Journal of Ethnopharmacology xxx (2008) xxx–xxx

Contents lists available at ScienceDirect

Journal of Ethnopharmacology

journal homepage: www.elsevier.com/locate/jethpharm

Inhibition of *Helicobacter pylori*-induced inflammation in human gastric epithelial AGS cells by *Phyllanthus urinaria* extracts

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ARTICLE INFO

Article history:
Received 10 December 2007
Received in revised form 1 May 2008
Accepted 21 May 2008
Available online xxx

Keywords:
Phyllanthus urinaria
Isolates
Chloroform and methanol extracts
Helicobacter pylori infection
Human gastric epithelial cells
NF-KB
IL-8

ABSTRACT

Aim of the study: Helicobacter pylori is linked to a majority of peptic ulcers and to some types of gastric cancer, and its resistance to antibiotic treatment is now found worldwide. This study is aimed at evaluating the antimicrobial activity of *Phyllanthus urinaria* Linnea (Euphorbiaceae), chloroform (PUC) and methanol (PUM) extracts, and its eight isolates on *H. pylori*-infected human gastric epithelial AGS cells.
Materials and methods: The *in vitro* anti-bacterial activity of *P. urinaria* chloroform (PUC) and methanol (PUM) extracts, and its eight isolates were determined. Additional experiments were also performed to know the PUC and PUM ability to inhibit the *H. pylori* adhesion to and invasion of AGS cells, in addition to the effect of PUC on NF-κB activity as well as IL-8 synthesis during *H. pylori* infection of AGS cells.
Results: The results revealed that crude extracts PUC and PUM showed potent antimicrobial activity against *H. pylori* than pure isolates. On the other hand, *in vitro H. pylori*-infection model revealed that the inhibition of bacterial adhesion and invasion to AGS cells has dramatically reduced by treatment of extract PUC, while PUM has the same moderate effect. Furthermore, *H. pylori*-induced nuclear factor (NF)-κB activation, and the subsequent release of interleukin (IL)-8 in AGS cells were also inhibited by the extract PUC.
Conclusions: These results open the possibility of considering *P. urinaria* a chemopreventive agent for peptic ulcer or gastric cancer, but this bioactivity should be confirmed *in vivo* in the future.

1. Introduction

The gram-negative bacterium *Helicobacter pylori* colonize the stomach where it can induce peptic ulcers, mucosa-associated lymphoid tissue (MALT) lymphoma, and gastric adenocarcinoma (Gerhard et al., 2002; Peek and Blaser, 2002). The most accepted regime for the eradication of *H. pylori* infection currently includes a triple therapy, which combines the antibiotic clarithromycin (CLR) and amoxicillin (AMX) with a proton pump inhibitor such as omeprazole. This chemotherapy, however, sometimes produces side-effects and fails to eliminate infection in 10–30% of patients (Cavallaro et al., 2006). The occurrence of strains resistant to antibiotics would be expected to increase, and it is nowadays important to search for non-antibiotic substances with anti-*H. pylori* activity. In human gastric epithelial AGS cells, *H. pylori* induces inflammatory-associated gene expression, including activation of the nuclear factor kappa B (NF-κB), and production of interleukin (IL)-8 (Naumann, 2001). NF-κB is a ubiquitous transcription factor complex belonging to the Rel family of proteins, and is a crucial regulator of many cellular processes including the control of the immune response and inflammation (Li and Verma, 2002). On the other hand, among the cytokines induced in the gastric mucosa colonized by *H. pylori*, IL-8 is one of the major proinflammatory cytokines, first isolated from monocytes as a neutrophil chemoattractant (Kido et al., 2001). IL-8 plays a crucial role in the initiation and maintenance of inflammatory response and recently has been identified to function as proangiogenic or carcinogenic factor based on the findings that gastric cancer cells in surgical specimens overexpressed IL-8 compared with corresponding normal mucosa (Kido et al., 2001).

Medicinal plants have been used as traditional remedies in treating and preventing gastrointestinal diseases for hundreds of years, and their anti-*H. pylori* activity has been widely demonstrated *in vitro* (Stamatis et al., 2003; Ustun et al., 2006; Ndip et al., 2007; Shih

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doi:10.1016/j.jep.2008.05.022

et al., 2007). *Phyllanthus urinaria* Linnea, one of the herbal plants belonging to the genus *Phyllanthus* (Euphorbiaceae), is widely distributed in tropical and subtropical countries including Taiwan. The species of *Phyllanthus* have long been used in folk medicine to treat kidney and urinary bladder disturbances, intestinal infections, diabetes, and hepatitis B in several parts of the world (Calixto et al., 1998). Particularly, *P. urinaria* is traditionally used in Taiwan to reduce heat, gastritis and ulcers, remove food stagnancy, improve eyesight, relieve inflammation, calm the liver, suppress *yang* hyperactivity of liver, detoxify poison from body and increase the flow of the urine (Chiu and Chang, 1998; Committee on Chinese Medicine and Pharmacy, 2003). Furthermore, the decoction from this species is commonly used as tea and juice in Taiwan for the treatment of inflammatory diseases (Kao, 1985). Although, various biological activities of *P. urinaria* have been reported, however, there is no report on its action against *H. pylori*-induced inflammation. In our previous study, we analyzed *P. urinaria* components, and their DPPH radical scavenging and inflammatory mediators, nitric oxide (NO), tumor necrosis factor (TNF)-α and interleukin (IL)-6 growth inhibitory activities in LPS/IFN-γ-activated murine peritoneal macrophages (Fang et al., 2008). In the present study, we examined the anti-bacterial properties of this species chloroform (PUC) and methanol (PUM) extracts, and its eight isolates. Additional experiments were also performed to know the PUC and PUM ability to inhibit the *H. pylori* adhesion to and invasion of AGS cells, in addition to the effect of PUC on NF-κB activity as well as IL-8 synthesis during *H. pylori* infection of AGS cells. With this approach, we hope to understand the protective mechanism of *P. urinaria* on *H. pylori*-induced inflammation and increase its clinical potential in gastrointestinal disease.

2. Materials and methods

2.1. Isolation of compounds from P. urinaria

The voucher specimen, and method for extraction and isolation were described previously (Fang et al., 2008). Briefly, the dried plant material (800 g) was extracted with chloroform (PUC) and methanol (PUM), sequentially to yield the respective solvent extracts. After exhaustive extraction, the combined extracts were filtered, and the solvent was dried by rotary evaporation under reduced pressure at a temperature of maximally 35 °C. The solvent free extracts were used for the present study. The dried chloroform extract (PUC, 14 g, 1.75% w/w) was subjected to column chromatography (CC) and eluted with a gradient of *n*-hexane/EtOAc (the ratios of *n*-hexane/EtOAc were from 100:0 to 0:100) to afford phyllanthin (**1**, 55 mg, 0.0069%), phyltetralin (**2**, 12 mg, 0.0015%), trimethyl 3,4-dehydrochebulate (**3**, 10 mg, 0.0008%), methylgallate (**4**, 75 mg, 0.0094%), and rhamnocitrin (**5**, 14 mg, 0.0018%). The dried methanol extract (PUM, 11 g, 1.375%, w/w) was subjected to repeated column chromatography on a silica gel and eluted with CH_2Cl_2/MeOH with a gradually increased ratio of methanol to afforded compounds, methyl brevifolincarboxylate (**6**, 26 mg, 0.0033%), quercetin-3-α-L-rhamnopyranoside (quercitrin, **7**, 8 mg, 0.001%), β-sitosterol 3-*O*-β-D-glucopyranoside (**8**, 25 mg, 0.0031%), and rutin (**9**, 32 mg, 0.004%). All the derivatives were identified by comparing their physical and spectral data as reported in our previous communication (Fang et al., 2008).

2.2. Bacterial and cell culture

H. pylori, strain 26695 (ATCC 700392) was used as a reference strain. Bacterial strain was recovered from frozen stocks on Brucella agar plates (Difco) containing 10% sheep blood, 6 μg/ml vancomycin and 2 μg/ml amphotericin B under microaerophilic conditions for 48–72 h as described previously (Lai et al., 2002, 2006).

AGS cells (ATCC CRL 1739; human gastric adenocarcinoma epithelial cell line) were cultured in F12 (Hyclone) supplemented with 10% de-complement FBS (Hyclone). Penicillin and streptomycin (GIBCO BRL) were also added if needed. In the bacterial adhesion, invasion assay, and induced IL-8 secretion, the cell culture medium was not supplemented with antibiotics.

2.3. Determination of anti-bacterial activity

The *in vitro* anti-bacterial activities of the isolates and extracts [dissolved in 0.2% (v/v) of dimethylsulfoxide (DMSO, Sigma–Aldrich)] were determined by disk agar diffusion method (Castillo-Juarez et al., 2007). Briefly, a total volume of 100 μl of *H. pylori* suspension (1×10^8 colony forming units (CFUs)/ml) was spread onto Mueller Hinton agar plates (BBL) containing 10% sheep blood. Sterile paper disks (6 mm, BBL) were placed on the agar surface with 10 μl of isolates (0.2 mM) and extracts (100 mg/ml) individually. DMSO was used as negative control and antibiotics amoxicillin (AMX, 0.05 mg/ml), clarithromycin (CLR, 0.05 mg/ml), and metronidazole (MTZ, 0.8 mg/ml) were used as positive control. After 72 h for incubation at 37 °C under the microaerophilic condition with humidity, the inhibition zone was determined in diameter.

2.4. Determination of minimum bactericidal concentration (MBC)

Broth microdilution MBCs were determined in 96-well plates (Falcon) using two-fold serial dilutions of isolates, extracts, or antibiotics. *H. pylori* were suspended in Brucella broth (Difco) containing 5% fetal bovine serum (Hyclone) and diluted to reach at 1×10^6 CFUs/ml. The plates were incubated in a microaerophilic condition at 37 °C for 48 h. Following incubation, 100 μl aliquots of the broth were plated onto Brucella agar plates containing 10% sheep blood to determine the viable CFUs. The MBC was defined as the lowest concentration of the tested sample completely inhibited visible bacterial growth on Brucella agar plate. The final DMSO concentration in the assay never exceeded 0.52% (v/v) and did not have any effect in the growth at this concentration.

2.5. Inhibition of H. pylori adhesion to and invasion into AGS cells

H. pylori adhesion to and invasion of cultured AGS cells were done using a standard gentamicin assay as previously described (Lai et al., 2006). The extracts PUC and PUM, and DMSO diluted in cell culture medium were added (to reach the indicated dilutions) directly to the cell culture medium for 10 min prior to inoculation of wells with *H. pylori* in log-phase. AGS cells were added with *H. pylori* at a MOI of 50 and incubated at 37 °C for 6 h. To determine the number of cell-adhesion bacteria, infected cells were washed three times to remove unbound bacteria and then lysed with distilled water for 10 min. Lysates were diluted in PBS, plated onto Brucella blood agar plates and cultured for 4–5 days, after which the CFUs were counted. To determine the number of viable intracellular bacteria, infected cells were washed three times in PBS and incubated with 100 μg/ml of the membrane-impermeable antibiotic gentamicin (Sigma–Aldrich) for 1.5 h at 37 °C to remove extracellular bacteria, followed by the same procedures as above to obtain CFUs. The adhesion or invasion activity was determined as the mean of at least six experiments performed in duplicate. The controls contained *H. pylori* infected AGS cells without test samples were used to establish 100% adhesion or invasion. The results were expressed as the percentage of relative inhibition of *H. pylori* adhesion or invasion, as compared with the controls.

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2.6. Transient transfection of NF-κB reporter gene

NF-κB-Luc reporter plasmid was kindly provided by Dr. Chih-Hsin Tang (Department of Pharmacology, China Medical University) (Tang et al., 2007). AGS epithelium was grown to 90% confluence in 12-well plates and was transfected using Lipofectamine 2000 (Invitrogen). After 24 h incubation, transfection was complete, and cells were incubated with various concentrations of PUC and then infected with *H. pylori* for 6 h. To prepare cell lysates, 100 μl of reporter lysis buffer (Promega) was added to each well, and cells were scraped from dishes. An equal volume of luciferase substrate (Promega) was added to all samples, and luminescence was measured in a microplate luminometer. The value of luciferase activity was normalized to transfection efficiency monitored by the cotransfected β-galactosidase expression vector obtained from Promega (Madison, MA, USA).

2.7. Interleukin-8 measurement

To detect IL-8 released by AGS cells during *H. pylori* infection, the levels of IL-8 was measured. AGS cells were added with various concentrations of PUC in cell culture medium before *H. pylori* infection. The treated cells then infected with *H. pylori* strain 2,6695 at a MOI of 1:100. The supernatants were collected and stored at −80 °C before analysis. The level of IL-8 in supernatants from AGS cell cultures was determined by using a sandwich enzyme-linked immunosorbent assay (ELISA) kit (R&D systems), according to the manufacturer's instruction (Rao et al., 2007).

2.8. Statistical analysis

The correlation of PUM and PUC anti-bacterial adhesion, invasion activity, and IL-8 secretion of treated AGS epithelial cells relative to DMSO treated control cells was determined by Student's *t*-test. $^{*}P < 0.05$, $^{**}P < 0.01$.

3. Results and discussion

3.1. Growth inhibition of H. pylori

The anti-*H. pylori* activities of *P. urinaria* isolates **1**–**9** except **8**, and extracts PUC and PUM were evaluated based on the disk agar diffusion method. The effect of β-sitosterol 3-*O*-β-D-glucopyranoside (**8**) was not tested because of its insolubility in culture media. DMSO used as negative control, showed no effect (0.2% total volume). As shown in Fig. 1, the extracts PUC and PUM were most active and inhibited *H. pylori* with inhibition zone of 21 and 19 mm at concentration of 100 mg/ml. This effect was nearly similar to the standard drug clarithromycin, which is one of the most commonly used antibiotics for treatment of *H. pylori* infection (inhibition zone of 22 mm at 0.05 mg/ml). Among the pure compounds tested at 0.2 mM concentration, all the isolates showed nearly similar inhibition zone range 10–14 mm to that of amoxicillin (inhibition zone of 15 mm at 0.05 mg/ml), another antibiotic used for the same purpose. Noticeably, the extracts PUC and PUM, and the tested isolates are more potent than another antibiotic metronidazole (8 mm of inhibition zone at 0.8 mg/ml). In this study, the tested isolates present in the crude extracts showed less inhibition at the concentration of 0.2 mM compared with the extracts PUC and PUM at 100 mg/ml. It seems these isolates contribute only in a minor extent to the *H. pylori* inhibition of the extract. Our current results indicate that isolation of pure compounds from the crude *P. urinaria* extract does not lead to an increase in the *H. pylori* inhibitory effect as expected. It is known that single agents are generally ineffective or poorly effective in eradicating *H. pylori* (Cavallaro et al., 2006). Hence, the activity of PUC and PUM extracts might either be caused by additional, not further identified plant compounds or might be mediated by the extract as a whole due to synergistic effects. This latter argument is consistent with the holistic approach of phytotherapy in that not single compounds but the extract as a multiple component mixture causes the desired effect (McChesney et al., 2007). Therefore, the crude extracts PUC and PUM are chosen for further experiments.

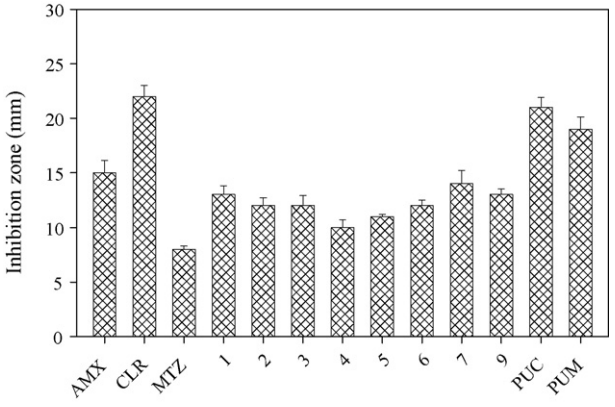

Fig. 1. Inhibitory effects of *P. urinaria* isolates, and its extracts PUC and PUM against *H. pylori*. The concentration of isolates and extracts was 0.2 mM and 100 mg/ml, respectively. DMSO was used as negative control, and the antibiotics amoxicillin (AMX, 0.05 mg/ml), clarithromycin (CLR, 0.05 mg/ml), and metronidazole (MTZ, 0.8 mg/ml) were used as positive control. Results were shown mean of different analysis of three independent experiments.

We next determined the MBC of pure isolates (**1**–**9** except **8**) and crude extracts (PUC and PUM) against *H. pylori*. The MBC ranged from 15.6 to 62.5 μM for pure isolates. The lowest MBC was 97.7 μg/ml recorded for the crude extracts PUC and PUM (Table 1). The MBC of standard drugs CLR and AMX which served as the positive control was 0.1 and 0.2 μg/ml, respectively, however, had a significant difference ($P < 0.05$) in activity to the isolates and extracts. The MBC values were found to be lower than the anti-bacterial values tested suggesting that the isolates and extracts were bacteriostatic at lower concentrations and bactericidal at higher concentrations (Gerhard et al., 2002).

Table 1
MBC of *Phyllanthus urinaria* isolates, and its chloroform (PUC) and methanol (PUM) extracts against *Helicobacter pylori*

Sample	MBC[a]
1	15.6
2	31.3
3	62.5
4	62.5
5	31.3
6	31.3
7	31.3
9	31.3
PUC	97.7
PUM	97.7
AMX	0.2
CLR	0.1
MTZ	100.0

[a] The concentration of pure isolates (**1**–**9** except **8**) were in μM, whereas the crude extracts of chloroform (PUC) and methanol (PUM), and standard drugs (AMX, CLR, MTZ) were in μg/ml. Percentage of inhibition was estimated with respect to a control that was incubated only with the solvent (DMSO).

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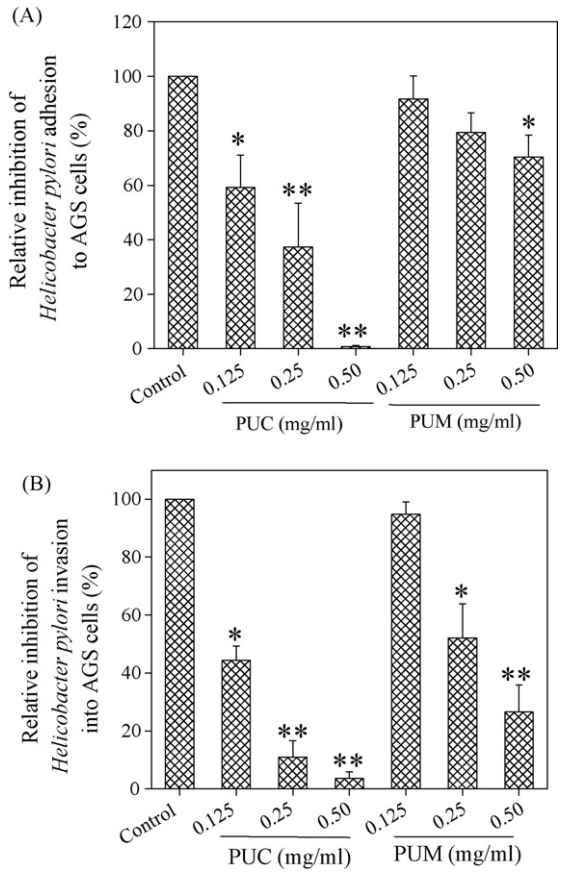

Fig. 2. Effect of *P. urinaria* extracts PUC and PUM on *H. pylori* anti-adhesion (A) and anti-invasion (B) of AGS cells. The bacteria to AGS cells that were untreated or treated with PUC or PUM, followed by infection with *H. pylori* at a MOI of 50 for 6 h. Each experiment was shown represent mean values ± S.D. of at least six independent experiments. The significant difference was set at $^{*}P < 0.05$; $^{**}P < 0.01$.

3.2. Treatment of PUC and PUM does not influence AGS cells viability

We then analyzed how *P. urinaria* extracts PUC and PUM treatment affects the viability of AGS cells. Assays were performed to assess the cell viability using trypan blue staining of untreated as well as test sample-treated AGS cells. At their maximum concentration (0.5 mg/ml) tested the extracts PUC and PUM have no significant effect upon AGS cell viability (data not shown).

3.3. Inhibition of H. pylori adhesion to and invasion of AGS cells

Since the extracts PUC and PUM determined to inhibit *H. pylori* growth at an effective level. These two extracts were further assayed with regard to their ability to inhibit the adhesion of *H. pylori* to AGS cells. As shown in Fig. 2A, the extract PUC exhibited a marked anti-adhesion activity against *H. pylori* with a concentration range from 0.125 to 0.5 mg/ml ($P < 0.05$ and $P < 0.01$ compared to 0.5% (v/v) of DMSO), while PUM has significant effect only at 0.5 mg/ml ($P < 0.05$ compare to 0.5% of DMSO). On the other hand, a significant inhibition of bacterial invasion into AGS cells by PUM was also found with a reduction of more than 60% in a range of concentrations from 0.25 to 0.5 mg/ml (Fig. 2B). Importantly, after treatment of PUC, the bacterial invasion activity was dramatically reduced more than 90% in a range of concentration of 0.125–0.5 mg/ml. Results from this study demonstrate that PUC and PUM have their ability to inhibit bacterial adhesion and invasion of AGS cells. Noticeably, PUC was more potent than PUM in the inhibition of *H. pylori* adhesion and invasion to AGS cells at lower concentrations. Thus, the extract PUC chosen for evaluation of anti-*H. pylori*-induced AGS cells inflammation.

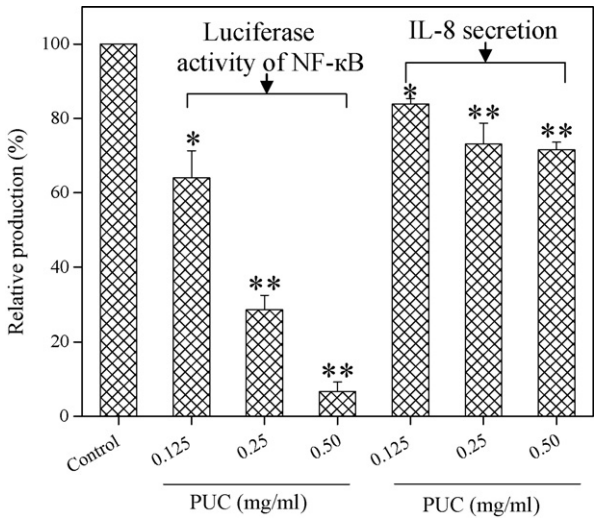

Fig. 3. Inhibitory effects of *P. urinaria* extract PUC on *H. pylori*-induced NF-κB activation and IL-8 production by AGS cells. The luciferase activity and IL-8 levels in supernatants was determined as described in materials and methods. Results are shown by mean values ± S.D. from at least three independent experiments. The significant difference was set at $^{*}P < 0.05$; $^{**}P < 0.01$.

3.4. PUC inhibits H. pylori-induced inflammation of AGS cells

Recent reports had demonstrated that *H. pylori*-induced IL-8 release from AGS cells is mediated activation of NF-κB (Brandt et al., 2005). To examine whether the PUC has its ability to inhibit inflammatory mediators in response to *H. pylori* infection, NF-κB-luciferase constructs were used to determine luciferase expression following pretreatment of PUC and infection with *H. pylori*. When AGS cells were transiently transfected with NF-κB-luciferase construct, pretreatment of cells with PUC prior to *H. pylori* infection led to a dose-dependent reduction in the stimulation of luciferase activity. As shown in Fig. 3, the extract PUC inhibited the luciferase activity by 35.96, 71.34 and 93.35% at concentration of 0.125, 0.25 and 0.50 mg/ml, respectively, compared to DMSO control. The exact mechanism whereby PUC inhibits NF-κB activation needs to study further.

A functional consequence of increased NF-κB activity is a parallel increase in IL-8 expression (Kim et al., 2006). To analyze whether PUC could prevent the *H. pylori*-induced IL-8 production, AGS cells were either left untreated or pretreated with the PUC prior to *H. pylori* infection. The significant induction of the cytokine was inhibited by pretreatment of PUC (Fig. 3). Even administration of 0.125 mg/ml inhibited IL-8 production comparable with that of DMSO-treated control cells, and the inhibition reached to 29.40% at concentration of 0.5 mg/ml (Fig. 3). The finding indicating that attenuation of IL-8 production by PUC pretreatment might contribute to prevent IL-8-induced inflammatory response. This may be due to inactivation of multiple intracellular signaling pathways induced by *H. pylori* infection and decrease of NF-κB translocation into the nucleus (Li and Verma, 2002). Conventional therapies suppress not only *H. pylori* but also the intestinal bacterial flora which produces side-effects as abdominal pain and diarrhea (Di Mario et al., 2006). In regards to this, since *P. urinaria* seems to have a restricted anti-bacterial spectrum, which may helpful as an option in the management of the bacterial infection.

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4. Conclusion

In summary, our results showed that the PUC of *P. urinaria* has its ability to inhibit *H. pylori* infection of epithelial cells and diminish the secretion of bacterial-induced inflammatory cytokine. Thus, indicates that PUC may be developed to a new potent drug for anti-*H. pylori* infection of cells. Future studies are needed to clarify the molecular mechanisms by which PUC inhibits *H. pylori*-mediated activation of NF-κB expression in gastric epithelial cells and to identify additional targets in gene regulation.

Acknowledgements

This study was supported by National Science Council of Taiwan (NSC96 – 2811-M-324–001), and by China Medical University (CMU-95–193), and in part by Tomorrow Medical Foundation (TMF2007–02). We thank Chiou-Yan Lin, and Yu-Fen Tseng for expert technical assistance.

References

Brandt, S., Kwok, T., Hartig, R., Konig, W., Backert, S., 2005. NF-κB activation and potentiation of proinflammatory responses by the *Helicobacter pylori* CagA protein. In: Proceedings of the National Academy of Sciences USA 102, pp. 9300–9305.

Calixto, J.B., Santos, A.R., Filho, V.C., Yunes, R.A., 1998. A review of the plants of the genus *Phyllanthus*: their chemistry, pharmacology, and therapeutic potential. Medicinal Research Reviews 18, 225–258.

Castillo-Juarez, I., Rivero-Cruz, F., Celis, H., Romero, I., 2007. Anti-*Helicobacter pylori* activity of anacardic acids from *Amphipterygium adstringens*. Journal of Ethnopharmacology 114, 72–77.

Cavallaro, L., Egan, B., Morain, C.O., Mario, F.D., 2006. Treatment of *Helicobacter pylori* infection. Helicobacter 11, 36–39.

Chiu, N.Y., Chang, K.H., 1998. The Illustrated Medicinal Plants of Taiwan, 3. Southern Materials Center Publishing Inc, Taipei, p. 57.

Committee on Chinese Medicine and Pharmacy, 2003. Department of Health, Executive Yuan, R.O.C. 2003. The Catalogue of Medicinal Plant Resources in Taiwan. Hanasty Printing Co., Ltd., Taipei.

Di Mario, F., Cavallaro, L.G., Scarpignato, C., 2006. 'Rescue' therapies for the management of *Helicobacter pylori* infection. Digestive Diseases 24, 113–130.

Fang, S.H., Rao, Y.K., Tzeng, Y.M., 2008. Anti-oxidant and inflammatory mediator's growth inhibitory effects of compounds isolated from Phyllanthus urinaria. Journal of Ethnopharmacology 116, 333–340.

Gerhard, M., Rad, R., Prinz, C., Naumann, M., 2002. Pathogenesis of *Helicobacter pylori* infection. Helicobacter 7, 17–23.

Kao, M.T., 1985. Popular Herbal Remedies of Taiwan, 1. Southern Materials Center Publishing Inc, Taipei, p. 89.

Kido, S., Kitadai, Y., Hattori, N., Haruma, K., Kido, T., Ohta, M., Tanaka, S., Yoshihara, M., Sumii, K., Ohmoto, Y., Chayama, K., 2001. Interleukin-8 and vascular endothelial growth factor-prognostic factors in human gastric carcinomas? European Journal of Cancer 37, 1482–1487.

Kim, S.Y., Lee, Y.C., Kim, H.K., Blaser, M.J., 2006. *Helicobacter pylori* CagA transfection of gastric epithelial cells induces interleukin-8. Cellular Microbiology 8, 97–106.

Lai, C.H., Kuo, C.H., Chen, Y.C., Chao, F.Y., Poon, S.K., Chang, C.S., Wang, W.C., 2002. High prevalence of *cag*A- and *bab*A2-positive *Helicobacter pylori* clinical isolates in Taiwan. Journal of Clinical Microbiology 40, 3860–3862.

Lai, C.H., Kuo, C.H., Chen, P.Y., Poon, S.K., Chang, C.S., Wang, W.C., 2006. Association of antibiotic resistance and higher internalization activity in resistant *Helicobacter pylori* isolates. Journal of Antimicrobial Chemotherapy 57, 466–471.

Li, Q., Verma, I., 2002. NF-κB regulation in the immune system. Nature Reviews Immunology 2, 725–734.

McChesney, J.D., Venkataraman, S.K., Henri, J.T., 2007. Plant natural products: back to the future or into extinction? Phytochemistry 68, 2015–2022.

Naumann, M., 2001. Host cell signalling in *Helicobacter pylori* infection. International Journal of Medical Microbiology 291, 299–305.

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., 2007. In vitro anti-*Helicobacter pylori* activity of extracts of selected medicinal plants from North West Cameroon. Journal of Ethnopharmacology 114, 452–457.

Peek, R.M., Blaser, M.J., 2002. *Helicobacter pylori* and gastrointestinal tract adenocarcinomas. Nature Reviews Cancer 2, 28–37.

Rao, Y.K., Fang, S.H., Tzeng, Y.M., 2007. Evaluation of the anti-inflammatory and anti-proliferation tumoral cells activities of *Antrodia camphorata*, *Cordyceps sinensis*, and *Cinnamomum osmophloeum* extracts. Journal of Ethnopharmacology 114, 78–85.

Shih, Y.T., Wu, D.C., Liu, C.M., Yang, Y.C., Chen, I.J., Lo, Y.C., 2007. San-Huang-Xie-Xin-Tang inhibits *Helicobacter pylori*-induced inflammation in human gastric epithelial AGS cells. Journal of Ethnopharmacology 112, 537–544.

Stamatis, G., Kyriazopoulos, P., Golegou, S., Basayiannis, A., Skaltsas, S., Skaltsa, H., 2003. *In Vitro* anti-*Helicobacter pylori* activity of Greek herbal medicines. Journal of Ethnopharmacology 88, 175–179.

Tang, C.H., Yang, R.S., Chen, Y.F., Fu, W.M., 2007. Basic fibroblast growth factor stimulates fibronectin expression through phospholipase C gamma, protein kinase C alpha, c-Src, NF-κB, and p300 pathway in osteoblasts. Journal of Cell Physiology 211, 45–55.

Ustun, O., Ozcelik, B., Akyon, Y., Abbasoglu, U., Yesilada, E., 2006. Flavonoids with anti-*Helicobacter pylori* activity from *Cistus laurifolius* leaves. Journal of Ethnopharmacology 112, 537–544.

Please cite this article in press as: Lai, C.-H., et al., Inhibition of *Helicobacter pylori*-induced inflammation in human gastric epithelial AGS cells by *Phyllanthus urinaria* extracts, J Ethnopharmacol (2008), doi:10.1016/j.jep.2008.05.022