e-ISSN: 2757-8836
REVIEW
J. Raw Mater. Process. Foods vol.7(1), (2026) 49-57

Recieved: 03/03/2026 Revised: 13/04/2026 Accepted article published: 08/05/2026 Published online: 30/06/2026

The Aroma and Aroma-Active Constituents of Mastic Gum (*Pistacia lentiscus*): A Mini Review

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DOI: https://doi.org/10.57252/jrpfoods.2026.4

Abstract

This study reviews the aroma and aroma-active compounds of the resin obtained from the mastic tree (*Pistacia lentiscus*), a plant with high economic value. The aroma profile of mastic is composed of terpene groups such as monoterpenes, monoterpenoids, and sesquiterpenes, along with aroma groups like alcohols, ketones, aldehydes, volatile phenols, and esters. Studies indicate that monoterpenes are the dominant group, with α-pinene identified as the major compound. Limited olfactometric studies also report α-pinene as the most prominent aroma-active compound, imparting forest-like, resinous, and terpenic notes to the mastic gum, followed by β-pinene (resinous, terpenic) and β-myrcene (pine-like, greenish). Furthermore, the aroma profile of mastic gum is influenced by various factors, including geographical location, climate conditions, plant variety, and harvest time. Due to its strong aroma and diverse bioactive properties, mastic shows great potential for applications in fields such as food and pharmacology. Future research should focus on the identification of aroma-active compounds, sensory validation, and the effects of geographical variation using advanced aroma.

Keywords: *Mastic gum, mastic tree, Pistacia lentiscus, aroma, aroma-active, olfactometry*

1.INTRODUCTION

Pistacia lentiscus (mastic tree) is a plant belonging to the genus Pistacia within the family Anacardiaceae (Tamburini et al., 2024). This dioecious species, meaning it has separate male and female trees, is an evergreen shrub characterized by its persistent green leaves and strong, distinctive aroma (Ottria et al., 2023). It is commonly known as the mastic tree due to the resin, secreted from its trunk. This resin is widely known as “mastic”, “mastic gum”, or “Chios mastic” (Boudieb et al., 2019). The tree grows in some countries surrounding the Mediterranean Sea such as Greece, Türkiye, Tunisia, and Morocco (Trabelsi et al., 2012). Due to its resilience to extreme weather events and rapid regeneration, it plays a vital role in preserving ecosystems (Said et al., 2011). Currently, the mastic tree is represented by two subspecies: the shrub form, *Pistacia lentiscus* L., and the cultivated *Pistacia lentiscus* var. Chia, which is highly valued economically (Daferera et al., 2002). The mastic gum of the cultivated plant *Pistacia lentiscus* var. Chia is a highly valuable product in some regions of the eastern parts of Chios Island in Greece and the Cesme district of Izmir, Türkiye (Kilic-Buyukkurt, 2025; Tamburini et al., 2024). The mastic gum and other parts of the mastic tree, such as its fruits and leaves, have been used in traditional medicine for the treatment of various diseases especially gastrointestinal disorders since ancient Greek times (Trabelsi et al., 2012; Ottria et al., 2023). The mastic gum has significant effects on human health due to its rich composition of volatile and non-volatile compounds. Among these, volatile constituents, particularly terpenes and terpenoids, are primarily responsible for its characteristic aroma. Consequently, mastic is widely used not only as chewing gum but also in the pharmaceutical, cosmetic, and food industries worldwide because of its distinctive sensory properties (Tamburini et al., 2024).

Although numerous studies have investigated the chemical composition of mastic gum and its essential oil, studies specifically addressing the aroma and aroma-active compounds of mastic gum remain limited. The present review provides a comprehensive summary of the available data on the aroma and aroma-active compounds of mastic gum. It also discusses their chemical composition, significance, and the factors influencing their formation.

The literature included in this review was identified through searches of the Web of Science and Google Scholar databases using keywords such as *Pistacia lentiscus*, mastic gum, aroma, volatile compounds, aroma-active compounds, GC-MS, and GC-O. Peer-reviewed articles published in English up to June 2025 and focusing on the aroma composition, aroma-active compounds, and factors affecting the aroma profile of mastic gum were included in this review.

2. AROMA COMPOUNDS of MASTIC GUM

The appearance, aroma, and taste of a product are the key attributes influencing consumer preference. Among these, aroma plays a significant role in determining product quality. Aroma compounds are volatile substances that can easily evaporate at room temperature. These substances are perceived when they reach the olfactory receptors in the human nasal cavity (Kesen et al., 2013; Selli et al., 2014). The aroma of a food product is formed by the combination of hundreds of different volatile compounds. Although these substances are typically present in trace amounts ranging from nanograms to micrograms, they significantly influence consumer preference due to their pivotal role in determining odor (Kesen et al., 2013). These volatile compounds, including terpenes, alcohols, aldehydes, esters, and ketones, are naturally produced in various parts of plants. The interactions among these compounds create the unique scent of a food product. Moreover, the contribution of each volatile compound to the overall aroma profile is indispensable, highlighting the complexity and importance of these molecules in defining food quality (Selli et al., 2014). Extraction, identification and quantification procedures are required to determine the volatiles in foods (Kilic-Buyukkurt et al., 2025). Various techniques such as liquid-liquid extraction, purge and trap extraction, headspace stir bar sorptive extraction (HS-SBSE), headspace solid-phase microextraction (HS-SPME), and solvent-assisted flavor extraction (SAFE), are employed for the extraction of the aroma compounds, depending on their volatility and solubility. These compounds are identified, after extraction, by using an instrumental technique known as gas chromatography-mass spectrometry (GC-MS) (Delahunty et al., 2006; Pan et al., 2023).

Mastic gum is characterized by its strong and distinctive aroma and its woody, slightly bitter taste (Negro et al., 2015; Rigling et al., 2019). Mastic gum primarily contains volatile compounds from the terpene group, such as monoterpenes, sesquiterpenes, monoterpenoids, and sesquiterpenoids. These volatiles contribute to the characteristic aroma of mastic gum. The mastic tree is recognized for its exceptional capacity to produce and store terpenes (Said et al., 2011). Some researchers have reported that monoterpenes are the most abundant compounds among the aroma components of mastic gum and its oil (Rigling et al., 2019; Tabanca et al., 2020; Dhouibi et al., 2020). In an earlier study in which the aroma profile of mastic gum (*P. lentiscus var*. Chia) was examined using the purge-and-trap extraction method (Kilic-Buyukkurt, 2025), aroma compounds belonging to monoterpenes, monoterpenoids, alcohols, sesquiterpenes, aldehydes, phenols, ketones, volatile acids, and esters were identified, monoterpenes being the predominant aroma group. Among the monoterpenes, *α*-pinene was found to be the most abundant compound, followed by *β*-myrcene. Camphene, *β*-pinene, sabinene, limonene, perillene, and verbenone were reported as minor compounds. Similarly, in a previous study by Rigling et al. (2019), in which the aroma compounds of mastic gum (*P. lentiscus* var. Chia) were investigated using HS-SPME and HS-SBSE, *α*-pinene was reported as the dominant compound, while *β*-myrcene, limonene, *β*-linalool, and perillene were identified as minor components.

Mastic gum contains approximately 1-3% essential oil (Paraschos et al., 2011). In a previous study in which the chemical composition of mastic essential oil was analyzed by using GC, it was discovered that the oil consisted of 90% monoterpenes (Boelens and Jimenez, 1991). Koutsoudaki et al. (2005) investigated the chemical composition of the mastic gum from *P. lentiscus* var. Chia and its essential oil by using GC-MS, and reported that *α*-pinene, *β*-myrcene, *β*-pinene, limonene, and *β*-caryophyllene were the main components in both samples. Generally, former studies have reported that mastic gum and its oil are quite rich in terms of monoterpenes such as *α*-pinene, *β*-pinene, and *β*-myrcene (Miyamoto et al., 2014; Papada and Kaliora, 2019; Dhouibi et al., 2020; Pachi et al., 2021).

The aroma quality of mastic oil is influenced by its chemical composition, which varies depending on the quality of the mastic gum. The literature states that high-quality mastic gum typically contains 60-80% *α*-pinene and 7-20% *β*-myrcene. However, an increase in *β*-myrcene content has been reported to lower the quality of the mastic gum. This variation can be attributed to several factors, such as the purity of the mastic gum, the specific timing of its collection, and the duration between resin exudation and harvesting (Daferera et al., 2002; Ottria et al., 2023). Additionally, geographical origin, variety, climatic conditions, harvest period, and extraction techniques significantly impact the terpene composition (Negro et al., 2015). Since each extraction method has its own advantages and limitations, methodological differences may contribute to variations in the reported volatile profiles of mastic gum (Tabanca et al., 2020; Pachi et al., 2021). Rigling et al. (2019) reported that HS-SBSE enabled the identification of additional aroma-active compounds that were not detected by HS-SPME, demonstrating the influence of extraction methodology on the volatile profile of mastic gum. Therefore, the extraction technique should also be considered when comparing the volatile composition reported in different studies. A study analyzed the chemical composition of mastic gum essential oils obtained by hydrodistillation from mastic trees in wild (*P. lentiscus* L.; Cesme-Uzunköy and Mordogan, Izmir, Türkiye) and cultivated (*P. lentiscus* var. Chia; Cesme-Germiyan, Izmir, Türkiye) forms (Tabanca et al., 2020). It was reported that the essential oils from wild trees in the two regions were qualitatively and quantitatively similar, whereas the cultivated form exhibited quantitative differences. In the wild samples,

α-pinene (52–56%) and myrcene (19–20%) were dominant, while the cultivated samples contained a higher proportion of α-pinene (71%) and smaller amounts of β-pinene (6%) and myrcene (3%). The observed differences were attributed to factors such as the extraction method, storage duration of the mastic gum, as well as the age of the mastic tree, environmental conditions, and the composition of the soil where the trees were grown (Tabanca et al., 2020).

3. AROMA-ACTIVE COMPOUNDS of MASTIC GUM

Hundreds of aroma compounds have been identified in foods, but only a limited number of these aroma compounds are responsible for its characteristic aroma. These compounds are known as aroma-active compounds (Pino, 2024). Aroma-active compounds are the volatile substances that can produce olfactory perception in humans and are responsible for the food's aroma even at low concentrations (Acree et al., 1984). The characteristic aroma of a food is dependent on the combination, concentrations, and the olfactory thresholds of these aroma-active compounds (Djebari et al., 2023). In the determination of these aroma-active compounds, instrumental techniques such as gas chromatography-olfactometry (GC-O) and/or gas chromatography-mass spectrometry-olfactometry (GC-MS-O) are employed (Gou et al., 2023). These methods are highly sensitive and utilize the human nose as a detector to describe the quality and intensity of the olfactory perception. The determination of aroma-active compounds by using GC-O can be performed through aroma extract dilution analysis (AEDA), detection frequency method (DF), and time-intensity method (OSME) (Serot et al., 2001; Pan et al., 2023). In addition, Odor Activity Values (OAVs), calculated as the ratio of a compound's concentration to its odor threshold, are commonly used as a complementary approach to evaluate the contribution of individual compounds to the overall aroma (Hou et al., 2024). Aroma compounds with OAVs greater than 1 are generally considered to contribute significantly to the overall aroma of the sample (Schmidberger and Schieberle, 2020; Hou et al., 2024).

The aroma profile of the mastic gum is quite complex due to the interaction of numerous volatile compounds. In particular, monoterpenes have been identified as some of the most important and abundant aroma-active compounds in mastic gum (Figure 1) (Kilic-Buyukkurt, 2025). Studies that have been carried out to identify the aroma-active compounds responsible for the characteristic odor of the mastic gum are limited (Rigling et al., 2019; Kilic-Buyukkurt, 2025). Some of the aroma-active compounds identified in these studies and their associated odors are presented in Table 1. The mastic gum has a unique aroma that includes woody, fresh-green, and resinous odors with hints of pine and citrus, as well as slightly sour/vinegar-like notes. This characteristic aroma is not derived from a single aroma-active compound but rather from a complex combination of various odorants. In an earlier study by Rigling et al. (2019), in which the aroma-active compounds of mastic gum (*P. lentiscus* var. Chia) were identified through AEDA, a total of 25 aroma-active compounds were reported.

The researchers stated that the compounds responsible for this odor were generally terpenes and that some of the strongest key odorants included *α*-pinene (resinous), *β*-pinene (resinous, terpenic), camphor (spicy), 2-nonanol (green), perillene (green), *β*-linalool (floral), and terpinen-4-ol (earthy). In another study (Kilic-Buyukkurt, 2025), the aroma-active compounds of mastic gum (*P. lentiscus* var. Chia) were analyzed olfactometrically using the AEDA method, with samples collected from two different

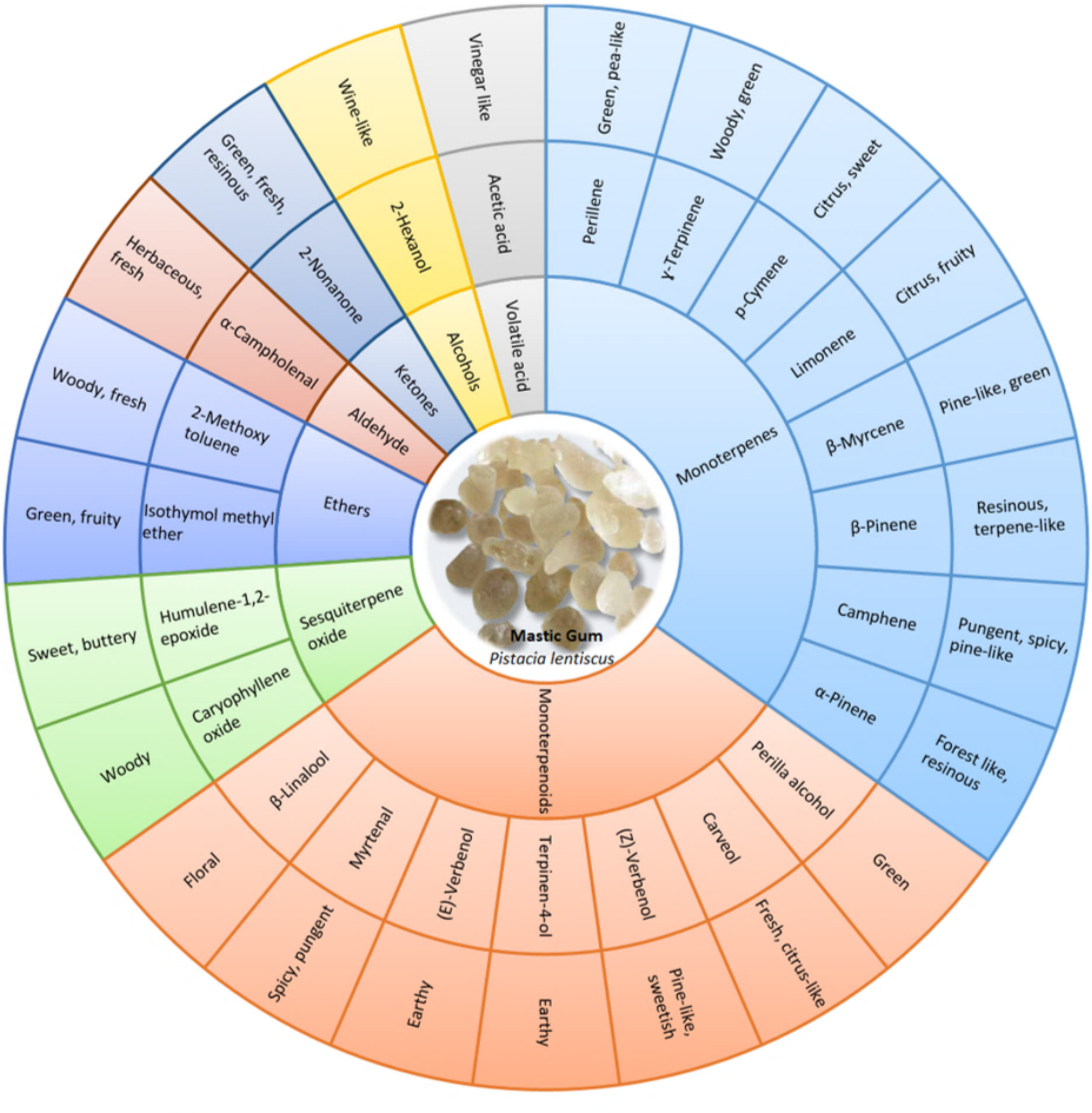

Figure 1. *Schematic illustration of the representative aroma-active compounds, their associated odor descriptors of mastic gum*

Table 1. *Aroma-active compounds identified in mastic gum and odor descriptions*

No	Aroma-active compounds	Chemical class	Odor descriptions	References
1	*α*-Pinene	Monoterpene	Forest-like, resinous	Rigling et al., 2019; Kilic-Buyukkurt, 2025
2	*6Z*-2,6-dimethyl-2,6-octadiene	Aliphatic hydrocarbon	Green, forest-like	Rigling et al., 2019
3	Camphene	Monoterpene	Pungent, spicy, pine-like	Rigling et al., 2019; Kilic-Buyukkurt, 2025
4	*β*-Pinene	Monoterpene	Resinous, terpene-like	Rigling et al., 2019; Kilic-Buyukkurt, 2025
5	*β*-Myrcene	Monoterpene	Pine-like, green	Rigling et al., 2019; Kilic-Buyukkurt, 2025
6	Limonene	Monoterpene	Citrus, fruity	Rigling et al., 2019; Kilic-Buyukkurt, 2025
7	*p*-Cymene	Monoterpene	Citrus	Kilic-Buyukkurt, 2025
8	2-Hexanol	Alcohol	Wine-like	Kilic-Buyukkurt, 2025
9	*γ*-Terpinene	Monoterpene	Woody, green	Rigling et al., 2019
10	2-Nonanone	Ketone	Green, fresh, resinous	Rigling et al., 2019
11	2-Methoxytoluene	Ether	Woody, fresh	Rigling et al., 2019; Kilic-Buyukkurt, 2025
12	Perillene	Monoterpene	Green, pea-like	Rigling et al., 2019; Kilic-Buyukkurt, 2025
13	Acetic acid	Volatile acid	Vinegar-like	Rigling et al., 2019; Kilic-Buyukkurt, 2025
14	*α*-Campholenal	Aldehyde	Herbaceous, fresh	Rigling et al., 2019; Kilic-Buyukkurt, 2025
15	*β*-Linalool	Monoterpenoid	Floral	Rigling et al., 2019; Kilic-Buyukkurt, 2025
16	Myrtenal	Monoterpenoid	Spicy, pungent	Rigling et al., 2019; Kilic-Buyukkurt, 2025
17	*(E)*-Verbenol	Monoterpenoid	Earthy, hay	Rigling et al., 2019; Kilic-Buyukkurt, 2025
18	Isothymol methyl ether	Ether	Green, fruity	Rigling et al., 2019
19	Terpinen-4-ol	Monoterpenoid	Earthy	Rigling et al., 2019
20	*(Z)*-Verbenol	Monoterpenoid	Pine-like, sweetish	Rigling et al., 2019; Kilic-Buyukkurt, 2025
21	Carveol	Monoterpenoid	Fresh, citrus-like	Rigling et al., 2019
22	Humulene-1,2-epoxide	Sesquiterpene oxide	Sweet, buttery	Rigling et al., 2019
23	Caryophyllene oxide	Sesquiterpene oxide	Woody	Kilic-Buyukkurt, 2025
24	Perilla alcohol	Monoterpenoid	Green	Kilic-Buyukkurt, 2025

The aroma-active compounds listed in Table 1 were compiled from the available studies in which aroma-active compounds were identified by GC-O using AEDA.

regions (Greece and Izmir province of Türkiye). The results showed that the compound contributing the most to the aroma, with the highest dilution factor in both regions, was *α*-pinene, which imparted a forest-like, resinous odor to the gums. Additionally, it was specified that the major compounds detected after *α*-pinene, were *β*-myrcene (pine-like odor), *β*-pinene (resinous odor), linalool (floral odor), perillene (greenish odor), and limonene (citrus-like odor) (Kilic-Buyukkurt, 2025).

Although the available studies employed similar analytical approaches based on GC-O and AEDA, their findings were largely consistent. Both studies identified *α*-pinene, *β*-pinene, *β*-myrcene, limonene, and perillene as the major aroma-active compounds of mastic gum. However, some compounds, including *γ*-terpinene, terpinen-4-ol, and humulene-1,2-epoxide, were reported only by Rigling et al. (2019), whereas *p*-cymene, 2-hexanol, caryophyllene oxide, and perilla alcohol were identified only by Kilic-Buyukkurt (2025). These differences may be related to the geographical origin of the mastic gum samples and other experimental factors. Overall, the available studies consistently highlight α-pinene as the dominant aroma-active compound of mastic gum.

GC-O and OAV analysis are fundamental tools for identifying aroma-active compounds; however, they provide limited information on the combined sensory effects and interactions among odorants. Therefore, aroma recombination and omission experiments are widely employed as complementary validation approaches within the molecular sensory science framework (Wang et al., 2025). In aroma recombination analysis, the identified key aroma-active compounds, typically those with OAVs greater than 1, are mixed at their quantified concentrations in an appropriate matrix to reconstruct the characteristic aroma of the food (Gou et al., 2023). Subsequently, omission experiments are performed by systematically excluding individual key odorants from the complete aroma model to evaluate their contribution to the overall aroma perception (Liu et al., 2012). Using this approach, Rigling et al. (2019) successfully reconstructed the characteristic aroma of Chios mastic gum and demonstrated that the omission of α-pinene, β-myrcene, limonene, β-linalool, and perillene resulted in significant sensory changes, confirming their essential contribution to the characteristic aroma of mastic gum.

4. CONCLUSION

Previous studies have shown that the mastic gum and oil of the mastic tree consist of various aroma groups with different chemical properties, predominantly terpenes, along with aldehydes, ketones, esters, and alcohols. The aroma-active compounds primarily responsible for its characteristic aroma and contributing most significantly to the overall aroma have been identified as terpenes such as α-pinene (forest-like, resinous odor), β-myrcene (pine-like, green odor), and β-pinene (resinous, terpene-like odor). However, research on the mastic gum of this globally significant medicinal and aromatic plant remains quite limited. Notably, due to its strong and unique aroma, the mastic gum and other parts of the mastic tree hold great potential for use in the food, cosmetic, and pharmaceutical industries. Moreover, the mastic gum and other components of the tree are highly valuable products with significant economic importance. Future research should focus on comprehensive aroma characterization, OAV evaluation, sensory validation of aroma-active compounds, and the effects of geographical origin, cultivar differences, environmental conditions, and processing techniques on the aroma profile of mastic gum.

ACKNOWLEDGEMENTS

We wish to thank Dr. Muharrem Keskin from Mustafa Kemal University, Hatay, Türkiye, for his outstanding editing and proof reading the manuscript.

DECLARATION OF CONFLICTING INTERESTS

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

FUNDING

None.

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