



Research Article

Analgesic, CNS Depressant and Antibacterial Activities of the Ethanol Extract of *Spilanthes paniculata* Leaves.

Md. Khalequeuzzaman,* Sadia Islam, Mst. Mahfuza Khatoon, Anik Kumar Dey

Department of Pharmacy, Gono Bishwabidyalay, Mirzanagar, Savar, Dhaka, Bangladesh

Abstract

Spilanthes paniculata is an important medicinal plant which is used to treat toothache, throat and gum infections. The present study was aimed to investigate the analgesic, CNS depressant and antibacterial activities of the ethanol extract of *Spilanthes paniculata* leaves. Analgesic activity was determined by formalin and acetic acid induced writhing method. In acetic acid induced writhing method, the SPE showed significant writhing inhibition ($p < 0.01$) 66.92% at a dose of 500mg/kg body weight as compared to standard drug indomethacin (60%; 10mg/kg body weight). In formalin test, the SPE showed a significant licking inhibition ($p < 0.01$) 46.77% at a dose of 500mg/kg body weight as compared to standard drug indomethacin (37.10%; 10mg/kg body weight). In CNS depressant activity, test animals showed significant decrease ($p < 0.001$) in number of movement in the dosages of 500mg/kg as compared to standard drug diazepam at a dose of 1mg/kg. In the anti-bacterial test against some gram positive and gram negative bacteria, it was found that the SPE showed moderate activity against most of the test organisms at a concentration of 800 μ g/disc. The above evidence suggest that ethanol extract of *Spilanthes paniculata* is a source of natural analgesic and CNS depressant along with moderate antibacterial activity.

Keywords: *Spilanthes paniculata*, Ethanol extract, Analgesic, CNS Depressant, Antibacterial activity.

* **Correspondence:** Md. Khalequeuzzaman, Associate Professor, Department of Pharmacy, Gono Bishwabidyalay, Nalam, Mirzanagar, Savar, Dhaka 1342, Bangladesh); Email: email:sobujph@gmail.com; Phone: +8801924865471

Introduction

The empirical use of plants as medicine can be traced back to over five millennia to ancient documents to early civilizations, such as in china, Egypt, India and the near east, but is certainly as old as mankind (Balick MJ, Cox PA 2020). Use of plant products is increasing in many segments at the population (Eisenberg et al 1993). At present thousands to plant metabolites are being successfully used for the treatment of variety of disease (Faransworth et al 1985). The use of the medicinal plant is increasing in many countries where 35% of drugs contain natural products.

Recent studies have shown that free radicals are responsible for producing pain and inflammation (Gao et al 2007). Pain is formally defined as an unpleasant sensory and emotional incident coupled with real or likely tissue injure. Pain acts as a word of warning sign against disorder of the body and has a practical function.

Analgesic mitigates pain as a symptom without affecting its reason (Akter et al 2009). Currently available analgesic drugs such as opiates and NSAIDs are not useful in all cases due to their adverse effects (Hasan et al 2009). As a result more and more people are turning to herbal medicines as the alternative treatment of pain.

Depression is a common, debilitating, life-threatening illness with an increasing morbidity and mortality. Furthermore, the World Health Organization revealed that depression is the fourth leading cause of disability worldwide, exceeded by lower respiratory infections, perinatal conditions and HIV/AIDS (The World health report 2001). Current antidepressant drugs, including various monoamine reuptake inhibitors and monoamine oxidase inhibitors, have proven to be effective and are available in clinic, but they are burdened with such disadvantage as slow onset of action, relatively low response and side effects, which make the research and development of new type antidepressants urgent (Tammainga et al 2002 and Adell et al 2005). The antidepressant effect of herbs has been paid more and more attention gradually because of increasing incidence of depression and predominance of traditional herbs in therapy.

Antimicrobial agents are essentially important in reducing the global burden of infectious diseases (Bhatia et al 2010). However, emergence and dissemination of multidrug resistant (MDR) strain in pathogenic bacteria have become a significant public health threat as there are fewer, or even sometimes no, effective antimicrobial agents available for the infection caused by pathogenic bacteria (Boucher et al 2009 and Giamarellou et al 2010). A vast number of medicinal plants have been recognized as valuable resources of natural antimicrobial compounds as an alternative that can potentially be effective in the treatment of these problematic bacterial infections (Iwu et al 1999).

Spilanthes paniculata belongs to Asteraceae family is a small tender annual that grows to about 12-15 inches and will spread to 24-30 inches which is native to the Americas and has been introduced to Asia, Africa, the Pacific islands, and Australia. The most common and widespread medicinal use for *Spilanthes paniculata* is to treat toothache, throat and gum infections. A mouth rinse of *spilanthes* extract can be used daily to promote gum health, and chewing as little as a single bud of the plant can numb the mouth and reduce the pain of toothache for up to 20 minutes depending on the sensitivity of the person (Pathak et al 2013). The leaves of *Spilanthes paniculata* possesses antioxidant activity (Haque et al. 2015) and also have Antidiabetic and thrombolytic effects (Akter et al 2014). In order to explore the potential biological activity of the ethanol extract of *Spilanthes paniculata* leaves we studied analgesic, CNS depressant and antibacterial activity.

Materials and Methods

Chemicals

All the chemicals and reagents used throughout the investigation were of reagent grade.

Plant Material

The leaves of *Spilanthes paniculata* are collected from Dhamrai Dhaka, Bangladesh and was identified by the department of Botany, Jahangirnagar University, Savar, Dhaka, Bangladesh. Immediately after collection the leaves were thoroughly washed with water. Then the leaves were dried under shade for 2 days and were ground to coarse powder with a mechanical grinder. The powdered plant was extracted individually with ethanol and ether in a Soxhlet apparatus. The mixture was filtered and the filtrate was concentrated in Rotaevaporator to yield semisolid mass. The extracts were preserved in refrigerator till further use.

Experimental animals

The experiments of analgesic and antidepressant activities were conducted on Swiss albino mice of both sexes, aged 5-6 weeks, weighting about 20-30 gm. The mice were purchased from department of pharmacy, Jahangirnagar University. Before initiating the experiment, the mice were kept in standard environmental conditions (temperature: $23.0 \pm 2.0^\circ\text{C}$, relative humidity: 55-65% and 12 h light/12 h dark cycle) and had free access to feed and water ad libitum. The animals were acclimatized to laboratory condition for one week prior to experiments. All protocols for animal experiment were approved by the institutional animal ethical committee.

In-vivo Analgesic Activity Evaluation

Acetic acid induced writhing test

Acetic acid induced writhing method is an analgesic behavioral observation assessment method that demonstrates a noxious stimulation in mice. The method was described by Sharma et al 2010. 50mg of crude ethanol extracts are triturated by the addition of small amount of suspending agent (Tween 80). Normal saline (0.9% NaCl) is slowly added to make the final volume up to 2.5ml. To prepare the standard, indomethacin 10mg was dissolved into 0.9% normal saline and made the volume up to 10ml. For preparing control sample, tween 80 (1%) was mixed properly in the normal saline to make the volume up to 5ml. The test samples, control (1% tween 80 in water) and standard (indomethacin) are administered orally with the help of a feeding needle at the beginning of the experiment. After 30 minutes, 0.7% acetic acid is injected intra-peritoneally to each of the animals of all the groups to create pain sensation. Then the animals are placed on an observation table. Approximately 5 minutes after the injection of acetic acid, a wave of contraction and elongation of abdominal musculature referred to as writhing is started and the number of writhing for the next 10 minutes are counted for each rat. Full writhing is not always accomplished by the animal, because sometimes the animals started to gibe writhing but they did not complete it. This incomplete writhing is considered as half-writhing. Accordingly, two half-writhing is considered as one full writhing. The number of writhes in each treated group is compared to that of a control group while indomethacin (10mg/kg) is used as a reference substance (positive control). The percent inhibition (% analgesic activity) is calculated by the following equation.

$$\% \text{ inhibition} = \frac{(A-B)}{A} \times 100$$

Where,

A= Average number of writhing of control per group

B= Average number of writhing of test per group

Formalin induced hind paw licking test

The analgesic activity of the drugs was determined using the formalin test described by Sharma et al 2010. 50mg of crude ethanol extract of *Spilanthes paniculata* is triturated by the addition of small amount of suspending agent. Normal saline (0.9% NaCl) was slowly added to make the final volume up to 2.5ml. To prepare the standard, indomethacin 10 mg is dissolved into 0.9% normal saline and made the volume up to 10ml. For preparing control sample, distilled water is mixed properly in the normal saline to make the volume up to 5 ml. The test samples, control (distilled water 10mg/kg) and standard (indomethacin 10mg) are administered orally with the help of a feeding needle at the beginning of the experiment. After 30 minutes, 0.05ml of 2.5% formalin (40% formaldehyde) in distilled water is injected into the dorsal surface of the right hind paw of the mice. Then the mice are individually placed in transparent cage observation chamber. The time spent licking the injected paw is recorded and the data were expressed as total licking time in the early phase (0-5 min) and the late phase (15-30 min) after formalin injection. The percent inhibition (%licking activity) is calculated by the following equation.

$$\% \text{ inhibition} = \frac{(A-B)}{A} \times 100$$

Where, A= Average number of licking of control per group

B= Average number of licking of test per group

Central nervous system (CNS) depressant activity

Hole cross method

The most consistent behavioral change is a hyperemotional response to novel environmental. The experiment was carried out as described by Takagi et al 1971. The aim of this study is to characterize the emotional behavior of mice using the hole-board test. The mice are divided into control, standard control and test group. The test groups receive ethanol extract of leaves of *spilanthes paniculata* at the dose of 250 and 500mg/kg body weight orally whereas control group receive vehicle (1% Tween 80 in water) at 10ml/kg body weight orally and standard group receive diazepam at the dose of 1 mg/kg body weight orally with the help of a feeding needle at the beginning of the experiment. A steel partition is fixed in the middle of a cage having a size of 30×20×14 cm. A hole of 3cm diameter is made at a height of 7.5cm in the center of the cage. The number of passages of a rat through the hole from one chamber to other is counted for a period of 3 min on 0, 30, 60, 90 and 120min after oral administration of test drugs.

Open field method

This experiment is carried out as described by Gupta et al 1971. The open field test is clearly the most frequently used of all behavioral tests in pharmacology and neuroscience. The mice are divided into control, standard and test group. The test groups receive ethanol extract of leaves of *Spilanthes paniculata* at the dose of 250 and 500 mg/kg body weight orally whereas control group receive vehicle (1% Tween 80 in water) at 10ml/kg body weight orally and standard group received diazepam at the dose of 1mg/kg body weight orally with the help of a feeding needle at the beginning of the experiment. The floor of an open field of half square meter is divided into a series of squares each alternatively colored black and white. The apparatus has 40 cm height a wall. The number of square visited by the animals was counted for 3 min, on 0, 30, 60, 90 and 120 min after oral administration of standard and sample.

Anti-bacterial Activity

Antibacterial activity of the ethanol extracts of leaves of *Spilanthes paniculata* was determined by disc diffusion technique (Bauer et al 1996). To determine the antibacterial activity of ethanol extract two gram-positive (*Staphylococcus aureus*, *Bacillus cereus*) and two gram-negative (*Escherichia coli*, *Pseudomonas aeruginosa*,) bacteria were used. For comparison Kanamycin-K (30µgm per disc) was used as standard. Nutrient agar media was reconstituted with distilled water in a conical flask according to specification (2.3%). It was then heated in water bath to dissolve the agar until a clear solution of agar was obtained. The media prepared was then transferred in 20ml and 5ml to prepare plates and slants respectively in a number of clean test tubes. The slants were used for making sub-culture of microorganism which in turn were used for sensitivity tests. The tubes were then plugged with cotton and sterilized in an autoclave at a temperature of 121°C and a pressure of 151 lb/sq. inch for 20 minutes. The test organisms were transferred from the pure culture to the agar slants with the help of an inoculating loop in an aseptic condition. The inoculated slants were then incubated at 37°C for 18-24 hours to assure the growth of the test organisms. This culture was then used within one week. With the help of an inoculating loop, the test organism was transferred from the subculture to the test tube containing 20 ml autoclaved media in an aseptic area. Then The test tube was shaken well by rotation to get a uniform suspension of organism. The bacterial suspensions were immediately transferred to the sterile petridishes in such a way as to obtain a uniform depth of media (approximately 4mm thick). The petridishes were rotated several times, first clockwise and then anti-clockwise to assure homogenous distribution of the test organisms. The plates were cooled to room temperature and it was stored in a refrigerator (4°C). After that the test sample and standard discs were prepared carefully at concentration of 800µg/disc and 30µgm/discs respectively. The Prepared discs were placed gently on the freshly seeded solidified agar plates with a sterile forceps. Standard discs and controlled discs were also placed on the test plates. The spatial arrangements of the discs were such that the discs were not closer than 15mm to the edge of the plates to prevent overlapping the zone of inhibition. The plates were then inverted and kept in a refrigerator for about 12-24 hours at 4°C to obtain maximum diffusion. Finally the plates were incubated at 37°C for 12-18 hours. After incubation, the antibacterial activities of the test samples were determined by measuring the diameter of inhibitory zones in terms of millimeter (mm).

Results

Determination of analgesic activity

Acetic acid-induced writhing test

In acetic acid induced writhing test, the ethanol extract of *Spilanthes paniculata* leaves significantly and dose dependently suppress the frequency of acetic acid-induced writhing in mice after oral administration. At 500mg/kg body weight, SPE showed 66.92% of writhing inhibition whereas at 10 mg/kg body weight, the standard drug indomethacin showed 60% of writhing inhibition.

Table1: Analgesic activity of *Spilanthes paniculata* leaves by Acetic acid-induced writhing test

| Treatment Group | Dose (body weight) | Mean of writhing | % of inhibition |
|--------------------------------|--------------------|------------------|-----------------|
| 1% Tween 80 in water (control) | 1ml/10gm | 32.50±8.74 | - |
| Indomethacin (standard) | 10 mg/kg | 13.00±3.65** | 60 |
| SPE | 250 mg/kg | 16.50±5.19* | 49.23 |
| | 500 mg/kg | 10.75±2.99** | 66.92 |

All the values are stated as Mean ± SD. (Where, n=4); significance at ***p<0.001, **p<0.01, *p<0.05 as compared to control.

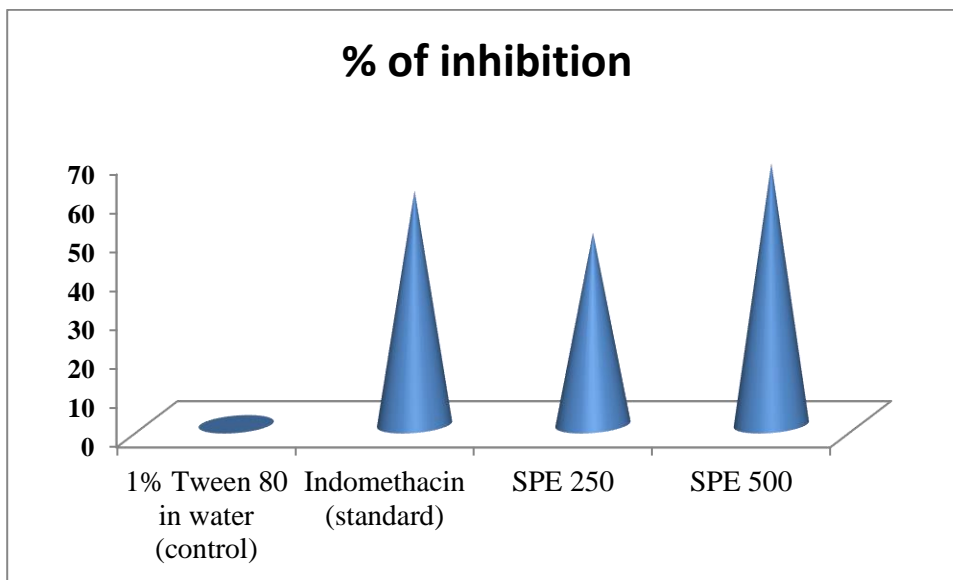


Figure-1: Analgesic activity of *Spilanthes paniculata* leaves by Acetic acid-induced writhing test

Formalin induced pain test

The ethanol extract of leaves of *Spilanthes paniculata* significantly suppressed the licking activity in the formalin-induced pain in mice in a dose dependent manner. The standard drug (Indomethacin) used in the experiment showed 37.10% licking inhibition with a dose of 10 mg/kg of body weight whereas SPE showed 46.77% licking inhibition with a dose of 500mg/kg of body weight.

Table2: Analgesic activity of *Spilanthes paniculata* leaves by Formalin induced pain test

| Treatment Group | Dose (body weight) | Mean of licking | % of inhibition |
|---------------------------|--------------------|-----------------|-----------------|
| Distilled water (control) | 10 ml/kg | 31.00±7.96 | - |
| Indomethacin (standard) | 10 mg/kg | 19.50±1.29* | 37.10 |
| SPE | 200 mg/kg | 21.50±2.08* | 30.64 |
| | 500 mg/kg | 16.50±3.42** | 46.77 |

All the values are stated as Mean ± SD. (Where, n=4); significance at ***p<0.001, **p<0.01, *p<0.05 as compared to control.

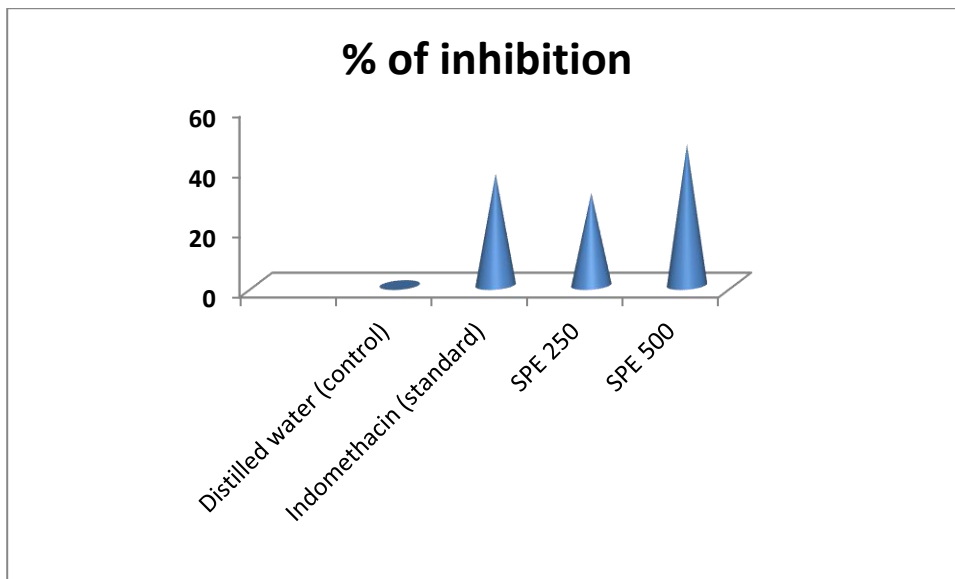


Figure-2: Analgesic activity of *Spilanthes paniculata* leaves by Formalin induced pain test

CNS depressant activity determination

Hole cross test

The animal treated with different doses of ethanol extract of *Spilanthes paniculata* leaves showed dose dependent reduction in the locomotor activity and it was comparable with that of standard drug diazepam. The extract produced reduction in spontaneous motor activity, and this effect may be attributed to CNS depression, as depression of locomotor activity is common to most neuroleptics.

Table3: CNS depressant activity of *Spilanthes paniculata* leaves by hole cross test

| Treatment Group | Dose (body weight) | No. of movements | | | | |
|--------------------------------|--------------------|------------------|--------------|--------------|-------------|--------------|
| | | 0 min | 30 min | 60 min | 90 min | 120 min |
| 1% tween 80 in water (control) | 10ml/kg | 12.75±0.96 | 13.50±2.38 | 13.75±2.21 | 9.25±4.57 | 12.00±2.58 |
| Diazepam (standard) | 1 mg/kg | 9.25±0.96** | 7.75±1.25** | 6.75±1.26*** | 4.25±1.50 | 3.00±1.41*** |
| SPE | 250 mg/kg | 11.25±0.96 | 10.75±1.89 | 7.75±0.96 | 6.75±1.26 | 5.75±0.50* |
| | 500 mg/kg | 9.50±0.96** | 4.25±0.96*** | 2.75±0.96*** | 2.00±0.82** | 1.50±0.57*** |

All the values are stated as Mean ± SD. (Where, n=4); significance at ***p<0.001, **p<0.01, *p<0.05 as compared to control

Open field test

Open field test was carried out to determine the depressive action of the test samples. In this test, the extract showed a noticeable dose dependent decrease in locomotion in the test animals. Test animals showed significant decrease in number of movement at dose 500 mg/kg after 120 min compared to standard.

Table4: CNS depressant activity of *Spilanthes paniculata* leaves by Open field test

| Treatment Group | Dose (body weight) | No. of movements | | | | |
|--------------------------------|--------------------|------------------|---------------|---------------|---------------|--------------|
| | | 0 min | 30 min | 60 min | 90 min | 120 min |
| 1% tween 80 in water (control) | 10ml/kg | 62.50±9.34 | 57.50±6.75 | 55.25±6.23 | 51.75±4.03 | 49.00±5.47 |
| Diazepam (standard) | 1 mg/kg | 55.00±7.26 | 25.00±4.96*** | 12.25±2.98*** | 10.50±2.38*** | 5.00±2.61*** |
| SPE | 250 mg/kg | 82.75±3.77 | 74.00±5.97** | 58.50±8.10 | 47.25±7.88 | 34.25±6.34* |
| | 500 mg/kg | 58.25±7.50 | 28.50±2.88*** | 15.75±2.06*** | 9.75±1.71*** | 4.75±0.96*** |

All the values are stated as Mean ± SD. (Where, n=4); significance at ***p<0.001, **p<0.01, *p<0.05 as compared to control.

Anti-bacterial activity

Evaluation of the antimicrobial activity of the ethanol extract of *Spilanthes paniculata* was determined initially by the disc diffusion method against different microorganisms. These organisms were frequently encountered in infectious diseases. It was observed that the extract used in the study exhibited a varying degree of antibacterial activity against all microorganisms tested.

Table5: Antibacterial activity of *Spilanthes paniculata* leaves by disk diffusion method.

| Bacteria | | Diameter of the zone of inhibition (mm) | |
|---------------|-------------------------------|---|----------------------------|
| | | SPE 800 µg/disc. | Kanamycin-K 30 µg/disc. |
| Gram Positive | <i>Staphylococcus aureus</i> | 16 | 25 |
| | <i>Bacillus cereus</i> | 9 | 26 |
| Gram Negative | <i>Pseudomonas aeruginosa</i> | 6 | 20 |
| | <i>Esherichia coli</i> | 8 | 22 |

Discussion

Scientific and methodical investigation of herbal plants has become a potential source for the discovery of lead compounds of high therapeutic value in terms of analgesic activity. Ethno-pharmacological studies have become increasingly invaluable in the development of modalities for the management of pain and related disorders. Thus green pharmaceuticals have now received considerable attention and popularity in this area due to its availability, less side effects and economic feasibility compared to the orthodox medicine. In this study the ethanol extract of the *Spilanthes paniculata* leaves showed significant analgesic activity ($p < 0.01$) at a dose of 500 mg/kg body weight compared to standard indomethacin. So the leaves of this plant can be used as an alternative analgesic medicine.

Central nervous system (CNS) depressants are drugs that can be used to slow down brain activity. CNS depressants may be prescribed by a physician to treat anxiety, muscle tension, pain, insomnia, acute stress reactions, panic attacks, and seizure disorders. CNS depression often results from the use of depressant drugs such as alcohol, opioids, barbiturates, benzodiazepines, general anesthetics etc. Drug overdose is often caused by combining two or more depressant drugs, although overdose is certainly possible by consuming a large dose of one depressant drug. In this study the ethanol extract of the *Spilanthes paniculata* leaves showed significant CNS depressant activity ($p < 0.001$) at a dose of 500 mg/kg body weight compared to standard diazepam. So the leaves of this plant can be used as an alternative CNS depressant medicine.

In the light of the evidence of the rapid global spread of antibiotic resistant bacterial strains, the need to find new antimicrobial agents is of paramount importance. Plants are rich in a wide variety of secondary metabolites such as tannins, alkaloids, phenolic compounds, and flavonoids, which have been found in vitro to have antimicrobial properties (Duraipandiyam et al 2006). In this study the ethanol extract of the *Spilanthes paniculata* leaves showed moderate antibacterial activity against *Staphylococcus aureus* among the four bacterial strains compared to standard Kanamycin.

Conclusion and Future Direction

This study revealed that the leaf extract of *Spilanthes paniculata* possesses good analgesic and CNS depressant activity. The plant extract also has moderate antibacterial activity. Further more specific studies may confirm the analgesic and CNS depressant potential of this plant which could open a new window on the use of this plant in traditional medicine.

List of Abbreviations

SPE: Ethanol extract of *Spilanthes paniculata*, SD: Standard Deviation, CNS: Central Nervous System, WHO: World Health Organization

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Author Contributions Statement

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M. Khalequeuzzaman and M. Khatoon designed the study protocol and S. Islam collected the plant. M. Khalequeuzzaman, M. Khatoon and S. Islam performed the experiments. Anik Kumar Dey contributed to data analysis.

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Data Availability Statement

Data relevant to the study is already included to the article or attached in the supplements. Raw data will be provided on reasonable request upon contacting with the corresponding.

References

- Adell A, Castro E, Celada P, Bortolozzi A, Pazos A, Artigas F. Strategies for producing faster acting antidepressants. *Drug Discov Today*; 2005; 10: 578-585. DOI: 10.1016/s1359-6446(05)03398-2
- Akter R, Hasan SMR, Siddiqua SA, Majumder MM, Hossain MM, Alam MA, et al. Evaluation of analgesic and antioxidant potential of the leaves of *Curcuma alismatifolia* Gagnep. *S. J. Pharm. Sci*; 2009 ; 1&2: 3-9. DOI: <http://doi.org/10.3329/sjps.v1i1.1779>
- Akter S, Rahman MA, Azad MAK, Mohiuddin M, Mamun AA, Sarker J et al. Antidiabetic and thrombolytic effects of ethanol extract of *Spilanthes paniculata* leaves. *Journal of Plant Sciences*; 2014; 2(6-1): 13-18. DOI: 10.11648/j.jps.s.2014020601.13
- Balick MJ, Cox PA. *Plants, People, and Culture: the Science of Ethnobotany*, Scientific American Library; 2020; New York, U.S.A. DOI: 10.4324/9781003049074
- Bauer AW, Kirby WMM, Sherris JC and Truck M. Antibiotic susceptibility testing by a standardized single disc method. *Am. J. Clin. Pahol*; 1996; 45,493-496. DOI: http://doi.org/10.1093/ajcp/45.4-ts_493
- Bhatia R and Narain JP. Thegrowing challenge of antimicrobial resistance in the South-East Asia Region - are we losing the battle. *Indian Journal of Medical Research*; 2010; 132(5), 482–486. DOI:10.4103/0971-5916.73313
- Boucher HW, Talbot GH, and Bradley JS. Bad bugs, no drugs: no ESKAPE! An update from the Infectious Diseases Society of America. *Clinical Infectious Diseases*; 2009; 48(1) pp. 1–12. DOI: 10.1086/595011
- Duraipandiyan , Ayyanar VM, and Ignacimuthu S. Antimicrobial activity of some ethnomedicinal plants used by Paliyar tribe from Tamil Nadu, India. *BMC Complementary and Alternative Medicine*; 2006; 6; 35. DOI: 10.1186/1472-6882-6-35
- Eisenberg DM, Kessler RC and Foster C. Unconventional Medicine in the United States: Prevalence, Costs and Patterns of Use. *N Eng J Med*; 1993; 328: 246-252. DOI: 10.1056/NEJMI99301283280406
- Faransworth N.R, Akerele O, Bingel A.S, Soejarto D.D, Guo Z. Medicinal plants in therapy. *Bull World Health Organ*; 1985; 63, 965-81. DOI: <https://iris.who.in/handle/10665/265180>
- Gao X, Kim HK, Chung JM. Reactive oxygen species (ROS) are involved in enhancement of NMDA-receptor phosphorylation in animal models of pain. *Pain*; 2007; 131: 261-271. DOI: 10.1016/J. Pain.2007.01.011
- Giamarellou H. Multidrug-resistant Gram-negative bacteria: how to treat and for how long. *International Journal of Antimicrobial Agents*; 2010; vol. 36, Supplement 2, pp. S50–S54. DOI: <https://doi.org/10.1016/j.ijantimicag.2010.11.014>
- Gupta BD, Dandiya PC and Gupta ML. A psychopharmacological analysis of behavior in rat. *Jpn J Pharmacol* ; 1971; 21: 293. DOI: 10.1254/jjp.21.293
- Haque S, Lopa SD, Das BK. Evaluation of antioxidant potential of *Spilanthes paniculata*. *Int J Pharm Pharm Sci*; 2015; 7(8): 390-392. doi: <https://journals.innovareacademics /6703/6893>

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Hasan SM, Jamila M, Majumder MM, Akter R, Hossain MM, Mazumder M, et al. Analgesic and Antioxidant Activity of the Hydromethanol Extract of *Mikania scandens* (L.) Willd. Leaves. *American Journal of Pharmacology and Toxicology*; 2009; 4(1): 1-7. DOI: <https://doi.org/10.3844/ajptsp.2009.1.7>

Iwu MW, Duncan AR, and Okunji CO. New antimicrobials of plant origin in. *Perspectives on new crops and new uses*, in *Plant Breeding Reviews*; 1999, J. Janick, Ed., ASHS Press, Alexandria, Virginia. DOI: 10.3390/microorganisms 9102041

Pathak K. Herbal medicine- A Rational Approach in Health Care System. *International Journal of Herbal Medicine*. 2013; 1(3): 86-89.

Sharma A, Bhatia S, Kharyaz MD, Gajbhiye V, Ganesh N, Namdeo AG et al. Anti-inflammatory and analgesic activity of different fractions of *Boswellia serrata*. *Int J Phytomed*; 2010; 2: 94-99. DOI: 10.5138/ijpm.2010.0975.0185.02015

Takagi K, Watanabe M and Saito H. Studies on the spontaneous movement of animals by the hole cross test: Effect of 2-dimethylaminoethane. Its acylates on the central nervous system. *Jpn J Pharmacol* ; 1971; 21:797-810. DOI: 10.1254/jjp.21.797

Tamminga CA, Nemeroff CB, Blakely RD, Brady L, Carter CS, Davis KL et al. Developing novel treatments for mood disorders: accelerating discovery. *Biol Psychiatry*; 2001; 52: 589-609. DOI: [https://doi.org/10.1016/S0006-3223\(02\)01470-1](https://doi.org/10.1016/S0006-3223(02)01470-1)

World Health Organization; *The World health report; 2001; Mental health: new understanding, new hope*. Geneva. DOI: <https://iris.who.int/handle/10665/42390>