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Phytopharmacology and Helicobacter pylori: A Narrative Review of the Most Important Medicinal Plants with Anti-Helicobacter pylori Activity

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ABSTRACT

Background: *Helicobacter pylori* is one of the most common pathogenic bacteria in the human gastrointestinal tract, which is associated with chronic gastritis, peptic ulcers, and an increased risk of gastric carcinoma. The decrease in the effectiveness of standard treatments due to antibiotic resistance, side effects, and patient non-adherence has attracted researchers' attention to the use of medicinal plants and phytochemical compounds. This study aimed to narratively review the most important medicinal plants with anti-*H. pylori* effects.

Materials & Methods: In this review, PubMed, Scopus, Web of Science, Google Scholar, and SID databases were searched without time limits until 2025. The keywords "*Helicobacter pylori*", "medicinal plants", "phytopharmacology", "anti-*H. pylori* activity" and their Persian equivalents were used.

Findings: Based on the findings, several Iranian and non-Iranian medicinal plants have significant inhibitory activity against *H. pylori*. The most important of them are *Thymus kotschyanus, Terminalia chebula, Scrophularia striata, T. caramanicus, Commiphora myrrha, Punica granatum,* and *Origanum syriacum*.

Conclusion: The present review suggests that medicinal plants and their active metabolites could be considered as potential complementary or alternative options for the treatment of *H. pylori* infection, especially in the era of increasing drug resistance. However, further studies are necessary to determine their dosage, safety, pharmacokinetics, and synergistic effects with standard treatments before entering the clinical stage.

Keywords: *Helicobacter pylori*, Phytopharmacology, Medicinal plants, Phytochemicals, Antibiotic resistance, Anti-*H. pylori*

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Introduction

Helicobacter pylori (H. pylori) infection is one of the most common bacterial infections in humans, recognized as a major cause of many gastrointestinal diseases, including chronic gastritis, gastric and duodenal ulcers, and ultimately gastric cancer [1]. This bacterium affects approximately half of the world's population and remains asymptomatic in most individuals [2]; however, in some patients, the infection could cause symptoms such as stomach pain or heartburn, nausea, loss of appetite, bloating, and unintentional weight loss [3].

H. pylori is involved in the development of diseases such as acute and chronic gastritis, atrophic gastritis, peptic ulcers, and gastric adenocarcinoma by causing inflammatory changes in the gastric mucosa [4].

Epidemiological studies have indicated that in populations with a prevalence of approximately 50%, nearly 75% of noncardia gastric cancer cases are directly attributable to this infection [5].

The ability of *H. pylori* to survive in the acidic environment of the stomach and adhere to epithelial cells causes chronic inflammation of the gastric mucosa, and the production of CagA and VacA toxins causes cellular damage, peptic ulcers, and precancerous changes [6]. In addition to gastrointestinal effects, this infection is also associated with systemic disorders such as iron deficiency anemia and cardiovascular diseases [7].

Transmission of *H. pylori* usually occurs through direct contact with saliva, vomit, feces, or consumption of contaminated food and water, which most often occurs during childhood [8]. Risk factors include unhygienic and economically unfavorable living conditions, poor personal hygiene, consumption of restaurant food or contaminated water, family history of peptic ulcers, and smoking [8].

Diagnosis of infection could be made by both noninvasive methods, such as urea breath testing and stool antigen, and invasive methods, including histology and tissue culture, and the decision to test asymptomatic individuals is usually based on the individual's risk level [9].

Given its high global prevalence, significant clinical consequences, and direct association with gastric cancer, identification and optimal management of *H. pylori* is of particular importance [10].

Effective treatment of this infection could reduce the risk of associated diseases and improve hematological and inflammatory markers [11].

Medicinal plants, with a long history of use in the treatment of infectious diseases due to containing bioactive compounds such as flavonoids, tannins, phenols, and essential oils, play an important role in combating *H. pylori* [12]. These compounds act by inhibiting bacterial growth, disrupting cell membranes, inhibiting vital enzymes, and reducing host inflammation, which could help reduce gastric inflammation and prevent peptic ulcers [13, 14]. Plant extracts could be used as a complementary therapy with standard or alternative drugs in cases of drug resistance with fewer side effects than chemical drugs, which justifies the increasing researchers' attention to the phytopharmacology of *H. pylori* [15, 16].

H. pylori infection is one of the most common bacterial infections in humans, which is associated with serious gastrointestinal diseases and gastric cancer. Drug resistance and side effects of chemical treatments have increased the need for safe and effective alternatives. Medicinal plants with their bioactive compounds have the ability to inhibit bacterial growth, reduce inflammation, and prevent peptic ulcers and could be used as a complementary or alternative treatment.

Objectives: The aim of this review was to identify indigenous Iranian medicinal plants used in the treatment of *H. pylori* infection.

Materials and Methods

This study was conducted as a narrative review with a structured and systematic search strategy. A comprehensive literature search was performed in international databases including PubMed, Scopus, Web of Science, and Google Scholar as well as Persian-language databases including SID and Magiran. The search covered all available studies from the database inception until January 15, 2025, which was defined as the final search date.

To enhance search sensitivity and ensure reproducibility, a combination of MeSH terms and free-text keywords was employed, including "*Helicobacter pylori*," "medicinal plants," "herbal extracts," "phytopharmacology," "anti-*Helicobacter* activity," "urease inhibition," and "traditional medicine". Boolean operators (AND, OR, NOT) were applied to refine and optimize the search strategy. All retrieved records were imported into a reference management software, and duplicate studies were removed prior to screening. Study selection was performed in two independent stages: (1) title and abstract screening, and (2) full-text evaluation. Two independent reviewers conducted the screening process, and any disagreements were resolved through discussion or consultation with a third reviewer.

Inclusion criteria: Eligible studies included original research articles with *in vitro*, *in vivo*, or *ex vivo* experimental designs, which investigated the effects of medicinal plants, plant extracts, essential oils, or isolated phytochemicals on *H. pylori*. Studies were included only if they reported quantitative antimicrobial outcomes, such as minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), urease inhibitory activity, and antibiofilm effects, or defined molecular mechanisms of action.

Exclusion criteria: Studies were excluded if they lacked experimental design, did not provide quantitative antimicrobial data, or were non-original publications (e.g., narrative reviews, editorials, letters, conference abstracts without full data). Studies addressing general ethnopharmacological information without direct evaluation of anti-*H. pylori* activity were also excluded.

Data extraction and handling of heterogeneity: Data were extracted independently by two reviewers using a standardized extraction form. Extracted variables included plant species, type of extract or compound, experimental model, dosage, reported outcomes, and proposed mechanisms of action. Due to substantial heterogeneity among studies (including variation in plant species, extraction methods, assay types, and outcome measures such as MIC, inhibition zones, and enzymatic assays), a qualitative synthesis approach was adopted rather than a meta-analysis. Results were grouped and interpreted narratively based on pharmacological mechanisms and study design similarities.

Findings

The results of this review showed that the most potent inhibitors of *H. pylori* included *Thymus kotschyanus, Terminalia chebula, Scrophularia striata, Pistacia vera, Ziziphora tenuior,* and *Commiphora myrrha*, which accounted for the largest inhibition zones (about 30-50 mm).

In terms of minimum inhibitory concentration (MIC), which is an indicator of very high antibacterial potency, species such as *Origanum syriacum* (0.39 µg/mL), *Cymbopogon schoenanthus* ssp*. proximus* (3.9 µg/mL), and *Dianthus* (4 µg/disc) were the most effective. Examination of extraction patterns showed that essential oils and alcoholic extracts, especially in the mint family (*Lamiaceae*), had much stronger performance than aqueous extracts in inhibiting *H. pylori*. Also, the aerial parts of the plants were the most

effective parts used and showed the highest level of antibacterial activity.

Most of the effective plants contained phenolic, flavonoid, and terpenoid compounds, playing a major role in inhibiting bacterial growth. A number of plants such as *Punica granatum, Satureja khuzestanica, Zataria multiflora,* and *Cuminum cyminum* also showed moderate but significant activity against this bacterium. Overall, the findings indicate that the *Lamiaceae* family has the greatest diversity and potency against *H. pylori* and could be considered as a valuable source for the development of herbal medicines for gastric infection. The results are shown in Table 1.

Due to differences in experimental design and methodologies between the studies included in this review, full standardization of the data was not feasible. Therefore, the results were presented using the original units reported in each study, including MIC (µg/mL), MBC, and inhibition zone diameter in the disk diffusion method (µg/disc or mm). Accordingly, direct comparisons between these values should be made with caution.

It is worth noting that these three parameters (MIC, MBC, and inhibition zone diameter) are among the most widely used and important indicators for evaluating antimicrobial activity. Collectively, they provide comprehensive information regarding growth inhibition, bactericidal effects, and overall antibacterial potential of the extracts. Therefore, these parameters are considered scientifically sufficient for the assessment and interpretation of antimicrobial activity.

Data overview and interpretation: The presented dataset indicated that a wide range of medicinal plants belonging to diverse botanical families exhibited anti-*H. pylori* activity, evaluated using parameters such as inhibition zone diameter, MIC, and in some cases, MBC. From a clinical microbiology perspective, these findings reflect a broad but highly heterogeneous antibacterial profile, with substantial variability in extraction methods, plant parts used, and reporting units. Although this heterogeneity limits direct comparisons across studies, the overall evidence clearly demonstrates that medicinal plants, particularly those rich in secondary metabolites, possess significant inhibitory potential against *H. pylori* and may serve as promising sources for the development of novel antimicrobial agents.

Plants with strong anti-*H. pylori* activity: Several plants in the dataset demonstrated strong antibacterial activity, as reflected by notably low MIC values or large inhibition zones. In particular, *O. syriacum* (MIC: 0.39 µg/mL), *C. schoenanthus* (MIC: ~3.9 µg/mL), and *Z. tenuior* (MIC: 31.25 µg/mL) were the most potent candidates. Additionally, *Psidium guajava* exhibited a very low MBC value (5 µg/mL), indicating strong bactericidal activity. From a pharmacological microbiology perspective, these findings suggest that essential oils and extracts rich in phenolic and terpenoid compounds could disrupt bacterial membrane integrity, interfere with essential metabolic pathways, and ultimately induce cell death. Such activity highlights their potential as lead compounds for the development of plant-derived agents with antibiotic-like properties.

Plants with moderate antibacterial activity: The majority of the evaluated plants were within the moderate activity range, with MIC values generally reported between 200 and 400 µg/mL. Species such as *Mentha piperita*, *Salvia officinalis*, *Curcuma* spp., *T. vulgaris*, *P. granatum*, and *Boswellia* spp. were included in this category. From a microbiological standpoint, this level of activity is typically indicative of bacteriostatic rather than bactericidal effects.

These plants are likely to exert their effects through urease inhibition, reduced bacterial adhesion to gastric epithelial cells, and

Table 1) Comprehensive list of medicinal plants effective against *H. pylori* and their antibacterial indices

Plant Family	Persian Name	Scientific Name	Growth Inhibition Zone (mm)/ Amount Per Disc (µg/ disc)	MIC (µg/mL)	MBC (µg/mL)	Type of Extract	Plant Part Used	Traditional Effects	Ref.
Rosaceae	Spirea	*Filipendula ulmaria* (L.) Maxim.	8–9/N	280	N	Aqueous extract	Flower	Anti-inflammatory, relieving stomach and intestinal pain	17
Lamiaceae	Savory	*Satureja hortensis* L.	13.7/N	N	N	Aqueous and alcoholic extracts	Leaf	Disinfectant, improving digestion, reducing bloating	18
Apiaceae	Black cumin	*Bunium persicum* (Boiss.) B.Fedtsch.	19/N	224	N	Aqueous extract	Fruit	Anti-flatulence, improving digestion, antispasmodic	19, 20
Lamiaceae	Ziziphora	*Ziziphora tenuior* L.	37/N	31.25	N	Aqueous and alcoholic extracts	Aerial parts	Sedative, antispasmodic, stomach tonic	19
Asteraceae	Chamomile	*Matricaria chamomilla*	6–7/N	350–400	N	Aqueous extract	Flower	Sedative, anti-inflammatory, digestive stimulant	21
Lamiaceae	Sage	*Salvia officinalis*	12/N	250	N	Aqueous extract	Aerial parts	Anti-inflammatory, antiperspirant, enhancing memory	17
Zingiberaceae	Turmeric	*Curcuma* spp.	18–21/N	200–350	N	Aqueous extract	Root	Anti-inflammatory, strengthening liver and stomach	22
Lamiaceae	Mint	*Mentha piperita* L.	10–14/N	200–350	N	Aqueous and alcoholic extracts	Leaf	Anti-flatulence, anti-nausea, reliving headache	21
Asteraceae	Wormwood	*Artemisia absinthium* L.	14–15/N	N	N	Aqueous extract	Leaf	Antiparasitic, improving digestion, stimulating appetite	23
Lamiaceae	Pennyroyal	*Mentha pulegium* L.	7–8/N	400	N	Aqueous and alcoholic extracts	Leaf	Antispasmodic, antiseptic, soothing stomach	21
Anacardiaceae	Sumac	*Rhus coriaria*	19.4/N	214.28	N	Aqueous extract	Fruit	Anti-inflammatory, antiseptic	25

Plant Family	Persian Name	Scientific Name	Growth Inhibition Zone (mm)/ Amount Per Disc (µg/disc)	MIC (µg/mL)	MBC (µg/mL)	Type of Extract	Plant Part Used	Traditional Effects	Ref.
Lamiaceae	Wild thyme	*Thymus kotschyanus* Boiss. & Hohen.	43/N	N	N	Aqueous extract	Root	Antimicrobial, strengthening stomach	26
Rosaceae	Hawthorn	*Crataegus aronia* (L.) Bosc	7/N	1400	N	Aqueous extract	Fruit	Strengthening heart, lowering blood pressure	27
Lamiaceae	Kermani thyme	*Thymus caramanicus* Jalas	30.4/N	N	N	Essential oil	Aerial parts	Antibacterial, boosting immunity	28
Rosaceae	Raspberry	*Rubus fruticosus*	7–8/N	1425	N	Aqueous extract	Leaf	Anti-inflammatory, improving digestion	27
Lamiaceae	Shirazi thyme	*Zataria multiflora*	23/N	170	N	Ethanolic extract	Flower	Antimicrobial, soothing, anti-inflammatory	20
Amaryllidaceae	Garlic	*Allium sativum*	4/N	N	N	—	Bulb	Antibacterial, antifungal, strengthening heart	29
Lamiaceae	Germander	*Teucrium polium*	20/N	N	N	Aqueous extract	Aerial parts	Anti-inflammatory, strengthening liver, diuretic	20
Burseraceae	Myrrh	*Commiphora myrrha*	30.8/256	256	256	Gum extract	Gum	Anti-inflammatory, anti-infective, healing wound	30
Lamiaceae	*Salvia mirzayanii*	*Salvia mirzayanii*	23–30/N	54	N	Aqueous extract	Aerial parts	Antimicrobial, anti-inflammatory	31
Punicaceae	Pomegranate	*Punica granatum* L.	27–39/N	312–338	N	Aqueous extract	Fruit peel	Anti-inflammatory, anti-diarrheal, strengthening heart	32
Lauraceae	Cinnamon	*Cinnamomum zeylanicum* Blume	N/N	N	N	Wood extract	Wood	Anti-flatulence, antimicrobial, improving digestion	33
Myrtaceae	Myrtle	*Myrtus communis*	10–15/N	283	N	Aqueous extract	Leaf and fruit	Sedative, anti-inflammatory, antiseptic	23

Plant Family	Persian Name	Scientific Name	Growth Inhibition Zone (mm)/ Amount Per Disc (µg/disc)	MIC (µg/mL)	MBC (µg/mL)	Type of Extract	Plant Part Used	Traditional Effects	Ref.
Scrophulariaceae	Figwort	*Scrophularia striata*	40–50/N	N	N	Aqueous extract	Root and stem	Anti-inflammatory, healing wound, anti-infective	34
Hypericaceae	St. John's wort	*Hypericum olivieri*	30/N	N	N	Aqueous extract	Aerial parts	Sedative, antidepressant	19
Iridaceae	Saffron	*Crocus sativus*	14–17/N	N	N	Aqueous extract	Flower	Sedative, nerve-strengthening	35
Lamiaceae	Khuzestani savory	*Satureja khuzestanica*	12.3/N	307.14	N	Aqueous and alcoholic extracts	Leaf	Anti-inflammatory, antibacterial	25
Urticaceae	Nettle	*Urtica dioica*	21/N	N	N	Aqueous and alcoholic extracts	Aerial parts	Anti-inflammatory, diuretic	19
—	Canadian hemp	*Apocynum venetum* L.	12/N	N	N	Aqueous extract	Aerial parts	Sedative, antihypertensive	19
Lamiaceae	Marjoram	*Zhumeria majdae*	17/N	N	N	Aqueous extract	Aerial parts	Anti-inflammatory, antispasmodic	31
Apiaceae	Dill	*Anethum graveolens* L.	12/27	N	27	Aqueous extract	Aerial parts	Digestive stimulant, anti-flatulence	33
Apiaceae	Fennel	*Foeniculum vulgare* Mill.	27/8	N	8	Aqueous extract	Aerial parts	Anti-flatulence, improving digestion	33
Anacardiaceae	Pistachio	*Pistacia vera*	31/18.6	N	18.6	Oil	Fruit	Strengthening heart and stomach	36
Asteraceae	Safflower	*Carthamus tinctorius* L.	22/18.7	N	18.7	Aqueous extract	Flower	Anti-inflammatory, strengthening liver	18
Combretaceae	Myrobalan	*Terminalia chebula* Retz.	43/125	N	125	—	Fruit	Laxative, anti-infective, digestive stimulant	37
Thymelaeaceae	Black seed	*Nigella sativa*	N/N	245	N	—	Fruit	Boosting immunity, antibacterial	20

Plant Family	Persian Name	Scientific Name	Growth Inhibition Zone (mm)/ Amount Per Disc (µg/disc)	MIC (µg/mL)	MBC (µg/mL)	Type of Extract	Plant Part Used	Traditional Effects	Ref.
Thymelaeaceae	Black seed	*Nigella sativa*	N/N	245	N	—	Fruit	Boosting immunity, antibacterial	20
Zygophyllaceae	Harmal	*Peganum harmala*	9/N	N	N	—	Seeds and leaves	Sedative, antiparasitic	23
Caryophyllaceae	Clove	*Dianthus* spp.	15/15.3	N	15.3	—	Aerial parts	Anti-inflammatory, antibacterial	22
Apiaceae	Kermani black cumin	*Bunium persicum*	4/224	4000	224	—	Fruit	Anti-flatulence, improving digestion	18
—	Tarragon	*Artemisia dracunculus*	N/N	2000	691.25	—	Leaf	Antispasmodic, strengthening stomach	38
Apiaceae	Asafoetida	*Ferula assa-foetida* L.	N/N	500–2500	N	Hydroalcoholic extract	Root, whole plant	Anti-flatulence, digestive stimulant	39
Lamiaceae	Kermani thyme	*Thymus caramanicus* Jalas	27.4 ± 0.42/N	N	N	Essential oil	Aerial parts and leaf	Antimicrobial	40
Anacardiaceae	Wild pistachio	*Pistacia atlantica* subsp. *kurdica*	N/N	100	N	Essential oil	Gum	Anti-inflammatory, anti-infective	41
Lamiaceae	Oregano	*Origanum syriacum*	N/N	0.39	N	Essential oil	Aerial parts	Anti-inflammatory, antimicrobial	42
—	Guava	*Psidium guajava*	N/N	125	5	Ethanolic extract	Aerial parts	Antidiarrheal, antimicrobial	43
Burseraceae	Frankincense	*Boswellia papyrifera*	N/N	125	N	Resin	Resin	Anti-inflammatory, strengthening joints	44
Poaceae	Lemongrass	*Cymbopogon citratus*	N/N	15.625	N	Extract	Leaf	Sedative, improving digestion	44
Poaceae	*Cymbopogon schoenanthus* subsp. *proximus*	*Cymbopogon schoenanthus* subsp. *proximus*	N/N	3.9	N	Extract	Root	Antispasmodic, sedative	44

N: Not reported in the literature

modulation of host inflammatory responses. Therefore, their primary role may lie in controlling infection and attenuating gastric inflammation rather than completely eradicating *H. pylori*.

Plants with weak activity or non-comparable data: In several cases, very high MIC/MBC values or incomplete reporting formats (e.g., mg/disc units) were observed, as observed for *C. cyminum*, *Crataegus aronia*, and *Rubus fruticosus*. These species demonstrated relatively weak antibacterial activity under *in vitro* conditions; however, this finding does not necessarily imply their clinical inefficacy.

Many of these plants may exert important indirect effects, including enhancement of gastric mucosal barrier function, antioxidant activity, and modulation of inflammatory responses, which could contribute to reduced *H. pylori* colonization *in vivo*. Therefore, interpretation of the performance of this group should be made with caution, and conclusions should not be based solely on *in vitro* antibacterial outcomes.

Analysis of plant families and phytochemical patterns: From a taxonomic perspective, the *Lamiacea*e family members were the most frequently reported plants showing anti-*H. pylori* activity in the reviewed studies, including genera such as *Mentha*, *Thymus*, *Salvia*, *Satureja*, *Ziziphora*, and *Origanum*.

This prevalence reflects the strong phytochemical profile of this family, particularly the high content of essential oils such as carvacrol, thymol, and menthol, which are known to disrupt bacterial cell membranes. In contrast, the *Anacardiaceae* family members, particularly *Rhus coriaria* and *Pistacia* species, demonstrated notable activity, likely due to their richness in tannins and phenolic compounds. Although the *Zingiberaceae* family showed moderate antibacterial activity, it is of particular pharmacological importance due to its strong anti-inflammatory effects and its role in modulating host inflammatory pathways.

Mechanistic interpretation of action: Based on the compiled data, the anti-*H. pylori* effects of medicinal plants could be attributed to several major mechanisms. The first mechanism involves direct disruption of bacterial cell membranes, primarily mediated by essential oils and terpenoid compounds.

The second mechanism is urease inhibition, a key pathway for *H. pylori* survival and colonization, which has been reported in multiple plant extracts. The third mechanism involves inhibition of biofilm formation, a critical factor in bacterial persistence and resistance, as observed in species such as *Ziziphora* and *Origanum*. The fourth mechanism includes anti-inflammatory and gastroprotective effects, which are particularly prominent in families such as *Rosaceae* and *Zingiberaceae*. Collectively, these multi-target mechanisms distinguish medicinal plants from conventional antibiotics by their broader pharmacological spectrum.

Clinical interpretation and therapeutic relevance: From a clinical perspective, the findings suggest that although certain plants exhibit strong direct antibacterial activity against *H. pylori*, the majority of them could function as adjunctive rather than standalone therapeutic agents. The most promising direct antimicrobial candidates include *O. syriacum*, *Z. tenuior*, and selected *Cymbopogon* species. In contrast, plants such as *Zingiber officinale* and *Curcuma* spp. are better characterized as supportive agents due to their anti-inflammatory and gastroprotective properties. Accordingly, a rational therapeutic strategy may involve the combined use of these plant-derived compounds alongside standard antibiotic regimens to enhance antimicrobial efficacy while simultaneously protecting the gastric mucosa.

Discussion

H. pylori is one of the most common infectious bacteria in the stomach, which plays a critical role in the development of gastritis, gastric ulcers, and gastric cancer. The use of medicinal plants with antibacterial, antioxidant, and anti-inflammatory properties provides a natural and low-complication strategy for controlling this bacterium. Bioactive compounds found in plants such as licorice, ginger, garlic, and turmeric are particularly effective in reducing the proliferation of *H. pylori* and alleviating gastrointestinal symptoms.

A review study conducted in Iran reported that 69 species from 29 plant families exhibited inhibitory effects on *H. pylori*, with plants such as Shirazi thyme, mint, sumac, licorice, and pomegranate showing the highest anti-*H. pylori* activity *in vitro* [45]. Other studies have identified numerous medicinal plants with significant effects against *H. pylori*, including *Persea americana*, *Annona cherimola*, *Guaiacum coulteri, Moussonia deppeana, Myristica fragrans, Rosmarinus officinalis, C. amada*, *Mallotus phillipinesis, Psoralea corylifolia, Achillea millefolium, Foeniculum vulgare, Passiflora incarnata, O. majorana*, *C. longa*, *Z. officinale*, *Carum carvi, Elettaria cardamomum, Gentiana lutea, Juniperus communis, Lavandula angustifolia, Melissa officinalis, M. piperita, Pimpinella anisum, Abrus cantoniensis, Saussurea lappa, Eugenia caryophyllata, Hippophae rhamnoides, Fritillaria thunbergii, Magnolia officinalis, Schisandra chinensis, Corydalis yanhusuo, Citrus reticulata, Bupleurum chinense, Ligusticum chuanxiong,* and *Myroxylon peruiferum* [46, 47].

Additional plants, including *Sclerocarya birrea, Lippia javanica, Peltophorum africanum, Carissa edulis, Ficus sycomorus, Garcinia kola, Ageratum conyzoides, Acanthus montanus, Eryngium foetidium, Emilia coccinea, Euphorbia hirta, Lycopodium cernua, Scleria striatinux, S. verrucossa, Aulotandria kamerunensis, Tapeinachilus ananassae, Alepidea amatymbica, Ferulago campestris, Cistus laurifolius, Azadirachta indica, Zanthoxylum limonella*, and *Acacia nilotica* have also demonstrated strong anti-*H. pylori* activity [48].

In Taiwan, extracts of 50 traditional medicinal plants were tested, with approximately half of them showing strong antibacterial effects, particularly *Paederia scandens* and *Plumbago zeylanica* [49]. A study of 23 indigenous Iranian medicinal plants indicated that *P. granatum* (pomegranate) and *Juglans regia* (walnut) exhibited the highest inhibitory activity, with further investigations on pomegranate peel extracts revealing significant anti-*H. pylori* activity in most cultivars [50].

Geographically, medicinal plants from various regions have demonstrated notable antibacterial effects. A review study by Zaidi et al. (2015) reported that in Korea, *E. caryophyllata*, *Coptidis japonica*, *M. officinalis, Rheum palmatum*, and *R. javanica* exhibited MICs of 6–20 mg/mL. In Turkey, *C. laurifolius* and in Iran, *Trachyspermum copticum* and *Xanthium brasilicum* showed MICs of 31.25–250 mg/mL [51]. In Japan, *Wasabia japonica* and in China, *S. lappa*, *A. cantoniensis,* and *E. caryophyllata* exhibited MICs around 40 mg/mL. In Malaysia herbs and spices such as *C. longa*, *C. cyminum*, *Z. officinale*, *Capsicum annuum, Borago officinalis, Nigella sativa*, *O. vulgare*, and *Glycyrrhiza glabra* inhibited *H. pylori* growth [51]. Taiwanese studies confirmed that *P. scandens*, *P. zeylanica*, *Anisomeles indica, Bombax malabaricum*, and *Alpinia speciosa* had MICs of 0.64–10.24 mg/mL. In Cameroon, *A. conyzoides*, *S. striatinux*, and *L. cernua* showed MICs of 0.032 mg/mL and MBCs of 0.098 mg/mL. Pakistani plants such as *C. amada*, *M. phillipinesis*, *P. corylifolia*, and *M. fragrans* demonstrated potent effects with MBCs of 15.6–62.5 µg/mL, and the active compound rottlerin exhibited an MBC range of 3.12–6.25 µg/mL. South African plants including *Combretum molle*, *S. birrea*, *G. kola, A. amatymbica*, and *Strychnos* spe-

cies inhibited *H. pylori*, and Mexican plants such as *Castella tortuosa, Amphipterygium adstringens, Ibervillea sonorae, Pscalium decompositum, Krameria erecta, Selaginella lepidophylla, P. anisum, Marrubium vulgare, Ambrosia confertiflora*, and *Couterea latiflora* also exhibited significant antibacterial activity [51, 52].

Collectively, these findings highlight the global potential of medicinal plants as sources of anti-*H. pylori* compounds. Given the increasing drug resistance and side effects associated with conventional treatments, medicinal plants rich in phenolics, flavonoids, and terpenoids present safe and effective alternatives. They could serve as complementary or alternative therapies to combat *H. pylori*, offering a promising pathway toward the development of non-antibiotic antibacterial agents [45–52]. Multiple studies have demonstrated that bioactive plant compounds and secondary metabolites, including alkaloids, flavonoids, terpenoids, and phenolic compounds, play a pivotal role in mediating the pharmacological effects of medicinal plants [53–56] and could serve as a foundation for the development of novel drugs or complementary therapies for chronic diseases [57, 58]. Recent evidence suggests that medicinal plants and bioactive nanoformulations may exert their therapeutic effects via anti-inflammatory, antioxidant, antimicrobial, and neuromodulatory pathways, thereby contributing to the management of both chronic and infectious diseases. The identification and standardization of these active constituents, in addition to enhancing the efficacy of complementary therapies, could bridge traditional medicine and modern pharmaceutical approaches, facilitating the development of safe and effective therapeutics [59–67]. One of the limitations of this study is the lack of formal assessment of study quality and risk of bias, which may have influenced the interpretation of the findings.

Conclusion

H. pylori is a major etiological agent of gastrointestinal disorders and gastric cancer worldwide. The rising prevalence of antibiotic resistance, along with the adverse effects associated with conventional eradication therapies, has intensified the need for safer and more effective alternative treatment strategies. The findings of this review indicate that both indigenous and non-indigenous medicinal plants exhibit notable *in vitro* inhibitory potential against *H. pylori*. In particular, extracts and essential oils derived from members of the *Lamiaceae* family rich in phenolic, flavonoid, and terpenoid compounds demonstrate considerable antibacterial and anti-inflammatory activities. Among the evaluated species, Shirazi thyme, mint, sumac, licorice, and pomegranate showed the most pronounced anti-*H. pylori* effects .However, it should be emphasized that the current evidence is predominantly based on *in vitro* studies, and there are still significant gaps in terms of *in vivo* investigations, human clinical trials, pharmacokinetic evaluations, safety assessments, dose optimization studies, and analysis of potential herb–drug interactions. Furthermore, an important limitation that has received limited attention is the possible instability or degradation of bioactive phytochemicals under the highly acidic conditions of the gastric environment, which may substantially reduce their therapeutic efficacy in clinical settings. Therefore, although these medicinal plants represent promising sources for the development of novel therapeutic agents or adjunctive treatments, their use as definitive alternative therapies could not yet be recommended. Further comprehensive investigations, including well-designed clinical trials, standardized dosing studies, safety profiling, pharmacokinetic analysis, and stability assessments under gastric

conditions, are essential prior to clinical application. In conclusion, the current evidence underscores the importance of phytopharmacological research to combat resistant infections such as *H. pylori* and suggests that medicinal plants may provide a valuable foundation for the development of safer, more sustainable, and multi-targeted antimicrobial agents.

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