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Lavendula Angustifolia, Rosmarinus Officinalis, Thymus Serpyllum and *Origanum rotundifolium*: Exploring natural solutions for inflammation and blood sugar management

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Abstract

The *Lamiaceae* family, including common herbs like rosemary and mint, is being investigated for its potential health benefits. In addition to numerous health benefits, research is looking into these plants' anti-inflammatory qualities and potential impacts on blood sugar regulation. More specifically, the Greek endemic Lamiaceae plants are proven to be of great importance, regarding their bioactive compounds and the antioxidant,

antidiabetic, and anti-inflammatory properties they have. Researchers are interested in understanding how *Lamiaceae* plant compounds might work in the body. Besides, Antioxidants have an increasingly important function in reducing tissue damage and cytotoxicity caused by hydrogen peroxide and oxygen radicals in a variety of human disorders. This knowledge could lead to the development of natural approaches for managing inflammation and potentially even diabetes. These plant-based options may offer a milder alternative to some conventional medications. By supporting the body's natural regulatory systems, Lamiaceae plants could contribute to a more holistic approach to well-being. This study's objective was to review the literature on the anti-inflammatory, antidiabetic, and antioxidant properties of the *Lamiaceae* species *Lavendula Angustifolia*, *Rosmarinus Officinalis*, *Thymus Serpyllum*, and *Origanum rotundifolium*.

Keywords: *Lamiaceae* Family, anti-diabetic activity, Antioxidant potential, Anti-inflammatory properties

Introduction

1. The *Lamiaceae* family plants

The *Lamiaceae* belongs to plants that bloom. An abundance of aromatic plants may be found throughout, including common culinary herbs like basil, mint, rosemary, oregano, thyme, and lavender. Certain species are trees, bushes, or infrequently, vines. Since they can be easily grown by stem cuttings, many members of the family are commonly cultivated for their aromatic properties as well as their ease of cultivation [Solomou et al.,2021].

The Lamiaceae family, also known as Labiatae, boasts an impressive diversity with over 7,000 species across 250 genera. Some of the largest genera include Salvia, Scutellaria, Stachys, and Thymus. These plants are found throughout the world (cosmopolitan distribution) and thrive in various ecosystems.

A hallmark of Lamiaceae is their aromatic nature. Most species produce a complex blend of bioactive compounds, contributing to their potent biological activity in both *in-vitro* and *in-vivo*. These secondary metabolites hold promise for their biological properties. Beyond their biological potential, Lamiaceae plants offer tremendous value across various industries. From food and cosmetics to flavoring, fragrance, and pharmaceuticals, this family plays a vital role. Their wide range of applications makes them widely cultivated and a crucial source of functional foods. This immense value has spurred extensive research on Lamiaceae species, delving into their biology, ecology, and diverse applications.

1.1 General morphological features

Plants are herbaceous or semi-shrubby. The stem usually has a characteristic square cross-section. The leaves are mostly simple, opposite and cruciform arranged on stem and without paraphiles. The plants are covered with glands or glandular hairs and have strong aromatic odor due to the existence of essential oils, and because of presence of these substances, the plants of the family have a very large commercial value, since they are used as aromatic and medicinal plants [Solomou et al.,2021].

The flowers are strongly zygomorphic, with a two-lipped corolla, which grow in large numbers together in the axils of the leaves by monochasia or dichasia, which form vertebrae or in extreme pits. The flowers of plants in the family are essentially hermaphrodite, but in several species, e.g., of the genera Mentha, Nepeta, Zizyphora, Thymus up to 50% of plants may have flowers where the male parts (stamens) are subsessile and sterile and the flowers are functional as females. The calyx is sessile, 5-parted, two-lipped and surrounds the oblong tube of the bilabiate, 5-parted rim. Of the 5 petals of the corolla, usually 3 form the lower lip and 2 the upper. Less often the 4 forms the lower and 1 upper or all together the lower, while the upper is completely missing (Teucrium) and then the stamens are completely uncovered. Stamens are 4 (the median missing), are pairwise unequal (bivalent) and adjoin the wreath(partners). In some genera (Salvia, Rosmarinus) there is only the lower pair of short stamens or at least this alone is fertile. The ovary is epiphytic, and consists of 2 carpels, but it is 4-lobed. It is divided, from flowering still, into four, deep lobes with the help pseudo-diaphragm. These four parts of the ovary, containing from a spermoblast, swell spherically and turn into a schizocarp, which splits into four carpels (monosperm carya), rarely forming small drupes (Prassium). The stipe is located at the base of the carpels and between them (gynobasal column) [Solomou et al.,2021].

Many species including: Rosmarinus spp., Micromeria spp., Nepeta spp., Teucrium spp., Scutellaria spp., Satureja spp., Salvia spp., Thymus spp., Origanum spp., Sideritis spp., Mentha spp., Lavandula spp., Stachys spp., Ocimum spp are known to exist.

2. Diabetes Mellitus

Diabetes is a long-term metabolic illness marked by high blood glucose levels. Over time, diabetes can cause significant harm to the heart, blood vessels, kidneys, eyes, nerves, and heart. Approximately 422 million individuals globally suffer from diabetes, with the majority residing in low- and middle-income nations. The disease is also responsible for 1.5 million deaths annually. Over the past few decades, there has been a steady increase in the prevalence of diabetes. [https://www.who.int/health-topics/diabetes].

The illness comes in two varieties. The most common is type 2 diabetes, which develops when the body becomes resistant to insulin and mostly affects adults. Type 2 diabetes has been far more common over the last three decades in all nations, regardless of wealth. Insulin-dependent diabetes, or type 1 diabetes, is a chronic condition in which the pancreas produces little to no insulin on its own [Trapali,2023], [Trapali,2022], [Trapali,2021], [Bourkoula et al.,2021]. The human insulin (INS) gene codes for the peptide hormone known as insulin, which is produced by the beta cells of the pancreatic islets. By encouraging the absorption of glucose from the blood into the liver, fat, and skeletal muscle cells, it regulates the metabolism of proteins, lipids, and carbs. Diabetes mellitus is brought on by reduced or absent insulin action. Insulin synthesis and blood secretion are impaired in type 1 diabetes mellitus due to the autoimmune response that destroys beta cells. The loss of beta cells in diabetes mellitus type 2 is not the result of an autoimmune process and is less apparent than in type 1. Although the exact cause of type 2 diabetes is unknown, peripheral tissue insulin resistance, a decline in islet beta cell number, and a drop in islet beta-cell secretory activity are all factors (Fig.1).

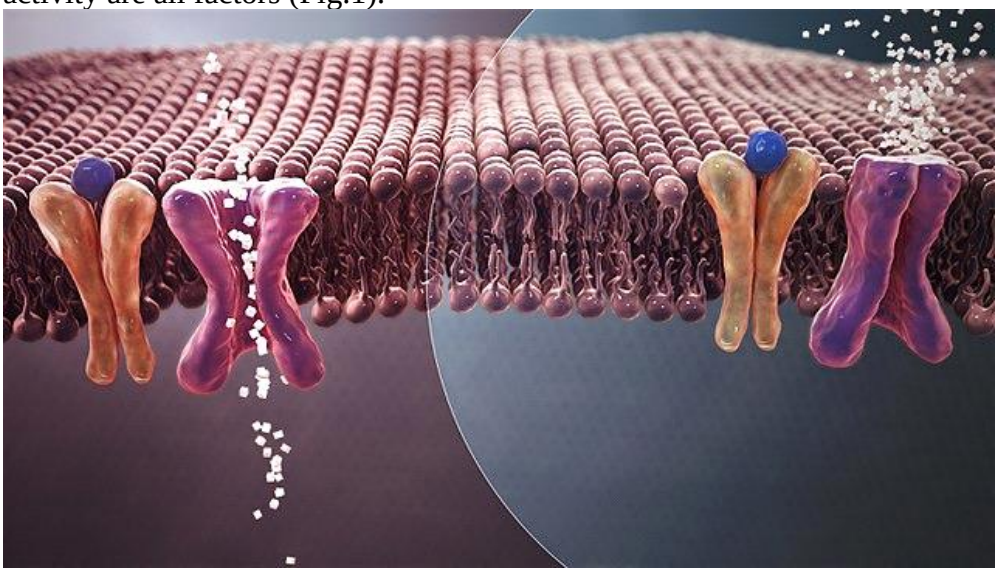

Figure 1: Mechanism of normal Blood Sugar (white crystals) uptake (Left) Vs. insulin resistance in Type 2 Diabetes (Right). https://commons.wikimedia.org/w/index.php?search=DIABETES+MELLITUS&title=Special:MediaSearch&go=Go&type=image

3. Inflammation Process

As a defensive mechanism of the immune system, inflammation is a complex reaction of body tissues to harmful stimuli including infections, damaged cells, or irritants. Inflammation serves to remove the initial source

of cell damage, remove necrotic cells and tissues that have been harmed by the first insult, and start the healing process for injured tissue [6]. Acute or chronic inflammation can occur. Acute inflammation is the body's initial response to damaging stimuli and is caused by an increase in the circulation's flow of plasma and leukocytes, particularly granulocytes, into the injured tissues [Ma et al., 2016]. A series of biochemical events involving the immune system, the local vascular system, and other cells in the injured tissue cause and promote the inflammatory response. The simultaneous inflammatory process-induced tissue death and healing is what characterizes chronic inflammation. Additionally, it consistently alters the types of cells, including mononuclear cells, that are present at the site of inflammation [Ma et al., 2016]. Moreover, Type 1 and Type 2 inflammation have been identified according to the helper T cell (Th1 and Th2) and cytokine types involved (Fig. 2).

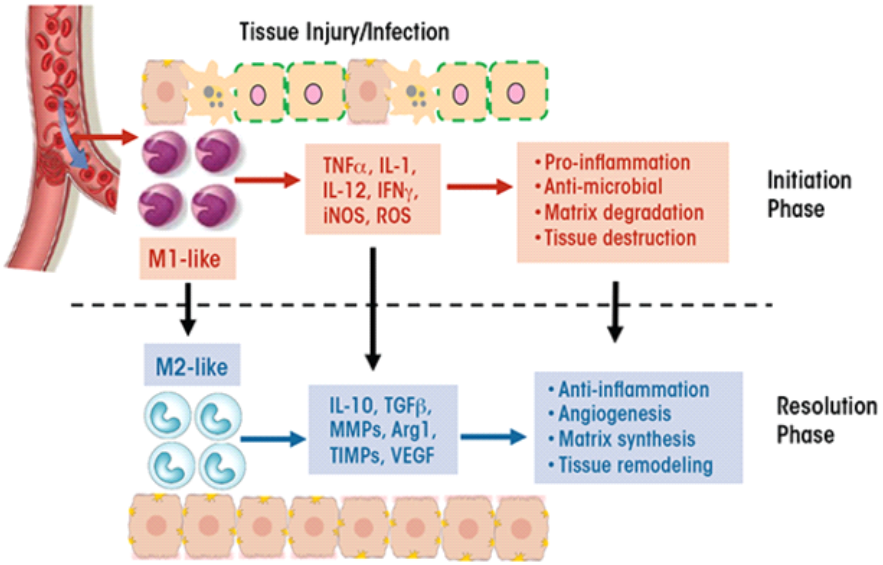

Figure 2: Diagram illustrating the role of macrophage plasticity in tissue damage. TNFα, interleukin (IL)-1 and -12, interferon γ (IFNγ), an enzyme that produces nitric oxide (iNOS), reactive oxygen species (ROS), and other pro-inflammatory and stress mediators are produced by macrophages that are recruited to the site of an injury or infection during the initiation phase of the inflammatory reaction. Changing their phenotype from M1 to M2, during the resolution phase of the injury, they appear anti-inflammatory effects and promote blood-vessel formation, matrix synthesis, and tissue remodeling.
https://commons.wikimedia.org/w/index.php?search=cytokines+in+inflammation&title=Special:MediaSearch&go=Go&type=image

4. Oxidation Process

The body goes through a natural and essential process called oxidation. On the other side, oxidative stress results from an imbalance between antioxidant and free radical activity. When free radicals are in good

working order, they can aid in the defense against bacteria that might cause diseases. When the body has more free radicals than antioxidants can neutralize, the free radicals can begin causing damage to proteins, DNA, and fatty tissues. This can eventually result in a wide range of disorders (Fig.3) [Pizzino et al.,2018]. It's debatable whether or not antioxidants can prevent certain diseases. Due to the pro-oxidant and antioxidant effects of high beta-carotene when combined with high oxygen tension from smoking, high beta-carotene doses were associated with an increased risk of lung cancer in smokers, a high-risk population. The usage of vitamin E appears to lower the risk of heart disease in less high-risk individuals. But while eating foods high in vitamin E may lower middle-aged and older men's and women's risk of coronary heart disease, taking vitamin E supplements also seems to increase the risk of heart failure, hemorrhagic stroke, and overall mortality. For this reason, the American Heart Association advises against using vitamin E supplements to prevent cardiovascular disease and instead suggests consuming foods high in antioxidant vitamins and other minerals. There is conflicting data on vitamin E supplementation in various illnesses, such Alzheimer's. Epidemiological research can yield different results than artificial tests utilizing isolated chemicals since dietary sources contain a larger spectrum of carotenoids and vitamin E tocopherols and tocotrienols from whole meals [Trapali,2023], [Trapali,2021], [Ma et al.,2016].

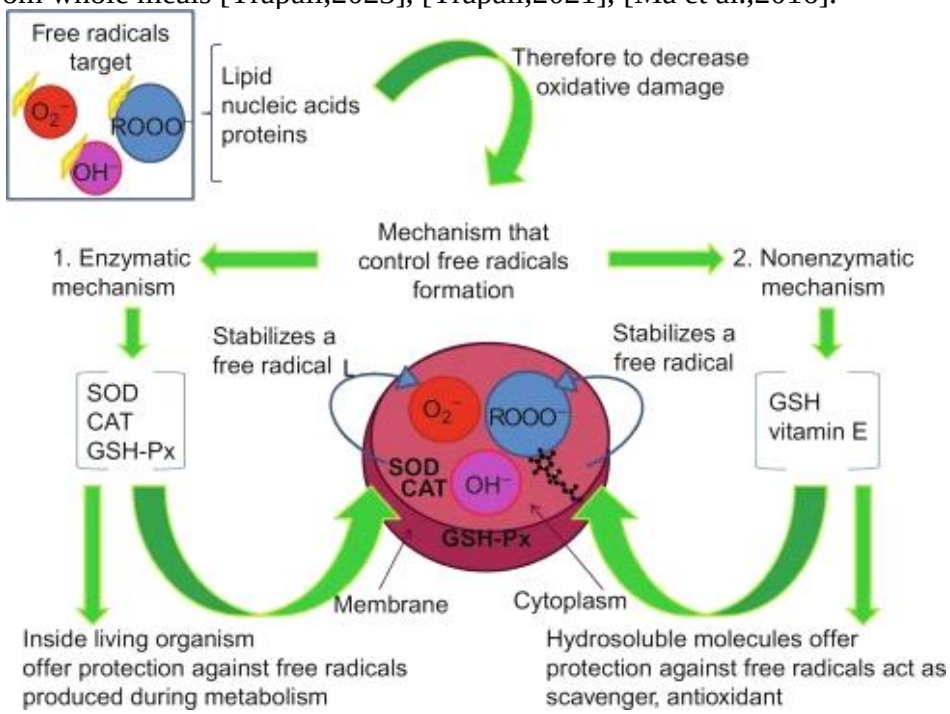

Figure 3: Oxidative stress process
https://www.sciencedirect.com/topics/neuroscience/oxidative-stress

Objective

The study's objective was to compile information from the literature regarding the anti-inflammatory, antidiabetic, and antioxidant properties of *Origanum rotundifolium*, *Rosmarinus officinalis*, *Lavendula angustifolia*, and *Thymus serpyllum*.

Results

1. Lavendula Angustifolia

Known by several names, including medicinal lavender, and common lavender. This plant is a perennial evergreen one (*Lavandula vera*, *Lavandula angustifolia* and, *Lavandula officinalis*) (Fig.4).

Fig 4. Lavender (Lavendula Angustifolia). https://commons.wikimedia.org/w/index.php?search=Lavender+%28Lavendula+Angustifolia%29+&title=Special:MediaSearch&go=Go&type=image

The latin verbs "*lavo*" and "*lavare*," which meaning is "wash" or "clean" are the source of the term lavender. Common names for lavender and its related substances include: English lavender, *Lavandula dentate*, *Lavandula dhofarensis*, *Lavandula burnamii etc*, limonene, perillyl alcohol, pink lavender, true lavender, and white lavender [8]. For a very long time, lavender has been used as a bath additive, formulating soaps and perfumes, food additives and as remedy for several diseases. Lavender species contain more than 100 molecules including essential oil, anthocyanins, phytosterols, sugars, minerals, tannins and coumarins [Letsiou et al.,2023], [Letsiou et al.,2023], [Tebb et al., 2023], [Habán et al.,2023]. Significant antioxidant potential is present in lavender, though the exact potential varies greatly among species. In the food industry, safe-to-eat antioxidants are essential because oxidative lipid breakdown lowers food quality and flavor. This

disintegration could be the consequence of heating techniques like microwave heating, or storing. By adding spike lavender essential oil (EO), one can stabilize the lipids, stop the formation of unwanted secondary oxidation products, and preserve the vitamin content [Hajhashemi et al.,2023].

A protective reaction to a variety of chemical, physical, and biological agents is inflammation. Every one of these things sets off a defensive response in the body. Acute and chronic are the two types, and each has a distinct set of effects. The immune system's overactive response, which releases inflammatory cells like neutrophils, lymphocytes, and macrophages, is linked to inflammation. Inflammatory mediator expression is linked to the immune system's critical function. Furthermore, a number of animal experimental models are used to test anti-inflammatory activity, including the paw edema in mice and rats caused by carrageenan, the mice formalin test, the mice ear edema caused by croton oil, the mice ear edema caused by TPA, and the LPS-stimulated cell line [Dobros et al.,2023]. Studies have shown that the anti-inflammatory properties of lavender stem from the existence of non-volatile terpenoids, polyphenols, and components of essential oils. Numerous studies have demonstrated that lavender oil inhibits important inflammation-related enzymes, including cyclooxygenase (COX), nitric oxide synthase (iNOS), and lipoxygenase (LOX) [Dobros et al.,2023].

Lavender angustifolia is used for many traditional medical and cosmetic products. Lavender has been recognized as having healing potential in the treatment of type 2 diabetes, and tests are currently being undertaken on it. The possible application of methanol extracts in the management of diabetic dyslipidemia has been studied. The results demonstrated that L. angustifolia decreased the in vitro activity of hormone-sensitive lipase (HSL) and pancreatic lipase (PL). The presence of gallic acid (10.1 and 14.5 g/mL IC50s for PL and HSL, respectively) and rosmarinic acid (125.2 and 51.5 g/mL IC50s for PL and HSL, respectively) may be linked to these inhibitory effects. [Batiha et al.,2023], Issa et al.,2011].

2. Rosmarinus Officinalis

Known by its common name, rosemary, *Rosmarinus officinalis* (RO) L. belongs to the *Lamiaceae* family. In addition to its culinary applications owing to its distinct scent, this plant is extensively utilized by native communities in areas where it grows naturally. RO is a woody, perennial herb with flowers that can be white, pink, purple, or blue. Its leaves are evergreen and fragrant (Fig.5). This is a strong herb from the Mediterranean region. The Latin words "ros" (dew) and "marinus" (sea) are the source of the phrase "dew of the sea". Forms vary in height from 1.5 m to 2 m, with

upright forms rarely reaching this height. The evergreen leaves measure 2-4 cm in length and 2.5 mm in width. They are green on top and white underneath, with dense, short, wooly hair [Akshay et al.,2019].

Fig 5. Rosmarinus officinalis
https://commons.wikimedia.org/w/index.php?search=Rosmarinus+officinalis&title=Special:MediaSearch&go=Go&type=image

Due to the chemical compounds that make up its composition are what give it its antioxidant qualities. Historically, studies have demonstrated the potential benefits of rosemary oil in the treatment or management of a wide range of illnesses, including diabetes mellitus and inflammatory diseases.

It should come as no surprise that Rosmarinus officinalis (RO) has been identified in numerous studies as a potent anti-diabetic agent. RO antioxidant qualities carry out a number of anti-diabetic and anti-hyperglycemic actions. In one study, rosemary extract lowered the blood glucose levels of normoglycemic, hyperglycemic, and diabetic rabbits [Bakirel et al.,2008], [Abu-Al-Basai et al.2010]. The extract also increased insulin secretion by promoting antioxidant enzyme activation and lipid peroxidation inhibition [Bakirel et al.,2008] [. Additionally, it was discovered that rosemary relieved delayed wound healing, a significant consequence of diabetes. Following the administration of rosemary, the body's improved antioxidant status is responsible for these anti-diabetic effects [Khalil et al., 2012], [de Oliveira et al.,2019].

Moreover, several studies demonstrated strong anti-inflammatory mechanisms exhibited by Rosmarinus officinalis. Leukocyte migration was found to be significantly inhibited in vivo by rosemary essential oil and extract. An anti-inflammatory response was produced as a result of the decrease in leukocytes at the site of inflammation. Additionally, pro-inflammatory compounds like nitric oxide and genes linked to inflammation

were inhibited by rosemary extract [Mengoni et al., 2011], [Benincá et al.,2011], [Gaya et al.,2013].

3. Thymus Serpyllum

Thymus is a genus that belongs to the *Lamiaceae* family. It comprises approximately 250 taxa worldwide, comprising 214 species and 36 sub-species. The Thymus genus originated in the Mediterranean area, especially in the Iberian Peninsula and North-West Africa (Fig.6).

From there, it extended to Asia, Europe, Greenland, North America, and Abyssinia. Because of its delicious flavor, healthful qualities, and medicinal qualities, plants in the Thymus genus are widely employed in the food, cosmetic, perfume, and pharmaceutical industries. Some species, such T. pulegioides L. (big thyme), T. serpyllum L. (wild thyme), and T. zygis L. (Spain thyme), are important commercial types grown around the world.

Fig 6. Thymus Serpyllum
https://commons.wikimedia.org/w/index.php?search=Thymus+Serpyllum.+&title=Special:MediaSearch&go=Go&type=image

Plants in the Thymus genus have extracts and characteristic monomer components that have been shown to be effective natural antioxidants that reduce oxidative stress, especially in the liver and heart. *Thymus Serpillum* (TS) essential oil (EO) showed the highest radical scavenging activity (EC50:0.94 g/mL). followed by oils of *Thymus algeiensis* (TA) (EC50: 1.64 g/mL) and *Thymus vulgaris* (TV) (EC50: 4.80 g/mL) which was confirmed by previous studies regarding the EOs of this plant [Salaria et al.,2023].

TS ability to inhibit diabetes mellitus was studied previously and the results showed that it targets 91 genes and contains 21 constituents as active ingredients, with scutellarein (producing the lowest concentration of Ca^{2+}) acting as the hub gene and most active ingredient, respectively. The main

mechanism of TS against diabetes is the inactivation of the advanced glycation end products (AGE) ()- Receptor for AGE (RAGE) signaling (oxidative stress induced) pathway, which may help to prevent diabetes-related comorbidities and disease progression. The mechanisms of TS against diabetes have been linked to 26 signaling pathways [Alamgeer et al., 2014].

4. Origanum rotundifolium

Another member of the Lamiaceae family is oregano. Since this plant grows at heights of 400–1800 m and in sunny locations, its name, Origanum, originates from the Greek name ὁρίγνον (origanon), which in turn comes from the words Ɔρος (oros = mountain) and γάνος (ganos = brightness). (Fig.7). Greece and Turkey are home to the most of Origanum species, which are found in the Mediterranean. Certain species of Origanum are annual or perennial herbs with small, round, oval-shaped leaves that can have toothed edges and pointed, obtuse tips. The flowers are grouped in spikes and may be white, pink, or purple in color [Picos-Salas et al.,2021].

Fig 7. Origanum rotundifolium
https://commons.wikimedia.org/w/index.php?search=Origanum+&title=Special:MediaSearch&go=Go&type=image

Reversed Phase, High pressure Liguid Diode Array chromatography Electrospray-Mass Ionization (RP-HPLC-DAD-ESI/MS) has been used to identify the flavone components of an aqueous infusion made from dried O. dictaminus herb. The extract contained a number of flavones such as: xanthomicrol (5,4′-dihidroxy-6,7,8-trimethoxyflavone), luteolin-7-O-diglucuronide, apigenin-7-O-triglucuronide, luteolin-7-O-rutinoside, and 6,8-di-C-hexosylapigenin [9]. The most often found flavones in the various polyphenolic extracts from Origanum species, according to these studies, are derivatives of luteolin and apigenin, which have demonstrated antioxidant, anti-cancer, and anti-inflammatory effects [Picos-Salas et al.,2021], [Maiettaet al., 2018]. Other flavones, like didymin that was extracted from

O. vulgare, showed biological characteristics in male mice, including anti-inflammatory activity and a decrease in the hepatic damage caused by CCl_4. Aras and associates used the DPPH, FRAP, and CUPRAC techniques to assess the antioxidant activity of O. acutidens leaves. The aqueous extract of this species exhibited effective DPPH radical scavenging action, as substantiated by the obtained data. The essential oil of O. rotundifolium has also been shown to have antioxidant potential; its activity was assessed by scavenging ABTS, H_2O_2, and superoxide radical.

Furthermore, research on plants in the Lamiaceae family has linked the anti-diabetic qualities of Origanum essential oil to its primary constituents, carvacrol and thymol. This suggests that the mechanism of action of EOs may differ based on their composition [Leyva-Lopez et al.,2017], [Leyva-López et al., 2017], [Aras et al., 2017].

Conclusion

This study emphasizes the possible health advantages of numerous Lamiaceae plants, such as oregano, thyme, lavender, and rosemary. Plants of the Lamiaceae family have a lot of antioxidant-producing chemicals, these antioxidants can aid in lowering the body's oxidative stress, which has been connected to a number of chronic illnesses. These plants may aid in better insulin activity and blood sugar regulation. Plants of the *Lamiaceae* family may have anti-inflammatory qualities that could lessen the symptoms of inflammatory diseases, which can be found in functional meals, which may provide a natural way to manage inflammation. The *Lamiaceae* family provide a natural source of substances that may be used in functional foods. These functional meals have the potential to improve general health and help manage chronic illnesses. As a perspective we suggest the following food applications: (i) Scentful teas steeped with dried lavender, rosemary, thyme, or oregano leaves may offer a daily serving of anti-inflammatory and antioxidant properties. Those looking for all-natural strategies to control their blood sugar levels or inflammation may find these teas especially enticing (ii) Yogurt Functional with Extracts of *Lamiaceae,* a concentrated extract of *Lamiaceae* plants added to yogurt may provide a probiotic foundation that is good for the gut as well as an anti-inflammatory and maybe anti-diabetic effect. This might be a delicious and practical method to include these health advantages in the diet. (iii) Fortified Spreads and Dips, for those who are more susceptible to chronic illnesses, this use may be especially helpful in boosting dietary consumption of these plant-based antioxidants. (iv) Functional Snack Bars with *Lamiaceae* Seeds: Adding *Lamiaceae* seeds, such as chia seeds infused with rosemary extract, to snack bars made with whole grains, nuts, and seeds like flax or chia could improve them even more. These bars might offer a convenient and wholesome supply of fiber,

good fats, and possibly even anti-inflammatory and anti-diabetic properties. (v) Cooking oils such as olive oil that are enhanced with *Lamiaceae* herbs like thyme or rosemary could be added during the extraction process. When used as a salad dressing or in cooking, this could give the oil a mild flavor and possibly health advantages. The precise mechanisms of action of these plants and the best doses for use in functional food applications require more investigation.To confirm the effectiveness and safety of functional foods based on the Lamiaceae family, clinical trials are required. Creation of shelf-stable, tasty functional meals with extracts from the Lamiaceae plant. Studies conducted on Lamiaceae plants ought to investigate possible synergistic relationships among various bioactive constituents.

It is imperative to look at how functional foods based on the *Lamiaceae* family interact with prescription drugs. These plants have the power to transform the functional food market and advance health by overcoming these obstacles and conducting additional research.

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References:

1. Solomou, A.D., Giannoulis, K.D., Skoufogianni, E., Kakara, S., Charvalas, G., Kollimenakis, A. (2021). Ecological Value, Cultivation and Utilization of Important Medicinal Plants (Sage, Oregano and Sideritis) in Greece. In: Ekiert, H.M., Ramawat, K.G., Arora, J. (eds) Medicinal Plants. Sustainable Development and Biodiversity 28. (2021).
   https://www.who.int/health-topics/diabetes
2. Trapali M. Antioxidant Activity in Patients with Type II Diabetes. Review of Clinical Pharmacology and Pharmacokinetics, 36(1):6 (2022)
3. Trapali M., Papadopoulou A. Genetic polymorphisms possibly implicated in Diabetes Mellitus. Review of Clinical Pharmacology and Pharmacokinetics, 37(1): 1-6 (2023)
4. Trapali M. Oxidic degradation of lipids in patients with type II diabetes. Review of Clinical Pharmacology and Pharmacokinetics, 35(2): 4 (2021)

5. Bourkoula A., Konsta E., Papadopoulou A., Trapali M. Lipidic classes involved in Diabetes mellitus. Review Nov Res Sci. NRS. 000685 (2021) DOI: 10.31031/NRS.2021.08.000685
6. Ma B, Whiteford JR, Nourshargh S, Woodfin A. Underlying chronic inflammation alters the profile and mechanisms of acute neutrophil recruitment. J Pathol. 240(3):291-303 (2016). doi: 10.1002/path.4776.
7. Pizzino G, Irrera N, Cucinotta M, Pallio G, Mannino F, Arcoraci V, Squadrito F, Altavilla D, Bitto A. Oxidative Stress: Harms and Benefits for Human Health. Oxid Med Cell Longev. 8416763 (2017). doi: 10.1155/2017/8416763.
8. Letsiou, S., Trapali, M., Tebbi, S.O., Benaida-Debbache, N.A simple and robust LC-ESI single quadrupole MS-based method to analyze polyphenols in plant extracts using deep eutectic solvents. MethodsX. 11: 102303 (2023)
9. Letsiou, S., Trapali, M., Vougiouklaki, D., Tsakni A. Antonopoulos, D., Houhoula, D. Antioxidant Profile of Origanum dictamnus L. exhibits Antiaging Properties against UVA Irradiation Cosmetics. 10(5), 124 (2023) https://doi.org/10.3390/cosmetics10050124
10. Tebbi, S.O., Trapali, M., Letsiou, S. Exploring the Anti-Diabetic, Antioxidant and Anti-Microbial Properties of Clematis flammula L. Leaves and Pistacia lentiscus L. Fruits Using Choline Chloride-Based Deep Eutectic Solvent Waste and Biomass Valorization, (2023) https://doi.org/10.1007/s12649-023-02360-9
11. Habán M., Korczyk-Szabó J., Certekov S., Ražná K. Lavandula Species, Their Bioactive Phytochemicals, and Their Biosynthetic Regulation. Int. J. Mol. Sci. 24: 8831 (2023). https://doi.org/ 10.3390/ijms24108831
12. Hajhashemi V, Ghannadi A, Sharif B. Anti-inflammatory and analgesic properties of the leaf extracts and essential oil of Lavandula angustifolia Mill. J Ethnopharmacol. 89(1):67-71(2023). doi: 10.1016/s0378-8741(03)00234-4.
13. Dobros N., Zawada KD., Paradowska, K., Phytochemical profiling, antioxidant and anti-inflammatory activity of plants belonging to the Lavandula genus. Molecules. 28(1),256 (2023). https://doi.org/10.3390/molecules28010256
14. Batiha, GE., Teibo, J.O., Wasef, L., Shaeen, H.M., Akomolafe, A.P., Teibo, T.K.A., Al-Kuraishy, H.M., Al-Garbeeb. A., Alexiou, A., Papadakis, M. A review of the bioactive components and pharmagological properties of *Lavandula* species. https://doi.org/10.1007/s00210-023-02392-x. (2023)

15. Issa A., Mohammad M., Hudaib M., Bustanji Y. A potential role of Lavandula angustifolia in the management of diabetic dyslipidemia. Journal of Medicinal Plants Research 5(16):3876-3882(2011)
16. Akshay K., Swathi K., Bakshi V., Boggula N. Rosmarinus officinalis L. an update review of its phytochemistry and biological activity. JDDT. 9(1): 323-330 (2019). http://dx.doi.org/10.22270/jddt.v9i1.2218.
17. Bakirel T, Bakirel U, Keleş OU, Ülgen SG, Yardibi H. In vivo assessment of antidiabetic and antioxidant activities of rosemary (Rosmarinus officinalis) in alloxan-diabetic rabbits. Journal of Ethnopharmacology. 116(1):64-73 (2008)
18. Abu-Al-Basal MA. Healing potential of Rosmarinus officinalis L. on full-thickness excision cutaneous wounds in alloxan- diabetic BALB/c mice. Journal of Ethnopharmacology. 131(2):443-450 (2010).
19. Khalil OA, Ramadan KS, Danial EN, Alnahdi HS, Ayaz NO. Antidiabetic activity of Rosmarinus officinalis and its relationship with the antioxidant property. African Journal of Pharmacy and Pharmacology. 6(14):1031-1036 (2012).
20. de Oliveira JR, Camargo SEA, de Oliveira LD. Rosmarinus officinalis L. (rosemary) as therapeutic and prophylactic agent J Biomed Sci. 9;26(1):5 (2019). doi: 10.1186/s12929-019-0499-8. PMID: 30621719; PMCID: PMC6325740
21. Mengoni ES, Vichera G, Rigano LA, Rodriguez-Puebla ML. Suppression of COX-2, IL-1β and TNF-α expression and leukocyte infiltration in inflamed skin by bioactive compounds from Rosmarinus officinalis L. Fitoterapia. 82(3):414-421 (2011).
22. Benincá JP, Dalmarco JB, Pizzolatti MG, Fröde TS. Analysis of the anti-inflammatory properties of Rosmarinus officinalis L. in mice. Food Chemistry. 124:468-475 (2011).
23. 24.Gaya M, Repetto V, Toneatto J, Anesini C, Piwien -Pilipuk G. Antiadipogenic effect of carnosic acid, a natural compound present in Rosmarinus officinalis, is exerted through the C/EBPs and PPARγ pathways at the onset of the differentiation program. Biochimica et Biophysica Acta. 1830(6):3796- 3806 (2013)
24. Salaria D, Rolta R, Lal UR, Dev K, Kumar V.A comprehensive review on traditional applications, phytochemistry, pharmacology, and toxicology of Thymus serpyllum. Indian J Pharmacol. 55(6):385-394 (2023). doi: 10.4103/ijp.ijp_220_22. PMID: 38174535; PMCID: PMC10821696
25. Alamgeer, M. "Evaluation of Hypoglycemic activity of Thymus serpyllum Linn in glucose treated mice." International Journal of

Basic Medical Sciences and Pharmacy (IJBMSP) 3(2) (2014)

26. Picos-Salas M., Heredia J., Leyva-López N., Ambriz-Pérez D., Gutiérrez-Grijalva Gutiérrez- Grijalva E. Extraction Processes Affect the Composition and Bioavailability of Flavones from Lamiaceae Plants: A Comprehensive Review. Processes 9:1675 (2021). https://doi.org/ 10.3390/pr9091675
27. Maietta M., Colombo R., Corana F., Papetti A. Cretan tea (Origanum dictamnus L.) as a functional beverage: An investigation on antiglycative and carbonyl trapping activities. Food Funct. 9: 1545–1556 (2018).
28. Leyva-Lopez N., Gutiérrez-Grijalva E.P., Vazquez-Olivo G., Heredia J.B. Essential oils of oregano: Biological activity beyond their antimicrobial properties. Molecules. 22(6), 989 (2017). https://doi.org/10.3390/molecules22060989.
29. Leyva-López N, Gutiérrez-Grijalva EP, Vazquez-Olivo G, Heredia JB. Essential Oils of Oregano: Biological Activity beyond Their Antimicrobial Properties. Molecules. 14; 22(6):989 (2017). doi: 10.3390/molecules22060989. PMID: 28613267; PMCID: PMC6152729
30. Aras A., Silinsin M., Bingol, MN., Bursal E., Identification of bioactive polyphenolic compounds and assessment of antioxidant activity of Origanum acutidens. ILNS. 66:1-8 (2017).