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Evaluating the Efficacy of *Thymus vulgaris L.* from the Garmian Region: Chemical Composition and Clinical Application for Gastric Bacterial Infections

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***Abstract* — Thymus vulgaris L. (thyme) is being studied as a potential adjunct therapy for Helicobacter pylori (H. pylori) infections. H. pylori is a Gran-negative bacterium associated with peptic ulcers and gastric cancer. Alternative treatment options are needed due to declining efficacy of conventional antibiotics. Bioactive compounds in thyme, such as p-cymene, carvacrol, and thymol, exhibit strong antimicrobial activity and have been widely used in traditional medicine. A three-week clinical trial involving 48 patients with infections compared thyme extract to a standard triple therapy (Pylokit: tinidazole, clarithromycin, and lansoprazole). The thyme extract significantly reduced bacterial load, with an average drop of 5.14 units by week three. This demonstrates greater efficacy than the chemical treatment and showed no adverse effects. Chemical tests with GC-MS showed thymol (59.99%) as the predominant antimicrobial constituent, followed by carvacrol and p-cymene. These findings suggest that thyme may represent a safe, natural, and effective therapeutic option against H. pylori, warranting further large-scale clinical investigations.**

***Keywords*— Helicobacter pylori, Gastritis, thyme extract, antimicrobial, clinical research**

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I. INTRODUCTION

Thyme (Lamiaceae) is widely used as a culinary herb and medicinal plant. It has been investigated for its antimicrobial properties, safety profile, and bioactive constituents such as thymol, flavonoids, tannins, and saponins (Adnan et al., 2023). A Gram-negative bacterium called Helicobacter pylori (H. pylori) is known to colonize the human gastric mucosa and is linked to peptic ulcers, chronic gastritis and is associated with a higher risk of gastric cancer (Zahid et al., 2020; Mladenova, 2021). The global increase in antibiotic resistance has progressively limited the effectiveness of conventional therapy approach, which combines antibiotics with proton pump inhibitors (Öztekin et al., 2021; Pandey, 2020).

Medical herbs, particularly thyme (*Thymus vulgaris*) have gained attention as alternative treatments because of their long-standing of use in traditional medicine for their antibacterial properties (El-Sherbiny & Elbestawy, 2022). Thyme essential oil contains major active compounds-p-cymene, carvacrol, and thymol-that exhibit potent antimicrobial effects against various infections, including *H. pylori*. Several laboratory studies have demonstrated that thyme extract can inhibit the growth of *H. pylori* strains, even those resistant to standard antibiotics, suggesting its potential role as a supplement or alternative therapy. Proposed mechanisms of action include disruption of bacterial cell membranes and inhibition of key enzymes required for bacterial survival. Additionally, thyme compounds may disrupt bacterial quorum sensing systems which is essential for forming and maintaining biofilms (Almanea, 2020). Biofilm formation by *H. pylori*, provides protection against both antibiotics and host immune defenses (Almanea, 2020; Karaca et al., 2023).

Apart from its antibacterial effects, thyme extract demonstrates notable antioxidant properties, which could enhance its therapeutic efficacy in treating *H. pylori* infection

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(Yassin et al., 2022). Oxidative stress plays a key role in the pathophysiology of gastric mucosal injury caused by *H. pylori* (Usmonovna, 2023). By scavenging reactive oxygen species (ROS), thyme extract may reduce inflammation and promote healing of gastric lesions, thereby limiting oxidative damage (Blaser, 1992). Moreover, thyme extract exhibits anti-inflammatory effects — mediated through the downregulation of pro-inflammatory cytokines such as TNF-α and IL-1β (Usmonovna, 2023). This is particularly valuable since the progression of *H. pylori*-induced gastritis largely depends on chronic inflammation, this anti-inflammatory action (Blaser, 1992).

The safety profile of thyme extract is also favorable, with few known adverse effects in human studies (Rojas et al., 2020). This supports its potential as a long-term therapeutic option, particularly in the context of rising antibiotic resistance. Incorporating thyme extract into *H. pylori* treatment regimens may therefore address both bacterial infection and associated inflammation (Kianersi et al., 2021; Gholami-Ahangaran et al., 2022). Its multifaceted mode of action, including antibacterial, antioxidant, and anti-inflammatory properties, positions it as a strong candidate for further clinical investigation (Gholami-Ahangaran et al., 2022).

Therefore, the present study aims at evaluating the efficacy of thyme extract as a potential alternative or adjunct therapy for *Helicobacter pylori* infection through examining its bioactive compounds, particularly thymol and carvacrol, in reducing *H. pylori* titers. Although thyme (*Thymus vulgaris*) is generally safe in culinary doses, it may cause adverse effects such as allergic reactions, digestive disturbances, hormonal effects (due to estrogen-like compounds), and drug interactions with anticoagulants, antihypertensives, and antidiabetic medications (Boskabady et al., 2014). Topical application of undiluted thyme essential oil may cause skin irritation, and excessive ingestion can induce nausea or vomiting (Salehi et al., 2020). Pregnant women should avoid high doses due to potential uterine stimulation, and patients with thyroid disorders should exercise caution, as thyme may affect thyroid function (Ahmed et al., 2019). Given its anticoagulant properties (linked to vitamin K), individuals receiving warfarin or similar medications should also exercise caution (Alissa et al., 2018). For safety, essential oils should always be diluted, and medical consultation is advised before therapeutic use.

II. MATERIALS AND METHODS

Plant Material and Preparation of Thyme Extract

The plant used in this research was Thymus vulgaris L., collected from the Garmian region, Iraq, and identified according to the Flora of Iraq. The exact Global Positioning System (GPS) coordinates were 35°13'42.29" E and 38°60'12.14" N. The aerial parts of the plants were harvested during and just after the blooming stage to maximize the concentration of bioactive phytochemicals. About 2 kg of the plant's aerial parts (tops) were collected between mid-May and June, while the plant was flowering, and then the plants were shade dried. The dry material was first milled, and medicinal components were infused into 5 gm of sample in 250 ml of hot water (80°C). After 30 minutes of seeping, the mixture was filtered, and the resulting infusion was administered to participants at a dose of three times daily. During the study, the participants were instructed to maintain their habitual dietary intake while reducing their consumption of sugary foods, tea, and coffee.

Clinical Research Stage

A three-week clinical study was conducted with a total of 48 participants of varying ages diagnosed with gastric bacterial infection, all of whom were otherwise in stable health without severe chronic disease. Participants were randomly divided into two groups, each consisting of 24 males and females. The first group received herbal treatment (thyme extract infusion), and the second group received the pharmaceutical therapy Pylokit, which included tinidazole (500 mg), clarithromycin (250 mg), and lansoprazole (30 mg).

At baseline, participants underwent diagnostic testing prior to therapy initiation. Follow-up testing was conducted at the end of each week during the treatment period. To monitor treatment efficacy, stool samples were collected and analyzed using the ichroma-II titer kit with the stool antigen test (SAT), which detects H. pylori antigens. This diagnostic approach was used for both initial confirmation of infection and post-treatment assessment, with results compared against the cutoff index (1.0).

Chemical Analysis

Previous studies have shown that thyme contains three key bioactive constituents: thymol, carvacrol, and p-cymene). Therefore, thyme samples from the Garmian region of Kurdistan, Iraq, were analyzed to confirm their chemical profile. Essential oils were extracted using the Clevenger apparatus, and subsequent analysis was performed with gas chromatography-mass spectrometry (GC-MS). Results indicated that 99.58% of the thyme extract was identified. The chemical composition was consistent with the thymol chemotype, with major components of thymol (59.99%), p-

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cymene (15.44%), linalool (4.19%), and carvacrol (2.85%). These findings are congruent with earlier research from the Iranian Research Organization for Science and Technology (IROST) in which they used an Agilent 7890B GC with a 5977A MSD to perform GC-MS analysis. Separation was obtained using an HP-5MS column (30 m × 0.25 mm × 0.25 µm) with helium as the carrier gas at a flow rate of (1 mL/min). The oven temperature was set to 50°C for 2 minutes, then increased at 10°C/min to 300°C and kept for 5 minutes. Mass spectra were achieved in electron ionization (EI) mode at 70 eV. (Table 1). This table is from the (IROST), which is congruent with previously published data.

Table 1: Chemical composition of Thymus vulgaris essential oil, (IROST).

Compound	RRI	Percent of Oil
Thymol	2225	59.99
Carvacrol	2228	2.85
p-Cymene	1270	16.01
α-Thujene	1019	0.6
α-Terpineol	1707	0.33
Boroneol	1702	1.77
Limonene	1194	0.34
α-Pinene	1016	0.62
δ-Cadinene	1763	0.08
Camphene	1057	0.59
β-Pinene	1104	0.16
Myrcene	1159	1.15
α-Terpinene	1174	1.01
β-Caryophyllene	1596	1.29
1,8Cineole	1202	0.22
β-Phellandrene	1203	0.11
γ-Terpinene	1242	6.36
Thymol methyl ether	1607	0.51
Camphor	1521	0.38
Linalool	1541	4.19
Terpinen-4-ol	1602	0.89
Isothymol	2171	0.13
Total		99.58

Volatile Oil Quantification in Soluble Extract

We measured the quantity of volatile oils (p-cymene, carvacrol, and thymol) in the aqueous thyme extract using (GC-MS). Dried thyme aerial portions were subjected to a three-hour organic solvent distillation process using Clevenger equipment to obtain the essential oil. The estimated oil yield was 0.8% (v/w) which is consistent with previously reported values for Thymus vulgaris L.

Regarding the infusion administration to participants, 2.5 g of dry thyme (approximately one teaspoon) was steeped in 250 mL of hot water (80°C) for 30 minutes. Based on to the GC-MS analysis (Table 1), the infusion's estimated concentration of the main bioactive components per 250 mL infusion were: p-Cymene: 16.01% → ≈3.2 mg, carvacrol: 2.85% → ≈0.57 mg, and thymol: 59.99% of total oil → ≈12 mg.

Although GC-MS confirmed the presence of volatile oils such as thymol and carvacrol, the aqueous extract likely contains numerous non-volatile bioactive compounds, including flavonoids, tannins, saponins, polar phenols, water-soluble antioxidants, and polysaccharides. These additional constituents may contribute to the antibacterial, antioxidant, and anti-inflammatory properties of thyme against H. pylori.

Given that GC-MS is limited to volatile compounds, it does not capture the full phytochemical profile of aqueous extracts. Future investigations should employ High-Performance Liquid Chromatography (HPLC) or Liquid Chromatography–Mass Spectrometry (LC-MS) to identify and quantify non-volatile components, thereby providing a more comprehensive understanding of the extract's multifactorial pharmacological effects.

Data Analysis

For statistical analysis, GenStat version 9 (Kianersi et al., 2021) was employed. Two-way analysis of variance (ANOVA) was applied to calculate P-values, and the effectiveness of the treatment methods were further evaluated using Duncan's multiple range test mn. Graphical representations of the results were prepared in Microsoft Excel 2010.

III. RESULTS

The results of this study showed that thyme extract was more effective than the standard triple therapy of tinidazole (500 mg), clarithromycin (250 mg), and lansoprazole (30 mg) in reducing Helicobacter pylori infection. Bacterial counts in patient samples decreased progressively over the course of the three-week treatment. Statistical analysis confirmed a significant

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difference (P-value < 0.05) between the effect of chemical drugs and the herbal treatment.

At baseline, the initial titer levels varied widely among the participants, with some reaching as high as 13 units. This variation highlights the high prevalence and severity of H. pylori infection in the study population. After one week of therapy, the average titer reduction was 2.7 units. Participants with higher initial titers showed greater decreases, in some cases falling to as low as 6 units, suggesting that thyme extract exerted antimicrobial activity from the first week of administration.

During the second week of treatment, bacterial titers continued to decline, with an average reduction of 4.04 units compared to baseline values. This consistent decrease indicates that herbal therapy maintained its antibacterial activity and prevented bacterial regrowth. By the end of the third week, the average reduction reached 5.14 units. At this stage, most participants had titers approaching zero or within negative ranges, suggesting near-complete eradication of the infection. The steady and significant decline in bacterial titers over the three-week treatment period demonstrates the potential of thyme extract as an effective therapeutic option for H. pylori infections. These findings provide strong preliminary evidence that thyme-based therapy could serve as a natural alternative to conventional antibiotic regimens (Figure 1)

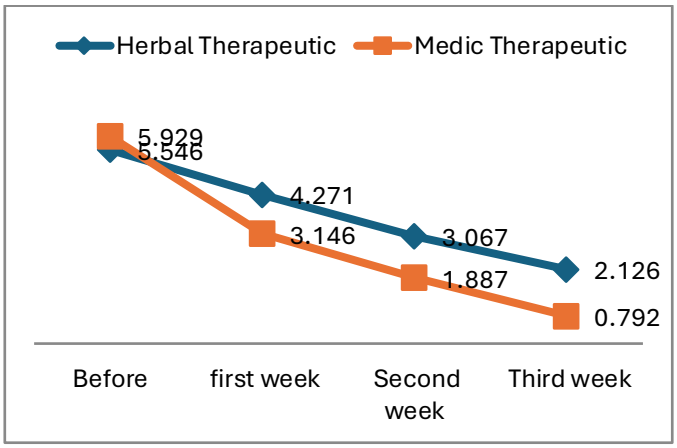

Figure 1: shows the declining trend in titer levels throughout the course of the three-week therapy.

IV. DISCUSSION

The findings of this study indicate that Thymus vulgaris L. extract demonstrated greater antibacterial efficacy against Helicobacter pylori than the commonly prescribed drugs tinidazole and clarithromycin. These results confirm the initial hypothesis that thyme may serve as an effective alternative therapy for gastric infections caused by H. pylori. Importantly, this study not only supports earlier laboratory-based research but also extends the evidence by providing clinical confirmation of thyme's therapeutic potential.

The results are consistent with previous investigations reporting that lifestyle and dietary habits, particularly the frequent consumption of fast foods and ready-made meals, are significant risk factors for H. pylori infection (Gholami-Ahangaran et al., 2022). In this study, the majority of infections occurred in males (15.84%), particularly those with frequent food consumption outside the home, while only 7.2% of females were affected (Table 2). Among the bioactive compounds identified in thyme are thymol, carvacrol, and p-cymene; these compounds were previously highlighted for their antibacterial properties (Smith et al., 2015; Thompson & Garcia, 2016; Diaz et al., 2017).

Dietary habits among different aged patients included frequent food intake and lowered consumption of sugary foods and sweeteners in tea and coffee

Table 2: Sociodemographic and Clinical Characteristics of Participants

	SOV	df	SS	MS	F calculate	P value
Medic Therap-eutic (MT)	Weeks	3	352.728	117.576	23.07	<.001
	Error	92	468.878	5.097		
	Total	95	821.606			
Herbal Therap-eutic (HT)	Weeks	3	158.394	52.798	6.98	<.001
	Error	92	695.951	7.565		
	Total	95	854.345			
Interac-tion MT*HT	Thera-peutic (T)	1	31.777	31.777	5.02	0.026
	Weeks(W)	3	487.916	162.639	25.69	<.001
	T*W	3	23.206	7.735	1.22	0.303
	Error	184	1164.829	6.331		
	Total	191	1707.729			

The clinical outcomes of thyme treatment were noteworthy. Within just one week, a substantial reduction in bacterial titers was observed, with an average decrease of 2.7 units and reductions of up to 6 units in certain individuals. Such rapid response highlights the potency of thyme's antibacterial activity and aligns with recent reports emphasizing the effectiveness of thymol and carvacrol as antimicrobial agents (Anderson Palmer, 2018). Continued reductions observed in the second and third weeks further underscore thyme's long-term therapeutic potential. By the end of the third week, bacterial titers had declined by an average of 5.14 units, with many participants nearing complete eradication of infection.The findings also highlighted that Thyme extract has a superior ability to reduce bacterial load without causing adverse effects, unlike the chemical treatment (Pylokit), as illustrated in Figure

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1. In contrast, tinidazole and clarithromycin are associated with various adverse effects, including nausea, peripheral neuropathy, hepatotoxicity, and the risk of antibiotic resistance (Saag, 1996; Fink & Farley, 2006; Foulds et al., 1991). The superior safety profile observed in this study strengthens the case for thyme as a natural therapeutic option.

The chemical analysis of thyme oil provides a mechanistic explanation for these results. GC-MS analysis revealed thymol as the predominant constituent (59.99%) of the oil (Table 1). Its activity is enhanced by the presence of p-cymene and carvacrol (Wright & Jones, 2019). Thymol exerts its antibacterial effect mainly by disrupting bacterial membranes. Additionally, linalool, though present in lower concentrations, also contributes to the extract's overall antibacterial activity (Davey & Brenwald, 1997).

Table 3: Significance compare between both groups of samples

Variable		Herbal Treatment Group	Chemical Treatment Group	Total
Participants		n=24	n=24	n=48
Gender	Male	17 (70.8%)	16 (66.7%)	33 (68.8%)
	Female	7 (29.2%)	8 (33.3%)	15 (31.2%)
Titer Levels		2.4 to 12	1 to 13	All participants
Treatment Duration		3 weeks	3 weeks	3 weeks
Adverse Effects		None reported	Nausea, Neuropathy	

Table 4: ANOVA Tables of Herbal Therapeutic, Medicine Therapeutic, and Both Interactions

Time	Herbal Therapeutic	Medic Therapeutic
Before	5.546^{a}	5.929^{a}
First week	4.271^{ab}	3.146^{bc}
Second week	3.067^{bc}	1.887^{cd}
Third week	2.126^{bcd}	0.792^{d}
P value	<0.001	<0.001

Note: a,b,c Means followed by different letters are statistically different ($p<0.05$).

CONCLUSION

This study demonstrates that Thymus vulgaris L. exhibits strong antibacterial properties and may offer a promising natural alternative for managing H. pylori infections. Patients receiving thyme extract experienced a rapid and sustained reduction in bacterial titers over three weeks Given its swift onset of action and prolonged therapeutic. effect, thyme extract holds potential as an adjunct or alternative treatment to conventional antibiotics. The key phytochemicals in thyme thymol, carvacrol, and p-cymene are well recognized for their antimicrobial, anti-inflammatory, and antioxidant properties, which are likely to act synergistically to inhibit gastric pathogens. Unlike pharmaceutical treatments such as tinidazole and clarithromycin, thyme extract appeared to pose fewer side effects. However, since adverse events and potential herb–drug interactions were not formally assessed in this study, further toxicological and pharmacokinetic evaluations are necessary. Comprehensive toxicological and pharmacokinetic evaluations, alongside large-scale clinical trials with rigorous safety monitoring, are required to establish its clinical utility. Moreover, future investigations should evaluate how thyme extract interacts with commonly used medications, especially in patients with chronic conditions. Finally, the observed association between dietary habits, particularly frequent fast-food consumption, and higher H. pylori prevalence, particularly in males, warrants the importance of considering lifestyle-related risk foster in disease prevention strategies. Overall, thyme extract appears to be a viable candidate for further clinical development. However, further research is essential to validate its efficacy and safety.

CONFLICT OF INTEREST

The author declares that there are no conflicts of interest regarding the publication of this paper

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