MEDLENTISK

Co-funded by the
Erasmus+ Programme
of the European Union

Good practice guide on lentisk fruit oil: from the field to the laboratory

ASSOCIATION INTERNATIONALE DES FORETS MEDITERRANEENNES

BURSA TEKNİK ÜNİVERSİTESİ 2010

Forêt Modèle de Provence

CIHEAM MAI CHANIA

Good practice guide on lentisk fruit oil: from the field to the laboratory

Edited by
International Association for Mediterranean Forests

Authors

International Association for Mediterranean Forests
Benguedouar Lamia (Jijel University)
Loudières Anaïs
Sebti Mohamed (Jijel University)

Forêt Modèle de Provence
Plazanet Nicolas

CIHEAM – Mediterranean Agronomic Institute of Chania
Ghosn Dany
Gotsiou Panagiota
Grigorakis Spyros
Loupasaki Sofia
Remoundou Ilektra
Rousou Maria
Verivaki Maria

Institut National de Recherches en Génie Rural, Eaux et Forêts
Fkiri Sondes
Mezni Faten
Stiti Boutheina

Bursa Technical University
Erkan Neşat
Parlak Salih

University of Cagliari
Allaw Mohamad
Bacchetta Gianluigi
Banni Sebastiano
Boi Maria Enrica
Caboni Pierluigi
Castangia Ines
Dessì Ludovica
Manca Maria Letizia
Manconi Maria
Meloni Francesca
Perra Matteo
Podda Lina
Sarigu Marco
Scano Alessandra
Syrbe Patrick
Zaru Marco

Layout: Bursa Technical University

"Partnership for an exchange of best practices on mastic tree fixed oil, an emblematic non-timber forest product in the Mediterranean"

This project is co-funded by the Erasmus+ Programme of the European Union within the framework of the project "MEDLENTISK, Partnership for an exchange of best practices on mastic tree fixed oil, an emblematic non-timber forest product in the Mediterranean" (2020-1-FR01-KA204-079807).

Coordinated by

Anaïs Loudières
AIFM
14 rue Louis Astouin, 13002 Marseille, France
+33 4 91 90 76 70, contact@aifm.org

Photographic credits: Cyprus Food Virtual Museum, Jijel University, Food and Agriculture Organization, Forêt Modèle de Provence, N. Boulamdaouar, F. Mezni, M. Sebti, G. Bacchetta.

This document is printed on PEFC-certified paper from sustainably managed forests by Marseille Imprimerie in June 2022.

Foreword

This good practices guide is the result of 22 months of exchanges between the partners and stakeholders of the MEDLENTISK project. It is an opportunity for all interested parties to share information on a forest resource that is little used by some, but already well known by others, as can be seen from the document.

It presents a combination of feedback accessible to all, as a real learning tool for users who will be able to discover, rediscover and become interested in a forest product which they are not or no longer familiar with.

The project partners hope to sharpen their interest and give better access to the knowledge that is linked to this product.

Context

Mediterranean forests produce many goods and services, such as wood, but also various non-wood products (mushrooms, honey, cork, resins, aromatic and medicinal plants, pine nuts).

The State of Mediterranean Forests 2018, published by the Food and Agriculture Organization (FAO) of the United Nations and Plan Bleu, reminds us of the importance of these Non-Wood Forest Products (NWFPs), whose value often exceeds that of wood and whose role in the development of the rural populations living in the area is fundamental. It also recalls that these resources (except for cork and pine nuts) are not well known, although they generate great value, hence the need to increase data and knowledge.

Non-Wood Forest Products are part of the cultural heritage of the Mediterranean basin. They contribute to human health and well-being as well as to the achievement of the United Nations Sustainable Development Goals, notably #2, #6, #12 and #13 (FAO and Plan Bleu, 2018).

Supported by the European Erasmus+ program, the project "*MEDLENTISK: Partnership for the exchange of good practices on fixed lentisk oil, an emblematic Non-Wood Forest Product in the Mediterranean*" has enabled six partners from five Mediterranean countries to come together to set up a collective reflection process on the lentisk tree in the Mediterranean, and more specifically on its fixed oil, its production, and applications.

Despite the difficulties linked to the health crisis and travel restrictions, the partners were able to meet and make exchanges on the lentisk tree and its Non-Wood Forest Products on several occasions. Emphasis was placed on a little-known product that is widespread in certain Mediterranean localities: fixed oil from the lentisk tree.

This guide was thus developed to present this Non-Wood Forest Product in an accessible format, which is typically Mediterranean and has numerous properties.

Contents

1. Introduction

The botanical genus *Pistacia* belongs to the *Anacardiaceae* family, which comprises 80 genera and about 870 *taxa*. *Pistacia* probably originated in Central Asia. Two centres of diversity have been described: 1) the Mediterranean Basin and the Middle East; 2) West and Central Asia (Mohannad and Duncan, 2012).

In detail, *Pistacia* counts 13 accepted *taxa* (Plantlist.org, 2022) in the world, while in the Mediterranean Basin it counts nine *taxa* (Euro+Med Plantbase, 2022):

1. *Pistacia atlantica* Desf.
2. *Pistacia atlantica* subsp. *Cypricola* H.Lindb. (preliminary accepted)
3. *Pistacia atlantica* subsp. *mutica* (Fisch. & C.A.Mey.) Rech. f.
4. *Pistacia eurycarpa* Yalt.
5. *Pistacia khinjuk* Stocks
6. *Pistacia lentiscus* L.
7. *Pistacia terebinthus* L.subsp. *palaestina* (Boiss.) Engl.
8. *Pistacia terebinthus* L. subsp. *terebinthus*
9. *Pistacia vera* L.

It also presents some hybrid, *Pistacia* × *saportae* Burnat (hybrid between *P. lentiscus* and *P. terebinthus*), and one variety, *Pistacia lentiscus* L. var. *chia*.

This genus was exploited by humans for thousands of years, as suggested by the frequent fruit (charred endocarps) and wood charcoal remains attested in archaeological sites in the Near East and the Mediterranean.

Pistacia lentiscus L., known as lentisk or mastic tree, is one of the most widespread species of the *Pistacia* genus, in the Mediterranean region. It is found around the Mediterranean Basin. The economic value of this plant is continuously increasing thanks to its diversified products.

The lentisk tree is a plant adapted to climate change, and therefore may have a sustainable future, as well as for the fixed oil extracted from its drupes, which is one of the products of lentisk that have become increasingly well known in recent years. Due the resilience of this emblematic plant and the promising biological and pharmaceutical properties of its oil, it is the focus of the cooperation project MEDLENTISK, to guide its possible uses. This oil is widely used and exploited in some regions of the Mediterranean (Algeria, Tunisia, and Sardinia), and less so in others (France, for example).

2. The lentisk tree

2.1. Botanical description

Taxonomy (Euro+MedPlantbase):

Kingdom Plantae

Division *Tracheophyta*

Sub-division *Spermatophytina*

Class *Magnoliopsida*

Superorder *Rosanae*

Order *Sapindales* Bercht. & J. Presl

Family *Anacardiaceae* R.Br.

Genus *Pistacia* L.

The common names of this plant in the different countries are: lentisque (French), lentisco (Italian), modditzi or chessa (Sardinian), skinos-σκίνος /σχίνος (Greek), sakızağacı (wild) (Turkish), dherw (Arabic)

2.2. Description

Pistacia lentiscus is an evergreen shrub or tree growing up to 10 meters, with dense and convoluted branches that support globular foliage. *Pistacia lentiscus* is dioecious and its flowers blossom between March and April in the leaf axils of one-year-old shoots. Leaves are glabrous, alternate, paripinnate, and, usually, consist of 6–10 elliptical-obtuse leaflets. Leaflet tips usually end with a sharp point. The flowers are small and clustered in inflorescences. Male flowers, reddish, are in 1-2.5 cm long compound clusters, while female flowers, yellow colored, are 1-3 cm long in sparsely branched clusters. Male plants are more producible than female plants (Boztok, 1999; Parlak, 2010; Akdemir et al., 2013; Abuduli, 2015). The male flowers have 4 or 5 stamens and a rudimentary pistil. Female flowers have

no petals and are characterized by the presence of a superior ovary. In common language the term 'berry' is used for lentisk's fruits, although botanically the fruit is a drupe: an indehiscent fruit with a fleshy mesocarp surrounding a hardened endocarp (pit or stone) containing a single seed. The fruit is first red and then black at maturity, about 4-7 mm in diameter. It is round-flattened and pointed, initially red, and black when ripe. The fruits ripen from late October to mid-December (Browicz, 1987; Boztok and Zeybek, 2004). Germination rate of seeds contained in black fruits is higher. Although the lentisk tree produces a large number of flowers and fruits, the number of fruits containing living seeds is very few. Most of the flowers cannot form fruit and a significant part of the fruits do not have seeds. Germination of seeds is hypogeic in all other *Pistacia* species but epigeic in lentisk (Palli and Aronne, 2000; Abuduli, 2015). Seeds are dispersed by birds. The male and female individuals, which have a wide variation in leaf size and shape and the number of leaflets, also vary in leaf form (Akdemir, 2013; Özel, 2006). *Pistacia lentiscus* forms taproot and many lateral roots in the young period. In the mature period, the lateral roots expand considerably and form fringe. Roots can go down to a depth of 20-25 meters (Akdemir et al., 2013; Mattia et al., 2005; Abuduli, 2015).The trunk of lentisk tree is not straight and its colour is light grey when young, and ash black in advanced age. It can live up to 100 years. Diameter at breast height can reach up to 40-50 cm (Parlak and Albayrak, 2010; Akdemir et al., 2013; Abuduli, 2015). Lentisk trees release strong resin odour from their trunks from the age of 5 until the age of 70. Usually, the plant secretes this resin to protect itself (Abuduli, 2015; Akdemir et al., 2013). Lentisk resin, which is an aromatic-smelling compound leaking from the trunk of lentisk, is obtained artificially from scratches on the tree trunk due to its economic value.

Biological form: Pcaesp (woody plants with bushy habit) or rarely Pscap (woody plants with arboreal habit).

Figure 1. Female (A) and male (B) inflorescences of *P. lentiscus* (Credits – M. Sebti).

Figure 2. Not ripe drupes of *P. lentiscus* (Credits - Forêt Modèle de Provence).

2.3. Geographical distribution

The plant grows in Southwestern and Southeastern Europe, Western Asia, Northern Africa, and Macaronesia.

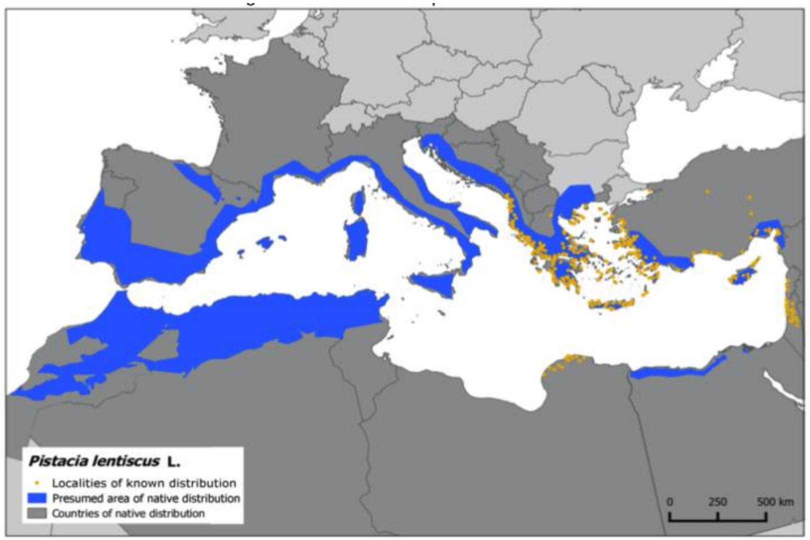

Figure 3. Geographic distribution of *Pistacia lentiscus* in the Mediterranean Basin (Credits – Food and Agriculture Organization).

2.4. Autecology and synecology

Pistacia lentiscus is heliophilic, thermophilic and xerophilic plant, which grows from sea level up to 1800 m, moreover it is resistant to water stress conditions (cold, frost or dryness). It is an indifferent edaphic species.

Pistacia lentiscus is a characteristic species of the order *Pistacio lentisci-Rhamnetalia alaterni* Rivas-Martínez 1975 of the class *Quercetea ilicis* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952. This class is characterized by vegetation communities that include prevalently evergreen and sclerophyllous forests, maquis and garrigues. They are found throughout the Mediterranean macrobioclimate, as well as in the temperate macrobioclimate [but only in the subMediterranean variant (Prodromo della vegetazione d'Italia, 2022)]. The order *Pistacio lentisci-Rhamnetalia alaterni* comprise typical sclerophyllous vegetation of Mediterranean Basin. It mostly occurs in the thermo and meso-Mediterranean thermotype (Prodromo della vegetazione d'Italia, 2022).

3. Lentisk oil

3.1. Definition and description

Lentisk tree oil is a yellow-green vegetable oil with a strong smell. This oil is extracted from the mature fruit of the lentisk tree. The oil is liquid at 32-34 °C; below this temperature it crystallizes (Leprieur, 1860; Maarouf et al., 2008).

Figure 4. Fixed oil of *Pistacia lentiscus* (Credits – F. Mezni)

The extraction of lentisk oil is a traditional activity. By traditional method, this oil is prepared for therapeutic purposes, notably in the treatment of burns and respiratory diseases. The extraction is very old and practiced by women, who pass it on from one generation to the next; it is based on non-ergonomic techniques; it is a long and arduous traditional process giving a low yield of around 5%. The extracted oil is also characterized by a poor quality affected by direct and repeated exposure to high temperatures (Mezni, 2019).

3.2. How to extract lentisk oil?

Lentisk oil is extracted from the ripe berries harvested between November and December. This extraction is carried out using two methods (Mezni, 2019): traditional and a new modern method.

The countries practicing this artisanal activity, which is tending to be modernized, are mainly Italy (Sardinia), Tunisia, Algeria, and Morocco.

The equipment and the principle of extraction are the same as for olive oil. However, there are specificities to the different regions.

3.2.1. In Sardinia

In Sardinia, the lentisk berry is harvested from mid-December to the beginning of February, depending on the year, the weather conditions, and the exposure of the subject. After harvesting, the berries are left to "rest"

for 3 to 4 days in a well-ventilated area. After the phase of cleaning the berries, they are poured into a container full of water and put on the fire to boil for 30 minutes.

A blackish deposit is formed (consisting of the coating on the berries and the black substance on the seeds - the latter lose their color after cooking and become pale yellow).

Once boiled, the "cooked" berries, which have swollen under the action of the hot water, are removed, and placed in a jute bag (other methods of extraction exist, this one is still used today in Sardinia).

The bag is pressed to obtain a red liquid mixed with water. This pressing liquid is put on the fire and mixed with cold water as soon as it boils, allowing the bitter to be better separated, then the oil is collected on the surface. The final product is green oil, which can be stored for several years.

3.2.2. In Tunisia

The artisanal method

Used by women in some forest areas of the country and passed down from mother to daughter, the first step consists of removing impurities (leaves, etc.) after picking. Then, the fruits are put in a clean container and immersed in water. Those that float on the surface are eliminated because they do not contain oil. The fruits that stagnate and/or melt are crushed under the action of small grinding stones (Fig. 5A); the crushed material is then poured into large containers and kneaded (Fig. 5B) by the feet adding cold water (Fig. 5C). The paste is then left to rest overnight in a cool, ventilated place to be kneaded a second time the next day. A quantity of cold water is then added to the grind. The top layer of this paste is removed, heated to boiling and then put in a cloth and pressed by hand (Fig. 5D) to separate the liquid phase from the solid phase (of the cake). The juice obtained is heated again until all the water has evaporated. The oil is then collected, filtered through a cloth, packed in bottles, and stored for sale or use. This method is laborious, uncontrolled and yields low quality oil.

***Figure 5**. Extraction of fixed lentisk oil by the artisanal method in Tunisia: crushing (A), mixing (B), skimming (C), pressing (D) (Credits - F. Mezni).*

3.2.3. In Algeria

After picking, the ripe berries are cleaned and then washed (Fig. 6) before they are crushed. Harvesting may take a few days, so before crushing, the fruit should be spread out on a clean surface and allowed to dry at room temperature to avoid contamination. Artisanal oil extraction requires adequate equipment, which all households should have, namely a grinding stone and a mortar (Fig. 7), depending on the region.

***Figure 6.** Lentisk twigs with ripe drupes (A) (Credits – M. Sebti), cleaning of the lentisk drupes (B) (Credits - N. Boulamdaouar, 2022).*

Other materials:

A metal or clay cooker, a pot, and a power source are needed in the hot extraction technique of lentisk oil, as well as a clean cloth for pressing and bottles for packaging the extracted oil.

Grinding stone:

This is considered a necessary item of household equipment as it is widely used to grind lentisk drupes, olives, cereals, and seeds (Fig. 7A).

Mortar:

Made of wood or copper, the mortar is a kitchen tool, often used to grind limited quantities (Fig. 7B and 8).

The principle of extraction of fixed lentisk oil remains the same, nevertheless, specificities or slight differences between regions are to be mentioned; both hot and cold extraction methods can be used as described below:

- ***Hot process***

This is the best known and the most widely used process, which consists of steaming the lentisk and then crushing it; or crushing it fresh and then heating or cooking it to facilitate extraction. The crushed material is then pressed into a clean cloth.

- ***Cold process***

The fruit is crushed with a stone, the crushed material is kneaded with the feet, the paste obtained is put in a cloth or jute bag, hung up, and left to drain overnight; the next day the first oils are recovered; then water is added, and the remaining oil is pressed out of it.

***Figure 7**.* Other lentisk oil extraction tools: millstone (A), copper mortar (B).

***Figure 8**.* Extraction of lentisk oil using the mortar (Credits - Jijel University).

It is true that these traditional processes are difficult, but it is important to preserve and conserve these empirical methods as a social and cultural heritage. The installation of a demonstration workshop in a house of local products or rural gite is an added value in the development of Mediterranean eco-tourism.

4. Good practices in fruits harvesting and oil extraction and storage

4.1. Exploitation of the fruits

The production of lentisk is variable, with good production linked to favorable climatic conditions during the year. In addition, the harvesting period can change with the geographical area; hence there may be a difference between southern and northern Mediterranean countries.

Based on the inflorescences, farmers can distinguish "non-productive" male lentisk trees from "productive" female lentisk trees (Fig. 9); it is then easy to locate areas and/or stations rich in lentisk before the harvesting season.

***Figure 9**.* Female plant of *Pistacia lentiscus* (Credits – M. Sebti).

It is rational to choose the best harvesting method to preserve the productive plants and allow their regeneration, because cutting branches and twigs destroys the species in the long term and production continues to decline (GIZ, 2018). If harvesting is done correctly, production only increases and evolves over time; this progression in berry production can be translated by the following function: $fn(x)=2(n-1)\,x$, where n is years and x is the production (Sebti, 2016). A hygienic quality product requires the respect of the rules and operating conditions, so some instructions for operators are needed, such as climate conditions, where it is highly recommended to collect it in sunny weather and to avoid rainy weather. To avoid the proliferation of fungi which reduces the quality of the product, the berries should not be moistened, so it is important to store them in paper or fabric bags (canvas, jute, etc.), or in wooden crates.

Healthy harvesting is still done by hand; the use of tools such as sticks, and destructive cutting of branches and twigs is not recommended. The harvest should be cleaned with water.

Figure 10. Non-destructive harvesting of lentisk fruits (Credits – F. Mezni).

4.2. Fixed oil extraction

Since the market demands certain standards, farmers and/or producers must respect certain measures during processing. In order to obtain good quality oil, it is necessary to avoid heating the fruit, the paste or the oil itself to a temperature exceeding 40°C.

To optimize the quality and yield of the oil, a new method has been developed by the research team at the Tunisian National Research Institute for Rural Engineering, Water and Forests. This method has improved the oil yield. The oil yield was improved from 5% (of the fruit weight) using the

traditional method, to 12% using the new method. The new method is also more ergonomic and timesaving. It reduces exposure to high temperatures which improves oil quality (Mezni, 2019). Finally, the technique has been improved by using modern processes and adequate equipment, with improved and significantly better yields, which can be doubled or tripled.

As an alternative technique to traditional crushing (by stone or mortar), a manual or electric chopper and an electric press made of stainless metal are adequate and allow for better oil quality and yield (Mezni, 2019; GIZ, 2018). New extraction methods that are less arduous, more practical and efficient, and more profitable and productive in terms of quality and quantity, are gradually being introduced.

Figure 11. Modern extraction equipment: manual chopper (A), electric chopper (B), hydraulic press (C), demonstration (D) (Credits – F. Mezni).

This new extraction technology is nowadays used by women lentisk oil producers in some areas in Tunisia and Algeria. These women have been trained to master the new method

4.3. Conditioning and storage of the oil

Like most fixed oils, the quality of lentisk oil can deteriorate over time. This is the phenomenon of oxidation, which is the result of exposure to air, light and heat. To minimize the oxidation of the oil, it is imperative to use dark glass bottles with sealed caps and a label indicating the origin of the oil and the date of extraction.

Figure 12. Commercial bottle of lentisk oil
(Credits – F. Mezni).

5. What are its biochemical properties?

5.1. Physico-chemical characterization

The acidity of lentisk fixed oil varies, depending on the extraction method, at between 6 and 14%. The peroxide value is less than 10 meq/kg (between 1.92 and 6 meq/kg). The refractive index varies between 1.463 and 1.468 (Ait Mohand et al., 2020; Siano et al., 2020; Kechidi et al.,2020; Karoui et al., 2020) (Table 1).

5.2. Mineral composition

Lentisk oil is a source of sodium (25.36 mg/ 100 g of oil) and potassium 2.17 mg/100 g of oil. Other minerals are present in low concentration (Dhifi et al., 2013) (Table 2).

5.3. Fatty acids

Like most vegetable oils, lentisk oil is composed of about 99% of fat. Unsaturated fatty acids amount to about 70% of the total fatty acids. Monounsaturated fatty acids represent about 50% and polyunsaturated fatty acids 20%. Oleic acid is the major fatty acid with a content of about 50%, followed by linoleic acid (20%) and palmitic acid (20%) (Table 2) (Mezni et al., 2012; Ait Mohand et al., 2020) (Table 3). Lentisk oil is characterized by high acidity. The free fatty acid profile shows oleic acid as the prominent one in terms of concentration (30%) followed by linoleic acid and palmitic acid, at 18% and 6%, respectively.

5.4. Triglycerides

The triglyceride composition of lentisk oil revealed the existence of 16 triglycerides with high contents of POO + SOL, OOO, and POL + SLL + PoOP. The main triglycerides found in the oil consist of mono- and polyunsaturated fatty acids (AitMohand etal., 2020) (Table 4).

5.5. Sterols

Ten sterols were quantified and identified in lentisk tree oil: cholesterol, campesterol, campestanol, tigmasterol, closterosterol+lanosterol, β-sitosterol, Δ5-avenasterol, β-amyrin, cycloartenol and 24-methylene-cycloartenol. β-sitosterol is the main sterol with a content of about 1224 mg/kg of oil, i.e., more than 54% of total sterols. Cholesterol is present at low levels according to the International Olive Oil Council standards (Trabelsi et al., 2012; Mezni et al., 2016; Karoui et al., 2020) (Table 5).

5.6. Phenols

Lentisk oil is rich in phenols which are natural antioxidants. The phenolic profile of this oil showed that it is mainly composed of phenolic acids and flavones. The total amount of phenols present in the oil is around 4260.57 mg/kg oil (Mezni et al., 2018; Sianoetal., 2020) (Table 6).

5.7. Tocopherols and carotenoids

The total tocopherol content was estimated to be 118.16 mg/kg oil. The α-tocopherol (vitamin E) content is about 96.77 mg/kg oil. The total carotenoid content is about 10.57 mg/kg oil. β-carotene is the main species identified in this oil, representing 4.9 mg/kg oil (Mezni et al., 2014, 2020; Karoui et al., 2020) (Table 7).

Interestingly, a further complete lipid analysis of the lentisk oil, produced in the south of Sardinia (Italy), was performed using liquid chromatography coupled to an ion mobility and a time-of-flight mass spectrometer (Cesar facilities at UNICA). Complex lipids were characterized with this method, which may provide by far more relevant information for evaluating lentisk fixed oil's biological activities, than just measuring the percentage of fatty acid composition as reported by different authors (see Siano et al. 2020). As a matter of fact, this novel methodology allowed to detect the presence of four fatty acids never reported before, 91 triacylglycerol species with a specific regiochemistry, the presence of five phosphatidylcholines, four phosphatidylethanolamines, one phosphatidylserine and a total of eight sphingomyelins (Caboni et al., 2022; manuscript in preparation).

6. What are its biological properties?

Thanks to this content, lentisk oil has a regenerative and protective effect on the skin: it can protect the skin cells from oxidative injury inhibiting the lipid oxidation and subsequent malondialdehyde formation, inducted by treatment with hydrogen peroxide. The lipid peroxidation product (malondialdehyde), if accumulated in tissue, readily interacts with

functional groups of proteins, lipoproteins, DNA, and RNA, involving different pathological states (lipid peroxidation: production, metabolism, and signaling mechanisms of malondialdehyde and 4-hydroxy-2-nonenal). It was disclosed that lentisk oil has a positive impact on skin repair, owing to its antioxidant properties, and the ability to promote cell proliferation, collagen synthesis and dermal reconstruction. Additionally, it can repair the lipid barrier function of skin, similarly to other natural oils, due to its moisturizing properties. It was also proven that the fixed oil of lentisk promotes proliferation of fibroblasts and new synthesis of collagen. Indeed, the collagen density in the tissue of rats treated with this oil was significantly higher than that found with other treatments (The healing effect of *Pistacia lentiscus* fruit oil on laser burn). The *in vivo* anti-inflammatory activity of oil was confirmed and related with its ability to inhibit or reduce the production of inflammatory mediators involved in the acute inflammatory response. Lentisk oil seems to act as a wound healing agent on one hand by the reduced production of the inflammatory mediators, and on the other hand, thanks to the antioxidant activity and stimulation of the production of antioxidant enzymes.

A modern and innovative strategy to improve the efficacy at the skin level of phytocomplexes contained in lentisk oil is their incorporation into nanocarriers. These systems can reduce the required dose and improve their accumulation in the skin, thus facilitating their application in cosmetic, cosmeceutical, and pharmaceutical products. In a new study, the *Pistacia lentiscus* fixed oil has been loaded in liposomes, which have been previously used to load several essential oils but only in a few fixed oils whose incorporation allowed to improve their beneficial activities [e.g., *Nigella sativa* seed oil and neem oil and, Nanotechnology for natural medicine: formulation of neem oil loaded phospholipid vesicles modified with argan oil as a strategy to protect the skin from oxidative stress and promote wound healing (Manca et al., 2021)]. *Pistacia lentiscus* fixed oil loaded liposomes were biocompatible, protected keratinocytes and fibroblasts against oxidative damages and in vitro promoted their migration in a cell monolayer lesion [formulation of liposomes loading lentisk oil to ameliorate topical delivery, attenuate oxidative stress damage and improve cell migration in scratch assay (Allaw et al., 2022)]. Obtained liposomal formulations seem to be a suitable system for the treatment and restoring of skin lesions. Formulations were also prepared using an easy, scalable, and low dissipative method, which can be replicated at industrial level to obtain a marketable and effective product. Additional studies (in progress) underlined that the co-loading of *Pistacia lentiscus* fixed oil with other natural antioxidants may potentiate the protective effect at the skin level, providing promising products.

Interestingly, detection in relatively high concentrations of palmitoleic acid may be relevant for its ability to strongly stimulate muscle insulin action and suppress hepatosteatosis (Cao et al., 2008; Yang et al., 2011), thus opening novel nutritional properties of fixed lentisk oil.

Taking into account that complex lipids demonstrated beneficial effects on human health such as anti-inflammatory, antimicrobial, anticancer, antihypertensive, and lowering of low-density lipoprotein, further studies are needed to better understand the role of these lipids. Considering the fact that complex lipids play an important role in prolonging the shelf life of the cold pressed oils by the increase of oxidative stability of the oil, further studies are also needed to prolong the shelf life of lentisk oil.

In the frame of this project, the protective effect of *Pistacia lentiscus* fixed oil has been investigated in pathological situations. Where pre-treatment protects lung, heart and brain tissue from damage related to exposure to environmental xenobiotics such as Benzo(a)pyrene (toxic from combustion of organic matter), histological and biochemical analysis revealed an architecturally normal tissue and a restoration of the cytosolic redox status of the various damaged tissues by increasing antioxidant activity (Benguedouar et al., 2019).

Treatment with anti-cancer drugs in the various chemotherapeutic protocols, such as doxorubcin and decetaxel, induces deleterious side effects on the other functions of the organism; here too, a pretreatment of a few days with the fixed oil of *Pistacia lentiscus* protects the liver tissue against the toxicity of these drugs whose prescription remains mandatory in oncology (Benguedouar et al., 2017).

Conversely, studies on the fixed oil of *Pistacia lentiscus* revealed its low toxicity. The high values of oral and intraperitoneal lethal doses of *Pistacia lentiscus* fixed oil (LD50 value = 37 ml/kg body wt., po; LD50 value = 2.52 ml/kg body wt., ip) confirmed a low acute toxicity (Boukeloua et al.,2012), showing that this oil is well tolerated.

Antimicrobial positive activities of *Pistacia lentiscus* fruit oil against bacteria and yeasts (*Listeria innocua, Salmonella enterica, Enterococcus faecalis, Shigella flexneri*, *Candida parapsilosis, C. tropicalis* and *C. glabrata*) have been reported with some differences depending on the microorganism tested. The maximum antibacterial activities were obtained against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. For yeasts, the oil exhibited high activity against *C. parapsilosis*. This study elaborately confirmed that Tunisian *Pistacia lentiscus* fruit oil contains compounds that can be used to treat many infections (Dhieb et al., 2021).

With the exception of Algeria and Tunisia, the medicinal use of this oil does not seem to be common in other Mediterranean pharmacopeias. Among the various uses of the therapeutic properties of this oil, only its healing effect has been studied and documented; its other medicinal benefits are still being developed in scientific studies.

7. Who exploits lentisk oil in the Mediterranean?

7.1. In Tunisia

In Tunisia, lentisk oil is mainly exploited in rural areas, especially in the north and northwest of the country, by (rural) women, either individually or grouped together, in Agricultural Development Groups (GDA). The role of these women is the extraction of the oil and its marketing. In recent years, some companies specializing in the marketing of oils have become involved in the Non Wood Forest Products value chain.

Given its soothing properties, this oil is used in some massage and wellness centers. It is also increasingly sought after (solicited) by consumers who use it for therapeutic and culinary purposes.

The oil is also transformed into several products and sold as a soap, cream, and balm.

7.2. In Algeria

In Algeria, this species is of particular interest; its fixed oil extracted from the berries is used in several industrial applications such as pharmaceuticals, food, and perfumery (Longo et al*.,* 2007).

The lentisk oil is exploited as follows:

- ✓ *Lentisk tree processing units*

Lentisk berries collected by women and children are sold to local processors. This know-how is still practiced in Algeria, in the center and especially in the north-east of the country. The manufacture of lentisk oil exists in extreme-east, in municipalities that are part of a protected area (Tozanli, 2018).

- ✓ *Cooperatives*

Units and cooperatives were installed in the extreme-east concerning the organization of the women of this region into cooperatives with the improvement of vegetable oil extraction techniques by introducing simple but efficient crushing machines. The purchase price of 1 kg of berries from collectors varies between 100 and 150 DA on average, depending on the season and the collection site.

- ✓ *Marketing*

The oil is transformed into several products to be marketed in the form of oil, cream, soap, balm, and shampoo. These various lentisk oil-based products are marketed in the herbalist's shops. The preparation methods and therapeutic indications are similar and/or inspired by traditional recipes reported by rural populations (Beldi et al., 2021).

Figure 13. Lentisk oil from Nabatia El Milia (Credits - Jijel University).

7.3. In Sardinia

In Sardinia, *Pistacia lentiscus* fixed oil is used both for culinary, traditional medicine, and cosmetic purposes. Traditionally in rural areas all over Sardinia oil was extracted by hot water method until last mid-century; the type of extraction required a lot of work with mediocre yields and production was gradually abandoned and replaced by the ever-widening supply of olive oil. Recently, thanks new studies, product development and wide availability of berries from spontaneous vegetation several enterprises start in oil production using cold extraction methods.

Contrary to lentisk vegetable oil, lentisk essential oil is not very common on the island as it is in mainland Italy. *Pistacia lentiscus* essential oil has a specific market in the cosmetic and pharmaceutical industry.

8. What is its economic interest?

Lentisk oil is only really exploited in Tunisia, Algeria and Sardinia:

8.1. In Tunisia

Lentisk oil, which is used on a family scale as a medicinal product, is increasingly being marketed. Its selling price is strongly influenced by the extraction method and the packaging, varying widely from 40 to 200 DT/liter (Mezni et al., 2019). The new techniques of oil extraction increase its production cost but improve its yield and quality, which has a positive effect on the economic profitability of this product. A woman is able to produce about 50 to 100 liters per year.

At the level of the local population, lentisk oil extraction provides an average annual income of 120 DT/household in 2012 (Daly et al., 2012). This income increased by using the new technology, it is at least 2000 DT per year in 2022.

8.2. In Algeria

Two thirds of the users of the plant are women, they use medicinal plants more than men. Traditionally, everyone uses the plant despite the intellectual level (academics, managers, etc.); users who are aware of the importance of phytotherapy have the knowledge and know-how of the uses of this plant (Helal, 2021). On the market, the selling price of this oil varies between 4000 and 5000 DA/liter. On average, a household produces 25 liter/year, i.e., an annual income of 112,500 DA/household (Sebti, 2016).

8.3. In Sardinia

Sardinia is the only region in Italy where *Pistacia lentiscus* fixed oil is commonly used. Annual production is difficult to estimate because most of product is sold directly by farmers within internal market, however, it's becoming more and more used by food, cosmetic, and pharmaceutical industries which estimate the use several hundred kg in last decade, with increasing interest. Market price depends on the quality and the kind of user; it is between 40 and 100 euro/kg. The yield of oil extraction is between 5% and 13% depending on the extraction methods.

The impression is that the market for *Pistacia lentiscus* fixed oil is immature. Producers are investigating a higher industrial demand which needs price reduction and quality standardization; many trials are promoted to optimize extraction, as has happened in the production of other oils, in order to achieve extraction efficiency without compromising the quality. Best results were achieved by using olive oil machines.

In Greece, Turkey, and France (other partner countries), fixed lentisk oil is not currently valorized, but thanks to the impulse provided by the current MEDLENTISK project a possible exploitation of this non-wood forest product is possible.

9. Other uses of the lentisk tree

9.1. Past uses [1]

9.1.1. The exploitation of lentisk fruits - evidence for fixed oil extraction?

Frequent evidence of wild *Pistacia* fruit remains (charred endocarps) in archaeological sites suggests exploitation by humans in the past. Such remains have been attested since the Paleolithic times, in the Near East, Anatolia, and the Eastern and Western Mediterranean, and are often found in association with other fruit species (almonds, oak acorns) within diverse contexts (domestic, funerary, ritual) (Stika, 1999; Goren-Inbar et al., 2002; Willcox, 2016; Morales, 2018; Rousou et al., 2021). Fruit identification is often done down to the genus level (*Pistacia*), so it is difficult to know with certainty whether the species *Pistacia lentiscus* is present in archaeobotanical contexts. The development and application of new methodological tools (Rousou et al., 2021), which enrich earlier observations (Kislev 1988), provides a more complete picture of the species (including lentisk) as exploited by man.

The fruits of the lentisk tree, like those of other species of the genus *Pistacia*, can be eaten raw, roasted or fried; they can be used for food preparations (bread), as a condiment (sausages), for the preparation of drinks, or even as fodder for domestic animals (Gennadios, 1914; Bailey & Danin, 1981; Ertuğ-

[1] *Part of the research on the Pistacia past uses was conducted within the framework of Maria Rousou's PhD research (Musée National d'Histoire Naturelle, Paris, ED 227, Sorbonne Université and Cyprus University), supported by an Onassis Foundation scholarship (ID: F ZO 066-1/2018-2019) and by the 7th Scholarship Programme of the Sylvia Ioannou Foundation.*

Yaras, 1997; Kislev, 1997; Savvides, 2000; Della et al. 2006; Hadjichambis et al., 2008; Papachristoforou, 2015; Secilmis et al., 2015; Alonso et al., 2016). The involvement of fire in these practices can result in the accidental charring of fruits. It can, thus, lead to their preservation in archaeological layers.

While the preservation of oil from lentisk or other *Pistacia* species is highly unlikely in archaeological contexts, the presence of large quantities of whole fruits or fruit fragments is often used as an argument for the possibility of oil extraction, which could indicate the fragmentation of the endocarp during the oil extraction process (de Lanfranchi et al., 1999; Loi 2013; Morales et al., 2013; Thi Mai et al., 2014; Willcox, 2016; Morales, 2018; Rousou et al., in review). Future experimental research could test this hypothesis. In addition to the medicinal properties known since ancient times and from medieval authors (e.g., Paul of Aegina *De Re Medica Libri Septem* book 4, sections I and XLIV) and by current ethnobotanical data, *Pistacia* oil has also probably been used for food preparations or for lighting (Whitehouse, 1957; Della et al., 2006; Hadjichambis et al., 2008; Gennadios 1914; Sabato et al., 2015; Labdelli et al., 2019).

9.1.2. The exploitation of wood, stem, and resin

In addition to the presence of fruit, charcoal from *Pistacia* wood is also attested among the archaeobotanical remains and indicates the possibility of the exploitation of this plant resource as fuel. The hypothesis of involuntary charring of fruit with *Pistacia* wood used as fuel is possible (Nisbet, 1980; Buxó-Piquet, 2008; Grau Almero, 2003, 2011; Kabukcu, 2018; Roberts et al., 2018; Moricca et al., 2020; Rousou et al., 2021; Willcox, 2011). Although further identification of *Pistacia* wood charcoals down to the species level may be tricky, if not all features identical to the anatomy of lentisk wood are achieved (Grundwag & Werker, 1976; Schweingruber 1990), the hypothesis of the presence of lentisk among *Pistacia* charcoals cannot be rejected. Lentisk wood is considered a good fuel, and it can also be used in the form of charcoal (Papachristoforou, 2015; Zapata Peña et al., 2003).

Wood can also be used for woodworking and construction (Grau Almero 2003; Grau Almero *et al.* 1998). Theophrastus (4thcentury BC) (*Historia Plantarum* 3.15.3; 5.3.2) and Pliny the Elder (1stcentury BC) (*Historia Naturalis* book 13.12) indicate the properties of *Pistacia* wood. The young shoots of the lentisk tree can be used in basketry (Gennadios 1914; Athanasiou, 2015; Papachristoforou, 2015; Zapata Peña et al., 2003). According to Isidore of Seville (6th-7thcentury BC), lentisk takes its name from the suppleness of its stem (*'lentus et mollis'*) (*Etymologiae* 17.7.51). In addition, the leaves, and galls of *Pistacia* contain tanning and dyeing substances and can be used in dyeing textiles or for tanning hides (Gennadios, 1914; Papachristoforou, 2015). All these uses leave little or no trace in archaeological contexts, which underlines the importance of developing future interdisciplinary research compiled with ethnobotanical studies.

Also of note is the famous Chios mastic, obtained from the *Chia* variety of lentisk, widely known for its medicinal properties and use in food (Freedman, 2011). The extraction and trade of lentisk, known at least since the 10thcentury BCE, has greatly influenced the history of Chios, where traces of exploitation since that period are still visible in the landscape and architecture of the island (Bakirtzis & Moniaros, 2019). Proteomic and genetic (ancient DNA) analyses on archaeological objects (pottery, mummies) have greatly enriched our knowledge about the uses of resin (wine preservation, embalming, incense, varnish) and its role in trade, especially during the Bronze Age and the Ancient period, as much as textual resources (Pliny the Elder *Historia naturalis* book 14. 24; Columella *De re rustica* 12.18ff) (McGovern 1997; Sarpaki 2001; Hansson & Foley, 2008; Pulak, 2008; Firth 2016; McGovern & Hall 2016; Merousis, 2010, 2016, 2019; Seprico & White 2000; Stern et al., 2018). The words *ki-ta-no* and *koi-no*, attested in the Linear B tablets of Knossos, attributed by some authors to the terebinth and lentisk tree respectively, could indicate the use of resin or, according to some authors, oil, from the lentisk tree (Melena, 1974; Sarpaki, 2001; Merousis, 2016). However, knowing that the resin can be extracted by different species of *Pistacia*, the attribution of the vernacular names attested in the texts to a particular species may be problematic (see Sarpaki, 2001 for discussion). Furthermore, as the chemical composition of the resin of different *Pistacia* species is similar, it is often difficult to attribute traces of *Pistacia* resin identified on archaeological objects to a particular species (Grundwag & Werker, 1976; Serpico & White, 2000).

The results from interdisciplinary approaches (archaeobotany, archaeology, history, ethnology, ethnoarchaeology) underline the importance of wild *Pistacia* resources in the past. Despite the limitations that each approach may encounter (preservation, identification), these data enrich our knowledge about their uses, which in some cases can still be observed among the traditional practices of actual local societies.

9.2. Current uses

The lentisk has been used since antiquity for many purposes; this section on other uses is by no means exhaustive but completes the uses and knowledge that we wish to highlight in this guide: dealing with the fixed oil extracted from fruits of the lentisk tree.

All parts of the plant are used: roots and wood (charcoal, fuel, and ash as a base to reduce the pH), leaves, berries (fruits) and resin. Rivera-Nunez and Obôn de Castro, (1991) quoted in De Lanfranchi et al. (1999), reports that the lentisk tree has multiple uses: while it is mainly exploited for the resin secreted by its stems, its leaves, wood, roots, and fruits are also used for food, domestic or medicinal purposes.

The virtues of this plant are multiple, and its products can treat a wide range of health problems: digestive problems, respiratory diseases, skin, and eye diseases (Sebti, 2020; Helal, 2021).

9.2.1. Fruits

Its fruit can also be used in the preparation of traditional dishes. It has also been studied in the laboratory for its antioxidant, anti-inflammatory, cytoprotective and anti-cancer activities.

Figure 14. Traditional Tunisian dish (sliga) (Credits - M. Sebti; F. Mezni).

Figure 15. Traditional lentisk dish (Meslouk) (Credits - Jijel University).

On the other side of the Mediterranean basin, to the East, this plant is not that commonly used but there are some traditional recipes reported in Cyprus (Cyprus Food Virtual Museum) and in Greece (Kasos, Naxos and Crete islands) for the use of the fruits of the lentisk tree soaked in water for making the traditional bread and pies (*σιηννόψωμο/σιηννόπιττες: ‘siinopsomo’/*‘siinopites’) and sweet cookies.

Figure 16. Traditional pies with fruits of lentisk from Cyprus (siinopites) (Credits – Cyprus Food Virtual Museum)

9.2.2. Resin

Beyond the fruit, one of the best-known uses is of course that of the resin, the mastic. Although there are many different varieties of small aromatic trees and shrubs of the *Pistacia* genus, only the *Pistacia lentiscus* produces a commercially exploitable quantity and quality of resin; only the variety grown in the southern part of the Aegean Island of Chios (Greece) was considered to be true mastic in the medieval period, a distinction it officially retains now as a Protected Designation of Origin product, according to the regulations of the European Union (Freedman, 2011). The mastic or 'mastiha' from Chios island, which is traditionally used in confectionery and perfumery, contains a variety of bioactive phytochemicals and has also been scientifically proven that it has important medicinal properties (Fukazawa et al., 2018; Tzani et al., 2018; Papada & Kaliora, 2019; Pachi et al., 2020).

Based on several research and clinical studies performed with Chios 'mastiha', the European Medicines Agency (EMA) and the European Food Safety Authority (EFSA) have officially granted (EMA 2015, 2016) health claims to the mastic of the lentisk tree, as traditional herbal medicine used for the treatment of mild dyspeptic disorders against skin inflammations and in the healing of minor wounds (EMA, 2015).

The mastic of the lentisk tree is also used in the preparation of candy and chewing gum to help fight cavities and to fortify the breath, in the preparation of a liqueur or as a food additive and flavoring agent (Baytop, 1999; Duru, 2003). It is used as a flavoring source in making ice cream and traditional desserts, coffee, and jams. The mastic is also used traditionally in cosmetic products, varnishing and in paint-making. Many famous paintings that symbolize the use of paints in fixing, such as Leonardo da Vinci's famous painting "Mona Lisa", have survived to the present day. Besides, it can be treated with various substances, used as a protective coating lacquer of works of art, high-quality varnish for airplanes, varnishing musical instruments, in floor polish and pastel paint and for obtaining high quality glue. It is also used in the manufacture of glass and porcelain as well as solder adhesive (Freedman, 2011; Onay et al., 2016).

The aerial parts of the lentisk tree or its resin are traditionally used for the treatment of coughs, throat ulcers, eczema, stomachache, kidney stones, and jaundice.

Figure 17. Lentisk tree resin (Credits - M. Sebti).

9.2.3. Twigs

In Tunisia, the twigs of the plant are used in flower bouquets and the extract is used to decorate pottery products. An important issue in which the natural lentisk trees in the maquis formation can be evaluated is the use of mastic branches as a green filling material in the production of bouquets in cut floristry.

In Greece, leaves and twigs were traditionally used in the past, in Naxos Island in the Cyclades, to make a kind of mattress in the coffin of deceased beloved people (Vavoula, 2017), probably to accompany them with their fresh smell.

Figure 18. Bouquet of flowers with twigs of lentisk tree (Credits - M. Sebti).

9.2.4. Leaves

The leaves of the lentisk tree are used as an antiparasitic against weevils, moths, and fleas, or slipped into shoes to prevent excessive sweating. Rich in tannins, the leaves can be used for leather tanning, especially in Libya. Leaves are also used as an ingredient in food, and as a hydrolat, herbal tea, and even in brandy, not to mention their use in the extraction of its essential oil.

The essential oil of lentisk has been widely studied for its antioxidant properties. It consists mostly of α-pinene, terpinen-4-ol, limonene, and myrcene, causing an antioxidant activity comparable to rosemary.

Lentisk tree leaf extracts consist of several families of compounds such as flavonoids, anthocyanins, phenolic acids (gallic acid, digallic acid, catechin), triterpenoids and tannins. These constituents are responsible for the leaves' antioxidant and anti-inflammatory activity.

Figure 19. Uses of lentisk leaves as an ingredient in food: drinking water (A), fermented milk (B); in the dishes (C) (Credits -M. Sebti).

9.2.5. Roots

The decoction of the roots is traditionally used (in Tunisia) for the treatment of respiratory problems.

9.2.6. Wood

The wood of the lentisk tree is particularly hard and is used in cabinet making, carpentry and as firewood. A wood veneer test was carried out by Forêt Modèle de Provence for use in marquetry, and the test proved successful. The wood can make excellent charcoal, and the ash can be used in soap making.

Figure 20. Ash-based soap.

9.2.7. *Pistacia lentiscus* for the phytoremediation and revegetation on mine sites

Among the different uses of *Pistacia lentiscus*, its application in phytoremediation and revegetation of substrates/soils polluted in metals and metalloids (i.e.: Zn, Pb, Cd, Hg, As) is noteworthy. The first studies were carried out after the accident in the Guadiamar River Valley (SW Spain) where 4 million m^3 of sludge contaminated by metal(loid)s were released into the Guadiamar River. Revegetation actions were implemented, indicating the potential of *P. lentiscus* in phytoremediation of sites polluted by metal(loids) (Fuentes et al., 2007; Dominiguez et al., 2008). Lately, several studies were carried out in the Sardinian mine context, showing that metals like Zn, Pb and Cd are mainly accumulated into roots, making *Pistacia lentiscus* suitable for phytostabilization, which use an exclusion mechanism mediated by the biomineral formation at the soil-root interface (Bacchetta et al., 2012; 2015; Concas et al., 2015; De Giudici et al., 2015). Finally, the implementation of soil amendments and the bioaugmentation with selected autochthonous bacterial strains can improve the survival of that species (Bacchetta et al., 2015; Tamburini et al., 2017).

Bibliography and sitography

Abuduli A., (2015). Evaluation of wild type Mastic tree (*Pistacia lentiscus* L.) Germplam by molecular markers, Marmara University, Institute For Graduate Studies in Pure and Applied Science, Master thesis, 135 p., İstanbul

Ait Mohand B., El Antari A., Benkhalti F., (2020). Chemical Composition of Pistacia lentiscus Seeds' Oil from Moroccan High Atlas Mountain. Journal of Food Quality, 2000, DOI: 10.1155/2020/5190491

Akdemir Ö.F., Tilkat E., Ahmet O.N.A.Y., Kilinç F.M., Süzerer V., Çiftçi Y.Ö., (2013). Geçmişten Günümüze Sakız Ağacı *Pistacia lentiscus* L. Batman Üniversitesi Yaşam Bilimleri Dergisi, 3(2), pp.1–28.

Alonso, N., Pérez Jordà, G., Rovira, N., López Reyes, D., (2016). Gathering and consumption of wild fruits in the east of the Iberian Peninsula from the 3rd to the 1st millennium BC. *Quaternary International 404*, 69–85. https://doi.org/10.1016/j.quaint.2015.07.021

Athanasiou, M., (2015). Η τέχνη της καλαθοπλεκτικής στην Κύπρο μέχρι το 1960 [I techni tis kalathoplektikis sthn Kypro mechri to 1960]. *Agrotis 466*, 65–67.

Bacchetta G., Cao A., Cappai G., Carucci A., Casti M., Fercia M.L., Lonis R., Mola F., (2012). A field experiment on the use of *Pistacia lentiscus* L. and *Scrophularia canina* L. subsp. *bicolor*(Sibth. et Sm.) Greuter for the phytoremediation of abandoned mining areas. Plant Biosyst 146: 1054 – 1063.

Bacchetta G., Cappai G., Carucci A., Tamburini E., (2015). Use of native plants for the remediation of abandoned mine sites in Mediterranean semiarid environments. Bull Environ Contam Toxicol 94: 326 – 333.

Bailey, C., Danin, A., (1981). Bedouin Plant Utilization in Sinai and the Negev. Economic Botany 35, 145–162.

Bakirtzis, N., Moniaros, X., (2019). Mastic Production in Medieval Chios: Economic Flows and Transitions in an Insular Setting. *Al-Masāq 31*, 171–195. https://doi.org/10.1080/09503110.2019.1596647

Baytop T., (1999). Therapy with medicinal plants in Turkey. Istanbul: Istanbul Nobel Tip Kitap Evleri Press.

Beldi M., Merzougui H., Lazli A., (2021). Etude ethnobotanique du Pistachier lentisque *Pistacia lentiscus* L. dans la wilaya d'El Tarf (Nordest algérien) - Ethnobotanical study of *Pistacia lentiscus* L. in El Tarf region (Northeastern Algeria). Ethnobotany Research and Applications. DOI: 10.32859/era.21.09.1–18

Benguedouar L., Sebti M., Abbas M., Chine K., Sayoud K., (2017). Effet protecteur de l'huile de fruits de *Pistacia lentiscus* L. contre la toxicité hépatique induite par l'association de la doxorubicine et le docetaxel chez le rat. Mémoire de fin d'études en Master Sciences Pharmacologiques. Université de Jijel Algérie.

Benguedouar L., Sebti M., (2019). Evaluation de l'effet préventif de l'huile de fruits du pistachier lentisque de la région de Jijel contre les toxicités aiguës cérébrale et pulmonaire induites par le benzo(a)pyrène chez la souris. Mémoire de fin d'études en Master Sciences Pharmacologiques. Université de Jijel Algérie.

Boukeloua A., Belkhiri A., Djerrou Z., Bahri L., Boulebda N., Hamdi Pacha Y., (2012). Acute toxicity of opuntia ficus indica and pistacia lentiscus seed oils in mice. African Journal of Traditional Complementary Alternative Medecine. 9(4):607-611

Boztok Ş., (1999). Sakız Yetiştiriciliği Ege Üniversitesi Tarımsal Uygulama ve Araştırma Merkezi, Çeşme Doğa ve Hayvan Severler ve Koruyanlar Derneği Yerel Gündem -21 İzmir, 15 s.

Boztok Ş., Zeybek U., (2004). *Pistacia* cinsine dahil bazı doğal bitkilerin sakız reçinesi kalitesi açısından irdelenmesi, gıda ve ilaç sanayinde değerlendirilmesi üzerine araştırma. Ege Üniversitesi Tarımsal Uygulama ve Araştırma Merkezi. İZMİR.

Brahmi, F., Haddad, S., Bouamara, K., Yalaoui-Guellal, D., Prost-Camus, E., de Barros, J.-P. P., … Lizard, G. (2020). Comparison of chemical composition and biological activities of Algerian seed oils of Pistacia lentiscus L., Opuntia ficus indica (L.) mill. and Argania spinosa L. Skeels. Industrial Crops and Products, 151, 112456. doi:10.1016/j.indcrop.2020.112456

Browicz F.A., (1987). *Pistacia lentiscus* L. var. *chia* (Anacardiacea) on Chios Island. Pl. Sys. Evol., vol.155, no.1-4, p.189–195.

Buxó, R., Piqué, R., (2008). Arqueobotánica. Los usos de las plantas en la PenínsulaIbérica. ARIEL Prehistoria, Barcelona.

Chaabani, E., Vian, M. A., Dakhlaoui, S., Bourgou, S., Chemat, F., & Ksouri, R. (2019). Pistacia lentiscus L. edible oil: Green extraction with bio-based solvents, metabolite profiling and in vitro anti-inflammatory activity. OCL Oilseeds and fats crops and lipids, 26.

Cao H, Gerhold K, Mayers JR, Wiest MM, Watkins SM, Hotamisligil GS., (2008). Identification of a Lipokine, a Lipid Hormone Linking Adipose Tissue to Systemic Metabolism. Cell 134(6):933-44.

Concas S., Lattanzi P., Bacchetta G., Barbafieri M., Vacca A., (2015). Zn, Pb and Hg contents of *Pistacia lentiscus* L. grown on heavy metal rich soils: implications for phytostabilization. Water Air Soil Pollut 226: 340 – 355.

Cyprus Food Virtual Museum.Traditional recipes for bread and pies with fruits of lentisk tree http://foodmuseum.cs.ucy.ac.cy/web/guest/36/civitem/2511, http://foodmuseum.cs.ucy.ac.cy/web/guest/parsintages/civitem/1641(as visited on 2 July 2021)

Daly H., Croitoru L., Tounsi K., Aloui A., Jebari S., (2012). Evaluation économique des biens et services des forêts tunisiennes. La Société des Sciences Naturelles de Tunisie (SSNT).

Davis P.H., (1967). *Linum* L. In: Davis PH. (ed.) Flora of Turkey and the East Aegean Islands. Edinburgh University Press, Edinburgh. 2: 425–450.

De Giudici G., Medas D., Meneghini C., Casu M.A., Giannoncelli A., Iadecola A., Podda S., Lattanzi P., (2015). Microscopic bio mineralization processes and Zn bioavailability: a synchrotron- based investigation of *Pistacia lentiscus* L. root. Environ Sci Pollut Res Int 22: 19352 – 19361.

De Lanfranchi F., Bui T. M., Girard M., (1999). La fabrication d'huile de lentisque (Linsticu ou chessa) en Sardaigne. In : Journal d'agriculture traditionnelle et de botanique appliquée, 41e année, bulletin n°2,1999. pp. 81–100.

Della, A., Paraskeva-Hadjichambi, D., Hadjichambis, A.C., (2006). An ethnobotanical survey of wild edible plants of Paphos and Larnaca countryside of Cyprus. Journal of Ethnobiology and Ethnomedicine 2, 34. https://doi.org/10.1186/1746-4269-2-34

Dhieb C., Trabelsi H. , Boukhchina S. , Sadfi-Zouaoui N., (2021). Evaluation of Antifungal and Antibacterial Activities of Tunisian Lentisc (*Pistacia Lentiscus* L.) Fruit Oil. Journal of Food and Nutrition Research. 9(4):177-181.

Dhifi W., Jelali N., Chaabani E., Beji M., Fatnassi S., Omri S., Mnif W., (2013). Chemical composition of Lentisk (*Pistacia lentiscus* L.) seed oil. African Journal of Agricultural Research. 8(16): 1395-1400.

Domınguez M.T., Maranon T., Murillo J.M., Schulin R., Robinson B.H., (2008). Trace element accumulation in woody plants of the Guadiamar Valley, SW Spain: a large-scale phytomanagement case study. Environ Pollut 152:50–59.

Duru M. E., Cakir A., Kordali S., Zengin H., Harmandar M., Izumi S., Hirata T., (2003). Chemical composition and antifungal properties of essential oils of three *Pistacia* species. *Fitoterapia*, *74*(1), 170–176.

Ertuğ-Yaras, F., (1997). An ethnoarchaeological study of subsistence and plant gathering in central Anatolia (Unpublished PhD thesis). Washington University, Washington.

Euro+Med Plantbase https://www.emplantbase.org/home.html (2022).

European Medicines Agency (EMA) 2015. EMA/HMPC/46758/2015. European Union herbal monograph on Pistacia lentiscus L., resina (mastic). Final edition.

European Medicines Agency (EMA) 2016. Final Assessment report on Pistacia lentiscus L., resina (mastic) (EMA/HMPC/46756/2015), Committee on Herbal Medicinal Products (HMPC) https://www.ema.europa.eu/documents/herbal-report/final-assessment-report-pistacia-lentiscus-l-resin-mastic_en.pdf

FAO and Plan Bleu, (2016). Geographic distribution of 24 major tree species in the Mediterranean and their genetic resources. Food and Agriculture Organization of the United Nations, Rome and Plan Bleu, Marseille.

FAO and Plan Bleu, (2018). State of Mediterranean Forests 2018. Food and Agriculture Organization of the United Nations, Rome and Plan Bleu, Marseille.

Firth, R., (2016). Re-considering the department concerned with aromatics, spices, honey and offerings at Knossos. Minos 39, 229-247

Freedman, P., (2011). Mastic: a Mediterranean luxury product. Mediterranean Historical Review26, 99–113. https://doi.org/10.1080/09518967.2010.536673

Fuentes D., Disante K.B., Valdecantos A., Cortina J., Vallejo V.R., (2007). Sensitivity of Mediterranean woody seedlings to copper, nickel and zinc. Chemosphere 66:412–420.

Fukazawa, T., Smyrnioudis, I., Konishi, M. et al. (2018). Effects of Chios mastic gum and exercise on physical characteristics, blood lipid markers, insulin resistance, and hepatic function in healthy Japanese men. Food Sci Biotechnol 27, 773–780. https://doi.org/10.1007/s10068-018-0307-3

GIZ, (2018). Guide des bonnes pratiques de récolte et d'extraction des huiles végétale et essentielle du pistachier lentisque en Algérie Coopération Allemande au Développement GIZP et programme « Gouvernance Environnementale et Biodiversité (GENBI). 2ème édition P 20 https://en.calameo.com/read/005804166ed50fc8181e5

Gennadios, P.G., (1914). Λεξικόν φυτολογικόν [Lexikon Phytologikon]. Εκδόσεις Μόσχου Χρ. Γκιούρδα [Moschou Ch. Gkiourda], Athens.

Goren-Inbar Naama, Sharon Gonen, Melamed Yoel, Kislev Mordechai, (2002). Nuts, nut cracking, and pitted stones at Gesher Benot Ya'aqov, Israel. Proceedings of the National Academy of Sciences 99, 2455–2460. https://doi.org/10.1073/pnas.032570499

Grau Almero E., (2003). "Antracoanálisisdel Castellet de Bernabé". En P. Guérin: El Castellet de Vernabé y el Horizonte Ibérico Pleno Edetano. Trabajos Varios del SIP, 101. Valencia, 345-351.

Grau Almero E., (2011). Charcoal analysis from Liwus (Larache, Morocco). SAGVNTVM EXTRA 11, 107–108.

Grau Almero E.; Pérez G. y Hernández A., (1998). "Paisaje y agricultura en la protohistoria extremeña". In A. Rodríguez Díaz (Coord.): Extremadura Protohistórica: Paleoambiente, Economía y Poblamiento. Cáceres, 31-62.

Grundwag M., Werker E., (1976). Comparative wood anatomy as an aid to identification of Pistacia L. species. Israel Journal of Botany 25, 152–167.

Hadjichambis A.C., Paraskeva-Hadijchambi D., Della A., Guisti M.E., De Pasquale C., Lenzarini C., Censorii E., Gonzales-Tejero M.R., Sanchez-Rojas C.P., Ramiro-Gutiérrez J.M., Skoula M., Johnson C., Sarpaki A., Hmamouchi M., Jorhi S., El-Demerdash M., El-Zayat M., Pieroni A., (2008). Wild and semi-domesticated food plant consumption in seven circum-Mediterranean areas. International journal of food sciences and nutrition 59, 383–414. https://doi.org/10.1080/09637480701566495

Hansson M.C., Foley B.P., (2008). Ancient DNA fragments inside Classical Greek amphoras reveal cargo of 2400-year-old shipwreck. Journal of Archaeological Science 35, 1169–1176. https://doi.org/10.1016/j.jas.2007.08.009

Helal Y., (2021). Ethnobotanique et valorisation des produits du Pistachier lentisque Mémoire de Master 2 (non publié). Université Batna1.

Karoui I.J., Ayari J., Ghazouani N., Abderrabba M., (2020). Physicochemical and biochemical characterizations of some Tunisian seed oils. Oil seeds and fats crops and lipids, 27, 29.

Kabukcu, C., (2018). Wood Charcoal Analysis in Archaeology, in: Pişkin, E., Marciniak, A., Bartkowiak, M. (Eds.), Environmental Archaeology: Current Theoretical and Methodological Approaches. Springer International Publishing, Cham, pp. 133–154. https://doi.org/10.1007/978-3-319-75082-8_7

Kechidi M. Chalal M.A., Bouzenad A., Gherib A., Touahr B[c]., Abou Mustapha M[d]., urihene M., (2020). Determination of the fixed oil quality of ripe *Pistacia lentiscus* fruits and *Opuntia-ficus indica* seeds. bioRxiv preprint doi: https://doi.org/10.1101/2020.11.20.392084

Kislev M.E., (1988). Fruit remains, in: Rothenberg, B. (Ed.), The Egyptian Mining Temple at Timna. Institute for Archaeo-Metallurgical Studies. Institute of Archaeology, University College London, London, pp. 263–240.

Kislev M.E., (1997). Chapter 8: Early agriculture and paleoecology of Netiv Hagdud, in: Bar-Yosef, O., Gopher, A. (Eds.), An Early Neolithic Village in the Jordan Valley. Part I: The Archaeology of Netiv Hagdud. Peabody Museum of Archaeology and Ethnology Harvard University, Cambridge, pp. 209–236.

Labdelli A., Zemour K., Simon V., Cerny M., Adda A., Merah O., (2019). Pistacia Atlantica Desf., a Source of Healthy Vegetable Oil. Applied Sciences 9. https://doi.org/10.3390/app9122552

Leprieur M., (1860). Journal de médecine, chirurgie et de pharmacie, 3[ème] volume, Publié par la société de science médicale et naturelle de bruscelles, p. 614-615.

Loi C., (2013). Preliminary Studies about the Productive Chain of Lentisk Oil through Ethnographic Witness and Experiments, in: Lugli, F., Stoppiello, A.A., Biagetti, S. (Eds.), Ethnoarchaeology: Current Research and Field Methods. Conference Proceedings, Rome, Italy, 13th-14th May 2010, BAR International Series. British Archaeological Reports International Series, Oxford, pp. 58–62.

Longo L., Scardino A., Vasapollo G., (2007). Identification and quantification of anthocyanins in the bernes of *Pistacia lentiscus* L., *Phillyrea latifolia* L. and *Rubia peregrina* L. Innovative Food Science and Emerging Technologies, 8: 360–364.

Maarouf T., Cherif A., Houaine N., (2008). Influence of *Pistacia lentiscus* oil on serum biochemical parameters of domestic rabbit Oryctolagus Cuniculus in mercury induced toxicity", European Journal of Scientific Research, 24, pp. 591–600.

Mattia C., Bischetti G. B., Gentile F., (2005). Biotechnical characteristics of root systems of typical Mediterranean species. Plant Soil., vol.278, no.1-2, p.23–32.

May, H., Slim, S., Messaoudi, F., Dali, B., Karmous, C., Azouzi, M., ... & Louhaichi, M. (2018). Chemical characteristics of fixed oil of lentisk tree (Pistacia lentiscus L.). Journal of New Sciences, 53, 3555-3560

McGovern P.E., Hall G.R., (2016). Charting a Future Course for Organic Residue Analysis in Archaeology. *Journal of Archaeological Method and Theory 23,* 592–622. https://doi.org/10.1007/s10816-015-9253-z

Mcgovern P.E., (1997). Wine of Egypt's Golden Age: An Archaeochemical Perspective. The Journal of Egyptian Archaeology 83, 69–108. https://doi.org/10.1177/030751339708300105

Melena J. L., (1974). «KI-TA-NO en las tablillas de Cnoso», Durius 2:1,45-55.

Merousis N., (2010). Τα "δάκρυα" των δέντρων. Οι χρήσεις ρητίνων στο Προϊστορικό Αιγαίο [Tadakryatondentron. I chrisis ton ritinon sto Proistoriko Aigaio], in: Merousis, N., Stephani, E., Nikolaidou, M. (Eds.), Ἰρις. Μελέτες στη μνήμη της καθηγήτριας Αγγελικής Πιλάλη-Παπαστερίου από τους μαθητές της στο Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης [Iris. Meletesstimnimi tis kathigitrias Aggelikis Pilali-Papasteriou apo tous mathites tis sto Aristoteleio Panepistimio Thessalonikis]. Kornilia Sfakianaki, Thessaloniki, pp. 257–275.

Merousis N., (2016). Did the Minoans consume only olive oil? ki-ta-no in the Knossos Tablets reconsidered. Pasiphae 10, 177–186. https://doi.org/10.1400/247056

Merousis N., (2019). Ρητινίτης οίνος και ρητινούχα ποτά στο προϊστορικό Αιγαίο: δεδομένα, υποθέσεις και ερμηνείες [Ritinitisoinos kai ritinoucha pota sto proistoriko Aigaio: dedomena, ypothesis kai erminies], in: Pikoulas, G.A. (Ed.), Οινονιστορώ XI. Ρετσίνα. Η διαχρονική Ιστορία της ρητίνης στην οινοποιητική τεχνική [OinonistoroXI. Retsina. I diachroniki istoria tis ritinis stin inopiitiki techniki]. Oinopoieio Kechris, Kalochori Thessalonikis, Athens, pp. 19–42.

Mezni F., Maaroufi A., Msallem M., Boussaid M., Larbi Khouja M., Khaldi A., (2012). Fatty acid composition, antioxidant and antibacterial activities of *Pistacia lentiscus* L. fruit oils. Journal of Medicinal Plants Research, 6(39), 5266–5271.

Mezni F., Khouja M.L., Gregoire S., Martine L., Khaldi A., Berdeaux O., (2014). Effect of growing area on tocopherols, carotenoids and fatty acid composition of *Pistacia lentiscus* edible oil, Natural Product Research, 28 (16) 1225–1230.

Mezni F., Labidi A., Khouja M.L., Martine L., Berdeaux O., Khaldi A., (2016). Diversity of sterol composition in Tunisian *Pistacia lentiscus* seed oil. Chemistry and biodiversity. 10.1002/cbdv.201500160

Mezni F., Slama A., Ksouri R., Hamdaoui G., Khouja M. L., Khaldi A., (2018). Phenolic profile and effect of growing area on *Pistacia lentiscus* seed oil. Food chemistry, 257: 206–210.

Mezni F., (2019). Fiche technico-économique du lentisque. GIZ.

Mezni F., Martine L., Khouja M. L., Berdeaux O., Khaldi A., (2020). Identification and quantitation of tocopherols, carotenoids and triglycerides in edible *Pistacia lentiscus* oil from Tunisia J. Mater. Environ. Sci., 11(1): 79–84.

Mohannad S., Duncan M.P., (2012). Taxonomic Revision of the Genus *Pistacia* L. (Anacardiaceae). American Journal of Plant Sciences.3: 12–32.

Morales J., (2018). The contribution of botanical macro-remains to the study of wild plant consumption during the Later Stone Age and the Neolithic of north-western Africa. Journal of Archaeological Science: Reports 22, 401–412. https://doi.org/10.1016/j.jasrep.2018.06.026

Morales J., Pérez-Jordà G., Peña-Chocarro L., Zapata L., Ruíz-Alonso M., López-Sáez J.A., Linstädter J., (2013). The origins of agriculture in North-West Africa: macro-botanical remains from Epipalaeolithic and Early Neolithic levels of IfriOudadane (Morocco). Journal of Archaeological Science 40, 2659–2669. https://doi.org/10.1016/j.jas.2013.01.026

Moricca C., Nigro L., Spagnoli F., Sabatini S., Sadori L., (2020). Plant Assemblage of the Phoenician Sacrificial Pit by the Temple of Melqart/Herakles (Motya, Sicily, Italy). Environmental Archaeology 1–13. https://doi.org/10.1080/14614103.2020.1852757

Nisbet R., (1980). I roghi del Tofet di Tharros: uno studio paleobotanico. Rivistadistudifenici 8, 111–126.

Onay A., Yıldırım A., Uncuoğlu Altınkut A., Özden Çiftçi Y., Tilkat E., (2016). Sakız Ağacı (*Pistacia lentiscus* L.) Yetiştiriciliği. Kitap, Dicle Üniversitesi Yayını, Diyarbakır.

Özel N., (2006). Sakız'ın taksonomisi ve biyolojik özellikleri, *Pistacia lentiscus* L. (Sakız Ağacı), Paneli, Ege Üniversitesi Tarımsal Uygulama ve Araştırma Merkezi.

Pachi, V. K., Mikropoulou, E. V., Gkiouvetidis, P., Siafakas, K., Argyropoulou, A., Angelis, A., ... & Halabalaki, M. (2020). Traditional uses, phytochemistry and pharmacology of Chios mastic gum (Pistacia lentiscus var. Chia, Anacardiaceae): A review. Journal of Ethnopharmacology, 254, 112485.https://doi.org/10.1016/j.jep.2019.112485

Papachristoforou, T., (2015). Αναφορά σε ένα από τα κυπριακά φυτά. Σχινιά (*Pistacia lentiscus* L.). Δέντρο της χρονιάς 2015 [Référence à l'une des plantes chypriotes. Schinia (*Pistacia lentiscus* L.). Arbre de l'année 2015. *Agrotis 466*, 62–63.

Palli M. E., Aronne G., (2000).Reproductive cycle in southern Italy of *Pistacia lentiscus* (Anacardiaceae). Plant Biosyst.,vol.134, no.3, p.365–371.

Papada E. & Kaliora A.C. (2019). Antioxidant and anti-inflammatory properties of mastiha: A review of preclinical and clinical studies. Antioxidants, 8(7): 208 https://doi.org/10.3390%2Fantiox8070208

Parlak S., Albayrak N., (2010). Sakız (*Pistacia lentiscus* var. *chia*)'ın Aşılama Yoluyla Çoğaltılması - Mastic tree vegetational propogation by grafting, Publication of Aegean Forest Research Institute, Technical Bulletin No:49, İzmir.

PRODROMO VEGETAZIONE ITALIANA https://www.prodromo-vegetazione-italia.org/, (2022).

Pulak, C., (2008). The Uluburun shipzreck and Late Bronze Age trade, in: Aruz, J., Benzel, K., Evans, J. (Eds.), Beyond Babylon. Art, Trade and Diplomacy in the Second Millennium B.C. The Metropolitan Museum of Art, New York. Yale University Press., New York, Haven and London, pp. 288–310.

Roberts N., Woodbridge J., Bevan A., Palmisano A., Shennan S., Asouti E., (2018). Human responses and non-responses to climatic variations during the last Glacial-Interglacial transition in the eastern Mediterranean. Quaternary Science Reviews 184, 47–67. https://doi.org/10.1016/j.quascirev.2017.09.011

Rousou M., Parés A., Douché C., Ergun M., Tengberg M., (2021). Identification of archaeobotanical Pistacia L. fruit remains: implications for our knowledge on past distribution and use in prehistoric Cyprus. Vegetation History and Archaeobotany 30, 623–639. https://doi.org/10.1007/s00334-020-00812-z

Rousou M., Parés A., Tengberg M., in review. Was Pistacia used only as fuel? Exploitation and uses of wild Pistacia resources at Late Aceramic Neolithic Choirokoitia (Khirokitia)

Sabato D., Masi A., Pepe C., Ucchesu M., Peña-Chocarro L., Usai A., Giachi G., Capretti C., Bacchetta G., (2015). Archaeobotanical analysis of a Bronze Age well from Sardinia: A wealth of knowledge. Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology 149, 205–215. https://doi.org/10.1080/11263504.2014.998313

Sarpaki A., (2001). Condiments, perfume and dye plants in Linear B: a look at the textual and archaeobotanical evidence. Meletimata 33, 195-266.

Savvides L., (2000). Edible wild plants of the Cyprus flora. Nicosia.

Schweingruber F.H., (1990). Anatomy of European woods. Paul Haupt Verlag, Bern Stuttgart.

Sebti M., (2016). Plan d'exploitation, guide de bonnes pratiques et formation pour l'extraction de l'huile de lentisque de la région pilote « Parc National d'El Kala » 2016 GIZ-GENBI. P. 120

Sebti M., (2020). Etude des Effets Toxiques de Plantes Aromatiques Spontanées de la Région de Jijel en vue d'une meilleure valorisation Pharmaceutique et phytopharmaceutique. Thèse de Doctorat Es-Sciences en Biologie. Université de Jijel. P. 123

Secilmis S.S., Yanık D.K., Gogus F., (2015). Processing of a novel powdered herbal coffee (Pistacia Terebinthus L. Fruits Coffee) and its sensorial properties. Journal of Food Science and Technology 52, 4625–4630. https://doi.org/10.1007/s13197-014-1475-7

Serpico M., White R., (2000). Resins, amber and bitumen, in: Nicholson, P.T. (Ed.), Ancient Egyptian Materials and Technology. Cambridge University Press, Cambridge, pp. 430–474.

Siano F., Cutignano A., Moccia S. et al. (2020). Phytochemical Characterization and Effects on Cell Proliferation of Lentisk (*Pistacia lentiscus*) Berry Oil: a Revalued Source of Phenolics. Plant Foods For Human Nutrition 75, 487–494.

Stern B., Heron C., Tellefsen T., Serpico M., (2008). New investigations into the Uluburun resin cargo. Journal of Archaeological Science 35, 2188–2203. https://doi.org/10.1016/j.jas.2008.02.004

Stika H.-P., (1999). Los macrorestosbotánicos de la Cova des Càrritx, in:Lull, V., Mico, R., Herrada, C.R., Risch, R. (Eds.), La Cova Des Càrritx y La Cova Des Mussol. ConsellInsular de Menorca, Barcelona, pp. 521–531.

Tamburini E., Sergi S., Serreli L., et al., (2017). Bioaugmentation-Assisted Phytostabilisation of abandoned mine sites in south west Sardinia. Bull Environ Contam Toxicol. 98(3):310–316.

THE PLANT LIST https://www.Plantlist.org (2022).

Thi Mai B., Girard M., de Lanfranchi F., (2014). Uses of the mastic tree (*Pistacia lentiscus* L.) in the West Mediterranean region: an example from Sardinia, Italy, in: Anderson, P., Peña-Chocarro, L., Heiss, A.G. (Eds.), Early Agricultural Remnants and Technical Heritage (EARTH): 8.000 Years of Resilience and Innovation. Oxbow Books, Oxford, pp. 293–298.

Tozanli S., (2018). Étude du marché algérien intérieur et import/export de la pistache, de la câpre, de l'amande amère et du safran. Rapport d'étude. PAP ENPARD Algérie. P. 75.

Trabelsi H., Aicha O., Cherif, Sakouhi F., Villeneuve P., Renaud J., Barouh N., Boukhchina S., Mayer P., (2012). Total lipid content, fatty acids and 4-desmethylsterols accumulation in developing fruit of *Pistacia lentiscus* L. growing wild in Tunisia. Food Chem. 131, 434.

Tzani, A., Doulamis, I.P., Konstantopoulos, P., Tzivras, D., Perrea, D.N. (2018) Chios mastic gum, the natural "tears" with lipid-lowering and anti-atherosclerotic properties: A new drug candidate? Hell. J. Atheroscler. 9, 1–4 Vavoula Evangelia (2017). In the personal blog (in greek) of Giorgos Manolashttps://orinosaxotis.blogspot.com/2017/08/17.html (as in 2 July 2021)

Whitehouse W.E., (1957). The pistachio nut—a new crop for the Western United States. Economic Botany 11, 281–321. https://doi.org/10.1007/BF02903809

Willcox G., (2011). Chapitre 24 - Témoignages d'une agriculture précoce à Shillourokambos. Etude du Secteur 1, in: Guilaine, J., Briois, F., Vigne, J.-D. (Eds.), Shillourokambos. Un établissement néolithique pré-céramique à Chypre. Les fouilles du Secteur 1. Errance, Ecole Française d'Athènes, Paris, pp. 599–605.

Willcox G., (2016). Les fruits au Proche-Orient avant la domestication des fruitiers, in: Ruas, M.-P. (Ed.), Des fruits d'ici et d'ailleurs. Regards sur l'histoire de quelques fruits consommés en Europe. Collection Histoire des savoirs. Omniscience, Paris, pp. 41–54.

Yang Z., Miyahara H., and Hatanaka A., (2011). Chronic administration of palmitoleic acid reduces insulin resistance and hepatic lipid accumulation in KK-Ay Mice with genetic type 2 diabetes. Lipids Health Dis 210:120.

Zapata Peña L., Peña-Chocarro L., Ibanez Estévez J.J., Gonzalez Urquijo J.E., (2003). Ethnoarchaeology in the Moroccan Jebala (Western Rif): wood and dung as fuel, in: Neumann, K., Butler, A., Kahlheber, S. (Eds.), Food, Fuel and Fields. Progress in African Archaeobotany, Africa Praehistorica. Heinrich-Barth-Institut, Köln, pp. 163–175.

Index

Table 1. Physico-chemical characterization of lentisk oil

Chemical character	Values	References
Acidity (mg/g of oil)	3.52 28.60 414.00	Brahmi et al., 2020 Kechidi et al., 2020 Karoui et al., 2020
Acidity (%)	6.17 14.41	Siano et al., 2020 Kechidi etal., 2020
Peroxide value (meq O2/kg)	2 5 6 1.92	Brahmi et al., 2020 Siano et al., 2020 Kechidi et al., 2020 Karoui et al., 2020
Density	1.02	Brahmi et al., 2020
Refractive index	1.468 1.463	Brahmi et al., 2020 Kechidi et al. 2020
K232	0.093 2.12	Brahmi et al., 2020 Karoui et al., 2020
K270	0.133 0.43	Brahmi et al., 2020 Karoui et al., 2020
Chlorophyll (ppm)	16.66 8.91	Brahmi et al., 2020 Karoui et al., 2020
Saponification value (mg of KOH/g of oil)	189.12 296.28	Karoui et al., 2020 Kechidi et al., 2020

Table 2. Mineral composition of lentisk oil

Minerals	mg/ 100 g of oil	References
Na	25.36	Dhifiet al., 2013
K	2.17	Dhifi et al., 2013
Ca	0.25	Dhifi et al., 2013
Mg	0.19	Dhifi et al., 2013
Fe	0.004	Dhifi et al., 2013
Cu	0.0001	Dhifi et al., 2013

Table 3. Fatty acid composition of lentisk oil

Fattyacid	%	References
Oleicacid	54.23	Mezni et al., 2012
	51.00	Dhifi et al., 2013
	46.30	May et al., 2018
	48.37	Chaabani et al., 2019
	44.20	Siano et al., 2020
	52.50	Ait Mohand et al., 2020
Palmiticacid	27.21	Mezni et al., 2012
	23.52	Dhifi et al., 2013
	22.55	Ait Mohand et al., 2020
	26.14	May et al., 2018
	23.96	Chaabani et al., 2019
	23.82	Siano et al., 2020
Linoleicacid	15.82	Mezni et al., 2012
	20.71	Dhifi et al., 2013
	22.14	Ait Mohand et al., 2020
	22.65	May et al., 2018
	23.31	Chaabani et al., 2019
	24.83	Siano et al., 2020
Palmitoleicacid	1.13	Mezni et al., 2012
	1.19	Dhifi et al., 2013
	0.38	Ait Mohand et al., 2020
	1.65	May et al., 2018
	1.34	Chaabani et al., 2019
	1.70	Siano et al., 2020
Stearicacid	1.58	Mezni et al., 2012
	1.41	Dhifi et al., 2013
	0.98	AitMohand et al., 2020
	0.76	May et al., 2018
	1.15	Chaabani et al., 2019
	1.36	Siano et al., 2020

Table 3. (Continued)

Fattyacid	%	References
Unsaturatedfattyacids	71.18	Mezni et al., 2012
	73.58	Dhifi et al., 2013
	76.47	AitMohand et al., 2020
	70.60	May et al., 2018
	74.88	Chaabani et al., 2019
	71.54	Siano et al., 2020
Saturatedfattyacids	28.79	Mezni et al., 2012
	26.42	Dhifiand et al., 2013
	23.53	AitMohand et al., 2020
	26.9	May et al., 2018
	25.12	Chaabani et al., 2019
	25.33	Siano et al., 2020

Table 4. Triglyceride composition of lentisk oil

Triglycerides	%	References
POO+SOL	27.58	Dhifi et al., 2013
	26.00	Mezni et al., 2020
	24.14	Ait Mohand et al., 2020
POL	21.50	Mezni et al., 2020
	17.39	Ait Mohand et al., 2020
	16.37	Dhifi et al., 2013
OOO	12.04	Dhifi et al., 2013
	13.38	Mezni et al., 2020
	15.74	Ait Mohand et al., 2020
PPO	8.51	Dhifi et al., 2013
	10.43	Mezniet al., 2020
	7.91	AitMohand et al., 2020
LOO	9.83	Dhifi et al., 2013
	9.66	Mezni et al., 2020
	-	Ait Mohand et al., 2020
PLL	7.97	Dhifi et al., 2013
	7.70	Mezni et al., 2020
	7.28	Ait Mohand et al., 2020
PLP	5.58	Dhifi et al., 2013
	7.03	Mezni et al., 2020
	3.96	Ait Mohand et al., 2020
OLL	5.67	Dhifi et al., 2013
	3.99	Mezni et al., 2020
	0.50	Ait Mohand et al., 2020
ALO	-	Dhifi et al., 2013
	1.56	Mezni et al., 2020
	-	Ait Mohand et al., 2020

Table 4. (Continued)

Triglycerides	%	References
SOO	-	Dhifi et al., 2013
	1.01	Mezni et al., 2020
	1.39	Ait Mohand et al., 2020
OLLn	-	Dhifi et al., 2013
	0.85	Mezniet al., 2020
	-	Ait Mohand et al., 2020
LLnP	-	Dhifi et al., 2013
	0.32	Mezniet al., 2020
	0.79	Ait Mohand et al., 2020
OOLn	-	Dhifi et al., 2013
	0.21	Mezni et al., 2020
	-	Ait Mohand et al., 2020
LLL	1.32	Dhifi et al., 2013
	0.17	Mezni et al., 2020
	2.64	Ait Mohand et al., 2020

Table 5. Sterol composition of lentisk oil

Sterols	(mg/kg)	References
Campesterol	68.20	Mezni et al., 2016
	88.45	Karoui et al., 2020
	42.00	Siano et al., 2020
	19.70	Brahmi et al., 2020
	996.00	Mezni et al., 2016
β-sitosterol	1217.43	Karoui et al., 2020
	750.00	Siano et al., 2020
	587.90	Brahmi et al., 2020
Cycloartenol	216	Mezni et al., 2016
	-	Karoui et al., 2020
	-	Siano et al., 2020
	-	Brahmi et al., 2020
24-methylene-cycloartenol	94.2	Mezni et al., 2016
	-	Karoui et al., 2020
	-	Siano et al., 2020
	-	Brahmi et al., 2020
Stigmasterol	54.10	Mezni et al., 2016
	31.05	Karoui et al., 2020
	16.00	Siano et al., 2020
	30.00	Brahmi et al., 2020
Cholesterol	-	Mezni et al., 2016
	9.93	Karoui et al., 2020
	-	Siano et al., 2020
	-	Brahmi et al., 2020

Table 6. Phenolic composition of the fixed oil of *Pistacia lentiscus*

Phenols	mg/kg of oil	References
Gallicacid	19.65 10.1	Mezni et al., 2018 Siano et al., 2020
Tyrosol	50.36 -	Mezni et al., 2018 Siano et al., 2020
protocatechuicacid	- 6	Mezni et al., 2018 Siano et al., 2020
p-hydroxybenzoicacid	- 73.8	Mezni et al., 2018 Siano et al., 2020
vanillicacid	812.91 11.8	Mezni et al., 2018 Siano et al., 2020
o-Coumaricacid	70.42 -	Mezni et al., 2018 Siano et al., 2020
Oleuropein-aglycon	91.29 -	Mezni et al., 2018 Siano et al., 2020
Caffeicacid	- 8	Mezni et al., 2018 Siano et al., 2020
Syringicacidisomer	- 1.6	Mezni et al., 2018 Siano et al., 2020
p-Coumaricacid	90.88 0.8	Mezni et al., 2018 Siano et al., 2020
Ferulicacid	54.5 0.1	Mezni et al., 2018 Siano et al., 2020
Rutin	- 1.6	Mezni et al., 2018 Siano et al., 2020

Table 6. (Continued)

Phenols	**mg/kg of oil**	**References**
Quercetin 3-O-glucoside	- 20.1	Mezni et al., 2018 Siano et al., 2020
Eryodictiol	- 15.7	Mezni et al., 2018 Siano et al., 2020
Quercetin	- 2.4	Mezni et al., 2018 Siano et al., 2020
Luteolin	207.64 1.8	Mezni et al., 2018 Siano et al., 2020
Naphtoresorcinol	29.76 -	Mezni et al., 2018 Siano et al., 2020
Salycilicacid	112.73 -	Mezni et al., 2018 Siano et al., 2020
Pinoresinol	482.18 -	Mezni et al., 2018 Siano et al., 2020
Apigenin	714.38 -	Mezni et al., 2018 Siano et al., 2020
Trans-4-hydroxy-3-methoxycinnamicacid	93.85 -	Mezni et al., 2018 Siano et al., 2020
4-hydroxyphenylacetic acid	39.75 -	Mezni et al., 2018 Siano et al., 2020
kaempferol	- 0.5	Meznietal., 2018 Sianoetal., 2020
Coumarin	300.87 -	Mezni et al., 2018 Siano et al., 2020

Table 6. (Continued)

Phenols	**mg/kg of oil**	**References**
Carnosicacid	126.03 -	Mezni et al., 2018 Siano et al., 2020
Transcinnamicacid	60.98 -	Mezni et al., 2018 Siano et al., 2020
Protocatechuicacid	30 -	Mezni et al., 2018 Siano et al., 2020
Total phenols	3358.08 339	Mezni et al., 2018 Siano et al., 2020

Table 7. Composition of tocopherols and carotenoids in the fixed oil of *Pistacia lentiscus*

Tocopherols	mg/kg of oil	References
α-tocopherol	7590 119.99 68.1	Dhifi et al., 2013 Mezni et al., 2020 Ghzaiel et al., 2021
ϒ-tocopherol	480 23.52	Dhifi et al., 2013 Mezni et al., 2020
β-tocopherol	470 -	Dhifi et al., 2013 Mezni et al., 2020
Total tocopherols	8111.13 143.51	Dhifi et al., 2013 Mezni et al., 2020
Carotenoids		
β-carotene	6.13	Mezni et al., 2020
Zeaxanthin	1.35	Mezni et al., 2020
lutein	2.07	Mezni et al., 2020
Total carotenoids	9.55 1480 2083.59	Mezni et al., 2020 Brahmi et al., 2020 Ghzaiel et al., 2021

Project team (Closing meeting of the project – Tabarka / Tunisia)

Co-funded by the
Erasmus+ Programme
of the European Union

ISBN: 978-2-494188-00-6