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## An Assessment of Antibacterial and Antifungal Activity of Methanolic Extracts of Kenyan *Physalis peruviana* L

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**Abstract:** *Physalis peruviana* L has been reported in traditional medicine for the treatment of bacterial, fungal, viral, protozoal diseases, as well as possessing immunomodulatory properties. The aim of this study was to assess the antibacterial and antifungal properties of various parts of methanolic *P. peruviana* extracts against 6 bacterial species and 2 fungal isolates. Antibacterial and antifungal activity of methanolic *P. peruviana* leaves, stem, fruit and root extracts were evaluated in vitro by agar diffusion method against *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25923, *Klebsiella pneumonia* local isolate, *Salmonella typhi* ATCC 700931, *Pseudomonas aeruginosa* ATCC 27853, *Bacillus cereus* ATCC 11778, *Candida albicans* ATCC 90028 and *Aspergillus flavus* local isolate. Minimum bactericidal concentration was carried out using the tube microdilution method. All *P. peruviana* methanolic extracts were also investigated for phytochemical components. Phytochemical investigation on methanolic *P. peruviana* extracts revealed the presence of tannins, saponins, flavonoids, and alkaloids. Statistical analysis for intra-group

inhibitory activity amongst the various methanolic *P. peruviana* extracts concentrations demonstrated significant differences ( $P < 0.05$ ) that were dose-dependent. The minimum inhibitory concentration and minimum microbicidal concentration against the test bacteria and fungi ranged from 3.9 to 62.5 mg/ml. Methanolic *P. peruviana* leaves extracts were the most potent against *E. coli*, *S. typhi*, *P. aeruginosa* and *B. cereus*. All *P. peruviana* extracts exhibited antibacterial and antifungal potential and can be considered as possible sources of noble antimicrobial agents for treating bacterial and fungal infections.

**Keywords:** Antibacterial, Antifungal, methanolic *Physalis peruviana* extracts, Phytochemicals

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## 1. Introduction

Since ancient times medicinal and herbal plants have been used for the treatment of infectious diseases (Redda *et al.*, 2014). Natural products from plant extracts either in the form of pure compounds or normalized extracts have unlimited opportunities for drug discoveries because of their unmatched chemical diversity (Sasidharan *et al.*, 2011). In Kenya as in many African countries, plants have been in use in traditional medicine for the treatment of many infectious diseases (Ogila, 2011).

According to a study carried out by (Kimang'a *et al.*, 2016), it can be deduced that three-quarters of the world population relies on herbal and traditional health care. Quite a number of factors have contributed to the growth of folk medicine worldwide. These factors include:- consumer preference for natural therapies, concerns on undesirable side effects of modern medicines and belief that herbal medicines are free from side effects, immense interests in alternative therapies, the belief that folk medicine might be of effective benefit compared to conventional treatments and that medicines have become inadequate due to increasing populations, tendency towards self medication, enhancement in quality, proof of efficacy and safety of folk medicines and exorbitant costs on synthetic medicines (Maobe *et al.*, 2013).

*Physalis peruviana* belongs to the Solanaceae family. Common English names for the plant include Cape gooseberry, Goldenberry, Husk Cherry, Peruvian Ground cherry, and Poha berry (Moriconi *et al.*, 1990). *Physalis peruviana* has been in use in folk medicine in many parts of the world including Kenya. There has been scanty information on the antibacterial and antifungal properties of Kenyan *P. peruviana* extracts. Therefore this study objective aimed at evaluating the antimicrobial activity of methanolic *P. peruviana* extracts against 6 bacterial isolates namely (*Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25923, *Klebsiella pneumonia local isolate*, *Salmonella typhi* ATCC 700931, *Pseudomonas aeruginosa* ATCC 27853, and *Bacillus cereus* ATCC 11778), and 2

fungal isolates namely *Candida albicans* ATCC 90028 and *Aspergillus flavus* local isolate. The extracts were also evaluated for Phytochemical composition.

## 2. Materials and Methods

### 2.1. Collection of *P. peruviana* Plant and Authentication

The *P. peruviana* plant materials were collected from Nyeri County [0°25'0" South, 36°57'0" East] located in the Central part of Kenya. Nyeri is 162 Km North of Nairobi. This area is known to have good reserves of *P. peruviana* L. The whole plant materials were collected in 2013 and identified by National Museums of Kenya Botanists and a Voucher specimen number EAH001PK deposited at the National Museums of Kenya Herbarium, Nairobi. Various parts; fruits, leaves, stem, and roots were separated, dried under shade and pulverized in a hammer mill fitted with a sieve of 0.5mm pores.

### 2.2. Sources of Chemicals and Media

Methanol was procured from Fisher Scientific, UK, Ltd. Mueller Hinton agar, Nutrient broth, Potato dextrose broth and Sabourauds dextrose agar (SDA) were purchased from UK, Biotech Laboratories Ltd, while Dimethylsulfoxide (DMSO) was procured from Sigma (Pool, Dorset, England).

### 2.3. Preparation of *P. peruviana* Plant Extracts

Preparation of *P. peruviana* extracts was carried out using methods described by Ubulom *et al.* (Ubulom *et al.*, 2011)). Pulverized plant parts were soaked separately in methanol, for 72 hrs with stirring at regular intervals. The extracts were repeatedly filtered using a sterile Whatman No. 1 filter paper (Jaca and Kambizi, 2011). The methanol extracts were concentrated under vacuum in a rotary evaporator.

The percentage yield was determined using the method used by Ogila (2011) as follows: - % yield = Weight of extract/Weight of ground material X 100 %. For identification purposes the extracts were assigned codes and interpreted as follows; Methanolic extracts of *Physalis peruviana* L leaf (MPPL), methanolic extracts of *Physalis peruviana* L stem (MPPS), methanolic extracts of *Physalis peruviana* L fruit (MPPF), and methanolic extracts of *Physalis peruviana* L root (MPPR).

All the extracts were kept desiccated at 4°C until use.

### 2.4. Antibacterial and Antifungal Evaluation of Methanolic *P. peruviana* Extracts

In this study, six bacterial isolates and two fungal isolates were used in testing *P. peruviana* antimicrobial activity. Four of the bacterial isolates were gram-negative (*Escherichia coli* ATCC

25922, *Klebsiella pneumonia* local isolate, *Salmonella typhi* ATCC 700931, *Pseudomonas aeruginosa* ATCC 27853), while the other two were gram-positive (*Staphylococcus aureus* ATCC 25923, *Bacillus cereus* ATCC 11778). There were two fungal isolates namely; *Candida albicans* ATCC 90028 and *Aspergillus flavus* local isolate. The organisms were obtained from a culture maintained in the Department of Medical Laboratory Sciences, Jomo Kenyatta University of Agriculture and Technology, Kenya. Antibacterial and antifungal inhibitory activities were evaluated using a modified disc diffusion method as described by Ogila (2011). To obtain active cultures for testing antibacterial and antifungal activity, a loopful of test organisms from stock cultures were transferred to test tubes of Muller Hinton and Sabouraud dextrose broth for bacteria and fungi respectively. The tubes were incubated overnight at 37°C. Dilutions for the cultures were made in each respective broth by comparing their turbidity with McFarland standard so as to achieve values corresponding to  $2 \times 10^6$ /ml and  $2 \times 10^5$ /ml colony-forming units/spore-forming units for bacteria and fungi respectively. The extracts were dissolved in DMSO in order to obtain concentrations ranging from 31.25 mg/ml to 250 mg/ml. Sterile filter paper discs (Whatman no. 1) of 6 mm diameter were impregnated with the different concentrations of crude extracts. Discs impregnated with distilled water and methanol served as negative controls. Ciprofloxacin 10 µg/ml and Amphotericin-B 10 µmg/ml were used as standards for antibacterial and antifungal drugs. Antibacterial and antifungal activity for each extract was carried out by spreading 100 µl of inoculums of each test organism on the recommended specific medium, Muller Hinton and Sabourauds for bacterial and fungal isolates respectively. The filter discs containing each extract were aseptically placed on inoculated plates. The plates were allowed to stand for 10 minutes for the diffusion of extract to take place. The plates for antibacterial activity were incubated at 37°C for 24 hrs, while plates for antifungal activity were incubated at room temperature (25°C) for 48 hrs. The antibacterial and antifungal activity was determined from the formation of inhibition zones surrounding the disc containing the extract in millimeters using vernier calipers. The experiment was carried in triplicate and results expressed as mean inhibition zones (mm) ± standard error of three triplicate readings.

#### 2.5. Determination of Minimum Inhibitory Concentration (MIC) and Minimum Microbicidal Concentration (MMC)

To analyze for MIC and MMC the method described by Doughari (2006) was used. The MIC was carried out by transferring 0.5 ml different concentrations (3.9, 7.8, 15.6, 31.2, 62.4, 124.8 mg) of the extract to sterile bottles containing Nutrient Broth (NB) or Potato Dextrose Broth (PDB) for bacterial and fungal isolates respectively. Each of the test bacteria suspension matched at 0.5 MacFarland turbidity standard or the fungal isolates at  $10^6$  spores/ml was introduced into a corresponding tube containing 0.5ml reconstituted NB or PDB for bacteria or fungi respectively. A set

of bottles containing bacteria or fungi for each specific broth were used as controls. All the cultures were incubated at 37°C for 24 hrs (bacteria), or at room temperature (25°C), 48 hrs in the dark for fungal isolates. After incubation at the specified conditions, the bottles containing concentrations with no visible growth were considered as MIC. The MMC test was carried out by inoculating Muller Hinton Agar or Sabourauds dextrose Agar plates with a loopful of culture from tubes that had no visible growth. Plates were incubated again at the right temperature and time conditions and examined for growth. Any concentration that exhibited no growth was taken as the MMC.

### 2.6. Phytochemical Screening

The presence of tannins, alkaloids, anthraquinones, flavonoids, steroids, and saponins was carried out using methods applied by Ubulom (2011).

### 2.7. Statistical Analysis

Microsoft Excell<sup>R</sup> was used as the tool to enter and capture data. The data were subjected to SPSS 15.0 package for statistical analysis. The results for the agar diffusion method were presented as mean  $\pm$  standard error. Intra-group comparisons for the various methanolic *P. peruviana* concentration inhibitions zones were determined by One-way ANOVA, followed by a posthoc Bonferroni statistical tool.

### 2.8. Ethical Considerations

Permission to carry out the study was granted by the Kenya Medical Research Institute (KEMRI) Ethical and Scientific Steering Committees, Kenya.

## 3. Results and Discussion

### 3.1. Percentage Yield of *P. peruviana* Extracts

The percentage yields for the methanolic *P. peruviana* extracts ranged from 0.8 to 8.5% (Table 1). *Physalis peruviana* methanolic leaves extract had the highest percentage yield, while the lowest yield was recorded in the methanolic *P. peruviana* fruit extract at 0.8 %.

**Table 1:** Percentage yield of methanolic extracts of *P. peruviana*

Plant extract	Amount of ground part in (g)	The yield of extract (g)	% Yield of the extract
<b>MPPL</b>	40	3.4	8.5
<b>MPPS</b>	100	5	5
<b>MPPF</b>	40	0.4	0.8
<b>MPPR</b>	100	5	5

MPPL = methanolic leaves extract, MPPS = methanolic stem extract, MPPF = methanolic fruit extract, MPPR = methanolic root extract.

### 3.2. Antimicrobial Activity of Methanolic *P. peruviana* Extracts by Agar Diffusion Method

Results for agar diffusion test against test bacteria and fungi: Gram-negative bacteria (*Escherichia coli* ATCC 25922, *Klebsiella pneumonia* a local isolate, *Salmonella typhi* ATCC 700931 and *Pseudomonas aeruginosa* ATCC 27853); Gram-positive bacteria: (*Staphylococcus aureus* ATCC 25923 and *Bacillus cereus* ATCC 11778) and fungal isolates (*Candida albicans* ATCC 90028 and *Aspergillus flavus* a local isolate) using methanolic *P. peruviana* extracts are presented (Table 2). Except methanolic *P. peruviana* stem and fruit extracts that had no antibacterial activity to *Pseudomonas aeruginosa* ATCC 27853, the extracts exhibited various inhibitory effects to *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25923, *Klebsiella pneumonia* local isolate, *Salmonella typhi* ATCC 700931, *Pseudomonas aeruginosa* ATCC 27853, *Bacillus cereus* ATCC 11778, *Candida albicans* ATCC 90028, and *Aspergillus flavus* local isolate. The highest antibacterial and antifungal activity at 250 mg/ml was recorded from the methanolic leaves extracts in *Bacillus cereus* ATCC 11778 ( $9.0 \pm 0.06$  mm) and *Aspergillus flavus* local isolate ( $9.33 \pm 0.33$  mm) respectively, while the lowest antibacterial and antifungal activity was recorded from methanolic fruit extracts to *Staphylococcus aureus* ATCC 25923 ( $1.30 \pm 0.06$ ) and *Candida albicans* ATCC 90028 respectively.

Statistical analysis for intra-group inhibitory activity amongst various extract concentrations demonstrated significant differences ( $P < 0.05$ ). The antimicrobial activity increased with an increase in extract concentration.

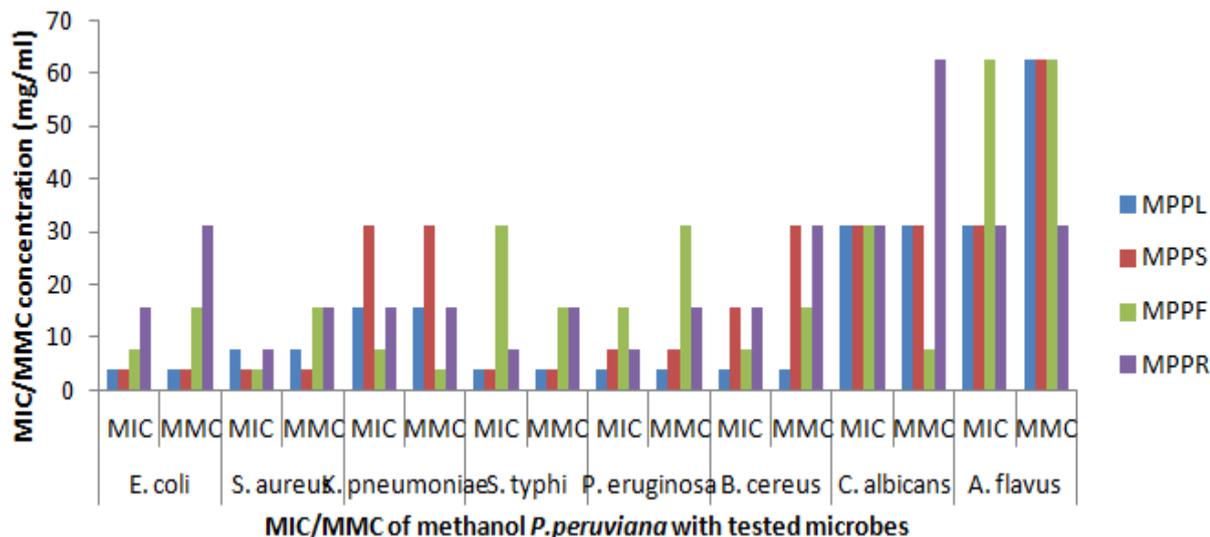
**Table 2:** Antimicrobial activity of methanolic *P. peruviana* extracts

Plant part/ Standard drug	Conc. (mg/ml)	<i>E. coli</i>	<i>S. aureus</i>	<i>K. pneumo</i>	<i>S. typhi</i>	<i>P. aeruginosa</i>	<i>B. cereus</i>	<i>C. albicans</i>	<i>A. flavus</i>	p- value
<b>MPPL</b>	31.25	2.17±0.03	3.20±0.10	2.00±0.00	-	-	3.10±0.06	4.10±0.06	4.20±0.06	0.00
	62.5	3.00±0.00	4.2±0.12	3.30±0.15	-	-	5.10±0.06	5.33±0.33	6.20±0.07	
	125	3.60±0.06	5.37±0.09	4.10±0.06	3.33±0.18	4.03±0.03	7.00±0.00	6.67±0.33	7.17±0.12	
	250	5.10±0.06	7.17±0.09	6.13±0.09	4.67±0.33	6.20±0.06	9.10±0.06	8.00±0.00	9.33±0.33	
<b>MPPS</b>	31.25	1.10±0.10	-	-	-	-	1.40±0.31	-	4.07±0.07	0.00
	62.5	2.13±0.13	-	-	-	-	2.33±0.18	2.20±0.12	5.00±0.00	
	125	3.07±0.07	-	2.10±0.06	1.73±0.37	-	3.33±0.18	4.13±0.13	5.40±0.00	
	250	4.00±0.00	1.57±0.78	4.03±0.03	2.33±0.18	-	4.00±0.00	6.17±0.12	6.47±0.29	
<b>MPPF</b>	31.25	-	-	-	-	-	2.07±0.07	-	-	0.00
	62.5	-	-	-	-	-	3.10±0.10	1.07±0.07	2.23±0.09	
	125	1.07±0.07	-	1.30±0.06	-	-	4.07±0.07	2.03±0.33	3.17±0.03	
	250	2.13±0.13	1.30±0.06	2.30±0.06	1.60±2.30	-	5.67±0.33	3.07±0.07	5.50±0.07	
<b>MPPR</b>	31.25	2.00±0.00	2.80±0.20	-	-	-	2.50±0.06	3.10±0.06	4.07±0.07	0.00
	62.5	3.33±0.03	4.27±0.13	3.03±0.03	-	-	5.10±0.10	6.20±0.12	4.67±0.18	
	125	4.03±0.03	5.03±0.03	4.13±0.09	-	3.87±0.13	6.73±1.33	6.67±0.33	6.20±0.07	
	250	5.00±0.00	7.00±0.00	6.00±0.00	4.03±0.03	5.47±0.09	9.30±0.15	8.20±0.06	9.10±0.07	
<b>Cipro</b>	10µg/ml	32.13±0.06	27.10±0.0	24.66±0.33	28.93±0.2	28.46±0.29	26.66±0.3	-	-	NA
<b>Amphot-B</b>	10µg/ml	-	-	-	-	-	-	29.10±0.05	29.33±0.33	NA

The values are expressed as mean inhibition zones (mm) ± SEM of three triplicate readings with ciprofloxacin and amphotericin B as reference standards, (-) sign indicates the extract had no antimicrobial activity against the test organism, NA = not applicable for the p-value. MPPL = methanolic leaves extract, MPPS = methanolic stem extract, MPPF = methanolic fruit extract, MPPR = methanolic root extract.

### 3.4. Minimum Inhibitory Concentration (MIC) and Minimum Microbicidal Concentration (MMC) of Methanolic *P. peruviana* Extracts against Test Bacteria and Fungi

*Physalis peruviana* methanolic extracts had MIC and MMC against the *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 25923, *Klebsiella pneumonia* local isolate, *Salmonella typhi* ATCC 700931, *Pseudomonas aeruginosa* ATCC 27853, *Bacillus cereus* ATCC 11778, *Candida albicans* ATCC 90028, and *Aspergillus flavus* local isolate ranged from 3.9 to 62.5 µg/ml. Methanol *P. peruviana* leaves extracts was the most potent against *E.coli*, *S.typhi*, *P.aeruginosa* and *B. cereus* with a MIC and an MMC of 3.9 mg/ml. The same potential was revealed by MPPS against *E. coli*, *S. aureus* and *S. typhi*, while MPPF exhibited the lowest activity to *A. flavus* with a MIC and an MMC of 62.5 mg/ml (Figure 1).



**Figure 1:** Minimum Inhibitory Concentration (MIC) and Minimum Microbicidal Concentration (MMC) of methanolic *P. peruviana* extracts to tested microbes

MPPL = methanol extracts of *P. peruviana* leaf; MPPS = methanol extracts of *P. peruviana* stem; MPPF = methanol extracts of *P. peruviana* fruit; MPPR = methanol extracts of *P. peruviana* root.

### 3.5. Phytochemical Components in Methanolic *P. peruviana* Extracts

Phytochemical analysis of methanolic *P. peruviana* leaves extracts revealed high concentrations of saponins and flavonoids, moderate alkaloids and traces of tannins. The methanolic *P. peruviana* stem extracts exhibited the presence of moderate saponins and flavonoids, while alkaloids were scarcely present. Methanolic *P. peruviana* fruit extracts only revealed saponins in trace amounts, while methanolic *P. peruviana* root extracts had trace amounts in tannins, saponins, and alkaloids. Steroids and anthraquinone were lacking in all methanolic *P. peruviana* extracts (Table 3).

**Table 3:** Phytochemical components of methanolic *P. peruviana* extracts

Plant extract	Phytochemical components					
	Tannins	Saponins	Steroids	Flavonoids	Alkaloids	Anthraquinone
MPPL	+	+++	-	+++	++	-
MPPS	-	++	-	++	+	-
MPPF	-	+	-	-	-	-
MPPR	+	+	-	-	+	-

MPPL = methanolic extracts of *P. peruviana* leaf; MPPS = methanolic extracts of *P. peruviana* stem; MPPF = methanolic extracts of *P. peruviana* fruit; MPPR = methanolic extracts of *P. peruviana* root. +++ (present in high concentration), ++ (moderately present), + (trace), - (absent)

The aim of this study was to assess the antibacterial, antifungal and phytochemical components of Kenyan *P. peruviana*.

The yield of methanolic *P. peruviana* extracts ranged from 0.8 – 8.5 % with leaf extracts exhibiting the highest yield and fruit extract having the lowest yield. It has been believed that the use of crude extracts as antimicrobial sources had potential success compared to the use of pure compounds from natural products (Ogila, 2011). Several studies revealed that *P. peruviana* possesses some antimicrobial activity (Maobe *et al.*, 2013; Jaca and Kambizi, 2011; Ferda and Zengin, 2013; Moshi *et al.*, 2012).

The agar disc diffusion assay revealed various inhibition zones to the bacterial and fungal isolates. The increasing order of activity that was dose-dependent was methanolic *P. peruviana* leaves, root, stem, and fruit extracts. At the highest dose of 250 mg/ml, the most sensitive bacteria isolate for methanolic leaves extract was *B. cereus* (9.10±0.06 mm), while the most sensitive fungal isolate was *A. flavus* (9.33±0.33 mm). In methanolic *P. peruviana* stem extract at 250 mg/ml, *K. pneumonia* emerged as the most sensitive bacteria isolate (4.03±0.03), while in the fungal category *A. flavus* was most sensitive (6.47±0.29 mm). *Pseudomonas aeruginosa* was found to be resistant to methanolic *P. peruviana* stem and fruit extracts. The standard drugs (Ciprofloxacin and amphotericin B) exhibited higher zones of inhibition to tested bacterial and fungal isolates respectively compared to *P. peruviana* extracts. Statistical analysis for intra-group inhibition zones amongst various *P. peruviana* extract concentrations demonstrated significant differences ( $P < 0.05$ ).

These results are in agreement with a study carried out on *P. peruviana* leaves extract (Jaca and Kambizi, 2011) in that *Bacillus subtilis*, *micrococcus kristinae*, *Staphylococcus aureus* ATCC 25923, *Proteus vulgaris* and *Serratia marcescens* were susceptible. Essential oils from *Physalis angulata* L a related plant species to *P. peruviana* was reported to exhibit antimicrobial activity against *Bacillus cereus*, *Klebsiella pneumonia*, while the aerial parts were active against *Candida albicans*, *Candida stellatoidea* and *Candida turulopsis* (Osho *et al.*, 2010). The inhibition zones demonstrated in this study concur the claim that inhibition zone diameters are dependent on bacterial strain and species used (Abubakar, 2010).

The minimum inhibitory concentration (MIC) and minimum microbicidal concentration (MMC) values are used as a measure of treatment outcomes of antimicrobial agents. *Physalis peruviana* methanolic extracts had MIC and MMC against test microbes ranging from 3.9 to 62.5 mg/ml. Methanolic *P. peruviana* leaves extracts were most potent against *E. coli*, *S. typhi*, *P. aeruginosa* and *B. cereus* with a MIC and an MMC of 3.9 mg/ml. Methanolic *P. peruviana* stem extracts revealed a similar potential of 3.9 mg/ml MIC and an MMC to *E. coli*, *S. aureus*, and *S. typhi*, while methanolic *P. peruviana* fruits extracts exhibited the lowest activity to *A. flavus* with a MIC and

an MMC of 62.5 mg/ml. MIC and MMC values are used to assess the treatment outcomes of antimicrobial agents. The current study is in agreement with that of (Abubakar 2010; Doughari 2010) in that MIC and MMC are associated with low MIC and MMC values resulting in higher activity of test microbes. This study concurs with a study carried out by Ogila *et al.* (2010) in that gram-positive bacteria in agar diffusion assay tends to be more sensitive to the methanolic extracts revealed by inhibition zones of *B. cereus* and *S. aureus* compared to gram-negative bacteria tested. Higher sensitivity to gram-positive bacteria could be attributed to possession of a less complex cell wall in gram-positive bacteria and that they are also devoid of the natural sieve effect due to small pores in their cell envelopes compared to gram-negative bacteria that possess a multilayered structure covered by an outer cell membrane (Ogila *et al.*, 2010).

Plant extracts have been found to contain phytochemicals that possess curative effects on microbial infections (Shakya, 2016). The current study revealed the presence of tannins in methanolic *P. peruviana* leaves and root extracts. Saponins were revealed in all *P. peruviana* methanolic extracts, while flavonoids were present in leaves and stem extracts. Alkaloids were isolated from leaves, stem and root methanolic *P. peruviana* extracts. Flavonoids are claimed to possess curative properties to a wide range of microbial infections (Cowan, 1999), while corticosteroids have been associated with the treatment of immune-mediated ailments such as psoriasis (Uva *et al.*, 2012). The antimicrobial effects of *P. peruviana* methanolic extracts in this study could probably be associated with the phytochemicals isolated.

The methanolic *P. peruviana* leaves and root extracts emerged as the most inhibitory extracts against the test bacterial and fungal isolates. An attempt to purify the extracts and subject them to a wider range of microorganisms could lead to the discovery of noble compounds that can be used to combat microbial infections.

#### 4. Conclusions

The methanolic *P. peruviana* leaves, stem, fruits, and roots extracts exhibited antibacterial and antifungal activity. Presence of phytochemicals isolated could have contributed to the antimicrobial activity of the *P. peruviana* extracts. This suggests that *P. peruviana* could be used to treat infections caused by those bacterial agents. Further studies on *P. peruviana* extracts should be carried out to investigate their probable anti-viral and anti-tumor potential at this era when HIV and cancer remain devastating diseases without cure globally.

#### Potential Conflicts of Interest

The authors declare no conflict of interest.

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## References

- Abubakar EM. (2010). Antibacterial potential of crude leaf extracts of *Eucalyptus camaldulensis* against some pathogenic bacteria. *AJPS*, 4(6): 202–209.
- Cowan MM. (1999). Plant products as antimicrobial agents. *Clin Microbiol Rev*, 12(4): 564–582.
- Doughari JH (2006). Antimicrobial activity of Tamarindus indica Linn. *Trop J Pharm Res*, 5(2): 597–603.
- Doughari JH. (2010). Evaluation of antimicrobial potentials of stem bark extracts of *Erythrina senegalensis* DC. *Afri J Microbiol Res*, 4(17): 1836–1841. Retrieved from <http://www.academicjournals.org/ajmr>
- Ferda G and Zengin F. (2013). The antimicrobial activity of *Physalis peruviana* L. *Bitlis Eren University Journal Science and Technology*, 3: 15–17.
- Jaca TP and Kambizi L. (2011). Antibacterial properties of some wild leafy vegetables of the Eastern Cape Province, South Africa. *J Med Plant Res*, 5(13): 2624–2628.
- Kimang'a A, Gikunju J, Kariuki D and Ogutu M. (2016). Safety and analgesic properties of ethanolic extracts of *Toddalia asiatica* (L) Lam. (Rutaceae) used for central and peripheral pain management among the East African ethnic communities. *Ethiop J Health Sci*. 26(1): 55–56.
- Maobe M A G, Gitu L, and Gatebe E, “et al” .(2013). Antimicrobial activities of eight selected medicinal herbs used for the treatment of diabetes, malaria, and pneumonia in the Kisii region, southwest Kenya. *Global J. Pharmacol*, 7(1): 25–33.  
<http://doi.org/10.5829/idosi.gjp.2013.7.1.65133>
- Moriconi DN, Rush MC and Flores H. (1990). *Tomatillo: A potential vegetable crop for Louisiana*. (pp. 407-413). In: *Advances in new crops*. (Janic, J. & Simon, J.E. eds). Timber Press, Portland. The USA.
- Moshi MJ, Otieno DF and Weisheit A. (2012). Ethnomedicine of the Kagera Region, north-western Tanzania. Part 3 : plants used in traditional medicine in Kikuku village, Muleba District. *J Ethnobiol Ethnomed*, 8(1): 14. <http://doi.org/10.1186/1746-4269-8-14>.
- Ogila KO, Ng'ang'a Z, Shililu J and Gachuhi K. (2010). Antibacterial and antifungal activity of

aqueous extracts of *Asparagus setaceus kuth* and *Caesalpinia volkensii harm*. *Int J Biol Sci*, 2(1): 1–6.

Ogila KO. (2011). Antimicrobial and immunomodulatory properties of extracts of *Asparagus setaceus Kunth and Caesalpinia volkensii Harm*. Jomo Kenyatta University of Agriculture and Technology. (Unpublished dissertation), Nairobi, Kenya.

Osho A, Adetunji T, Fayemi SO and Moronkola DO. (2010). Antimicrobial activity of essential oils of *Physalis Angulata L*. *Afr. J. Tradit Complement Altern Med*, 7(4): 303–306.

Redda YT, Kebede E, Cruz C, Gugsu G, Awol and Mangetse B. (2014). Potential Antibacterial Activity of Crude Extracts from *Aloe vera*, *Zingiber officinale*, and *Vinca major* Medicinal Plants. *Int J Microbiol Res*, 5(3): 202–207.

Sasidharan S, Chen Y, Saravanan D, Sundram K and Latha YL. (2011). Extraction, isolation, and characterization of bioactive compounds from plants' extracts. *Afri J Tradit Complement Altern Med*, 8(1): 1–10.

Shakya AK. (2016). Medicinal plants : *Future source of new drugs*, 4(4): 59–64.

Ubulom P, Akpabio E, Ejikeme C and Mbon R. (2011). Antifungal activity of aqueous and ethanolic extracts of *Picralima nitida* seeds on *Aspergillus flavus*, *Candida Albicans*, and *Microsporum Canis*. *J Res Pharm. Biotech*, 3(5): 57–60.

Uva L, Miguel D, Pinheiro C. (2012). Mechanisms of action of topical corticosteroids in Psoriasis. *Int J Endocrinol*, 1(1): 1–16. DOI: 10.1155/2012/561018