Original Research Article

~~*In-Vitro*~~ Phytochemical analysis and Antimicrobial Susceptibility ~~and Phytochemical Constituents~~ of Methanol Leaf Extract of *Prosopis africana* ()against ~~some~~ Selected Microorganisms.

Comment [OP1]: State the common name here

Abstract

The idea that certain plants have~~d~~ healing potentials was known long before human beings discovered the existence of pathogens. The crude methanolic leaf extract of *Prosopis africana* was assayed for antimicrobial potency using Agar-well diffusion technique against *Salmonella typhi*, *Klebsiella pneumoniae*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, Methicillin-Resistant *Staphylococcus aureus* (MRSA) and *Candida albicans*. Qualitative phytochemical screening was also carried out. The results of the antimicrobial screening showed antimicrobial potency against the test isolates with various degrees of zone of inhibition which varied between 10mm – 22mm. The highest zone was reported~~noted~~ against *Klebsiella pneumoniae* (22mm), followed by *Streptococcus pyogenes* and *Candida albicans* (21mm), *Salmonella typhi* (20mm), MRSA (19 mm) and then *Pseudomonas aeruginosa* (18mm). Chloramphenicol and Fluconazole are used as reference standard and their zones of inhibitions ranged from 26mm–29mm. The Minimum Inhibitory Concentration (MIC) of the extract ranged between 12.50mg/mL – 50.00mg/mL whilst the Minimum Bactericidal Concentration (MBC) and Minimum Fungicidal Concentration (MFC) of the extract were at 50.00mg/mL. The result of phytochemical screening revealed the presence of carbohydrates, flavonoids, phenols/tannins, saponins, terpenes, steroids, cardiac glycosides and alkaloids as secondary metabolites. The findings clearly ~~result of this study~~ showed that methanolic leaf extract of *P. africana* has proved its use in folklore as an

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alternative antimicrobial agent and further research can lead to isolation of a new lead of medical importance.

Key **words~~worlds~~**: Antimicrobial Susceptibility, *Prosopis africana*, Phytochemical Constituents, 96-well microplates, MIC, MBC, ~~and~~ MFC.

1. Introduction

Infectious diseases are particularly ~~a~~ major challenges to public health, despite tremendous scientific discovery of medicines for their treatment [1]. This is due to increase in resistance to antibiotics by pathogenic microorganisms as a result of misuse and over prescription of antibiotics which has affected our ability to treat patients empirically [2][3]. So in recent years there has been continuous and urgent need to discover new antimicrobial compounds with diverse chemical structures and novel mechanisms of action because the incidence of new and re-emerging infectious diseases and development of resistance to the antibiotics in current clinical use [4]. However, nature is endowed with providing continuous new biomolecules with novel structures that are designed to interact with biological systems to provide defense against infectious diseases [5].

The presence of bioactive principles such as alkaloids, phenols, tannins, glycosides and essential oils amongst others is responsible for the medicinal properties of plants [6]. It is necessary to screen medicinal plants for the presence of these bioactive chemicals which may lead to a new active principle. Scientific studies available on medicinal plants indicate that promising phytochemical can be developed for many health problems [7]. The benefits of using plant derived medicines are that they are relatively cheaper and stable.

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P. africana (Guill. & Perr.) Taub. belongs to kingdom plantae, division tracheophyta, class magnoliopsida, order fabales and family fabaceae. It is a renowned and versatile tree of immense economic value amid the rural communities in the Guinea savanna of Nigeria. It is mostly found in savanna countries of Africa like Senegal and Nigeria [8]. Literature gives an account of its uses as folk medicines for several ailment and virtually all its parts are of medicinal value~~.~~ [9] reported that the stem bark is used as remedies for dysentery, gonorrhea, bronchitis and skin diseases. In Niger State of Nigeria, the twigs, leaves, bark, and secondary roots are used for treatment and relieve of typhoid fever, dental decay, malaria as well as stomach cramps while, [10] attested that the bark and root decoctions are utilized for the treatment of Trypanosomiasis in cattle and on lesions as a lotion.

It is in knowledge domain that antimicrobial resistance is a great challenge to holistic treatment of infectious diseases as a result of either the use of substandard antibiotics, misuse or over prescription. There is therefore, need for search to discovering new lead principles that will be effective, safe, readily available and cost effective. This study was aimed to determine the phytochemical and antimicrobial properties of *P. africana* towards the development of new antimicrobial agent.

Comment [OP2]: Check for typographical and syntax errors.
2. What is the problem and rationale of the study?
3. Delete unnecessary statements.
4. Few citations is present. Please increase.

2.0 Materials and Methods

2.1 Plant Sample Collection and Identification

The leaves of *P. africana* were~~as~~ collected in ~~from~~ Bida,~~ in~~ Niger State, Nigeria.~~,~~ The voucher specimen was prepared~~,~~ the plant was identified and voucher specimen was deposited in herbarium unit of the Department of Medicinal Plant Research and Traditional Medicine (MPR&TM), National Institute for Pharmaceutical Research and Development (NIPRD), Idu-Abuja, Nigeria.

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70 **2.2 Preparation and Preservation of Plant Material**

71 The leaves were properly washed under clean-running tap water to remove the dirt and air dried
72 at room temperature for a week. The dried leaves were pulverized into powder with clean
73 wooden pestle and mortar, and sieved. The pulverized sample was stored in a clean plastic
74 container, properly labeled and tightly covered at 37°C prior for further analysis.

Comment [OP3]: Citation needed

75 **2.3 Extraction of Crude Extract**

76 One hundred grams (100g) of the pulverized leave of *P. africana* was accurately weighed and
77 subjected to cold maceration in 500mL of absolute methanol for 72 h at laboratory temperature.
78 The macerated extract was filtered using Whatman No.1 filter paper. The extraction was
79 repeated for the maximum extraction of the active ingredients and to also obtain reasonable
80 yield (crude extract). The filtrate was dried using water bath at 45°C until all the solvent
81 evaporated out.

Comment [OP4]: Citation needed

82 The percentage yield of the crude extract (PYCE) was calculated using the formula by [11].

$$PYCE = \frac{Mass\ of\ the\ crude\ extract\ obtained}{Mass\ of\ the\ pulverized\ plant\ sample} \times 100$$

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85 **2.4 Phytochemical Screening of the Extract**

86 The qualitative phytochemical screening of the leaves of *P. africana* was carried out in
87 Pharmacognosy unit, Department of Medicinal Plant Research and Traditional Medicine,
88 NIPRID, Idu-Abuja. The standard methods illustrated by [12][13] [14] were adopted to test for
89 the presence of carbohydrates, flavonoids, phenols/tannins, saponins, terpenes, steroids, alkaloids
90 and cardiac glycosides.

91 **3.4.1 Determination of carbohydrates: (Molisch's Reagent Test)**

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The fraction of the extract was mixed with 2mL of Molisch's reagent and the mixture was properly shaken. Thereafter, 2mL of concentrated H_2SO_4 was slowly and carefully added. The appearance of a purple ring/violet at the interphase signifies the presence of carbohydrates.

3.4.2 Determination of flavonoids

i. Alkaline Reagent Test

To the extract, 2mL of 2% solution of NaOH was mixed. An intense yellow colouration was formed which later turned colourless when few drops of diluted acid was added which signifies the presence of flavonoids.

ii. Shinoda Test

To the extract, few drops of Mg ribbon fragments were added followed by concentrated HCl. Pink scarlet colour appeared after few minutes which signifies the presence flavonoids.

3.4.3 Determination of phenols/tannins

The fraction of the extract was mixed with 2mL of 2% solution of $FeCl_3$. A blue-green or black colouration which appeared signifies the presence of phenols and tannins.

3.4.4 Determination of saponins: (Froth Test)

The fraction of the extract was mixed with 5mL of distilled H_2O in a test tube and was vigorously shaken for 30 seconds. The formation of the stable foam signifies the presence of saponins.

3.4.5 Determination of terpenes: (Libermann's Test)

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The fraction of the extract was mixed with each of 2mL of chloroform and 2mL of acetic acid. The mixture was then cooled down. Thereafter, concentrated H_2SO_4 was slowly and carefully added and the colour changed from violet to blue which signifies the presence of terpenes.

3.4.6 Determination of steroids: (Salkoski's Test)

To the extract, about 2mL of the chloroform was mixed. Concentrated H_2SO_4 was slowly and carefully added and shaken gently. A reddish brown colour signifies the presence of steroids.

3.4.7 Determination of cardiac glycosides: (Keller-kilani Test)

The extract was mixed with 2mL of glacial acetic acid containing 1-2 drops of 2% solution of $FeCl_3$. The mixture was then poured into another test tube containing 2mL of concentrated H_2SO_4. A brown ring at the interphase signifies the presence of cardiac glycosides.

3.4.8 Determination of alkaloids

i. Dragendoff's Test

To 2mL of 1% HCl, the extract was added. Dragendoff's reagent was then added to the mixture. The resulting turbidity of the precipitate was considered as a proof for the presence of alkaloids.

ii. Hagner's Test

To another 2mL of 1% HCl, the extract was added. Hagner's reagent was then added to the mixture. The resulting turbidity of the precipitate was deemed as an evidence for the attendance of alkaloids.

iii. Wagner's Test

To another 2mL of 1% HCl again, the extract was added. Wagner's reagent was then added to the mixture. The resulting turbidity of the precipitate was believed to be a testimony for the existence of alkaloids.

Comment [OP5]: Delete please. Not necessary because you have made a summary statement above that include all these. It makes the study cumbersome.

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2.5 The Test Microorganisms

Antimicrobial activity of methanol extract of leaves of *P. africana* was investigated against five bacterial isolates and one fungal isolate which were obtained from Vaccine Discovery and Research Laboratory, Centre for Genetic Engineering and Biotechnology, Federal University of Technology, Minna, Nigeria. The bacteria strains used~~which were~~ for the study include *Salmonella typhi, Klebsiella pneumoniae*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, Methicillin-Resistant *Staphylococcus aureus* (MRSA) and the fungi used for the study was *Candida albicans*. The tested bacteria were maintained on Nutrient agar at 37°C for 24 h and *Candida albicans* on Potatoes Dextrose Agar at 30°C for 48-72 h.

2.6 In~~n~~oculum Preparation

A loopful of isolated colonies were inoculated into 4 mL sterile Mueller-Hinton Broth (MHB) for bacteria and Sabouraud Dextrose Broth (SDB) for fungi and incubated at 37°C for 2 h. The turbidity of actively growing microbial suspensions were adjusted with freshly prepared MHB and SDB using $BaSO_4$ turbidity standard to match turbidity standard of 0.5 McFarland. This turbidity was equivalent to approximately $1.5x10^8$ CFU/mL cells for bacteria, and $1.5x10^7$ spores/mL for the fungi strain. ~~fungi strain.~~ The grown suspension was used for further testing.

2.7 Preparation of Crude Extract

For the preparation of the stock solution, 0.5g of the crude extract was accurately weighed using analytical weighing balance into a sterile tube containing 1mL of 2% Dimethylsulfoxide (DMSO). This was vortexed to allow the extract to completely dissolve and 9mL of sterile distilled water was added to give final extract concentration of 50mg/mL. Double fold dilutions was carried out to give extract concentrations of 25mg/mL, 12.5mg/mL and 06.25mg/mL using sterile distilled water respectively.

Comment [OP6]: Citation needed

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158 **2.8 *In-vitro* Antimicrobial Susceptibility Assay of the Extract**

159 Susceptibility test of the extract against the isolates were determined in the Microbiology
160 Laboratory, Ibrahim Badamasi Babangida University Lapai in Niger State, Nigeria using Kirby-
161 Bauer agar diffusion method according to NCCLS standards ([15][16]. The Mueller-Hinton Agar
162 (MHA) and Sabouraud Dextrose Agar (SDA) were used for the antimicrobial activity test. About
163 100 µL of MHB and SDB cultures containing 0.5 McFarland equivalents to approximately
164 $1.5x10^8$ CFU/mL cells for bacteria, and $1.5x10^7$ spores/mL for fungi strain were dispensed into
165 empty sterile petri dishes using micropipettes. Twenty three millilitres (23mL) of sterilized MHA
166 and SDA maintained between 50 – 45°C was added to the appropriate petri dishes and rocked
167 gently for even distribution of the organisms under aseptic condition and allowed to gel under
168 safety hood for 1 h. On each of the plates containing bacteria isolates. Five wells of 8 mm in
169 diameter were made on the agar plates using sterile metallic cork borer and labelled properly.
170 The base of the wells was sealed with 30 µL of MHA and SDA. Thereafter, 200µL of different
171 concentrations of the extract were carefully and aseptically added with the aid of micropipette
172 into each well and left in the safety hood for 2 h for proper diffusion of the extracts into the agar
173 and then incubated at 37°C for 24 h for bacteria. The same procedure was repeated for fungi
174 strain and incubated at 25°C for 48 h for fungi. The experiment was set up in duplicates. The
175 plates were observed for activity and zones of inhibitions were measured and recorded as mean
176 zone of inhibition. The diameter of each zone was accurately measured with a spotless and
177 translucent ruler in millimetre (mm) in vertical and horizontal manner and mean was determined.

178 Control experiments were set up by using standard antibiotics, Chloramphenicol (250mg) for
179 bacteria strain and fluconazole (80mg) for fungi specie as reference standards for positive
180 control. Sterile MHA and SDA plates were used as Media Sterility Control (MSC) and MHA and

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181 SDA plates with the used organisms streaked as Organism Viability Control (OVC). All the

182 controls were given the same treatment as the experiments.

Comment [OP7]: Citation needed

183 **2.9 Determination of Minimum Inhibitory Concentration (MIC)**

184 The minimum inhibitory concentration (MIC) value of the extract of *P. africana* leaves extract

185 was determined by microdilution broth method in 96-well microplates [17]. Chloramphenicol

186 (Fidson, Nigeria) and Fluconazole (Pfizer, UK) were used as the standard drug for bacteria and

187 fungi at stock concentration of 50µg/ml. Controls of sterility for the Mueller-Hinton nutrient

188 broth, control culture (inoculum), Chloramphenicol, Fluconazole, crude extract and DMSO were

189 carried out. The microwell plates were closed and incubated aerobically at 37°C for 24 h.

190 Thereafter, 50µL of tetrazolium dye was applied into each well with further 2 h incubation at

191 37°C and colour change was observed. Any well with reddish-pink colour signifies the microbial

192 growth, which was noted and documented as positive (MIC). All assays were carried out in

193 triplicate.

194 MIC was carried out on the extract against the isolates using the broth microdilution method

195 (BMM) in 96 micro wells titre plates using NCCLS method [16] with little modification. A

196 volume of 50µL of the extract was dispensed into first row and the same volume of the sterilized

197 media (MHB and SDB) was dispensed into each well except the first row. A two-fold dilution

198 was carried out from row 2 by taking 50µL of the extract to the next row, mixed well and the

199 serial dilution continued to row 7 where 50µL from the wells was discarded away. Then, 50µL

200 of 0.5 McFarland of 2 h culture was added to each well in row 1-7. The rows 8 and 9 were the

201 OVC and MSC. The plates were incubated at 37°C for 24 h. The test was carried out in duplicate

202 and the values are express in mean.

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203 **2.10 Determination of Minimum Bactericidal and Fungicidal Concentration (MBC and**
204 **MFC)**
205 The MBC and MFC were determined from the Minimum Inhibitory Concentration (MIC) result
206 by subculturing from the wells that shows no any sign of turbidity in the MIC test and streak on
207 the freshly prepared MHA and SDA plates and incubate at 37°C for 24 to 48 h and the plates
208 were checked for the present or absent of the growth.

Comment [OP8]: Citation needed.

Comment [OP9]: Check for typographical and grammatical errors.
Summarize methods as quick as possible.
Always cite an author in your Lab protocols.

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211 **3.0 Results**

212 **3.1 Phytochemical Constituents**

213 Qualitative biological active compounds of the methanolic crude extract disclosed the occurrence
214 of carbohydrates, flavonoids, phenols/tannins, saponins, terpenes, steroids, cardiac glycosides
215 and alkaloids respectively as demonstrated in table 1 below.

216 **3.2 Antimicrobial Activity**

217 The methanolic crude extract has antimicrobial efficacy against all the test isolates at 50 and 25
218 mg/mL of concentration, while *Salmonella typhi*, *Klebsiella pneumoniae*, *Streptococcus*
219 *pyogenes* and Methicillin-Resistant *Staphylococcus aureus* (MRSA) showed activity even at
220 12.50mg/mL. The extract at 0.625mg/mL however had no activity against all the tested
221 organisms. The antimicrobial controls were active against all tested organisms except
222 *Pseudomonas aeruginosa* (figure 1).

223 **3.3 Minimum Inhibitory and Bactericidal Concentrations of the Crude Extract against**
224 **Sensitive Organisms**

225 Minimum Inhibitory Concentration (MIC) was carried out on all the isolates where *Salmonella*
226 *typhi* and *Streptococcus pyogenes* had MIC of 12.50mg/mL. MRSA, *Klebsiella pneumoniae* and

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227 *C. albicans* had MIC of 25mg/mL while the MIC of *Pseudomonas aeruginosa* was at 50mg/mL
228 (table 2). The MBC of *Salmonella typhi*, *Klebsiella pneumoniae*, *Streptococcus pyogenes*,
229 MRSA were at 50mg/mL and *C. albicans* had the MFC of 50mg/mL (table 3).

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235 **Table1: Phytochemical constituents of methanolic leaves**

Phytochemicals	**Tests**	**Inference**
Carbohydrates	Molisch	+
Flavonoids	Alkaline	+
Phenol/Tannins	Ferric Chloride	+
Saponins	Froth	+
Terpenes	Liebermann	+
Steroids	Salkowski	+
Alkaloids	Dragendoff's	+
	Hagner's	+
	Wagner's	+
Cardiac glycosides	Keller-Kilani	+

236 Key: + = Present - = Absent

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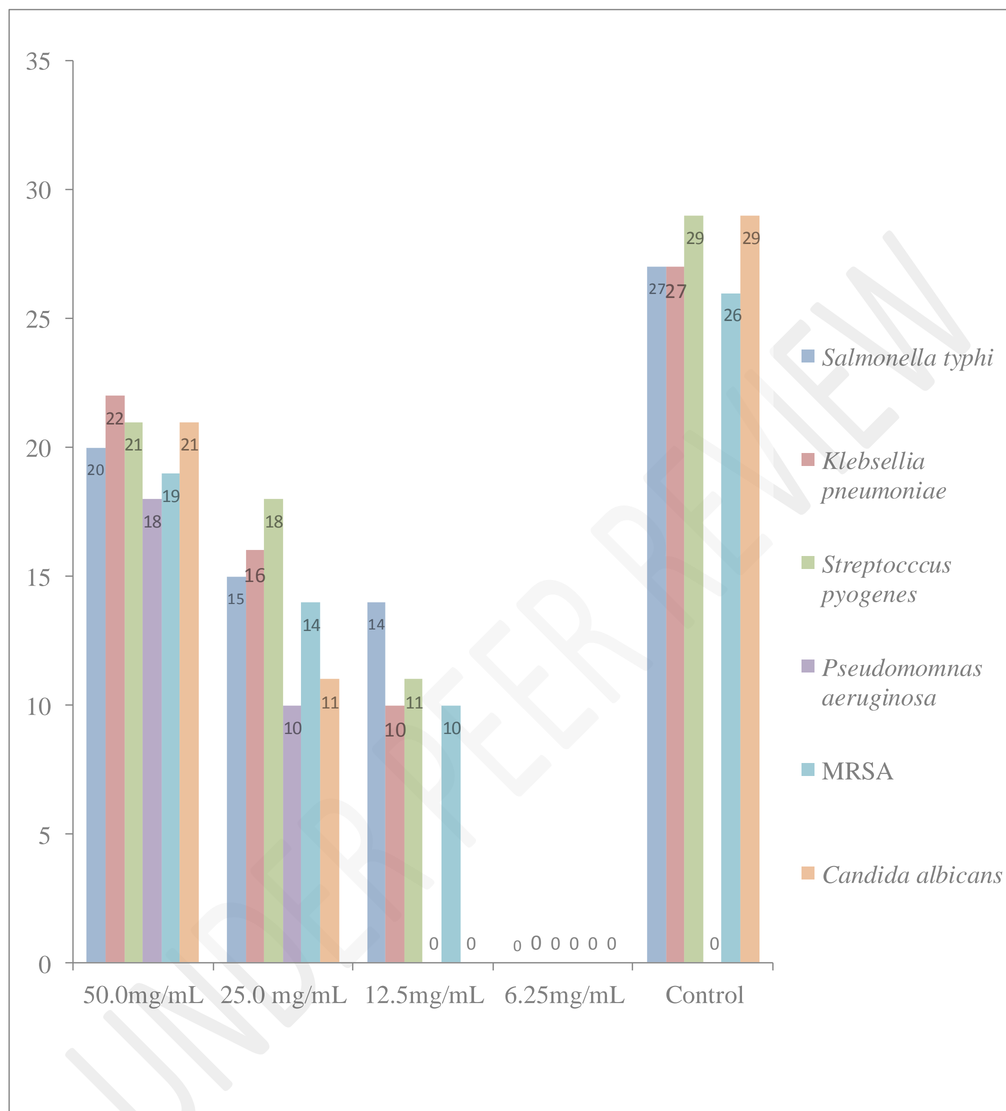

237 Fig. 1: Mean zone of inhibition of methanolic extract of *P. africana* on the test organisms (mm).

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241 **Table 2: Minimum Inhibitory Concentration of Methanol Extract of *P. africana* on the test**
242 **Organisms**

Organisms	Minimum Inhibitory Concentration (mg/mL)	Control (mg/mL)
Salmonella typhi	12.5	50
Streptococcus pyogenes	12.5	50
MRSA	25.0	50
Klebsiella pneumoniae	25.0	50
Pseudomonas aeruginosa	50.0	50
Candida albicans	25.0	50

243

244 **Table 3: Minimum Bactericidal and Fungicidal Concentration of Methanol Extract of *P. africana***
245 **on the test Organisms**

Organisms	MBC/MFC (mg/mL)
Salmonella typhi	50.0
Streptococcus pyogenes	50.0
MRSA	50.0
Klebsiella pneumoniae	50.0
Candida albicans	50.0

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247 **4.0 Discussion**

248 Determining the phytochemical constituents to identify the possible therapeutic agents contained
249 in this plant in order to establish the basis for their uses in folklore medical practice is important
250 to discovery of new active principle.

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251 Variety of different natural chemical compounds such as saponins, tannins, alkaloids, terpenoids,
252 cyanoglycosides, oleic, flavonoids and stearic acids have been found to confer antimicrobial
253 properties to plants and plant products [18] [19] [20]. [21] stated that flavonoids are polyphenolic
254 phytocompounds which are found in plants and possess antifungal, antibacterial, anticancer, anti-
255 inflammatory as well as antioxidant properties. In accordance with the study conducted by [22]
256 the seed and pod of *Prosopis africana* shows the presence of saponin, alkaloids, steroids,
257 flavonoids, phlabotanin and tannin, the result of this study also showed the presence of saponin,
258 alkaloids, steroids, flavonoids, carbohydrates, terpenes, cardiac glycosides and tannin which is in
259 agreement with findings by [6] but different from the findings by [23], where tannins, saponins
260 and terpenes were absent in methanol leaf extract of *Prosopis africana*. The study by [24],
261 showed the absence of tannins in *Prosopis lappacea*. The occurrence of these bioactive
262 compounds in reasonable amount in the leaves of *P. africana* could have been responsible for its
263 characteristic antimicrobial properties. These are recognized to have antibacterial agent and may
264 be utilized traditionally for the treatment of infectious diseases [25]. [21] stated that flavonoids
265 are polyphenolic phytocompounds which are found in plants and possess antifungal,
266 antibacterial, anticancer, anti-inflammatory as well as antioxidant properties.

267 Antimicrobial analysis of methanol crude leaf extract of *P. africana* exhibited some level of
268 antimicrobial properties against microorganisms which include *Streptococcus pyogenes*,
269 *Pseudomonas aeruginosa*, Methicillin-Resistant *Staphylococcus aureus* (MRSA) *Salmonella*
270 *typhi, Klebsiella pneumoniae*, and the fungi used for the study was *Candida albicans* at various
271 concentrations from 50mg/mL to 6.25mg/mL with varied diameters zones of inhibition ranging
272 from 1mm for 29mm. [22] tested the aqueous and methanol extract of seed and pod of *P.*
273 *africana* against fifteen bacteria at a fix concentration of 25mg/mL and recorded zone of

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274 inhibition ranging from 5mm to 17mm. [26] also reported the antimicrobial activities of *P.*
275 *africana* ethanol and aqueous stem and root extract against clinical isolates of oral pathogens
276 namely *Streptococcus mutans*, *Staphylococcus saprophyticus* and *C. albicans* with significant
277 action. The study by [25], revealed activity against *Pseudomonas aeruginosa, Staphylococcus*
278 *aureus, and Bacillus subtilis* at concentrations comparable to the findings of this study. However,
279 the study by [27], showed no activity against *K. pneumoniae*. The result of this study showed no
280 activity against tested organisms at concentration of 6.25mg/mL. Interestingly, the extract had
281 activity against MRSA at 12.5mg/mL concentration with MIC of 25.0mg/mL. This is very
282 promising because of the facts that further purification may exhibit better activity which could
283 lead to discovery of a new lead against antibiotics resistant *Staphylococcus aureus*. It is also
284 worthy of notice that the extract is also active against *Pseudomonas aeruginosa* at crude MIC of
285 50.0mg/mL.

Comment [OP10]: Proof-read this again and reference each findings appropriately with current and related literatures.

286 **5. Conclusion**

287 The methanolic leaf extract of *P. africana* has displayed varied activity against pathogenic
288 microorganisms and could represent candidate of antimicrobial agent against some human
289 pathogenic microbes. Furthermore, the bioactive ingredients indicated that the plant part have
290 proved its usage in the folkloric medicine for the management of different ailments and could be
291 the basis of alternative anti-infective therapy. Therefore, these findings shall broaden and
292 enhance global data base of the antimicrobial property of the active ingredients present.

293 **6. Limitation of the study and Way Forward**

Comment [OP11]: State the way forward for this study.

294 The limitation of this study includes lack of funding to permit us to buy solvents for
295 fractionations which will enable us to obtain a pure compound.

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296 **Conflict of Interest**

297 The authors declared no conflict of interest.

298

299 **References**

Comment [OP12]: Arrange references and citations according to the Journal's guidelines.

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