








Review

Phytochemicals in *Helicobacter pylori* Infections: What Are We Doing Now?

Bahare Salehi ^{1,2} , Farukh Sharopov ³ , Miquel Martorell ⁴ , Jovana Rajkovic ⁵,
Adedayo Oluwaseun Ademiluyi ⁶ , Mehdi Sharifi-Rad ^{7,*}, Patrick Valere Tsouh Fokou ^{8,*} ,
Natália Martins ^{9,10,*} , Marcello Iriti ^{11,*}  and Javad Sharifi-Rad ^{12,13,*} 

- ¹ Medical Ethics and Law Research Center, Shahid Beheshti University of Medical Sciences, Tehran 88777539, Iran; bahar.salehi007@gmail.com
 - ² Student Research Committee, Shahid Beheshti University of Medical Sciences, Tehran 22439789, Iran
 - ³ Department of Pharmaceutical Technology, Avicenna Tajik State Medical University, Rudaki 139, Dushanbe 734003, Tajikistan; shfarukh@mail.ru
 - ⁴ Nutrition and Dietetics Department, Faculty of Pharmacy, University of Concepción, Concepción, 4070386 VIII–Bio Bio Region, Chile; mmartorell@udec.cl
 - ⁵ Institute of Pharmacology, Clinical Pharmacology and Toxicology, Medical Faculty, University of Belgrade, 11129 Belgrade, Serbia; jolarajkovic@yahoo.com
 - ⁶ Functional Foods, Nutraceuticals and Phytomedicine Unit, Department of Biochemistry, Federal University of Technology, Akure 340252, Nigeria; ademiluyidayo@yahoo.co.uk
 - ⁷ Department of Medical Parasitology, Zabol University of Medical Sciences, Zabol 61663335, Iran
 - ⁸ Department of Biochemistry, Faculty of Science, University of Yaounde 1, Yaounde P.O. Box 812, Cameroon
 - ⁹ Faculty of Medicine, University of Porto, Alameda Prof. Hernâni Monteiro, 4200-319 Porto, Portugal
 - ¹⁰ Institute for Research and Innovation in Health (i3S), University of Porto, 4200-135 Porto, Portugal
 - ¹¹ Department of Agricultural and Environmental Sciences, Milan State University, via G. Celoria 2, 20133 Milan, Italy
 - ¹² Phytochemistry Research Center, Shahid Beheshti University of Medical Sciences, Tehran 11369, Iran
 - ¹³ Department of Chemistry, Richardson College for the Environmental Science Complex, The University of Winnipeg, Winnipeg, MB R3B 2G3, Canada
- * Correspondence: m.sharifirad@zamu.ac.ir (M.S.-R.); tsouh80@yahoo.fr (P.V.T.F.); ncmartins@med.up.pt (N.M.); marcello.iriti@unimi.it (M.I.); javad.sharifirad@gmail.com or javad.sharifirad@sbmu.ac.ir (J.S.-R.); Tel.: +98-54-322-51-790 (M.S.-R.); +237-676620503 (P.V.T.F.); +351-22-5512100 (N.M.); +39-2-5031-6766 (M.I.); +98-21-88200104 (J.S.-R.)

Received: 6 July 2018; Accepted: 7 August 2018; Published: 10 August 2018



Abstract: In this critical review, plant sources used as effective antibacterial agents against *Helicobacter pylori* infections are carefully described. The main intrinsic bioactive molecules, responsible for the observed effects are also underlined and their corresponding modes of action specifically highlighted. In addition to traditional uses as herbal remedies, *in vitro* and *in vivo* studies focusing on plant extracts and isolated bioactive compounds with anti-*H. pylori* activity are also critically discussed. Lastly, special attention was also given to plant extracts with urease inhibitory effects, with emphasis on involved modes of action.

Keywords: plant products; *Helicobacter pylori*; opportunistic colonization; phytopharmacology; *in vitro*/*in vivo* findings; anti-urease activity

1. Introduction

Plant products, their enriched-derived extracts, and their isolated bioactive molecules have been increasingly studied due their renowned health attributes, largely used in folk medicine over centuries for multiple purposes [1–9]. Indeed, phytomedicine is garnering much attention among the medical and scientific communities [10–12]. Commercially available synthetic drugs have often been negatively pointed out due to their side effects and related toxicity [13]. In fact, the active molecules used in pharmaceutical formulation are formerly derived from bioactive molecules extracted from plants and other living organisms [14]. Also, a growing number of studies have progressively underlined the multiple bioactive properties conferred by plant formulations [15,16]. Specifically, the antimicrobial effects of multiple plant preparations have been progressively confirmed and supported by both in vitro and in vivo studies and clinical trials [17–21]. Thus, their lower costs, high effectiveness, bioavailability, bioefficacy, and few to no adverse effects have led to intensive research on this topic [22–28].

Among the various opportunistic infections, those caused by *Helicobacter pylori*, a human opportunistic pathogen, is attracting much attention [29]. In fact, it is widely recognized that this bacterium plays an important role in the etiology of peptic and gastric ulcers and even gastric cancers and gastric lymphomas [29]. About half of the worldwide population is colonized by this bacterium, but there are only about 20% who manifest clinical symptoms, which has been linked to the ability of some *H. pylori* strains to both adapt to host's immunological responses and to support an ever-changing gastric environment [29]. Relatedly, increasing rates of antibiotic-resistant *H. pylori* strains have been found, and therefore, the search for new eradication strategies and effective antibiotic therapies has become an issue of crucial importance [30]. Hence, research effort is focused on exploring plants as sources of anti-*H. pylori* agents.

Based on these findings, the present report aims to provide an extensive overview of *Helicobacter pylori* infections, namely describing its involvement in triggering gastric cancer and the most common antimicrobials used in *H. pylori* eradication. Special attention is also given to medicinal plants and their corresponding extracts and isolated constituents used as anti-*H. pylori* agents and urease inhibitors. This review was performed by consulting the databases of PubMed, Web of Science, Embase, and Google Scholar (as a search engine); only full-text available articles were considered, and articles published from 2008 to 2018 were prioritized. The search strategy included the combination of following keywords: "*Helicobacter pylori*", "anti-*Helicobacter*", "medicinal plant", "plant extract", "essential oil", "bioactive", "phytochemical", "antimicrobial", and "eradication".

2. *Helicobacter pylori* and Gastric Cancer

H. pylori infection has been implicated in the development of gastric cancer, a multifactorial disease and a leading cause of mortality. The risk factors for gastric cancer have been shown to include environmental factors and factors that influence host–pathogen interaction, as well as the complex interplay between these factors [31]. Modern lifestyle, high stress levels, smoking and excessive alcohol consumption, nutritional deficiencies, and prolonged use of non-steroidal anti-inflammatory drugs (NSAIDs) are amongst the most relevant etiological environmental factors [32].

This bacterial infection has been linked to the initiation of chronic gastritis that could later lead to adenocarcinoma of the intestine [33]. However, several mechanisms have been proposed to represent the involvement of *H. pylori* infection in tumorigenesis. Several bacterial virulence factors, such as the cytotoxin-associated gene A (CagA) protein, present in the DNA insertion element Cag pathogenicity island (CagPAI), were found to be of prominent importance in carcinogenesis [34]. Likewise, bacterial peptidoglycan can be delivered into gastric epithelial cells, where it activates a phosphoinositide 3-kinase (PI3K)-Akt pathway leading to cell proliferation, migration, and prevention of apoptosis [35]. Furthermore, *H. pylori*-induced gastric inflammation involves the cyclooxygenase-2 (COX2)/prostaglandin E2 (PGE2) pathway and inflammatory marker interleukin 1 β (IL-1 β), which are important factors triggering chronic active gastritis and

adenocarcinoma [31]. Studies have also shown that *H. pylori* infection-induced oxidative stress and DNA damage coupled with dysregulation of E-cadherin/ β -catenin/p120 interactions also play critical roles in tumorigenesis [31]. Several environmental and dietary factors have also been suggested to modify *H. pylori*-induced adenocarcinoma [36]. Gastric adenocarcinoma is strongly influenced by dietary salt intake, with high salt intake aggravating tumorigenesis [37].

3. Antimicrobials for *H. pylori* Eradication

The success of *H. pylori* eradication markedly depends on the type and duration of treatment, patient compliance to therapy, and antibiotic resistance. For example, because it is difficult to achieve optimal eradication of *H. pylori* infection in patients with peptic ulcers, combinational regimens using two or three antibiotics in addition to a proton pump inhibitor or bismuth are often prescribed to achieve higher eradication rates and to prevent antibiotic resistance emergence [38,39]. These regimens, also known as triple therapies, have cure rates of around 85–90%. They are usually administered for a period of about 10–14 days, in which treatment regimens include the following: (A) bismuth subsalicylate, metronidazole, and tetracycline for 14 days; (B) omeprazole, amoxicillin, and clarithromycin for 10 days; and (C) lansoprazole, amoxicillin, and clarithromycin for either 10 or 14 days.

Unfortunately, the heightening of antimicrobial resistance has been associated with increases in the standard triple therapies failure to eradicate *H. pylori* infection [40]. Hence, research is focusing on developing potent and effective antibacterial regimens that will favor total eradication of the infection. Nonetheless, any eradication treatment comes with some degree of adverse effects, such as nausea, metallic taste, vomiting, skin rash, and diarrhea. Therefore, efforts are being channeled towards the development of effective treatments with few to no side effects.

In the Maastricht V/Florence Consensus Report, 43 experts from 24 countries provided recommendations on the basis of the best available evidence and relevance to the current therapeutic options of management of *H. pylori* infection in the various clinical scenarios [41].

4. Plant Extracts and Phytochemicals with Anti-*Helicobacter pylori* Activity

Considering that *H. pylori* infection has been associated with gastrointestinal diseases, including chronic gastritis, peptic ulcer, gastric carcinoma, and mucosa-associated lymphoid tissue lymphoma [42], and that, due to the widespread use of therapeutic agents for the eradication of this bacterium and associated-side effects, increasing rates of *H. pylori* strains with acquired resistance have been discovered. So, the urgent need for alternative has been rekindled and aided by the use of natural drugs [32].

Despite, the newly proposed and used tri-therapy regimens, the cost of acid suppressors and stomach protectors make it inaccessible to the majority of the population [43]. Naturally-derived drugs, including herbs, have been shown to display anti-*H. pylori* activities with minimal side effects, easy accessibility, and affordability [42,44]. In fact, many medicinal plants have been reported in the traditional management of gastrointestinal disorders. Many of these medicinal plants have gone through bioassays to assess their potency against *H. pylori*. Here, the anti-*H. pylori* activity of medicinal plants and isolated bioactive molecules is discussed [45].

Almost all plant parts have been tested for anti-*H. pylori* activity. Plant extract preparations include water (Table 1), essential oils (Table 2), or organic solvents, such as the following: ethanol (Table 3); methanol (Table 4); acetone (Table 5); chloroform (Table 6); petroleum ether (Table 7); methanol/water, ethanol/water, methanol/petroleum, and methanol/dichloromethane extracts (Table 8); and other plant extracts (Table 9).

The susceptibility of *H. pylori* isolates and strains to 543 extracts from 246 plant species was tested by disc diffusion, agar diffusion, agar dilution, and broth microdilution assays. Activity ranged from 1.56–100,000 µg/mL for minimal inhibitory concentration (MIC) and 7–42 mm for inhibition zone diameters (IZDs). However, disparities were observed among the methods used and the tested concentrations: some extracts were tested at very high concentrations (100,000 µg/mL) that might have resulted in biased conclusions. Though many plants (246 species) showed anti-*H. pylori* activity in vitro, very few have been screened for activity in animal models.

Organic extracts of *Carum carvi*, *Xanthium brasiliicum*, and *Trachyspermum copticum* have demonstrated antibacterial activity against 10 clinical isolates of *H. pylori* [46]. In addition, ethanolic extracts of *Cuminum cyminum* and propolis exhibited significant in vitro inhibitory effect against *H. pylori* and, therefore, could be considered a valuable support in the treatment of infection, even contributing to the development of new and safer agents for inclusion in anti-*H. pylori* therapy regimens [47]. Some popular plant species used in Brazilian cuisine and folk medicine in the treatment of gastrointestinal disorders were also investigated for their antibacterial effects, among which *Bixa orellana*, *Chamomilla recutita*, *Ilex paraguariensis*, and *Malva sylvestris* were the most effective against *H. pylori* [48].

Bioactive plant compounds were also tested for their anti-*H. pylori* potency (Table 10), namely those isolated from the *Allium sativum* (cloves), *Convolvulus austro-aegyptiacu* (aerial parts), *Glycyrrhiza glabra* (roots), *Hydrastis canadensis* (rhizomes), *Sanguinaria canadensis* (rhizomes), and *Tinospora sagittata* (aerial parts) species. Berberine, a benzylisoquinoline alkaloid, isolated from *Hydrastis canadensis*, revealed the lowest MIC value (0.78 µg/mL), being therefore considered the most effective bioactive compound, followed by diallyl tetrasulfide (3–6 µg/mL), allicin (4 µg/mL), and palmatine (3.12–6.25 µg/mL) isolated from *Allium sativum* and *Tinospora sagittate*, respectively.

Table 1. Plant aqueous extracts with anti-*Helicobacter pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Acacia nilotica</i> (L.) Delile	Leguminosae	Flowers	MIC = 8–64 µg/mL	[49]
<i>Adhatoda vasica</i> Nees	Acanthaceae	Whole plant	MIC = 16–512 µg/mL	[49]
<i>Alepidea amatymbica</i> Eckl. and Zeyh	Apiaceae	Roots/Rhizomes	IZD = 8.0 ± 8.2 mm	[50,51]
<i>Amphipterygium adstringens</i> (Schltdl.) Standl.	Anacardiaceae	Aerial parts	MIC = 62.5–125 µg/mL	[52]
<i>Annona cherimola</i> Mill.	Annonaceae	Leaves/Stem	MIC = 500 µg/mL	[52]
<i>Artemisia ludoviciana</i> Nutt. subsp. <i>mexicana</i> (Willd. ex Spreng.) Fernald	Compositae	Leaves/stems	MIC = 125 µg/mL IZD = 0–15 mm;	[52]
<i>Bridelia micrantha</i> (Hochst.) Baill.	Phyllanthaceae	Bark	MIC ₅₀ = 48–313 mg/mL; MIC ₉₀ = 78 ≥ 625 µg/mL	[53]
<i>Buddleja perfoliata</i> Kunth	Scrophulariaceae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Calandrinia ciliata</i> (Ruiz and Pav.) DC. (cited as <i>Calandrinia micrantha</i> Schltdl.)	Portulacaceae	Leaves/Stems	MIC = 1000 µg/mL	[52]
<i>Calotropis procera</i> (Aiton) W.T. Aiton	Apocynaceae	Leaves	MIC = 16–256 µg/mL	[49]
<i>Campyloneurum amphostenon</i> (Kunze ex Klotzsch) Fée	Polypodiaceae	Flowers	MIC = 8–256 µg/mL	[49]
<i>Casuarina equisetifolia</i> L.	Casuarinaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Chenopodium incisum</i> Poir. (cited as <i>Teloxys graveolens</i> (Willd.) W. A. Weber)	Amaranthaceae	Fruit	MIC = 128–1024 µg/mL	[49]
<i>Cichorium intybus</i> L.	Asteraceae	Aerial parts	MIC = 250 µg/mL	[52]
<i>Cinnamomum zeylanicum</i> Blume	Asteraceae	Root	IZD < 9 mm	[47]
<i>Cistus laurifolius</i> L.	Lauraceae	Bark	IZD < 9 mm	[47]
<i>Citrus reticulata</i> Blanco	Cistaceae	Flowers	MIC = 62.5–125 µg/mL	[54]
<i>Cocculus hirsutus</i> (L.) Diels.	Rutaceae	Fruit shell	MIC = 100 µg/mL	[55]
<i>Combretum molle</i> R. Br. Ex G. Don	Menispermaceae	Leaves	IZD = 22 mm (200–1000 µg/mL)	[56]
<i>Coriandrum sativum</i> L.	Combretaceae	Bark	IZD = 2.7 ± 5.5 mm	[50,51]
<i>Corydalis yanhusuo</i> W.T. Wang	Apiaceae	Seed	IZD = 9 mm; MIC = 1.25–5 mg/mL	[47]
<i>Cuminum cyminum</i> L.	Papaveraceae	Stem	MIC = 100 µg/mL	[55]
<i>Cuphea aequipetala</i> Cav.	Apiaceae	Seed	IZD < 9 mm	[47]
<i>Cynara scolymus</i> L.	Lythraceae	Aerial parts	MIC = 125 µg/mL	[57]
<i>Cyrtocarpa procera</i> Kunth	Asteraceae	Leaves	MIC = 125 µg/mL	[52]
	Asteraceae	Leaves	IZD = 18 mm; MIC = 1.25–5 mg/mL	[47]
	Anacardiaceae	Bark	MIC = 125 µg/mL	[58]
	Anacardiaceae	Bark	MIC = 250 µg/mL	[52]

Table 1. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Desmos cochinchinensis</i> Lour.	Annonaceae	Leaves	IZD = 10.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Dysphania ambrosioides</i> (L.) Mosyakin and Clemants (cited as <i>Teloxys ambrosioides</i> (L.) W. A. Weber)	Amaranthaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Elettaria cardamomum</i> (L.) Maton.	Zingiberaceae	Seeds	IZD < 9 mm	[47]
<i>Eryngium carlinae</i> F. Delaroché	Apiaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Eugenia caryophyllata</i> Thunb	Myrtaceae	Flower	MIC = 60 µg/mL	[55]
<i>Eupatorium petiolare</i> Moc. ex DC.	Compositae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Fagonia arabica</i> L.	Zygophyllaceae	Whole plant	MIC = 16–256 µg/mL	[49]
<i>Foeniculum vulgare</i> Mill. var. dulce DC	Apiaceae	Seed	IZD < 9 mm; MIC = 5–10 mg/mL	[47]
<i>Fritillaria thunbergii</i> Miq.	Liliaceae	Stem	MIC = 40 µg/mL	[55]
<i>Garcinia kola</i> Heckel	Guttiferaceae	Seeds	IZD = 1.0 ± 2.6 mm	[50,51]
<i>Geum iranica</i> Khatamsaz	Rosaceae	Root	IZD = 24–35 mm (100 µg/mL)	[60]
<i>Gnaphalium canescens</i> DC.	Compositae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Grindelia inuloides</i> Willd.	Compositae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Hesperozygis marifolia</i> Epling	Lamiaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Heterotheca inuloides</i> Cass.	Compositae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Juniperus communis</i> L.	Cupressaceae	Berry	IZD < 9 mm	[47]
<i>Larrea tridentata</i> (Sessé and Moc. ex DC.) Coville	Zygophyllaceae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Ligusticum striatum</i> DC (cited as <i>Ligusticum chuanxiong</i> Hort.)	Apiaceae	Root	MIC = 100 µg/mL	[55]
<i>Lippia graveolens</i> Kunth (cited as <i>Lippia berlandieri</i> Schauer)	Verbenaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Ludwigia repens</i> J. R. Forst.	Onagraceae	Aerial parts	MIC = 125 µg/mL	[52]
<i>Machaeranthera riparia</i> (Kunth) A.G. Jones	Compositae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Machaeranthera tanacetifolia</i> (Kunth) Nees	Compositae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Mentha × piperita</i> L.	Lamiaceae	Leaves	IZD < 9 mm	[47]
<i>Mirabilis jalapa</i> L.	Nyctaginaceae	Aerial parts	MIC = 250 µg/mL	[52]
<i>Monarda citriodora</i> var. <i>austromontana</i> (Epling) B. L. Turner (cited as <i>Monarda austromontana</i> Epling)	Lamiaceae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Olea europaea</i> L.	Oleaceae	Leaves/Stem	MIC = 125 µg/mL	[52]
<i>Origanum vulgare</i> L.	Lamiaceae	Leaves	IZD = 25 mm; MIC = 0.6–2.5 mg/mL	[47]
<i>Orthosiphon aristatus</i> (Blume) Miq. (cited as <i>Orthosiphon stamineus</i> Benth)	Lamiaceae	Leaves	IZD = 9.0 ± 1.3 mm (240 µg/disc)	[59]
		Stem	IZD = 8.0 ± 0.1 mm (240 µg/disc)	[59]

Table 1. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Peumus boldus</i> Mol.	Monimiaceae	Leaves	>1500 µg/mL	[61]
<i>Plantago major</i> L.	Plantaginaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Priva grandiflora</i> (Ortega) Moldenke	Verbenaceae	Aerial parts	MIC = 250 µg/mL	[52]
<i>Prunus avium</i> L.	Rosaceae	Peduncles	IZD = 9 mm; MIC = 5–10 mg/mL	[47]
<i>Rosmarinus officinalis</i> L.	Lamiaceae	Leaves	IZD < 9 mm	[47]
<i>Ruta chalepensis</i> L.	Rutaceae	Leaves	MIC = 1000 µg/mL	[52]
<i>Salvia officinalis</i> L.	Lamiaceae	Leaves	IZD = 10 mm; MIC = 1.25–10 mg/mL	[47]
<i>Sclerocarya birrea</i> A. Rich Hochst	Anacardiaceae	Stem bark	MIC = 0.16–2.5 mg/mL; IZD = 15.0 ± 2.7 mm	[50,51]
<i>Tagetes lucida</i> Cav.	Compositae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Tecoma stans</i> (L.) Juss. ex Kunth	Bignoniaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Terminalia catappa</i> L.	Combretaceae	Aerial parts	MIC = 125 µg/mL	[62]
<i>Terminalia chebula</i> Retz	Combretaceae	Fruit	MIC = 125 mg/mL; MBC = 150 mg/mL	[63]
<i>Thymus serpyllum</i> L.	Lamiaceae	Aerial parts	IZD = 10 mm; MIC = 1.25–10 mg/mL	[47]
<i>Tillandsia usneoides</i> L.	Bromeliaceae	Aerial parts	MIC = 1000 µg/mL	[52]
<i>Tinospora sagittata</i> Gagnep.	Menispermaceae	Root	MIC = 100 µg/mL	[55]
<i>Tithonia diversifolia</i> (Hemsl.) A.G.	Compositae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Verbena carolina</i> L.	Verbenaceae	Aerial parts	MIC = 62.5–125 µg/mL	[52]
<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Rhizome	IZD = 9 mm; MIC = 2.5–5 mg/mL	[47]

MIC, minimal inhibitory concentration; IZD, inhibition zone diameter; MBC, minimal bactericidal concentration.

Table 2. Plant essential oils with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Abies mariesii</i> Mast. (cited as <i>Abies maritima</i>)	Pinaceae	Pine	IZD = 22 ± 2 mm (500 µg/disc) IZD = 14 ± 1 mm (500 µg/disc)	[64] [64]
<i>Allium sativum</i> L.	Amaryllidaceae	Cloves	8–32 µg/mL	[65]
<i>Artemisia dracunculus</i> L.	Compositae	Tarragon	IZD = 7 ± 0 mm (500 µg/disc)	[64]
<i>Carum carvi</i> L.	Apiaceae	Caraway	IZD = 12 ± 0 mm (500 µg/disc)	[64]

Table 2. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Cinnamomum zeylanicum</i> Blume	<i>Lauraceae</i>	Bark	MIC = 0.3 μ L/mL; IZD = 24.8 mm	[66]
			IZD = 63 \pm 0.5 mm (500 μ g/disc)	[64]
			IZD = 45 \pm 5 mm (500 μ g/disc)	[64]
<i>Cistus ladanifer</i> L.	<i>Cistaceae</i>	Cistus	IZD = 8 \pm 0 mm (500 μ g/disc)	[64]
			IZD = 16 \pm 1.5 mm (500 μ g/disc)	[64]
<i>Citrus aurantium</i> L.	<i>Rutaceae</i>	Orange blossom	>88% inhibition (0.3 μ L/mL)	[66]
			IZD = 12 \pm 0 mm (500 μ g/disc)	[64]
<i>Citrus limon</i> (L.) Burm. f.	<i>Rutaceae</i>	Lemon	IZD = 16 \pm 0 mm (500 μ g/disc)	[64]
			IZD = 16 \pm 0 mm (500 μ g/disc)	[64]
<i>Citrus paradise</i> Macfad	<i>Rutaceae</i>	White grapefruit	IZD = 16 \pm 0 mm (500 μ g/disc)	[64]
		Grapefruit	IZD = 14 \pm 10 mm (500 μ g/disc)	[64]
		Tea tree	IZD = 29 \pm 2.5 mm (500 μ g/disc)	[64]
<i>Cupressus sempervirens</i> L.	<i>Cupressaceae</i>	Cypress	IZD = 17 mm (500 μ g/disc)	[64]
			IZD = 13 \pm 0.5 mm (500 μ g/disc)	[64]
<i>Cymbopogon citratus</i> (DC.) Stapf	<i>Poaceae</i>	Lemongrass	IZD = 9 \pm 0 mm (500 μ g/disc)	[64]
			IZD = 19 \pm 3.5 mm (500 μ g/disc)	[64]
<i>Daucus carota</i> L.	<i>Apiaceae</i>	Carrot seed	IZD = 11 \pm 10 mm (500 μ g/disc)	[64]
			IZD = 32 \pm 7 mm (500 μ g/disc)	[64]
<i>Dittrichia viscosa</i> (L.) Greuter subsp. <i>revoluta</i>	<i>Asteraceae</i>	Aerial parts	IZD = 23 \pm 0.05 mm (500 μ g/disc)	[64]
			0.33 μ L/mL *	[67]
<i>Eucalyptus globulus</i> L.	<i>Myrtaceae</i>	Eucalyptus	IZD = 8 \pm 0.5 mm (500 μ g/disc)	[64]
			IZD = 16 \pm 1.5 mm (500 μ g/disc)	[64]
<i>Eugenia caryophyllus</i> (Spreng.) Bullock and S. G. Harrison	<i>Myrtaceae</i>	Clove-bud	IZD = 10 \pm 1 mm (500 μ g/disc)	[64]
		Clove-leaf	IZD = 12 \pm 10 mm (500 μ g/disc)	[64]
<i>Heracleum persicum</i> L.	<i>Apiaceae</i>	Fruits	IZD = 13 \pm 2.5 mm (500 μ g/disc)	[64]
			>88% inhibition (0.3 μ L/mL)	[66]
<i>Juniperus communis</i> L.	<i>Cupressaceae</i>	Berry	IZD = 25 \pm 5 mm (500 μ g/disc)	[64]
			IZD = 14 \pm 0.5 mm (500 μ g/disc)	[64]
<i>Leptospermum scoparium</i> J. R. Forst and G. Forst	<i>Myrtaceae</i>	Manuka	IZD = 10 \pm 1 mm (500 μ g/disc)	[64]
			IZD = 23 \pm 3 mm (500 μ g/disc)	[64]
<i>Aloysia citriodora</i> Palau (cited as <i>Lippia citriodora</i>)	<i>Verbenaceae</i>	Aerial parts	IZD = 29 \pm 2 mm (500 μ g/disc)	[64]
			IZD = 7 \pm 0 mm (500 μ g/disc)	[64]
<i>Matricaria chamomilla</i> L. (cited as <i>Matricaria recutita</i>)	<i>Compositae</i>	Flowers	IZD = 15 \pm 10 mm (500 μ g/disc)	[64]
			IZD = 9 \pm 0.3 mm (500 μ g/disc)	[64]
<i>Melaleuca alternifolia</i> Cheel.	<i>Myrtaceae</i>	Tea tree		

Table 2. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Ocimum basilicum</i> L.	Lamiaceae	Aerial parts	IZD = 9 ± 0.3 mm (500 µg/disc)	[64]
<i>Origanum vulgare</i> L.	Lamiaceae	Leaves	IZD = 8 ± 0.5 mm (500 µg/disc)	[64]
<i>Pimpinella anisum</i> L.	Apiaceae	Anise	IZD = 19 ± 4 mm (500 µg/disc)	[64]
<i>Salvia sclarea</i> L.	Lamiaceae	Aerial parts	IZD = 12 ± 10 mm (500 µg/disc)	[64]
<i>Salvia officinalis</i> L.	Lamiaceae	Leaves	IZD = 10 ± 2 mm (500 µg/disc)	[64]
<i>Sassafras officinale</i> Siebold	Lauraceae	Aerial parts	IZD = 10 ± 10 mm (500 µg/disc)	[64]
<i>Satureja montana</i> L.	Lamiaceae	Savory	IZD = 7 ± 0 mm (500 µg/disc)	[64]
<i>Syzygium aromaticum</i> (L.) Merr. and L. M. Perry	Myrtaceae	Buds	IZD = 25 ± 5 mm (500 µg/disc)	[64]
<i>Thymus vulgaris</i> L.	Lamiaceae	Thyme	IZD = 13 ± 5 mm (500 µg/disc)	[64]
<i>Thymus zygis</i> L.	Lamiaceae	Red thyme	>88% inhibition (0.3 µL/mL)	[66]
<i>Zataria multiflora</i> Boiss.	Lamiaceae	Aerial parts	IZD = 15 ± 5 mm (500 µg/disc)	[64]
			IZD = 12 ± 10 mm (500 µg/disc)	[64]
			IZD = 19 ± 0.5 mm (500 µg/disc)	[64]
			MIC = 0.3 µL/mL	[66]
			IZD = 23.6 mm	[66]

* Initial population of 8.52 ± 0.30 log₁₀ colony forming unit (CFU)/mL reduced to 7.67 ± 0.22 log₁₀CFU/mL; MIC, minimal inhibitory concentration; IZD, inhibition zone diameter.

Table 3. Plant ethanolic extracts with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Abrus cantoniensis</i> Bge.	Leguminosae	Aerial parts	MIC = 40 µg/mL	[55]
<i>Alepidea Amatybica</i> Eckl. and Zeyh	Apiaceae	Roots/rhizomes	IZD = 6.7 ± 6.7 mm	[50,51]
<i>Amomum villosum</i> Lour.	Zingiberaceae	Fruit	MIC = 100 µg/mL	[55]
<i>Bixa orellana</i> L.	Bixaceae	Seed	MIC ≤ 625–1250 µg/mL	[48]
<i>Bupleurum chinense</i> DC.	Apiaceae	Aerial parts	MIC = 60 µg/mL	[55]
<i>Chamomilla recutita</i> (L.) Rauschert	Compositae	Inflorescences	MIC ≤ 625 µg/mL	[48]
<i>Cichorium intybus</i> L.	Asteraceae	Root	IZD = 12 mm; MIC = 1.25–10 mg/mL	[47]
<i>Cinnamomum zeylanicum</i> Blume	Lauraceae	Bark	IZD = 20 mm; MIC = 1.25–5 mg/mL	[47]
<i>Citrus reticulata</i> Blanco	Rutaceae	Fruit shell	MIC = 60 µg/mL	[55]
<i>Combretum molle</i> R. Br. Ex G. Don	Combretaceae	Bark	IZD = 12.9 ± 4.7 mm	[50,51]

Table 3. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Convolvulus austro-aegyptiacu</i> Abdallah and Saad	Convolvulaceae	Aerial parts	MIC = 100–200 µg/mL	[67]
<i>Coriandrum sativum</i> L.	Apiaceae	Seed	IZD = 12 mm; MIC = 5–10 mg/mL	[47]
<i>Corydalis yanhusuo</i> W.T. Wang	Papaveraceae	Stem	MIC = 60 µg/mL	[55]
<i>Cuminum cyminum</i> L.	Apiaceae	Seed	IZD = 14 mm; MIC = 0.075–0.6 mg/mL	[47]
<i>Cynara scolymus</i> L.	Asteraceae	Leaves	IZD = 25 mm; MIC = 0.15–0.6 mg/mL	[47]
<i>Elettaria cardamomum</i> (L.) Maton.	Zingiberaceae	Seed	IZD = 18 mm; MIC = 0.6–2.5 mg/mL	[47]
<i>Eugenia caryophyllata</i> Thunb	Myrtaceae	Flower	MIC = 40 µg/mL	[55]
<i>Foeniculum vulgare</i> Mill. var. <i>dulce</i> DC	Apiaceae	Seed	IZD < 9 mm	[47]
<i>Fritillaria thunbergii</i> Miq.	Liliaceae	Stem	MIC = 40 µg/mL	[55]
<i>Garcinia kola</i> Heckel	Guttiferae	Seeds	MIC = 0.63–5 mg/mL; IZD = 9.2 ± 7.2 mm	[50,51]
<i>Hippophae rhamnoides</i> L.	Elaeagnaceae	Leaves	MIC = 60 µg/mL	[55]
<i>Ilex paraguariensis</i> A. St.-Hil.	Aquifoliaceae	Green leaves	MIC ≤ 625–5000 µg/mL	[48]
		Roasted leaves	MIC ≤ 625–5000 µg/mL	[48]
<i>Juniperus communis</i> L.	Cupressaceae	Berry	IZD = 10 mm; MIC = 1.25–10 mg/mL	[47]
<i>Ligusticum striatum</i> DC (cited as <i>Ligusticum chuanxiong</i>)	Apiaceae	Root	MIC = 60 µg/mL	[55]
<i>Lysimachia christinae</i> Hance	Primulaceae	Whole plant	MIC = 100 µg/mL	[55]
<i>Magnolia officinalis</i> Rehd. et Wils.	Magnoliaceae	Bark	MIC = 60 µg/mL	[55]
<i>Malva sylvestris</i> L.	Malvaceae	Leaves and inflorescences	MIC ≤ 625–5000 µg/mL	[48]
<i>Melia azedarach</i> L. (cited as <i>Melia toosendan</i>)	Meliaceae	Fruit	MIC = 100 µg/mL	[55]
<i>Mentha × piperita</i> L.	Lamiaceae	Leaves	IZD < 9 mm	[47]
<i>Piper longum</i> L.	Piperaceae	Spike	MIC = 100 µg/mL	[55]
<i>Prunus avium</i> L.	Rosaceae	Peduncles	IZD = 10 mm; MIC = 1.25–10 mg/mL	[47]
<i>Rosmarinus officinalis</i> L.	Lamiaceae	Leaves	IZD = 20 mm; MIC = 1.25–10 mg/mL	[47]
<i>Salvia officinalis</i> L.	Lamiaceae	Leaves	IZD = 14 mm; MIC = 1.25–5 mg/mL	[47]
<i>Saussurea costus</i> (Falc.) Lipsch. (cited as <i>Saussurea lappa</i>)	Compositae	Root	MIC = 40 µg/mL	[55]
<i>Schisandra chinensis</i> Baill.	Schisandraceae	Fruit	MIC = 60 µg/mL	[55]
<i>Sclerocarya birrea</i> A. Rich Hochst	Anacardiaceae	Stem bark	IZD = 3.3 ± 5.0 mm	[50,51]
<i>Thymus serpyllum</i> L.	Lamiaceae	Aerial parts	IZD = 22 mm; MIC = 1.25–10 mg/mL	[47]
<i>Tinospora sagittata</i> Gagnep.	Menispermaceae	Aerial parts	MIC/MBC = 6250 µg/mL	[42]
<i>Trigonella foenum-graecum</i> L.	Leguminosae	Seed	MIC = 40 µg/mL	[55]
<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Rhizome	IZD = 25 mm; MIC = 0.075–0.6 mg/mL	[47]

MIC, minimal inhibitory concentration; IZD, inhibition zone diameter.

Table 4. Plant methanolic extracts with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Acacia nilotica</i> (L.) Delile	<i>Leguminosae</i>	Leaves	MIC = 8–128 µg/mL	[49]
		Flowers	MIC = 8–64 µg/mL	[49]
<i>Acanthus montanus</i> (Nees) T. Anders	<i>Acanthaceae</i>	Leaves stalk	IZD = 6–22 mm (25µg/disc)	[68]
<i>Achillea millefolium</i> L.	<i>Compositae</i>	Aerial parts	MIC = 1.56–100 µg/mL	[69]
<i>Adhatoda vasica</i> Nees	<i>Acanthaceae</i>	Whole plant	MIC = 64–512 µg/mL	[49]
<i>Aframomum pruinatum</i> Gagnepain	<i>Zingiberaceae</i>	Seed	MIC = 128 µg/mL	[70]
<i>Ageratum conyzoides</i> L.	<i>Compositae</i>	Whole plant	IZD = 6–22 mm (25 µg/disc); MIC = 63–1000 µg/mL; MBC = 195–12,500 µg/mL	[68]
<i>Alchemilla fissa</i> Günther and Schummel	<i>Rosaceae</i>	Aerial parts	MIC = 4–32 µg/mL	[71]
<i>Alchemilla glabra</i> Neygenf.	<i>Rosaceae</i>	Aerial parts	MIC = 4–32 µg/mL	[71]
<i>Alchemilla monticola</i> Opiz	<i>Rosaceae</i>	Aerial parts	MIC = 4–32 µg/mL	[71]
<i>Alchemilla viridiflora</i> Rothm.	<i>Rosaceae</i>	Aerial parts	MIC = 4–16 µg/mL	[71]
<i>Alchornea triplinervia</i> (Spreng.) Müll.Arg.	<i>Euphorbiaceae</i>	Aerial parts	MIC = 250 µg/mL	[72]
<i>Alepidea amatymbica</i> Eckl. and Zeyh	<i>Apiaceae</i>	Roots/rhizomes	IZD = 6.1 ± 6.4 mm	[50,51]
<i>Alpinia galanga</i> (L.) Willd. (cited as <i>Languas galanga</i>)	<i>Zingiberaceae</i>	Tuber	IZD = 21.5 ± 1.9 mm (240 µg/disc)	[59]
<i>Amphipterygium adstringens</i> (Schltdl.) Standl.	<i>Anacardiaceae</i>	Aerial parts	MIC = 250 µg/mL	[52]
<i>Anoda cristata</i> (L.) Schltdl.	<i>Malvaceae</i>	Leaves/stem	MIC = 500 µg/mL	[52]
<i>Artemisia ludoviciana</i> Nutt. subsp. <i>mexicana</i> (Willd. ex Spreng.) Fernald	<i>Compositae</i>	Leaves/stem	MIC = 250 µg/mL	[52]
<i>Aulotandria kamerunensis</i> (Loes)	<i>Zingiberaceae</i>	Rhizome	IZD = 16–22 mm (25 µg/disc)	[68]
<i>Bidens pilosa</i> L.	<i>Compositae</i>	Leaves	MIC = 128–512 µg/mL	[73]
<i>Bryophyllum pinnatum</i> (Lam.) Kurz	<i>Crassulaceae</i>	Leaves	MIC = 32 µg/mL; MBC = 256 µg/mL	[74]
<i>Calandrinia ciliata</i> (Ruiz and Pav.) DC. (cited as <i>Calandrinia micrantha</i>)	<i>Portulacaceae</i>	Leaves/Stem	MIC = 250 µg/mL	[52]
<i>Calophyllum brasiliense</i> Cambess.	<i>Clusiaceae</i>	Bark	MIC = 31 µg/mL; IZD = 7–8 mm (62.5–1000 µg/disc)	[75]
<i>Calotropis gigantea</i> (L.) W.T. Aiton	<i>Apocynaceae</i>	Leaves	IZD = 9.8 ± 1.2 mm (240 µg/disc)	[59]
<i>Calotropis procera</i> W.T. Aiton	<i>Apocynaceae</i>	Flowers	MIC = 64–256 µg/mL	[49]
<i>Capsella bursa-pastoris</i> (L.) Medik.	<i>Brassicaceae</i>	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Carum carvi</i> L.	<i>Apiaceae</i>	Seeds	MIC = 100 µg/mL	[69]
<i>Casuarina equisetifolia</i> L.	<i>Casuarinaceae</i>	Fruit	MIC = 128–512 µg/mL	[49]
<i>Centella asiatica</i> (L.) Urb.	<i>Apiaceae</i>	Whole plant	IZD = 13.0 ± 0.9 mm (240 µg/disc)	[59]

Table 4. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Chenopodium incisum</i> Poir. (cited as <i>Teloxys graveolens</i>)	Amaranthaceae	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Chromolaena odorata</i> (L.) R.M. King and H. Rob.	Asteraceae	Leaves	IZD = 25.3 ± 1.6 mm (240 µg/disc)	[59]
<i>Cistus laurifolius</i> L.	Cistaceae	Flowers	MIC = 62.5–125 µg/mL	[54]
<i>Colubrina asiatica</i> (L.) Brongn.	Rhamnaceae	Leaves	IZD = 16.3 ± 2.1 mm (240 µg/disc)	[59]
<i>Combretum molle</i> R. Br. Ex G. Don	Combretaceae	Bark	IZD = 13.1 ± 5.3 mm	[50,51]
<i>Cosmos caudatus</i> Kunth	Asteraceae	Leaves	IZD = 23.0 ± 0.9 mm (240 µg/disc)	[59]
<i>Cuminum cyminum</i> L.	Apiaceae	Seed	MIC = 100 µg/mL	[69]
<i>Curcuma longa</i> L.	Zingiberaceae	Rhizome	MIC = 12.5–100 µg/mL	[69]
<i>Curcuma longa</i> L./ <i>Zingiber officinale</i> L.	Zingiberaceae	Rhizome	MIC = 3.125–100 µg/mL	[69]
<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	Aerial parts	MIC = 31.2 µg/mL	[52]
		Stem	IZD = 28.5 ± 1.5 mm (240 µg/disc)	[59]
<i>Cyrtocarpa procera</i> Kunth	Anacardiaceae	Bark	MIC = 62.5 µg/mL	[58]
<i>Derris trifoliata</i> Lour.	Leguminosae	Stem	IZD = 47.0 ± 0.9 mm (240 µg/disc)	[59]
			IZD = 8.5 ± 1.0 mm (240 µg/disc)	[59]
<i>Dysphania ambrosioides</i> (L.) Mosyakin and Clemants (cited as <i>Teloxys ambrosioides</i>)	Amaranthaceae	Aerial parts	MIC = 250–500 µg/mL	[52]
<i>Elettaria cardamomum</i> (L.) Maton.	Zingiberaceae	Seed	MIC = 3.125–100 µg/mL	[69]
<i>Emilia coccinea</i> (Sims) G. Don	Compositae	Whole plant	IZD = 6–22 mm (25 µg/disc)	[68]
<i>Eryngium carlinae</i> F. Delaroche	Apiaceae	Aerial parts	MIC = 31.2 µg/mL	[52]
		Whole plant	IZD = 6–18 mm (25 µg/disc)	[68]
<i>Eryngium foetidum</i> L.	Apiaceae	Leaves	MIC = 64–512 µg/mL	[73]
<i>Eucalyptus torrelliana</i> F. Muell.	Myrtaceae	Stem bark	MIC = 12.5–200 µg/mL	[76]
<i>Eupatorium petiolare</i> Moc. ex DC.	Compositae	Aerial parts	MIC = 125 µg/mL	[52]
<i>Euphorbia hirta</i> L.	Euphorbiaceae	Whole plant	IZD = 6–18 mm (25 µg/disc)	[68]
<i>Euphorbia umbellata</i> (Pax) Bruyns	Euphorbiaceae	Bark	44.6% inhibition (256 µg/mL)	[77]
<i>Fagoniaar abica</i> L.	Zygophyllaceae	Whole plant	MIC = 32–256 µg/mL	[49]
<i>Ficus deltoidea</i> Jack	Moraceae	Leaves	IZD = 12.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Foeniculum vulgare</i> Mill. var. <i>dulce</i> DC	Apiaceae	Seeds	MIC = 50–100 µg/mL	[69]
<i>Garcinia kola</i> Heckel	Guttiferae	Seeds	IZD = 7.1 ± 5.8 mm	[50,51]
<i>Galinsoga ciliata</i> (Raf.) S. F. Blake	Compositae	Leaves	MIC = 128–512 µg/mL	[73]
<i>Gentiana lutea</i> L.	Gentianaceae	Root	MIC = 3.125–100 µg/mL	[69]
<i>Ginkgo biloba</i> L.	Ginkgoaceae	Leaves	MIC = 100 µg/mL	[69]
<i>Glycyrrhiza glabra</i> L.	Leguminosae	Root	IDZ = 19 mm (10 mg/mL)	[78]

Table 4. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Gnaphalium canescens</i> DC.	Compositae	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Grindelia inuloides</i> Willd.	Compositae	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Haplopappus spinulosus</i> (Pursh) DC.	Compositae		MIC = 125 µg/mL	[52]
<i>Hesperozygis marifolia</i> Epling	Lamiaceae	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Heterotheca inuloides</i> Cass.	Compositae	Aerial parts	MIC = 31.25 µg/mL	[52]
<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	Stem	IZD = 13.7 ± 1.2 mm (240 µg/disc)	[59]
		Leaves	IZD = 14.3 ± 1.0 mm (240 µg/disc)	[59]
<i>Hippocratea celastroides</i> HBK	Hippocrateaceae	Root bark	MIC = 31.25–125 µg/mL	[79]
		Leaves	MIC = 7.81–31.25 µg/mL	[79]
		Stem	MIC = 7.81–15.63 µg/mL	[79]
<i>Hydrastis canadensis</i> L.	Ranunculaceae	Rhizome	MIC = 0.78–50 µg/mL	[80]
<i>Illicium verum</i> Hook. f.	Schisandraceae	Fruit	MIC = 50–100 µg/mL	[69]
		Leaves	IZD = 8.0 ± 0.7 mm (240 µg/disc)	[59]
		Stem	IZD = 9.2 ± 0.8 mm (240 µg/disc)	[59]
<i>Jatropha podagrica</i> Hook.	Euphorbiaceae	Root	IZD = 34.0 ± 2.5 mm (240 µg/disc)	[59]
<i>Juniperus communis</i> L.	Cupressaceae	Berry	MIC = 25–100 µg/mL	[69]
<i>Kaempferia galanga</i> L.	Zingiberaceae	Leaves	IZD = 46.0 ± 0.1 mm (240 µg/disc)	[59]
		Tuber	IZD = 11.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Larrea tridentata</i> (Sessé and Moc. ex DC.) Coville	Zygophyllaceae	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Laurus nobilis</i> L.	Lauraceae	Leaves	MIC = 50–100 µg/mL	[69]
<i>Lavandula angustifolia</i> Mill.	Lamiaceae	Flower	MIC = 100–1000 µg/mL	[69]
<i>Limncharis flava</i> (L.) Buchenau	Alismataceae	Leaves	IZD = 11.0 ± 1.1 mm (240 µg/disc)	[59]
<i>Lippia graveolens</i> Kunth (cited as <i>Lippia berlandieri</i>)	Verbenaceae	Aerial parts	MIC = 31.2 µg/mL	[52]
<i>Lithraea molleoides</i> (Vell.) Engl.	Anacardiaceae	Aerial parts	MIC = 18–125 µg/mL	[81]
<i>Ludwigia repens</i> J. R. Forst.	Onagraceae	Aerial parts	MIC = 500 µg/mL	[52]
		Whole plant	IZD = 16–22 mm (25 µg/disc); MIC = 63–250 µg/mL; MBC = 195–12500 µg/mL	[68]
<i>Lycopodium cernua</i> (L.) Pic. Serm	Lycopodiaceae	Whole plant		
<i>Machaeranthera parviflora</i> A. Gray	Compositae	Aerial parts	MIC = 31.2 µg/mL	[52]
<i>Machaeranthera riparia</i> (Kunth) A.G. Jones	Compositae	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Machaeranthera tanacetifolia</i> (Kunth) Nees	Compositae	Aerial parts	MIC = 125 µg/mL	[52]
<i>Marantodes pumilum</i> (Blume) Kuntze (cited as <i>Labisia pumila</i>)	Primulaceae	Root	IZD = 8.0 ± 0.5 mm (240 µg/disc)	[59]
<i>Marrubium vulgare</i> L.	Lamiaceae	Leaves/stem	MIC = 31.2 µg/mL	[52]

Table 4. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Melastoma malabathricum</i> L. (blue variety)	<i>Melastomataceae</i>	Leaves	IZD = 25.7 ± 0.8 mm (240 µg/disc)	[59]
		Stem	IZD = 18.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Melissa officinalis</i> L.	<i>Lamiaceae</i>	Leaves	MIC = 100 ≥ 100 µg/mL	[69]
<i>Mentha × piperita</i> L.	<i>Lamiaceae</i>	Leaves	MIC = 25–100 µg/mL	[69]
<i>Mimosa pudica</i> L.	<i>Leguminosae</i>	Leaves/Stem	MIC = 500 µg/mL	[52]
<i>Mitrasacme indica</i> Wight (cited as <i>Mitrasacme alsinoides</i>)	<i>Loganiaceae</i>	Whole plant	IZD = 14.2 ± 1.9 mm (240 µg/disc)	[59]
<i>Monarda citriodora</i> var. <i>austromontana</i> (Epling) B. L. Turner. (cited as <i>Monarda austromontana</i>)	<i>Lamiaceae</i>	Leaves	IZD = 13.3 ± 2.3 mm (240 µg/disc)	[59]
<i>Monarda austromontana</i>	<i>Lamiaceae</i>	Aerial parts	MIC = 125 µg/mL	[52]
<i>Moussonia deppeana</i> (Schltdl. and Cham.) Klotzsch ex Hanst.	<i>Gesneriaceae</i>	Leaves/stem	MIC = 15.6 µg/mL	[52]
<i>Myristica fragrans</i> Houtt.	<i>Myristicaceae</i>	Seed	MIC = 3.125–25 µg/mL	[69]
<i>Neptunia oleracea</i> Lour.	<i>Leguminosae</i>	Leaves	IZD = 28.3 ± 4.1 mm (240 µg/disc)	[59]
<i>Ocimum basilicum</i> L.	<i>Lamiaceae</i>	Aerial parts	MIC = 31.2 µg/mL	[52]
<i>Origanum majorana</i> L.	<i>Lamiaceae</i>	Aerial parts	MIC = 50–100 µg/mL	[69]
<i>Origanum vulgare</i> L.	<i>Lamiaceae</i>	Leaves	MIC = 100 ≥ 100 µg/mL	[69]
<i>Orthosiphon aristatus</i> (Blume) Miq. (cited as <i>Orthosiphon stamineus</i>)	<i>Lamiaceae</i>	Leaves	IZD = 22.0 ± 2.4 mm (240 µg/disc)	[59]
		Stem	IZD = 16.0 ± 0.9 mm (240 µg/disc)	[59]
<i>Paeonia × suffruticosa</i> Andrews	<i>Paeoniaceae</i>	Root Cortex	IZD = 17 ± 0.08 mm (1 mg/disc)	[82]
<i>Parkia speciosa</i> Hassk.	<i>Leguminosae</i>	Seed	IZD = 18.0 ± 0.1 mm (240 µg/disc)	[59]
<i>Passiflora edulis</i> Sims (cited as <i>Passiflora incarnata</i>)	<i>Passifloraceae</i>	Aerial parts	MIC = 50–100 µg/mL	[69]
<i>Persicaria minor</i> (Huds.) Opiz (cited as <i>Polygonum minus</i>)	<i>Polygonaceae</i>	Leaves	IZD = 15.5 ± 1.1 mm (240 µg/disc)	[59]
<i>Petroselinum crispum</i> (Mill.) Fuss	<i>Apiaceae</i>	Aerial parts	MIC = 100 ≥ 100 µg/mL	[69]
<i>Phaeomeria imperialis</i> (Roscoe) Lindl.	<i>Zingiberaceae</i>	Flowers	IZD = 16.3 ± 1.4 mm (240 µg/disc)	[59]
<i>Phyllanthus niruri</i> L.	<i>Phyllanthaceae</i>	Whole plant	IZD = 29.7 ± 1.4 mm (240 µg/disc)	[59]
<i>Piper betle</i> L.	<i>Piperaceae</i>	Leaves	IZD = 23.5 ± 0.8 mm (240 µg/disc)	[59]
<i>Plantago major</i> L.	<i>Plantaginaceae</i>	Aerial parts	MIC = 250 µg/mL	[52]
<i>Plectranthus amboinicus</i> (Lour.) Spreng.	<i>Lamiaceae</i>	Aerial parts	MIC = 31.2 µg/mL	[52]
<i>Pluchea indica</i> (L.) Less.	<i>Compositae</i>	Leaves	IZD = 23.0 ± 1.3 mm (240 µg/disc)	[59]
<i>Poliomintha longiflora</i> A. Gray	<i>Lamiaceae</i>	Leaves/stem	MIC = 250 µg/mL	[52]
<i>Priva grandiflora</i> (Ortega) Moldenke	<i>Verbenaceae</i>	Aerial parts	MIC = 500 µg/mL	[52]
<i>Psidium guajava</i> L.	<i>Myrtaceae</i>	Leaves	IZD = 33.0 ± 2.3 mm (240 µg/disc)	[59]
<i>Quercus rugosa</i> Née	<i>Fagaceae</i>	Leaves	MIC = 125 µg/mL	[52]

Table 4. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Rosmarinus officinalis</i> L.	Lamiaceae	Leaves	MIC = 12.5–100 µg/mL	[69]
<i>Ruta chalepensis</i> L.	Rutaceae	Leaves	MIC = 62.5 µg/mL	[52]
<i>Salvia officinalis</i> L.	Lamiaceae	Leaves	MIC = 25–100 µg/mL	[69]
<i>Sanguinaria canadensis</i> L.	Papaveraceae	Rhizome	MIC = 12.5–50 µg/mL	[80]
<i>Scleria woodii</i> var. <i>ornata</i> (Cherm.) J. Schultze-Motel (cited as <i>Scleria striatonux</i>)	Cyperaceae	Root	IZD = 6–30 mm (25 µg/disc); MIC = 63–1000 µg/mL; MBC = 195–12,500 µg/mL	[68]
<i>Scleria verrucosa</i> (Wild)	Cyperaceae	Root	IZD = 4–20 mm (25 µg/disc)	[68]
<i>Sclerocarya birrea</i> A. Rich Hochst	Anacardiaceae	Stem bark	IZD = 3.0 ± 4.4 mm	[50,51]
<i>Solanum torvum</i> Sw.	Solanaceae	Seed	IZD = 17.3 ± 1.6 mm (240 µg/disc)	[59]
<i>Stachys setifera</i> C. A. Mey.	Lamiaceae	Aerial parts	IZD = 12.3 ± 0.8 mm (240 µg/disc)	[59]
<i>Tagetes lucida</i> Cav.	Compositae	Aerial parts	IZD = 38.3 mm (8 mg/disc)	[83]
<i>Tanacetum partshenium</i> (L.) Sch. Bip.	Compositae		MIC = 500 µg/mL	[52]
<i>Tapeinochilos ananassae</i> (Hassk.) K. Schum.	Costaceae	Rhizome	MIC = 62.5 µg/mL	[52]
<i>Tecoma stans</i> (L.) Juss. ex Kunth	Bignoniaceae	Aerial parts	IZD = 6–18 mm (25 µg/disc)	[68]
<i>Tillandsia usneoides</i> L.	Bromeliaceae	Aerial parts	MIC = 500 µg/mL	[52]
<i>Tinospora sinensis</i> (Lour.) Merr. (cited as <i>Tinospora cordifolia</i>)	Menispermaceae	Stem	MIC = 125 µg/mL	[52]
<i>Tithonia diversifolia</i> (Hemsl.) A.G.	Compositae	Aerial parts	IZD = 13.7 ± 2.7 mm (240 µg/disc)	[59]
<i>Verbena carolina</i> L.	Verbenaceae	Aerial parts	MIC = 62.5 µg/mL	[52]
<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Rhizome	MIC = 500–1000 µg/mL	[69]
			MIC = 6.25–50 µg/mL	[69]
			IZD = 19.7 ± 1.5 mm (240 µg/disc)	[59]

MIC, minimal inhibitory concentration; MBC, minimal bactericidal concentration; IZD, inhibition zone diameter.

Table 5. Plant acetone extracts with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Acacia nilotica</i> (L.) Delile	Leguminosae	Leaves	MIC = 8–128 µg/mL	[49]
		Flowers	MIC = 4–64 µg/mL	[49]
<i>Adhatoda vasica</i> Nees	Acanthaceae	Whole plant	MIC = 16–512 µg/mL	[49]
<i>Alepidea Amatybica</i> Eckl. and Zeyh	Apiaceae	Roots/Rhizomes	IZD = 7.0 ± 6.5 mm	[50,51]
<i>Bridelia micrantha</i> (Hochst.) Baill.	Phyllanthaceae	Bark	IZD = 16–23 mm	[53]
<i>Calotropis procera</i> W.T. Aiton	Apocynaceae	Leaves	MIC = 32–256 µg/mL	[49]
		Flowers	MIC = 8–128 µg/mL	[49]

Table 5. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Casuarina equisetifolia</i> L.	Casuarinaceae	Fruit	MIC = 128.0–1024 µg/mL	[49]
<i>Cocculus hirsutus</i> (L.) Diels.	Menispermaceae	Leaves	IZD = 22–24 mm (200–1000 µg/mL)	[56]
<i>Combretum molle</i> R. Br. Ex G. Don *	Combretaceae	Bark	MIC ₅₀ = 0.08–1.25 mg/mL; IZD = 10.7 ± 4.7 mm;	[50,51]
<i>Desmostachya bipinnata</i> (L.) Stapf.	Gramineae	Whole plant	MIC = 1.3 mg/mL	[84]
<i>Fagonia abica</i> L.	Zygophyllaceae	Whole plant	MIC = 16–128 µg/mL	[49]
<i>Garcinia kola</i> Heckel	Guttiferae	Seeds	IZD = 8.8 ± 5.2 mm	[50,51]
<i>Sclerocarya birrea</i> A. Rich Hochst *	Anacardiaceae	Stem bark	MIC ₅₀ = 0.06–1.25 mg/mL; IZD = 14.7 ± 2.5 mm	[50,51]

* Exhibited remarkable bactericidal activity against *H. pylori*, killing more than 50% of the strains within 18 h at 4 × MIC and led to complete elimination within 24 h; MIC, minimal inhibitory concentration; MIC₅₀, minimal inhibitory concentration required to inhibit 50% of cells growth; IZD, inhibition zone diameter.

Table 6. Plant chloroform extracts with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Calotropis gigantea</i> (L.) W.T. Aiton	Apocynaceae	Leaves	IZD = 14.0 ± 0.9 mm (240 µg/disc)	[59]
<i>Cedrus libani</i> A. Rich	Pinaceae	Cones	MIC = 31.2 µg/mL	[54]
<i>Centaurea solstitialis</i> L.	Asteraceae	Aerial parts	MIC = 1.95 µg/mL	[54]
<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Whole plant	IZD = 8.2 ± 0.4 mm (240 µg/disc)	[59]
<i>Chromolaena odorata</i> (L.) R.M. King and H. Rob.	Asteraceae	Leaves	IZD = 27.5 ± 1.0 mm (240 µg/disc)	[59]
<i>Cistus laurifolius</i> L.	Cistaceae	Flowers	MIC = 1.95 µg/mL	[54]
<i>Colubrina asiatica</i> (L.) Brongn.	Rhamnaceae	Leaves	IZD = 10.0 ± 0.9 mm (240 µg/disc)	[59]
<i>Cosmos caudatus</i> Kunth	Asteraceae	Leaves	IZD = 11.7 ± 0.5 mm (240 µg/disc)	[59]
<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	Stem	IZD = 18.0 ± 1.4 mm (240 µg/disc)	[59]
<i>Derris trifoliata</i> Lour.	Leguminosae	Stem	IZD = 47.0 ± 1.7 mm (240 µg/disc); MIC ₅₀ = 2 mg/mL MIC ₉₀ = 4 mg/L	[59]
<i>Desmos cochinchinensis</i> Lour.	Annonaceae	Leaves	IZD = 38.0 ± 1.0 mm (240 µg/disc)	[59]
<i>Desmostachya bipinnata</i> (L.) Stapf.	Gramineae	Whole plant	IZD = 30.0 ± 2.1 mm (240 µg/disc) MIC = 5 mg/mL	[84]
<i>Eucalyptus camaldulensis</i> Dehnh	Myrtaceae	Stem bark	MIC = 25–100 µg/mL	[76]
		Leaves	MIC = 50 µg/mL	[76]

Table 6. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Eucalyptus torelliana</i> F. Muell.	Myrtaceae	Leaves	MIC = 25–400 µg/mL	[76]
		Stem bark	MIC = 50–100 µg/mL	[76]
<i>Ficus deltoidea</i> Jack	Moraceae	Leaves	IZD = 10.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Heterotheca inuloides</i> Cass.	Compositae	Leaves	IZD = 11.2 ± 1.2 mm (240 µg/disc)	[59]
		Stem	IZD = 9.6 ± 0.6 mm (240 µg/disc)	[59]
<i>Hypericum perforatum</i> L.	Hypericaceae	Aerial parts	MIC = 7.8–31.2 µg/mL	[54]
<i>Jatropha podagrica</i> Hook.	Euphorbiaceae	Leaves	IZD = 10.0 ± 0.5 mm (240 µg/disc)	[59]
		Root	IZD = 42.0 ± 0.5 mm (240 µg/disc)	[59]
<i>Kaempferia galanga</i> L.	Zingiberaceae	Leaves	IZD = 66.0 ± 0.1 mm (240 µg/disc)	[59]
		Tuber	IZD = 18.3 ± 1.0 mm (240 µg/disc)	[59]
<i>Alpinia galanga</i> (L.) Willd. (cited as <i>Languas galanga</i>)	Zingiberaceae	Tuber	IZD = 24.2 ± 1.6 mm (240 µg/disc)	[59]
<i>Limnocharis flava</i> (L.) Buchenau	Alismataceae	Leaves	IZD = 14.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Melastoma malabathricum</i> L. (blue variety)	Melastomataceae	Leaves	IZD = 22.2 ± 1.3 mm (240 µg/disc)	[59]
		Stem	IZD = 7.2 ± 0.4 mm (240 µg/disc)	[59]
<i>Mimosa pudica</i> L.	Leguminosae	Whole plant	IZD = 8.8 ± 1.6 mm (240 µg/disc)	[59]
<i>Mitrasacme indica</i> Wight (cited as <i>Mitrasacme alsinoides</i>)	Loganiaceae	Leaves	IZD = 9.5 ± 1.1 mm (240 µg/disc)	[59]
<i>Momordica charantia</i> L.	Cucurbitaceae	Fruits	MIC = 31.2–125 µg/mL	[54]
<i>Neptunia oleracea</i> Lour.	Leguminosae	Leaves	IZD = 10.7 ± 2.0 mm (240 µg/disc)	[59]
<i>Orthosiphon aristatus</i> (Blume) Miq. (cited as <i>Orthosiphon stamineus</i>)	Lamiaceae	Leaves	IZD = 18.3 ± 2.2 mm (240 µg/disc)	[59]
		Stem	IZD = 11.3 ± 1.0 mm (240 µg/disc)	[59]
<i>Paeonia × suffruticosa</i> Andrews	Paeoniaceae	Root Cortex	IZD = 23.9–26.7 mm (1–10 mg/disc)	[82]
<i>Parkia speciosa</i> Hassk.	Leguminosae	Seed	IZD = 26.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Phaeomeria imperialis</i> (Roscoe) Lindl.	Zingiberaceae	Flowers	IZD = 14.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Phyllanthus niruri</i> L.	Phyllanthaceae	Whole plant	IZD = 9.8 ± 0.8 mm (240 µg/disc)	[59]
<i>Piper betle</i> L.	Piperaceae	Leaves	IZD = 25.8 ± 0.8 mm (240 µg/disc)	[59]
<i>Pluchea indica</i> (L.) Less.	Compositae	Leaves	IZD = 11.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Persicaria minor</i> (Huds.) Opiz (cited as <i>Polygonum minus</i>)	Polygonaceae	Leaves	IZD = 12.3 ± 0.8 mm (240 µg/disc)	[59]
<i>Psidium guajava</i> L.	Myrtaceae	Leaves	IZD = 10.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Sambucus ebulus</i>	Adoxaceae	Aerial parts	MIC = 31.2 µg/mL	[54]
<i>Sesbania grandiflora</i> (L.) Pers.	Leguminosae	Leaves	IZD = 8.8 ± 1.1 mm (240 µg/disc)	[59]
<i>Solanum torvum</i> Sw.	Solanaceae	Seed	IZD = 8.7 ± 0.0 mm (240 µg/disc)	[59]
<i>Tinospora sinensis</i> (Lour.) Merr. (cited as <i>Tinospora cordifolia</i>)	Menispermaceae	Stem	IZD = 19.2 ± 5 mm (240 µg/disc)	[59]
<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Rhizome	IZD = 41.5 ± 7.0 mm (240 µg/disc)	[59]

MIC, minimal inhibitory concentration; MIC₅₀ and MIC₉₀, minimal inhibitory concentration required to inhibit 50% and 90% of cells growth, respectively; IZD, inhibition zone diameter.

Table 7. Plant petroleum ether extracts with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Calotropis gigantea</i> (L.) W.T. Aiton	Apocynaceae	Leaves	IZD = 13.2 ± 0.8 mm (240 µg/disc)	[59]
<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Whole plant	IZD = 8.5 ± 0.6 mm (240 µg/disc)	[59]
<i>Chromolaena odorata</i> (L.) R.M. King and H. Rob.	Asteraceae	Leaves	IZD = 20.3 ± 1.4 mm (240 µg/disc)	[59]
<i>Colubrina asiatica</i> (L.) Brongn.	Rhamnaceae	Leaves	IZD = 11.0 ± 0.9 mm (240 µg/disc)	[59]
<i>Cosmos caudatus</i> Kunth	Asteraceae	Leaves	IZD = 16.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	Stem	IZD = 29.5 ± 1.5 mm (240 µg/disc)	[59]
<i>Derris trifoliata</i> Lour.	Leguminosae	Stem	IZD = 42.0 ± 0.9 mm (240 µg/disc); MIC ₅₀ = 1 mg/mL; MIC ₉₀ = 2 mg/L	[59]
<i>Desmostachya bipinnata</i> (L.) Stapf.	Gramineae	Whole plant	IZD = 42.0 ± 1.0 mm (240 µg/disc)	[59]
<i>Ficus deltoidea</i> Jack	Moraceae	Leaves	MIC = 1.5 mg/mL IZD = 8.0 ± 0.1 mm (240 µg/disc)	[59]
<i>Heterotheca inuloides</i> Cass.	Compositae	Leaves	IZD = 11.5 ± 1.1 mm (240 µg/disc)	[59]
<i>Jatropha podagrica</i> Hook.	Euphorbiaceae	Stem	IZD = 13.2 ± 0.1 mm (240 µg/disc)	[59]
<i>Kaempferia galanga</i> L.	Zingiberaceae	Leaves	IZD = 13.0 ± 1.1 mm (240 µg/disc)	[59]
<i>Alpinia galanga</i> (L.) Willd. (cited as <i>Languas galanga</i>)	Zingiberaceae	Root	IZD = 15.5 ± 1.4 mm (240 µg/disc)	[59]
<i>Limnocharis flava</i> (L.) Buchenau	Alismataceae	Tuber	IZD = 47.3 ± 3.1 mm (240 µg/disc)	[59]
<i>Melastoma malabathricum</i> L. (blue variety)	Melastomataceae	Leaves	IZD = 62.0 ± 0.1 mm (240 µg/disc)	[59]
<i>Mimosa pudica</i> L.	Leguminosae	Stem	IZD = 18.3 ± 1.0 mm (240 µg/disc)	[59]
<i>Mitrasacme indica</i> Wight (cited as <i>Mitrasacme alsinoides</i> R. Br.)	Loganiaceae	Leaves	IZD = 24.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Neptunia oleracea</i> Lour.	Leguminosae	Leaves	IZD = 14.0 ± 2.3 mm (240 µg/disc)	[59]
<i>Orthosiphon aristatus</i> (Blume) Miq. (cited as <i>Orthosiphon stamineus</i>)	Lamiaceae	Stem	IZD = 10.5 ± 0.8 mm (240 µg/disc)	[59]
<i>Parkia speciosa</i> Hassk.	Leguminosae	Whole plant	IZD = 8.5 ± 0.6 mm (240 µg/disc)	[59]
<i>Pereskia sacharosa</i> Griseb.	Cactaceae	Leaves	IZD = 11.0 ± 0.6 mm (240 µg/disc)	[59]
<i>Etlingera elatior</i> (Jack) R.M.Sm. (cited as <i>Phaeomeria imperialis</i>)	Zingiberaceae	Leaves	IZD = 10.5 ± 0.8 mm (240 µg/disc)	[59]
<i>Phyllanthus niruri</i> L.	Phyllanthaceae	Leaves	IZD = 17.7 ± 2.8 mm (240 µg/disc)	[59]
<i>Piper betle</i> L.	Piperaceae	Stems	IZD = 12.7 ± 0.5 mm (240 µg/disc)	[59]
		Seeds	IZD = 10.5 ± 0.8 mm (240 µg/disc)	[59]
		Leaves	IZD = 13.3 ± 0.5 mm (240 µg/disc)	[59]
		Flowers	IZD = 18.0 ± 1.1 mm (240 µg/disc)	[59]
		Whole plant	IZD = 14.0 ± 1.6 mm (240 µg/disc)	[59]
		Leaves	IZD = 54.2 ± 0.8 mm (240 µg/disc)	[59]

Table 7. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Pluchea indica</i> (L.) Less.	Compositae	Leaves	IZD = 13.7 ± 1.9 mm (240 µg/disc)	[59]
<i>Persicaria minor</i> (Huds.) Opiz (cited as <i>Polygonum minus</i>)	Polygonaceae	Leaves	IZD = 15.5 ± 0.6 mm (240 µg/disc)	[59]
<i>Psidium guajava</i> L.	Myrtaceae	Leaves	IZD = 8.5 ± 0.8 mm (240 µg/disc)	[59]
<i>Sesbania grandiflora</i> (L.) Pers.	Leguminosae	Leaves	IZD = 10.8 ± 1.0 mm (240 µg/disc)	[59]
<i>Solanum torvum</i> Sw.	Solanaceae	Seeds	IZD = 11.0 ± 0.9 mm (240 µg/disc)	[59]
<i>Tinospora sinensis</i> (Lour.) Merr. (cited as <i>Tinospora cordifolia</i>)	Menispermaceae	Stems	IZD = 10.7 ± 0.8 mm (240 µg/disc)	[59]
<i>Zingiber officinale</i> Roscoe	Zingiberaceae	Rhizome	IZD = 33.3 ± 1.6 mm (240 µg/disc)	[59]

MIC, minimal inhibitory concentration; MIC₅₀, minimal inhibitory concentration required to inhibit 50% of cells growth; IZD, inhibition zone diameter.

Table 8. Plant methanol/water, ethanol/water, methanol/petroleum, and methanol/dichloromethane extracts with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
Methanol/Water (70:30, v/v)				
<i>Acacia seyal</i> Delile	Leguminosae	Stem	MIC = 20 mg/mL	[84]
		Leaves	MIC = 20 mg/mL	[84]
<i>Alhagi maurorum</i> Medik.	Leguminosae	Whole plant	MIC = 0.79 mg/mL	[84]
<i>Bidens bipinnata</i> L.	Compositae	Whole plant	MIC = 25 mg/mL	[84]
<i>Capparis spinose</i> L.	Capparaceae	Aerial parts	MIC = 10 mg/mL	[84]
<i>Casimiroa edulis</i> Llave and Lex	Rutaceae	Unripe fruit	MIC = 20 mg/mL	[84]
<i>Centaurea alexandrina</i> Delile	Compositae	Whole plant	MIC = 80 mg/mL	[84]
<i>Centaurea pelia</i> DC.	Compositae	ND	MIC = 0.625–5 mg/mL	[85]
<i>Centaurea thessala</i> Hausskn. ssp. <i>drakiensis</i> (Freynd and Sint.) Georg	Compositae	ND	MIC = 0.625–5 mg/mL	[85]
<i>Cerastium candidissimum</i> L.	Caryophyllaceae	ND	MIC = 0.625–2.5 mg/mL	[85]
<i>Chamomilla recutita</i> (L.) Rauschert	Compositae	ND	MIC = 0.625–2.5 mg/mL	[85]
<i>Cleome africana</i> Botsch.	Cleomaceae	Whole plant	MIC = 0.158 mg/mL	[84]
<i>Conyza albida</i> Willd. ex Spreng.	Asteraceae	ND	MIC = 0.625–2.5 mg/mL	[85]
<i>Conyza bonariensis</i> (L.) Cronquist.	Asteraceae	ND	MIC = 0.625–2.5 mg/mL	[85]
<i>Cota palaestina</i> Reut. ex Unger and Kotschy (cited as <i>Anthemis melanolepis</i>)	Compositae	ND	MIC = 0.625–2.5 mg/mL	[85]
<i>Desmostachya bipinnata</i> (L.) Stapf.	Gramineae	Whole plant	MIC = 0.040 mg/mL	[84]
<i>Diplotaxis acris</i> (Forssk.) Boiss.	Cruciferae	Whole plant	MIC = 10 mg/mL	[84]
<i>Dittrichia viscosa</i> (L.) Greuter subsp. <i>revoluta</i>	Asteraceae	ND	MIC = 0.625–2.5 mg/mL	[85]
<i>Euphorbia retusa</i> Forssk.	Euphorbiaceae		MIC = 2.5 mg/mL	[84]
		Root	MIC = 10 mg/mL	[84]
<i>Glossostemon brugueiri</i> Desf.	Sterculiaceae	Leaves	MIC = 25 mg/mL	[84]

Table 8. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
<i>Hamada elegans</i> (Bunge) Botsch.	Chenopodiaceae	Whole plant	MIC = 10 mg/mL	[84]
<i>Haplophyllum tuberculatum</i> (Forssk.) A. Juss.	Rutaceae	Whole plant	MIC = 1.58 mg/mL	[84]
<i>Lythrum salicaria</i> L.*	Lythraceae	Aerial parts	IZD = 17 ± 0.08 mm (500 mg/mL)	[86]
<i>Marrubium vulgare</i> L.	Lamiaceae	Whole plant	MIC = 0.251 mg/mL	[84]
<i>Ocimum basilicum</i> L.	Lamiaceae	Aerial parts	MIC = 0.625–5 mg/mL	[85]
<i>Origanum dictamnus</i> L.	Lamiaceae	Aerial parts	MIC = 0.625–5 mg/mL	[85]
<i>Origanum majorana</i> L.	Lamiaceae	Aerial parts	MIC = 0.625–5 mg/mL	[85]
<i>Origanum vulgare</i> L.	Lamiaceae	Leaves	MIC = 0.625–2.5 mg/mL	[85]
<i>Schouwia thebaica</i> Webb.	Brassicaceae	Whole plant	MIC = 25 mg/mL	[84]
<i>Sisymbrium irio</i> L.	Brassicaceae	Whole plant	MIC = 0.074 mg/mL	[84]
<i>Stachys alopecuros</i> (L.) Benth.	Lamiaceae	Aerial parts	MIC = 0.625–2.5 mg/mL	[85]
<i>Thymbra capitata</i> (L.) Cav. (cited as <i>Thymus capitatus</i>)	Lamiaceae	Whole plant	MIC = 12.5 mg/mL	[84]
<i>Trifolium alexandrinum</i> L.	Leguminosae	Whole plant	MIC = 25 mg/mL	[84]
Ethanol/Water (70:30, v/v)				
<i>Calophyllum brasiliense</i> Cambess.	Clusiaceae	Bark	MIC = 31 µg/mL; IZD = 8–14 mm (62.5–1000 µg/disc)	[75]
<i>Cocculus hirsutus</i> (L.) Diels.	Menispermaceae	Leaves	IZD = 26 mm (200–1000 µg/mL)	[56]
<i>Fridericia chica</i> (Bonpl.) L. G. Lohmann (cited as <i>Arrabidaea chica</i>)	Bignoniaceae	Fresh leaves	12.5	[87]
<i>Hancornia speciosa</i> Gomez	Apocynaceae	Bark	MIC = 125 µg/mL	[88]
Methanol/Petroleum (1:1)				
<i>Carum bulbocastanum</i> (L.) Koch.	Apiaceae	Fruit	MIC = 31.25–250 µg/mL	[46]
<i>Carum carvi</i> L.	Apiaceae	Fruit	MIC = 31.25–125 µg/mL	[46]
<i>Glycyrrhiza glabra</i> Linn	Leguminosae	Root	MIC = 15.6–250 µg/mL	[46]
<i>Mentha longifolia</i> (L.) Huds.	Lamiaceae	Aerial parts	MIC = 31.25–125 µg/mL	[46]
<i>Salvia limbata</i> C. A. Mey.	Lamiaceae	Aerial parts	MIC = 125–250 µg/mL	[46]
<i>Salvia sclarea</i> L.	Lamiaceae	Aerial parts	MIC = 125–500 µg/mL	[46]
<i>Trachyspermum ammi</i> (L.) Sprague (cited as <i>Trachyspermum copticum</i>)	Apiaceae	Aerial parts	MIC = 31.25–250 µg/mL	[46,89]
<i>Xanthium strumarium</i> subsp. <i>brasilicum</i> (Vell.) O. Bolòs and Vigo (cited as <i>Xanthium brasilicum</i>)	Compositae	Aerial parts	MIC = 31.25–250 µg/mL	[46,89]
<i>Ziziphora clinopodioides</i> Lam.	Lamiaceae	Aerial parts	MIC = 31.25–125 µg/mL	[46]
Methanol/Dichloromethan				
<i>Cyrtocarpa procera</i> Kunth	Anacardiaceae	Bark	MIC = 62.5 µg/mL	[58]

* Methanol/water (80:20, v/v); ND, not defined; MIC, minimal inhibitory concentration; IZD, inhibition zone diameter.

Table 9. Plant cyclohexane, dichloromethane, ethyl acetate, n-Butanol, n-Hexane, and other extracts with anti-*H. pylori* activity.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
Cyclohexane				
<i>Alchemilla fissa</i> Günther and Schummel	<i>Rosaceae</i>	Aerial parts	MIC = 64–256 µg/mL	[71]
<i>Alchemilla glabra</i> Neygenf.	<i>Rosaceae</i>	Aerial parts	MIC = 64–256 µg/mL	[71]
<i>Alchemilla monticola</i> Opiz	<i>Rosaceae</i>	Aerial parts	MIC = 8–64 µg/mL	[71]
<i>Alchemilla viridiflora</i> Rothm.	<i>Rosaceae</i>	Aerial parts	MIC = 64–256 µg/mL	[71]
Dichloromethane				
<i>Alchemilla fissa</i> Günther and Schummel	<i>Rosaceae</i>	Aerial parts	MIC = 64–256 µg/mL	[71]
<i>Alchemilla glabra</i> Neygenf.	<i>Rosaceae</i>	Aerial parts	MIC = 64–256 µg/mL	[71]
<i>Alchemilla monticola</i> Opiz	<i>Rosaceae</i>	Aerial parts	MIC = 16–64 µg/mL	[71]
<i>Alchemilla viridiflora</i> Rothm.	<i>Rosaceae</i>	Aerial parts	MIC = 16–128 µg/mL	[71]
<i>Calophyllum brasiliense</i> Cambess.	<i>Clusiaceae</i>	Bark	MIC = 125 µg/mL; IZD = 7–10 mm (62.5–1000 µg/disc)	[75]
<i>Cyrtocarpa procera</i> Kunth	<i>Anacardiaceae</i>	Bark	MIC = 15.6 µg/mL	[58]
Ethyl acetate				
<i>Alepidea Amatybica</i> Eckl. and Zeyh	<i>Apiaceae</i>	Roots/rhizomes	IZD = 8.5 ± 4.8 mm	[50,51]
<i>Bidens pilosa</i> L.	<i>Compositae</i>	Leaves	MIC = 128–512 µg/mL IZD = 12–20 mm;	[73]
<i>Bridelia micrantha</i> (Hochst.) Baill.	<i>Phyllanthaceae</i>	Bark	MIC ₅₀ = 4.8–156 µg/mL; MIC ₉₀ = 4.8–2500 µg/mL	[53]
<i>Calophyllum brasiliense</i> Cambess.	<i>Clusiaceae</i>	Bark	MIC = 125 µg/mL; IZD = 7–8 mm (62.5–1000 µg/disc)	[75]
<i>Combretum molle</i> R. Br. Ex G. Don	<i>Combretaceae</i>	Bark	IZD = 10.7 ± 4.7 mm	[50,51]
<i>Desmostachya bipinnata</i> (L.) Stapf.	<i>Gramineae</i>	Whole plant	MIC = 0.79 mg/mL	[84]
<i>Eryngium foetidum</i> (Linn)	<i>Apiaceae</i>	Leaves	MIC = 128–512 µg/mL	[73]
<i>Garcinia kola</i> Heckel	<i>Guttiferae</i>	Seeds	IZD = 5.1 ± 4.6 mm	[50,51]
<i>Galinsoga ciliata</i> (Raf.) S. F. Blake	<i>Compositae</i>	Leaves	MIC = 128–512 µg/mL	[73]
<i>Geranium wilfordii</i> Maxim	<i>Geraniaceae</i>	Aerial parts	MIC = 30 µg/mL	[90]
<i>Paeonia</i> × <i>suffruticosa</i> Andrews	<i>Paeoniaceae</i>	Root Cortex	IZD = 14.1–19.9 mm (1–10 mg/disc)	[82]
<i>Physalis alkekengi</i> L. var. <i>franchetii</i> (Mast.) Makino	<i>Solanaceae</i>	Aerial parts	MIC = 500 µg/mL	[91]
<i>Sclerocarya birrea</i> A. Rich Hochst	<i>Anacardiaceae</i>	Stem bark	IZD = 13.2 ± 2.8 mm	[50,51]

Table 9. Cont.

Species	Family	Parts	Anti- <i>H. pylori</i> Potency	Ref.
n-Butanol				
<i>Centaurea solstitialis</i> L. subsp. <i>solstitialis</i>	<i>Asteraceae</i>	Aerial parts	MIC = 31.2 µg/mL	[54]
<i>Cistus laurifolius</i> L.	<i>Cistaceae</i>	Flowers	MIC = 62.5–125 µg/mL	[54]
<i>Hypericum perforatum</i> L.	<i>Hypericaceae</i>	Aerial parts	MIC = 15.6–31.2 µg/mL	[54]
<i>Momordica charantia</i> L.	<i>Cucurbitaceae</i>	Fruits	MIC = 62.5 µg/mL	[54]
n-Hexane				
<i>Calophyllum brasiliense</i> Cambess.	<i>Clusiaceae</i>	Bark	IZD = 7–14 mm (100–400 µg/disc)	[92]
			IZD = 7–8 mm (62.5–1000 µg/disc)	[75]
<i>Cyrtocarpa procera</i> Kunth	<i>Anacardiaceae</i>	Bark	IZD = 14 mm (400 mg/mL)	[75]
			MIC = 31 µg/mL	[58]
<i>Eucalyptus camaldulensis</i> Dehrh	<i>Myrtaceae</i>	Stem bark	MIC = 25–200 µg/mL	[76]
		Leaves	MIC = 50 µg/mL	[76]
<i>Eucalyptus torelliana</i> F. Muell.	<i>Myrtaceae</i>	Leaves	MIC = 25–50 µg/mL	[76]
		Stem bark	MIC = 25–200 µg/mL	[76]
<i>Mitrella kentii</i> (Bl.) Miq	<i>Annonaceae</i>	Bark	MIC = 125 µg/mL	[93]
<i>Paeonia × suffruticosa</i> Andrews	<i>Paeoniaceae</i>	Root Cortex	IZD = 29.9–31.3 mm (1–10 mg/disc)	[82]
Others				
<i>Camellia sinensis</i> (L.) Kuntze	<i>Theaceae</i>	Young shoots	IZD = 22.5 mm (20–60 µg/disc)	[94]
			MBC = 4 mg/mL	
<i>Chenopodium ambrosioides</i> L.	<i>Amaranthaceae</i>	Aerial parts	IZD = 18 mm (20–60 µg/disc)	[94]
			MBC = 5.5 mg/mL	
			MIC = 16 mg/L *	[95]

* 1 and 2 × MIC completely inhibited *H. pylori* growth at 24 h; MIC, minimal inhibitory concentration; MIC₅₀, minimal inhibitory concentration required to inhibit 50% of cells growth; MBC, minimal bactericidal concentration; IZD, inhibition zone diameter.

Table 10. Bioactive compounds with anti-*H. pylori* activity.

Plant Species	Bioactive Compounds	Anti- <i>H. pylori</i> Potency (MIC)	Ref.
<i>Allium sativum</i> L. (cloves)	Allicin (garlic poder)	4 µg/mL	[96]
	Allicin	6 µg/mL	[96]
	Diallyl disulfide	100–200 µg/mL	[96]
	Diallyl tetrasulfide	3–6 µg/mL	[96]
<i>Convolvulus austro-aegyptiacu</i> Abdallah and Saad (aerial parts)	Scopoletin	50–200 µg/mL	[67]
	Scopolin	50–100 µg/mL	[67]
<i>Glycyrrhiza glabra</i> L. (roots)	Licoricidin	6.25–12.5 µg/mL	[78]
	Licoisoflavone	6.25 µg/mL	[78]
	Fuscaxanthone I	15.2–122.0 µM	[97]
	Beta-Mangostin	18.3–147.3 µM	[97]
	Fuscaxanthone A	16.3–131.2 µM	[97]
	Cowanin	16.3–130.6 µM	[97]
	Cowaxanthone	4.6–152.3 µg/mL	[97]
	Alpha-Mangostin	19.0–76.1 µM	[97]
	Cowanol	15.7–126.4 µM	[97]
	Isojacareubin	23.9 µM	[97]
	Fuscaxanthone G	16.3–130.6 µM	[97]
	Nigrolineabiphenyl B	56.5–226.3 µM	[97]
	1,3,5,6-Tetrahydroxyxanthone	29.9–240.3 µM	[97]
Vokensiflavone	14.4–115.7 µM	[97]	
Morelloflavone	14.0–112.3 µM	[97]	
<i>Hydrastis canadensis</i> L. (rhizomes)	Berberine	0.78–25 µg/mL	[80]
	β-Hydrastine	25–100 µg/mL	[80]
<i>Sanguinaria canadensis</i> L. (rhizomes)	Sanguinarine	6.25–50 µg/mL	[80]
	Chelerythrine	25–100 µg/mL	[80]
	Protopine	25 ≥ 100 µg/mL	[80]
<i>Tinospora sagittata</i> Gagnep. (aerial parts)	Palmatine	3.12–6.25 µg/mL	[42]

MIC, minimal inhibitory concentration.

5. In Vivo Findings

H. pylori colonization is increasingly being associated with a heightened risk of developing upper gastrointestinal tract diseases. Despite many plant extracts having demonstrated a prominent *H. pylori* inhibition capacity in culture, it is of crucial importance to assess their in vivo efficacy, because it is pivotal to ascertain their effective antibacterial potency. However, a relatively low number of medicinal plants have been investigated to date for in vivo activity, as discussed below.

Paeonia lactiflora root extract (100 µg/mL) showed a complete inhibition of *H. pylori* colonization ($4\text{--}5 \times 10^5$ colony forming unit (CFU)), being the antibacterial potential equivalent to of ampicillin used as positive control (10 µg/mL) ($2\text{--}4 \times 10^5$ CFU) [98]. Time course viability experiments were also performed in simulated gastric environments to assess the anti-*H. pylori* activity of garlic (*Allium sativum*) oil (16 and 32 µg/mL). A rapid anti-*H. pylori* action in artificial gastric juice was found. Nevertheless, the anti-*H. pylori* activity displayed by garlic oil was noticeably affected by food materials and mucin, despite the fact that a substantial activity remained under simulated gastric conditions [65]. Also, *H. pylori*-inoculated Swiss mice receiving 125, 250, or 500 mg/kg of *Bryophyllum pinnatum* or ciprofloxacin (500 mg/kg) for 7 days, showed a significant reduction of *H. pylori* colonization on gastric tissue from 100% to 17%. In addition, the highest *B. pinnatum* extract tested (85.91 ± 52.91 CFU) and standard drug ciprofloxacin (25.74 ± 16.15 CFU) also reduced significantly ($p < 0.05$) the bacterial load of gastric mucosa as compared with untreated infected mice (11883 ± 1831 CFU) [74]. On the other hand, *Eryngium foetidum* methanol extract (381.9 ± 239.5 CFU) and positive control ciprofloxacin (248 ± 153.2 CFU) significantly reduced the bacterial load in gastric mucosa at the same dose (500 mg/kg) compared with untreated and inoculated mice (14350 ± 690 CFU) [73].

Hippocratea celastroides hydroethanolic root-bark extract, a widely used plant against gastric and intestinal infections, also showed anti-*H. pylori* efficacy in naturally infected dogs. In a study of 18 experimental dogs treated with a dose of 93.5–500 mg/kg of *H. celastroides* extract in weight and 19 infected dogs receiving amoxicillin–clarithromycin–omeprazole (control treatment), the results showed effectiveness of 33.3 and 55% in the experimental and control groups, respectively [99].

On the other hand, Ye et al. [95], aiming to investigate the in vivo bactericidal effects of *Chenopodium ambrosioides* L. against *H. pylori*, randomly assigned *H. pylori*-infected mice into plant extract group, triple therapy control (lansoprazole, metronidazole, and clarithromycin), blank control, and *H. pylori* control groups. The obtained eradication ratios, determined by rapid urease tests (RUTs) and histopathology, were, respectively, 60% (6/10) using RUT and 50% (5/10) using histopathology for the test group and both 70% (7/10) for the control group. In addition, the histopathologic evaluation revealed a massive bacterial colonization on the gastric mucosa surface and slight mononuclear cells infiltration after *H. pylori* inoculation, but no obvious inflammation or other pathologic changes in gastric mucosa were stated between the *C. ambrosioides*-treated mice and the standard therapy.

Tinospora sagittata and its main component, palmatine, showed in vitro bactericidal effects on *H. pylori* strains, with both MIC and minimal bactericidal concentration (MBC) values of 6250 µg/mL, whereas palmatine's MIC value against *H. pylori* SCYA201401 was 6.25 µg/mL and against *H. pylori* SS1 was 3.12 µg/mL. The time-kill kinetic study evidenced a dose-dependent and progressive decline in the numbers of viable bacteria up to 40 h. *H. pylori*-infected mice treated with extract, palmatine, or control therapy (omeprazole, clarithromycin, and amoxicillin), presented eradication ratios of, respectively, 80%, 50%, and 70%. The anti-*H. pylori* activity found in *T. sagittata* extracts and its major constituent, palmatine, both in culture and animal models, clearly highlights the antibacterial potential of this plant in the treatment of both infected humans and animals [42].

Total alkaloids fraction activity (TASA) of *Sophora alopecuroides* L., widely used in herbal remedies against stomach-associated diseases, were also investigated on 120 *H. pylori*-infected BALB/c mice mouse gastritis. A total of 100 infected mice were randomly assigned into 10 treatment groups: group I (normal saline); group II (bismuth pectin); group III (omeprazole); group IV (TASA 2 mg/day); group V (TASA 4 mg/day); group VI (TASA 5 mg/day); group VII (TASA + bismuth pectin); group VIII (TASA + omeprazole); group IX (bismuth pectin + clarithromycin + metronidazole); and group X (omeprazole + clarithromycin + metronidazole). The mice were sacrificed 4 weeks after treatment. Real-time PCR was used to detect 16sDNA of *H. pylori* to test both the colonization and mice clearance of bacteria of each treatment. Hematoxylin and eosin staining and immunostaining of mice gastric mucosa were also used to observe the general inflammation and related factors: IL-8, COX2, and nuclear factor-kappa B (NF- κ B) expression changed after treatments. TASA combined with omeprazole or bismuth pectin showed promising antimicrobial activity against *H. pylori*, as well as conventional triple therapy. Indeed, hematoxylin and eosin staining and immune-staining of mice gastric mucosa evidenced that the inflammation on mice gastric mucosal membrane were also clearly relieved in TASA combined treatments and conventional triple therapy compared with normal saline-treated mice. Accordingly, from immunohistochemistry results, *H. pylori*-induced IL-8, COX2, and NF- κ B were consistently suppressed in the seventh, eighth, ninth, and tenth groups to a certain extent [100].

Pastene et al. [101] investigated the inhibitory effects of a standardized apple peel polyphenol-rich extract (*Malus pumila* Mill., cited as *Malus domestica*) against *H. pylori* infection and vacuolating bacterial toxin (VacA)-induced vacuolation and found that the preparation significantly prevented vacuolation in HeLa cells with an IC₅₀ value of 390 μ g gallic acid equivalents (GAE)/mL and an in vitro anti-adhesive effect against *H. pylori*. A significant inhibition was also stated with 20–60% reduction of *H. pylori* attachment at concentrations between 0.250 and 5 mg GAE/mL. In a short-term infection model (C57BL/6/J mice), doses of 150 and 300 mg/kg/day showed an inhibitory effect on *H. pylori* attachment. Orally administered apple peel polyphenols also showed an anti-inflammatory effect on *H. pylori*-associated gastritis, lowering malondialdehyde levels and gastritis scores.

Kim et al. [102] investigated the GutGard™ ability (a flavonoid rich, *Glycyrrhiza glabra* root extract) to inhibit *H. pylori* growth both in Mongolian gerbils and C57BL/6 mouse models. Infected male Mongolian gerbils were orally treated once daily 6 times/week for 8 weeks with 15, 30, and 60 mg/kg GutGard™. Bacterial identification in the biopsy samples of gastric mucosa, via urease, catalase, and ELISA, as well as immunohistochemistry revealed a dose-dependent inhibition of *H. pylori* colonization in gastric mucosa by GutGard™. As well, the administration of 25 mg/kg GutGard™ in *H. pylori*-infected C57BL/6 mice significantly reduced *H. pylori* colonization in gastric mucosa, suggesting its usefulness in *H. pylori* infection prevention.

Calophyllum brasiliense stem bark preparations are popular remedies for the treatment of chronic ulcers. A current report evidenced gastroprotective, gastric acid inhibitory properties and anti-*H. pylori* activity in culture (MIC = 31 μ g/mL) [75]. Hydroethanolic (50, 100, and 200 mg/kg) and dichloromethane (100 and 200 mg/kg) fractions-treated Wistar rats ulcerated by acetic acid and inoculated with *H. pylori*, showed a marked delay in ulcer healing and reduced the ulcerated area in a dose-dependent manner [75]. While the dichloromethane fraction, at 200 mg/kg, increased PGE2 levels, both the hydroethanolic and dichloromethane fractions decreased the number of urease-positive animals, as confirmed by the reduction of the *H. pylori* presence in histopathological analysis. This aspect suggests that the antiulcer activity of *C. brasiliense* is partly linked with its anti-*H. pylori* efficacy [75]. Also, phenolic-rich oregano (*Origanum vulgare*) and cranberry (*Vaccinium macrocarpon*) extracts showed a prominent ability to inhibit *H. pylori* through urease inhibition and disruption of energy production by inhibition of proline dehydrogenase at the plasma membrane [103].

6. Urease Inhibition

The current therapies are challenged by the considerable number of emerging *H. pylori*-resistant strains. This fact has driven the need for alternative anti-*H. pylori* therapies that ideally should have good stability and low toxicity and to be able to inhibit urease activity [62]. It has been shown that *H. pylori* urease activity is crucial in bacterial survival and pathogenesis [104].

The inhibitory potency of some anti-*H. pylori* medicinal plants has been reported [62] and even investigated by some authors in the involved mechanisms of antibacterial action of those plant products [63].

Table 11 briefly shows the studied plant extracts with prominent anti-urease activity. Amin et al. [49] demonstrated that the methanolic and acetone extracts of some medicinal plants were able to inhibit urease activity. In fact, *Acacia nilotica* flower methanol and acetone extracts evidenced anti-*H. pylori* activity, being MIC values of 8–64 µg/mL and 4–64 µg/mL, respectively. Both extracts inhibited urease activity at 8.2–88.2% and 9.2–86.6%. *Calotropis procera* leaf and flower methanol and acetone extracts, with MIC values of 16–256 µg/mL, 32–256 µg/mL, and 8–128 µg/mL also displayed urease inhibitory effects, being, respectively, 12.2–48.2% and 7.2–58.2% for leaf and 9.3–68.2% for flower acetone extracts [49]. While *A. nilotica* extract exerted a competitive inhibition, that of *C. procera* extract displayed a mixed type of inhibition [49]. In addition, *Casuarina equisetifolia* fruit methanol extract, with MIC values varying from 128–512 µg/mL, also displayed 12.2–86.2% inhibition of urease activity [49].

In another study, *Camellia sinensis* young non-fermented and semi-fermented shoot extracts, presented inhibition zone diameter (IZD) and MBC of, respectively, 22.5 mm at 20–60 µg/disk and 4 mg/mL, and 18 mm at 20–60 µg/disk and 5.5 mg/mL. They both inhibited Ure A and Ure B subunits production at 2.5 and 3.5 mg/mL [94]. Also, the *Chamomilla recutita* flower extract, which inhibited *H. pylori* growth at an MIC₉₀ value of 125 mg/mL and a MIC₅₀ value of 62.5 mg/mL, was able to inhibit the urease production [105]. In the same line, the methanol fraction of *Euphorbia umbellata* bark extract inhibited both *H. pylori* growth (44.6% inhibition) at 256 µg/mL and urease activity (78.6% inhibition) at 1024 µg/mL [77]. Moreover, the *Peumus boldus* flower aqueous extract showed anti-adherent activity against *H. pylori* and inhibited urease activity with an IC₅₀ value of 23.4 µg GAE/mL [61]. The aqueous extract of *Terminalia chebula* fruit showed activity with MIC and MBC values of 125 mg/mL and 150 mg/mL, respectively, and inhibited *H. pylori* urease activity at a concentration of 1–2.5 mg/mL [63].

Table 11. Urease inhibitory potential of plant extracts.

Plant Species	Parts	Extraction Solvent	Concentration Tested	Urease Inhibition	Ref.
<i>Acacia nilotica</i> (L.) Delile	Leaves	Methanol	8–128 µg/mL	8.21–88.21%	[49]
	Flowers	Acetone	8–128 µg/mL	9.20–86.56%	[49]
<i>Calotropis procera</i> (Aiton) W.T. Aiton	Leaves	Methanol	16–256 µg/mL	12.23–48.22%	[49]
	Leaves	Acetone	32–256 µg/mL	7.23–58.21%	[49]
	Flowers	Acetone	8–128 µg/mL	9.33–68.21%	[49]
<i>Camellia sinensis</i> (L.) Kuntze	Young shoots	Methanol: water (62.5:37.5 v/v) non-fermented extract	2.5 mg/mL	100% Ure A and B	[94]
		Methanol: water (62.5:37.5 v/v) semifermented extract	3.5 mg/mL	100% Ure A and B	[94]
<i>Casuarina equisetifolia</i> L.	Fruit	Methanol	128–512 µg/mL	12.21–86.21%	[49]
<i>Chamomilla recutita</i> (L.) Rauschert	Flowers	Olive oil	31.25–250 mg/mL	Inhibited urease production	[105]
<i>Euphorbia umbellata</i> (Pax) Bruyns	Bark	Methanol	1024 µg/mL	78.6%	[77]
<i>Peumus boldus</i> Mol.	Leaves	Water		IC ₅₀ = 23.4 µg GAE/mL	[61]
<i>Terminalia chebula</i> Retz	Fruit	Water	1–2.5 mg/mL	Inhibited urease activity	[63]

IC₅₀, 50% inhibitory concentration. GAE, gallic acid equivalents.

7. Conclusions and Future Perspectives

Overall, the report suggests that the studied plant extracts possess anti-*H. pylori* activity, strengthening the claims made by traditional medicine practitioners about their putative anti-ulcerative properties. However, very few of them were investigated for efficacy in animal models or the ability to inhibit urease activity. Further studies are warranted for efficacy studies in animal models, elucidation of effective modes of action (including urease inhibition), and clinical trials in human being.

Author Contributions: All authors contributed equally to this work. B.S., J.S.-R., P.V.T.F., and N.M. critically reviewed the manuscript. All the authors read and approved the final manuscript.

Funding: The APC was funded by N Martins.

Acknowledgments: N. Martins would like to thank the Portuguese Foundation for Science and Technology (FCT–Portugal) for the Strategic project ref. UID/BIM/04293/2013 and “NORTE2020—Programa Operacional Regional do Norte” (NORTE-01-0145-FEDER-000012).

Conflicts of Interest: The authors declare no conflict of interest.

References

- Sharifi-Rad, M.; Nazaruk, J.; Polito, L.; Morais-Braga, M.F.B.; Rocha, J.E.; Coutinho, H.D.M.; Salehi, B.; Tabanelli, G.; Montanari, C.; del Mar Contreras, M.; et al. *Matricaria* genus as a source of antimicrobial agents: From farm to pharmacy and food applications. *Microbiol. Res.* **2018**, *215*, 76–88. [[CrossRef](#)]
- Sharifi-Rad, M.; Roberts, T.H.; Matthews, K.R.; Bezerra, C.F.; Morais-Braga, M.F.B.; Coutinho, H.D.M.; Sharopov, F.; Salehi, B.; Yousaf, Z.; Sharifi-Rad, M.; et al. Ethnobotany of the genus *Taraxacum*—Phytochemicals and antimicrobial activity. *Phytother. Res.* **2018**. [[CrossRef](#)] [[PubMed](#)]
- Salehi, B.; Zucca, P.; Sharifi-Rad, M.; Pezzani, R.; Rajabi, S.; Setzer, W.N.; Varoni, E.M.; Iriti, M.; Kobarfard, F.; Sharifi-Rad, J. Phytotherapeutics in cancer invasion and metastasis. *Phytother. Res.* **2018**, *32*, 1425–1449. [[CrossRef](#)] [[PubMed](#)]
- Sharifi-Rad, J.; Iriti, M.; Setzer, W.N.; Sharifi-Rad, M.; Roointan, A.; Salehi, B. Antiviral activity of *Veronica persica* Poir. on herpes virus infection. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 11–17. [[CrossRef](#)]
- Mishra, A.P.; Saklani, S.; Salehi, B.; Parcha, V.; Sharifi-Rad, M.; Milella, L.; Iriti, M.; Sharifi-Rad, J.; Srivastava, M. *Satyrium nepalense*, a high altitude medicinal orchid of Indian Himalayan region: Chemical profile and biological activities of tuber extracts. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 35–43. [[CrossRef](#)]
- Mishra, A.P.; Sharifi-Rad, M.; Shariati, M.A.; Mabkhot, Y.N.; Al-Showiman, S.S.; Rauf, A.; Salehi, B.; Župunski, M.; Sharifi-Rad, M.; Gusain, P.; et al. Bioactive compounds and health benefits of edible *Rumex* species—A review. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 27–34. [[CrossRef](#)]
- Monjazebe Marvdashti, L.; Abdolshahi, A.; Hedayati, S.; Sharifi-Rad, M.; Iriti, M.; Salehi, B.; Sharifi-Rad, J. Pullulan gum production from low-quality fig syrup using *Aureobasidium pullulans*. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 22–26. [[CrossRef](#)]
- Salehi, B.; Anil Kumar, N.V.; Şener, B.; Sharifi-Rad, M.; Kılıç, M.; Mahady, G.B.; Vlaisavljevic, S.; Iriti, M.; Kobarfard, F.; Setzer, W.N.; et al. Medicinal plants used in the treatment of human immunodeficiency virus. *Int. J. Mol. Sci.* **2018**, *19*, 1459. [[CrossRef](#)] [[PubMed](#)]
- Bagheri, G.; Mirzaei, M.; Mehrabi, R.; Sharifi-Rad, J. Cytotoxic and antioxidant activities of *Alstonia scholaris*, *Alstonia venenata* and *Moringa oleifera* plants from India. *Jundishapur J. Nat. Pharm. Prod.* **2016**, *11*, e31129. [[CrossRef](#)]
- Sharifi-Rad, M.; Salehi, B.; Sharifi-Rad, J.; Setzer, W.N.; Iriti, M. *Pulicaria vulgaris* Gaertn. essential oil: An alternative or complementary treatment for Leishmaniasis. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 18–21. [[CrossRef](#)]
- Sharifi-Rad, J.; Tayeboom, G.S.; Niknam, F.; Sharifi-Rad, M.; Mohajeri, M.; Salehi, B.; Iriti, M.; Sharifi-Rad, M. *Veronica persica* Poir. extract—antibacterial, antifungal and scolicidal activities, and inhibitory potential on acetylcholinesterase, tyrosinase, lipoxxygenase and xanthine oxidase. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 50–56. [[CrossRef](#)]

12. Sharifi-Rad, J.; Sharifi-Rad, M.; Salehi, B.; Iriti, M.; Roointan, A.; Mnayer, D.; Soltani-Nejad, A.; Afshari, A. In vitro and in vivo assessment of free radical scavenging and antioxidant activities of *Veronica persica* Poir. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 57–64. [[CrossRef](#)]
13. Martins, N.; Barros, L.; Ferreira, I.C. In vivo antioxidant activity of phenolic compounds: Facts and gaps. *Trends Food Sci. Technol.* **2016**, *48*, 1–12. [[CrossRef](#)]
14. Sharifi-Rad, J.; Ayatollahi, S.A.; Varoni, E.M.; Salehi, B.; Kobarfard, F.; Sharifi-Rad, M.; Iriti, M.; Sharifi-Rad, M. Chemical composition and functional properties of essential oils from *Nepeta schiraziana* Boiss. *Farmacía* **2017**, *65*, 802–812.
15. Salehi, B.; Mishra, A.P.; Shukla, I.; Sharifi-Rad, M.; Contreras, M.d.M.; Segura-Carretero, A.; Fathi, H.; Nasrabadi, N.N.; Kobarfard, F.; Sharifi-Rad, J. Thymol, thyme, and other plant sources: Health and potential uses. *Phytother. Res.* **2018**. [[CrossRef](#)] [[PubMed](#)]
16. Sharifi-Rad, M.; Varoni, E.M.; Iriti, M.; Martorell, M.; Setzer, W.N.; del Mar Contreras, M.; Salehi, B.; Soltani-Nejad, A.; Rajabi, S.; Tajbakhsh, M.; et al. Carvacrol and human health: A comprehensive review. *Phytother. Res.* **2018**. [[CrossRef](#)] [[PubMed](#)]
17. Martins, N.; Barros, L.; Henriques, M.; Silva, S.; Ferreira, I.C. In vivo anti-candida activity of phenolic extracts and compounds: Future perspectives focusing on effective clinical interventions. *BioMed Res. Int.* **2015**, *2015*, 247382. [[CrossRef](#)] [[PubMed](#)]
18. Sharifi-Rad, M.; Mnayer, D.; Morais-Braga, M.F.B.; Carneiro, J.N.P.; Bezerra, C.F.; Coutinho, H.D.M.; Salehi, B.; Martorell, M.; del Mar Contreras, M.; Soltani-Nejad, A.; et al. *Echinacea* plants as antioxidant and antibacterial agents: From traditional medicine to biotechnological applications. *Phytother. Res.* **2018**. [[CrossRef](#)] [[PubMed](#)]
19. Snow Setzer, M.; Sharifi-Rad, J.; Setzer, W.N. The search for herbal antibiotics: An in-silico investigation of antibacterial phytochemicals. *Antibiotics* **2016**, *5*, 30. [[CrossRef](#)] [[PubMed](#)]
20. Sharifi-Rad, J.; Mnayer, D.; Roointan, A.; Shahri, F.; Ayatollahi, S.; Sharifi-Rad, M.; Molaei, N. Antibacterial activities of essential oils from Iranian medicinal plants on extended-spectrum β -lactamase-producing *Escherichia coli*. *Cell. Mol. Biol.* **2016**, *62*, 75–82. [[PubMed](#)]
21. Sharifi-Rad, M.; Iriti, M.; Gibbons, S.; Sharifi-Rad, J. Anti-methicillin-resistant *Staphylococcus aureus* (MRSA) activity of Rubiaceae, Fabaceae and Poaceae plants: A search for new sources of useful alternative antibacterials against MRSA infections. *Cell. Mol. Biol.* **2016**, *62*, 39–45. [[PubMed](#)]
22. Sharifi-Rad, J.; Salehi, B.; Varoni, E.M.; Sharopov, F.; Yousaf, Z.; Ayatollahi, S.A.; Kobarfard, F.; Sharifi-Rad, M.; Afdjei, M.H.; Sharifi-Rad, M.; et al. Plants of the *Melaleuca* Genus as Antimicrobial Agents: From Farm to Pharmacy. *Phytother. Res.* **2017**, *31*, 1475–1494. [[CrossRef](#)] [[PubMed](#)]
23. Sharifi-Rad, M.; Varoni, E.M.; Salehi, B.; Sharifi-Rad, J.; Matthews, K.R.; Ayatollahi, S.A.; Kobarfard, F.; Ibrahim, S.A.; Mnayer, D.; Zakaria, Z.A.; et al. Plants of the genus *Zingiber* as a source of bioactive phytochemicals: From tradition to pharmacy. *Molecules* **2017**, *22*, 2145. [[CrossRef](#)] [[PubMed](#)]
24. Sharifi-Rad, J.; Salehi, B.; Schnitzler, P.; Ayatollahi, S.A.; Kobarfard, F.; Fathi, M.; Eisazadeh, M.; Sharifi-Rad, M. Susceptibility of herpes simplex virus type 1 to monoterpenes thymol, carvacrol, p-cymene and essential oils of *Sinapis arvensis* L., *Lallemantia royleana* Benth. and *Pulicaria vulgaris* Gaertn. *Cell. Mol. Biol.* **2017**, *63*, 42–47. [[CrossRef](#)] [[PubMed](#)]
25. Sharifi-Rad, J.; Salehi, B.; Stojanović-Radić, Z.Z.; Fokou, P.V.T.; Sharifi-Rad, M.; Mahady, G.B.; Sharifi-Rad, M.; Masjedi, M.R.; Lawal, T.O.; Ayatollahi, S.A.; et al. Medicinal plants used in the treatment of tuberculosis—Ethnobotanical and ethnopharmacological approaches. *Biotechnol. Adv.* **2017**. [[CrossRef](#)] [[PubMed](#)]
26. Salehi, B.; Ayatollahi, S.A.; Segura-Carretero, A.; Kobarfard, F.; Contreras, M.D.M.; Faizi, M.; Sharifi-Rad, M.; Tabatabai, S.A.; Sharifi-Rad, J. Bioactive chemical compounds in *Eremurus persicus* (Joub. & Spach) Boiss. essential oil and their health implications. *Cell. Mol. Biol.* **2017**, *63*, 1–7. [[PubMed](#)]
27. Abdolshahi, A.; Naybandi-Atashi, S.; Heydari-Majd, M.; Salehi, B.; Kobarfard, F.; Ayatollahi, S.A.; Ata, A.; Tabanelli, G.; Sharifi-Rad, M.; Montanari, C.; et al. Antibacterial activity of some Lamiaceae species against *Staphylococcus aureus* in yoghurt-based drink (Doogh). *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 71–77. [[CrossRef](#)]

28. Sharifi-Rad, J.; Roointan, A.; Setzer, W.N.; Sharifi-Rad, M.; Iriti, M.; Salehi, B. Susceptibility of *Leishmania major* to *Veronica persica* Poir. extracts-In vitro and in vivo assays. *Cell. Mol. Biol. (Noisy-le-Grand France)* **2018**, *64*, 44–49. [[CrossRef](#)]
29. Percival, S.L.; Suleman, L. Biofilms and *Helicobacter pylori*: Dissemination and persistence within the environment and host. *World J. Gastrointest. Pathophysiol.* **2014**, *5*, 122. [[CrossRef](#)] [[PubMed](#)]
30. Modolo, L.V.; de Souza, A.X.; Horta, L.P.; Araujo, D.P.; de Fátima, Â. An overview on the potential of natural products as ureases inhibitors: A review. *J. Adv. Res.* **2015**, *6*, 35–44. [[CrossRef](#)] [[PubMed](#)]
31. Zhang, X.-Y.; Zhang, P.-Y.; Aboul-Soud, M.A. From inflammation to gastric cancer: Role of *Helicobacter pylori*. *Oncol. Lett.* **2017**, *13*, 543–548. [[CrossRef](#)] [[PubMed](#)]
32. Sharifi-Rad, M.; Fokou, P.; Sharopov, F.; Martorell, M.; Ademiluyi, A.; Rajkovic, J.; Salehi, B.; Martins, N.; Iriti, M.; Sharifi-Rad, J. Antiulcer Agents: From Plant Extracts to Phytochemicals in Healing Promotion. *Molecules* **2018**, *23*, 1751. [[CrossRef](#)] [[PubMed](#)]
33. Sipponen, P.; Marshall, B.J. Gastritis and gastric cancer: Western countries. *Gastroenterol. Clin. N. Am.* **2000**, *29*, 579–592. [[CrossRef](#)]
34. Park, J.Y.; Forman, D.; Waskito, L.A.; Yamaoka, Y.; Crabtree, J.E. Epidemiology of *Helicobacter pylori* and CagA-Positive Infections and Global Variations in Gastric Cancer. *Toxins* **2018**, *10*, 163. [[CrossRef](#)] [[PubMed](#)]
35. Nagy, T.A.; Frey, M.R.; Yan, F.; Israel, D.A.; Polk, D.B.; Peek, R.M. *Helicobacter pylori* regulates cellular migration and apoptosis by activation of phosphatidylinositol 3-kinase signaling. *J. Infect. Dis.* **2009**, *199*, 641–651. [[CrossRef](#)] [[PubMed](#)]
36. Wroblewski, L.E.; Peek, R.M.; Wilson, K.T. *Helicobacter pylori* and gastric cancer: Factors that modulate disease risk. *Clin. Microbiol. Rev.* **2010**, *23*, 713–739. [[CrossRef](#)] [[PubMed](#)]
37. Tsugane, S. Salt, salted food intake, and risk of gastric cancer: Epidemiologic evidence. *Cancer Sci.* **2005**, *96*, 1–6. [[CrossRef](#)] [[PubMed](#)]
38. Gisbert, J.; Gonzalez, L.; Calvet, X.; García, N.; López, T.; Roque, M.; Gabriel, R.; Pajares, J. Proton pump inhibitor, clarithromycin and either amoxicillin or nitroimidazole: A meta-analysis of eradication of *Helicobacter pylori*. *Aliment. Pharmacol. Ther.* **2000**, *14*, 1319–1328. [[CrossRef](#)] [[PubMed](#)]
39. Molina-Infante, J.; Gisbert, J.P. Optimizing clarithromycin-containing therapy for *Helicobacter pylori* in the era of antibiotic resistance. *World J. Gastroenterol.* **2014**, *20*, 10338–10347. [[CrossRef](#)] [[PubMed](#)]
40. Hsu, P.-I.; Wu, D.-C.; Chen, W.-C.; Tseng, H.-H.; Yu, H.-C.; Wang, H.-M.; Kao, S.-S.; Lai, K.-H.; Chen, A.; Tsay, F.-W. Randomized controlled trial comparing 7-day triple, 10-day sequential, and 7-day concomitant therapies for *Helicobacter pylori* infection. *Antimicrob. Agents Chemother.* **2014**, *58*, 5936–5942. [[CrossRef](#)] [[PubMed](#)]
41. Malfertheiner, P.; Megraud, F.; O'Morain, C.A.; Gisbert, J.P.; Kuipers, E.J.; Axon, A.T.; Bazzoli, F.; Gasbarrini, A.; Atherton, J.; Graham, D.Y.; et al. Management of *Helicobacter pylori* infection-the Maastricht V/Florence Consensus Report. *Gut* **2017**, *66*, 6–30. [[CrossRef](#)] [[PubMed](#)]
42. Rong, Q.; Xu, M.; Dong, Q.; Zhang, Y.; Li, Y.; Ye, G.; Zhao, L. In vitro and in vivo bactericidal activity of *Tinospora sagittata* (Oliv.) Gagnep. var. *craveniana* (S.Y.Hu) Lo and its main effective component, palmatine, against porcine *Helicobacter pylori*. *BMC Complement. Altern. Med.* **2016**, *16*, 331. [[CrossRef](#)] [[PubMed](#)]
43. Lansdorp-Vogelaar, I.; Sharp, L. Cost-effectiveness of screening and treating *Helicobacter pylori* for gastric cancer prevention. *Best Pract. Res. Clin. Gastroenterol.* **2013**, *27*, 933–947. [[CrossRef](#)] [[PubMed](#)]
44. Wang, Y.C. Medicinal plant activity on *Helicobacter pylori* related diseases. *World J. Gastroenterol.* **2014**, *20*, 10368–10382. [[CrossRef](#)] [[PubMed](#)]
45. Vale, F.F.; Oleastro, M. Overview of the phytomedicine approaches against *Helicobacter pylori*. *World J. Gastroenterol.* **2014**, *20*, 5594–5609. [[CrossRef](#)] [[PubMed](#)]
46. Nariman, F.; Eftekhari, F.; Habibi, Z.; Massarrat, S.; Malekzadeh, R. Antibacterial activity of twenty Iranian plant extracts against clinical isolates of *Helicobacter pylori*. *Iran. J. Basic Med. Sci.* **2009**, *12*, 105–111.
47. Nostro, A.; Cellini, L.; Bartolomeo, S.D.; Campli, E.D.; Grande, R.; Cannatelli, M.; Marzio, L.; Alonzo, V. Antibacterial effect of plant extracts against *Helicobacter pylori*. *Phytother. Res.* **2005**, *19*, 198–202. [[CrossRef](#)] [[PubMed](#)]

48. Cogo, L.L.; Monteiro, C.L.B.; Miguel, M.D.; Miguel, O.G.; Cunico, M.M.; Ribeiro, M.L.; de Camargo, E.R.; Kussen, G.M.B.; Nogueira, K.d.S.; Costa, L.M.D. Anti-*Helicobacter pylori* activity of plant extracts traditionally used for the treatment of gastrointestinal disorders. *Braz. J. Microbiol.* **2010**, *41*, 304–309. [[CrossRef](#)] [[PubMed](#)]
49. Amin, M.; Anwar, F.; Naz, F.; Mehmood, T.; Saari, N. Anti-*Helicobacter pylori* and urease inhibition activities of some traditional medicinal plants. *Molecules* **2013**, *18*, 2135–2149. [[CrossRef](#)] [[PubMed](#)]
50. Njume, C.; Afolayan, A.J.; Samie, A.; Ndip, R.N. Inhibitory and Bactericidal Potential of Crude Acetone Extracts of *Combretum molle* (Combretaceae) on Drug-resistant Strains of *Helicobacter pylori*. *J. Health Popul. Nutr.* **2011**, *29*, 438–445. [[CrossRef](#)]
51. Njume, C.; Jide, A.A.; Ndip, R.N. Aqueous and Organic Solvent-Extracts of Selected South African Medicinal Plants Possess Antimicrobial Activity against Drug-Resistant Strains of *Helicobacter pylori*: Inhibitory and Bactericidal Potential. *Int. J. Mol. Sci.* **2011**, *12*, 5652–5665. [[CrossRef](#)] [[PubMed](#)]
52. Castillo-Juarez, I.; Gonzalez, V.; Jaime-Aguilar, H.; Martinez, G.; Linares, E.; Bye, R.; Romero, I. Anti-*Helicobacter pylori* activity of plants used in Mexican traditional medicine for gastrointestinal disorders. *J. Ethnopharmacol.* **2009**, *122*, 402–405. [[CrossRef](#)] [[PubMed](#)]
53. Okeleye, B.I.; Bessong, P.O.; Ndip, R.N. Preliminary phytochemical screening and in vitro anti-*Helicobacter pylori* activity of extracts of the stem bark of *Bridelia micrantha* (Hochst., Baill., Euphorbiaceae). *Molecules* **2011**, *16*, 6193–6205. [[CrossRef](#)] [[PubMed](#)]
54. Yesilada, E.; Gurbuz, I.; Shibata, H. Screening of Turkish anti-ulcerogenic folk remedies for anti-*Helicobacter pylori* activity. *J. Ethnopharmacol.* **1999**, *66*, 289–293. [[CrossRef](#)]
55. Li, Y.; Xu, C.; Zhang, Q.; Liu, J.Y.; Tan, R.X. In vitro anti-*Helicobacter pylori* action of 30 Chinese herbal medicines used to treat ulcer diseases. *J. Ethnopharmacol.* **2005**, *98*, 329–333. [[CrossRef](#)] [[PubMed](#)]
56. Poovendran, P.; Kalaigandhi, V.; Poongunran, E. Antimicrobial activity of the leaves of *Cocculus hirsutus* against gastric ulcer producing *Helicobacter pylori*. *J. Pharm. Res.* **2011**, *4*, 4294–4295.
57. Palacios-Espinosa, J.F.; Arroyo-Garcia, O.; Garcia-Valencia, G.; Linares, E.; Bye, R.; Romero, I. Evidence of the anti-*Helicobacter pylori*, gastroprotective and anti-inflammatory activities of *Cuphea aequipetala* infusion. *J. Ethnopharmacol.* **2014**, *151*, 990–998. [[CrossRef](#)] [[PubMed](#)]
58. Escobedo-Hinojosa, W.I.; Del Carpio, J.D.; Palacios-Espinosa, J.F.; Romero, I. Contribution to the ethnopharmacological and anti-*Helicobacter pylori* knowledge of *Cyrtocarpa procera* Kunth (Anacardiaceae). *J. Ethnopharmacol.* **2012**, *143*, 363–371. [[CrossRef](#)] [[PubMed](#)]
59. Uyub, A.M.; Nwachukwu, I.N.; Azlan, A.A.; Fariza, S.S. In-vitro antibacterial activity and cytotoxicity of selected medicinal plant extracts from Penang Island Malaysia on metronidazole-resistant-*Helicobacter pylori* and some pathogenic bacteria. *Ethnobot. Res. Appl.* **2010**, *8*, 095–106. [[CrossRef](#)]
60. Shahani, S.; Monsef-Esfahani, H.R.; Saeidnia, S.; Saniee, P.; Siavoshi, F.; Foroumadi, A.; Samadi, N.; Gohari, A.R. Anti-*Helicobacter pylori* activity of the methanolic extract of *Geum iranicum* and its main compounds. *Z. Naturforsch. C J. Biosci.* **2012**, *67*, 172–180. [[CrossRef](#)]
61. Pastene, E.; Parada, V.; Avello, M.; Ruiz, A.; Garcia, A. Catechin-based procyanidins from *Peumus boldus* Mol. aqueous extract inhibit *Helicobacter pylori* urease and adherence to adenocarcinoma gastric cells. *Phytother. Res.* **2014**, *28*, 1637–1645. [[CrossRef](#)] [[PubMed](#)]
62. Pinheiro Silva, L.; Damacena de Angelis, C.; Bonamin, F.; Kushima, H.; José Mininel, F.; Campaner dos Santos, L.; Karina Delella, F.; Luis Felisbino, S.; Vilegas, W.; Regina Machado da Rocha, L.; et al. *Terminalia catappa* L.: A medicinal plant from the Caribbean pharmacopeia with anti-*Helicobacter pylori* and antiulcer action in experimental rodent models. *J. Ethnopharmacol.* **2015**, *159*, 285–295. [[CrossRef](#)] [[PubMed](#)]
63. Malekzadeh, F.; Ehsanifar, H.; Shahamat, M.; Levin, M.; Colwell, R.R. Antibacterial activity of black myrobalan (*Terminalia chebula* Retz) against *Helicobacter pylori*. *Int. J. Antimicrob. Agents* **2001**, *18*, 85–88. [[CrossRef](#)]
64. Bergonzelli, G.E.; Donnicola, D.; Porta, N.; Corthésy-Theulaz, I.E. Essential Oils as Components of a Diet-Based Approach to Management of *Helicobacter* Infection. *Antimicrob. Agents Chemother.* **2003**, *47*, 3240–3246. [[CrossRef](#)] [[PubMed](#)]
65. O’Gara, E.A.; Maslin, D.J.; Nevill, A.M.; Hill, D.J. The effect of simulated gastric environments on the anti-*Helicobacter* activity of garlic oil. *J. Appl. Microbiol.* **2008**, *104*, 1324–1331. [[CrossRef](#)] [[PubMed](#)]

66. Hosseinienejad, Z.; Moghadam, S.D.; Ebrahimi, F.; Abdollahi, M.; Zahedi, M.J.; Nazari, M.; Hayatbakhsh, M.; Adeli, S.; Sharififar, F. In vitro screening of selected Iranian medicinal plants against *Helicobacter pylori*. *Int. J. Green Pharm.* **2011**, *5*, 282–285.
67. Awaad, A.S.; Al-Rifai, A.A.; El-Meligy, R.M.; Alafeefy, A.M.; Zain, M.E. New Activities for Isolated Compounds from *Convolvulus austro-egyptiacus* as Anti-ulcerogenic, Anti-*Helicobacter pylori* and Their Mimic Synthesis Using Bio-guided Fractionation. *Phytother. Res.* **2015**. [[CrossRef](#)] [[PubMed](#)]
68. Ndip, R.N.; Malange Tarkang, A.E.; Mbullah, S.M.; Luma, H.N.; Malongue, A.; Ndip, L.M.; Nyongbela, K.; Wirmum, C.; Efange, S.M. In vitro anti-*Helicobacter pylori* activity of extracts of selected medicinal plants from North West Cameroon. *J. Ethnopharmacol.* **2007**, *114*, 452–457. [[CrossRef](#)] [[PubMed](#)]
69. Mahady, G.B.; Pendland, S.L.; Stoia, A.; Hamill, F.A.; Fabricant, D.; Dietz, B.M.; Chadwick, L.R. In vitro susceptibility of *Helicobacter pylori* to botanical extracts used traditionally for the treatment of gastrointestinal disorders. *Phytother. Res.* **2005**, *19*, 988–991. [[CrossRef](#)] [[PubMed](#)]
70. Kouitcheu Mabeku, L.B.; Nanfack Nana, B.; Eyoum Bille, B.; Tchuenteu Tchuenguem, R.; Nguempi, E. Anti-*Helicobacter pylori* and antiulcerogenic activity of *Aframomum pruinosum* seeds on indomethacin-induced gastric ulcer in rats. *Pharm. Biol.* **2017**, *55*, 929–936. [[CrossRef](#)] [[PubMed](#)]
71. Krivokuca, M.; Niketic, M.; Milenkovic, M.; Golic, N.; Masia, C.; Scaltrito, M.M.; Sisto, F.; Kundakovic, T. Anti-*Helicobacter pylori* Activity of Four *Alchemilla* Species (Rosaceae). *Nat. Prod. Commun.* **2015**, *10*, 1369–1371. [[PubMed](#)]
72. Lima, Z.P.; Calvo, T.R.; Silva, E.F.; Pellizzon, C.H.; Vilegas, W.; Brito, A.R.; Bauab, T.M.; Hiruma-Lima, C.A. Brazilian medicinal plant acts on prostaglandin level and *Helicobacter pylori*. *J. Med. Food* **2008**, *11*, 701–708. [[CrossRef](#)] [[PubMed](#)]
73. Kouitcheu Mabeku, L.B.; Eyoum Bille, B.; Nguempi, E. In Vitro and In Vivo Anti-*Helicobacter* Activities of *Eryngium foetidum* (Apiaceae), *Bidens pilosa* (Asteraceae), and *Galinsoga ciliata* (Asteraceae) against *Helicobacter pylori*. *Biomed. Res. Int.* **2016**, *2016*, 2171032. [[CrossRef](#)] [[PubMed](#)]
74. Kouitcheu Mabeku, L.B.; Eyoum Bille, B.; Tchouangueu, T.F.; Nguempi, E.; Leundji, H. Treatment of *Helicobacter pylori* infected mice with *Bryophyllum pinnatum*, a medicinal plant with antioxidant and antimicrobial properties, reduces bacterial load. *Pharm. Biol.* **2017**, *55*, 603–610. [[CrossRef](#)] [[PubMed](#)]
75. Souza Mdo, C.; Beserra, A.M.; Martins, D.C.; Real, V.V.; Santos, R.A.; Rao, V.S.; Silva, R.M.; Martins, D.T. In vitro and in vivo anti-*Helicobacter pylori* activity of *Calophyllum brasiliense* Camb. *J. Ethnopharmacol.* **2009**, *123*, 452–458. [[CrossRef](#)] [[PubMed](#)]
76. Miguel, G.; Faleiro, L.; Cavaleiro, C.; Salgueiro, L.; Casanova, J. Susceptibility of *Helicobacter pylori* to essential oil of *Dittrichia viscosa* subsp. *revoluta*. *Phytother. Res.* **2008**, *22*, 259–263. [[CrossRef](#)] [[PubMed](#)]
77. Minozzo, B.R.; Lemes, B.M.; Justo, A.D.S.; Lara, J.E.; Petry, V.E.K.; Fernandes, D.; Bello, C.; Velloso, J.C.R.; Campagnoli, E.B.; Nunes, O.C.; et al. Anti-ulcer mechanisms of polyphenols extract of *Euphorbia umbellata* (Pax) Bruyns (Euphorbiaceae). *J. Ethnopharmacol.* **2016**, *191*, 29–40. [[CrossRef](#)] [[PubMed](#)]
78. Fukai, T.; Marumo, A.; Kaitou, K.; Kanda, T.; Terada, S.; Nomura, T. Anti-*Helicobacter pylori* flavonoids from licorice extract. *Life Sci.* **2002**, *71*, 1449–1463. [[CrossRef](#)]
79. Hinojosa, W.I.; Quiroz, M.A.; Alvarez, I.R.; Castaneda, P.E.; Villarreal, M.L.; Taketa, A.C. Anti-*Helicobacter pylori*, gastroprotective, anti-inflammatory, and cytotoxic activities of methanolic extracts of five different populations of *Hippocratea celastroides* collected in Mexico. *J. Ethnopharmacol.* **2014**, *155*, 1156–1163. [[CrossRef](#)] [[PubMed](#)]
80. Mahady, G.B.; Pendland, S.L.; Stoia, A.; Chadwick, L.R. In vitro susceptibility of *Helicobacter pylori* to isoquinoline alkaloids from *Sanguinaria canadensis* and *Hydrastis canadensis*. *Phytother. Res.* **2003**, *17*, 217–221. [[CrossRef](#)] [[PubMed](#)]
81. Garro, M.F.; Salinas Ibanez, A.G.; Vega, A.E.; Arismendi Sosa, A.C.; Pelzer, L.; Saad, J.R.; Maria, A.O. Gastroprotective effects and antimicrobial activity of *Lithraea molleoides* and isolated compounds against *Helicobacter pylori*. *J. Ethnopharmacol.* **2015**, *176*, 469–474. [[CrossRef](#)] [[PubMed](#)]
82. Ngan, L.T.M.; Moon, J.-K.; Shibamoto, T.; Ahn, Y.-J. Growth-Inhibiting, Bactericidal, and Urease Inhibitory Effects of *Paeonia lactiflora* Root Constituents and Related Compounds on Antibiotic-Susceptible and -Resistant Strains of *Helicobacter pylori*. *J. Agric. Food Chem.* **2012**, *60*, 9062–9073. [[CrossRef](#)] [[PubMed](#)]
83. Khanavi, M.; Safavi, S.M.; Siavashi, F.; Falah Tafti, A.; Haji Mahmoudi, M.; Haji Akhoundi, A.; Rezazadeh, S.A.; Foroumadi, A.R. Evaluation of anti-*Helicobacter pylori* activity of methanol extracts of some species of *Stachys* and *Melia*. *J. Med. Plants* **2008**, *28*, 74–80.

84. Ramadan, M.A.; Safwat, N.A. Antihelicobacter Activity of a Flavonoid Compound Isolated from *Desmostachya Bipinnata*. *Aust. J. Basic Appl. Sci.* **2009**, *3*, 2270–2277.
85. Stamatis, G.; Kyriazopoulos, P.; Golegou, S.; Basayiannis, A.; Skaltsas, S.; Skaltsa, H. In vitro anti-*Helicobacter pylori* activity of Greek herbal medicines. *J. Ethnopharmacol.* **2003**, *88*, 175–179. [[CrossRef](#)]
86. Manayi, A.; Khanavi, M.; Saiednia, S.; Azizi, E.; Mahmoodpour, M.R.; Vafi, F.; Malmir, M.; Siavashi, F.; Hadjiakhoondi, A. Biological activity and microscopic characterization of *Lythrum salicaria* L. *DARU J. Pharm. Sci.* **2013**, *21*, 61. [[CrossRef](#)] [[PubMed](#)]
87. Mafioletti, L.; da Silva Junior, I.F.; Colodel, E.M.; Flach, A.; Martins, D.T. Evaluation of the toxicity and antimicrobial activity of hydroethanolic extract of *Arrabidaea chica* (Humb. & Bonpl.) B. Verl. *J. Ethnopharmacol.* **2013**, *150*, 576–582. [[PubMed](#)]
88. Moraes Tde, M.; Rodrigues, C.M.; Kushima, H.; Bauab, T.M.; Villegas, W.; Pellizzon, C.H.; Brito, A.R.; Hiruma-Lima, C.A. *Hancornia speciosa*: Indications of gastroprotective, healing and anti-*Helicobacter pylori* actions. *J. Ethnopharmacol.* **2008**, *120*, 161–168. [[CrossRef](#)] [[PubMed](#)]
89. Nariman, F.; Eftekhari, F.; Habibi, Z.; Falsafi, T. Anti-*Helicobacter pylori* activities of six Iranian plants. *Helicobacter* **2004**, *9*, 146–151. [[CrossRef](#)] [[PubMed](#)]
90. Zhang, X.Q.; Gu, H.M.; Li, X.Z.; Xu, Z.N.; Chen, Y.S.; Li, Y. Anti-*Helicobacter pylori* compounds from the ethanol extracts of *Geranium wilfordii*. *J. Ethnopharmacol.* **2013**, *147*, 204–207. [[CrossRef](#)] [[PubMed](#)]
91. Wang, Y.; Wang, S.L.; Zhang, J.Y.; Song, X.N.; Zhang, Z.Y.; Li, J.F.; Li, S. Anti-ulcer and anti-*Helicobacter pylori* potentials of the ethyl acetate fraction of *Physalis alkekengi* L. var. *franchetii* (Solanaceae) in rodent. *J. Ethnopharmacol.* **2017**, *211*, 197–206. [[CrossRef](#)] [[PubMed](#)]
92. Lemos, L.M.S.; Martins, T.B.; Tanajura, G.H.; Gazoni, V.F.; Bonaldo, J.; Strada, C.L.; Silva, M.G.D.; Dall'Oglio, E.L.; de Sousa Júnior, P.T.; Martins, D.T.D.O. Evaluation of antiulcer activity of chromanone fraction from *Calophyllum brasiliense* Camb. *J. Ethnopharmacol.* **2012**, *141*, 432–439. [[CrossRef](#)] [[PubMed](#)]
93. Sidahmed, H.M.A.; Azizan, A.H.S.; Mohan, S.; Abdulla, M.A.; Abdelwahab, S.I.; Taha, M.M.E.; Hadi, A.H.A.; Ketuly, K.A.; Hashim, N.M.; Loke, M.F.; et al. Gastroprotective effect of desmosdumotin C isolated from *Mitrella kentii* against ethanol-induced gastric mucosal hemorrhage in rats: Possible involvement of glutathione, heat-shock protein-70, sulfhydryl compounds, nitric oxide, and anti-*Helicobacter pylori* activity. *BMC Complement. Altern. Med.* **2013**, *13*, 183. [[PubMed](#)]
94. Hassani, A.R.; Ordouzadeh, N.; Ghaemi, A.; Amirmozafari, N.; Hamdi, K.; Nazari, R. In vitro inhibition of *Helicobacter pylori* urease with non and semi fermented *Camellia sinensis*. *Indian J. Med. Microbiol.* **2009**, *27*, 30–34. [[PubMed](#)]
95. Ye, H.; Liu, Y.; Li, N.; Yu, J.; Cheng, H.; Li, J.; Zhang, X.-Z. Anti-*Helicobacter pylori* activities of *Chenopodium ambrosioides* L. in vitro and in vivo. *World J. Gastroenterol.* **2015**, *21*, 4178–4183. [[CrossRef](#)] [[PubMed](#)]
96. O'Gara, E.A.; Hill, D.J.; Maslin, D.J. Activities of Garlic Oil, Garlic Powder, and Their Diallyl Constituents against *Helicobacter pylori*. *Appl. Environ. Microbiol.* **2000**, *66*, 2269–2273. [[CrossRef](#)] [[PubMed](#)]
97. Nontakham, J.; Charoenram, N.; Upamai, W.; Taweechoitapatr, M.; Suksamrarn, S. Anti-*Helicobacter pylori* xanthones of *Garcinia fusca*. *Arch. Pharm. Res.* **2014**, *37*, 972–977. [[CrossRef](#)] [[PubMed](#)]
98. Jung, J.; Bae, K.H.; Jeong, C.-S. Anti-*Helicobacter pylori* and Antiulcerogenic Activities of the Root Cortex of *Paeonia suffruticosa*. *Biol. Pharm. Bull.* **2013**, *36*, 1535–1539. [[CrossRef](#)] [[PubMed](#)]
99. Garcia-Alonso, G.; Monroy-Noyola, A.; Contreras-Arellano, A.; Mariscal-Durand, J.F.; Galvez-Molina, Y.; Vazquez-Velazquez, A.; Garcia-Jimenez, S.; Nunez, P.; Cardoso-Taketa, A.; Villarreal, M.L. Preclinical evaluation of anti-*Helicobacter* spp. activity of *Hippocratea celastroides* Kunth and its acute and sub-acute toxicity. *BMC Complement. Altern. Med.* **2016**, *16*, 445. [[CrossRef](#)] [[PubMed](#)]
100. Tian, A.; Xu, T.; Liu, K.; Zou, Q.; Yan, X. Anti-*Helicobacter pylori* effect of total alkaloids of *sophora alopecuroides* in vivo. *Chin. Med. J.* **2014**, *127*, 2484–2491. [[PubMed](#)]
101. Pastene, E.; Speisky, H.; García, A.; Moreno, J.; Troncoso, M.; Figueroa, G. In Vitro and in Vivo Effects of Apple Peel Polyphenols against *Helicobacter pylori*. *J. Agric. Food Chem.* **2010**, *58*, 7172–7179. [[CrossRef](#)] [[PubMed](#)]
102. Kim, J.M.; Zheng, H.M.; Lee, B.Y.; Lee, W.K.; Lee, D.H. Anti-*Helicobacter pylori* Properties of GutGard. *Prev. Nutr. Food Sci.* **2013**, *18*, 104–110. [[CrossRef](#)] [[PubMed](#)]

103. Lin, Y.; Kwon, Y.; Labbe, R.; Shetty, K. Inhibition of *Helicobacter pylori* and associated urease by oregano and cranberry phytochemical synergies. *Appl. Environ. Microbiol.* **2005**, *71*, 8558–8564. [[CrossRef](#)] [[PubMed](#)]
104. Kuwahara, H.; Miyamoto, Y.; Akaike, T.; Kubota, T.; Sawa, T.; Okamoto, S.; Maeda, H. *Helicobacter pylori* Urease Suppresses Bactericidal Activity of Peroxynitrite via Carbon Dioxide Production. *Infect. Immun.* **2000**, *68*, 4378–4383. [[CrossRef](#)] [[PubMed](#)]
105. Shikov, A.N.; Pozharitskaya, O.N.; Makarov, V.G.; Kvetnaya, A.S. Antibacterial activity of *Chamomilla recutita* oil extract against *Helicobacter pylori*. *Phytother. Res.* **2008**, *22*, 252–253. [[CrossRef](#)] [[PubMed](#)]



© 2018 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).