Epilepsy is an episodic brain dysfunction featured by recurring erratic spontaneous seizures followed by cognitive, social, neurobiological, and psychological consequences. Conventional anti-epileptic drugs are associated with several untoward effects, and hence long-term treatment compliance is a major problem in the management of epilepsy. Herbal drugs have shown promising efficacy as potent anticonvulsants in the past few years. In light of this, the anticonvulsant effect of alcoholic extract of leaves of *Helianthus tuberosus* (AHT) against maximal electroshock (MES) induced convulsions was investigated. In the present investigation, an indigenous plant, *H. tuberosus* was studied for its protective effect against maximal electroshock (MES) induced convulsions in Wistar albino rats. The rats were pre-treated with different doses (100, 200, 400 mg/kg) of alcoholic extract of leaves of *H. tuberosus* for 14 days, and then, they were subjected to maximal electroshock seizures (40 mA for 0.2 seconds) treatment. Alcoholic extract of leaves of *H. tuberosus* at the dose of 400 mg/kg significantly reduced the duration of hind limb extension and the protection of rats against maximal electroshock-induced seizures. The reference standards phenytoin (20 mg/kg) provided complete protection. Thus, the present study revealed an anticonvulsant effect of *H. tuberosus* against maximal electroshock-induced convulsions in rats.

**Keywords:** Anti-epileptic drugs, Epilepsy, Extract, *Helianthus tuberosus*

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**INTRODUCTION**

Epilepsy is a chronic disorder that causes unprovoked, recurrent seizures. A seizure is a sudden rush of electrical activity in the brain.\[1\] It is usually caused by abnormal electrical discharge of neurons in the brain due to several etiological factors such as cerebral damage, neurocysticercosis, traumas, congenital cortical abnormality, cerebral tumour or infections, and an imbalance between excitatory and inhibitory neurotransmitters of brain.\[2\] More than 80 million people have epilepsy globally, with 80% of them being from developing countries. The incidence of epilepsy is 40–70 per 100000 per year in developed countries; it is much higher in developing countries. Its prevalence rate ranges from 5 to 10 per 1000 population affecting all the age groups, especially young people in first two decades of life and elderly with higher chances of mortality.\[3,4\] Epileptic seizures can be treated with several categories of anti-epileptic drugs such as barbiturates, benzodiazepines, phenytoin, ethosuccimide, carbamazepine, gabapentin, levetiracetam etc with more than one mechanism of action.\[5\] These anti-epileptic drugs are associated with a wide range of dose-dependent side effects, chronic toxicity, and teratogenicity. More than 35% of the patients continue to suffer from epileptic seizures despite being on anti-epileptic drugs, emphasizing the need for alternative medicines devoid of such adverse effects.\[6\] Medicinal plants have been frequently used to treat epilepsy in traditional medicine, wherein they have exhibited their efficacy as promising anticonvulsant medicines and have been put forward as invaluable sources of new anti-epileptic drugs.\[7\] Hence a need arises for novel anticonvulsant drugs with improved efficacy and reduced adverse effects and drug interactions, unlike the conventional anti-epileptic drugs available.\[8\] *H. tuberosus* L., is one of such herbal medicines can be effective against epilepsy.\[9\] *H. tuberosus*, commonly known...
as Jerusalem artichoke, is a traditional medicinal plant belonging to the sunflower plant family. Its therapeutic potential has been well documented in traditional, complementary, and alternative medicine for more than a century. Several pharmacological investigations have revealed that *H. tuberosus* possesses anticancer, antioxidant, anti-fungal, anti-diabetic, α-Glucosidase inhibitory properties and is used as a functional food.\(^{[7,9]}\) To the best of our knowledge, *H. tuberosus* has been traditionally claimed to possess anticonvulsant and nerve tonic properties but hasn’t yet been explored scientifically.\(^{[10,11]}\) In light of this, the investigation of the anticonvulsant effect of alcoholic extract of leaves of *H. tuberosus* (AHT) against maximal electroshock (MES) induced convulsions was carried out.

**Material and Methods**

**Plant Material Collection and Authentication**

Fresh leaves of *H. tuberosus* were collected from the area of Marathwada region of Maharashtra, India. The plant materials were taxonomically identified and authenticated by the Botanical Survey of India, Pune, India. (Voucher specimen no. BSI/WC/Tech./2020/225). The plant materials were shade dried until all the water molecules evaporated, and plants became well dried for grinding. After drying, the plant materials were ground well using a mechanical blender into a fine powder and transferred into air-tight containers with proper labeling for future use.

**Preparation of Extract**

*H. tuberosus* leaves powder was subjected to extraction by using different types of solvents, i.e., pet. Ether, chloroform, ethanol, and methanol by continuous soxhlet extraction method. A rotary vacuum evaporator removed the solvents; the remaining mass of extract was concentrated and dried.\(^{[10,11]}\) The extracts were stored in a desiccator for further phytochemical screening. Alcoholic extract of leaves of *H. tuberosus* was used for further study.

**Preliminary Phytochemical Screening**

The alcoholic extract of leaves of *H. tuberosus* was analyzed for phytochemical constituents such as terpenoids, alkaloids, quinones, flavonoids, saponins, steroids, and phenolic compounds using the standard qualitative phytochemical methods.\(^{[12,13]}\)

**High-Performance Thin Layer Chromatography (HPTLC) Studies of Extract Instrumentation**

HP-TLC system of CAMAG, Muttenz, Switzerland, Anchrom Enterprises (I) Pvt. Ltd, Mumbai, consisting of sample applicator (Linomat 5), Twin trough glass chamber with lid (10 × 10 cm, CAMAG, Muttenz, Switzerland), UV cabinet (Aetron, Mumbai) with dual-wavelength (254/366 nm) and the HPTLC photo-documentation (Aetron, Mumbai) was used for study.\(^{[14]}\) FT-IR, NMR was recorded at the Department of Chemistry, North Maharashtra University, Jalgaon LC-MS was carried out at Venture Centre, Pune. IR spectra were recorded using KBr on “JASCO FT-IR 460 plus” by DRIFT method.\(^{[15]}\) H-NMR spectra was recorded in CDCl3 solution on “FTNMR VARIAN MERCURY YH-300” using tetramethyl silane (TMS) as internal standard. Purity checking and Mass Spectra recording was carried by liquid chromatography–electrospray ionization mass spectrometry (LC–ESI/MS) with accurate mass measurements up to four decimals. It was recorded on Agilent LC-MS Q-TOF (6200 series TOF/6500 series) (5301 Stevens Creek Blvd, Santa Clara, CA 95051, United States) equipped with a dual AJS ESI with improved sensitivity [AJS–ESI: Agilent Jet Stream Electrospray Ionizer] and Q-TOF B.05.01 software version.

**Chromatographic Conditions**

The sample was spotted in the form of bands of the width of 6 mm with a 100 µL sample syringe (Hamilton, Bonaduz, Switzerland) on precoated silica gel aluminum plate 60 F\(_{254}\) (5 cm × 10 cm) with 250 µm thickness (E. MERCK, Darmstadt, Germany) using a CAMAG Linomat 5 sample applicator (Switzerland). The slit dimensions 5 mm × 0.45 mm and scanning speed of 20 mm/second were employed. The linear ascending development was carried out in 10 cm × 10 cm twin trough glass chamber (CAMAG, Muttenz, Switzerland) using Ethyl Acetate: Methanol (8: 2 v/v) as mobile phase. The optimized chamber saturation time for the mobile phase was 15 minutes. The length of the chromogram run was 8 cm and the development time was approximately 15 minutes. TLC plates were dried in a current of air with the help of a hair drier.\(^{[15]}\)

**Sample Preparation**

10 mg of alcoholic extract of leaves of *H. tuberosus* was dissolved in 100 mL of methanol. 10 µL volume of clear supernatant sample was applied on the TLC plate.\(^{[16]}\)

**Calculation of RF Values**

Plate was observed in the daylight, under UV light (254 and 366 nm). The following formula calculated retention factor (Rf).\(^{[17]}\)

\[
R_f = \frac{A}{B}
\]

A = distance between the point of application and central point of the spot of material being examined.

B = distance between the point of application and the mobile phase front.

**Drugs and Chemicals**

All the chemicals and drugs were purchased from standard vendors from the local market.

**Animals**

Swiss male albino mice (18–22 g) and Wistar albino rats of either sex (150–200 g) were used. They were maintained at 25 ± 2°C and relative humidity of 45 to 55% and under
standard environmental conditions (12 hours light: 12 hours dark cycle). The animals had free access to food. All the experiments were carried out between 12:00–16:00 hours. The animals were shifted from animal house to the laboratory one hour before the start of the experiment. The respective apparatus was cleaned with damp cloth wherever necessary to avoid possible bias due to other trials left by previous animals.

**Ethical Clearance**

Institutional Animal Ethical of D. Y. Patil College of Pharmacy, Akurdi, Pune approved the protocol (Approval No.-DYP COP/IAEC/2021/05).

**Preliminary Acute Toxicity Test**

Healthy adult male Swiss albino mice (18–22 g) were subjected to acute toxicity studies as per guidelines (AOT 425) suggested by the organization for economic cooperation and development (OECD-2000). The mice were observed continuously for 2 hours for behavioral and autonomic profiles and for any sign of toxicity or mortality up to seven days.[18]

**General Pharmacological Observation**

Behavioral effects of AHT (100, 200 and 400 mg/kg) were assessed by the method described by Irwin et al. (1968). The mice were divided into six groups (n = 6) and treated with AHT extracts at 30, 100 and 300 mg/kg doses. The animals were then placed in an observation cage and observed after 30 minutes of administration up to 2 hours for behavioral changes. The observation parameters consisted of body position, locomotion, rearing, respiration, righting reflex, and lacrimation. The observation parameters consisted of body position, alertness, reactivity to touch stimuli, righting reflex and lacrimation.[19]

**Evaluation of Anticonvulsant Activity using MES induced Convulsions**

48 rats (220–250 gm) of either sex were randomly divided in 08 groups, each consisting of 06 rats, and were treated with respective doses of AHT for 14 days. On 14th day, one hour after administering the respective treatment, all rats were subjected to maximal electroshock shock (40 mA for 0.2 seconds) using an electro-convulsiometer. The duration of hind limb extension and percentage of rats protected (i.e., abolition of hind limb extension before 10 seconds) was recorded and compared with control rats. Phenytoin (20 mg/kg p.o.) was used as a reference standard.[20,21]

**Statistical Analysis**

The results were reported as mean ± SEM. Differences between group means were assessed by one-way analysis of variance (ANOVA) followed by Dunnett’s test to assess the significance of differences between individual groups. p > 0.05 was considered insignificant.

**RESULTS**

**Preliminary Phytochemical Screening:**

The results of preliminary phytochemical screening hydro alcoholic extract of seeds of *H. tuberosus* revealed the presence of saponins, alkaloids, tannins, steroids, glycosides.

**HP-TLC Studies of Extract**

The Band 5 at Rf Value 0.37 was scratched and subjected to structure elucidation (Figs. 1-7, Table 1 and 2).

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**Fig. 1:** Alcoholic extract of leaves of *H. tuberosus* at 366 nm, volume applied 10 mL.

**Fig. 2:** Alcoholic extract of leaves of *H. tuberosus* at 254 nm, volume applied 10 mL.
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Fig. 3: Alcoholic extract of leaves of H. tuberosus at visible light, volume applied 10 mL. The spot at Rf Value 0.37 was scratched, extracted with methanol and evaporated to dryness (The process required semi preparative TLC to achieve a sufficient amount) for further analysis by IR, NMR and Mass Spectrometry

Spot at Rf Value – 0.37

![FT-IR Spectrum of Spot at Rf – 0.37](image)

**Table 1: FT-IR spectral data for compound at Rf-0.37**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Part of molecule</th>
<th>Vibration</th>
<th>General range (cm⁻¹)</th>
<th>Frequency (cm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ar Ring</td>
<td>a) C=C stretch</td>
<td>1500–1650</td>
<td>1528</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) C-H stretch</td>
<td>3000–3100</td>
<td>3081</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) C-H bend</td>
<td>740–762</td>
<td>713</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Overtone</td>
<td>1700–2000</td>
<td>1700–2000</td>
</tr>
<tr>
<td>2</td>
<td>-COOH</td>
<td>O-H stretch</td>
<td>2500–3500</td>
<td>2600–3400</td>
</tr>
<tr>
<td>3</td>
<td>-COOH-</td>
<td>C=O stretch</td>
<td>1650–1750</td>
<td>1714</td>
</tr>
<tr>
<td>4</td>
<td>CH₂</td>
<td>a) C-H stretch</td>
<td>2850–3000</td>
<td>2978</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-(Aliphatic)</td>
<td>1300–1470</td>
<td>1430</td>
</tr>
<tr>
<td>5</td>
<td>-C=C- bond</td>
<td>a) C=C stretch</td>
<td>1600–1680</td>
<td>1612</td>
</tr>
</tbody>
</table>

![NMR Spectrum of compound at Rf-0.37](image)

Probable Structure of the Isolated Compound is as in Fig. 7.

**Preliminary Acute Toxicity Test**

Oral administration of alcoholic extract of leaves of *H. tuberosus* (AHT) did not produce any toxic effect in mice, and no mortality was observed up to 2000 mg/kg, thus being safe.

**General Pharmacological Observation**

Mice orally treated with the AHT extract (100, 200 and 400 mg/kg) and subjected to the general observations did not differ in their behavior and other parameters determined during the observation periods. They were
**Table 2:** Interpretation of NMR spectrum

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>δ (ppm)</th>
<th>No of Protons</th>
<th>Multiplicity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.944</td>
<td>2 H</td>
<td>D</td>
<td>2 CH₃ Protons of the cyclohexane ring</td>
</tr>
<tr>
<td>2</td>
<td>2.242</td>
<td>2 H</td>
<td>D</td>
<td>2 CH₂ Protons of the cyclohexane ring</td>
</tr>
<tr>
<td>3</td>
<td>3.802</td>
<td>3 H</td>
<td>S</td>
<td>3 Protons of CH₃</td>
</tr>
<tr>
<td>4</td>
<td>3.673, 4.086, 4.458</td>
<td>4 H</td>
<td>S</td>
<td>O-H Protons</td>
</tr>
<tr>
<td>4</td>
<td>4.152 and 4.264</td>
<td>3 H</td>
<td>M</td>
<td>3 protons (1 H on each carbon) of cyclohexane ring</td>
</tr>
<tr>
<td>5</td>
<td>6.672 - 7.046</td>
<td>5 H</td>
<td>M</td>
<td>Protons of aromatic ring and attached to C=C part</td>
</tr>
<tr>
<td>6</td>
<td>10.858</td>
<td>1 H</td>
<td>S</td>
<td>COOH proton</td>
</tr>
</tbody>
</table>

**Table 3:** Effect of alcoholic extract of *H. tuberosus* (AHT) leaves against MES induced convulsions

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Duration of hind limb extension (Mean ± SEM)</th>
<th>Mice protected/ Mice used</th>
<th>% Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td>20.59 ± 0.65</td>
<td>0/6</td>
<td>0</td>
</tr>
<tr>
<td>AHT100</td>
<td>20.36 ± 0.55</td>
<td>0/6</td>
<td>0</td>
</tr>
<tr>
<td>AHT200</td>
<td>19.70 ± 0.72</td>
<td>6/6</td>
<td>0</td>
</tr>
<tr>
<td>AHT400</td>
<td>17.51 ± 0.52*</td>
<td>2/6</td>
<td>33.33</td>
</tr>
<tr>
<td>Phenytoin 20</td>
<td>8.64 ± 0.40**</td>
<td>6/6</td>
<td>100</td>
</tr>
</tbody>
</table>

The phytoconstituents in herbal medicines play an important role in the execution of their pharmacological effects.\(^{[13]}\) Hence the AHT extract was subjected to preliminary phytochemical analysis, and the results revealed the presence of the various phytoconstituents such as saponins, alkaloids, tannins, steroids, glycosides. The preliminary phytochemical analysis does not give us an idea about the specific constituent for the anticonvulsant activity. Hence taking into consideration the revealed preliminary phytoconstituents, the extract was further subjected to HPTLC analysis.\(^{[15-17]}\) The results of the HPTLC analysis revealed the presence of phytoconstituents, namely 4-((E)-3-(4-hydroxy-3-methoxyphenyl) acryloyloxy)-1,3,5-trihydroxycyclohexanecarboxylic acid.

Before evaluating the pharmacological activity of any drug, it has to be screened for its toxicity. In this context, the extract was subjected to acute oral toxicity testing.\(^{[10,19]}\) The results revealed that the extract was safe up to 2000 mg/kg dose without any difference in their behavior and other parameters. The anticonvulsant activity of the extract was determined by using MES induced seizure model.

The MES seizure test is a widely applicable preclinical model of epilepsy because drugs that are effective against tonic hind limb extension induced by electroshock generally have proven to be effective against partial and tonic-clonic seizures in human beings.\(^{[27]}\) In the present study, AHT extract significantly (P < 0.05) reduced the duration of hind limb extension and showed potential anticonvulsant activity at a dose of 400 mg/kg. The results were following the previous studies carried out.\(^{[4,5]}\) It has often been stated that an anti-epileptic drug that blocks maximal electroshock-induced tonic extension acts by blocking the spread of seizure, which may be attributed to the anticonvulsant mechanism of the extract.\(^{[28]}\) Also, the presence of 4-((E)-3-(4-hydroxy-3-methoxyphenyl) acryloyloxy)-1,3,5-trihydroxycyclohexanecarboxylic acid phytoconstituents may be attributed to the anticonvulsant activity of the extract.

**Conclusion**

In the present investigation, AHT extract showed significant prevention of MES-induced seizures, suggesting the putative...
mechanisms of action, which might be due to different phytochemicals in these extracts interacting simultaneously. The exact mechanisms and their contributions to the anticonvulsant property of these extracts will be better understood after detailed phytochemical and biochemical analysis, which is underway.

REFERENCES