones may be reduced or transformed by heat, while terpenes can evaporate or oxidize — affecting the flavour quality of processed products. Profiling traditional varieties enables optimized harvest timing and gentler processing that preserve signature aromas (Pino and Queris, 2011).

**3. Authentication, traceability and value-addition (GI and branding)**

Chemical fingerprints built from VOC profiles can support authentication of high-value regional products and geographic indications (GI). For districts like Malda and Murshidabad, where specific varieties have local identity, volatile fingerprints combined with other markers (sugars, acids) can assist in traceability, reduce fraud, and reinforce GI branding initiatives. Studies have demonstrated that volatile markers (e.g., certain sesquiterpenes) can help distinguish cultivars (Ali *et. al,* 2018).

**4. Breeding and conservation**

Aroma is a complex, multigenic trait. Identifying key VOCs and their biosynthetic pathways allows breeders to select parent lines that combine desirable aroma with agronomic traits (yield, pest resistance, shelf life). For conservationists, characterizing aroma chemotypes provides an additional criterion to prioritize unique local landraces for in-situ and ex-situ conservation. This is particularly relevant in Malda/Murshidabad where farmer-maintained diversity includes varieties with unique organoleptic profiles (Tandel *et. al.,* 2023).

**5. Health, nutrition and functional properties**

Some VOCs (e.g., certain terpenes) possess bioactive properties viz. antimicrobial, anti-inflammatory or antioxidant effects at least in model systems. While aroma concentrations in fruit are low and not substitutes for nutritional attributes, these bioactivities may contribute to shelf stability or interact with other phytochemicals to influence overall functional properties of the fruit or processed products. More work is needed to translate laboratory bioactivity into nutritional claims.

VOCs also determine post-harvest and processing quality. Many aroma compounds are labile: esters and lactones increase during ripening and give ripe fruit its fruity/peachy character, whereas monoterpenes and sesquiterpenes dominate green and fresh notes but can be lost or transformed by heat, storage and mechanical handling. For Malda–Murshidabad mango landraces used both for fresh consumption and for processed products (pulp, pickles, dried slices), knowledge of which VOCs are heat-stable or lost during processing guides harvest timing, low-temperature handling and processing choices to retain desirable sensory traits (Maldonado-Celis *et al.,* 2019; Tandel *et al.,* 2023).

Beyond flavour and processing, VOC profiles are powerful tools for authentication, traceability and value-addition. Chemical fingerprints derived from HS-SPME–GC–MS or related platforms allow differentiation among cultivars and can support geographic-indication branding or premium marketing for regionally prized varieties. Multivariate analyses of VOC datasets (PCA, HCA, PLS) commonly separate cultivars into clusters on the basis of marker volatiles, which can be translated into objective quality metrics for supply chains and GI applications for Malda and Murshidabad mangoes (Shimizu *et al.*, 2021; Tandel *et al*., 2023).

**Objective of the study:** Comprehensive, cultivar-specific volatile studies exist for many commercial cultivars worldwide. The traditional variety Champa was chosen because of its unique aroma. The mature fruit has the aroma of the champaka flower, *Michelia champaca* L. The chemical eugenol has been identified from Champa variety in an earlier study by the authors and their team members (De *et al.,* 2021b). Identifying, documenting more volatile signatures is therefore important for cultural identity and market differentiation of regional mangos of Malda and Murshidabad districts.

## MATERIALS AND METHODS

### Study Area

Murshidabad, a district of the state of West Bengal in eastern India (Figure 1) is situated on the left bank of the river Ganges, covering an area of 5,341 km² (2,062 sq mi). The district comprises two distinct regions separated by the river Bhagirathi (Figure 2). To the west, there is the Rarh area, a high, undulating continuation of the plateau of Chota Nagpur. The eastern portion is known as the Bagri, which is a fertile, low-lying alluvial tract, a part of the deltaic area of the river Ganges. Murshidabad district is drained by two main rivers - Bhagirathi and Jalangi, along with their tributaries. Bhagirathi, a branch of the Ganges, flows southwards from Farakka barrage, the point of its origin, divides Murshidabad district into more or less equal halves.


**Figure 1. Location of the Murshidabad district (highlighted) in the state of West Bengal, India.**


**Figure 2. Map of Murshidabad district, West Bengal.**

**Plant materials :** Fruits of the traditional mango (*Mangifera indica* L.) variety, Champa of Murshidabad District of West Bengal, were obtained from a mango orchard in Azimgaunge, Murshidabad and their pulps were stored. Raw mango samples were transplanted into plastic centrifuge tubes and kept at -20º. Samples were kept in a refrigerator ( -20º) for over a year before starting the experiments. The tubes were changed at intervals to avoid rotting.

**Traditional Mango varieties used in this study:** Champa, a traditional mango variety collected from Murshidabad district was used for this study.

**Description of the Mature fruit of the Champa traditional mango variety:** The fruit which is morphologically a drupe is short in length (9 cm), with a narrow width, ratio of length/width is small, shape of cross section is circular, colour of the skin is green and yellow, and density of lenticels is dense. The colour contrast between lenticels and skin is strong, with large size of the lenticels. The cockiness due to the presence of the lenticels is present, shallow cavity at stalk is present. Shallow neck is present. Shape of ventral shoulder is rounded outwards; shape of dorsal shoulder is rounded downwards. Groove in the ventral shoulder is absent, and bulging on the ventral shoulder is also absent. Shallow sinus is present; depth of sinus is low. Bulging at the proximal stylar scar is absent, point at the stylar scar is medium. Diameter of the stalk attachment is small. Predominant colour of skin of the ripe fruit is yellow green, speckling of skin is weak, thickness of skin is thin, adherence of the flesh to the skin is medium. Main colour of the flesh of the ripe fruit is medium yellow. Firmness of the flesh of the ripe fruit is soft, with medium juiciness, and medium texture of flesh (Figure 3a & 3b).


**Figure 3. (a) Mature fruit of the traditional mango variety, Champa collected from Murshidabad district. (b) Two mature fruits of the traditional mango variety, Champa.**

**Processing of tissue for analysis of volatile and secondary metabolites via GC-MS:** Processing was performed following the methods of GC-MS technique. Pulps (about 2 gm) were removed from the main stock and two groups of samples were prepared: a test group and an aliquot, of the sixteen different mango varieties.

**GC-MS**

The experiment was carried out in the Central Instrumentation Facility, Bose Institute, Kolkata, India. For GC-MS Thermo fisher GC was used. The column (HP5) was fused silica 50 m × 0.25 mm I.D. Analysis conditions were 20 minutes at 100°C, 3 minutes at 235°C for column temperature, 240°C for injector temperature, helium was the carrier gas and split ratio was 5:4. The sample (1 µl) was evaporated in a split less injector at 300°C.Run time was 22 minutes. The components were identified by GC coupled with MS

**Identification of components**

Interpretation of the mass spectrum, GC-MS was conducted using the database of National Institute Standard and Technology (NIST) having more than 62,000 patterns. The spectrum of the unknown components was compared with the spectrum of the known components stored in the National Institute of Standard and Technology (NIST) library. The name, molecular weight and structure of the components of the test materials were ascertained.

**Chemicals:** Methanol and purified water, paraffin for blocking were used. Standards were dissolved in methanol solution at a concentration of 2.0 mg/10 mL of methanol and stored in glass vials at −20 °C for 24 h until the injection filtration in the equipment of GC-MS.

# RESULTS

Fruit pulp of the traditional mango variety, Champa were analysed and quantified by GC-MS. Some of the important compounds which were found are:

1. **Phenol, 2-methoxy-4-(1-propenyl) [Figure 4a & 4b].**

- **Molecular Formula:** $C_{10}H_{12}O_2$
- **Molecular weight:** 164.2011
- **IUPAC Name:** sodium 2-methoxy-4-prop-1-enylphenolate
- **Description:**

  Phenol, 2-methoxy-4-(1-propenyl)-, commonly known as anethole, is an organic compound characterized by its aromatic structure and functional groups. It features a methoxy group (-OCH3) and a propenyl group (-CH=CH-CH3) attached to a phenolic ring, contributing to its unique properties. Anethole is a colourless to pale yellow liquid with a sweet, licorice-like aroma, making it a popular flavouring agent in food and beverages, as well as in perfumes and cosmetics. It is slightly soluble in water but more soluble in organic solvents, reflecting its hydrophobic nature. Anethole exhibits low toxicity and is generally recognized as safe for consumption in regulated amounts. Additionally, it possesses antimicrobial and antifungal properties, which have led to its use in traditional medicine. The compound is also of interest in various chemical syntheses and can be derived from natural sources such as star anise and fennel. Its chemical stability and reactivity make it a valuable compound in both industrial and laboratory settings.

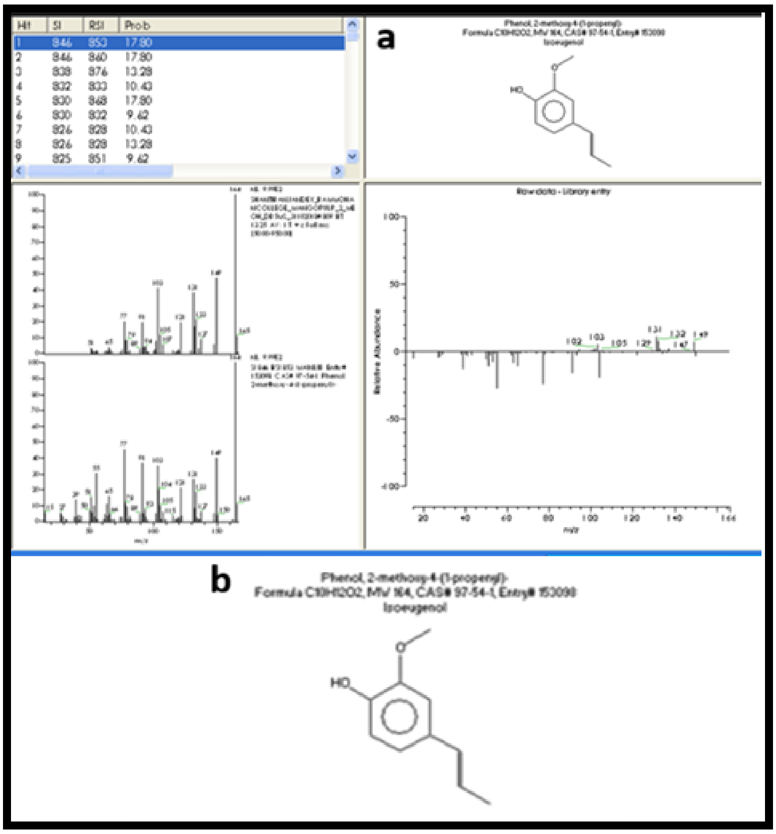


**Figure 4. (a). The GC-MS spectrum of Phenol, 2-methoxy-4-(1-propenyl)**

**found in the traditional mango variety, Champa. (b) Chemical structure of Phenol, 2-methoxy-4-(1-propenyl) from the traditional mango variety, Champa.**

2. **Phthalic acid, isobutyl 2-pentyl ester [Fig 5a & 5b].**

**Molecular Formula:** $C_{17}H_{24}O_4$

**Molecular weight:** 292.4 g/mol

**IUPAC Name:** 1-*O*-(2-methylpropyl) 2-*O*-pentan-2-yl benzene-1,2-dicarboxylate

**Description: Phthalic acid esters (PAEs):**

Have not only been identified in the organic solvent extracts, root exudates, and essen tial oils of a large number of different plant species, but also isolated and purified fro m various algae, bacteria, and fungi. PAEs are reported to possess allelopathic, antimi crobial, insecticidal properties (Ling *et.al.*, 2021).

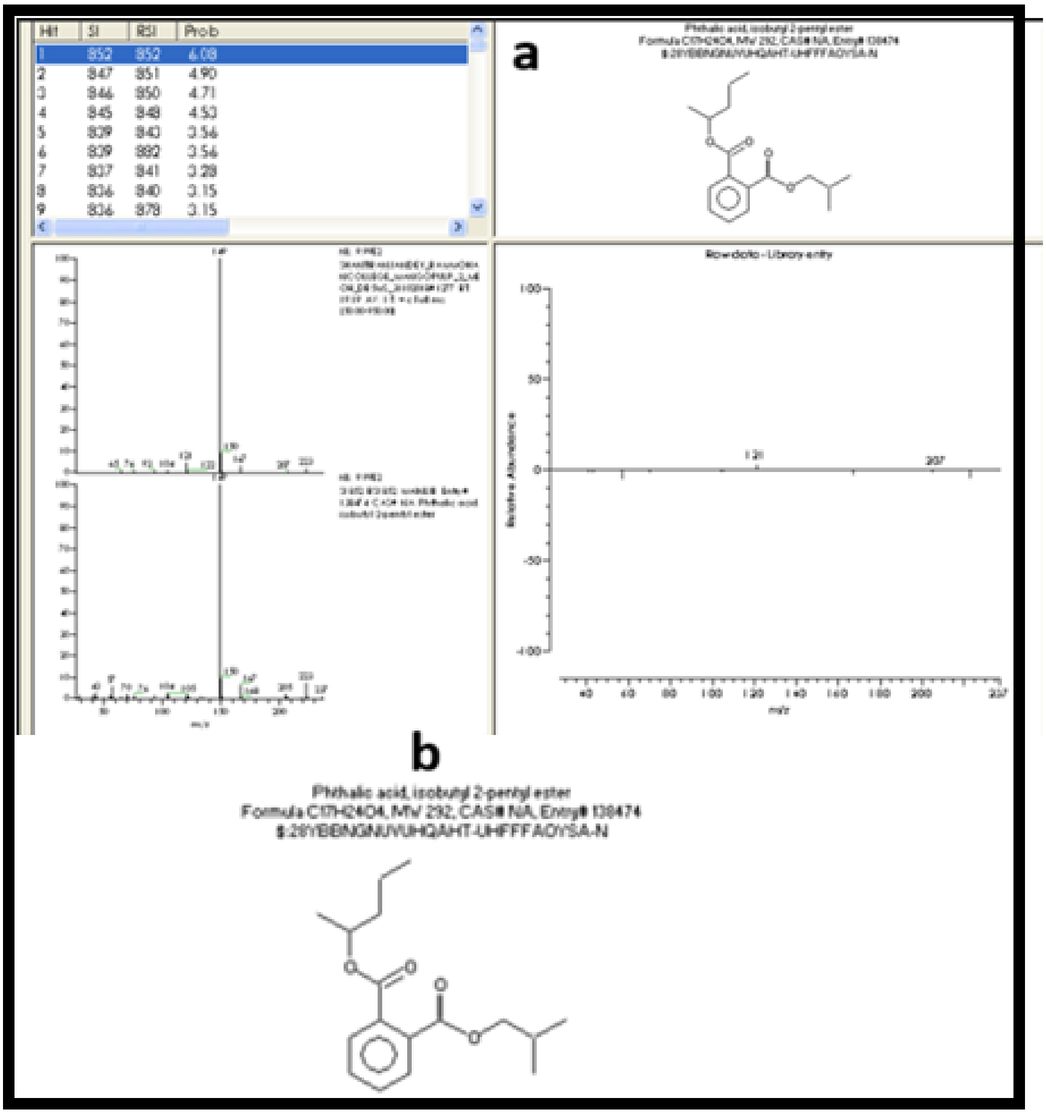


**Figure 5. (a). The GC-MS spectrum of Phthalic acid, isobutyl 2-pentyl ester found in the traditional mango variety, Champa. (b). Chemical structure of Phthalic acid, isobutyl 2-pentyl ester from the traditional mango variety, Champa.**

3. **Adamantane-1-(3,3-dichloropropyn-1-yl): [Figure 6a & b].**
**Molecular Formula:** C13H16C12
**Molecular Weight**: 243.18 g/mol
**IUPAC Name:** 1-(3,3-dichloroprop-1-ynyl) adamantane
**Description of Adamantane**: Adamantane is an affluent natural pharmacophore found in several plants, like *Hypericum sinaicum*, *Hypericum subsessile.*

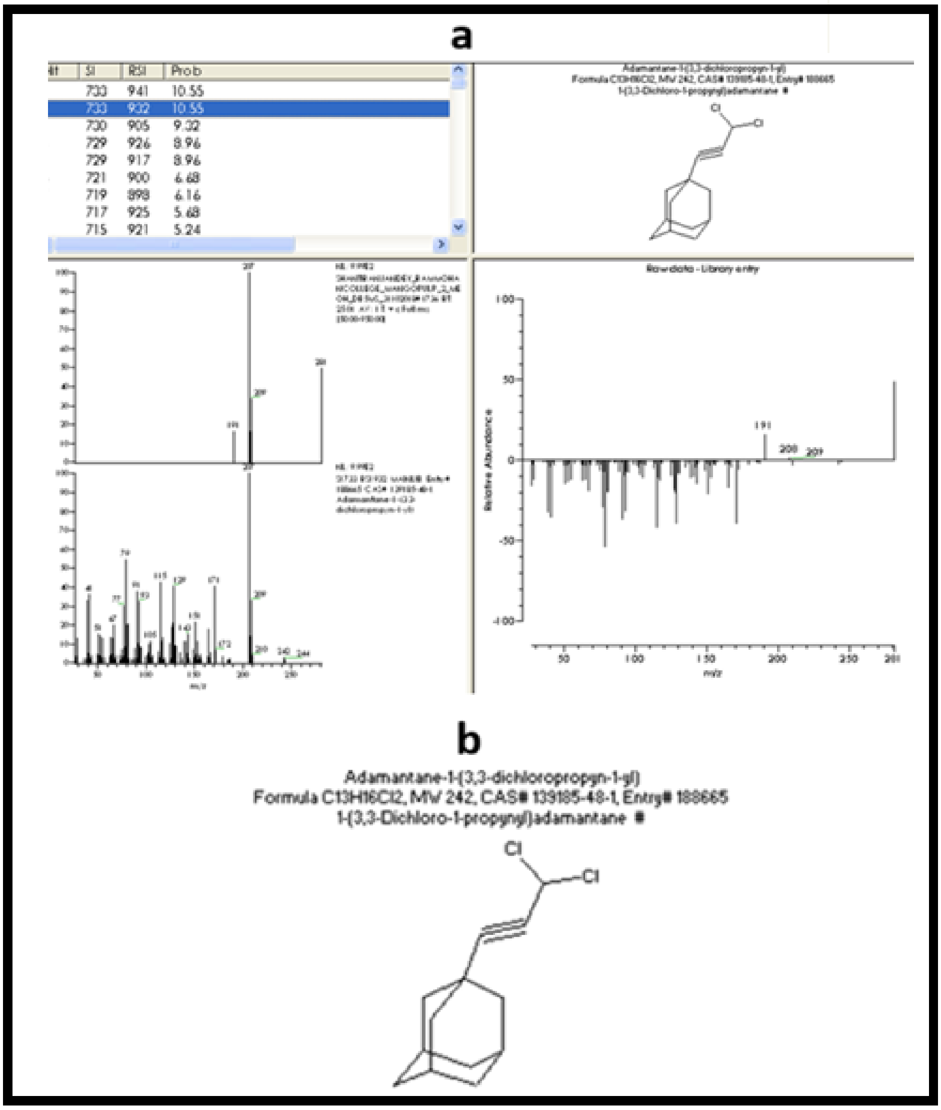


**Figure 6. (a). The GC-MS spectrum of Adamantane-1-(3,3-dichloropropyn-1-yl) found in the traditional mango variety, Champa. (b). Chemical structure of Adamantane 1(-3-3 dichclorpropgn-1-yl) from the traditional mango variety, Champa.**

4. **Eugenol [Figure 7a & 7b].**

- **Molecular formula: $C_{10}H_{12}O_2$**
- **Molecular weight: 164.20 g/mol**
- **IUPAC Name: 2-methoxy-4-prop-2-enylphenol**

- **Description:** Eugenol is a naturally occurring phenolic molecule found in several plants such as cinnamon, clove, and bay leaves. It has been reported in Champa variety by first author and team (De *et al.*, 2021c).

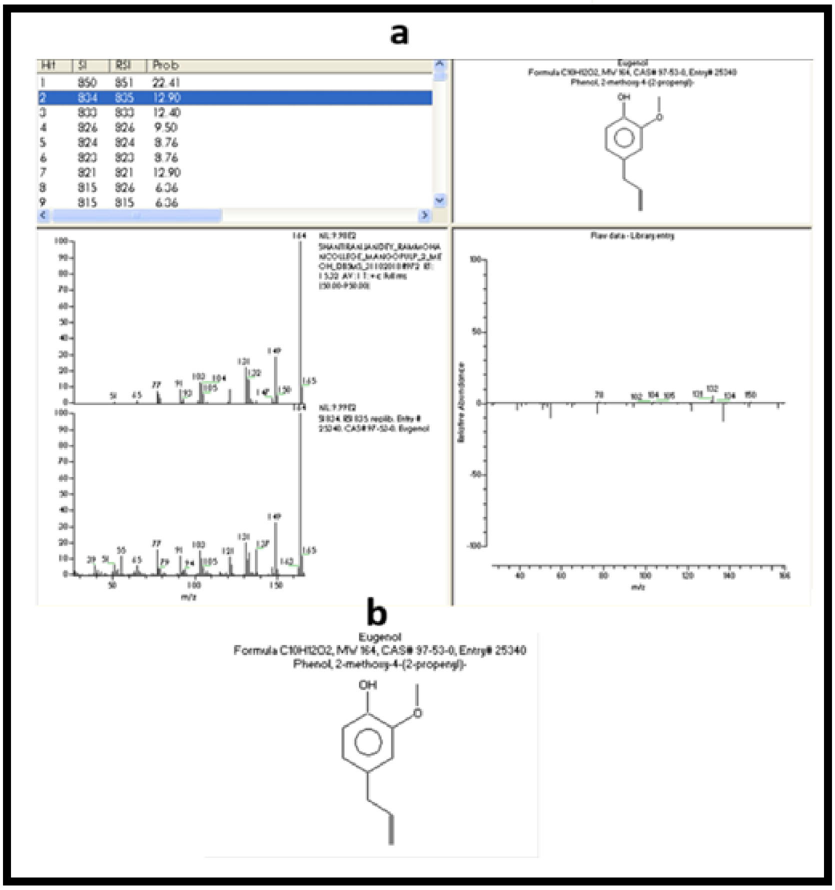

**Figure 7. (a). The GC-MS spectrum of Eugenol found in the traditional mango variety, Champa. (b). Chemical structure of Eugenol from the traditional mango variety, Champa.**

## DISCUSSION

Aroma is often polygenic and interacts with maturity, carotenoid content and texture; identifying specific VOC markers linked to consumer-preferred sensory attributes enables breeders to combine aroma with agronomic traits such as disease resistance or shelf life. For districts that maintain traditional germplasm, documenting VOC diversity helps prioritize unique landraces (those with rare apocarotenoids, lactone profiles or terpene combinations) for *in-situ* and *ex-situ* conservation and for use in participatory breeding programs (Pino, 2005; Tandel *et al.,* 2023). Regionally focused work on the Volatile Organic Compounds (VOCs) among mango varieties is growing (Singh *et al*., 2004, Singh, 2011, Preethi *et al*., 2014). From a breeding and conservation perspective, volatile chemistry provides selectable traits and conservation priorities.

Finally, VOCs have broader scientific and practical relevance: they can indicate biochemical state (ripeness, stress, pest or pathogen interactions) and sometimes have functional bioactivities (antimicrobial or antioxidant effects in model systems) that affect shelf life and microbial spoilage. Building a local VOC database for Malda and Murshidabad cultivars—and linking it to sensory panels and agronomic metadata—will create actionable knowledge for growers, processors and marketers while protecting the intangible value of traditional mango varieties (Maldonado-Celis *et al.*, 2019; Tandel *et al.*, 2023).

## CONCLUSION

Traditional mango varieties of Malda and Murshidabad contain rich and varied volatile profiles that underpin their sensory identity and economic value. Terpenes, esters, lactones, aldehydes and apocarotenoids in differing proportions create the complex mango bouquet that consumers prize. Systematic chemical profiling, linked with sensory evaluation, conservation and value-chain strategies, can help conserve these landraces while maximizing their cultural and commercial worth.

**Limitation of the study:** It was not possible to do the chemical profiling for all the traditional mango varieties collected, identified and documented by first author and team due to financial constraints. So only Champa was chosen because of its distinct aroma.

## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this work.

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## REFERENCES

Ali S. B., Ghatak, B., Debabhuti, N., Sharma, P., Ghosh, A., Tudu, B., Bhattacharya, N. & Bandyopadhyay, R. (2018). Detection of β-caryophyllene in mango using a quartz crystal microbalance sensor. *Sensors and Actuators B: Chemical*, 255 (Part 3), 3064-3073. https://doi.org/10.1016/j.snb.2017.09.131.

De, M. & Dey, S. R. (2021). Variation in the pulp quality of some rare indigenous mango (*Mangifera indica* L.) varieties of West Bengal. *International Journal of Experimental Research and Review*, 26, 70 -78. https://doi.org/10.52756/ijerr.2021.v26.005

De, M., Das, J., Saha, M., Pal, A. & Dey, S. R. (2014). Documentation and characterization of the indigenous mango (*Mangifera indica* L.) varieties of Malda and Murshidabad districts of West Bengal. *J Environ & Sociobiol*, 11(2), 187-198pp.

De, M., Dutta, S., Ray, S., & Dey, S. (2021a). Visual clustering analysis of some traditional mango (*Mangifera indica* L.) varieties of Murshidabad district, West Bengal, using Clust Vis web tool. *International Journal of Advancement in Life Sciences Research*, 4(3), 32-43. https://doi.org/https://doi.org/10.31632/ijalsr.2021.v04i03.005

De, M., Ray, S., Dutta, S., & Dey, S. (2021b). Eugenol found by GC-MS analysis of the methanolic extract of the fruit pulp of indigenous mango (*Mangifera indica* L.) variety, Champa from Murshidabad district of West Bengal, India. *International Journal of Advancement in Life Sciences Research*, 4(1), 22 - 30. https://doi.org/https://doi.org/10.31632/ijalsr.20.v04i01.004

Maldonado-Celis, M. E., Yahia, E. M., Bedoya, R., Landázuri, P., Loango, N., Aguillón, J., Restrepo, B., & Ospina, J. C. G. (2019). Chemical composition of mango (*Mangifera indica* L.) fruit: nutritional and phytochemical compounds. *Frontiers in Plant Science*, 10, 1073. https://doi.org/10.3389/fpls.2019.01073

Pino, J. A. & Queris, A. (2011). Analysis of volatile compounds of mango wine. *Food Chemistry*, 125 (4), 1141-1146. https://doi.org/10.1016/j.foodchem.2010.09.056.

Pino, J. A., Mesa, J., Muñoz, Y., Martí, M. P., & Marbot, R. (2005). Volatile components from mango (*Mangifera indica* L.) cultivars. *Journal of Agricultural and Food Chemistry*, 53(6), 2213–2223. https://doi.org/10.1021/jf0402633

Preethi P., Soorianathasundaram, K. & Subramanian, K. S. (2014). Aroma volatile compounds of mango cultivars Neelum and Banganapalli. Biochem Cell Arch, 14 (2), 421-425.

Shimizu, K., Matsukawa, T., Kanematsu, R., Itoh, K., Kanzaki, S., Shigeoka, S. & Kajiyama, S. (2021). Volatile profiling of fruits of 17 mango cultivars by HS-SPME-GC/MS combined with principal component analysis, *Bioscience, Biotechnology, and Biochemistry*, 85 (8), 1789–1797, https://doi.org/10.1093/bbb/zbab097

Singh, Z. (2011). Aroma volatiles emissions from mango fruit: a closer look at various Pre and postharvest regulatory factors. *Acta Hort*, 906, 267-273.

Singh, Z., Lalel, H. J. D. & Nair, S. (2004). A review of mango fruit aroma volatile compounds: state of the art research. *Acta Hort*, 645, 519-527

Tandel, J., Tandel, Y., Kapadia, C., Singh, S., Gandhi, K., Datta, R., Singh, S. & Yirgu, A. (2023). Nontargeted metabolite profiling of the most prominent Indian mango (*Mangifera indica* L.) cultivars using different extraction methods. *ACS Omega*, 8(43):40184-40205. https://doi.org/10.1021/acsomega.3c03670.

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