8(1): 80-92, 2025

Journal of Food and Bioprocess Engineering

Journal homepage: https://jfabe.ut.ac.ir

Review article

A comparative analysis of anti-inflammatory effects of essential oils and extracts from 37 species of *Lamiaceae* family on inflammatory bowel disease (IBD)

Nastaran Kazemivash [a], Parisa Ziarati [b, *]

[a] *Department of Pharmacognosy, Faculty of Pharmacy, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran*
[b] *Halal Research Center of IRI, Food and Drug Administration, Ministry of Health and Medical Education, Tehran, Iran*

A B S T R A C T

Inflammatory bowel disease (IBD) is a chronic, idiopathic, and irreversible disorder affecting the intestines, commonly presenting as Crohn's disease (CD) and ulcerative colitis (UC). Although the precise cause remains unknown, substantial evidence points to genetic predisposition, environmental factors, nutritional influences, and immune system dysfunction as significant contributors to disease development and progression. Furthermore, research highlights the impact of oxidative stress, along with viral, microbial, and parasitic infections, in aggravating IBD symptoms. While no definitive cure exists, various therapeutic approaches ranging from traditional medications to innovative biologic treatments are employed to manage and reduce symptoms. Over recent decades, standard options such as aminosalicylates, corticosteroids, and immunomodulators have been widely used, with biologic agents like infliximab offering additional benefits for some patients. Nonetheless, the limitations of these therapies emphasize the pressing need for more effective and alternative strategies. In this regard, ethnomedicinal studies have increasingly investigated plant-based remedies for inflammatory conditions, with notable attention given to the *Lamiaceae* family due to its strong anti-inflammatory properties. This review explores the therapeutic potential of approximately 37 *Lamiaceae* species, assessing their role in IBD management and their viability as complementary or alternative options to existing treatments.

Keywords: Inflammatory bowel disease (IBD); Crohn's disease (CD); Essential oils; Extracts; Treatment; *Lamiaceae* family

Received 18 Oct 2025; Received in revised form 24 Oct 2025; Accepted 26 Oct 2025

1. Introduction

Crohn's disease (CD) and ulcerative colitis (UC) are the two main clinical forms of chronic, relapsing inflammatory bowel disease (IBD) (Hu et al., 2022). CD can affect any part of the gastrointestinal tract, from the mouth to the anus, and is characterized by transmural inflammation, which leads to thickening of the intestinal wall. In contrast, UC is confined to the rectum and the mucosal layers of the colon, presenting as a non-transmural inflammatory condition (Baumgart & Sandborn, 2007). Both diseases cause chronic, recurrent symptoms such as abdominal pain and diarrhea, and affect males and females equally (Ananthakrishnan, 2015; Hu et al., 2022). While IBD can develop at any age, it is more common in younger and older individuals compared to those in middle age (Stange, 2006). The progression of CD is discontinuous, appearing in a patchy pattern, whereas UC spreads in a continuous manner. During the disease process, disruptions in blood flow, increased vascular permeability, oxidative stress, and leukocyte migration contribute to inflammation (Kumar-Nayak & Kumar, 2017). The inflammatory response begins with the conversion of membrane phospholipids

Abbreviations: AA, Arachidonic Acid; CD, Crohn's Disease; IBD, Inflammatory Bowel Disease; LOXs, lipoxygenases; MAP, Mycobacterium avium subspecies paratuberculosis; NSAIDs, non-steroidal anti-inflammatory drugs; ROS, Reactive oxygen species; SNPs, single nucleotide polymorphisms; UC, ulcerative Colitis.

*Corresponding author.
E-mail address: *ziarati @iau.ac.ir* (P. Ziarati).

https://doi.org/10.22059/JFABE.2025.404536.1219

into arachidonic acid (AA) by the enzyme phospholipase A2 (PLA2). AA is then metabolized into leukotrienes (LTB, LTC, LTD) and prostaglandins (PGE, PGF) through two distinct pathways, one involving cyclooxygenases (COX-1, COX-2) and the other lipoxygenases (LOXs). Non-steroidal anti-inflammatory drugs (NSAIDs), which act as COX inhibitors, are commonly used to alleviate inflammation and associated symptoms such as pain and fever (Cao et al., 2020; Qureshi & Dua, 2025). The diagnosis of IBD is typically based on clinical evaluation, supplemented by endoscopic, histological, laboratory, and radiological assessments. Historically, IBD was most prevalent in industrialized regions such as North America, Europe, and Oceania (Kaplan & Windsor, 2021). However, its incidence has risen globally, with an estimated 1–2 million cases in Europe and the United States, along with increasing rates in developing regions of Asia, Africa, and South America. In many areas, UC is reported to be more common than CD. Given the rising global burden of IBD, it is now recognized as a significant public health challenge, necessitating urgent efforts to enhance its diagnosis, management, and treatment (Ng et al., 2013; Kaplan, 2018; Sykora et al., 2018).

Although the exact cause of IBD remains unknown, substantial evidence suggests that its development is driven by a complex interplay of genetic predisposition, dietary factors, environmental influences, and immune system dysregulation (Baumgart & Sandborn, 2007). This paper reviews existing treatments for IBD-related inflammation, with a particular focus on plant-based therapies proposed in the literature. Currently, standard treatments for IBD include corticosteroids, non-steroidal anti-inflammatory drugs (NSAIDs), antibiotics, immunosuppressants, and biologic agents targeting tumor necrosis factor-alpha (TNF-α) (Triantafillidis & Stanciu, 2012; Brune & Patrignani, 2015). Additionally, an in vivo study has shown that lupeol and its derivatives exhibit stronger anti-inflammatory activity than indomethacin, a commonly used anti-inflammatory drug (Zhu et al., 2016). The medical treatment of IBD primarily involves several major drug classes, including aminosalicylates (5-ASA), corticosteroids (e.g., prednisolone and hydrocortisone), sulfasalazine, mesalazine, methotrexate, immunomodulators (e.g., azathioprine), and biologic agents (e.g., infliximab and adalimumab) (Hanauer, 2008). Antibiotics such as ciprofloxacin and metronidazole are typically used for initial treatment; however, prolonged or repeated use can worsen the disease and lead to adverse side effects. Additionally, hormonal therapies, oral contraceptives, and nonsteroidal anti-inflammatory drugs (NSAIDs) have been identified as potential risk factors for IBD (Cornish et al., 2008; Shaw et al., 2010; Chan et al., 2011; Ananthakrishnan et al., 2012). Given the limitations and side effects associated with these treatments, there is a growing interest in exploring alternative therapeutic approaches (Vohra et al., 2021). This study aims to investigate the medicinal potential of the *Lamiaceae* family as a valuable resource for creating innovative, effective, and more straightforward adjunct therapies to support the treatment of IBD.

2. Role of lifestyle and environmental factors in IBD

Several studies have highlighted the role of environmental factors, such as stress, anxiety, depression, physical inactivity, disrupted sleep patterns, breastfeeding during childbirth, and decreased quality of life, in the development of IBD (Bernstein et al., 2010; Ananthakrishnan et al., 2013; Bager et al., 2013; Ananthakrishnan, 2015). Analysis of IBD in monozygotic twins strongly supports the contribution of both genetic and environmental factors, particularly in CD (Xu et al., 2025). Additionally, published evidence suggests that environmental factors like smoking and tobacco exposure play a significant role in the pathogenesis of IBD (Lamb et al., 2019; Mi et al., 2025). Animal models of IBD indicate a complex interplay between genetic, bacterial, and immunological factors in intestinal inflammation. For instance, disruption of the cytosolic receptor of the innate immune system, NOD2 / CARD15, which responds to intestinal microbial products, can lead to the compensatory activation of various proinflammatory cytokines (Crane et al., 2002). A decrease in immunological tolerance due to overexposure to bacterial substances may contribute to the development of IBD. The most common pathogens involved in bowel inflammation and IBD include *Helicobacter pylori* (Reshetnyak et al., 2021), *Clostridium difficile* (Bai et al.,2023), *Escherichia coli* (Petersen et al., 2015), *Listeria monocytogenes* (Miranda-Bautista et al.,2014), *Campylobacter concisus* (Nielsen et al., 2012), and possibly *Mycobacterium avium* subspecies *paratuberculosis* (MAP) (Rath et al., 2011).

3. Genetic background of IBD

Genetic factors play a prominent role in the development of IBD and can be studied alongside environmental factors to gain a deeper understanding of the disease. Genome-wide association studies (GWAS) identified genetic variations associated with specific diseases by analyzing molecular markers across the entire genome in large populations. These studies often focus on the genetic diversity of single nucleotide polymorphisms (SNPs) as markers. By comparing allelic frequency and genotypic polymorphisms of SNPs in healthy individuals versus patients, these variations can be used for diagnostic purposes (Ek et al., 2014). In general, IBD is more common among individuals who are genetically predisposed to the disease. Several genetic factors have been identified, including polymorphisms in the nucleotide-binding oligomerization domain-containing protein 2 (NOD2 / CARD15), which acts as a sensor for bacterial peptidoglycan, as well as autophagy-enhancing polymorphisms in the ATG16L1 gene, IRGM (Immunity-related GTPase M) protein polymorphisms, and genetic variations in the IL-23 pathway (Marcuzzi et al., 2013; Kaistha & Levine, 2014). Studies have shown that familial aggregation of inflammatory bowel disease (IBD) occurs in 5-32% of patients, highlighting the hereditary basis of the disease. The presence of IBD (both CD and UC) in certain genetic syndromes, such as Turner syndrome, further supports the role of genetic predisposition in IBD (Uhlig et al., 2014; Gatti et al., 2021). Genetic studies in the Ashkenazi Jewish population, which has a largely similar genetic architecture, have observed a higher prevalence of IBD compared to non-Jewish Europeans. This suggests the presence of risk alleles specific to this population (Kenny et al., 2012). Genetically, IBD is considered a multigene disorder that contributes to the development of both UC and CD (Borowitz, 2023). In a recent trans-ethnic analysis, 38 new loci associated with IBD were identified, showing a striking overlap between European and Asian ancestry groups (Liu et al., 2015). The genetic factors linked to this disease are primarily associated with innate immunity and autophagy. Most of the genes linked to (CD, IBD1) and (UC, IBD2) have been traced to chromosomes 16q and 12q, respectively (Tsianos et al., 2011; Chehel-Cheraghi et al., 2016). The genetic factor for CD was first identified in 2001 through a mutation in the nucleotide-binding oligomerization domain-containing protein 2 gene (NOD2). This gene encodes a receptor protein that activates autophagy in intestinal epithelial cells (Peloquin et al., 2016). Further studies have shown that the NOD2 gene and polymorphisms in the NOD2 gene (R702W and G908R), IL23R, and ATG16L1, as well as mutations in the IL-10 receptor, are among the factors that can contribute to colitis (Hampe et al., 2007; Cadwell et al., 2010; Marchiando et al., 2013; Hubbard-Lucey et al., 2014; Xiao et al., 2021). The FUT2 gene, located on chromosome 19, encodes a fucosyltransferase 2 enzyme. Carriers of the FUT2 null allele, along with the absence of the mucus layer in CD, highlight the relationship between this gene's activity and the disease (McGovern et al., 2010). To date, approximately 240 gene loci have been identified through genome-wide scans that may be linked to the predisposition and occurrence of IBD. These include FOXO3, IGFBP1, and XACT in Crohn's disease, as well as ECM1, LYRM4, CDKAL1, STAT3, and JAK2 mutations in ulcerative colitis (Fisher et al., 2008; McGovern et al., 2010; de Lange et al., 2015; Annese, 2020; Mamootil, 2023). About 160 genetic loci have been identified for both types of IBD. Notably, 110 out of 163 genetic loci are shared between Crohn's disease and ulcerative colitis, including the IL10RA/B genes. The clinical similarities observed in homozygous mutations of these genes suggest a probable association of risk loci between the diseases (Glocker et al., 2009; Glocker et al., 2010; Florez et al., 2022). Additionally, it remains unclear whether the relationship between dysbiosis and gut microbiota function is a cause or a consequence of IBD (Joossens et al., 2011; Machiels et al., 2014; Chassaing et al., 2015). Overall, further comprehensive studies on the relevant genes (Fig. 1) and the influence of genetic variations on covalent modifications, including the addition or removal of glycosylation, are needed (Dalvi et al., 2024). Phosphorylation and variations in proteolytic susceptibility (Lassen et al., 2014; Murthy et al., 2014) could help define new pathways for targeted IBD treatments. It is likely that the accumulation and combination of risk genes and alleles alone will not fully explain the emergence and progression of IBD, and ongoing research into interventional agents remains critical.

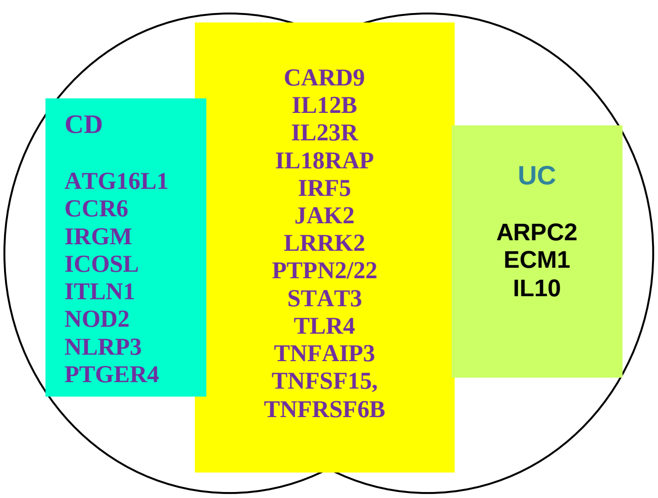

Fig. 1. Identified related genes with Crohn's disease (CD), ulcerative colitis (UC) and overlapped between them.

4. Analysis of *Lamiaceae* family plants in the context of IBD

4.1. *Traditional and modern usages of the Lamiaceae family*

While most members of the *Lamiaceae* family are primarily used for culinary purposes (Stefanaki & van Andel, 2021), ornamental flowers (Dong et al., 2018), and in the fragrance industry (Jain et al., 2022), their medicinal uses have also been recognized for treating various diseases (Milevskaya et al., 2018). Plants from this family have been used traditionally for a wide range of disorders across different cultures since ancient times. As one of the largest plant families, rich in volatile compounds and distinct scents, *Lamiaceae* plants have been employed to treat ailments such as diarrhea, high fever, cough, suppurative infections, bleeding, influenza, rheumatism, dysmenorrhea, and bronchial asthma (Nieto, 2017). These aromatic plants have been especially used in traditional medicine due to the biological metabolites. Extensive research on the essential oils of the *Lamiaceae* family has demonstrated a variety of beneficial activities, including anti-inflammatory, antiasthmatic, anticancer, antiviral, antioxidant, antitussive, and antipyretic properties (Çelik et al., 2021). Additionally, their antimicrobial, antifungal, antiparasitic, antidiabetic, antipruritic, decongestant, antinociceptive, carminative, antirheumatic, antidepressant, neuroprotective, cholinergic, sedative, and antiseptic effects have been widely studied (Dhayalan et al., 2015; Carovic-Stanko et al., 2016; Bekut et al., 2018; Uritu et al., 2018; Ouakouak et al., 2019). Further research comparing these results highlights that the potent antioxidant and anti-inflammatory activities of these plants can largely be attributed to their polyphenols and diterpenoids (Kavitha et al., 2012; Dhawan et al., 2013). Exploration of therapeutic combinations using medicinal plant resources, particularly those known to inhibit, reduce, or alleviate disease symptoms, has seen significant growth in recent years. This growing interest in plant-based treatments is rooted in the long-standing historical use of medicinal plants, which have been affordable and widely accessible across various cultures (Bahmani et al., 2014).

4.2. *Plants phytomorphology*

The *Lamiaceae* family, also known as *Labiatae* (mint family), is a prominent and diverse group of plants that includes 236 genera and approximately 7,000 species. These plants are highly valued for their biological and medicinal applications, and they have a cosmopolitan distribution across regions such as the Mediterranean, Southwest Asia, South Africa, and Australia (Chrysargyris, 2024). Members of the *Lamiaceae* family are typically annual or perennial herbs, though some species may also grow as shrubs or, more rarely, trees. They are easily identified by their quadrangular stems and simple, opposite leaves. The family is also notable for the presence of two primary types of trichomes: peltate and capitate. These plants produce aromatic, volatile essential oils that play key roles in pollination, defense signaling, and communication between plants (Dudareva et al., 2013). The flowers of *Lamiaceae* plants are usually zygomorphic and arranged in terminal spikes. A distinctive feature of these flowers is their symsepalous calyx with conspicuous ribs, and their sympetalous tubular corolla with two lips. Most *Lamiaceae* plants have four stamens, except for those in the *Salvia* genus, which typically have only two, and their fruit is a

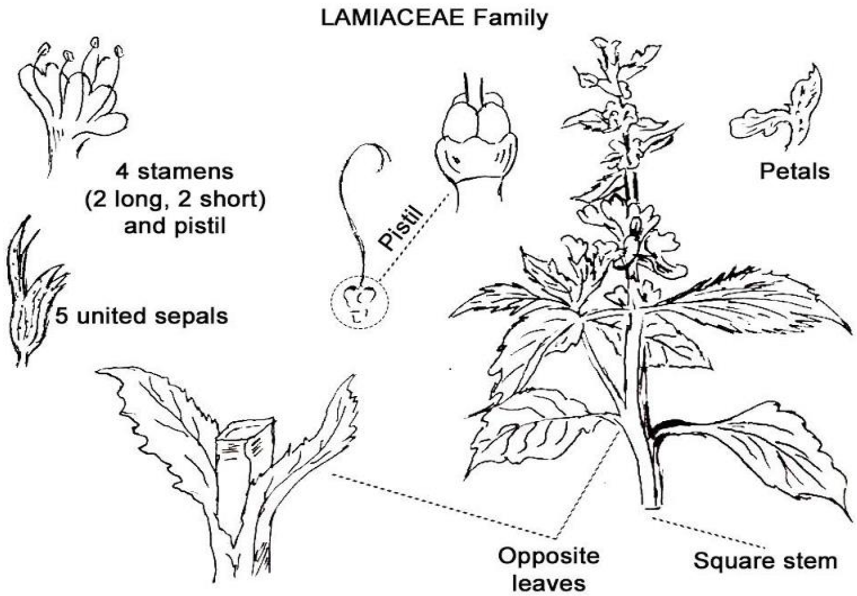

Fig. 2. The common characteristics of the *Lamiaceae* family (Source: compiled by author, Dr Kazemivash).

schizocarp containing four nutlets (Cristea et al., 2014; Elpel, 1998) (Fig. 2).

Due to their wide-ranging medicinal properties, the *Lamiaceae* family is considered significant from economic, ecological, ethnobotanical, and floristic perspectives (Stankovic, 2020; Haas et al., 2024).

4.3. Phytochemistry of the Lamiaceae family

Phytochemicals, also known as plant metabolites, are organic compounds synthesized during the metabolic processes of plants. These metabolites are categorized into two groups: primary and secondary metabolites. Primary metabolites, found in all plants, are essential for vital and daily activities, such as nutrition and reproduction. These include carbohydrates, proteins, nucleic acids, fats, and lipids. In contrast, secondary metabolites are produced in lower concentrations and play a supportive role in plants. They are often induced under environmental stress and serve functions such as acting as antioxidants or cell membrane stabilizers, combating pathogenic factors, aiding in wound healing, attracting pollinators, and serving as anti-herbivore agents (Croteau et al., 2000; Loreto et al., 2014; Kigathi et al., 2019). In plant taxonomy, the presence of specific chemicals, whether in combination or alone, can be used as identification keys for classification (Thrane, 2001). The main groups of secondary metabolites include terpenes, phenolic compounds, and nitrogen- and sulfur-containing compounds. Among these, terpenes form the largest group, originating from acetyl-CoA or glycolytic intermediates. Terpenes encompass monoterpenes, sesquiterpenes, diterpenes, triterpenes, and polyterpenes (Dudareva et al., 2013).

The application of plant metabolites in clinical treatments and healthcare has gained significant attention, with extensive studies conducted in this field. In medicinal research on the *Lamiaceae* family, both plant extracts and essential oils derived from various plant parts have been explored. Phytochemically, the plants of this family can be divided into two key groups. The first group, the subfamily *Nepetoideae*, produces volatile terpenoids (monoterpenes, sesquiterpenes, and diterpenes) and includes species such as *Salvia* sp. and *Mentha* sp. The second group consists of subfamilies like *Ajugoideae, Lamioideae, Scutellarioideae, Peronematoideae, Premnoideae, Callicarpoideae, Prostantheroideae, and Viticoideae*, which produce non-volatile secondary metabolites of the polar fraction. Numerous compounds have been identified during research on this family, including α- and β-pinene, menthol, thymol, limonene, eucalyptol, monoterpenes, sesquiterpenes, phenolic acids, and alkaloids (Frezza et al., 2019).

Essential oils, one of the most important compounds extracted from various parts of dried *Lamiaceae* plants, are volatile due to their aromatic, vaporous nature, and are typically identified through methods such as gas chromatography (GC) (Gautam et al., 2014; Russo et al., 2015). Terpenoids, especially monoterpenoids, are the most common components of these essential oils, synthesized by the aerial parts of the plant. Additionally, the quantity and chemical composition of the extracted essential oils depend on factors such as the plant's age, extraction method, soil composition, climate, and harvest time (Cimino et al., 2021; Ramos Da Silva et al., 2021). This review summarizes the findings of studies on the bioactive compounds of 37 plants from the *Lamiaceae* family in Table 1.

4.4. Anti-inflammatory effects of plants

Studies using plant compounds in vitro and in animal models have demonstrated their involvement in various biological processes, such as scavenging free radicals, promoting anti-inflammatory activity, regulating gut microbiota homeostasis, maintaining mucosal barrier integrity, and activating intestinal T cells. Additionally, plant-based therapeutic agents are generally considered safe with minimal health risks and are eco-friendly (Larussa et al., 2017). The findings so far indicate that extracts and essential oils derived from different parts of the *Lamiaceae* family plants exhibit varying degrees of anti-inflammatory effects, supporting their potential use in managing and treating inflammatory bowel diseases (IBD). Research on two Ocimum species (*O. basilicum* L. and *O. gratissimum* L.) found that the essential oils from their leaves demonstrated significant topical anti-inflammatory effects in a xylene-induced ear edema model in adult albino mice. It is important to note that the anti-inflammatory potency of these essential oils depends on the extraction method and their specific chemical composition (Table 1) (Okoye et al., 2014).

Another study on *O. gratissimum* leaf extract confirmed its anti-inflammatory and antioxidative effects through the inhibition of neutrophil activity, reduction of cytokine levels, and scavenging of free radicals in a trinitrobenzene sulfonic acid (TNBS)-induced colitis model in rats (Abiodun et al., 2020). Additionally, research has suggested that the anti-inflammatory effects of *O. gratissimum* extract at all tested doses may be attributed to its flavonoid content, which is associated with the inhibition of phosphodiesterases and the biosynthesis of protein cytokines (Tankoet et al., 2008).

In a separate study, two fractions of *Origanum vulgare* Linn leaf extract were tested for their anti-inflammatory properties by analyzing cytokine responses in THP-1 macrophages. The results indicated that the plant fractions could inhibit the secretion of low-density oxidized lipoprotein (oxLDL)-induced pro-inflammatory cytokines (TNF-α, IL-1β, and IL-6) while enhancing the release of the anti-inflammatory cytokine IL-10 through the downregulation of NF-κB expression in THP-1 cells (Ocaña-Fuentes et al., 2020). The anti-inflammatory effects of hydro-ethanolic leaf extract of *Ocimum basilicum* were also investigated in an ovalbumin-induced rat model of asthma. The findings demonstrated significant improvements in interstitial inflammation and emphysema, highlighting its potential in alleviating respiratory tract inflammation (Eftekhar et al., 2019). Moreover, a study on the aqueous extract of *Scutellaria baicalensis* Georgi identified major flavonoid derivatives, including wogonin, baicalin, and baicalein. These compounds were shown to suppress LPS-induced COX-2 protein expression, an enzyme that catalyzes the production of prostaglandins during the inflammatory process (Lee et al., 2007).

A comparative study on five genera of the *Lamiaceae* family (*Lavandula officinalis* Chaix, *Melissa officinalis* L., *Mentha piperita* L., *Salvia officinalis* L., and *Scutellaria orientalis* L.) revealed that all extracts exhibited significant inhibition of cyclooxygenase (COX) and lipoxygenase (LOX) enzymes, along with strong DPPH radical scavenging activity. These effects were possibly attributed to their flavonoid content. Among them, M. *officinalis* L., L. *officinalis Chaix*, and M. *piperita* L. exhibited the highest DPPH radical scavenging activity for trapping superoxide anions and alkoxyl radicals, as well as the strongest inhibitory activity against COX-2 and 12-15/LOX enzymes, respectively (Lee et al., 2007). In addition to the *L. officinalis* Chaix extract, the essential oil of *Lavandula angustifolia* Mill. was separately examined, and its anti-inflammatory effects were confirmed using two experimental models: carrageenan-induced pleurisy and croton oil-induced ear edema (Silva et al., 2015).

In an assessment of ovalbumin-induced acute asthma in BALB/c mice, treatment with *Lavandula stoechas* L. extract was found to reduce histopathological alterations in lung cells. The extract also lowered the expression levels of IL-6 and TNF-α compared to the control group. Additionally, it was observed that treatment with the extract reduced edema and infiltration of lymphocytes, monocytes, eosinophils, neutrophils, and macrophages within the interstitial spaces, exhibiting anti-inflammatory effects similar to those of dexamethasone (Erfanian et al., 2024). Besides the extract, the essential oil of *L. stoechas* also demonstrated anti-inflammatory potential in an *in vitro* model of lipopolysaccharide (LPS)-stimulated macrophages (Zuzarte et al., 2013). A comparison of inflammatory processes between *Lavandula dentata* and *Lavandula stoechas* using a carrageenan-induced paw edema model in mice demonstrated that only *L. stoechas* significantly reduced COX-2 expression, increased iNOS expression, and exhibited anti-inflammatory (Algieri et al., 2016; Erfanian et al., 2024).

Melissa officinalis L. (lemon balm), a member of the *Lamiaceae* family known for its lemon-scented aroma and richness in rosmarinic acid and quercetin, was evaluated in a separate study. Results showed that even at low doses, ethanolic and aqueous extracts of *M. officinalis* reduced pro-oxidant production and exhibited anti-inflammatory activity in the carrageenan-induced paw edema model (Draginic et al., 2022). In addition to these studies, the potential anti-inflammatory activity of *Salvia officinalis* has been investigated both independently and in combination with other *Lamiaceae* species. Flavonoids and terpenes are the major bioactive compounds in this plant (Murthy et al., 2014), and the type of extract appears to influence its anti-inflammatory effects. Among the various extracts, the chloroform extract has demonstrated greater anti-inflammatory activity compared to aqueous, ethanolic, methanolic, and even essential oil extracts (Baricevic et al., 2001; Mansourabadi et al., 2015). The anti-inflammatory effects of flavonoids and rosmarinic acid from *S. officinalis* have also been observed in the mouse carrageenan-induced inflammation model and epidermal studies (Osakabe et al., 2004; Chen et al., 2015; Mansourabadi et al., 2015).

An experiment on methanolic extracts of *Salvia officinalis* L. demonstrated an increase in blood neutrophil count, suggesting a defensive cellular response while preventing excessive leukocyte accumulation at the lesion site, thereby contributing to its anti-inflammatory effect (Dal Pra et al., 2011). Additionally, studies on *Salvia officinalis* leaf and flower extracts, which contain significant amounts of flavonoids, have investigated their anti-inflammatory potential in tumor-mediated inflammation models. As one of the key genera in the *Lamiaceae* family, *Salvia* has been widely studied for the anti-inflammatory properties of its extracts and essential oils (Ghorbani et al., 2017).

A study evaluating the anti-inflammatory activity of extracts from the aerial parts of three *Salvia* species (*S. fruticosa*, *S. verticillata*, and *S. trichoclada*) using a carrageenan-induced inflammation model in male rats demonstrated significant anti-inflammatory effects, with *Salvia fruticosa* exhibiting the strongest activity (Maphosa et al., 2012). The study concluded that flavonoids were likely responsible for this effect. Additionally, *S. fruticosa* is a rich source of antioxidant compounds, including flavonoids, which contribute to reducing nitric oxide (NO) and reactive oxygen species (ROS) production, promoting macrophage activation, and inhibiting inflammatory pathways associated with the neoplastic process (Brindisi et al., 2021).

Statistical analysis of research on the aqueous and ethanolic leaf extracts of this plant demonstrated dose-dependent anti-inflammatory effects in carrageenan-induced edema models in mice and rats. These extracts inhibited pain receptors by interfering with the synthesis of inflammatory cytokines and mediators such as kinins, histamine, and prostaglandins. At the highest concentrations, their anti-inflammatory effects were comparable to those of indomethacin (Qnais et al., 2010). Another *Salvia* species, *Salvia melissiflora* Benth., was investigated for its phytochemical composition, anti-inflammatory, antinociceptive, and antioxidant properties. Oral administration of its ethanol extract in mice led to a reduction in the second phase of formalin-induced nociception, lipopolysaccharide (LPS)-induced

Table 1. Summary of main bioactive compounds reported in some the *Lamiaceae* species.

Scientific name	Reported main components	References
Ocimum basilicum L. *Ocimum gratissimum* L.	**Essential oils:** Monoterpenes, sesquiterpenes ,α-pinene , 1,8-cineole	(Okoye et al., 2014)
	Extract: Eugenol, Thymol, Linalool, Sinapic acid, Rosmarinic acid, Ethyl cinnamate, p-cymene, Terpinolene , 1,8-cineole, Xanthomicrol	(Abiodun et al., 2020; Takeuchi et al., 2020)
Scutellaria baicalensis Georgi	**Essential oils:** Sesquiterpenoids, Monoterpenoids, Caryophyllene	(Wang et al., 2022)
	Extract: Flavonoids as (baicalin, baicalein, wogonoside, wogonin)	(Lee et al., 2007)
Mentha piperita L. *Salvia officinalis* L. *Lavandula officinalis* Chaix. *Melissa officinalis* L. *Scutellaria orientalis* L.	**Extract:** Flavonoid glycosides and aglycones with flavone, isoflavone, flavonol, methylated flavonoids, and flavonol skeletons, anthocyanidin , glycosides, coumarin, catechin, terpenoids, and hydroxycinnamic , fatty acyls	(Şener et al., 2024)
	Main compounds in *Salvia officinalis* L. Essential oils: 2-cyclopenten-1-one, 2-hexadecen-1-ol, and torulosol	(Ghorbani et al.,2017)
Rosmarinus officinalis L. *Melissa officinalis L.* *Thymus pulegioides L.* *Mentha piperita L.*	**Extract:** Triterpene	(Jordamović et al., 2023)
Nepeta pogonosperma Jamzad et Assadi	**Essential oils:** 4aα, 7α, 7aα nepetalactone, 1,8- cineole,α-terpineol, (E)-α-bisabolene, terpinen-4-ol, linalool, β-pinene	(Ali et al., 2012; Asgarpanah et al., 2013)
Leonotis leonurus (L) R. BR.	**Extract:** Alkaloids, saponins (of steroid and or triterpenoids groups), tannins	(Maphosa et al., 2012)
Salvia fruticosa Mill. *Salvia verticillata* L. *Salvia trichoclada* Benth.	**Extract:** Flavonoids (rutin, quercetin, and luteolin), biflavonoids,, triterpenoids (ursolic acid)	(Çadirci et al., 2012)
Thymus serpyllum L.	**Essential oils:** Sabinene, terpinen-4-ol, phellandral and thymol	(Al-Mijalli et al., 2025)
Lamium garganicum L.	**Extract:** Iridoid, phenylethanoid and flavonoid glycosides i.e., shanzhiside methyl ester, 8-O-acteylshanzhiside methyl ester, 6-O-syringyl-8-O-acetylshanzhiside methyl ester, 6-hydroxyipolamiide, lamalbide, dehydropenstemoside, and sesamoside	(Akkol et al., 2008)
Stachys lavandulifolia Vahl.	**Essential oils:** (-)-α-bisabolol, bicyclogermacrene, δ-cadinene, spathulenol	(Barreto et al., 2016)
Zataria multiflora Boiss.	**Essential oils**: p-cymene, -terpinene, thymol, carvacrol	(Hosseinzadeh et al., 2000)
Mentha spicata L.	**Essential oils:** Menthone, menthol, carvone	(Yousuf et al., 2013)
Lavandula stoechas L.	**Essential oils:** β-pinene, 1,8-cineole	(Erfanian et al., 2024)
Oreganum vulgare Linn	**Extract**: Trans-sabinenehydrate, thymol and carvacrol	(Ocaña-Fuentes et al., 2020)
Mentha pulegium L.	**Extract**: Rosmarinic acid , ellagic acid, eriodictyol, naringenin and chlorogenic acid	(Politeo et al., 2018)
Lavandula augustifolia Mill.	**Essential oils:** α-pipene, D-limolene, Eucalyptol, linalyl acetate, camphora, borneol, α-terpinol, cyclohexanol, linalool, caryophyllene	(Silva et al., 2015)
Coleus forsteri (Benth.) A.J.Paton	**Extract:** Abietane diterpenes as (coleon U, coleon U-quinone ,8α,9α-epoxycoleon U-quinone , horminone , 7α-hydroxyroyleanone, 6β,7α-dihydroxyroyleanone , 7α-acetoxy-6β-hydroxyroyleanone, 7α-formyloxy-6β-hydroxyroyleanone)	(Nicolas et al., 2023)
Premna schimperi Engl.	**Extract:** Flavonoids, terpenoids, steroids, phenols, cardiac glycosides, tannins, alkaloids, anthraquinones	(Arega et al., 2023)

Continued

Lamium album L.	**Extract:** Flavonoids , phenolic acids, fatty acids, iridoids, triterpenes, saponins, polysaccharides, tannins, phytoecdysteroids, mucilage	(Trouillas et al., 2003; Kelayeh et al., 2019)
Vitex trifolia L.	**Extract:** Phenols, flavonoids, terpenoids	(Ghafari et al., 2022)
Nepeta bracteata Benth	**Extract:** Diterpenoids, angustanoic acid,7a-hydroxycallitrisic acid, 1- phenanthrenecarboxylic acid, angustanoic acid, jiadifenoic acid	(Zhang et al., 2021)
Origanum majorana L. *Thymus vulgaris L.*	**Extract:** Flavonoids ,flavones, flavonols, Rosmarinic acid ,syringic acid	(Napoli et al., 2022)
Salvia melissiflora Benth	**Extract:** Caffeic acid ,Chlorogenic acid ,Isoquercetin ,Quercetin ,Rosmarinic acid	(Oliveira et al., 2024)
Schizonepeta tenuifolia Briq	**Essential oils:** Monoterpenes, sesquiterpenes, aldehydes, ketones, quinones, alcohols, phenols, carboxylic acids , esters	(Zhao & Zhou, 2022)
Vitex madiensis Oliv.	**Extract:** Flavonoids, phenolic acids (caffeic acid, chlorogenic), coumarins , anthrones , terpenes	(Lengbiye et al., 2020; Nsonde Ntandou et al., 2025)
Perilla frutescens (L.) Britton	**Essential oils:** Perilla ketone, elemicin , beta- myristicin, beta-caryophyllene ,elemicine, limonene	(Chen et al., 2015)
Thymbra capitata (L.) Cav.	**Essential oils:** Carvacrol , p-cymene , ɣ-terpinene	(Alves-Silva et al., 2023)
Salvia keerlii Benth.	**Essential oils:** Pentadecanoic acid, myristic acid, methyl dehydroabietate, and ursolic acid	(Serrano-Vega et al., 2020)

Continued.

hyperalgesia, and carrageenan-induced edema. These effects, likely linked to COX-2 inhibition, have been attributed to the presence of rosmarinic acid, oleanolic acid, and ursolic acid, which are known to modulate several cytochrome P450 enzymes (Oliveira et al., 2024).

In a separate study, another species of this genus, *Salvia keerlii* (SAKE) Benth., was examined for its anti-inflammatory properties. Evaluation using the 12-O-tetradecanoylphorbol-13-acetate-induced mouse ear edema model showed that the chloroform extract, rich in flavonoids and phenolic compounds, inhibited inflammation by suppressing phospholipase A2 and protein kinase C production. Further analysis indicated that its antinociceptive activity, assessed via the acetic acid-induced writhing method, could be attributed to the inhibition of prostaglandin synthesis (Serrano-Vega et al., 2020).

The anti-inflammatory effects of *Mentha spicata* (L.) and *Mentha pulegium* L. extracts have been investigated in two separate studies. The methanol extract of *M. spicata* was evaluated for its effects on inflammation in adult albino rats using the carrageenan-induced paw edema method. The extract exhibited significant anti-inflammatory activity by modulating prostaglandin released during type 2 inflammation (2–5 h), with effects persisting up to 6 h (Yousuf et al., 2013).

The study on *Mentha pulegium* hydroalcoholic extract demonstrated that it attenuated LPS-induced inflammation by inhibiting TLR-4 and NF-κB expression, leading to an anti-inflammatory effect in peripheral blood mononuclear human cells (PBMCs) (Mohammadi et al., 2024). In another comparative study, the anti-inflammatory effects of extracts from six *Lamiaceae* species (*Mentha piperita* L., *Thymus pulegioides* L., *Rosmarinus officinalis* L., *Salvia officinalis* L., *Lavandula officinalis* L., and *Melissa officinalis* L.) were evaluated using the inhibition of albumin denaturation assay *in vitro*. Triterpene fractions, identified as key components of these plants, were analyzed using thin-layer chromatography (TLC) and high-performance liquid chromatography (HPLC). Among the tested species, *R. officinalis* L. exhibited the strongest dose-dependent anti-inflammatory activity, followed by *M. officinalis* L., *S. officinalis* L., *M. piperita* L., *L. officinalis* L., and *T. pulegioides* L., respectively. The study further established a direct correlation between extract concentration and anti-inflammatory potency in these plants (Ghorbani et al., 2017).

Additionally, another research highlighted that *Thymus vulgaris* L. exhibited the anti-inflammatory activity among the studied plants, attributed to its high abundance of flavonols, surpassing *Rosmarinus officinalis* L. and other *Lamiaceae* species (Napoli et al., 2022). The essential oil of *Thymus herba-barona*, rich in phenolic compounds such as carvacrol and thymol, was assessed in a lipopolysaccharide-stimulated macrophage model and confirmed to inhibit nitric oxide production, supporting the anti-inflammatory potential of the *Thymus* genus (Zuzarte et al., 2013). Furthermore, a study on *Thymus serpyllum* L. essential oil (EO) revealed significant anti-inflammatory effects *in vitro* via the 5-lipoxygenase (5-LOX) inhibition method (Al-Mijalli et al., 2025). Another member of the *Lamiaceae* family, *Zataria multiflora* Boiss, was evaluated for its ethanolic and aqueous extracts using acetic acid, cotton pellet granuloma, and xylene-induced ear edema models in mice and rats. Both extracts exhibited significant anti-inflammatory activity in both acute and chronic inflammation models, likely due to their high flavonoid content (Hosseinzadeh et al., 2000).

A study on *Nepeta cataria* essential oil revealed that it contains 79.27% nepetalactone, which is likely responsible for its anti-inflammatory activity, as demonstrated in a carrageenan-induced edema test in a mouse model (Ricci et al., 2010). More recently, the analgesic and anti-inflammatory effects of *Nepeta crispa* Willd. were reported in animal models, further supporting the therapeutic potential of this genus (Ali et al., 2012). Additionally, an analysis of the main components of *Nepeta pogonosperma* essential oil demonstrated its anti-inflammatory role in a formalin-induced paw edema model across all tested doses in rats (Ali et al., 2012; Valimehr et al., 2015). Moreover, the anti-inflammatory effects of both the essential oil and extract of *N. pogonosperma* were observed in rat brain mixed cells using LPS as an inflammatory agent, where they significantly inhibited nitric oxide (NO) production, further confirming their potential in neuroinflammation management (Valimehr et al., 2015).

The investigation of the anti-inflammatory effects of *Nepeta bracteata* Benth. revealed that its bioactive compounds, primarily terpenoids (especially diterpenes), were isolated using HPLC and column chromatography methods. The results demonstrated that all tested doses of the extract inhibited nitric oxide (NO) production, with IC_{50} values < 50 μM, while exhibiting minimal effects on RAW 264.7 macrophage bioactivity. The anti-inflammatory potential of this plant extract was further confirmed through an MTT colorimetric assay in lipopolysaccharide (LPS)-stimulated RAW 264.7 macrophages, which highlighted a correlation between its anti-inflammatory and antioxidant properties (Zhang et al., 2021). Similarly, a study on *Leonotis leonurus* (L.) R. Br. leaf aqueous extract demonstrated significant anti-inflammatory activity in carrageenan- and histamine-induced paw edema models in rats. Additionally, the N-butanol extract of *Salvia fruticosa* exhibited the highest anti-inflammatory effect at a 200 mg/kg dose in carrageenan-induced paw edema, while showing consistent activity at all tested doses in the histamine-induced model. The analgesic effects observed in this experiment were partially attributed to the release of arachidonic acid via cyclooxygenase and prostaglandin pathways (Ali et al., 2012). Moreover, methanol and chloroform extracts of *Salvia fruticosa* (500 mg/100 g BW) significantly reduced inflammation by 20% and 41%, respectively, in a rat paw edema model. Notably, their anti-inflammatory efficacy was comparable to that of Voltaren, a well-known reference drug (El-Ansari et al., 2009).

Another species of this genus, *Leonotis nepetaefolia* R. Br., has also been reported to exhibit similar anti-inflammatory effects (Ramos et al., 2021). The *Coleus* genus, belonging to the *Lamiaceae* family, is primarily cultivated for its ornamental foliage; however, its therapeutic properties have also been recognized. The anti-inflammatory effects of *Coleus amboinicus* Lour. (Loreto et al., 2014) and *oleus forsteri* (Benth.) (Nicolas et al., 2023) extracts have been investigated in separate studies. In an experiment on uric acid-induced nephrotoxicity in rats, treatment with *C. amboinicus* Lour. extract was found to promote GPx concentrations, increase TGF-1β levels, and restore blood urea nitrogen (BUN) and serum creatinine levels to normal values, confirming its anti-inflammatory potential (Loreto et al., 2014). Additionally, a study on *C. forsteri* (Benth.) ethanolic and cyclohexane extracts demonstrated their ability to inhibit inflammatory cytokines IL-6 and TNF-α, as well as the deleterious kynurenine pathway metabolite quinolinic acid (QUIN), in LPS-induced human macrophage models (Nicolas et al., 2023). In traditional medicine, *Premna schimperi* Engl. has been used for treating inflammation. A recent study assessed its anti-inflammatory properties using the cotton pellet-induced granuloma, carrageenan-induced, and formalin-induced paw edema models in Wistar albino rats. The results showed a reduction in paw edema at all tested doses without any signs of toxicity. Phytochemical screening of the methanol extract identified a variety of bioactive compounds, including flavonoids, terpenoids, steroids, phenolics, cardiac glycosides, tannins, alkaloids, and anthraquinones, which are likely responsible for the observed anti-inflammatory effects (Arega et al., 2023).

Lamium album L., contains a wide range of phenolic compounds and iridoids in its aerial parts, which act as free radical scavengers and exert anti-inflammatory effects by inhibiting arachidonic acid metabolism through the lipoxygenase pathway (Trouillas et al., 2003; Kelayeh et al., 2019). Similarly, the anti-inflammatory effects of *Lamium garganicum* L. extract were demonstrated in carrageenan-induced hind paw edema, PGE2-induced hind paw edema, and 12-O-tetradecanoyl-13-acetate (TPA)-induced mouse ear edema models (Akkol et al., 2008; Trouillas et al.,2003). These effects are largely attributed to secondary metabolites such as phenolics, which are known to be the main contributors to the plant's antioxidant and anti-inflammatory properties.

Research on *Vitex trifolia* L. leaves hydroalcoholic extract has also highlighted its anti-inflammatory and antioxidant potential. In an investigation using the MTT assay on RAW 264.7 cells, the extract exhibited no toxicity up to a concentration of 100 μg/mL, with an IC50 value of 51.59 ± 4.32%. Further analysis of ROS and pro-inflammatory cytokines showed that the extract inhibited TNF-α production induced by LPS, reduced LPS-induced COX activity, and confirmed a positive correlation between its antioxidant and anti-inflammatory effects (Ghafari et al., 2022).

Another member of the *Lamiaceae* family, *Vitex madiensis* Oliv., has also been evaluated for its anti-inflammatory properties. The aqueous extract of the plant was tested using carrageenan- and histamine-induced inflammation models in male and female Wistar rats. The extract, which is rich in flavonoids, significantly inhibited inflammation at a dose of 400 mg/kg, yielding results consistent with those observed in other species of this genus (Lengbiye et al., 2020; Nsonde Ntandouet al., 2020).

The antioxidant, cytotoxicity, and anti-inflammatory effects of *Schizonepeta tenuifolia* (ST) Briq. extract have been widely studied in recent years. Investigations into the antioxidant properties of ST aqueous and polysaccharide extracts using DPPH, NO, and deoxyribose oxidation assays confirmed the plant's strong potential to inhibit free radicals and protect liposomes. This effect was linked to an increase in the activity of antioxidant enzymes, including catalase, superoxide dismutase, and glutathione peroxidase (Tae & Kim, 2012; Wang et al., 2012). Additionally, ST extract was found to enhance the cytotoxicity of mouse thylakoid cells via the Nrf2/ARE pathway (Do et al., 2019). The anti-inflammatory effects of *S. tenuifolia* essential oil were evaluated in a carrageenan-induced pleurisy model in rats, where the treatment significantly reduced inflammation markers such as leukocytes, malondialdehyde, myeloperoxidase, and interleukin-1β. These effects were attributed to TNF-α suppression, inhibition of lipid peroxidation, and downregulation of pro-inflammatory cytokines TNF-α, IL-1β, and IL-6 (Wang et al., 2012; Do et al., 2019).

Studies on *Perilla frutescens* (L.) Britt. leaf extract have also demonstrated its ability to reduce ROS levels through direct free radical scavenging activity. Furthermore, its anti-inflammatory effects were shown to be mediated through two pathways: the inhibition of Src family kinases (SFKs) and the reduction of intracellular Ca^{2+} levels, leading to decreased activation of human neutrophils (Chen et al., 2015). Similarly, essential oil from *Thymbra capitata* (L.) Cav., with carvacrol as its major component (79.5%), has been reported to possess significant anti-inflammatory activity. This was evidenced by the inhibition of NO production, inducible nitric oxide synthase (iNOS), and pro-IL-1β protein levels in lipopolysaccharide-stimulated macrophages (Alves-Silva et al., 2023). Another plant with notable anti-inflammatory properties is *Stachys lavandulifolia* Vahl., which has been used in traditional medicine across various Asian countries.

Oral administration of this plant's essential oil, along with its main active compound (-)-α-bisabolol, was tested in a carrageenan-induced pleurisy model in mice. The treatment effectively inhibited the synthesis of pro-inflammatory cytokines TNF-α and IL-1β, which play a crucial role in leukocyte migration and plasma protein regulation, suggesting its potential therapeutic application for inflammatory disorders (Barreto et al., 2016).

5. Conclusion

This narrative review examined the therapeutic potential of bioactive fractions derived from 37 plant species within the *Lamiaceae* family for managing inflammatory bowel disease (IBD). The findings highlight the significant role of these plant-derived compounds in modulating inflammatory responses through the downregulation of pro-inflammatory cytokines, inhibition of oxidative stress, and regulation of key cellular signaling pathways. The anti-inflammatory effects observed in these species are largely attributed to the presence of flavonoids, terpenoids, steroids, and phenolic compounds, which exhibit immunomodulatory and antioxidant properties. Collectively, the reviewed studies provide robust scientific evidence supporting the traditional medicinal use of these plants in inflammation-related disorders. Furthermore, these insights pave the way for future research into their mechanistic actions and potential applications in developing novel, plant-based therapeutics for IBD.

Conflict of interest

The authors declare that there is no conflict of interest.

References

Abiodun, O.O., Nwadike, N., Sosanya, A.S., Ogunleye, F.N. (2020). Ocimum gratissimum Linn (Lamiaceae) protects Wistar rats against inflammation and oxidative stress in Trinitrobenzene sulphonic acid induced colitis. *Thai Journal of Pharmaceutical Sciences*, 8, 44(3). doi: https://doi.org/10.56808/3027-7922.2445

Akkol,E.K., Yalçın, F.N.,Kaya, D.,Çalış, İ.,Yesilada, E.,Ersöz,T.(2008).In vivo anti-inflammatory and antinociceptive actions of some Lamium species. *Journal of Ethnopharmacology*, 19;118(1):166-172. doi: 10.1016/j.jep.2008.04.001.

Algieri, F., Rodriguez-Nogales, A., Vezza, T.,Garrido-Mesa, J.,Garrido-Mesa, N.,Utrilla, M.P., González-Tejero, M.R., Casares-Porcel, M., Molero-Mesa, J., et al.(2016). Anti-inflammatory activity of hydroalcoholic extracts of Lavandula dentata L. and Lavandula stoechas L. Journal of ethnopharmacology, 22;190:142-58. doi: 10.1016/j.jep.2016.05.063.

Ali, T., Javan, M., Sonboli, A., Semnanian, S. (2012). Evaluation of the antinociceptive and anti-inflammatory effects of essential oil of Nepeta pogonosperma Jamzad et Assadi in rats. *DARU Journal of Pharmaceutical Sciences*, 4;20(1):48. doi: 10.1186/2008-2231-20-48.

Al-Mijalli, S.H., Mrabti, H.N., Elbouzidi, A., Ashmawy, N.S., Batbat, A., Abdallah, E.M., Laaboudi, W., Aladhadh, M., Alshabrmi, F.M., Alnasser, S.M., Addi, M. (2025). Thymus serpyllum L. Essential Oil: Phytochemistry and in Vitro and in Silico Screening of Its Antimicrobial, Antioxidant and Anti-Inflammatory Properties. Phyton (0031-9457), 1,94(1).

Alves-Silva, J.M., Pedreiro, S., Cavaleiro, C., Cruz, M.T., Figueirinha, A., Salgueiro, L. (2023). Effect of Thymbra capitata (L.) Cav. on inflammation, senescence and cell migration. *Nutrients*, 17,15(8),1930.

Ananthakrishnan, A.N., Higuchi, L.M., Huang, E.S., et al. (2012). Aspirin, nonsteroidal anti-inflammatory drug use, and risk for Crohn disease and ulcerative colitis: a cohort study. *Ann Intern Med*., 156(5),350–9.

Ananthakrishnan, A.N. (2015). Epidemiology and risk factors for IBD. Nat Rev Gastroenterol Hepatol, 12, 205–217.

Ananthakrishnan, A.N., Long, M.D., Martin, C.F., et al., (2013). Sleep disturbance and risk of active disease in patients with Crohn's disease and ulcerative colitis. *Clin Gastroenterol Hepatol*, 11(8),965–71.

Andrade, J. M., Faustino, C., & Garcia, C. (2018). Rosmarinus officinalis L.: an update review of its phytochemistry and biological activity. *Future Science OA*, *4*(4), FSO283. https://doi.org/10.4155/fsoa-2017-0124

Annese, V. (2020). Genetics and epigenetics of IBD. Pharmacol. Res, 159, 104892. https://pubmed.ncbi.nlm.nih.gov/32464322.

Arega, M., Nardos, A., Debella, A., Dereje, B., Terefe, L., Abebe, A. (2023). Evaluation of anti-inflammatory activity of the methanol extracts of Premna schimperi Engl (Lamiaceae) leaves in rats. Journal of Experimental *Pharmacology*, 14;15:437-447. doi: 10.2147/JEP.S432615. 14; 15: 437-447.

Asgarpanah, J., Sarabian, S., & Ziarati, P. (2013). Essential oil of *Nepeta* genus (Lamiaceae) from Iran: a review. *Journal of Essential Oil Research*, *26*(1), 1–12. doi.org/10.1080/10412905.2013.851040.

Bager, P., Simonsen, J., Nielsen, N.M., et al. (2012). Cesarean section and offspring's risk of inflammatory bowel disease: a national cohort study. *Inflamm Bowel Dis*,18(5),857–62.

Bahmani, M., Shirzad, H., Majlesi, M., Shahinfard, N., Rafieian-Kopaei, M. (2014). A review study on analgesic applications of Iranian medicinal plants. *Asian Pacific Journal of Tropical Medicine*, 7, S43–S53.

Bai, M., Guo, H., Zheng, X.Y. (2023). Inflammatory bowel disease and *Clostridium difficile* infection: clinical presentation, diagnosis, and management. *Therap Adv Gastroenterol*., 28,16,17562848231207280. doi: 10.1177/17562848231207280.

Baricevic, D., Sosa, S., Della Loggia, R., Tubaro, A., Simonovska, B., Krasna, A., Zupancic, A. (2001). Topical anti-inflammatory activity of Salvia officinalis L. leaves: the relevance of ursolic acid. *J Ethnopharmacol.* ,75(2-3),125-132. doi: 10.1016/s0378-8741(00)00396-2.

Barreto, R.S., Quintans, J.S., Amarante, R.K., Nascimento, T.S., Amarante, R.S., Barreto, A.S., Pereira, E.W.et al. (2016). Evidence for the involvement of TNF-α and IL-1β in the antinociceptive and anti-inflammatory activity of Stachys lavandulifolia Vahl. (Lamiaceae) essential oil and (-)-α-bisabolol, its main compound, in mice. *Journal of Ethnopharmacology*, 15;191:9-18. doi: 10.1016/j.jep.2016.06.022.

Baumgart, D.C., Sandborn, W.J. (2007). Gastroenterology 2: Inflammatory bowel disease: clinical aspects and established and evolving therapies. *Lancet*, 18, 379–87. doi: 10.1016/S0140-67360760751-X.

Bekut, M., Brkic, S., Kladar, N., Dragovi ´ c, G, Gavari ´ c, N., Bozin, B. (2018). Potential of selected Lamiaceae plants in anti(retro)viral therapy.*Pharmacological Research*, 133:301-314. doi: 10.1016/j.phrs.2017.12.016.

Bernstein, C.N., Singh, S., Graff, L.A., et al. (2010). A prospective population-based study of triggers of symptomatic flares in IBD. *Am J Gastroenterol*,105(9),1994–2002.

Borowitz, S.M. (2023). The epidemiology of inflammatory bowel disease: Clues to pathogenesis? *Front Pediatr*., 17;10:1103713. doi: 10.3389/fped.2022.1103713.

Brindisi, M., Bouzidi, C., Frattaruolo, L., Loizzo, M.R., Cappello, M.S., Dugay, A., Deguin, B, et al. (2021). New insights into the antioxidant and anti-inflammatory effects of Italian Salvia officinalis leaf and flower extracts in lipopolysaccharide and tumor-mediated inflammation models. *Antioxidants*,19,10(2),311.

Brune, K., Patrignani, P. (2015). New insights into the use of currently available nonsteroidal anti-inflammatory drugs. *J Pain Res.*, 20,8,105-18. doi: 10.2147/JPR.S75160.

Byun, M.W. (2014). Schizonepeta tenuifolia ethanol extract exerts anti-inflammatory activity through the inhibition of TLR4 signaling in lipopolysaccharide-stimulated macrophage cells. *J. Med. Food*, 17(3):350-6. doi: 10.1089/jmf.2013.2928.

Çadirci, E., Süleyman, H., Gürbüz, P., Uz, A.Y., Güvenalp, Z., Demirezer, L.Ö. (2012). Anti-inflammatory effects of different extracts from three Salvia species. T*urkish Journal of Biology*, 36(1),59-64.

Cadwell, K., Patel, K.K., Maloney, N.S., Liu, T.C., Ng, A.C., Storer, C.E., et al. (2010). Virus-plus-susceptibility gene interaction determines Crohn's disease gene Atg16L1 phenotypes in intestine. *Cell*, 141,1135–45.

Cao, C., Jin, R., Wei, H., Liu, Z., Ni, S., Liu, G.J., Young, H.A.,Chen, X.,Liu,G. (2020). Adaptive in vivo device for theranostics of inflammation: Real-time monitoring of interferon-γ and aspirin. *Acta Biomater*., 1,101,372-383. doi: 10.1016/j.actbio.2019.10.021.

Carovic-Stanko, K., Petek, M., Grdi sa, M. (2016). Medicinal plants of the family Lamiaceae as functional foods—a review," Czech Journal of Food Sciences, 34 (5), 377–390.

Çelik, G., Kılıç, G., Kanbolat, S. (2021). Biological activity, and volatile and phenolic compounds from five Lamiaceae species. *Flavour and Fragrance Journal*, 36 (2), 223–232.

Chan, S.S., Luben, R., Bergmann, M.M., et al. (2011). Aspirin in the aetiology of Crohn's disease and ulcerative colitis: a European prospective cohort study. *Aliment Pharmacol Ther*, 34(6),649–55.

Chassaing, B., Koren, O., Goodrich, J.K., Poole, A.C., Srinivasan, S., et al. (2015). Dietary emulsifiers impact the mouse gut microbiota promoting colitis and metabolic syndrome. *Nature*, 519,92–96.

Chehel Cheraghi, S., Ebrahimi Daryani, N., Ghabaee, M. (2016). A Survey on Migraine Prevalence in Patients with Inflammatory Bowel Disease, A Single Centre Experience. Middle East J Dig Dis. ,8(4), 282-288. doi: 10.15171/mejdd.2016.37.

Chen, C.Y., Leu, Y.L., Fang, Y., Lin, C.F., Kuo, L.M., Sung, W.C., Tsai, Y.F., Chung, P.J., Lee, M.C., Kuo, Y.T., Yang, H.W. (2015). Anti-inflammatory effects of Perilla frutescens in activated human neutrophils through two independent pathways: Src family kinases and Calcium. *Scientific reports*, 14,5(1),18204.

Chrysargyris, A. (2024). It Runs in the Family: The Importance of the Lamiaceae Family Species. *Agronomy*, *14*(6), 1274. Cimino, C., Maurel, O.M., Musumeci, T., Bonaccorso, A., Drago, F., Souto, E.M.B. et al. (2021). Essential Oils: Pharmaceutical Applications and Encapsulation Strategies into Lipid-Based Delivery Systems. *Pharmaceutics*, 3; 13(3):327. doi: 10.3390/pharmaceutics13030327.

Cornish, J.A., Tan, E., Simillis, C., et al. (2008). The risk of oral contraceptives in the etiology of inflammatory bowel disease: a meta-analysis. *Am J Gastroenterol* , 103(9), 2394–400.

Crane, A.M., Bradbury, L., van Heel, D.A., McGovern, D.P., Brophy, S., Rubin, L., Siminovitch, K.A., Wordsworth, B.P., Calin, A., Brown, M.A. (2002). Role of NOD2 variants in spondylarthritis. *Arthritis Rheum* ,46,1629–1633. doi: 10.1002/art.10329.

Cristea, V. (2014). Plante Vasculare: Diversitate, Sistematică, Ecologie S, i Important, ă; Presa Universitara Clujeana: Cluj-Napoca, Romania, ISBN 978-973-595-648-6.

Croteau, R., Kutchan, T.M., Lewis, N.G. (2000) Natural Products (Secondary metabolites). In: Buchanan BB, Gruissem w, Jones RL, editors. *Biochemistry & molecular biology of plants.USA: Courier companies, Inc*, 1250-1318.

Dal Pra, V., Bisol, L.B., Detoni, S., Denti, M., Grando, J., Pollo, C., Pasquali, T.R., Hoffmann, A.E., Mazutti, M.A., Macedo, S.M. (2011). Anti-inflammatory activity of fractionated extracts of Salvia officinalis. *Journal of Applied Pharmaceutical Science*, 30,67-71.

Dalvi, A., Bargir, U.A., Natraj, G., Shah, I., Madkaikar, M. (2024). Diagnosis and Management of Infections in Patients with Mendelian Susceptibility toMycobacterial Disease. *Pathogens,* 25,13(3),203. doi: 10.3390/pathogens13030203.

de Lange, K.M., Barrett, J.C. (2015). Understanding inflammatorybowel disease via immunogenetics. *J. Autoimmun*, 64, 91–100.

Dhawan, N.G., Ambrina, S.K., Prateek, S. (2013). A general appraisal of Leonotis nepetifolia (L.) R. Br: An essential medicinal plant. *Env. Pharmacol. Life Sci*., 2(8),118-121.

Dhayalan, M., Anitha Jegadeeshwari, L., Nagendra Gandhi N. (2015). Biological activity sources from traditionally usedtribe and herbal plants material. *Asian Journal of Pharmaceutical and Clinical Research*, 8(6), 11–23.

Do, M.H., Choi, J.,Kim, Y.,Park, H.Y., Ha, S.K., Hur, J. (2019). Schizonepeta tenuifolia reduces methylglyoxal-induced cytotoxicity and oxidative stress in mesangial cells. *J. Funct. Food.*, 62, 103531. doi: 10.17221/504/2015-CJFS.

Dong, A. X., Xin, H. B., Li, Z. J., Liu, H., Sun, Y. Q., Nie, S.; Zhao, Z. N., Cui, R. et al. (2018). High Quality Assembly of the Reference Genome for Scarlet Sage, Salvia Splendens, an Economically Important Ornamental Plant. *Giga Science*7, giy068. doi: 10.1093/gigascience/giy068.

Draginic, N, Andjic, M., Jeremic, J., Zivkovic, V., Kocovic, A., Tomovic, M., Bozin, B., Kladar, N., et al. (2022). Anti-inflammatory and antioxidant effects of Melissa officinalis extracts: A comparative study. Iran J Pharm Res. ,5, 21(1), e126561. doi: 10.5812/ijpr-126561.

Dudareva, N., Klempien, A., Muhlemann, J.K., Kaplan, I. (2013). Biosynthesis, Function and Metabolic Engineering of Plant Volatile Organic Compounds. *New Phytol*., 198(1):16-32. doi: 10.1111/nph.12145.

Eftekhar, N., Moghimi, A., Mohammadian Roshan, N., Saadat, S., Boskabady, M.H. (2019). Immunomodulatory and anti-inflammatory effects of hydro-ethanolic extract of Ocimum basilicum leaves and its effect on lung pathological changes in an ovalbumin-induced rat model of asthma. *BMC complementary and alternative medicine*, 4;19(1):349. doi: 10.1186/s1290601927654.

Ek, W.E., D'Amato,M., Halfvarson,J.(2014).The history of genetics in inflammatory bowel disease.*Annals Gastro*, 27,294–303.

El-Ansari, M.A., Aboutabl, E.A., Farrag, A.R., Sharaf, M., Hawas, U.W., Soliman, G.M., El-Seed,G.S.(2009).Phytochemical andpharmacological studies on Leonotis leonurus. *Pharmaceutical biology*, 47(9):894-902. DOI:10.1080/13880200902942428.

Elpel, T. J. (1998). *Botany in a day: Thomas J. Elpel's herbal field guide to plant families.* 3rd ed. Hollowtop Outdoor Primitive School. Edition 6.2, October 2021.

Erfanian, N., Fazlpour, F., Safarpour, H., Askari, S.F., Foadoddini, M., Nasseri, S. (2024). Exploring the anti-inflammatory effects of Lavandula stoechas L. extract on ovalbumin-induced acute asthma in BALB/c mice. *Avicenna Journal of Phytomedicine*. 15(2):933-942. doi: 10.22038/AJP.2024.25175.

Florez, M.A., Tran, B.T., Wathan, T.K., DeGregori, J., Pietras, E.M., King, K.Y. (2022). Clonal hematopoiesis: Mutation-specific adaptation to environmental change. *Cell Stem Cell.*, 2,29(6),882-904. doi: 10.1016/j.stem.2022.05.006.

Franke, A., McGovern, D.P., Barrett, J.C., Wang, K., Radford Smith, G.L., Ahmad, T, et al. (2010). Genome-wide meta-analysis increases to 71 the number of confirmed Crohn's disease susceptibility loci. *Nat Genet*, 42, 1118–25.

Frezza, C., Venditti,A., Serafini,M., Bianco, A. (2019). Chapter 4 Phytochemistry, Chemotaxonomy, Ethnopharmacology, and Nutraceutics of Lamiaceae. *In Studies in Natural Products Chemistry, Elsevier*, 62, 125–178.

Gatti, L.V., Basso, L.S., Miller, J.B. *et al.* (2021). Amazonia as a carbon source linked to deforestation and climate change. *Nature,* 595, 388–393

Gatti, S., Gelzoni, G., Catassi, G.N., Catassi, C. (2021). The Clinical Spectrum of Inflammatory Bowel Disease Associated with Specific Genetic Syndromes: Two Novel Pediatric Cases and a Systematic Review. Front Pediatr., 26,9,742830. doi: 10.3389/fped.2021.742830.

Ghafari, A.T., Jahidin, A.H., Zakaria, Y. & Hasan, M.H. 2021. phytochemical screening and high-performance thin-layer chromatography of Vitex trifolia leaves hydroalcoholic extract: Potential anti-inflammatory properties. Journal of Pharmaceutical Science International, 33(28A): 111-121. https://doi.org/10.9734/jpri/2021/v33i28A31515.

Ghorbani, A., Esmaeilizadeh, M. (2017). Pharmacological properties of Salvia officinalis and its components. Journal of traditional and complementary medicine, 13, 7(4),433-440. doi: 10.1016/j.jtcme.2016.12.014.

Glocker, E.O., Frede, N., Perro, M., Sebire, N., Elawad, M.,Shah, N., et al. (2010). Infant colitis – it's in the genes. *Lancet* ,376,1272.

Glocker, E.O., Kotlarz, D., Boztug, K., Gertz, E.M., Schäffer, A.A., Noyan, F., et al. (2009). Inflammatory bowel disease and mutations affecting the interleukin-10 receptor. *N Engl J Med*, 361,2033–45.

Hampe, J., Franke, A., Rosenstiel, P., Till, A., Teuber, M., Huse, K., et al. (2007). A genome-wide association scan of nonsynonymous SNPs identifies a susceptibility variant for Crohn disease in ATG16L1. *Nat Genet,* 39, 207–11.

Hanauer, S.B. (2008). Review article: Evolving concepts in treatment and disease modification in ulcerative colitis. *Aliment Pharmacol Ther*.,27,15-21.

Haas, R. A., Crișan, I., Vârban, D., & Vârban, R. (2024). Aerobiology of the Family Lamiaceae: Novel Perspectives with Special Reference to Volatiles Emission. *Plants*, *13*(12), 1687. doi: 10.3390/plants13121687.

Hosseinzadeh, H., Ramezani, M., Salmani, G.A. (2000). Antinociceptive, anti-inflammatory and acute toxicity effects of Zataria multiflora Boiss extracts in mice and rats. Journal of ethnopharmacology, 73(3):379-85. doi: 10.1016/s0378-8741(00)00238-5.

Hu, K., He, H., Yuan, X., Du, X., Liu, R., Yang, P., Yang, Q., Zhang, Y., Qiao, J. (2022). Carboxymethyl Chitosan Oligosaccharide Holds Promise for Treatment of Stenosis Crohn's Disease. *ACS Pharmacol Transl Sci*., 20,5(8), 562-572. doi: 10.1021/acsptsci.2c00035.

Hubbard-Lucey, V.M., Shono, Y., Maurer, K., West, M.L., Singer, N.V., Ziegler, C.G., et al. (2014). Autophagy Gene Atg16l1 Prevents Lethal T Cell Alloreactivity Mediated by Dendritic Cells. *Immunity*, 41,579–91.

Jain, P.L.B., Patel, S.R., Desai, M.A. (2022). Patchouli Oil: An Overview on Extraction Method, Composition and Biological Activities. *J. Essent. Oil Res*., 34, 1–11.

Joossens, M., Huys, G., Cnockaert, M., DePreter, V.,Verbeke, K., et al. (2011). Dysbiosis of the faecal microbiota in patients with Crohn's disease and their unaffected relatives. *Gut*, 60,631–37. doi: 10.1136/gut.2010.223263.

Jordamović, N., Pehlivanović, B., Nikšić, H., Gušić, I., Korić, E., Dedić, M., Tuna-Repovac, B., Bečić, F., Durić, K. (2023). Anti-proliferative and anti-inflammatory activity of triterpene extracts from plant species belonging to Lamiaceae family. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas*, 1, 22 (6).

Kaistha, A., Levine, J. (2014). Inflammatory bowel disease: the classic gastrointestinal autoimmune disease. Current problems in pediatric and adolescent health care, 44(11),328-34.

Kaplan, G.G., Ng, S.C. (2017). Understanding and preventing the global increase of Inflammatory Bowel Disease.*Gastroenterology*,152(2):313-321.e2. doi: 10.1053/j.gastro.2016.10.020.

Kaplan, G.G., Windsor, J.W. (2021). The four epidemiologic stages in the global evolution of inflammatory bowel disease. *Nat Rev Gastroenterol Hepatol*., 18,56–66. doi: 10.1038/s41575-020-00360-x.

Kavitha, T., Nelson, R., Thenmozhi, R., Priya, E. (2012). Antimicrobial activity and phytochemical analysis of Anisomeles malabarica (L.). R.Br. J. Microbiol.Biotech, 2(1),1-5.

Kelayeh, T.P., Abedinzade, M., Ghorbani, A. (2019). A review on biological effects of Lamium album (white dead nettle) and its components. Journal of Herbmed Pharmacology, 9,8(3),185-193.

Kenny, E.E., Pe'er, I., Karban, A., et al. (2012). A genome-wide scan of Ashkenazi Jewish Crohn's disease suggests novel susceptibility loci. *PLoS Genet* ,8: e1002559.

Kigathi, R.N., Weisser, W.W., Reichelt, M., Gershenzon, J., Unsicker, S.B. (2019). Plant Volatile Emission Depends on the Species Composition of the Neighboring Plant Community. *BMC Plant Biol*. 6;19(1):58. doi: 10.1186/s12870-018-1541-9.

Nayak, B., & Kumar, A. (2017). Activity of leukotrienes in inflammation. *Eur J Pharm And Med Res*, 4, 207-15.

Lamb, C.A., Kennedy, N.A., Raine, T., et al. (2019). British Society of Gastroenterology consensus guidelines on the management of inflammatory bowel disease in adults. Gut, 68, 68(Suppl 3): s1-s106. doi: 10.1136/gutjnl-2019-318484.

Larussa, T., Imeneo, M., Luzza, F. (2017). Potential role of nutraceutical compounds in inflammatory bowel disease. *World J. Gastroenterol*., 23, 2483–2492.

Lassen, K.G., Kuballa. P., Conway, K.L., et al. (2014). Atg16L1 T300A variant decreases selective autophagy resulting in altered cytokine signaling and decreased antibacterial defense. *Proc Natl Acad Sci U S A*,111,7741–7746. doi: 10.1073/pnas.1407001111.

Lee, J.K., Song, Y.K., Lim, H.H. (2007). Analgesic and anti-inflammatory effect of Scutellaria baicalensis. *The Journal of Korean Medicine*,28(4),124-35.

Lengbiye, E.M., Messi, L.M., Rasoazanany, E.O., Luyeye, F.L., Mbing, J.N., Kapepula, P.M., Ngombe, N.K., et al. (2020). Microscopic Studies, Mineral composition and Bioactivity of Vitex madiensis Oliv.(Lamiaceae). *Discovery Phytomedicine*,7(4),177-85.

Liu, J.Z., Van Sommeren, S., Huang, H., Ng, S.C., Alberts, R., Takahashi, A., Ripke, S., Lee, J.C., Jostins, L., Shah, T., et al. (2015). Association analyses identify 38 susceptibility loci for inflammatory bowel disease and highlight shared genetic risk across populations. *Nat. Genet.*, 47, 979–986.

Loreto, F., Pollastri, S., Fineschi, S., Velikova, V. (2014). Volatile Isoprenoids and Their Importance for Protection against Environmental Constraints in the Mediterranean Area. *Environ. Exp. Bot*., 103, 99–106.

Machiels, K., Joossens, M., Sabino, J., De Preter, V., Arijs, I., et al. (2014). A decrease of the butyrate-producing species Roseburia hominis and Faecalibacterium prausnitzii defines dysbiosis in patients with ulcerative colitis. *Gut* ,63,1275–83. doi: 10.1136/gutjnl-2013-304833.

Mamootil, D. (2023). Pediatric Ulcerative Colitis in Siblings. *Cureus*, 22, 15(6),e40829. doi: 10.7759/cureus.40829.

Mansourabadi, A.M., Sadeghi, H.M., Razavi, N., Rezvani, E. (2015). Anti-inflammatory and analgesic properties of salvigenin, Salvia officinalis flavonoid extracted. *Adv Herb Med.*, 1(3): 31-41.

Maphosa, V., Adedapo, A.A., Moyo, B., Masika, P.J. (2012). Anti-inflammatory and analgesic activities of the aqueous extract of Leonotis leonurus leaves in rats. *African Journal of Biotechnology*,11(26),6878-83.

Marchiando, A.M., Ramanan, D., Ding, Y., Gomez, L.E.,Hubbard-Lucey, V.M., Maurer, K., et al.(2013). A deficiency in the autophagy gene Atg16L1 enhances resistance to enteric bacterial infection. *Cell Host Microbe*, 14,216–24.

Marcuzzi, A., Bianco, A.M., Girardelli, M., Tommasini, A., Martelossi, S., Monasta, L., et al. (2013). Genetic and functional profiling of Crohn's disease: autophagy mechanism and susceptibility to infectious diseases. BioMed research international,2013,297501.

Mc Govern, D.P., Jones, M.R., Taylor, K.D., et al. (2010). Fucosyltransferase 2 (FUT2) non-secretor status is associated with Crohn's disease. *Hum Mol Genet*,19,3468–3476.

Mi, Y., Tan, Y., Yu, Y. *et al*. (2025). Relationship between smoking status and ulcerative colitis: a meta-analysis based on a case control study. *Sci Rep*, 15, 13329.

Milevskaya, V.V., Prasad, S., Temerdashev, Z.A. (2019). Extraction and Chromatographic Determination of Phenolic Compounds from Medicinal Herbs in the Lamiaceae and Hypericaceae Families: A Review. *Microchem. J.*, 145, 1036–1049.

Miranda-Bautista, J., Padilla-Suarez, C., Bouza, E., Munoz, P., Menchen, L., Marin-Jimenez, I. (2014). Listeria monocytogenes infection in inflammatory bowel disease patients: case series and review of the literature. European journal of gastroenterology & hepatology,26(11),1247-1252.

Mohammadi, F., Rahimi, K., Ahmadi, A., Hooshmandi, Z., Amini, S., Mohammadi, A. (2024). Anti-inflammatory effects of Mentha pulegium L. extract on human peripheral blood mononuclear cells are mediated by TLR-4 and NF-κB suppression. *Heliyon*, 4;10(1): e24040. doi: 10.1016/j.heliyon.2024.e24040.

Mohanta, O., Das, P.K., Panda, S.S. *et al.* (2025). Anti-inflammatory activity of *Leonotis nepetifolia* leaf essential oil in LPS-stimulated RAW 264.7 cells and its molecular mechanism of action. *Sci Rep* 15, 32978

Murthy, A., Li, Y., Peng, I., et al. (2014). A Crohn's disease variant in Atg16l1 enhances its degradation by caspase 3. *Nature*, 506,456–462. doi: 10.1038/nature13044. https://pubmed.ncbi.nlm.nih.gov/24553140

Napoli, E., Ruberto, G., Carrubba, A., Sarno, M., Muscarà, C., Speciale, A., Cristani, M., Cimino, F., Saija, A. (2022). Phenolic profiles, antioxidant and anti-inflammatory activities of hydrodistillation wastewaters from five Lamiaceae species. *Molecules*, 1,27(21),7427.

Ng, S.C., Bernstein CN, Vatn MH, Kakatos PL, Loftus EV, Tysk C, et al. (2013). Geographic variability and environmental risk factors in inflammatory bowel disease. *Gut.*, 62,630–49. doi: 10.1136/gutjnl-2012-303661.

Nicolas, M., Lasalo, M., Chow, S., Antheaume, C., Huet, K., Hnawia, E., Guillemin, G.J., Nour, M., Matsui, M. (2023). Anti-inflammatory activities of Coleus forsteri (formerly Plectranthus forsteri) extracts on human macrophages and chemical characterization. *Frontiers in Pharmacology*, 9;13:1081310. doi: 10.3389/fphar.2022.1081310.

Nielsen, H., Engberg, J., Ejlertsen, T., Bücker, R., Nielsen, H. (2012). Short-term and medium-term clinical outcomes of Campylobacter concisus infection. *Clinical Microbiology and Infection,* 18(11), E459-E65.

Nieto, G. (2017). Biological activities of three essential oils of the Lamiaceae family," Medicines, 23;4(3):63. doi: 10.3390/medicines4030063.

Nsonde Ntandou, G.F., Dianzitoukoulou Matsima, L.D., Ingabire, J., Makemba Nkounkou, G.S., Nkundineza, J.C., ABENA, A.A. (2020). Anti-Inflammatory and Central Analgesic Effect of the Aqueous Extract of the Leaves of Vitex Madiensis Oliv (Lamiaceae-Viticoïdeae). *Sch Int J Tradit Complement Med*, 3(1), 12-17, doi: 10.36348/sijtcm.2020.v03i01.002.

Ocaña-Fuentes, A., Arranz-Gutiérrez, E., Señorans, F.J., Reglero, G. (2010). Supercritical fluid extraction of oregano (Origanum vulgare) essentials oils: anti-inflammatory properties based on cytokine response on THP-1 macrophages. *Food and Chemical Toxicology*, 48(6):1568-75. doi: 10.1016/j.fct.2010.03.026.

Okoye, F.B., Obonga, W.O., Onyegbule, F.A., Ndu, O.O., Ihekwereme, CP. (2014). Chemical composition and anti-inflammatory activity of essential oils from the leaves of Ocimum basilicum L. and Ocimum gratissimum L.(Lamiaceae). *Int J Pharm Sci Res.*, 1, 5(6), 2174-80. doi:10.13040/IJPSR.0975-8232.5(6).2174-80 .

Oliveira, C.S., Barbosa, F.L., Ehrenfried, C.A., Rodrigues, T.E., Salvador, M.J., Zampronio, A.R., Stefanello, M.É. (2024). Chemical Constituents and Anti-inflammatory, Antinociceptive, and Antioxidant Activities of Salvia melissiflora Aerial Parts. *Revista Brasileira de Farmacognosia*, 34(2), 350-357.

Orlova, E., Yeh, A., Shi, M., Firek, B., Ranganathan, S. et al. (2019). Genetic association and differential expression of PITX2 with acute appendicitis. *Hum Genet*., 138(1), 37-47. doi: 10.1007/s00439-018-1956-2.

Osakabe, N., Yasuda, A., Natsume, M., Yoshikawa,T. (2004). Rosmarinic acid inhibits epidermal inflammatory responses: anticarcinogenic effect of Perilla frutescens extract in the murine two-stage skin model. *Carcinogenesis*, 25(4): 549-57. doi: 10.1093/carcin/bgh034.

Ouakouak, H., Benchikha, N., Hassani, A., Ashour, M. L. (2019). Chemical composition and biological activity of Mentha citrata Ehrh., essential oils growing in southern Algeria. *Journal of Food Science and Technology*, 56 (12), 5346–5353, 2019. doi: 10.1007/s13197-019-04005-z.

Peloquin, J.M., Goel, G., Villablanca, E.J., Xavier, R.J. (2016). Mechanisms of pediatric inflammatory bowel disease. Annu Rev Immunol, 34,31–64. doi: 10.1146/annurev-immunol-032414-112151.

Petersen, A.M., Halkjær, S.I., Gluud, L.L. (2015). Intestinal colonization with phylogenetic group B2 Escherichia coli related to inflammatory bowel disease: a systematic review and meta-analysis. *Scandinavian journal of gastroenterology* ,50(10),1199-207.

Pignatti, S. Flora d'Italia, vol. 2, Edagricole, Bologna, Italy, 1982.

Politeo, O., Bektašević, M., Carev, I., Jurin, M., Roje, M. (2018). Phytochemical composition, antioxidant potential and cholinesterase inhibition potential of extracts from Mentha pulegium L. Chemistry & biodiversity, 15(12), e1800374.

Qnais, E.Y., Abu-Dieyeh, M., Abdulla, F.A., Abdalla, S.S. (2010). The antinociceptive and anti-inflammatory effects of Salvia officinalis leaf aqueous and butanol extracts. Pharmaceutical Biology, 48(10):1149-56. doi: 10.3109/13880200903530763.

Qureshi O, Dua A. (2025). COX Inhibitors. StatPearls. Treasure Island (FL): StatPearls, Available from: https://www.ncbi.nlm.nih.gov/books/NBK549795/

Ramos Da Silva, L.R., Ferreira, O.O., Cruz, J.N.; De Jesus Pereira Franco, C., Oliveira Dos Anjos, T., Cascaes, M.M., Almeida Da Costa, W., et al. (2021). Lamiaceae Essential Oils, Phytochemical Profile, Antioxidant, and Biological Activities. *Evid. Based Complement.* Alternat Med. 2021:6748052. doi: 10.1155/2021/6748052.

Rath, T., Roderfeld, M., Blocher, S., Rhode, A., Basler, T., Akineden, O., et al. (2011). Presence of intestinal Mycobacterium avium subspecies paratuberculosis (MAP) DNA is not associated with altered MMP expression in ulcerative colitis. BMC gastroenterology, 11, 34.

Reshetnyak, V.I., Burmistrov, A.I., Maev, I.V. (2021). Helicobacter pylori: Commensal, symbiont or pathogen? World J Gastroenterol., 21, 27(7), 545-560. doi: 10.3748/wjg.v27.i7.545. https://pubmed.ncbi.nlm.nih.gov/33642828/.

Ricci, E.L., Toyama, D.O., Lago, J.H., Romoff, P., Kirsten, T.B., Reis-Silva, T.M., Bernardi, M.M. (2010). Anti-nociceptive and anti-inflammatory actions of Nepeta cataria L. var. citriodora (Becker) Balb. essential oil in mice. *J Health Sci Inst*., 28(3), 289-93.

Russo, R., Corasantini, M.T., Bagetta, G., Morrone, L.A. (2015). Exploration of Cytotoxicity of Some Essential Oils for Translation in Cancer Therapy. Evid. Based Complement. *Alternat. Med.*, 2015:397821. doi: 10.1155/2015/397821.

Schieffer, K.M., Williams, E.D., Yochum, G.S., Koltun, W.A. (2016). Review article: the pathogenesis of pouchitis. Aliment Pharmacol *Ther*,44(8),817-35. doi: 10.1111/apt.13780.

Şener, K., Ekici, M., Gönülalan, E.M., Bodur, E. (2024). Comparative Study of the Anti-Inflammatory Pathway Enzyme Activities of Selected Plant Extracts from Lamiaceae Family. *Fabad Journal of Pharmaceutical Sciences*, 1,49(1),197-210.

Serrano-Vega, R., Pérez-González, C., Alonso-Castro, Á.J., Zapata-Morales, J.R., Pérez-Gutiérrez, S. (2020). Anti-inflammatory and antinociceptive activities of Salvia keerlii. Pharmacognosy Magazine,16(67). doi:10.4103/pm.pm_223_19. https://phcog.com/article/view/2020/16/67/27-33

Shaw, S.Y., Blanchard, J.F., Bernstein, C.N. (2010). Association between the use of antibiotics in the first year of life and pediatric inflammatory bowel disease. *Am J Gastroenterol*,105(12),2687–92.

SILVA, G.L., Luft, C., Lunardelli, A., Amaral, R.H., MELO DA, Donadio. M.V., Nunes, F.B., et al. (2015). Antioxidant, analgesic and anti-inflammatory effects of lavender essential oil. *Anais da Academia Brasileira de Ciências*, 4,87,1397-1408.

Stange, E.F., Travis, S.P., Vermeire, S., Beglinger, C., Kupcinkas, L., Geboes, K., Barakauskiene, A., Villanacci, V., Von Herbay, A., Warren, B.F., Gasche, C., Tilg, H., et al. (2006). European Crohn's and Colitis Organisation. European evidence based consensus on the diagnosis and management of Crohn's disease: definitions and diagnosis. *Gut*. ,55 Suppl 1(Suppl 1), i1-15. doi: 10.1136/gut.2005.081950a.

Stefanaki, A., van Andel, T. (2021). Chapter 3—Mediterranean Aromatic Herbs and Their Culinary Use. In Aromatic Herbs in Food; Galanakis, C.M., Ed.; Academic Press: Cambridge, MA, USA, pp. 93–121. ISBN 978-0-12-822716-9.

Sykora, J., Pomahacova, R., Kreslova, M., Cvalinova, D., Stych, P., Schwarz, J. (2018). Current global trends in the incidence of pediatric-onset inflammatory bowel disease. *World J Gastro*, 24:2741–63. doi: 10.3748/wjg.v24.i25.2741.

Tae, K.S., Kim, S.J. (2012). Inhibition of iNOS and DNA Oxidation by Methanol Extract of Schizonepeta tenuifolia. Trop. *J. Pharm. Res.*,11, 397–404.

Takeuchi, H., Takahashi-Muto, C., Nagase, M., Kassai, M., Tanaka-Yachi, R., Kiyose, C. (2020). Anti-inflammatory effects of extracts of sweet basil (Ocimum basilicum L.) on a co-culture of 3T3-L1 adipocytes and RAW264. 7macrophages. *Journal of oleo science*, 2,69(5),487-493. doi: 10.5650/jos.ess19321.

Tanko, Y., Magaji,G.M., Yerima,M.,Magaji, R.A., Mohammed,A.(2008). Anti-nociceptive and anti-inflammatory activities of aqueous leaves extract of Ocimum Gratissimum (Labiate) in Rodents. *African Journal of Traditional, Complementary and Alternative Medicines*, 22;5(2):141-6. doi: 10.4314/ajtcam.v5i2.31265.

Thrane, U. (2001). Development in the Taxonomy of Fusarium Species Based on Secondary Metabolites." In Fusarium: Paul E. Nelson memorial symposium, edited by B. A. Summerell. St.Paul, Minnesota: APS Press, 29-49.

Triantafillidis, J.K., Stanciu,C. (2012). Inflammatory bowel disease: etiopathogenesis, diagnosis, treatment. 4th Edition, "Technogramma", 2012 Athens, Greece.

Trouillas, P., Calliste, C.A., Allais, D.P., Simon, A., Marfak, A., Delage, C., Duroux, J.L. (2003). Antioxidant, anti-inflammatory and antiproliferative properties of sixteen water plant extracts used in the Limousin countryside as herbal teas. *Food chemistry*, 1,80(3),399-407.

Tsianos, E.V., Katsanos, K.H., Tsianos, V.E. (2011). Role of genetics in the diagnosis and prognosis of Crohn's disease. World J Gastroenterol. ,17(48),5246-59. doi: 10.3748/wjg.v17.i48.5246. /

Uhlig, H.H., Schwerd, T., Koletzko, S., Shah, N., Kammermeier, J., Elkadri, A., Ouahed, J., Wilson, D.C., Travis, S.P., Turner, D., et al. (2014). The Diagnostic Approach to Monogenic Very Early Onset Inflammatory Bowel Disease. Gastroenterology, 147, 990–1007.e3.

Uritu, C. M., Mihai, C. T., Stanciu, G. D. (2018). Medicinal plants of the family Lamiaceae in pain therapy: A review. *Pain Research and Management*, 8;2018:7801543. doi: 10.1155/2018/7801543.

Valimehr, S., Sanjarian, F., Sabouni, F., Hashemi, H., Sharafi, A. (2015). Anti-inflammatory effects of essential oil, aerial parts and hairy roots extracts of Nepeta pogonosperma on rat brain mixed cells. *Research Journal of Pharmacognosy*, 1,2(4),5-10.

Vohra, S., Punja, S., Jou, H., Schlegelmilch, M., Wilson, B., Spavor, M., Grundy, P., Mackie, A.S., Conway, J., Hartfield, D. (2021). Comparative Effectiveness of Pediatric Integrative Medicine: A Pragmatic Cluster-Controlled Trial. Children (Basel), 20,8(4),311. doi: 10.3390/children8040311.

wildflowers-and-weeds.com/Plant_Families/Lamiaceae.htm

Wang, B.S., Huang, G.J., Tai, H.M., Huang, M.H. (2012). Antioxidant and anti-inflammatory activities of aqueous extracts of Schizonepeta tenuifolia Briq. *Food Chem. Toxicol.*, 50(3-4):526-31. doi: 10.1016/j.fct.2011.12.010.

Wang, X.D., Shi, S.L., Ma, Y.Z. (2022). Determination of essential oil from Scutellaria baicalensis Georgi (Lamiaceae) by GC-MS, and assessment of its insecticidal properties. *Tropical Journal of Pharmaceutical Research*, 10,21(6),1249-54.

Xiao, L., Rao, J.N., Wang, J.Y. (2021). RNA-binding proteins and long noncoding RNAs in intestinal epithelial autophagy and barrier function. *Tissue Barriers*, 3, 9(2), 1895648. doi: 10.1080/21688370.2021.1895648.

Xu, P., Xi, Y., Kim, J.W., Zhang, M., Gao, C., Wang, Y., Xu, M., Wang, X., Ren, S., Yang, D., Wang, Q., Xie, W. (2025). A loss-of-function human ADAR variant activates innate immune response and promotes bowel inflammation. *Nat Commun*., 29,16(1), 8560. doi: 10.1038/s41467-025-63554-4.

Yousuf, P.M., Noba, N.Y., Shohel, M., Bhattacherjee, R., Das, B.K. (2013). Analgesic, anti-inflammatory and antipyretic effect of Mentha spicata (Spearmint). *British Journal of Pharmaceutical Research*, 3(4), 854-64.

Zhang, M., Chen, M., Hou, Y., Fan, C., Wei, H., Shi, L., Ma, G., Zhang, J. (2021). Inflammatory and Cytotoxic Activities of Abietane Terpenoids from Nepeta bracteata Benth. *Molecules*, 15, 26(18), 5603.

Zhao, X., Zhou, M. (2022). Chemical constituents of Schizonepeta tenuifolia Briq. and their pharmacological effects. *Molecules*, 17, 27(16), 5249.

Zhu, Y., Li, X., Chen, J., Chen, T., Shi, Z., Lei, M., Fei, X. (2016). The pentacyclic triterpene lupeol switches M1 macrophages to M2 and ameliorates experimental inflammatory bowel disease. *Int Immunopharmacol*, 30, 74 - 84.

Zuzarte, M., Gonçalves, M.J., Cavaleiro, C., Cruz, M.T., Benzarti, A., Marongiu, B., Maxia, A., Piras, A., Salgueiro, L. (2013). Antifungal and anti-inflammatory potential of Lavandula stoechas and Thymus herba-barona essential oils. *Industrial Crops and Products*, 1, 44, 97-103.