Activity of Bulgarian propolis against 94 *Helicobacter pylori* strains *in vitro* by agar-well diffusion, agar dilution and disc diffusion methods

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Propolis exhibits antimicrobial, anti-inflammatory and other biological effects. The aim of this study was to evaluate the activity of 30% ethanolic extract of Bulgarian propolis against 94 *Helicobacter pylori* strains by three methods. By the agar-well diffusion method, only 13.8% of the strains exhibited no inhibition by 30 μl propolis extract (containing 9 mg propolis) and all isolates were inhibited to some extent by 90 μl of the extract (27 mg propolis) per well. The mean diameters of growth inhibition by 30, 60 or 90 μl propolis extract or 30 μl 96% ethanol per well were 16.8, 19.2, 27.5 and 8.3 mm, respectively. The propolis extract was more active than the ethanol ($P < 0.001$). With 90 μl propolis extract per well, 69.4% of the strains exhibited large diameters of growth inhibition (>20 mm) versus 26.6% with 30 μl per well ($P < 0.001$). With moist propolis discs, inhibition was detected in more strains (92.1%) than with dried discs (78.2%, $P < 0.05$), with mean inhibitory diameters of 18.7 and 13.8 mm, respectively. By the agar dilution method, 100 and 300 μg propolis ml⁻¹ inhibited the growth of 57.1% and 76.2%, respectively, of the 21 strains tested. In conclusion, Bulgarian propolis had a strong and dose-dependent activity against most of the *H. pylori* strains tested. Although the effect of propolis on *H. pylori in vitro* is promising, further microbiological, pharmacological and clinical trials are required.

Introduction

Propolis (bee glue) is a resinous hive product collected by honey bees from living plants. In temperate zones, the main sources of propolis are the buds of poplars (Bankova et al., 2000). It is important to know the plant sources because if no suitable plants are available for the honeybees, toxic substances may be included in the propolis (Bankova et al., 2000). Bee glue is composed of resins (flavonoids and related phenolic acids), wax, essential oils, pollen and organic compounds (Burdock, 1998). Propolis exhibits antimicrobial, antioxidant, anti-inflammatory, anaesthetic and other properties (Bankova et al., 2000). Synergism between propolis and antibacterial agents has been observed (Krol et al., 1993, Stepanovic et al., 2003). The antimicrobial properties of propolis are related to the synergistic effect of its compounds (Santos et al., 2002). The bee glue affects the cytoplasmic membrane and inhibits bacterial motility and enzyme activity (Mirzoeva et al., 1997). Propolis exhibits bacteriostatic activity against different bacterial genera and can be bactericidal in high concentrations (Drago et al., 2000, Mirzoeva et al., 1997). Although allergic reactions following propolis use have been reported, the bee glue is relatively non-toxic according to Burdock (1998).

There are only limited data concerning the activity of bee glue on *Helicobacter pylori* (Banskota et al., 2001). The aim of the present study was to evaluate the activity of 30% ethanolic extract of Bulgarian propolis against a large number of clinical *H. pylori* isolates *in vitro* by agar-well diffusion, agar dilution and disc diffusion methods.

Methods

A total of 94 *H. pylori* strains, isolated from antral biopsy specimens of patients with gastroduodenal diseases, were included in the study. The specimens were transported in Stuart transport medium (Merck) for less than 5 h. A smear was prepared from one part of each specimen for modified Gram staining, and a part of each specimen was used for a rapid urease test. The remaining part of the specimen was homogenized in 0.1 ml sterile saline and inoculated onto Columbia agar (Becton Dickinson) containing 10 μg vancomycin, 5 μg trimethoprim, 5 μg ceftulodin and 5 μg amphotericin B ml⁻¹ and/or 10% defibrinated sheep blood, and 1% Isovitalex (Becton Dickinson).

Selective and non-selective media were used for primary culture of the...
specimens. Plates were incubated microaerophilically (Helico-Camp Pack gas-generating envelopes, National Centre of Infectious and Parasitic Diseases, NCIPD or Campy Pack envelopes, Becton Dickinson) at 35°C for 3–12 days. H. pylori was identified by Gram staining of the colonies, lack of aerobic growth and testing for the presence of urease, oxidase and catalase. Stock cultures were maintained in 15% glycerol broth at −70°C. They were subcultured onto blood Mueller–Hinton agar (NCIPD) with 1% Isovitalex and incubated microaerophilically at 35°C for 48–72 h.

The activity of 30% ethanolic extract of Bulgarian propolis (w/v, purchased from Hygitest, Sofia, Bulgaria) was tested against 94 H. pylori strains by the agar-well diffusion method. Ethanol (96%) was used as a control. H. pylori inocula (McFarland turbidity standard 2) were prepared in Mueller–Hinton broth (NCIPD) and were plated onto Mueller–Hinton agar with 5% sheep blood and 1% Isovitalex in three directions by sterile swabs. Wells (7 mm diameter) were punched in the plates using a sterile stainless steel borer. The wells were filled with 30, 60 or 90 μl propolis extract (containing 9, 18 or 27 mg propolis per well, respectively) or 30 μl 96% ethanol per well. The plates were incubated microaerophilically at 35°C for 72 h. The diameters of the inhibitory zones were measured in millimetres.

The activity of 300, 100, 30 and 10 μg propolis ml−1 was tested against 21 H. pylori strains by an agar dilution method using blood Mueller–Hinton agar with 1% Isovitalex and H. pylori inocula corresponding to McFarland turbidity standard 2 (1 μl per spot). The plates were incubated microaerophilically at 35°C for 72 h. If H. pylori growth appeared on the plate, the isolate was considered to be resistant to the corresponding concentration.

The disc diffusion method, using paper discs containing 5 μl of either 30% ethanolic extract of Bulgarian propolis (1·5 mg of propolis per disc) or 96% ethanol, was performed for 87 H. pylori strains. Moist propolis discs were prepared immediately before testing and dry propolis discs were prepared in the same way and left to dry for 2–3 days. H. pylori colonies were suspended in Mueller–Hinton broth and adjusted to a density equal to McFarland turbidity standard 2. Suspensions were spread onto the plates with sterile cotton swabs and then the discs were added. The plates were incubated microaerophilically at 35°C for 72 h. The diameters of the inhibitory zones were measured in millimetres.

The agar-well diffusion and disc diffusion methods were performed on fresh H. pylori isolates, and the agar dilution method was carried out on stock cultures. Isolates were tested in duplicate and mean values of growth inhibition for each strain were taken into account. Chi-square with Yates’ correction was used as a statistical method to determine significance.

### Results and Discussion

In the agar-well diffusion test with 30 μl volumes per well, the propolis extract inhibited more strains than the ethanol (86.2% versus 35.6%, P < 0.001, Table 1). With 90 μl volumes per well, the propolis extract inhibited all of the H. pylori strains tested, versus 86.2% with 30 μl per well (P < 0.05). The effect of propolis extract on H. pylori growth was dose-dependent. With 90 μl propolis extract per well, 69.4% of the H. pylori strains exhibited large diameters of growth inhibition (> 20 mm), versus 26.6% with 30 μl per well (P < 0.001).

The effect of propolis against Gram-positive bacteria and yeasts is much greater than that against Gram-negative bacteria (Drago et al., 2000; Stepanovic et al., 2003). However, as only 7.2% of the H. pylori strains exhibited no inhibition by the agar-well diffusion method using 60 μl propolis extract per well, all the isolates were inhibited by 90 μl of the extract per well, Bulgarian propolis seems to possess a marked antibacterial activity against H. pylori in vitro.

Similar results were obtained by the disc diffusion method. More than 60% of the H. pylori strains exhibited considerable growth inhibition (diameter ≥ 15 mm) with moist propolis discs. Ethanol exhibited a slight inhibitory effect on H. pylori, with inhibitory zone diameters ≥ 15 mm in only 23.1% of isolates. Propolis in dried discs retained antibacterial activity, resulting in a considerable growth inhibition (≥ 15 mm) in 46% and strong inhibition (≥ 20 mm) in 27.6% of the H. pylori strains. Moist propolis discs inhibited more strains (92.1%) than dried propolis discs (78.2%, P < 0.05). It is known that the flavonoid levels in aged propolis are 20% lower than those in fresh propolis and that some labile propolis compounds are highly active (Bonvheji & Coll, 2000; Mirzoeva et al., 1997). However, in the present

### Table 1. Activity of 30% ethanolic extract of propolis and 96% ethanol against H. pylori strains by agar-well diffusion and disc diffusion methods

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Agar-well diffusion method</th>
<th>Disc diffusion method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 μl Ethanol</td>
<td>5 μl of 30% ethanolic</td>
</tr>
<tr>
<td></td>
<td>EEP*</td>
<td>(moist disc)</td>
</tr>
<tr>
<td></td>
<td>60 μl Ethanol</td>
<td>5 μl of 30% ethanolic</td>
</tr>
<tr>
<td></td>
<td>EEP*</td>
<td>(dried disc)</td>
</tr>
<tr>
<td></td>
<td>90 μl Ethanol</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Corresponding propolis concentration (mg)</td>
<td>9</td>
<td>1·5</td>
</tr>
<tr>
<td>No. of H. pylori strains tested</td>
<td>94</td>
<td>1·5</td>
</tr>
<tr>
<td>Mean diameter of growth inhibition (mm)</td>
<td>16·8</td>
<td>1·5</td>
</tr>
<tr>
<td>Growth inhibition diameter (mm)</td>
<td>7–48</td>
<td>1·5</td>
</tr>
<tr>
<td>Strains with no growth inhibition (%)</td>
<td>13·8</td>
<td>1·5</td>
</tr>
<tr>
<td>Strains with growth inhibition &gt;15 mm (%)</td>
<td>48·9</td>
<td>1·5</td>
</tr>
<tr>
<td>Strains with growth inhibition &gt;20 mm (%)</td>
<td>26·6</td>
<td>1·5</td>
</tr>
</tbody>
</table>

*EEP, 30% ethanolic extract of propolis.
study, the effect of dried propolis discs on most *H. pylori* strains, with a mean inhibitory zone diameter of 13-8 mm, strongly suggests the presence of relatively stable antibacterial compounds in the agent.

The effect of Bulgarian propolis on *H. pylori* growth, detected by both the agar-well diffusion method and the disc diffusion technique, was confirmed by the agar dilution method. Even 10 µg propolis ml\(^{-1}\) inhibited 14.3 % of the 21 *H. pylori* isolates tested, whereas 30, 100 and 300 µg propolis ml\(^{-1}\) inhibited 47.6 %, 57.1 % and 76.2 % of the strains, respectively.

Many factors may influence the antibacterial activity of bee glue (the propolis origin, bee species and extract preparation). Flavonoids (pinocembrin and galangin) and esters of phenolic acids have been associated with the antibacterial activity of European propolis (Grange & Davey, 1990). The chemical composition of bee glue exhibits considerable geographic differences. Propolis from Bulgaria, Turkey, Greece and Algeria usually contains mainly flavonoids and esters of caffeic and ferulic acids (Velikova et al., 2000). According to Hegazi et al. (2000), Austrian propolis has exhibited a high activity against *Candida albicans* and German propolis has been very active against *Staphylococcus aureus* and *Escherichia coli*. The effect of Brazilian propolis on *H. pylori* has been associated with lambdane-type diterpenes and some prenylated phenolic compounds (Banskota et al., 2001).

It is interesting that the effect of Bulgarian propolis on *H. pylori* was similar to that of Brazilian propolis fractions against oral anaerobic bacteria (MIC, 64–1024 µg ml\(^{-1}\)) (Santos et al., 2002), as well as to the effect of the Bulgarian propolis on Gram-negative anaerobic rods. Sixteen clinical strains within the genera of *Prevotella* (15 strains) and *Porphyromonas* (1 strain) were evaluated by the agar-well diffusion method (30 µl propolis extract per well) and growth inhibition was observed in 87.5 % of the strains, with considerable inhibition (≥15 mm diameters) in 31-2 % (L. Boyanova, unpublished results).

In conclusion, Bulgarian propolis has a strong and dose-dependent activity against most of the *H. pylori* strains tested. The synergism between propolis and antimicrobial agents, as well as the anti-inflammatory, anaesthetic and tissue-regenerative properties of the bee glue (Bankova et al., 2000), can be additional advantages for evaluating propolis as a possible candidate in the treatment of *H. pylori* infection. Although the effect of propolis on *H. pylori* in vitro is promising, further microbiological, pharmacological and clinical trials are required.

References


