

1 **ANTIBACTERIAL ACTIVITY OF AQUEOUS AND ETHANOLIC ROOT**
2 **EXTRACTS OF *PERICOPSIS LAXIFLORA* AGAINST MULTIDRUG-RESISTANT**
3 **UROPATHOGENIC BACTERIA ISOLATED FROM PATIENTS WITH BENIGN**
4 **PROSTATIC HYPERPLASIA.**

5
6
7 ***Abstract***

8 Urinary tract infections are a fairly common complication in patients with benign prostatic
9 hyperplasia (BPH). Indeed, urinary tract obstruction and urinary retention facilitate bacterial
10 proliferation in these patients. This study aimed to evaluate the antibacterial activity of
11 aqueous and ethanolic extracts of *Pericopsis laxiflora* roots against multidrug-resistant
12 bacteria isolated from the urine of patients with BPH. Antibacterial activity was assessed
13 using the agar diffusion method (zone of inhibition) combined with double dilutions in liquid
14 media (MIC, MBC) against four uropathogenic bacterial strains: *Klebsiella pneumoniae*,
15 *Proteus mirabilis*, *Proteus spp.* and *Escherichia coli*. The inhibition zone diameters obtained
16 with the ethanolic extract ranged from 11.2 mm to 16.1 mm, while those of the aqueous
17 extract ranged from 8.1 to 10.5 mm. The minimum bacterial counts (MBCs) of the ethanolic
18 extract were 12.50 mg/mL (*P. mirabilis*, *Proteus spp.*) and 50 mg/mL (*K. pneumoniae*, *E.*
19 *coli*), respectively. The MBCs of the aqueous extract ranged from 50 mg/mL to 100 mg/mL.
20 Both extracts exhibited bactericidal activity against all strains studied. These results suggest
21 that *P. laxiflora* could be a potential source of new antimicrobial molecules for the treatment
22 of urinary tract infections, which are quite common in patients with benign prostatic
23 hyperplasia.

24 **Keywords:** *Pericopsis laxiflora*, antibacterial activity, urinary tract infections, multidrug-
25 resistant bacteria.

26
27 **Introduction**

28 Urinary tract infections (UTIs) caused by bacteria are among the most common microbial
29 infections worldwide (Flores-Mireles et al., 2015; Hsu et al., 2025). While quite common in
30 women, UTIs also represent a major public health problem, particularly among older men.
31 Indeed, in men, benign prostatic hyperplasia (BPH) facilitates the occurrence of UTIs
32 (Honoré et al., 2015). This is due to urinary tract obstruction and urinary retention, which
33 promote bacterial growth (Gandaglia et al., 2013; Oshodi et al., 2015). In these urinary tract

34 infections, the bacteria most often implicated belong to the Enterobacteriaceae family, and in
35 particular *Escherichia coli*, *Klebsiella pneumoniae* and species of the genus *Proteus* (Heising,
36 2010; Sokhn et al., 2020). To effectively combat urinary tract infections, several synthetic
37 antibiotics are used. However, the effectiveness of these so-called conventional synthetic
38 antibiotics is now compromised. This observation is linked to the increasing emergence of
39 multidrug-resistant bacteria, particularly those producing β -lactamases (Ogbolu et al., 2018;
40 Medugu et al., 2022).

41 Faced with this situation, the search for new antimicrobial substances derived from medicinal
42 plants is emerging as a promising alternative. Indeed, medicinal plants have always held a
43 prominent place in traditional African medicine because they constitute a potential source of
44 bioactive compounds (Kirbag et al., 2009; Shivani and Shadma, 2023). Moreover, several
45 scientific studies based on medicinal plants have demonstrated antibacterial activity against
46 various bacterial strains responsible for urinary tract infections (Gadisa and Tadesse,
47 2021). *Pericopsis laxiflora* is a plant belonging to the Fabaceae family. It is widely used in
48 traditional medicine for the treatment of various infections (Sarfo-Antwi et al., 2021).

49 Several scientific studies have been conducted on this plant, particularly on its leaves and
50 trunk bark (Abou et al., 2016; Fadipe et al., 2019). The present study therefore aims to
51 evaluate the antibacterial activity of aqueous and ethanolic extracts of *Pericopsis laxiflora*
52 roots against multidrug-resistant uropathogenic bacteria isolated from urinary tract infections
53 in patients with benign prostatic hyperplasia.

54 **Materials and Methods**

55 **Plant Material**

56 Roots of *P. laxiflora* were collected in January 2026 in the village of Lataha in the northern
57 region of Côte d'Ivoire (Poro Region). This plant had been identified by botanists at the
58 National Flores Centre, where a sample is kept. After harvesting, these roots were transported
59 to the laboratory for analysis.

60 **Bacterial Strains**

61 Four potentially resistant, β -lactamase-producing uropathogenic clinical bacteria were used.
62 These bacteria were isolated from urine samples of patients with benign prostatic hyperplasia
63 presenting with urinary tract infections. They are *Klebsiella pneumoniae*, *Proteus mirabilis*,
64 *Proteus* spp. and *Escherichia coli*. They were provided by the Bacteriology Laboratory of the
65 Regional Hospital Center (CHR) of Daloa (Côte d'Ivoire) (Table 1).

66 **Table 1:** Antibacterial profiles of the bacterial strains studied

| Bacterial strains | Ampicillin | Cephotaxime | Nitrofurantoin | Nalidixic acid | β -lactamase activity |
|----------------------|------------|-------------|----------------|----------------|-----------------------------|
| | 10 μ g | 30 μ g | 300 μ g | 30 μ g | |
| <i>K. pneumoniae</i> | R | R | R | R | + |
| <i>P. mirabilis</i> | R | R | R | R | + |
| <i>Proteus spp.</i> | R | R | R | R | + |
| <i>E. coli</i> | R | R | R | R | + |

67 R : Resistant

68 Preparation of aqueous and ethanolic extracts

69 The roots of *P. laxiflora* were dried at room temperature in the laboratory for 30 days,
70 protected from sunlight. After drying, they were ground using an electric grinder (RETSCH,
71 Type AS 200, Germany) to obtain a fine powder, which was used to prepare the different
72 extracts (aqueous and ethanolic). The aqueous extract of *P. laxiflora* roots was obtained
73 according to the method described by Guede-Guina et al. (1997). One hundred (100) grams of
74 root powder were macerated in 1 L of distilled water and homogenized under magnetic
75 stirring for 24 hours at 25°C using a magnetic stirrer (RCT IKAMAG). The resulting
76 homogenate was filtered twice through clean cloth and once through Whatman filter paper
77 (No. 2). The volume of the resulting aqueous filtrate was first reduced using a Büchi rotary
78 evaporator at 60°C. The remaining aqueous filtrate was then evaporated in a Med Center
79 Venticell oven at 50°C to yield a powder, which constitutes the aqueous extract (EAq). The
80 same procedure was performed, replacing the distilled water with ethanol, to prepare the
81 ethanolic extract (EEth). However, in this case, the volume of the ethanolic filtrate was
82 concentrated using the rotary evaporator at 60°C. The extracts were stored in a refrigerator for
83 antibacterial testing.

84 Phytochemical analysis of extracts

85 The phytochemical study was conducted according to the method proposed by Toure et al.
86 (2011). It was based on precipitation and/or staining tests in test tubes. The secondary
87 metabolites analyzed were total phenols, flavonoids, tannins, cardiotoxic glycosides, saponins,
88 sterols, and terpenes.

89 Sensitivity test to extracts

90 This was based on the punched-well method in Mueller-Hinton agar, according to the method
 91 proposed by Ouattara et al. (2013). Petri dishes containing Mueller-Hinton agar were covered
 92 with the inoculum of each bacterium, the concentration of which was estimated at 1.5×10^6
 93 CFU/mL. After drying the Petri dishes in an oven for 30 min at 37°C, 6 mm diameter wells
 94 were made in each one. Each well was then filled with 80 µL of a 100 mg/mL extract
 95 (aqueous or ethanolic extracts). A control well was also prepared on each Petri dish,
 96 containing 80 µL of sterile distilled water. Ampicillin (10 µg) was also used as a standard
 97 control. After 45 minutes of pre-diffusion, all Petri dishes were incubated at 37°C for 18
 98 hours. The diameter of the growth inhibition zone around each well was measured to assess
 99 the effect of the extracts.

100 **Determination of Minimum Inhibitory Concentrations and Bactericidal**

101 Minimum inhibitory concentrations (MICs) were determined using the double liquid dilution
 102 method as proposed by Ouattara et al. (2013). The MIC represents the lowest concentration at
 103 which no visible bacterial growth is observed. As for the minimum bactericidal concentration
 104 (MBC), it corresponds to the lowest concentration at which less than 0.01% of the bacteria in
 105 the initial suspension survived after 24 hours. It was determined by inoculating new Mueller-
 106 Hinton culture media from the tube used to observe the MIC. Furthermore, the MBC/MIC
 107 ratio was calculated to assess the antibacterial activity of each extract. An extract is
 108 considered bactericidal if this ratio is less than or equal to 4, and bacteriostatic if it is greater
 109 than 4.

110 **Results**

111 The results of the phytochemical study showed a diversity of secondary metabolites in the
 112 extracts studied. These chemical compounds were distributed differently within the two
 113 extracts derived from the roots of *P. laxiflora*. However, it appears that the ethanolic extract is
 114 richer in phenolic compounds (total phenols, flavonoids) and then in sterols and terpenes
 115 compared to the aqueous extract (Table 2).

116 **Table 2:** Phytochemical screening of *P. laxiflora* root extracts

| Secondary metabolites | Extracts | |
|-----------------------|----------|-----|
| | EEth | Eaq |
| Total phenols | +++ | + |
| Flavonoids | +++ | + |
| Catechetical Tannins | - | - |

| | | |
|----------------------|----|---|
| Gallic tannins | + | + |
| Cardiac glycosides | + | + |
| Alkaloids | + | + |
| Sterols and terpenes | ++ | - |

117 EEth: ethanolic extract, EAq: aqueous extract, -: absence; +: presence

118 Susceptibility testing of *Pericopsis laxiflora* root extracts revealed varying inhibition zone
 119 diameters against the tested strains (Table 3). The ethanolic extract exhibited the highest
 120 inhibition zone diameters against all tested strains. With this extract, the inhibition zone
 121 diameters ranged from 11.2 mm (*K. pneumoniae*) to 16.1 mm (*P. mirabilis*). For the aqueous
 122 extract, the diameters ranged from 8.1 mm (*K. pneumoniae*) to 10.5 mm. It is clear that both
 123 extracts were more sensitive to *P. mirabilis* and *Proteus spp.* strains compared to *K.*
 124 *pneumoniae* and *E. coli*.

125 **Table 3:** Inhibition diameters of extracts at 100 mg/mL (mm)

| Bacterial strains | Extracts | | Ampicillin (10 µg) |
|----------------------|----------|------|-----------------------|
| | EEth | EAq | |
| <i>K. pneumoniae</i> | 11.2 | 8.1 | - |
| <i>P. mirabilis</i> | 16.1 | 10.5 | - |
| <i>Proteus spp.</i> | 14.5 | 10.2 | - |
| <i>E. coli</i> | 12.1 | 8.3 | - |

126 EEth: ethanolic extract, EAq: aqueous extract, -: no inhibition

127 The antibacterial parameters of the studied extracts are recorded in Table 4. The results
 128 obtained corroborate those obtained with the inhibition zone diameters. Indeed, the MIC and
 129 MBC values also show greater efficacy of the ethanolic extract compared to the aqueous
 130 extract. However, the ethanolic extract was more active against *P. mirabilis* and *Proteus spp.*
 131 than against *K. pneumoniae* and *E. coli*. For this ethanolic extract, the MBCs were 12.50
 132 mg/mL (*P. mirabilis*, *Proteus spp.*) and 50 mg/mL (*K. pneumoniae*, *E. coli*), respectively. The
 133 same observation was made at the level of the CMBs of the aqueous extract which proved to
 134 be more active against strains of *P. mirabilis* (50 mg/mL), *Proteus spp* (50 mg/mL) than on *K.*
 135 *pneumoniae* (100 mg/mL) and *E. coli* (100 mg/mL).

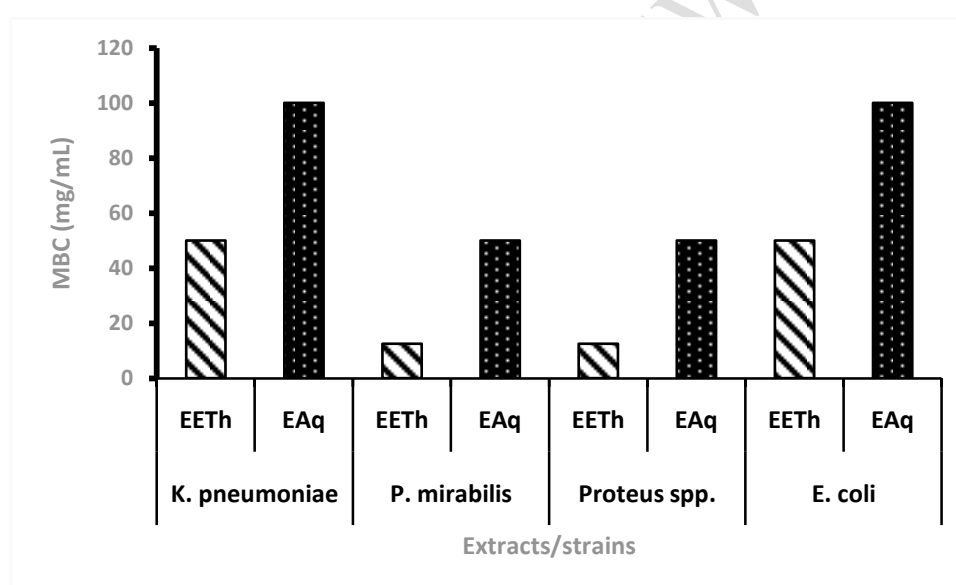
136 **Table 4:** Antibacterial parameters of the extracts studied

| Bacterial strains | Extracts | MIC | MBC | MBC/MIC |
|-------------------|----------|-----|-----|---------|
|-------------------|----------|-----|-----|---------|

| | | (mg/mL) | (mg/mL) | |
|----------------------|------|---------|---------|---|
| <i>K. pneumoniae</i> | EEth | 50 | 50 | 1 |
| | EAq | 50 | 100 | 2 |
| <i>P. mirabilis</i> | EEth | 6.25 | 12.50 | 2 |
| | EAq | 12.50 | 50 | 4 |
| <i>Proteus spp.</i> | EEth | 12.50 | 12.50 | 1 |
| | EAq | 25 | 50 | 2 |
| <i>E. coli</i> | EEth | 50 | 50 | 1 |
| | EAq | 50 | 100 | 2 |

137 EEth: ethanolic extract, EAq: aqueous extract, MIC: minimum inhibitory concentration,
 138 MBC: minimum bactericidal concentration

139 Figure 1 shows a comparative action of the activities of the aqueous and ethanolic extract of
 140 *Pericopsis laxiflora* roots on the different strains studied.



141
 142 **Figure 1:** Comparative minimum bactericidal concentrations of the different extracts on the
 143 bacteria studied.

144
 145
 146 **Discussion**

147 The various chemical groups identified in this study have already been found in extracts from
 148 other organs of *P. laxiflora*. Indeed, some authors have stated that extracts from various organs
 149 of *P. laxiflora* contain these chemical compounds (Ouattara et al., 2025). Most of these groups
 150 are known for their interesting biological properties, particularly their antibacterial activity

151 (Saad et al., 2025). The superior activity of the ethanolic extract compared to the aqueous
152 extract could be explained by better extraction of bioactive compounds in ethanol, as
153 observed in the phytochemical study. The low sensitivity of *K. pneumoniae* and *E. coli* strains
154 to the studied extracts suggests the presence of higher β -lactamase activity in these strains.
155 Indeed, some authors, in evaluating the activities of medicinal plant extracts on *K.*
156 *pneumoniae* and *E. coli*, had observed a stronger resistance of these two bacterial strains
157 compared to other uropathogenic strains (Salinas-Moreno et al., 2023; Ghaly et al., 2025).
158 However, the fact that the MBC/MIC ratios were all below 4 indicates the bactericidal activity
159 of both the aqueous and ethanolic extracts against the studied strains (Musa et al., 2026).
160 These promising results are thought to be linked to the presence of phytomolecules such as
161 flavonoids, tannins, and alkaloids, known for their antimicrobial properties. These chemical
162 groups were identified in the phytochemical analysis conducted during this study. Indeed,
163 these compounds act through various mechanisms, including alteration of the bacterial cell
164 membrane, inhibition of protein synthesis, and inactivation of enzymes essential for bacterial
165 metabolism (Ghédira et al., 2024; Saad et al., 2025). However, the superior activity of the
166 ethanolic extract can be explained by the greater solubility of certain chemical groups of
167 secondary metabolites, particularly phenolic compounds, in ethanol. Moreover, several
168 similar observations have been reported in other scientific works on the antimicrobial activity
169 of medicinal plant extracts against strains of urinary tract infections (Musa et al., 2026).

170 **Conclusion**

171 This study demonstrated the antibacterial activities of aqueous and ethanolic extracts of
172 *Pericopsis laxiflora* roots against multidrug-resistant uropathogenic bacteria isolated from
173 patients with benign prostatic hyperplasia. Both extracts showed bactericidal activity against
174 the bacterial strains studied. However, the ethanolic extract exhibited greater activity than the
175 aqueous extract. These results suggest that this plant could be a potential source of new
176 antimicrobial molecules for the treatment of urinary tract infections, which are quite common
177 in patients with benign prostatic hyperplasia.

178

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