

Phytochemical Profile and Biological Activities of *Malva sylvestris* L. as a Basis for Improving Food Quality: A Review

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Abstract. *Malva sylvestris* L. (common mallow) is a widely distributed traditional edible plant with well-documented ethnomedicinal uses. This review summarizes its phytochemical profile and the associated biological activities. Numerous studies have shown that extracts of *M. sylvestris* L. possess antimicrobial, antioxidant, and anti-inflammatory properties, as well as hepatoprotective and anticancer effects. The rich phytochemical composition and multifunctional properties of mallow make it a promising natural additive for the development of functional foods with enhanced nutritional and biological value, providing beneficial effects on human health. The application of *M. sylvestris* L. in the food industry represents a potential natural alternative for improving product quality, extending shelf life, and supporting overall human health.

1 Introduction

Malvaceae is a family of flowering plants comprising more than 220 genera. The genus *Malva* L. includes approximately 40 species worldwide, of which 13 are distributed in Europe. Many members of this family are of considerable economic importance in the agricultural, textile, food, pharmaceutical, and ornamental sectors. Several species are well known as fiber crops, such as cotton (*Gossypium* spp.) and kenaf (*Hibiscus cannabinus*), whereas others are cultivated as food plants, including okra (*Abelmoschus esculentus*), cacao (*Theobroma cacao*), lime tree (*Tilia* spp.), durian (*Durio zibethinus*), and several edible *Malva* species (*M. parviflora*, *M. sylvestris*, and *M. verticillata*) [1–3].

Malva sylvestris L., commonly known as common mallow in Europe, is an annual or perennial plant that can reach a height exceeding one meter. The species is characterized by bright pink flowers with purple veins and heart-shaped leaves divided into five to seven lobes. It typically grows in moist habitats, such as meadows, salt marshes, and along ditches or riverbanks, and exhibits a high degree of adaptability, thriving under a wide range of soil types, moisture conditions, and pH levels [1, 4].

There is substantial evidence indicating that plants belonging to the family Malvaceae were used as early as prehistoric times. During Late Mesolithic excavations, pollen grains were discovered on human teeth and subsequently identified as *Malva* sp. The presence of this pollen suggests that the plant was either consumed or applied for medicinal purposes [5]. In antiquity, mallow was widely used by the Greeks and Romans for its emollient and laxative properties. All parts of the plant were employed in the preparation of various infusions, decoctions, poultices, liniments, lotions, baths, and gargles. Mallow was also regarded as a

medicinal vegetable and was frequently consumed after boiling, as documented by Theophrastus and Dioscorides (Laguna, 1555). This tradition has persisted to the present day, particularly in Italy, Morocco, and Turkey [3, 6].

In Berendes' (1902) translation of *De Materia Medica* by Dioscorides (Book II, Chapter 144), *Malva sylvestris* L. and *M. rotundifolia* L. were described as beneficial for digestive, urinary, and inflammatory disorders, while topical applications were recommended for the treatment of gingivitis, burns, and wounds [7].

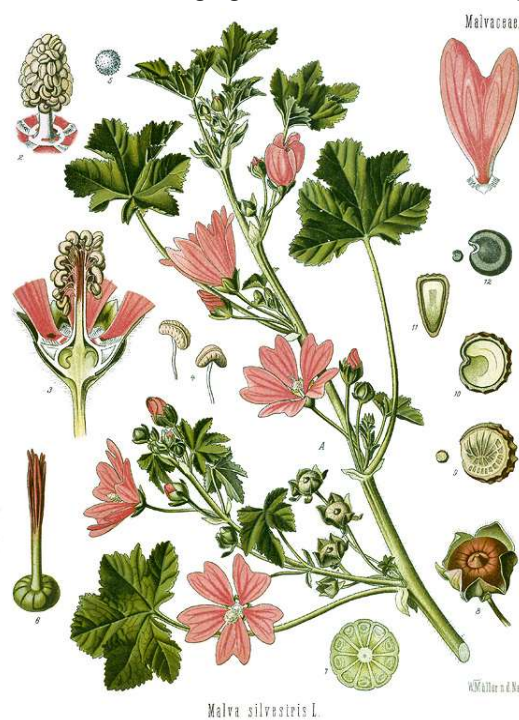


Fig. 1. *Malva sylvestris* in a 19th-century botanical illustration

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In various Mediterranean regions, *Malva* species continue to be widely used in both folk medicine and traditional cuisine. In Sicily and Sardinia, decoctions of *M. sylvestris* and *M. parviflora* are consumed as laxatives and diuretics, whereas cataplasms are applied to ulcers and skin lesions [7]. At present, the young leaves, flowers, and fruits are eaten raw or incorporated into soups, stews, and pastries [3, 8]. In Turkey, *Malva* is commonly prepared with minced meat or cooked in olive oil [8], while in Belarus it is even fermented in sauerkraut [9]. Throughout southern Europe, the fruits are often eaten by children, whereas the leaves are mainly consumed cooked or stewed [2]. *Malva sylvestris* is frequently included in multi-herbal preparations containing two or more plant species [10].

Various traditional culinary preparations—particularly in Middle Eastern regions—include *M. sylvestris* leaves. In general, the plant is used in many areas where leafy vegetables such as spinach, sorrel, and similar greens are commonly consumed [4, 6, 11].

2 Functional food potential

The rich phytochemical profile of *Malva sylvestris*, particularly its high content of polysaccharides, including mucilage, together with potent antioxidants, makes its extracts highly promising ingredients for food supplements and functional foods. The complex physiological processes involved in nutrient absorption within the gastrointestinal tract may benefit from the presence of these bioactive compounds, which can actively modulate digestive interactions and contribute to protection against pathogens and other disease-causing agents [12]. Numerous studies have underscored the significance of *M. sylvestris* as a medicinal herb, while also highlighting its considerable potential as a functional food. This species is regarded as both important and versatile due to its well-documented therapeutic properties, its extensively characterized chemical composition, and its long-standing history of traditional use [2].

Recent research highlights the potential of mallow as a functional ingredient in edible coatings designed to improve food preservation and quality. Extracts from its leaves and flowers, together with polysaccharide mucilage derived from its seeds, have been incorporated into edible coatings applied to bakery and meat products, demonstrating multiple technological and functional benefits [13]. These benefits include reduced moisture loss, improved texture, inhibition of microbial growth, and extension of shelf life. The combination of mallow-derived components with postbiotics or other bioactive agents may further enhance their protective and stabilizing effects. *Malva sylvestris* thus demonstrates considerable potential as a natural preservative when incorporated into or applied to food systems. Its inclusion has been reported to enhance both the safety and sensory attributes of foods, while simultaneously enriching them with beneficial bioactive compounds. These compounds exhibit antioxidant and antimicrobial activities, which can delay microbial proliferation and prevent oxidative deterioration, and

they also increase the functional value of foods by supporting health-promoting effects.

3 Biological activity

Malva sylvestris is among the most extensively studied and frequently cited medicinal herbs in relation to the treatment of respiratory disorders. It has been recognized throughout history for its broad spectrum of therapeutic applications and is sometimes referred to as a “panacea”, reflecting its use across a wide range of ailments. A research team in India has undertaken efforts to establish pharmacopoeial standards for the standardization of this species. The quality, identity, purity, and strength of the powdered material were systematically assessed, and the results were used to define key parameters, such as ash values, solubility in alcohol and water, and successive extractive yields. In addition, qualitative phytochemical screening was conducted to determine major physicochemical characteristics, including total alkaloids, flavonoids, phenols, nitrogen content, lipid content, sterols/terpenes, proteins, and carbohydrates. The study emphasizes the need for comprehensive characterization of this herbal drug to support quality control procedures and regulatory evaluation [14].

Traditionally, mallow has been employed in the treatment of a wide range of infections and diseases. It is commonly used in the management of colds, coughs, tonsillitis, and bronchitis. In the case of digestive disorders, its use is not only traditionally recommended but also supported by veterinary studies. Further research confirms the plant’s beneficial effects on various skin conditions, including eczema, burns, and wound healing processes [15].

A study conducted in Brazil surveyed 333 individuals of different age groups and from multiple regions to determine which medicinal herbs are most frequently used in traditional healing practices and for which symptoms. *Malva sylvestris* was identified as the second most commonly used medicinal plant, particularly for the treatment of toothache, gingival bleeding, sore throat, and the relief of various inflammatory conditions [16].

Aqueous extracts obtained from the aerial parts of *M. sylvestris* are considered effective remedies for inflammatory diseases of mucous membranes, cystitis, and diarrhea. Numerous studies indicate that its therapeutic properties are largely attributable to the presence of mucilage, phenolic compounds, and flavonoids present in both the leaves and flowers [17].

A substantial body of literature reports that common mallow exerts beneficial effects on multiple physiological systems, including the digestive, respiratory, genitourinary, muscular, and skeletal systems. In addition to its internal uses, recent investigations have demonstrated positive effects on various dermatological conditions, such as acne, skin irritation, and minor wounds. It is also widely used as an antiseptic, emollient, and demulcent [3, 6, 7, 10, 18, 19].

Several studies indicate that mallow acts as a mild laxative, diuretic, and hepatoprotective or detoxifying

agent, effects that are primarily attributed to its high polysaccharide content [20]. In Iran, the aerial parts of the plant are used in the form of extracts and tinctures as a febrifuge, for respiratory ailments, as a depurative, and for the treatment of mouth ulcers [18]. In Algeria, the flowers of *Malva sylvestris* are applied topically to treat abscesses, boils, swelling, and insect bites, while infusions are administered internally to relieve abdominal pain, colic, otitis, and asthma [17, 19].

According to several sources, the use of mallow is widespread throughout Spain. Traditionally, it is used to treat coughs, colds, and sore throats, most commonly prepared as an infusion of the flowers, either alone or in combination with *Origanum vulgare* or *Sambucus nigra*. For bronchitis and asthma, a decoction prepared from the leaves is commonly used for steam inhalation. Herbal teas made from the flowers or leaves are also widely consumed, either on their own or mixed with *Chamaemelum nobile* or other local herbs, depending on regional practices and seasonal availability. For skin inflammations, ointments or pomades prepared from the flowers and leaves are typically applied [21].

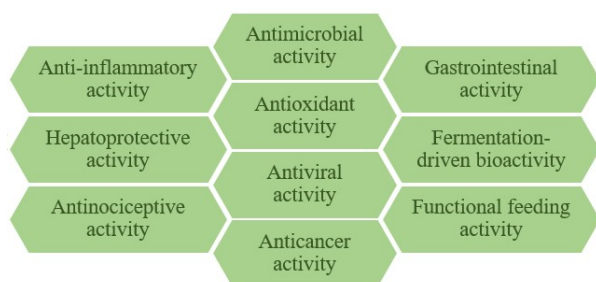


Fig. 2. Biological activities of *Malva sylvestris*

3.1 Antioxidant activity

Antioxidants are essential bioactive compounds, and the consumption of antioxidant-rich foods within a balanced diet is widely associated with the prevention of numerous degenerative diseases. Their beneficial effects are primarily attributed to key constituents such as phenolic compounds, flavonoids, vitamins, terpenoids, minerals, and mucilages. These compounds function as critical defense mechanisms against free radicals, including reactive oxygen species (ROS), which are continuously generated within the human body. It is well established that free radicals and the resulting oxidative stress play a central role in age-related degenerative diseases and are major contributors to the development of cancer. The human body can obtain these important antioxidant compounds through food, dietary supplements, or medicinal preparations [22].

Numerous studies have demonstrated pronounced antioxidant activity in extracts of *Malva sylvestris*, and the range of compounds associated with this activity continues to expand with ongoing research. Comparative analyses between cultivated and wild populations indicate that wild mallow often exhibits higher antioxidant potential [6]. Much of the current research focuses on plant-derived antioxidants due to their greater safety profile and suitability for

incorporation into food systems. In many plant species, the concentration of phenolic compounds with strong free-radical-scavenging capacity plays a crucial role in supporting their application as natural agents for the prevention of oxidative deterioration [1, 6].

The antioxidant and radical-scavenging activities of aqueous extracts of mallow have been consistently confirmed by numerous studies. These investigations have resulted in the isolation and identification of a wide range of phenolic compounds, flavonoids, vitamins, and other biologically active phytochemicals [23-30].

Mallow extract also exhibits a strong protective effect against lipid peroxidation under conditions of elevated oxidative stress, such as those induced by Fenton reagents. In comparative assays with other plant extracts, including *Laurus nobilis* and *Arum italicum*, *Malva sylvestris* consistently demonstrated superior efficacy in inhibiting the formation of reactive oxygen species and preserving unsaturated fatty acids. By effectively preventing lipid degradation, the extract maintains the structural integrity of biomolecules more efficiently than the other extracts evaluated.

This marked stabilizing and antioxidant capacity highlights the potential of mallow as a natural preservative capable of protecting lipid-rich and oxidation-sensitive systems from oxidative damage. Overall, the plant functions not only as a potent antioxidant but also as a protective agent that preserves the quality and functionality of lipid-containing systems under oxidative conditions [31].

Malva sylvestris extract has repeatedly demonstrated strong antioxidant and cytoprotective properties. In a study investigating lithium-induced toxicity, exposure to lithium caused severe oxidative stress in the testes and heart of male rats, as evidenced by increased lipid peroxidation, accumulation of reactive oxygen species, and reduced activity of key antioxidant enzymes. Treatment with mallow extract significantly reduced oxidative stress markers and restored antioxidant enzyme activity. Histopathological analysis further demonstrated that the extract preserved tissue architecture and prevented cellular degeneration in both organs. These protective effects are attributed to the high content of phenolic compounds and flavonoids, which exert potent free-radical-scavenging and membrane-stabilizing effects [32].

In a complementary study on lithium carbonate-induced nephrotoxicity, *Malva sylvestris* extract similarly attenuated renal oxidative stress, normalized serum biomarkers of kidney function, such as creatinine and urea, restored electrolyte homeostasis, and preserved the histological integrity of renal tissue [33]. Taken together, these findings indicate that mallow exerts broad organ-protective effects and underscore its potential as a natural therapeutic agent against lithium-induced oxidative damage.

3.2 Anti-inflammatory activity

The aqueous extract of the aerial parts of *Malva sylvestris* has been investigated for its effects on lipemia, glycemia, inflammation, and gastric ulcers,

using rats as experimental models. The results demonstrated significant anti-inflammatory activity [27, 34]. Similarly, alcoholic extracts of *M. sylvestris* have shown notable anti-inflammatory effects in several studies [35-37].

Among the identified metabolites, anthocyanins - highlighted for their well-known anti-inflammatory properties - were of particular interest. One such compound, malvidin-3-glucoside, was isolated and proposed as a chemical marker of mallow. Subsequent research confirmed that this anthocyanin is capable of inhibiting phospholipase A₂, a key enzyme involved in inflammatory pathways [23].

Furthermore, the literature reports the isolation and identification of several additional classes of metabolites from *M. sylvestris*, many of which have demonstrated significant anti-inflammatory activity [3].

3.3 Anticancer activity

Cancer comprises a broad group of diseases that can affect almost any tissue in the body and continues to represent one of the leading causes of mortality worldwide, according to the World Health Organization (WHO). Although available data remain limited, several reports suggest that *Malva sylvestris* possesses anticancer potential. One study demonstrated the cytotoxic activity of mallow leaf extracts against murine and human cancer cell lines using an MTT assay, revealing a significant reduction in cancer cell proliferation [38].

Another investigation reported comparable cytotoxic effects of the extracts across multiple cancer cell lines [25]. In B16 cells, the extract exhibited pronounced antiproliferative activity, with inhibition rates 61% and 97% higher than those observed in the control, and overall, the flower extract was found to be more effective than the leaf extract.

In recent years, the body of evidence supporting the antiproliferative properties of *M. sylvestris* has continued to expand.

3.4 Hepatoprotective activity

Extracts of *Malva sylvestris* have demonstrated strong hepatoprotective effects against paracetamol-induced liver injury [39]. In this and several subsequent studies, mice and rats were used as experimental models to assess the plant's protective potential under various forms of induced cellular stress. In one model, vanadium exposure was employed to elevate reactive oxygen species (ROS) levels, thereby inducing oxidative stress. A key biomarker of this process is the accumulation of thiobarbituric acid reactive substances (TBARS), formed during lipid peroxidation.

Researchers observed a clear protective effect of mallow decoction against vanadium-induced renal damage. Oral administration of the decoction effectively prevented the increase in TBARS levels, an effect attributed to its high phenolic content and strong antioxidant activity, which together counteracted the resulting nephrotoxicity. These findings strongly

support the potential of *Malva sylvestris* as a valuable therapeutic agent, particularly in models of diabetes and inflammation-induced oxidative stress [40].

Table 1. Ethnomedicinal uses of *Malva sylvestris* extracts

Ethnomedicinal uses	Reference
Weight loss	Boudjelal et al. ^[36]
Respiratory tract disorders, uterus postpartum recovery	Azab ^[60]
Antiseptic, astringent, abdominal pain, colic, otitis, asthma	Boubakr et al. ^[17] Alarcón et al. ^[21] Al-Quran ^[15]
Against constipation, colds, canker sores	Boubakr et al. ^[17] Alarcón et al. ^[21]
Diuretic, against gingivitis, toothache	Leonti et al. ^[7] Oliveira et al. ^[16]

3.5 Wound healing activity

For centuries, *Malva sylvestris* has been traditionally applied topically due to its well-documented wound-healing properties. This activity has been experimentally evaluated using diethyl ether and chloroform extracts of the flowers in Wistar rat models [41]. In both treatment groups, a statistically significant reduction in wound area was observed in comparison with the control group, and rats treated with mallow extracts exhibited faster epithelialization than those treated with a conventional reference drug. Histological analysis further revealed enhanced tissue regeneration in wounds treated with a cold cream formulation containing the plant extract.

Taken together, these findings support the conclusion that *M. sylvestris* promotes wound healing and tissue repair, with particularly pronounced effects compared to other treatment groups. Histopathological evaluation confirmed that the plant significantly enhanced both wound contraction and collagen turnover [29, 42-45].

Several studies have also demonstrated that the flowers of mallow can be effectively utilized in the treatment of wounds, particularly cutaneous injuries and bacterially infected lesions. Reported applications further include inflammatory and dermatological conditions such as eczema, rheumatic inflammation, acne, and minor skin disorders. In addition, subsequent research has explored the plant's systemic effects, highlighting its broad spectrum of biological activities [29, 44].

3.6 Antinociceptive activity

A well-documented study investigated the antinociceptive activity of the aqueous extract of *Malva*

sylvestris using established experimental pain models in mice. The extract elicited pronounced antinociceptive effects, achieving 76.4% inhibition in the writhing test, as well as significant inhibition of both the neurogenic phase (61.8%) and the inflammatory phase (46.6%) in the formalin-induced pain model. These findings suggest that mallow contains bioactive constituents with considerable antinociceptive potential. The proposed mechanism of action appears to be primarily associated with inhibition of the cyclooxygenase (COX) pathway, rather than the activation of opioid receptors [46].

3.7 Antiviral activity

A study investigated dichloromethane extracts of *Malva sylvestris*, from which ten phenolic compounds were isolated and identified. These compounds were evaluated for their potential antiviral properties, with particular focus on NADPH inhibition and inhibition of the SARS-CoV-2 main protease (Mpro; 6LU7). The isolated phytochemicals demonstrated promising activity in molecular docking simulations, suggesting potential inhibitory effects against SARS-CoV-2. These findings provide a foundation for further research on both the crude extract and the isolated compounds, as well as their potential applications in the prevention and treatment of SARS-CoV-2 infection [47].

3.8 Gastrointestinal activity

A study demonstrated that leaf extracts of *Malva sylvestris* exhibit pronounced laxative activity. In a constipation model, the extracts significantly improved intestinal motility, shortened defecation time, and increased defecation frequency. In addition, they enhanced antioxidant status by elevating glutathione levels and reducing oxidative stress. These results indicate that mallow extracts may represent a promising natural agent for supporting digestive function and alleviating constipation [21]. The plant extracts have also demonstrated potential anti-ulcerogenic properties [34].

Clinical evidence suggests that the aqueous extract of the flowers is both effective and safe for the treatment of functional constipation. A placebo-controlled clinical trial reported a significant increase in bowel movement frequency and a reduction in constipation-associated symptoms. Experimental studies in animal models further corroborate these findings, demonstrating that mallow extract enhances gastrointestinal motility, stimulates intestinal water secretion, attenuates oxidative stress, and improves physiological parameters associated with constipation [48].

Despite these encouraging findings, the number of available clinical studies remains limited, and long-term data are lacking. Moreover, the underlying mechanisms of action have not yet been fully elucidated, although the observed effects are most likely attributable to the high content of mucilage, polyphenols, and lignans, which facilitate water retention in the intestines and improve stool consistency.

3.9 Fermentation-driven bioactivity

Extracts of *Malva sylvestris* have been shown to support the growth and metabolic activity of lactic acid bacteria, particularly *Lactiplantibacillus plantarum* 299V, *Pediococcus acidilactici* IRZ12B, and *Lactiacaseibacillus rhamnosus* GG. The bioactive compounds present in the plant - including sugars, phenolic compounds, and other nutrients - create a favorable environment that promotes efficient bacterial proliferation during fermentation. As a result, the fermented extracts exhibit enhanced antioxidant activity and improved antibacterial effects, particularly against *Salmonella enterica* and *Yersinia enterocolitica*.

These findings indicate that common mallow is not only a valuable source of bioactive compounds, but also actively contributes to the efficiency and overall quality of the fermentation process. Nevertheless, further research is required to confirm the associated health benefits of these fermented extracts and to identify the specific bioactive constituents responsible for the observed effects. In addition, optimizing fermentation conditions, enhancing the stability and bioavailability of the plant's compounds, and investigating synergistic combinations with probiotics or prebiotics may further strengthen its potential as a functional food ingredient [49].

Table 2. Medicinal uses of *Malva sylvestris* extracts

Medicinal uses	Reference
Bronchitis and inflammations	Pirbalouti et al.[41]
Wound healing	Pirbalouti et al.[53] Pirbalouti et al.[41] Kovalik[42] Fahimi et al.[29]
Skin injuries, burns, acne, dermatitis, eczema, cut or infected wounds Reduces inflammation, itching, dryness	Barros et al.[6] Pirbalouti et al.[41] Cerbo et al.[13]
Eyes, throat pain, cough Toothache, genital tract	Barros et al.[6] Natnoo et al.[19]
Against gastralgia and as laxative	Dogan et al.[8] Jabria et al.[20]
Stomach, diarrhea pectoral, rheumatism, haemorrhoids, constipation, colitis	Natnoo et al.[19] Barros et al.[6] Pirbalouti et al.[41] Hamed et al.[37] Elsagh et al.[48]

3.10 Functional feeding activity

The incorporation of *Malva sylvestris* extract in aquaculture diets not only provides nutritional benefits but may also enhance food quality along the production chain. Dietary supplementation with the extract improved the quality of rainbow trout flesh by increasing the content of beneficial fatty acids and

antioxidant compounds, thereby enhancing its nutritional value for human consumption. In addition, the extract stimulated the fish immune response by increasing digestive enzyme activity and elevating serum and mucus immunoglobulin levels, resulting in improved health status and greater resistance to pathogens. Overall, supplementation with mallow extract enhances both the nutritional quality of fish meat and the general health of the cultured species [50].

Another study showed that adding *Malva sylvestris* leaf powder to broiler diets, especially at 1.5%, increased average daily gain and improved feed efficiency. These benefits are likely due to positive effects on immunity, antioxidant status, gut microbiology, and intestinal structure, suggesting that mallow can serve as an effective feed supplement [51].

The incorporation of *Malva sylvestris* extracts into functional foods has demonstrated beneficial effects on animal health. Regular supplementation has been shown to improve skin and coat condition, reduce inflammation, and alleviate symptoms such as itching, dryness, and dermal malodor. These effects are likely attributable to the plant's combined antioxidant, anti-inflammatory, and other bioactive properties [13].

3.11 Antimicrobial activity

Various parts of *Malva sylvestris* have been systematically evaluated for their antimicrobial properties, with extracts tested against a wide spectrum of microbial strains. Although some extracts exhibited only minimal antifungal activity, others demonstrated pronounced antibacterial effects, indicating a degree of selective antimicrobial potential.

Overall, the methanolic extracts of *M. sylvestris* exhibited the highest antimicrobial activity, whereas choline chloride-citric acid (NADES) extracts showed moderate to high antibacterial and antifungal effects. In contrast, ethanolic, n-hexane, and dichloromethane extracts displayed low or no antimicrobial activity against the tested microorganisms [4]. The human pathogenic strains employed in the assays included *Staphylococcus aureus*, *Enterococcus faecalis*, *Streptococcus agalactiae*, *Candida kefyr*, and *Candida albicans*. The plant-pathogenic strains included *Erwinia carotovora* and *Sclerotinia sclerotiorum* [52].

Further comprehensive and optimized investigations of *Malva sylvestris* extracts are warranted. In particular, the selection of pathogenic strains should be carefully justified, with emphasis on microorganisms for which preliminary biological activity has been reported. Notably, some studies have indicated that methanolic extracts of mallow exhibit no antibacterial or antifungal activity [54]. To ensure accurate interpretation and avoid potentially misleading conclusions, it is essential to provide a detailed and precise description of the extraction procedures and experimental methodologies employed.

The compiled and systematically organized results of the reviewed studies are summarized in Table 3.

4 Phytochemical composition

Numerous studies have systematically examined different parts of *Malva sylvestris* for their content of total phenols, flavonoids, carotenoids, carbohydrates, and overall antioxidant activity [6, 22, 28, 29, 45, 52, 55–57]. These investigations have employed standardized and well-established analytical methods, including DPPH, FRAP, ABTS, and intracellular ROS-scavenging assays. In addition, several publications have focused on the isolation and identification of individual phytochemical constituents using HPLC, GC-MS, and other advanced chromatographic techniques, leading to the characterization of essential oils, fatty acids, coumarins, and mucilage-related components [1, 2, 6, 58–61].

Inductively coupled plasma-based techniques, including ICP-MS and ICP-OES, as well as various AAS-based methods, have also been applied to determine the micro- and macroelemental composition of *M. sylvestris* leaves [62]. Only a limited number of studies have examined the transfer and accumulation of heavy metals from soil into plant tissues, providing preliminary evidence that mallow may exhibit characteristics of a potential hyperaccumulator species. Additional research addressing the presence of toxic metals suggests that the plant shows a certain degree of tolerance to elevated concentrations of specific elements [63–65].

Most available studies have been performed on *Malva sylvestris* samples obtained from commercial sources, whereas relatively few investigations have examined plant material directly collected from urban or rural environments intended for human consumption. The phytochemical composition of the leaves is the most extensively investigated [6, 22, 45, 55–59], which is expected, given that leaves represent the most accessible and commercially distributed plant part, commonly available in pharmacies and herbal shops.

Following the leaves, a substantial body of research, much of it medically oriented, has focused on the flowers of mallow [2, 6, 22, 52, 55, 57, 58]. Due to their shorter harvesting period and lower biomass yield, studies on flowers remain comparatively limited and are predominantly concentrated within the medical field. Nevertheless, the chemical profiles of leaves and flowers are largely comparable, as they share most of the identified phytochemical constituents.

M. sylvestris also produces fruits that, upon drying, release the plant's seeds. As noted earlier, these seeds have been traditionally consumed raw for centuries [2], making them the third major focus of phytochemical investigations. Some studies have analyzed the entire fruits, whereas others have focused specifically on cleaned and dehulled seeds [1, 6, 55, 70]. Across these investigations, consistently high levels of fatty acids, phytosterols, and saponins have been reported. However, the limited availability of this plant material, together with the practical challenges associated with its collection, remains a significant constraint for potential applications in food or pharmaceutical products.

Table 3. Antimicrobial activity of different *Malva sylvestris* extracts

Microorganism	Extracted part	Effect	Reference
Escherichia coli	Leafs	High antibacterial effects of methanolic extracts No activity for n-hexane and dichloromethane extracts	Razavi et al. ^[4] Memdueva et al. ^[52]
	Flowers	Modest antibacterial effects of NADE extracts No antibacterial effects of ethanolic extracts	
	Roots	High antibacterial effects of NADE extracts No antibacterial effects of ethanolic extracts	Memdueva et al. ^[52]
Staphylococcus aureus (HP)	Leafs	High antibacterial effects of methanolic extracts No activity for n-hexane and dichloromethane extracts	Razavi et al. ^[4]
	Flowers	High antibacterial effects of NADE extracts Low antibacterial effects of ethanolic extracts	Memdueva et al. ^[52]
	Roots	High antibacterial effects of NADE extracts Low antibacterial effects of ethanolic extracts	Memdueva et al. ^[52]
Staphylococcus hominis	Seeds	No activity of methanolic extracts	Kumarasamy et al. ^[54]
Bacillus cereus	Leafs	High antibacterial effects of NADE extracts Low antibacterial effects of ethanolic extracts	Memdueva et al. ^[52]
	Flowers		
	Roots		
Pseudomonas aeruginosa	Leafs	Modest antibacterial effects of extracts Low antibacterial effects of ethanolic extracts	Memdueva et al. ^[52]
	Flowers		
	Roots		
Serratia marcescens	Seeds	No activity of methanolic extracts	Kumarasamy et al. ^[54]
Enterococcus faecalis (HP)	Leafs	High antibacterial effects of methanolic extracts	Razavi et al. ^[4]
	Flowers	No activity for n-hexane and dichloromethane extracts	
Streptococcus agalactiae (HP)	Leafs	High antibacterial effects of methanolic extracts	Razavi et al. ^[4]
	Flowers	No activity for n-hexane and dichloromethane extracts	
Erwinia carotovora (PP)	Leafs	Strong antibacterial effects of methanolic extracts	Razavi et al. ^[4]
	Flowers	No activity for n-hexane and dichloromethane extracts	
Candida kefyr (HP)	Leafs	Modest antifungal activity of methanolic extracts	Razavi et al. ^[4]
	Flowers	No activity for n-hexane and dichloromethane extracts	
Candida albicans (HP)	Leafs	Modest antifungal activity of methanolic extracts	Razavi et al. ^[4]
	Flowers	No activity for n-hexane and dichloromethane extracts	
Aspergillus niger	Leafs	Modest antifungal activity of methanolic extracts No activity for n-hexane and dichloromethane extracts	Razavi et al. ^[4]
	Flowers	High antifungal activity of NADE extracts Low activity for ethanolic extracts	Memdueva et al. ^[52]
	Roots	High antifungal activity of NADE extracts Low activity for ethanolic extracts	Memdueva et al. ^[52]
Penicillium sp.	Leafs	Modest antifungal activity of methanolic extracts	Razavi et al. ^[4]
	Flowers	No activity for n-hexane and dichloromethane extracts	
Penicillium chrysogenum	Leafs	High antifungal activity of NADE extracts Low activity for ethanolic extracts	Memdueva et al. ^[52]
	Flowers		
	Roots		
Sclerotinia sclerotiorum (PP)	Leafs	Modest antifungal activity of methanolic extracts	Razavi et al. ^[4]
	Flowers	No activity for n-hexane and dichloromethane extracts	
Aspergillus flavus	Leafs	Modest antifungal activity of NADE extracts Low activity for ethanolic extracts	Memdueva et al. ^[52]
	Flowers		
	Roots		
Aspergillus ochraceus	Leafs	Low antifungal activity of NADE extracts Low activity for ethanolic extracts	Memdueva et al. ^[52]
	Flowers		
	Roots		
Fusarium oxysporum	Leafs	Low antifungal activity of NADE extracts Low activity for ethanolic extracts	Memdueva et al. ^[52]
	Flowers		
	Roots		
Aspergillus parasiticus	Leafs	Low antifungal activity of NADE extracts Low activity for ethanolic extracts	Memdueva et al. ^[52]
	Flowers		
	Roots		

Information regarding the use of *M. sylvestris* roots—either for food or medicinal purposes—remains scarce, which explains why they have been relatively underinvestigated. The available studies on roots primarily assess total phenols, flavonoids, alkaloids, tannins, and anthocyanins, and are largely comparative in nature, aiming to relate these parameters to those observed in other plant parts [52]. It is anticipated that future research examining the transport of nutrients and pollutants from soil to aerial tissues would provide more comprehensive insights into root composition; however, such data remain limited or largely unavailable at present.

4.1 Carbohydrates

Polysaccharides, a major class of carbohydrates, are widely used in the food industry because they modulate the rheological properties of foods. They serve as thickeners, texture modifiers, stabilizers, and emulsifiers in various applications [45].

The aerial parts of *Malva sylvestris* have been analyzed for their polysaccharide composition. Identified monosaccharides and oligosaccharides include fructose, glucose, sucrose, trehalose, and raffinose [6], as well as arabinose and rhamnose [37, 56]. In addition, uronic acids such as D-galacturonic acid and D-glucuronic acid have also been reported.

4.2 Lipids – fatty acids and phytosterols

4.2.1 Wax compounds

Several wax constituents have been identified in *Malva sylvestris*, including 1-nonadecanol, 1-heptacosanol, heptacosane, octacosane, nonacosane, (12Z)-pentacosene, 1,21-docosadiene, and 6-propyltridecane [2].

4.2.2 Fatty acids

Several studies have identified a wide range of fatty acids in mallow, including capric, lauric, myristic, myristoleic, pentadecanoic, palmitic, palmitoleic, heptadecanoic, stearic, oleic, linoleic, α -linolenic, arachidic, eicosenoic, cis-11,14-eicosadienoic, cis-11,14,17-eicosatrienoic, heneicosanoic, behenic, tricosanoic, lignoceric, caproic, and margaric acids [1, 6], as well as hexadecanoic, tetradecanoic, and dodecanoic acids [2]. Particularly noteworthy are dihydromalvalic acid, dihydrosterculic acid, and malvalic acid - unusual cyclopropenoid fatty acids characteristic of certain *Malvaceae* species. These compounds exhibit unique biochemical properties and may hold biological significance for humans, although their potential effects remain largely unexplored [1, 27].

4.2.3 Phytosterols

Only a limited number of studies have successfully isolated and identified phytosterols in *Malva sylvestris*. Sylvestrosterols A, B, and C appear to be characteristic of *Malva* species and represent a structurally distinct subgroup of phytosterols, contributing not only to the biochemical uniqueness of the plant but also to its potential pharmacological relevance [65]. Other phytosterols identified in *M. sylvestris* include campesterol, stigmasterol, β -sitosterol, γ -sitosterol, fucosterol, gramisterol, cycloartenol, avenasterol, and 9,19-cyclolanostan-3-ol [1].

4.3 Tocopherols

Several studies have confirmed a high tocopherol content in the leaves of mallow, with all four isoforms - α -tocopherol, γ -tocopherol, β -tocopherol, and δ -tocopherol - identified in the species [6].

4.4 Terpenoids

Among the terpenoids isolated and identified from *Malva sylvestris*, several are exceptionally rare and appear to be highly specific to the Malvaceae family. These include malvanoyl glucoside, blumenol A, (6R,7E,9S)-9-hydroxy-4,7-megastigmadien-3-one, dihydroactinidiolide, (3S,5R,6S,7E,9R)-5,6-epoxy-3,9-dihydroxy-7-megastigmene, (3R,7E)-3-hydroxy-5,7-megastigmadien-9-one, (3S,5R,6R,7E,9R)-3,5,6,9-tetrahydroxy-7-megastigmene, (+)-dehydrovomifoliol [6, 66, 67]. These compounds exhibit notable biological activity and are of particular relevance to the pharmacological profile of the species.

Other terpenoids commonly encountered in medicinal plants have also been identified in *M. sylvestris*, including caryophyll-4(12),8(13)-dien-5 α -ol, epi- α -cadinol, eudesmol, τ -muurolol, α -bisabolol oxide A, (E,E)-geranyl linalool, β -damascenone, camphor, menthone, linalool acetate, globulol, α -humulene epoxide II, and ar-curcumenone [2].

4.4.1 Saponins

In *Malva sylvestris*, the saponins Sylvestrogenin A, B and C have been isolated. These compounds are rare and appear to be specific to this plant genus. Beyond their expected biological activities, they have also demonstrated measurable cytotoxic effects [65].

4.4.2 Carotenoids

In *Malva sylvestris*, the carotenoids identified include cryptoxanthin, violaxanthin and carotene [60], as well as the apocarotenoid derivative (3R,7E)-3-hydroxy-5,7-megastigmadien-9-one [25].

4.4.3 Essential oils

According to Gasparetto et al. [11], the fatty acid fraction of *Malva sylvestris* consists predominantly of

palmitic acid (26.6%), oleic acid (23%), malvalic acid (11%), lauric acid (15.6%), myristic acid (6.6%), stearic acid (5.6%), palmitoleic acid (5.6%), linoleic acid (4%) and vernolic acid (1.6%), with stearic acid also present in trace amounts.

Usami et al. [2] identified 143 compounds in the flowers of *Malva sylvestris* using GC-MS analysis. The major constituents of the essential oil were hexadecanoic acid (10.55%), 2-methoxy-4-vinylphenol (6.24%) and pentacosane (5.18%). The essential oil composition consisted of hydrocarbons (25.4%), alcohols (18.78%), acids (16.66%), ethers (5.01%), ketones (7.28%), esters (12.43%), aldehydes (2.30%) and minor components (2.00%). The floral aroma was attributed primarily to α -copaene, phenylethyl alcohol, terpinen-4-ol, phenylacetaldehyde, decanal, 1-(2-methylene-3-butenyl)-1-(methylenepropyl)-cyclopropane and β -damascenone, the latter being identified as a key aroma-active compound.

In addition, the authors identified a broad range of volatile compounds in the essential oil of *Malva sylvestris*, including monoterpenes, sesquiterpenes, alcohols, aldehydes, ketones, hydrocarbons and aromatic derivatives. Among the major constituents were linalool, menthol, borneol, carvacrol, 2-methoxy-4-vinylphenol, caryophyll-4(12),8(13)-dien-5 α -ol, epi- α -cadinol, eudesmol, τ -muurolol, acorenone, α -bisabolol oxide A, (E,E)-geranyl linalool, phytol, β -farnesene, aromadendrene, epi- β -caryophyllene, β -selinene, α -muurolene, β -bisabolene, δ -cadinene, caryophyllene oxide, Z-muurola-4(14),5-diene, α -calacorene, β -atlantol, pentadecane, 1-hexadecene, hexadecane, furfural, 2-pentylfuran, limonene, phenylacetaldehyde, (E)- β -ocimene, nonanal, phenylethyl alcohol, camphor, lilac aldehyde, terpinen-4-ol, decanal, 2,3-dihydrobenzofuran, α -copaene, β -damascenone, (E)- β -ionone and pentacosane [2].

4.4.4 Pigments

The chlorophylls identified - chlorophyll a and chlorophyll b - are the primary photosynthetic pigments in plants, responsible for light absorption and the conversion of radiant energy during photosynthesis. Xanthophylls, meanwhile, play a key role in photoprotection by dissipating excess light energy and preventing oxidative damage to plant tissues [28, 60].

4.5 Phenolic compounds

Phenolic compounds are secondary metabolites of plant origin that include flavonoids, phenolic acids, tannins, coumarins, and related classes of compounds. In plants, they fulfill essential protective functions, contributing to defense against ultraviolet radiation, pathogens, insects, and oxidative stress. Numerous studies have documented elevated levels of phenolic compounds in both the leaves and flowers of *Malva sylvestris*. The plant is particularly rich in flavonoids, such as quercetin, kaempferol, and myricetin; phenolic acids, including caffeic and chlorogenic acids; coumarins, such as scopoletin; and several additional bioactive constituents

[2, 58, 67, 68]. These compounds significantly contribute to the plant's pronounced antioxidant capacity and its ability to scavenge free radicals. When consumed, the phenolic constituents present in *M. sylvestris* may contribute to the reduction of oxidative stress, support immune function, promote cardiovascular health, and exert anti-inflammatory effects. In addition, they can influence sensory characteristics, imparting mild bitterness or astringency, and enhance the stability of food products during storage.

4.5.1 Flavonoids

Flavonoids in *Malva sylvestris* are found predominantly in the flowers, with anthocyanins - particularly malvidin 3,5-diglucoside (malvin) - being especially abundant [69]. Flavonols such as quercetin and kaempferol are also common, as is typical for members of the Malvaceae family [68].

Several large-scale phytochemical studies have identified a wide range of flavonoid compounds, including:

- Glycosylated gossypetin derivatives: gossypetin 3-O- β -D-glucopyranosyl-8-O- β -D-glucuronopyranoside; gossypetin 3-glucoside-8-glucuronide.
- Hypolaetin derivatives: hypolaetin 4'-methyl ether 8-glucuronide [58], hypolaetin-3-sulfate, hypolaetin-4-methyl-ether, hypolaetin-8-O- β -D-glucuronopyranoside [68].
- Other flavonoids and anthocyanins: quercetin, rutin [62], gossypin, malvidin, delphinidin, genistein, myricetin, leucoanthocyanins, cyanidin, petunidin, and various apigenin derivatives.
- Anthocyanin glycosides: malvidin 3,5-diglucoside, malvidin 3-O-glucoside, delphinidin 3-O-glucoside, malvidin 3-O-(6'-O-malonylglucoside)-5-O-glucoside [68].
- Additional glucuronide/glycoside derivatives: 3-O- β -D-glucopyranosyl-8-O- β -D-glucuronopyranoside, isoscutellarein-8-O- β -D-glucuronopyranoside [68].

These findings highlight the remarkable diversity of flavonoids present in *M. sylvestris*, particularly in its flowers, contributing to its broad pharmacological and antioxidant profile.

4.5.2 Simple phenols

Among the simple phenols, several compounds have been isolated and identified in *Malva sylvestris*, including caffeic acid, chlorogenic acid, p-coumaric acid, 4-hydroxybenzoic acid, 4-methoxybenzoic acid, 4-hydroxy-3-methoxybenzoic acid, 4-hydroxy-3-methoxydihydrocinnamic acid, ferulic acid, methyl 2-hydroxydihydrocinnamate, n-trans-feruloyl tyramine, rosmarinic acid, 4-hydroxybenzyl alcohol, and tyrosol [25, 58, 67]. Additionally, eugenol, methyl eugenol, and 2,6-dimethoxyphenol have also been identified [2].

4.5.3 Tannins and coumarins

Among the tannin compounds, only tannic acid has been isolated from *Malva sylvestris* [28, 58].

Regarding coumarins, the identified compounds include scopoletin [58, 59], malvone A [70], and malvaline. These metabolites exhibit a range of biological activities, including antioxidant, anti-inflammatory and antimicrobial effects, as well as immunomodulatory potential. Some, such as scopoletin, have also been investigated for their possible cardioprotective and hepatoprotective properties [58].

4.6 Alkaloids

Extremely small, and rather exceptional, traces of alkaloids have been detected in the aerial parts of *Malva sylvestris*. This finding is consistent with the plant's long-established use as an edible species [28, 52].

4.7 Mucilages

The antiulcerogenic activity of *Malva sylvestris* may be attributed to its high mucilage content [45]. In modern medicine, mucilage—produced by numerous plant species—is widely employed as an excipient in pharmaceutical formulations and consists primarily of sugar and uronic acid units. These pharmaceutically relevant polysaccharides exhibit a broad spectrum of functional applications, serving as water-retention agents, thickeners, binders, emulsion stabilizers, disintegrants, suspending agents, gelling agents, and film-forming materials. Owing to these versatile properties, mucilages have been successfully utilized for many years in both the food and pharmaceutical industries [70].

The water-soluble mucilage isolated from the leaves of *Malva sylvestris* is a high-molecular-weight acidic polysaccharide with an approximate molecular mass of 6.0×10^6 Da. The polymer consists predominantly of neutral and uronic sugars, including L-rhamnose, D-galactose, D-galacturonic acid, and D-glucuronic acid. Structural analyses indicate that the polysaccharide backbone is primarily composed of 1,2-linked and 1,4-linked α -L-rhamnopyranose residues, some of which bear side chains at position 4. These branches include β -(1 \rightarrow 4)-linked D-galactopyranose, as well as terminal β -D-galactopyranose and β -D-glucuronic acid units. The repeating unit is characterized by the sequence (1 \rightarrow 4)-[β -D-glucuronic acid-(1 \rightarrow 3)- β -D-galactose]- α -L-rhamnose.

The mucilage contains approximately 94% carbohydrate and a minor peptide fraction (~5%). Its acidic and highly branched structure contributes to the observed anti-complementary activity [61]. The high mucilage content may also contribute to the plant's laxative properties.

4.8 Other compounds

The isolated compound identified as 2-methyl-3-methoxy-5,6-dihydroxy-1,4-naphthoquinone (malvone

A) is a phytoalexin—an antimicrobial metabolite produced by plants in response to pathogen attack [66].

Niacin (vitamin B₃) is a water-soluble vitamin that plays a key role in energy metabolism and supports the proper functioning of the nervous and digestive systems, as well as skin health. Vitamin B₃ has been detected in the leaves of *Malva sylvestris* [28].

Thiamin (vitamin B₁) and riboflavin (vitamin B₂) are also present in the plant [28]. When consumed through food, these vitamins contribute to human health by supporting energy production, nervous system function and cellular protection.

Ascorbic acid is found in high concentrations in various parts of mallow. Vitamin C is a water-soluble antioxidant that protects plant cells from oxidative stress and supports growth and defense mechanisms. In humans, it is essential for collagen synthesis, immune function and wound healing [6, 28, 55, 57].

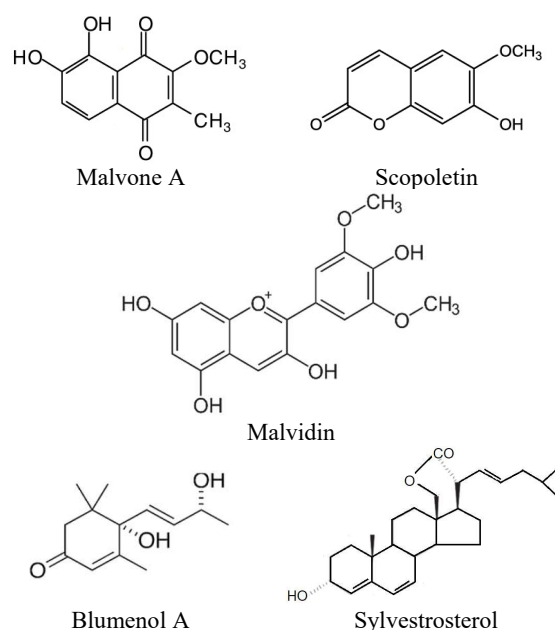


Fig. 4. Selected phytochemical compounds isolated from *M. sylvestris* that are characteristic of the Malvaceae family

5 Micro- and macroelements

The leaves of *Malva sylvestris* are the most extensively investigated plant part, as they are widely consumed as food and are the most readily accessible for collection and commercial use. Nevertheless, relatively few studies have assessed their macro- and microelement composition. Only two studies analyzed plants collected from specific geographical locations [66], whereas all other investigations examined material obtained from commercial sources [62].

Malva sylvestris was identified as one of the dominant wild plant species growing near uncontrolled waste dumps in the Mostaganem region of Algeria [63]. The plant was analyzed to evaluate its capacity for heavy metal accumulation and its potential use as a bioindicator of soil contamination. The results demonstrated that mallow accumulated measurable

concentrations of several metals, including Fe, Zn, Cu, Pb, and Cd. Among these, Fe and Zn were present at the highest levels, whereas Pb and Cd were detected in lower, but still significant, concentrations.

The calculated bioaccumulation factors indicated that mallow possesses a moderate capacity to absorb and retain metals, particularly essential micronutrients such as Fe and Zn, while also being capable of accumulating potentially toxic elements when they occur at elevated concentrations.

Overall, the authors concluded that *M. sylvestris* can serve as a reliable bioindicator for monitoring heavy metal pollution in terrestrial ecosystems. However, because the plant is sometimes used for food or medicinal purposes, elevated levels of accumulated metals may pose a health risk. This underscores the importance of regular environmental monitoring and the implementation of effective pollution control measures in affected areas [63].

Several researchers have investigated the potential of mallow to accumulate or adsorb toxic metals. Two studies demonstrated that plant powder (MSP) acts as an effective natural adsorbent for the removal of Hg^{2+} ions from aqueous solutions. The first study reported that MSP, either alone or in combination with charcoal, can efficiently adsorb mercury, with adsorption capacity influenced by factors such as pH and adsorbent dosage. The second study confirmed that MSP is effective not only in freshwater but also in seawater, highlighting its versatility [64]. Collectively, these findings indicate that MSP is a low-cost, environmentally friendly material with strong potential for mercury removal from water.

6 Conclusions

Malva sylvestris is an important and versatile plant owing to its extensive traditional and medicinal uses. The evidence summarized in this review demonstrates that mallow exhibits a broad spectrum of biological activities, making it a promising candidate for exploration in both pharmaceutical applications and functional food development. A diverse array of phytochemicals has been identified in extracts of *M. sylvestris*, including polysaccharides; coumarins; anthocyanins such as malvin and malvidin 3-(6"-malonylglucoside)-5-glucoside, malvone A (2-methyl-3-methoxy-5,6-dihydroxy-1,4-naphthoquinone), malvaline, scopoletin, polyphenols, folic acid, vitamins A, C, E, and several B-group vitamins, as well as tannins. Collectively, these compounds contribute to the plant's extensive range of biological activities.

Therefore, common mallow can be regarded as a traditionally used and clinically supported species with well-documented therapeutic potential and demonstrated efficacy.

Malva sylvestris exhibits clear potential for use as a functional food. Its leaves and flowers are rich in phenolic compounds, flavonoids, mucilages, and other bioactive constituents that display strong antioxidant and anti-inflammatory activities, helping to protect biomolecules and modulate metabolic pathways relevant to human health.

Further research is warranted to explore its preservative properties, as the plant's antioxidant profile suggests that it may contribute to extending the shelf life of foods into which it is incorporated. Clinical and experimental evidence also supports its dietary use. Standardized extract preparations have been shown to enhance intestinal function by increasing bowel movement frequency and improving stool consistency when used as a food supplement. These findings demonstrate genuine nutraceutical benefits beyond in vitro antioxidant activity, showing measurable effects in humans and animals.

Metabolomic and phytochemical analyses have identified numerous phenolic compounds and other metabolites likely responsible for these biological activities, providing a mechanistic basis for the plant's functional food potential. Multiple reviews synthesizing ethnobotanical, nutritional, and pharmacological evidence highlight *Malva sylvestris* as a promising candidate for incorporation into functional food and nutraceutical formulations.

Research aimed at identifying the active compounds responsible for these bioactivities could contribute to the discovery of new therapeutic agents. However, studies investigating the incorporation of *M. sylvestris* into food products—whether to enhance nutritional value, extend shelf life, or modify texture and flavor—remain extremely limited, highlighting the need for further investigation in this area.

Despite the promising bioactive properties of *Malva sylvestris* for use in functional foods, there is a notable lack of microbiological studies on food products containing this plant. The introduction of new or previously untested ingredients into food matrices can alter their microbiological profile, potentially affecting safety and shelf life, even in products that were well-characterized prior to enrichment. Therefore, to fully assess the suitability of mallow as a functional food ingredient, comprehensive studies are required to evaluate its impact on the microbiological status, stability, and overall safety of the foods into which it is incorporated. Such investigations will be essential to support its application in the development of nutritionally enhanced and microbiologically safe food products.

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