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Research Article

Gas Chromatography-Mass Spectrometry Profile, Anti-Bacterial and Anti-Ulcer Potentials of *Paulownia elongata* Leaves Extract on Indomethacin Ulcer Induced Rats

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ABSTRACT

Since the beginning of time, people have employed plants as one of the most significant sources for treating a variety of human maladies. This study sought to determine the phytochemical composition of *Paulowinia elongata* stem-bark extract, as well as the impact it had on certain bacterial strains and ulcers brought on by indomethacin in albino rats. In terms of medicinal herbs, *Paulowinia elongata* is among the most significant. *Paulowinia elongata* has a variety of parts that have been found to have anti-inflammatory, anti-ulcerogenic, and anti-diabetic properties. These parts include the stem bark, leaves, flowers, and roots. *Paulowinia elongata* has a wide spectrum of pharmacological properties, according to the literature that is currently available, which can be attributed to the presence of phytochemicals. *Paulowinia elongata* stem-bark extracts were assessed for anti-ulcerogenic efficacy, phytochemical capacity, and anti-bacterial potential in the current study. The anti-ulcerogenic impact was evaluated histopathology, the GCMS method to identify phytochemicals, and the disc diffusion method to identify antibacterial activity. Results showed that *Paulowinia elongata* stem-bark has antibacterial properties against human pathogens such as *Escherichia coli*, *Salmonella typhi*, *staphylococcus aureus*, and *Klebsiella pneumonia*, and that *Paulowinia elongata* stem-bark methanol crude extract contains phytochemical constituents. Additionally, it showed that indomethacin-induced ulcers in albino rats were greatly reduced by the extract.

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INTRODUCTION

Peptic ulcers typically appear when aggressive variables outweigh protective ones (Abdel-Sater, 2011). The most prevalent gastrointestinal illness, peptic ulcer disease (PUD), has a high death and morbidity rate (Daniel *et al.,* 2017).

Helicobacter pylori, acid-pepsin hypersecretion, non-steroidal anti-inflammatory drugs, sometimes idiopathic due to tobacco use, psychological stress, rapid gastric emptying, and Zollinger-Ellisson syndrome, which causes an excessive and uncontrollable production of acid, are the main factors that upset the balance between aggressive and defensive factors. Ulcer development may attributed to complication of aforementioned conditions (Baron and Calam, 2001; Manan *et al.,* 2011; Nayaka *et al.,* 2011).

Duodenal and gastric ulcers may develop as a result of this digestive tract disorder (GIT). It caused the deaths of about 301,400 persons in 2013 (Abubakar *et al.,* 2015; Harsha *et al.,* 2017). 86% of PUD patients in Sub-Saharan Africa who had surgery also had duodenal ulcers, whereas the remaining 14% also had gastric ulcers. Major issues requiring surgery included perforation (35%), bleeding (7%), obstruction (30%), and chronic cases (28%), while the overall death rate was 5.7% (Rickard, 2016).

Stress, alcohol usage, smoking, the Zollinger Ellison syndrome, and age-related reductions in prostaglandin levels are also risk factors for PUD (Stewart and Ackroyd, 2011). PUD was frequently caused by the use of nonsteroidal anti-inflammatory drugs (NSAIDs) and H. pylori infection (Kumar *et al.,* 2011; Teka *et al.,* 2016).

Worldwide, primary healthcare is largely provided by traditional medicine (Kang *et al.,* 2017). Due to its higher cultural acceptance, better compatibility with the human body, and less adverse effects, traditional medicine is used by about 75–80% of individuals in poor nations (Kumar *et al.,* 2011). Numerous medicinal plants as well as their secondary metabolites have been reported to have antiulcer properties (Mekonnen *et al.,* 2020).

Paulownia, a fast-growing, deciduous hardwood tree with nine distinct species and a few natural hybrids, is indigenous to China and belongs to the family *Paulowniaceae* (formerly the Scrophulariaceae) (Freeman *et al.,* 2012).

P. albiphloea, P. australis, P. catalpifolia, P. elongata, P. fargesii, P. fortunei, P. kawakamii, and P. tomentosa are significant species in this genus (Zhu *et al.,* 1986). There are several regions of the world where *Paulownia* species can be found growing naturally or in cultivation, including China, Japan, Southeast Asia, Europe, North and Central America, and Australia. The genus' species thrive on marginal lands and are highly adaptive to a wide range of edaphic and climatic conditions (Yadav *et al.,* 2013).

Paulownias are being introduced in certain African nations because of its notable qualities. In many nations, *Paulownia* may be grown as an agricultural crop (Uguz and Kara, 2019). Currently, 24 million hectares of land are used to grow *Paulownia* for a variety of applications (Johnson, 2000).

According to Zhu *et al.* (1986); Yadav *et al.* (2013) and Wo'zniak *et al.* (2019), *Paulownia*s are thought to be therapeutic plants. Their remedies can be used to treat bruises and gonorrhoea, as well as to promote hair growth and delay graying (Yamauchi *et al.,* 1987). *Paulownia* species produce a large number of secondary metabolites, according to numerous phytochemical investigations (Zhu *et al.,* 1986; Duran-Zuazo *et al.,* 2013). Asthma, erysipelas, bacteriologic diarrhoea, bronchopneumonia, enteritis, high blood pressure, and tonsillitis are just a few of the diseases that are treated with various preparations made of bark, fruit, xylem, or leaves in traditional Chinese medicine (Si *et al.,* 2013).

Flavonoids, terpenoids, and tannins are the active components of antiulcer action (Mekonnen *et al.,* 2020). Since the leaves have been used to treat frostbite and leg ulcers, *Paulownia* may also offer wound-healing capabilities (Zhao, 2003). The most significant plant components used in folk herbal medicine are leaves, fruits, and flowers (Kang *et al.,* 1999; Jiang *et al.,* 2004; Smejkal *et al.,* 2007).

Antioxidant, anti-inflammatory, and antibacterial action against Staphylococcus aureus and Pseudomonas aeruginosa has also been observed in pharmacological trials (Kim *et al.,* 2000, Jo and Kim 2019). However, there is paucity of knowledge about the chemical make-up and biological characteristics of *Paulownia elongata* leaves.

Moreover, there is currently little knowledge available regarding the ideal application and GC-MS profile of *Paulownia elongata* leaves as a possible anti-bacterial and anti-ulcer agent.

Figure 1: *Paulownia* leaves

METHODS AND MATERIALS

Plant material

Paulownia elongata leaves were collected at Nasaurip Sukundi road within Wukari, Taraba State Nigeria in the

month of 7th September, 2022. Plant identity was confirmed by a specialist at the Department of Biology, Faculty of Pure and Applied Sciences, Federal University, Wukari. The leaves were thoroughly rinsed and dried under shade after which they were ground into fine powder.

Preparation of plant material

The plant *Paulownia elongata* was thoroughly rinsed with distilled water to remove any dirt or dust, and then it was dried out completely and powdered using a laboratory grinder (FGR350, Quest Scientific). Methanol extraction was then performed by adding 150g of the powdered samples to an Erlenmeyer flask, which was covered and shaken periodically for seven days while the mixture was left to stand at room temperature. The mixture was then filtered with cheese cloth and the filtrate was kept frozen until it was needed.

Preparation of test samples

The crude extracts of *Paulownia elongata* were used in antibacterial assay. The crude extracts were tested by disc diffusion method on nutrient agar medium as described by Pundir and Jain (2010). Exactly 3 mg of the crude sample was dissolved in 3 mL of methanol giving a stock solution of 1000µg/mL. Different volumes from the stock solution were taken (25, 50, 100, 250, 500, 1000 ppm each), and dissolved in 5mL of methanol to make final concentration respectively.

Preparation of agar plates

Preparations of agar plates were performed based on method described by Pundir and Jain (2010). Nutrient agar was prepared according to manufacturer's instruction with 14 g of dried agar dissolved in 500 mL distilled water. The agar solution was heated until boiling followed by sterilization in autoclave at 121°C.

The agar solution was then poured into a sterile petri plate and allowed to cool down and forming a gel. The plates were divided into eight sections by making a line marking on the outside surface of the plate. The eight sections were for each test samples namely the 25, 50, 100, 250, 500, 1000 ppm samples, tetracycline 30 µg (positive control) and methanol (negative control). The plates were sealed using paraffin and keep chilled at 4°C upon bacteria inoculation.

Preparation of bacterial broth

Antibacterial assay: Antibacterial activity of leaves were determined against four pathogenic bacterial strains *E. coli, Salmonella typhi, Klebsiellia pneumonia* and *Staphylococcus aureus* using disc diffusion method as reported by various authors (Prashanth *et al.,* 2006; Umar *et al.,* 2019). The extract was dissolved using methanol (MeOH) and sterilized by filtration and stored at 4^oC until use.

Tetracycline, a common antibiotic, was used to compare the zone of inhibition of the pure strains of bacteria. The extracts were then tested for their ability to fight against the various bacterial strains. *Paulownia elongata* leaves were tested for antibacterial activity using a set of five dilutions (50, 100, 200, 300, and 400 g/mL) and the common antibiotic tetracycline disc. Tetracycline was used as a standard medication in a control experiment, and sterile plates containing Mueller-Hinton agar were held at 37°C for 3 hours. The setup was kept at a temperature of 37°C for 18 to 24 hours, and the zones of growth inhibition around the discs were measured in millimetre.By estimating the width of the inhibitory zones on the surface of the agar around the disc, the test organisms' antibacterial activity on the plant extracts was quantified. The experiment was done in duplicate four times, and the statistical programme SPSS 22 was used to obtain the average values of the diameter of the inhibitory zones.

3.3 Experimental Animals

Forty male albino rats weighing between (150-190g) were obtained on 19th October, 2022 from HEMA ANIMALS FARM Federal Housing Estate, Bajabure Gerie, Adamawa State, Nigeria. Apparently healthy albino rats (n = 30) were used for the experiment under close supervision of animal care staff of the department of Biochemistry and housed in metallic cages at the Animal House of the department of Biochemistry, Federal University, Wukari, Taraba State. The animals were left to acclimatize to the laboratory conditions of ambient temperature (20 - 27^0C) and a 12-hour light-dark cycle for two weeks. The animals were fed on standard commercial rat feed and clean water *ad libitum*. All the experiment was conducted based on the approval of the Animal and Research ethical committee of federal university Wukari.

3.4 Chemical and reference drug

The analytical-grade compounds utilised in this experiment were all purchased from SIGMA. The reference medication, omeprazole, was purchased from a pharmacy in Yola, Adamawa State, Nigeria. The medication, which treats ulcers, stops the enzymes in the stomach wall that produce acid, which is the main cause of peptic ulcers. By inhibiting the enzymes, less stomach acid is produced, enabling the ulcer to heal (Umaru *et al.,* 2018).

3.5 Experimental protocol

Seven groups of albino rats, including a normal group, a negative and positive control group, and three groups for extract dosage, were randomly assigned. The animals were dehydrated two hours prior to the experiment's start and denied food for 24 hours, with the exception of the groups of animals that were normal.

Group 1: Normal control (diet/water)

Group 2: Rats (induced ulcer indomethacin 25mg/kg/bwt +diet /water)

Group 3: Rats (induced ulcer indomethacin 25mg/kg/bwt +diet/water + Omeprazole)

Group 4: Rats (induced ulcer indomethacin 25mg/kg/bwt +diet /water +100mg/kg/bwt extracts)
Group 5: Rats (induced ulcer indomethacin 25mg/kg/bwt +diet /water +200mg/kg/bwt extracts)
Group 6: Rats (induced ulcer indomethacin 25mg/kg/bwt +diet /water +300mg/kg/bwt extracts).
Group 7: Rats (induced ulcer indomethacin 25mg/kg/bwt +diet /water +400mg/kg/bwt extracts)

Gas Chromatography-Mass Spectrometry (GC-MS) profiling methods:
GC MS was used to profile the chemical components. 1µL of the crude extract that was dissolve in methanol. The combined 7890A gas chromatograph system (Agilent 19091-433HP, USA) and mass spectrophotometer was used to perform the GC-MS analysis. It was equipped with an HP-5 MS fused silica column (5% phenyl methyl siloxane 30.0 m250 m, film thickness 0.25 m), interfaced with a 5675C Inert MSD with Triple-Axis detector. A column velocity flow of 1.0 mL min-1 of helium gas was used as the carrier gas.Other GC-MS conditions include the following: a 1µL injector in split mode with a split ratio of 1:50 and injection temperature of 300°C; an ion source temperature of 250°C; an interface temperature of 300°C; a pressure of 16.2 psi; a 1.8 mm out time; and other conditions. Starting at 36°C for 5 minutes, the column temperature increased to 150 V at a rate of 4°C min-1.

Determination of Levels of Liver Biochemical Parameters in Rats Administered Ethanolic Extracts of Fruits of *D. tripetala*
Level of selected biochemical parameters such as aspartate aminotransferase (AST), alanine aminotransferase (ALT), urea and creatinine were determined using auto-chemistry analyzer Landwind LW E60B, China.

Statistical Analysis
All values obtained were expressed as mean ± SEM. The data were analyzed by appropriate ANOVA followed by Duncan's multiple range tests where appropriate. The significance was at $p \leq 0.05$.

RESULTS

GC-MS Phytochemical profile of *Paulownia elongata* leaves methanol crude extract
The GC-MS chromatogram of methanol leaves extracts of *Paulownia elongata* in Fig. 1 recorded a total of 24 peaks corresponding to the bioactive compounds that were recognized by relating their peak retention time, peak area (%), height (%) and mass spectral fragmentation patterns to that of the known compounds described by the National Institute of Standards and Technology (NIST) library.

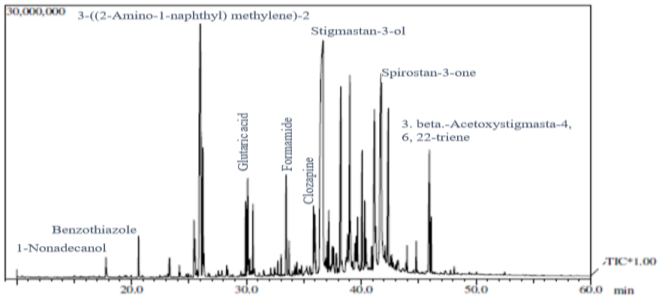

Figure 2: GC-MS chromatogram of *Paulownia elongata* methanol leaves crude extract

Table 1: Phytochemical profile of *Paulownia elongate* leaves methanol crude extract

S. No.	Name	R.Time	Area	Area %
1	1-Nonadecanol,	18.003	20140685	12.39
2	Benzothiazole,	20.564	47077702	2.90
3	3-((2-Amino-1-naphthyl)methylene) -2-benzo	26.219	46075616	2.84
4	3-(4-Chlorophenyl)-2-(o-tolylaminomethyl)-	29.944	21480520	1.32
5	Glutaric acid,	30.110	43602935	2.68
6	tert-Butyldimethylsilyl 4-methyl-2-((2,2,3,3,	30.580	19843075	1.22
7	1,4-Dimethyl-2-cyclohexyl-5-cyclopenty l ben	33.469	43028242	2.65
8	Formamide,	35.854	19658038	1.21
9	Sarcosine,	36.684	416805744	25.65
10	Clozapine,	37.174	18387764	1.13
11	Stigmastan-3-ol,	38.231	103888785	6.39
12	Adamantanoneazine	39.015	90515888	5.57
13	Stigmasta-5, 22-dien-3-ol, acetate, (3.beta.)-	39.692	16547771	1.02
14	Stigmasta-4,22-diene-3-one	40.084	52267517	3.22
15	Camphene	40.316	21728388	1.34
16	Globulol	41.164	105257793	6.48
17	Cryptomeridiol	41.761	188611177	11.61
18	Spirostan-3-one	42.367	84398595	5.19
19	2-Dodecen-1-yl(-)succinic anhydride	45.950	65898138	4.05
20	3.beta.-Acetoxystigmasta-4,6,22-triene	46.104	18643566	1.15
21	Cholesta-4, 6-dien-3-ol	47.367	811398595	5.19
22	2-Dodecen-1-yl(-)succinic anhydride	48.950	65898138	4.05
23	Cholestan-16-one	49.104	174564356	1.15
24	Heptane, 1,1-dicyclohexyl-	50.367	184298599	5.19

Antibacterial activities effect of *Paulownia elongate* leaves methanol crude extract

Table 2: Effect of *Paviownia elongata leaves methanol crude extract* (µg/mL) on Gram positive and Gram-negative bacteria in millimeter (mm).

Conc. (µg/mL)	Organism	Tetracycline (30 µg/mL)	Methanol
50	*Salmonella typhi*	20.71+ 0.5	52.67 + 0.5
	Escherichia coli	20.47± 0.5	11.25 ± 0.0
	Staphylococcus aureus	20.64± 0.5	6.33 ± 0.5
	Klebsiella pneumonia	20.34± 0.5	8.33 ± 0.5
100	*Salmonella typhi*	20.65± 0.5	8.33 ± 0.5
	Escherichia coli	20.34± 0.5	16.000 ± 1.0*
	Staphylococcus aureus	20.61± 0.5	20.333 ± 0.5
	Klebsiella pneumonia	20.62± 0.5	11.05 ± 0.0
200	*Salmonella typhi*	20.33 ± 0.5	10.30 ± 2.3
	Escherichia coli	20.34 ± 0.5	15.33 ± 1.1
	Staphylococcus aureus	20.32 ± 0.5	9.33 ± 3.0
	Klebsiella pneumonia	20.34 ± 0.5	18.00 ± 0.0*
300	*Salmonella typhi*	20.36 ± 0.5	20.00 ± 0.0
	Escherichia coli	20.31 ± 0.5	17.25 ± 0.0
	Staphylococcus aureus	20.33 ± 0.5	14.00 ± 0.0
	Klebsiella pneumonia	20.32 ± 0.5	16.00 ± 0.0
400	*Salmonella typhi*	20.22 ± 0.0	20.30 ± 0.5
	Escherichia coli	20.18± 0.0	12.0 ± 0.0
	Staphylococcus aureus	20.16 ± 0.0	14.0 ± 0.0
	Klebsiella pneumonia	20.14± 0.0	15.3 ± 1.1

Result is Mean ± SD. N = 3

*= significant activity was observed when compared to the control ($p<0.05$)

Concentration of standard is 30 µg/mL of tetracycline, Conc= Concentration

Table 3: Effect of *Paulownia elongata leaves methanol crude extract* on indomethacin induced ulcer rats and percentage protection

Group	Treatment/Dose (mg/kg/bwt)	Methanol Crude extract	Percentage (%)
Group 1	-	-	-
Group 2 (-ve) control	25	2.93 ± 0.70	0.00
Group 3 (+ve) control (omeprazole)	25	0.11 ± 0.05	96.25
Group 4	50	2.25 ± 0.20	5.86
Group 5	100	1.22 ± 0.07	17.99
Group 6	200	1.50 ± 0.27	37.24
Group 7	300	1.21 ± 0.16	49.37
Group 8	400	0.99 ± 0.13*	**58.56**

Result is Mean ± SD. N = 5

*= significant activity was observed. Concentration of standard is 25 µg/mL of Omeprazole

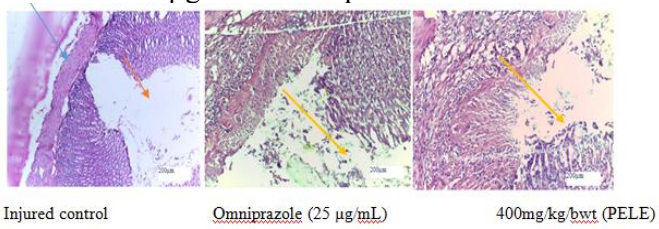

Figure 3: Histopathology of gastric mucosa stained with HandE of the rats subjected to induction of ulcer by indomethacin. Animals were treated orally with omeprazole and of *Paulownia elongata* Leaves Methanol Crude Extract at 400 mg/kg/wt for 14 days. The blue arrow indicated the absence of epithelial layers (ulcer area internal) and the red arrow indicated epithelial layers remaining (ulcer edge). The yellow showed healing portion of the ulcerated area. The microphotographs depict the activity of the crude at 400mg/kg/bwt in the groups' magnification of 200µg.

Table 4: Effect of *Paulowinia enlogate* stem bark extract (PELE) on biochemical parameters in 14 days after treatment on Indomethacin Induced Ulcer Rats**.**

Biochemical Parameters	Treatment	
	Control solution (Normal saline)	PELE 400mg/kg
Creatinine	0.19±0.12[a]	0.27±0.09[a]
ALP (mg/dL)	197.10±18.56[a]	211.13±19.22[a]
AST (mg/dL)	164.13±23.67[a]	178.12±29.18[a]
ALT (mg/dL)	65.07±4.13[a]	70.15±7.23[a]
BUN (mg/dL)	53.83±1.58[a]	57.21±4.13[a]

Administration of 400mg/kg methamolic extract of *Pauwlownia elongata* showed a potential of enhancing levels selected biochemical parameters non-significantly.

DISCUSSION

Flavonoids, triterpenoids, alkaoids, tannins, saponins, and phenolic substances were discovered in the leaves of the empress tree (Paulownia elongata) extract after

phytochemical screening. The existence of some of these phytochemicals in this plant was previously discovered by He *et al.* (2016), who showed that its methanol and aqueous-based leaves, fruit, stem, and root extracts showed good antioxidant activity because of the presence of flavonoids and phenolic compounds. Since flavonoids and phenolic chemicals could be seen in the extract, the current discovery supports this plant's antioxidant abilities. The general composition of the chemical constituents were found to be 24 compounds which includes 10.65 1-Nonadecanol, 8.95 Sarcosine, 7.57 Adamantanoneazine, 7.33 Cryptomeridiol, 7.28 Stigmastan-3-ol, 6.25 Cholesta-4, 6-dien-3-ol, Heptane 1,1-dicyclohexyl and Spirostan-3-one, 6.19 Globulol, 5.78 Benzothiazole, 4.86 2-Dodecen-1-γ-l(-)succinic anhydride, 3-((2-Amino-1-naphthyl)methylene)-2-benzo, 4.77 Stigmasta-4,22-diene-3-one, 4.01 1,4-Dimmethyl-2-cyclohexyl-5-cyclopentylben, 3.81 Glutaric acid, 3-(4-Chlorophenyl)-2-(O-tolylaminomethyl)-, 2.81 tert-butyldimenthylsilyl-4-menthyl-2-((2,2,3,3,), 2.70 Camphene, 2.47 Formamide, 2.42 Clozapine, 2.28 3-β-Acetoxystiqmasta-4,6,22-triene, Cholestan-16-one and 2.01 Stigmasta-5,22-dien-3-ol, acetate as shown in Table 1.

The result is comparable with report of Umaru *et al.* (2022), GC-MS analysis of an methanolic extract of *Senna alata* that led to the identification of different compounds by relating their peak retention time, peak area (%), height (%) and mass.

Rresult of screening plant extracts for antibacterial activity as shown in Table 2 showed that most organisms were sensitive to the extract. In the present study, different concentrations of *Paulownia elongata* leaves extracts 50, 100, 200, 300 and 400 mg/mL were tested against four isolated organisms and were sensitive to inhibition at different concentrations.

The activity of *Paulownia elongata* against selected bacterial was significant when compared to the test control at all the concentration tested. Higher growth inhibition rate was observed at 50 µg/mL though significant inhibition was observed in all the test bacteria. The maximum inhibition of the methanol leaf extracts were against the isolated organisms, at 50, 300 and 400 µg/mL concentration on Salmonella typhi, of 52.67±0.5, 20.00±0.0, and 20.30±0.5 mm respectively, while Staphylococcus aureus at 100 µg/mL of 20.333±0.5 mm and Klebsiella pneumonia at 200 µg/mL of 18.0±0.0 when compared to the test control. Weaker inhibition was observed at 50 µg/mL of *Staphylococcus aureus* and *Klebsiella pneumonia* at 6.33±0.5 mm and 8.33±0.5 mm respectively, at 8.33±0.5 mm and 9.33±3.0 mm of 100 and 200 µg/mL of *Salmonella typhi* and *Staphylococcus aureus* respectively.

The antibacterial test utilizing well diffusion assay, Gram-negative bacteria were shown to be susceptible to the plant extract compared to Gram-positive bacteria, except 100 µg/mL at 20.33±0.5 of *Staphylococcus aureus*, which showed the only time gram-positive was significantly different to the control, which is in agreement with some published results (Mahesh and Satish, 2008; Mavri *et al.*, 2012). Gram-negative bacteria are usually less sensitive to antibiotics compared to Gram-positive bacteria due to the intrinsic resistance and lack of penetration to antimicrobial compounds, such as daptomycin, tetracycline (Miquel *et al.*, 2016; Kamf, 2019). It could be due to the outer membranous make up of the Gram-negative bacteria (Mavri *et al.*, 2012; Baek *et al.*, 2015).

Some researchers detected the antimicrobial activity of *C. tamala* against a number of organisms (Hassan *et al.*, 2016). They reported that extract of *C. tamala* possessed different degrees of antimicrobial activity against all tested Gram-positive and Gram-negative bacteria similar to our result where only *S. aureus* was found to be effective. Phytochemicals flavonoids, terpenoids, tannins, and alkaloids present in extracts of *C. tamala* showed antihelminthic, antidiarrhoeal, and antimicrobial activities(Hassan *et al.*, 2016). In this present study the methanolic leave extract of *Paulownia elongata* has many bioactive compounds like flavonoids, alkaloid, terpenoids which are could be responsible for the pharmacological activity.

Table 3 showed the effect of the extract in group 4-8 (50 – 400 mg/kg/bwt) is significant when compared with group 3 (positive control) showed increase gastro-protective effect as the dose increases. It shows the inhibitory effect of the extract and indomethacin, the highest percentage inhibition of ulcer lesion was produced by the reference drug Omeprazole at 25mg/kg/bwt followed by the extract at 400 mg/kg/bwt in group 8, thus showing that at higher doses of the extract, the percentage inhibition would be higher than the drug.

The methanol extract of the leaf of *Paulownia elongata* as presented in Table 3 (50, 100, 200, 300, and 400 mg/kg/bwt) and Omeprazole (25 mg/kg, drug control) significantly inhibited ulcer formation in this model by 5.86, 17.99, 37.24, 49.37, and 58.56%, respectively.

The reduction of the lesions seen with the methanol extract of *Paulownia elongata* suggests that part of the protective mechanism could involve mucosal defensive factors. Gastric mucosal damage caused by indomethacin and other related nonsteroidal anti-inflammatory drugs which result from the inhibition of prostaglandins synthesis via the arachidonic pathway (Vane, 1971; Ferreira and Vane, 1974). By sustaining gastric microcirculation and inducing the release of bicarbonate and mucus, prostaglandins perform protective activities in the stomach (Garner *et al.*, 1979; Zhang *et al.*, 2020).

Thus, the effect of the extract in this study suggests, it may posse's cytoprotective action probably by

enhancing prostaglandin synthesis. The extract significantly ($p<0.05$) protected gastric mucosa against indomethacin challenge. indomethacin -induced gastric mucosal lesions, predominant in the glandular part of the stomach, are caused by the direct toxic action of ethanol, reduction of the secretion of bicarbonate and depletion of gastric wall mucus (Marhuend *et al.,* 1993). Researchers reported that, agent that enhance mucosal defensive factors inhibit agents of induced gastric mucosal lesions (Robert *et al.,* 1979). This is in conformity with our earlier suggestion that *Paulownia elongata* extract may owe its anti-ulcer effect to cytoprotection probably due to enhancement of prostaglandins synthesis. The level of cytoprotection provided by the extract against indomethacin-induced ulcers directly shows that it may increase prostaglandins synthesis, even though the precise mechanism of cytoprotection is yet unknown.

The plant *Paulownia elongata* methanol crude extract contains many polar phytochemicals including flavonoids and other polyphenols (Omale *et al.,* 2013). The presence of polyphenols and flavonoids may be contributory to the anti-ulcerogenic property observed in this experiment.

Due to their effects on protein precipitation and vasoconstriction, polyphenols and flavonoids may reduce the onset of ulcers. Their astringent activity may aid in precipitating microscopic proteins at the ulcer site, resulting in the formation of an impermeable coating that blocks digestive fluids and shields the underlying mucosa from irritants and toxins (Zhang *et al.,* 2020; Nwafor *et al.,* 2000). This propensity to bind with proteins also explains the fact that polyphenols inhibit enzymes responsible for acid secretions in the stomach thus offering gastro protection (Adebayo-Gege *et al.,* 2023).

Because herbal plants contain bioactive chemicals that dissolve in various solvent systems, many studies have noticed and agreed that they have therapeutic value (Das *et al.,* 2010).

Recently, there has been a lot of interest in using plant material as an alternative strategy to manage pathogenic microorganisms, and it has been demonstrated that several plant product components are specifically targeted against pathogenic bacteria that are resistant to antibiotics (Chandra, 2013).

The emerging spread of multidrug resistant pathogens has substantially threatened the current antibacterial therapy. Antibiotic resistance is the major problem that continues challenge to the healthcare sector in both developing and developed countries (Kokila and Jeevan, 2021). Therefore, efforts must be made to find a potent, natural medication that is also safe. The antiviral, antibacterial, antifungal, anthelmintic, antimoluscal, and anti-inflammatory activities of plants have been the subject of numerous reports (Mahesh and Satish, 2008).

CONCLUSION

Strong antibacterial and antiulcer activities were exhibited in the methanolic leaves extract of Paulownia elongata. Due to the presence of phytochemicals, the extracts demonstrated anti-ulcer activity against indomethacin-induced ulcer. The extract's antioxidative and phytochemical components may be responsible for this effect. The improvement in insulin and enzyme activity in the liver and kidneys may be responsible for this decrease. These characteristics support Paulownia elongata leaf extract's empirical usage as an antibacterial and antiulcer agent.

Though different doses of the extract gave varying degrees of anti-ulcer activity and could be a potential source of new anti-ulcer agents however, more studies need to be undertaken to identify, isolate and purify specific compounds, as well as *in vivo* research responsible for the antibacterial and anti-ulcer effect of this extract.

Competing Interest

The authors declare that they have no competing interest

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