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## GUM MASTIC (*Pistacia lentiscus* L.) COMPONENTS AND THEIR EFFECTS ON HUMAN HEALTH

## КОМПОНЕНТЫ МАСТИКОВОЙ КАМЕДИ (*Pistacia lentiscus* L.) И ИХ ВЛИЯНИЕ НА ЗДОРОВЬЕ ЧЕЛОВЕКА

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Мастиковая камедь (*Pistacia lentiscus* L.), смола, содержащая в своем составе смолу и эфирное масло (1–2 %), полученная путем нанесения длинных надрезов на ствол и толстые ветви эвкалипта, который производился веками. Эвкалипт, который широко культивируется в странах от побережья до Средиземного моря в мире и в Эгейском и Средиземноморском регионах в нашей стране, с древних времен был частью альтернативной медицины. Это растение в виде куста с зелеными ароматными листьями, высота которых может достигать 6–8 м; имеет экономическое значение из-за промышленного и медицинского использования эфирных масел и смолы в его листьях и плодах. Мастика, полученная из этого дерева, используется при лечении многих заболеваний, таких как рак, бешенство, чесотка и укусы змей, изжога. Область применения не ограничивается этим, но мастичная смола используется во многих отраслях, таких как медицина, краска, косметика и строительство. В этом исследовании особое внимание уделяется компонентам, происхождению, областям использования и влиянию мастичной камеди на здоровье человека.

Mastic gum (*Pistacia lentiscus* L.), resin containing resin and essential oil (1–2 %) in its composition, obtained by making long scratches on the trunk and thick branches of the gum tree, which has been produced for centuries. The gum tree, which is extensively cultivated in the countries with a coast to the Mediterranean region in the world and in the Aegean and Mediterranean regions in our country, has been a part of alternative medicine since ancient times. This plant is in the form of a bush with green, aromatic leaves that can reach 6–8 m in height; It has an economic importance due to the industrial and health uses of the essential oils and resin in its leaves and fruits. Mastic gum obtained from this tree is used in the treatment of many diseases such as cancer, rabies, scabies, snake bites, and heartburn. The usage area is not limited to this, but mastic gum is a part of many industries such as medicine, paint, cosmetics and construction. In this study, the components, origin, usage areas and effects of mastic gum on human health are emphasized.

*Ключевые слова:* здоровье человека, состав, мастиковая камедь, камедь.

**Keywords:** human health, composition, mastic gum, gum tree.

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**Introduction.** Türkiye harbors an important diversity of species due to its geographical location and the fact that it is surrounded by seas on three sides. One of the most important of this diversity is the mastic tree, a member of the Anacardiaceae family, which grows in the Aegean region, especially in Çeşme and Karaburun districts in our country. The mastic tree is an economically important plant due to the industrial and health uses of the essential oils and resin in its leaves and fruits. In some countries such as Tunisia and Algeria, the oil obtained from this tree is used in daily foods, salads and pastries. Its essential oils are used as a therapeutic agent in rabies, intestinal and lung diseases, scabies and snake bites, heartburn and various dental diseases.

The mastic tree (*Pistacia lentiscus* var. *chia* Duham.) is the sole source of commercial mastic gum, which is obtained by utilizing the trunk and branches of the plant. Due to the low yield of females, only male trees are used in mastic production. Today, mastic is a natural resin used in more than sixty fields, especially in the food, perfume and pharmaceutical industries (Onay et al., 2016). Mastic, which has long been associated with the Greek island of Chios, has been produced in neighboring Western Anatolia, in the Çeşme peninsula of İzmir, where the ecological conditions are the same, although not as widespread and abundant as in Chios. However, as a result of the decrease in agricultural activities in the peninsula in the last 20 years, mastic tree cultivation has been negatively affected and the existing mastic tree presence has been under the threat of extinction due to intensive construction.

Mastic gum is a valuable product that has been produced for centuries, cultivated and traded especially in Chios since ancient times, and whose remains were found in the Uluburun shipwreck, which is considered to be the oldest shipwreck in the world. Mastic gum is obtained by long scratches on the trunk and thick branches of the mastic tree and contains resin and essential oils. Mastic gum, which is both an economic and scientific value, is a value that should be protected for Turkey due to the components it contains and its benefits for human health.

**Mastic Gum Tree.** Gum trees grow naturally in countries with a Mediterranean climate such as Portugal, Spain, France, Italy, Greece and Turkey. This plant, which can grow up to 200 m above sea level, is found in İzmir, Marmaris, Kuşadası, Ankara İncesu, Kayseri, Muğla, Datça, Antalya, Tarsus, Ulaş, Seyhan and Hatay regions in Turkey.

*P. lentiscus* L., a natural vegetation of the Mediterranean and Aegean regions, belongs to the genus *Pistacia* of the family Anacardiaceae (Sumacaceae) of the order Sapindales. Other important members of the Anacardiaceae family include *P. atlantica* Desf. (*hedgerow*), *P. terebinthus* L. (*melliferus*) and *P. vera* L. (*pistachio*). However, *P. lentiscus* L. can be easily distinguished from other species in the genus *Pistacia* in the Mediterranean and Middle East region due to its evergreen habit.

Flowering in the mastic tree takes place in March-April and a large number of flowers are produced. In the gum tree, which is a dioecious species, flowers without perianth develop in the leaf axils of 1-year shoots. The small, reddish flowers are in clusters. Male flowers are compound, 1-2.5 cm long, and female flowers are sparse, 1-3 cm long. The fruits of the gum tree are usually 4-7 mm in diameter, pointed, rounded, flattened at the edges. The color of the fruits changes from red to black as they ripen. The fruits ripen between October and December.

Mastic gum is a liquid resin obtained in droplets by making longitudinal scratches on the trunk of a mature gum tree. Usually the plant secretes this resin for self-protection. It has been reported that male plants have higher gum production potential than females. At harvest time, white clay called “Trapezi” or “table” is sprinkled under the tree to keep the fallen gum clean and transparent. After harvesting, the gum is collected and sacked by sweeping under the tree with a broom. Harvesting is done twice a year in August and September. Rain during the harvest is undesirable and can spoil or erode the gum. However, if the gum is fresh, it can also mix with rainwater and cause discoloration. Color is an important parameter in the quality of gum resin. If the gum appears transparent and clean, it is of better quality because oxidized gum turns yellow and cloudy. Gum should be stored for a short time. The longer it is stored, the whiter it turns and then yellow. Mastic gum production starts when the tree is 5 or 6 years old, but for maximum gum yield, trees should be over 12 years old.

**Cultivation.** The economic cultivation of the mastic gum tree is largely carried out in the south of Chios within the Chios mastic gum producers’ association. This cultivation discipline was included in the Representative List of the Intangible Cultural Heritage of Humanity by UNESCO in 2014.

Gum tree cultivation requires work all year round. It starts from mid-June until July with the cleaning process under the trees. In addition to tools specially designed to remove weeds, stones, dried branches and leaves, tools such as trowels and dustpan are also used. Then white clay containing calcium carbonate, also called “masa”, is spread on the ground and the area is leveled. This clay not only cleans the area but also accelerates the freezing and coagulation of the resin, giving it a shine. This creates a clean and suitable surface for the gum to drip and for easy harvesting. After creating a suitable area for harvesting, the next step is to make the first drawing on the tree trunk at a depth of 2-3 mm and a length of 4-5 cm with a tool called “kentitiri”.

In order to ensure easy flow of resin, resin flows in drops through these scratches on the branches of the tree facing the ground (Kılıç, 2019). A mature tree can have more than 100 wounds, but excessive scratches cause premature aging of the plant. The first drawing phase starts in mid-July and after a period of 3-4 weeks, there is a break of 10-15 days. During this interim period, the dripping gum also hardens sufficiently to become palpable. While the gum flowing from

the scratches is initially dull green due to the chlorophyll it contains, it turns yellow due to oxidation over time. In mid-August, the first harvest is started. During harvesting, a spatula with a wooden handle is used to fill the gum into saddles. After the first harvest is completed, drawings are made twice a week for 3-4 weeks. After the second drawings, there is a second break of 10-15 days and after the break, the second picking is done. In the second picking, unlike the first, even the smallest droplets on the ground are collected, including those hanging on the trunk and branches.

In the second collection, unlike the first, even the smallest droplets on the ground are collected, including those hanging on the trunk and branches. With the second collection, the annual collection is completed. Mastic gum production continues in this way from June to September. The harvested mastic is left to dry until November and then washed and cleaned. During this washing, the “lostra” process is also performed, which gives the drops a shine. The harvested drops should be stored at minus 20 °C for the best quality. Although mastic gum is a product that does not spoil or stale for many years, it is recommended to consume it within 2-3 years after the production date in terms of quality.

**Multiplication.** Traditional propagation of the mastic tree takes place in three ways: germination of seeds, rooting of cuttings and grafting. Gum trees, like other species of the genus *Pistacia*, are pollinated by wind. Gum can be obtained after many years from the plant that develops from the seed and gum yield in these trees varies depending on the genotypic characteristics of the seed from which the tree develops due to the dioecious nature of the species. In addition, due to fertilization problems such as parthenocarpy and underdevelopment of the ovary, germination rates of the seeds are different between genotypes. Although the gum tree produces a large number of flowers, the number of fruits containing viable seeds is very small and the fruits are mostly hollow inside and therefore have no seeds. Studies on fruits of different colors showed that red or greenish-white fruits have an underdeveloped embryo or are parthenocarpic. In contrast to red and white fruits, the viability rate of the seeds contained in black fruits is relatively higher and therefore harvesting the seeds after they turn black increases the germination rate.

Sapling production by cuttings is traditionally done by planting 40-50 centimeter branch cuttings in February and March. It has been observed that rooting success in cuttings production is low. The study conducted by Isfendiyaroğlu reported that rooting was observed in cuttings prepared from one-year shoots of gum tree when treated with different hormone mixtures and that rooting was highest in cuttings taken in February and lower in other months. However, the number of cuttings that can be taken from the mother plant is also limited as the number of gum-bearing elite trees that can be used for propagation by cuttings is small. Although some promising findings have recently been obtained in cuttings propagation, there are still difficulties in vegetative propagation of the plant due to the low rate of adventitious root development from cuttings (Mascarello et al., 2019). Mascarello et al., who studied vegetative propagation with cuttings *in vitro*, reported that the rooting rate was low and the number of plants adapted to the *in vivo* environment was also low, but quantitative findings on rooting percentage were not presented in the study. Although the recent results obtained in rooting of cuttings are promising, it is necessary to convert these shrub-formed trees to tree form since the plants formed as a result of gum tree propagation by vegetative methods *in vivo* acquire a shrub form. The products obtained from the small number of gum gardens established with these traditional methods used for gum tree propagation are insufficient to meet the demands. Therefore, the existing propagation techniques should be supported by biotechnological propagation methods.

**Components of mastic gum.** The resin contains natural polymers, volatile compounds, aromatic compounds, phytosterols, polyphenolic molecules and many active secondary metabolites that have been identified and isolated for the first time in nature. The combination of 80 compounds whose structures have been determined confirms why gum resin is so intensively used not only as food but also in health and personal care. While cis-1,4-poly- $\beta$  myrcene has been identified as the main polymer of the resin, it also contains a small amount (about 2-3 %) of essential oils.

Physical and chemical properties of mastic gum are given in Tables 1 and 2.

Table.1

*Physical properties of mastic gum (Kılıç, 2019)*

Index	Meaning
Density (d <sub>20</sub> ) (g/ml)	0.96–1.08
Softening Point (°C)	45–55
Melting Range (°C)	85–105
Moisture (%)	max 1.5
Total Ash (%)	max 0.2
Natural Additives (%)	max 1.5
Acidity Index	50–60
Saponification Number	70–85
Resolution	insoluble in water (% soluble in isopropyl alcohol, acetone, hexane, methanol, chloroform, diethyl ether, n-butyl ether)

Since 1930, chemical content studies have been carried out on the resin of *Pistacia lentiscus* species, but to date, the entire chemical content of the resin has not yet been determined. Only eighty of them have been identified. These components confirm why gum resin is used not only as food but also for health and personal care.

Table.2

*Chemical properties of mastic gum (Kılıç, 2019)*

Index	Meaning
Gum Essential Oil (%)	1–3
Natural Polymer ( <i>Poli-β-mirsen</i> ) (%)	25–30
Masticadienonic acid (%)	12–15
Isomasticadienonic acid (%)	12–15
Oleanonic acid (%)	6–8
Moronic acid (%)	3–6
Masticadienolic acid (%)	1–3
Isomastikadienolic acid (%)	1–3
Other Triterpenic acids (%)	3–5
Other Compounds (%)	20–25

Miyamoto et al. (2014) found that  $\alpha$ -pinene is the main constituent of gum essential oil (82.26 %) and that the oil contains twenty different constituents in varying proportions. These are  $\beta$ -pinene (2.96 %),  $\beta$ -myrcene (1.92 %), linalool (1.50 %), verbenone (1.50 %), pinocarvenal (1.25 %), limonene (0.84 %),  $\alpha$ -terpineol (0.77 %),  $\beta$ -caryophyllene (0.77 %),  $\beta$ -caryophyllene (0.77 %),  $\beta$ -caryophyllene (0.25 %), and  $\alpha$ -pinene (0.25 %), 73 %, verbenol (0.71 %), p-cymene 8-ol (0.54 %), myrcenol (0.43 %), p-cymene (0.41 %), camphenal (0.31 %), myrcenal (0.29 %), (E)-carveol (0.23 %), 2-undecanone (0.16 %), cariphylene oxide (0.14 %),  $\alpha$ -caryophyllene (0.09 %) and (E)-Me isoeugenol (0.07 %).

It was stated that the ratio of  $\alpha$ -pinene and  $\beta$ -myrcene in *P. lentiscus* L. essential oil determines the authenticity of gum drops and the amount of  $\beta$ -myrcene determines the marketing status of gum drops. While 60-80 %  $\alpha$ -pinene and 7-20 %  $\beta$ -myrcene content in the composition is a desirable feature, the increase in the  $\beta$ -myrcene ratio decreases the quality of gum drops. The  $\alpha$ -pinene ratio in the content of gum drops should not be less than 99:1, and if it is different, it indicates adulteration.

Apart from the monoterpene  $\alpha$ -pinene (~80 %), which is the most dominant component in the essential oil, monoterpenes such as  $\beta$ -pinene, camphene,  $\beta$  myrcene and limonene, monoterpene alcohols such as linalool and  $\beta$ -caryophyllene sesquiterpene were also identified. Other components such as tyrosol, p-hydroxy benzoic acid, p-hydroxy phenyl acetic acid, phenolic compounds such as p-hydroxy phenyl acetic acid, vanillic acid and gallic acid were reported to have concentrations of less than 0.5 % in the essential oil.

It was observed that the polymeric fraction of the non-volatile part of the gum drops, which ranges from 3–10 % and has a wide molecular weight distribution, has cis-1,4-poly  $\beta$ -myrcene as the main polymer. This polymer acts as a plasticizer in the monomeric resin fraction. The  $\beta$ -myrcene, which is formed in high amounts in the tree itself and is found in the essential oil, is a conjugated double bonded compound prone to polymerization. When the resin leaches from the tree,  $\beta$ -myrcene rapidly polymerizes and solidifies by radical chain reactions.

**Effects of mastic gum on human health.** Medically important phytochemicals such as terpenoids, flavonoids, phenolic and non-phenolic acids, fatty acids and essential oils isolated from the resin and different plant parts are the reason why the mastic tree was used in pharmacological studies in the past. Today, the positive effect of gum drops on oral and digestive disorders has been scientifically proven. Many researchers have investigated the beneficial effects of gum drops on gastrointestinal disorders and its antimicrobial properties against *Helicobacter pylori*, *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus* and *Porphyromonas gingivalis* strains. Due to its antiseptic effect, monoterpenes and other groups of substances were found to have inhibitory properties against *Helicobacter pylori*, which causes peptic ulcer. In a study conducted at the Faculty of Pharmacy of the University of Athens, it was found that gum and its oil have a significant antibacterial and fungicidal effect. It was also reported that gum resin, which has antibacterial properties, also functions as anti-inflammatory, antioxidant, antiatherogenic, hepatoprotective and cardioprotective properties (Onay et al., 2016). In dentistry, gum gum, which provides protection against plaque formation on teeth by using as an oral antiseptic against bacterial growth, is used in toothpaste production and as filling material. Beneficial effects of gum resin on the regulation of plasma inflammatory in people with Crohn's disease and the clinical course of the disease have also been reported. In recent years, an increasing number of studies have shown that gum resin exhibits potential antiproliferative properties against various types of tumors that cause cancer in humans, which may form the basis for future chemical cancer prevention applications (Onay et al., 2016). Phenylpropane compounds, which are found in very small amounts in the essential oil, have antiseptic and cramp-resolving effects. Mastic gum has also been used in skin ointments prepared to heal inflammations caused by burns, eczema and frostbite, and to regulate cholesterol, triglycerides and blood pressure.



Pharmaceutical companies use gum resin in the production of tablets and capsules, self-absorbing surgical threads and wound bandages. It is added to drinks such as the Greek “ouzo” against possible stomach pains. In addition, Perikos, in his book, mentions the resin’s aphrodisiac effect, its use in sunscreens due to its ability to absorb ultraviolet rays, its use against gallbladder inflammation and stones, and its use against chronic bronchitis due to its terpene content, citing studies on this subject.

**Uses of mastic gum in the food industry.** Mastic gum has a wide range of uses in the food industry. It is used as a natural additive and flavoring agent in pastry products such as custard, ice cream, cookies, cakes, especially in milk desserts; in beverages such as coffee, soda, sahlep; gum liquor, flavoring of alcoholic beverages; tobacco and of course chewing gum. Turkish delight, biscuits, candy and halva with gum drops can also be added to these foods. In addition, it is used as a preservative in ready-made soups, in breads to give flavor and prolong their life, to give consistency to spices and different sauces, in fish dishes to deodorize by mixing with oil, and in polishing chocolates. Used extensively as a spice in Arab countries, mastic gum is integrated into the traditional desserts and meat dishes of the peoples of Greece, Turkey, Lebanon and Syria.

**Conclusion.** Mastic gum is a product used in many areas, especially in the food industry, which is increasing in popularity day by day, and is of great importance both economically and in terms of health. However, it has been used for the treatment of human health since ancient times. Today, mastic gum, which is intensively produced and traded in Chios Island of Greece, is used in many products either raw or processed and is very valuable. However, mastic gum is in danger of extinction due to both the inadequacy of reproduction techniques and increasing tourism investments. It is necessary to take the necessary precautions and develop new biotechnological propagation methods before losing this richness in our country, and accordingly, the production of mastic gum should be increased.

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### МЕТОДИЧЕСКИЕ ПОДХОДЫ К ОЦЕНКЕ ЭКСПОЗИЦИИ ТРИГАЛОМЕТАНАМИ ИЗ ПИТЬЕВОЙ ВОДЫ С УЧЕТОМ МНОЖЕСТВЕННОСТИ ПУТЕЙ ПОСТУПЛЕНИЯ В ОРГАНИЗМ

### METHODOLOGICAL APPROACHES TO THE ASSESSMENT OF TRIHALOMETHANES EXPOSURE FROM DRINKING WATER TAKING INTO ACCOUNT THE MULTIPLE ROUTES OF ENTRY INTO THE BODY

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Согласно проводимым за рубежом научным исследованиям ингаляционный и кожный пути поступления в организм летучих органических соединений, присутствующих в питьевой воде, могут вносить преимущественный вклад в формирование риска здоровью при использовании воды для питьевых и хозяйственно-бытовых целей. В работе представлены результаты расчетов экспозиции приоритетными побочными продуктами дезинфекции – тригалометанами. Показано, что при определении приемлемого поступления (экспозиции) необходимо определять суммарную дозу вещества и ее составляющих (с учетом путей поступления), при которой не будет превышено значение приемлемого риска. Полученные результаты свидетельствуют о необходимости учета множественных путей поступления при гигиенической регламентации тригалометанов в питьевой воде.

The data of modern scientific research indicate a predominant contribution to the formation of health risk by inhalation and skin routes of entry into the body of certain groups of chemicals, including trihalomethanes, when water is used for drinking and household purposes. The paper presents the results of approbation of the method of hygienic regulation of chemicals in drinking water according to health risk criteria. It is shown that when determining an acceptable intake (exposure), it is necessary to determine the total dose of a substance and its components (taking