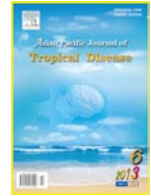




Contents lists available at ScienceDirect

## Asian Pacific Journal of Tropical Disease

journal homepage: [www.elsevier.com/locate/apjtd](http://www.elsevier.com/locate/apjtd)

Document heading

doi:10.1016/S2222-1808(13)60104-8

© 2013 by the Asian Pacific Journal of Tropical Disease. All rights reserved.

# Phytochemical screening, antioxidants and antimicrobial potential of *Lantana camara* in different solvents

Rabia Naz, Asghari Bano\*

Department of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan

## PEER REVIEW

## Peer reviewer

Diego Alejandro Sampietro, Assistant Professor, Phytochemistry and Plant Biotechnology, National University of Tucumán, Argentina.

E-mail: [dasampietro2006@yahoo.com.ar](mailto:dasampietro2006@yahoo.com.ar)

## Comments

This is a good study in which the authors evaluated the antimicrobial potential of *L. camara* leaf extracts in different solvents and also analyzed the antioxidant and phytochemicals in leaves. The results are interesting and suggest the presence of potential phytochemicals, antioxidants and active compounds which could be identified and thus, find its way into the antimicrobial drugs.

Details on Page 485

## ABSTRACT

**Objective:** To evaluate the antioxidant activity, hydrogen peroxide radicals scavenging activity, reducing power, the total phenolic and flavonoids contents, and antimicrobial and antifungal activities of methanol, ethanol and water extracts of leaves of *Lantana camara* (*L. camara*).

**Methods:** Methanol, ethanol and water extracts were evaluated against four Gram positive and Gram negative bacterial isolates (*Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Bacillus subtilis*) and two fungal strains (*Aspergillus fumigatus* and *Aspergillus flavus*). Methanol extract at different concentrations was tested for antioxidant potential and phytochemicals were determined by using spectrophotometric method.

**Results:** The total phenolic content was (40.859±0.017) mg gallic acid/g in the leaves of *L. camara*, while the total flavonoids was (53.112±0.199) mg/g dry weight. Methanol leaf extract of *L. camara* showed maximum antibacterial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa* and was also effective against other bacterial strains as compared to ethanol and aqueous extracts of leaves. The methanol leaf extract of *L. camara* exhibited significant inhibition (71%) and (66%) against *Aspergillus fumigatus* and *Aspergillus flavus* respectively.

**Conclusions:** The methanol extract of the *L. camara* leaves is effective against selected bacterial and fungal strains. Its phytochemical contents have broad antimicrobial properties and the plant might be a novel source of antimicrobial drug.

## KEYWORDS

MIC, Antioxidants, Phytochemicals, Antimicrobial, *Lantana camara*

## 1. Introduction

Resistance to antimicrobial agents is a major global public health problem[1]. Infectious diseases account for approximately one-half of all death in tropics. Despite the progress made in the understanding of microorganisms and their control in industrialized nations, incidents due to drug resistant microorganisms and the emergence of unknown disease causing microbes, posed enormous public health concern[2]. *Streptococcus pyogenes*, *Staphylococcus aureus* and *Streptococcus pneumoniae*, the organisms that causes respiratory and cutaneous infection, as well as *Pseudomonas* and members of *Enterobacteriaceae*, causing diarrhea and

urinary tract infections and sepsis, are now resistant to virtually all of the known antibiotics[3]. This resistance is largely due to indiscriminate use of antimicrobial drugs commonly used for the treatment of infectious diseases[4]. Furthermore some antibiotics have serious undesirable side effect which limit their application, so there is serious need to develop new antimicrobial agents that are very effective with minimal unwanted side effect. Plants represent a potential source of novel antibiotic prototypes[5].

*Lantana camara* (*L. camara*) is mainly used as a herbal medicine and in some areas as firewood and mulch[6]. It is also used for the treatment of cancers, chicken pox, measles, asthma, ulcers, swellings, eczema, tumors, high

\*Corresponding author: Asghari Bano, Department of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan.

Tel: +92 51 9064 3096

Fax: +92 51 90643138

E-mail: [banoasghari@gmail.com](mailto:banoasghari@gmail.com)

Foundation Project: Supported by the Higher Education Commission (HEC) of Pakistan. The personal identification number (PIN) for this financial support/scholarship is 0 74-0998-Av4-036.

Article history:

Received 23 Sep 2013

Received in revised form 31 Sep, 2nd revised form 2 Oct, 3rd revised form 20 Oct 2013

Accepted 23 Nov 2013

Available online 28 Dec 2013

blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism, malaria and atoxy of abdominal visceral[7]. Extracts from the leaves exhibit antimicrobial, insecticidal and nematocidal activity and also contain verbascoside, which possesses antimicrobial, immunosuppressive and antitumor activities[8]. Several previous reports have described antifungal, anti proliferative and antimicrobial activities of *L. camara*[9–13]. The present study aims to investigate the phytochemicals, free radical scavenging activities and antimicrobial potential of leaves extract of the commonly used medicinal plant *L. camara*.

## 2. Materials and methods

### 2.1. Plant materials

Fresh leaves of *L. camara* were collected from Margalla Hills of Quaid-i-Azam University Islamabad, Pakistan. The plants were identified by the National Herbarium, Department of Plant Sciences, Quaid-i-Azam University Islamabad.

### 2.2. Processing of the plant material

Plant leaves were washed thoroughly with distilled water. The leaves were dried under shade at room temperature. The dried leaves of *L. camara* were finely grinded using electrical grinder and stored in air tight containers for further use. A total of 250 g of the pulverized plant material was extracted for 4 d in methanol, ethanol and sterile water[14]. The separated extracts were then filtered through Whatman’s No. 1 filter paper and the methanol and ethanol filtrate were then separately condensed to dryness using rotary evaporator. The thick extracted mass was then dried at room temperature. Dried extract was collected in an air tight container and stored at 4 °C for further analysis.

### 2.3. Chemicals

1,1-diphenyl-2-picryl-hydrazyl (DPPH), methanol, ferric chloride, chloroform, H<sub>2</sub>SO<sub>4</sub>, HCl, benzene, NH<sub>4</sub>OH, potassium ferro-cyanide, sodium chloride, ethanol, Folin-Ciocalteu, Na<sub>2</sub>CO<sub>3</sub>, gallic acid, hydrogen peroxide and ascorbic acid were obtained from Sigma Chemical Co. (St. Louis, MO, USA).

### 2.4. DPPH radical scavenging activity

The antioxidant activity was assessed in DPPH radical scavenging system using gallic acid and ascorbic acid as a positive control, and the decrease in absorbance was determined at 517 nm in a spectrophotometer (HITACHI Model: U-1100 573 × 415)[15–17].

$$\text{DPPH scavenging effect (\%)} = 1 - \frac{A_0 - A_1}{A_0} \times 100$$

Where A<sub>0</sub> was the absorbance of the control reaction and A<sub>1</sub> was the absorbance in the presence of the sample[18].

### 2.5. Hydrogen peroxide–scavenging activity

The ability of the extracts to scavenge hydrogen peroxide was determined according to the method of Ruch *et al*[19]. Absorbance of the hydrogen peroxide activity was recorded at 230 nm in a spectrophotometer (HITACHI Model: U-1100 573 × 415). Hydrogen peroxide scavenging ability (in triplicate) was calculated by following equation:

$$\text{Hydrogen peroxide scavenging activity (\%)} = 1 - A_1/A_0 \times 100$$

A<sub>0</sub> was the absorbance of the control and A<sub>1</sub> was the absorbance of the sample.

### 2.6. Reducing power assay

The reducing powers of the extracts were determined according to the method described by Chung *et al*[20]. The extract which have reduction potential, react with potassium ferricyanide (Fe<sup>3+</sup>) to form potassium ferrocyanide (Fe<sup>2+</sup>), which then reacts with ferric chloride to form ferric ferrous complex that has an absorption maximum at 700 nm in a spectrophotometer (HITACHI Model: U-1100 573 × 415).

Potassium ferricyanide + Ferric chloride potassium  
Antioxidant → Ferrocyanide + Ferrous chloride

### 2.7. Preliminary phytochemical screening

Phytochemical screening of the *L. camara* was performed to detect the presence of different classes of constituents, such as alkaloids, phenolics, flavonoids, tannin, saponins, terpenes, phlobatannins and coumarins[21,22].

### 2.8. Quantitative analysis of phytochemicals

#### 2.8.1. Total phenolic contents (TPC)

TPC of *L. camara* were determined by the Folin-Ciocalteu colorimetric method using gallic acid as a standard, and the absorbance was measured at 765 nm in a spectrophotometer (HITACHI Model: U-1100 573 × 415). Results were expressed as gallic acid equivalent (GAE) mg/g of dried extract. Data for plant extract was recorded in triplicate[15,23].

#### 2.8.2. Determination of the total flavonoids content

Total flavonoids content was determined according to the protocol of Sakanaka *et al*[24]. The absorbance was measured immediately at 510 nm in a spectrophotometer (HITACHI Model: U-1100 573 × 415). Flavonoids were estimated as mg/g of dried fraction. All samples were run in triplicate.

#### 2.8.3. Determination of total tannins

Tannin content was determined by using Van-Burden and Robinson WC method[25]. Absorbance at 120 nm was recorded in a spectrophotometer (HITACHI Model: U-1100 573 × 415) within 10 min and tannins contents were expressed as mg/g of the dried fraction.

## 2.9. Test microorganism

The test microorganisms used in this investigation included bacteria *Staphylococcus aureus* ATCC 6538 (*S. aureus*), *Pseudomonas aeruginosa* ATCC 7221 (*P. aeruginosa*), *Klebsiella pneumoniae* (*K. pneumoniae*) and *Bacillus subtilis* ATCC 6059 (*B. subtilis*); and fungi *Aspergillus fumigatus* (*A. fumigatus*) and *Aspergillus flavus* (*A. flavus*). The bacterial isolates were first sub cultured in a nutrient broth (SIGMA) and incubated at 37 °C for 18 h, while the fungal isolates were sub cultured on a Sabouraud dextrose agar (MERCK) for 72 h at 25 °C.

## 2.10. Positive and negative control

Penicillin (1 mg/mL) was used as positive control for the test bacterial strains. Sterilized distilled water and dimethyl sulfoxide were used as negative control.

## 2.11. Antibacterial activity

Antibacterial activity of the methanol, ethanol and aqueous extract of *L. camara* leaf extract was determined by using the agar–well diffusion method[26]. The bacterial strains were first cultured in a nutrient broth for 18 h prior to use and standardized to 0.5 McFarland standards ( $10^6$  CFU/mL).

Nutrient agar medium was prepared by adding nutrient agar 2.3 g in 100 mL of distilled water; pH was adjusted at 7.0 and was autoclaved. It was allowed to cool up to 45 °C. Petri plates were prepared by pouring 75 mL of seeded nutrient agar and allowed to solidify. Wells were bored into the agar using a sterile 6 mm diameter cork borer. Approximately 100  $\mu$ L of the crude extract at 12 mg/mL were added into the wells, allowed to stand at room temperature for about 2 h and incubated at 37 °C. Controls were set in parallel in which case the respective solvents were used to fill the well. The plates were observed for zones of inhibition after 24 h. The effects were compared with those of penicillin at a concentration of 1 mg/mL.

## 2.12. Determination of relative percentage inhibition

The relative percentage inhibition of the test plant extract with respect to positive control was calculated by using the following formula[27].

$$\text{Relative percentage inhibition of the test extract} = \frac{100 \times (X - Y)}{Z - Y}$$

Where, X is total area of inhibition of the test extract, Y is total area of inhibition of the solvent, and Z represents total area of inhibition of the standard drug. The total area of the inhibition was calculated by using area =  $\pi r^2$ ; where, r=radius of zone of inhibition.

## 2.13. Assay for antifungal activity

The agar tube dilution method was used for the determination of antifungal activity of *L. camara* leaves extract in different solvents[28]. The samples were prepared by dissolving 12 mg extract in 1 mL of dimethyl sulfoxide. Culture media was

prepared by dissolving 6.5 g of Sabouraud dextrose agar (MERCK) per 100 mL distilled water (pH 5.6). The 10 mL of Sabouraud dextrose agar was dispensed in screw capped tubes or cotton plugged test tubes and was autoclaved at 121 °C for 21 min. Tubes were allowed to cool at 50 °C and Sabouraud dextrose agar was loaded with 67  $\mu$ L of extract pipetted from the stock solution. The tubes containing the media were then allowed to solidify in slanting position at room temperature. Three slants of the extract sample were prepared for fungus species. The tubes containing solidified media and plant extract were inoculated with 4 mm diameter piece of inoculum, taken from seven days old culture of fungus. One test tube of each extract was prepared, used as positive control. Slants without extract were used as negative control. The test tubes were incubated at 28 °C for 7 d. Cultures were examined twice weekly during the incubation. Reading was taken by measuring the linear length (mm) of fungus in slant and growth inhibition was calculated with reference to negative control.

Percentage inhibition of fungal growth for each concentration of compound was determined as

$$\% \text{ inhibition of fungal growth} = 1 - \frac{\text{Linear growth in test}}{\text{Linear growth in control}} \times 100$$

## 3. Results

### 3.1. DPPH radical–scavenging activity

Results shown in Table 1 indicates the relative activities against ascorbic acid and butylated hydroxytoluene (BHT). The activity of 0.8 mg/mL BHT was the highest followed by ascorbic acid and *L. camara* leaf extracts respectively. Leaves extracts of the plant quenched DPPH in a dose dependent manner: [ $R^2=0.9837$ ] for *L. camara* against the control (ascorbic acid and BHT).

**Table 1**

Analysis of DPPH radical scavenging activity of leaf extracts of *L. camara*.

Plant and drugs (mg/mL)	% inhibition $\pm$ SD	Logarithm equation	IC <sub>50</sub> (mg/mL)	
<i>L. camara</i>	0.2	45.00 $\pm$ 0.47	y=19.871ln(x)+43.994 $R^2=0.9837$	$\geq 0.2$
	0.4	56.17 $\pm$ 0.41		
	0.6	64.83 $\pm$ 0.44		
	0.8	73.13 $\pm$ 0.42		
Ascorbic acid	0.2	61.40 $\pm$ 0.57	y=15.853ln(x)+61.372 $R^2=0.9999$	$\leq 0.2$
	0.4	72.37 $\pm$ 0.30		
	0.6	78.63 $\pm$ 0.40		
	0.8	83.47 $\pm$ 0.46		
Gallic acid	0.2	70.43 $\pm$ 0.50	y=14.029ln(x)+69.801 $R^2=0.9795$	$\leq 0.2$
	0.4	78.80 $\pm$ 0.40		
	0.6	83.93 $\pm$ 0.38		
	0.8	90.63 $\pm$ 0.55		

### 3.2. Hydroxyl radical–scavenging activity

The scavenging abilities of selected plant leaves fraction extracts on hydroxyl radical inhibition by the 2–deoxyribose

oxidation method are shown in Table 2. The results are indicated as the inhibition rate. Leaf extract of *L. camara* showed good hydroxyl radical scavenging activities (45%–73%) at a concentration of 0.2–0.8 mg/mL in the reaction mixture. Leaf extract showing hydroxyl radical–scavenging activity was increased with increasing concentration of the extract sample. Leaf fraction of *L. camara* had higher activity but lower than that of ascorbic acid and BHT (Table 2).

**Table 2**

Analysis of hydroxyl radical scavenging activity of leaf extracts of *L. camara*.

Plant and drugs (mg/mL)	% inhibition±SD	Logarithm equation	IC <sub>50</sub> (mg/mL)
<i>L. camara</i>	0.2		≤ 0.2
	0.4	y=16.365ln(x)+54.281 R <sup>2</sup> =0.987 4	
	0.6		
	0.8		
Ascorbic acid	0.2		67.40±0.47
	0.4	82.37±0.20	y=18.224ln(x)+67.989 R <sup>2</sup> =0.985 3
	0.6	86.63±0.75	
	0.8	93.47±0.46	
Gallic acid	0.2	79.77±0.42	
	0.4	85.13±0.33	y=12.587ln(x)+78.234 R <sup>2</sup> =0.870 9
	0.6	89.07±0.23	
	0.8	98.97±0.37	

### 3.3. Reducing power

The reducing power of the selected plant leaf extract increased with increase in concentration. At 0.8 mg/mL concentration, the leaves extracts of *L. camara* showed absorbance of 0.888 (Table 3). Thus, the plant leaves extracts exhibited a lower reducing ability than the standard. Also, the reducing ability was found to be the concentration dependent. With increasing concentration, the reducing ability of all the leaves extracts was found to increase. In this case, at 0.8 mg/mL, the reducing power was found to be at maximum value.

**Table 3**

Analysis of reducing power ability of leaf extracts of *L. camara*.

Plant and drugs (mg/mL)	% inhibition± SD	Logarithm equation	IC <sub>50</sub> (mg/mL)
<i>L. camara</i>	0.2		≤0.2
	0.4	y=0.1055ln(x)+0.701 4 R <sup>2</sup> =0.757 8	
	0.6		
	0.8		
Ascorbic acid	0.2		0.815±0.006
	0.4	0.843±0.004	y=0.1485ln(x)+0.7812 R <sup>2</sup> =0.668 2
	0.6	0.881±0.003	
	0.8	1.058±0.06	
Gallic acid	0.2	0.856±0.006	
	0.4	0.878±0.002	y=0.3147ln(x)+0.772 2 R <sup>2</sup> =0.628 7
	0.6	0.985±0.002	
	0.8	1.370±0.006	

### 3.4. Qualitative analysis of phytochemicals

Results of phytochemical screening presented in Table 4 reveals moderate concentration of alkaloids, phenolics, flavonoids, tannin, saponin, terpenoids, phlobetanin and coumarine.

**Table 4**

Qualitative phytochemical analysis of leaf extracts of *L. camara*.

Constituents	Presence	
Alkaloids	Dragondorff's test	–
	Mayer's test	+++
Phenolic		+++
Flavonoids		+++
Tannin		++
Saponin		++
Terpenoids		–
Phlobetanin		–
Coumarin		–

+++ : Strongly positive, ++ : Moderately positive, + : Weakly positive, – : Negative.

### 3.5. Quantitative analysis of phytochemicals

#### 3.5.1. TPC

TPC was determined in comparison with standard gallic acid and the results were expressed in terms of mg GAE/g dry sample of plant. TPC values for *L. camara* was (40.859±0.017) as mg GAE/g dry sample.

#### 3.5.2. Total flavonoid content

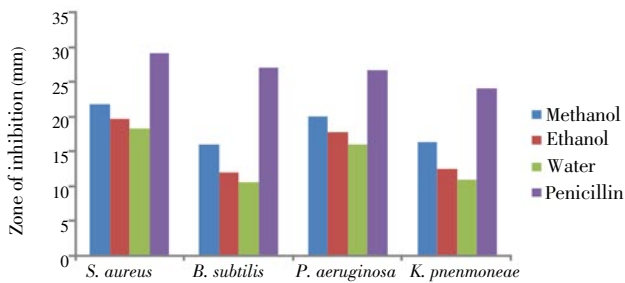
Total flavonoid content was determined in comparison with standard rutin and the results expressed in terms of mg RU/g of dry sample of plant. Total flavonoid content values for *L. camara* (53.112±0.199) was mg RU/g dry sample.

#### 3.5.3. Estimation of tannin

The results of total tannin were presented in Table 5. The amount of tannin for *L. camara* (0.860±0.038) mg/g of the dried fraction in dry sample.

### 3.6. Antibacterial activity

The antibacterial activity of methanol, ethanol crude extracts and water extracts of leaves of *L. camara* was investigated against two gram positive (*B. subtilis* and *S. aureus*) and two gram negative (*P. aeruginosa* and *K. pneumoniae*) bacterial strains (Figure 1). The methanol and ethanol extracts of *L. camara* exhibited the maximum zone of inhibition 21.7 mm and 19.7 mm against gram positive strain *S. aureus* and 20 mm and 17.7 mm zone of inhibition against gram negative strain *P. aeruginosa* and showed minimum antibacterial activity against *B. subtilis* and *K. pneumoniae*. The results revealed that aqueous leaf extracts of *L. camara* has minimum antibacterial activity against four bacterial strains as compared to methanol and ethanol solvents.

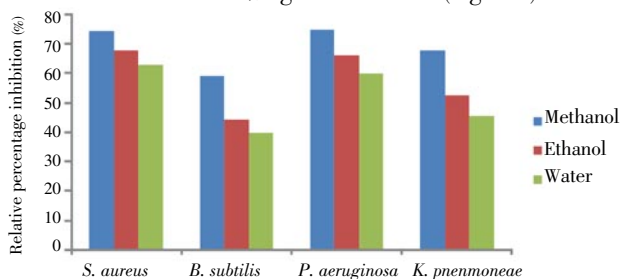


**Figure 1.** Antibacterial activities profile of methanol, ethanol and water extracts from leaves tissue of *L. camara*.

### 3.7. Relative percentage inhibition

The standard drug (Penicillin) was used to determine the relative percentage inhibition of antibacterial activity of *L. camara* leaves extract in different solvents.

Methanol leaf extract of *L. camara* exhibited maximum relative percentage inhibition (74.9% and 74.8% respectively) against *P. aeruginosa* and *S. aureus*, while minimum percentage inhibition was recorded against *B. subtilis*. Ethanol leaf extract of *L. camara* showed maximum relative percentage inhibition (67.9%) against *S. aureus*, while water leaf extract showed maximum inhibition of 63% against *S. aureus* (Figure 2).



**Figure 2.** Determination of relative percentage inhibition of methanol, ethanol and water extracts from leaves tissue of *L. camara* compared to standard antibiotics.

### 3.8. Minimum inhibitory concentration (MIC)

Results showed in Table 5 revealed the MIC of methanol, ethanol and water extracts of *L. camara*. MIC values of methanol extract of *L. camara* ranged between 5–8 mg/mL, ethanol 6.5–12 mg/mL and MIC of water leaf extract was recorded 8 mg/mL and 10 mg/mL against *S. aureus* and *P. aeruginosa*, while MIC was not determined against *B. subtilis* and *K. pneumoniae*. MIC range of penicillin (standard drug) was recorded between 0.05–0.25 against four bacterial strains.

**Table 5**

MIC values of methanol, ethanol and water extracts from leaves tissue of *L. camara*.

Test bacteria	MIC (mg/mL)			Penicillin mg/mL
	Methanol mg/mL	Ethanol mg/mL	Water mg/mL	
<i>S. aureus</i>	5.0	6.5	8.0	0.05
<i>B. subtilis</i>	8.0	10.0	nd	0.20
<i>P. aeruginosa</i>	5.0	8.0	10.0	0.05
<i>K. pneumoniae</i>	8.0	12.0	nd	0.25

PC: Penicillin, nd: Not determined.

### 3.9. Antifungal activity

Antifungal activity of methanol and water leaf extracts of *L. camara* was investigated against two fungal strains viz. *A. fumigatus* and *A. flavus* (Table 6). Methanol leaf extract of *L. camara* showed 71.4% and 66.4%, while water extract showed 61.5% and 57.8% inhibition against *A. fumigatus* and *A. flavus* respectively (Table 6).

**Table 6**

Antifungal activity of methanol and aqueous extracts from leaves tissue of *L. camara*.

Test fungi	Linear growth (cm)		Percentage inhibition (%)	
	Methanol	Water	Methanol	Water
<i>A. fumigatus</i>	2.8	4.0	71.4	61.5
Control	9.8	10.3	–	–
<i>A. flavus</i>	3.33	4.3	66.4	57.8
Control	9.9	10.2	–	–

## 4. Discussion

From the present study the maximum radical scavenging and antimicrobial activities of methanol extract of leaves of *L. camara* was investigated.

The phytochemical compositions of *L. camara* reported previously<sup>[29]</sup>. With regards to reducing power, higher reducing activities can be attributed to higher amounts of polyphenolics and the reducing capacity of a compound may reflect its antioxidant potential<sup>[30]</sup>. It has been reported that the reducing properties are generally associated with the presence of reductones, which have been shown to exert antioxidant action by breaking the free radical chain by donating a hydrogen atom<sup>[31]</sup>.

*L. camara* has been studied extensively for their antibacterial properties. *L. camara* possess many important biological activities viz., antipyretic, antimicrobial, antimutagenic, antimicrobial, fungicidal, insecticidal, nematicidal and others<sup>[29]</sup>. Lantadenes which present in all *L. camara* is believed to be responsible for almost all the biological activities. In addition, other secondary metabolites such as alkaloids, terpenoids, and phenolics could be held partially responsible for some of these biological activities<sup>[32]</sup>.

Therefore, antibacterial activities of *L. camara* leaf and flower extracts might be due to the presence of some of these chemical constituents particularly lantadenes and thesaside in the extracts. The presence of phenolics, anthocyanins and proanthocyanidins in *L. camara* leaves which could also be responsible for the antibacterial properties of the *L. camara* have been documented<sup>[33]</sup>.

Antimicrobial activity of different plant extracts on phytopathogenic bacteria was studied and reported by other workers<sup>[34]</sup>. The methanol leaf extracts of various medicinal plants showed significant antibacterial and antifungal activity against *A. flavus*, *Dreschlera turcica* and *Fusarium verticillioides*

have been reported<sup>[35]</sup>. Methanolic extracts of root and shoots of the herb *Heracleum candicans* wall (Apiaceae), showed antifungal effect against *Pythium* and *Aspergillus* species<sup>[36]</sup>.

The value of medicinal plants lies in phytochemical constituents that cause definite pharmacological action on the human body<sup>[37]</sup>. The plants are the vital source of innumerable number of antimicrobial compounds. Several phytoconstituents like flavonoids, phenolics and polyphenols, tannins, terpenoids, sesquiterpenes *etc.*, are effective antimicrobial substances against a wide range of microorganisms<sup>[37]</sup>.

The study showed that the methanol leaf extract of *L. camara* had more antimicrobial potential than ethanol and water extract. The antimicrobial activity of *L. camara* may be attributed to the various phytochemical constituents present in the crude extract. The purified compounds may have even more effectiveness with respect to inhibition of bacterial and fungal strains. The work carried was a basic approach to find out the antimicrobial activity of *L. camara* in different solvents. We therefore suggest more work should be required to isolate, identify and characterized the active components and also possibly their mechanism of biological action and thus, find its way into the arsenal of antimicrobial drugs.

### Conflict of interest statement

We declare that we have no conflict of interest.

### Acknowledgements

The authors would like to thank the Higher Education Commission (HEC) of Pakistan for providing the necessary financial support for the study. The personal identification number (PIN) for getting this financial support/scholarship from HEC is 0 74–0998–Av4–036.

---

### Comments

#### Background

Plants have been used to treat a variety of ailments and the introduction of orthodox medicine did not affect their use. *L. camara* belongs to Verbenaceae family and is reported to be used in traditional medicine system for the treatment of itches, ulcers, cuts, swellings, eczema, bilious fever and cataract. The literature reported that different parts of the plants are used in the treatment of cold, whooping cough, bronchitis, chicken pox and eye injuries.

#### Research frontiers

Research was performed on leaves of *L. camara* in different solvents to determine the most efficient solvent system against microbial infections. The leaf extract in three different solvents have been studied against both Gram

negative and Gram positive bacterial strains and also against two fungal species (*A. fumigatus* and *A. flavus*). Antioxidants and phytochemical screening of *L. camara* leaves have also been studied.

#### Related reports

Our results of efficient methanol extract are in agreement with the previous work which showed that in plants most of the compounds having antimicrobial potential (Verma *et al.*, 2006). Methanol leaf extract is more effective against pathogenic bacterial strains than ethanol or water extracts (Naz *et al.*, 2011). Previous studies using extracts from *Lantana* species showed that they were able to inhibit the growth of Gram-positive bacteria strains (Júnior *et al.*, 2005).

#### Innovations & breakthroughs

Data regarding potential of leaf extract of *L. camara* against Gram positive and Gram negative bacterial strains, against fungal *Aspergillus* species in different solvents and also about antioxidants and phytochemicals is scarce. This study has shown that methanol leaf extract had a significant higher antimicrobial potential than ethanol and water leaf extracts.

#### Applications

The present study indicated that the antibacterial and antifungal activities vary with the different solvents of plant leaf material used. *L. camara* was effective even at low concentration against bacterial and fungal pathogens. The solvent extracted leaves extracts of *L. camara* contains some highly potential phytochemicals, which could be characterized and effective against bacterial and fungal infections.

#### Peer review

This is a good study in which the authors evaluated the antimicrobial potential of *L. camara* leaf extracts in different solvents and also analyzed the antioxidant and phytochemicals in leaves. The results are interesting and suggest the presence of potential phytochemicals, antioxidants and active compounds which could be identified and thus, find its way into the arsenal of antimicrobial drugs.

---

### References

- [1] Okello SV, Nyunja RO, Natondo GW. Ethnobotanical study of medicinal plants used by Sabaots of Mt. Elgon Kenya. *Afr J Tradit Complement Altern Med* 2010; 7(1): 1–10.
- [2] Abdullah N, Zulkifli KS, Abdullah A, Aziman N, Kamarudin WSSW. Assessment on the antioxidant and antibacterial activities of selected fruit peels. *Int J Chem Tech Res* 2012; 4(4): 1534–1542.
- [3] Hammuel C, Abdullahi MS, Mankilik M, Anyim BP, Adesina OB, Inekwe UV, et al. The phytochemical and antimicrobial activities of oil from the seed of thevetia peruviana plant. *J Appl Environ*

- Biol Sci* 2011; **1**(12): 597–601.
- [4] Kaushik P, Goyal P. *In vitro* evaluation of *Datura innoxia* (thorn-apple) for potential antibacterial activity. *Indian J Microbiol* 2008; **48**(3): 353–357.
- [5] Musa AM, Abbas G, Aliyu AB, Abdullahi MS, Akpulu IN. Phytochemical and antimicrobial screening of *Indigofera conferta* Gillett (Papilionaceae). *Res J Med Plant* 2008; **2**(2): 74–78.
- [6] Saraf A, Quereshi S, Sharma K, Khan NA. Antimicrobial activity of *Lantana camara* L. *J Exp Sci* 2011; **2**(10): 50–54.
- [7] Mandal S, Debmandal M, Saha K, Pal NK. *In vitro* antibacterial activity of three Indian spices against methicillin-resistant *Staphylococcus aureus*. *Oman Med J* 2011; **26**(5): 319–323.
- [8] Albayrak S, Aksoy A, Albayrak S, Sagdic O. *In vitro* antioxidant and antimicrobial activity of some Lamiaceae species. *Iran J Sci Technol* 2013; **A1**: 1–9.
- [9] Nagumanthri V, Rahiman S, Tantry BA, Nissankararao P, Kumar MP. *In vitro* antimicrobial activity of *Acacia nilotica*, *Ziziphus mauritiana*, *Bauhinia variegata* and *Lantana camara* against some clinical isolated strains. *Iran J Sci Technol* 2012; **A2**: 213–217.
- [10] Sousa EO, Almeida TS, Rodrigues FFG, Campos AR, Lima SG, Costa JGM. *Lantana montevidensis* Briq improves the aminoglycoside activity against multiresistant *Escherichia coli* and *Staphylococcus aureus*. *Indian J Pharmacol* 2011; **43**(2): 180–182.
- [11] Mushatq S, Haider MS, Ali A, Javed S, Khokhar I, Mukhtar I. *In vitro* comparative screening of antibacterial and antifungal activities of some common weeds extracts. *Pak J Weed Sci Res* 2012; **18**(1): 15–25.
- [12] Ganjewala D, Sam S, Khan KH. Biochemical compositions and antibacterial activities of *Lantana camara* plants with yellow, lavender, red and white flowers. *EurAsia J BioSci* 2009; **3**(10): 69–77.
- [13] Nedelcheva A, Pavlova D, Krasteva L, Nikolov S. Medicinal plants biodiversity and their resources of one serpentine site in the Rhodope MTS. (Bulgaria). *Natura Montenegrina* 2010; **9**(3): 373–387.
- [14] Parivuguna V, Gnanaprabhal R, Dhanabalan R, Doss A. Antimicrobial properties and phytochemical constituents of *Rheo discolor* hance. *Ethnobot Leaflets* 2008 **12**: 841–845.
- [15] Oh MM, Carey EE, Rajashekar CB. Antioxidant phytochemicals in lettuce grown in high tunnels and open field, Hort. *Environ Biotechnol* 2011; **52**(2): 133–139.
- [16] Talukdar AD, Tarafdar RG, Choudhury MD, Nath D, Choudhury S. A review on pteridophyte antioxidants and their potential role in discovery of new drugs. *Assam Univ J Sci Technol* 2011; **7**(1): 151–155.
- [17] Ullah S, Bano A, Girmay S, Tan G. Anticancer, antioxidant and antimicrobial activities of *Suaeda fruticosa* related to its phytochemical screening. *Int J Phytomed* 2012; **4**(2): 284–291.
- [18] Modarresi A, Chahardehi M, Ibrahim D, Sulaiman SF. Antioxidant, antimicrobial activity and toxicity test of *Pilea microphylla*. *Int J Microbiol* 2010; doi: 10.1155/2010/826830.
- [19] Mohammadpour M, Sadeghi A, Fassihi A, Saghaei L, Movahedian A, Rostam M. Synthesis and antioxidant evaluation of some novel ortho-hydroxypyridine-4-one iron chelators. *Res Pharm Sci* 2012; **7**(3): 171–179.
- [20] Krishnaswamy T, Sellamuthu M, Subramaniam P. *In vitro* radical scavenging potential of pod and seed extracts of *Bauhinia tomentosa* L. *Int J Pharm Pharm Sci* 2013; **5**(1): 346–351.
- [21] Kumar RS, Rajkapoor B, Perumal P. Antitumor and cytotoxic activities of methanol extract of *Indigofera linnaei* Ali. *Asian Pac J Cancer Prev* 2011; **12**: 613–618.
- [22] Hamid AA, Aiyelaagbe OO. Preliminary phytochemical, antibacterial and antifungal properties of *Alafia barteri* stem grown in Nigeria. *Eur J Med Plants* 2011; **1**(2): 26–32.
- [23] Samiullah, Bano A, Girmay S, Tan G. Total phenolic content, antioxidant, antimicrobial and anticancer activities of *Lespedeza bicolor* Turcz (Papilionaceae). In: Nejadkoorki F, editor. International Conference on Applied Life Sciences; 2012 Sep 10–12; Turkey. Croatia: InTech; 2012: 259–264.
- [24] Hussein MA. A convenient mechanism for the free radical scavenging activity of resveratrol. *Int J Phytomed* 2011; **3**(4): 459–469.
- [25] Oyewole OI, Akingbala PF. Phytochemical analysis and hypolipidemic properties of *Jatropha tanjorensis* leaf extract. *Eur J Med Plants* 2011; **1**(4): 180–185.
- [26] Naz R, Bano A. Antimicrobial potential of *Ricinus communis* leaf extracts in different solvents against pathogenic bacterial and fungal strains. *Asian Pac J Trop Biomed* 2012; **2**(12): 944–947.
- [27] Naz R, Bano A, Yasmin H, Ullah S, Farooq U. Antimicrobial potential of the selected plant species against some infectious microbes used. *J Med Plants Res* 2011; **5**(21): 5247–5253.
- [28] Nazli R, Sohail T, Nawab B, Yaqeen Z. Antimicrobial property of *Gliricidia sepium* plant extract. *Pak J Agr Res* 2011; **24**: 1–4.
- [29] Yuan Z, Hu XP. Repellent, antifeedant, and toxic activities of *Lantana camara* leaf extract against *Reticulitermes flavipes* (Isoptera: Rhinotermitidae). *J Econ Entomol* 2012; **105**(6): 2115–2121.
- [30] Rao ASVC, Reddy SG, Babu PP, Reddy AR. The antioxidant and antiproliferative activities of methanolic extracts from Njavara rice bran. *BMC Complement Altern Med* 2010; **10**: 4.
- [31] Kumar KHN, Rakshitha HR, Navyashree SN, Chauhan JB. *In-vitro* antioxidant studies of *Pritchardia arecina*. *Int J Pharm Sci Drug Res* 2012; **4**(2): 140–142.
- [32] Ganjewala D, Sam S, Khan KH. Biochemical compositions and antibacterial activities of *Lantana camara* plants with yellow, lavender, red and white flowers. *EurAsia J BioSci* 2009; **3**: 69–77.
- [33] Bhakta D, Ganjewala D. Effect of leaf positions on total phenolics, flavonoids and proanthocyanidins content and antioxidant activities in *Lantana camara* (L). *J Sci Res* 2009; **1**(2): 363–369.
- [34] Saraf A, Quereshi S, Sharma K, Khan NA. Antimicrobial activity of *Lantana camara* L. *J Exp Sci* 2011; **2**(10): 50–54.
- [35] Mahesh B, Satish S. Antimicrobial activity of some important medicinal plant against plant and human pathogens. *World J Agr Sci* 2008; **4**(S): 839–843.
- [36] Ambikapathy V, Gomathi S, Panneerselvam A. Effect of antifungal activity of some medicinal plants against *Pythium debaryanum* (Hesse). *Asian J Plant Sci Res* 2011; **1**(3): 131–134.
- [37] Shah SMM, Khan FA, Shah SMH, Chishti KA, Pirzada SMSS, Khan MA, et al. Evaluation of phytochemicals and antimicrobial activity of white and blue capitulum and whole plant of *Silybum marianum*. *World Appl Sci J* 2011; **12**(8): 1139–1144.