Research Article

An Investigation of The Phytochemical Richness of Fresh Musa Paradisiaca L. (Plantain) Stem Juice and Its Anticonvulsant Potential on Pentylenetetrazole (Ptz)-Challenged Rats

Sabastine Chinweike Ugwuoke[1], Valentine Odirachukwumma Nwanelo[1], Yusuf Dawoye[1], Obiora Celestine Ugwu[1,2], Dionysius Obinna Osuji[1], Martins Obinna Ogugofor[1,3], Ikechukwu Jacob Okoro[1], Chigozie Paul Odo[1], Treasure Nneka Nelson[1], Chioma Assumpta Anosike[4]

1. Department of Biochemistry, University of Nigeria, Nigeria; 2. Department of Pharmacology, Enugu State University of Science and Technology, Nigeria; 3. Department of Medical Biochemistry, Enugu State University of Science and Technology, Nigeria; 4. University of Nigeria, Nigeria

This study was aimed at determining the therapeutic value of fresh *Musa paradisiaca* L. (MP) stem juice as a potential treatment for epileptic convulsions using a pentylenetetrazole (PTZ)-induced seizure model in rats. Six groups of albino rats (n = 4) were involved in the study. Group I was treated with normal saline (p.o), while group II was untreated and group III received diazepam (4 mg/kg, p.o). Group IV, V, and VI received 50, 75, and 100% v/v oral doses of MP stem juice, respectively). The treatment lasted for 10 days, followed by PTZ (85 mg/kg b.w, i.p) administration 60 min later. A lethality test and phytochemical screening were conducted. The rats were closely watched and meticulously monitored for seizure manifestations/episodes with the aid of a stopwatch. From the results, the MP stem juice up to 100% (v/v) was safe in mice and numerous bioactive compounds were found with phenols being the most abundant (9.46 ± 0.03 mg/g), followed by alkaloids (5.54 ± 0.98 mg/g) and flavonoids (4.27 ± 1.23 mg/g). For the seizure manifestation, three intermittent seizures (episodes 1, 2, and 3) were observed and the stem juice (75 and 100% v/v) significantly ($p < 0.05$) increased the latency periods of episode 1 tonic and clonic seizures. The stem juice at 50% (v/v) delayed the onset of episode 2 seizures for over 10 minutes more than the untreated group. The

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groups that received 75 and 100% (v/v) of the stem juice did not experience seizures during episode 2 as seen in episode 1. The standard and the test groups did not experience seizures during episode 3. The findings of this study have demonstrated that fresh MP stem juice could prevent convulsions by increasing the latencies and decreasing the duration of seizures in PTZ-challenged rats. This study, however, provides the pharmacological evidence for the folk claim behind the use of *Musa paradisiaca* stem juice to manage epileptic convulsions or seizure disorders.

Corresponding author: Sabastine Chinweike Ugwuoke, sabastine.ugwoke.88417@unn.edu.ng

Background

Epilepsy poses a lot of disease burdens on humans and brings about psychosocial stigma which ruins their interpersonal relationship. It is specifically a chronic neurological disorder that produces recurrent seizures spontaneously, leading to a brief lapse of attention, muscle jerks, or convulsions (Fischer *et al*., 2014). Seizures occur when nerve cells (i.e. neurons) are no longer in control of the electrical signal they fire, which in turn interferes with the passage of signal from one neuron to another (Beck and Elger, 2008). Convulsion is a form of seizure that involves body movement due to increased muscle tone. Seizure leads to changes in behavior, body movements, feelings, and consciousness. Two or more seizures that occur at least 24 hours apart are considered to be epilepsy (WHO, 2023). Different types of seizures exist and with a wide range of symptoms and severity. Most seizures last from 30 seconds to 2 minutes but the one that lasts beyond five minutes is a serious medical issue (Neubauer, 2008). Each year, over 50 million people are affected by seizure disorder globally, out of which over 80% live in Sub-Saharan Africa and Asia where the standard of living is very low (Adewumi *et al*., 2020). This is presumable due to the advanced incidence of antecedent factors such as brain infections, cranial and perinatal traumas as well as infections in these low- and middle-income countries (Ba-Diop *et al*., 2014). The majority of these risk factors can be reduced or prevented with orthodox medications, but the associated debilitating side effects are far-reaching. According to the World Health Organization (WHO) fact sheet on epilepsy, the premature death risk in people living with epilepsy (PLWE) is thrice that of the general population, whereas over 70% of the PLWE could survive if properly diagnosed and treated [3]. Despite the advances made towards the prevention/treatment of neurological disorders, epilepsy has remained defying to cure. Several licensed antiepileptic drugs (AEDs) have been in use, but have neither cured nor have the disease

relapsed completely, and are characterized by cognitive dysfunction and intolerant issues (Foster *et al.*, 2020; Mutanana *et al.*, 2020). Studies have shown that, despite the use of these drugs, up to 30% of patients continue to suffer a seizure crisis (He *et al.*, 2021; Chen *et al.*, 2018). However, the development of more bio-friendly pharmacological preparations that can overcome these limitations associated with existing AEDs becomes an important goal for this study. Natural products obtained mainly from plants are of greatest contribution and their advent showed a remarkable development in the medicinal treatment of various diseases (Newman and Cragg, 2020). These traditional systems of medicine are widely used in developing countries where over 80% of the population solely depends on traditional medicine or folk remedies for primary healthcare needs (Tugume and Nyakoojo, 2019). In recent years, several plants have demonstrated high levels of potency against seizures/convulsions; and results from the phytochemical and pharmacological studies reviewed that it is due to the presence of bioactive compounds such as flavonoids and other phenolics that have similar mechanisms of action as their synthetic counterparts (Edo *et al.*, 2023).

Before now, our forefathers used to manage epileptic convulsions using ordinary roots and herbs without having adequate knowledge of the therapeutic implications. For instance, certain herbalists from various parts of Nigeria reportedly claim that Plantain (*Musa paradisiaca*) stalk juice cures seizure disorders and convulsions. Additionally, the Ezike-Oba people in Igbo-Eze North LGA of Enugu State Nigeria cure febrile (infantile) convulsions by giving a convulsing child, the mother's urine to drink; other approaches are also exploited such as the use of local palm kernel oil, ripe tomato grown organically and so on (Ugwuoke *et al.*, 2023). This plant shares several physical features with the Banana (*Musa sapientum*) (MS) because they belong to the same Musaceae family, but the MP tree is larger and taller than the MS tree, which has thicker trunks and leaves (Reddy *et al.*, 2018). Although both plants have been used interchangeably for managing seizures/febrile convulsions in different southeastern Nigerian communities, MP seems to be more preferably used by the majority of the people in Nsukka, Agulu, and Obowo in Enugu, Anambra and Imo States, respectively (Ugwuoke *et al.*, 2023). Various parts of the MP plant such as roots, leaves, and flowers have been used traditionally- the sap is reportedly used as a remedy for dysentery, diarrhea, hysteria, and epilepsy; the fruit is eaten as food; the leaf juice for treating wounds, cuts and insect bites; while the leaves can induce abortion; and a cold infusion of the root is used to cure venereal diseases and anaemia (Ajijolakewu *et al.*, 2021). Additionally, the fruit has reportedly been used as an aphrodisiac, antiscorbutic, and diuretic agent (Onyenekwe *et al.*, 2013). Medicinal plants' pharmacological potentials are mainly brought about by

the bioactive ingredients or compounds in them such as flavonoids, terpenes, saponins, tannins, proteins, alkaloids, and phenolic components (Tungmunnithum *et al.*, 2018; Rao *et al.*, 2016).

Previous studies on MP plants have reviewed the presence of phytochemicals such as phenolic compounds, flavonoids; and others including alkaloids, tannins, and saponins (Onyenekwe *et al.*, 2013; Gervásio and Batitucci 2023). Furthermore, a recent study has also proven that MP stem juice has the therapeutic ability to prevent seizures by positively influencing the associated biochemical parameters such as GABA, glutamate, GABA-T, and brain histology of the experimental rats (Ugwuoke *et al.*, 2023). In this study, however, we aim to explore how the *Musa paradisiaca* stem juice influences the physical manifestation of seizures and to further establish the scientific basis for the folkloric claim.

Material and Methods

Material

Plant material

MP stem samples used for this study were collected fresh on February 13, 2022, from the plantain plantation located at Obeke village, Uwani Akpotoro Obimo, Nsukka LGA, Enugu State, Nigeria. The specimen was identified by Mr. Alfred Ozioko, a taxonomist at the International Centre for Ethno-medicine and Drug Development (InterCEDD) Nsukka, Enugu State Nigeria. The voucher specimen was deposited in the herbarium unit of the Botany Department, University of Nigeria, Nsukka for future reference.

Experimental animals

A total of forty-two (42) animals were used for the experiment, eighteen (18) adult albino mice (18-26 g) and twenty-four (24) adult male Albino rats (120 - 220 g). They were bred and obtained from the Laboratory unit of the Department of Pharmacology and Toxicology, University of Nigeria, Nsukka. On transfer to the work area, animals were acclimatized for seven days under standard laboratory conditions with free access to standard pellets (Guinea Feeds Plc, Nigeria) and water before the commencement of the experiment. All animal experiments were conducted in compliance with the National Research Council's Guide for the Care and Use of Laboratory Animals and approved by the

Ethical Committee on the Use of Laboratory Animals, Faculty of Biological Sciences, University of Nigeria, Nsukka (Reference No: UNN/FBS/EC/1090).

Equipment and chemicals

The equipment and chemicals used for this study were of analytical grade. Some of them were obtained from the Biochemistry Department, University of Nigeria, Nsukka, while others were purchased from the Springboard Research Laboratory, Awka, Anambra State, Nigeria. They include, but are not limited to the following:

Equipment: Mortar and pestle (Sevico Plast, Nigeria), Volumetric flask, Beaker, test tubes and measuring cylinder (Pyrex, England), Weighing balance (Mettler Toledo PB 602, Switzerland), Whatman filter paper, separating funnel, water bath, conical flask.

Chemicals/Kits: Pentylenetetrazole (Sigma Aldrich Chem. Co., USA); Diazepam (Hoffman-la Roche, Switzerland); Chloroform, Sodium Hydroxide, Ferric Chloride, 90% Ethanol, Potassium Hydroxide, Deionized/distilled water (STC, Nsukka), Dragendorff's reagent, Mayer's reagent, Wagner's reagent,10% acetic acid, Fehling solution, diethylether and dil. HCl. Other reagents used for the assays were commercial test Kits and products of Randox, UK, Biovendor, Czech Republic, TECO Diagnostics, USA, and Centronic GmbH, Germany.

Methods

Preparation of MP stem juice

A fresh sample of *Musa paradisiaca* (MP) stem was cut and washed free of dirt. It was sliced into smaller fragments and the juice was then extracted by mechanical crushing using a plastic mortar and pestle, followed by filtration. Following the method of dosing by Onyenekwe *et al.* (2013) in which the dose of 100% (v/v) was prepared from 100 mL of the stem juice in a volumetric flask; 75% (v/v) was prepared from 75 mL of the stem juice made up to 100 mL with distilled water in a volumetric flask; 50% (v/v) was prepared from 50 mL of the stem juice made up to 100 mL with distilled water in a volumetric flask; while 25% (v/v) was made from 25 mL of the stem juice made up to 100 mL with distilled water in a volumetric flask.

Phytochemical analysis of MP stem juice

The qualitative and quantitative screening of the phytochemical constituents of the stem juice was carried out using the methods of Harborne (2013) and Trease and Evans (2002).

Acute toxicity and lethality (LD_{50}) study

The oral median lethal doses (LD_{50}) of the stem juice were determined in the albino mice using the Organization for Economic Co-operation and Development (OECD) 425 guidelines as reported by Onyenekwe *et al.* (2013) and Swopna and Karishma (2018).

Experimental design

A pentylenetetrazole (PTZ)-induced seizure model was adopted for this study according to Gupta *et al*. (1999), involving albino rats (n = 24) which were randomly distributed into six (6) groups of four rats each (n=4). The animals were administered with freshly prepared MP stem juice by oral intubation. Group I received saline (p.o) served as the normal control, whereas group II was untreated. Group III (i.e., Standard control) received diazepam (4 mg/kg b.w, p.o); Groups IV, V, and VI received 50, 75, and 100% (v/v) oral doses of MP stem juice, respectively. The treatment lasted for 10 days before seizure induction with PTZ.

Induction procedure

Seizure induction was done on the last day (i.e. 10^{th} day) of treatment. All the experimental animals, except the normal control group, were injected with PTZ (85mg/kg b.w, i.p) 45 min after treatment with the stem juice (Gupta *et al*., 1999). The rats were closely observed and meticulously monitored for seizure manifestations/episodes with the aid of a stopwatch.

The experimental protocol was summarized as follows;

- Group I: Normal control (Saline only)
- Group II: Untreated control (Saline + PTZ administration)
- Group III: Standard control (4 mg/kg Diazepam + PTZ administration)
- Group IV: 50% (v/v) MP Stem juice + PTZ administration
- Group V: 75% (v/v) MP Stem juice + PTZ administration
- Group VI: 100% (v/v) MP Stem juice + PTZ administration

Evaluation of seizure activity (Seizure manifestation)

Intermittent seizure episodes 1, 2, and 3 were meticulously monitored; tonic and clonic seizure latencies as well as durations were accurately noted using a stopwatch according to the method of Gupta *et al*. (1999). Tonic seizure was noted based on the stiffness of the muscles, while clonic seizure was noted based on the twitching or jerking movement of the rats' muscles.

Statistical analysis

Data were analyzed using one-way analysis of variance (ANOVA) with repeated measures using Statistical Product and Service Solution (SPSS) version 21. Results were expressed as mean ± SD and a p-value < 0.05 was considered significant.

Results

Phytochemical screening of MP stem juice

Table 1 shows that MP stem juice contains alkaloids, flavonoids, phenols, saponins, tannins, and steroids, but no terpenoids were detected. However, for their relative abundances, while phenols were found in relatively high abundance (9.46 ± 0.03 mg/g), alkaloids, flavonoids, and tannins were found in moderate concentrations, 5.54 ± 0.98, 4.27 ± 1.23 and 3.64 ± 0.02 mg/g, respectively. Others, including saponins and steroids, were found in low concentrations, 1.27 ± 0.01 and 0.84 ± 0.03 mg/g, respectively.

S/N	Phytoconstituents	Relative Abundance	Amount (mg/g)
1	Alkaloids	++	5.54 ± 0.98
2	Flavonoids	++	4.27 ± 1.23
3	Phenol	+++	9.46 ± 0.03
4	Saponins	+	1.27 ± 0.01
5	Tannins	++	3.64 ± 0.02
6	Steroids	+	0.84 ± 0.03
7	Terpenoids	ND	-

Table 1. *Phytochemical screening of M. paradisiaca stem juice*

Values are presented as mean ± SD.

***Key**: Low Concentration (+); Moderate Concentration (++); High Concentration (+++); Not detected (ND)*

Determination of acute toxicity

Table 2 shows that no death was recorded when MP stem juice was administered to the mice for all the doses (5, 10, 25, 50, 75, and 100% v/v).

S/N	Groups	MP Stem Juice Dosage (% v/v)	Mortality
1	Group I	5	000
2	Group II	10	000
3	Group III	25	000
4	Group IV	50	000
5	Group V	75	000
6	Group VI	100	000

Table 2. Results of the acute toxicity test of MP stem juice

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N = 3 for each group; ooo = No death; XXX = death

Anticonvulsant effect of MP stem juice on PTZ-induced seizure in rats

(Episode 1)

The three graded doses of MP stem juice (50, 75, and 100% v/v) caused an increase in the latency period of PTZ-induced tonic and clonic seizures; and a reduction in the duration of the clonic seizure episode (Table 3).

Medium and high doses, 75, and 100% (v/v) of MP stem juice produced a significant ($P < 0.05$) increase in the latency periods of tonic seizures in groups V and VI (21.93 ± 8.60 min and 15.22 ± 2.61 min, respectively) when compared to that of group II (4.96 ± 1.19 min). There was a non-significant ($p > 0.05$) increase in the tonic seizure latency in group IV (10.44 ± 1.23 min) compared to that of group III (7.46 ± 5.86 min) but it increased significantly ($p < 0.05$) with groups V and VI (23.62 ± 9.64 min and 16.07 ± 2.67 min, respectively).

In group IV, the latency period of clonic seizures (11.26 ± 1.38 min) was non-significantly ($p > 0.05$) higher compared to that of group II (5.44 ± 1.28 min) but was significantly ($P < 0.05$) higher (23.62 ± 9.64 and 16.07 ± 2.67 min, respectively) with groups V and VI that received 75 and 100% v/v stem juice.

Clonic seizure duration was non-significantly ($p > 0.05$) reduced in groups IV, V, and VI as well as in group III when compared to that of group II. All experimental rats survived the seizure crises and were also active at the end of episode 1 seizures.

Groups	Tonic seizure latency (min)	Clonic seizure onset (min)	Clonic seizure duration (min)	Status of animals after Episode 1
I	-	-	-	Alive/Active
II	4.96 ± 1.19^{a}	5.44 ± 1.28^{a}	1.31 ± 0.77^{a}	Alive/Active
III	7.46 ± 5.86^{a}	$8.11 \pm 6.71^{a,b}$	0.65 ± 0.54^{a}	Alive/Active
IV	$10.44 \pm 1.23^{a,b}$	$11.26 \pm 1.38^{a,b}$	0.64 ± 0.36^{a}	Alive/Active
V	21.93 ± 8.60^{c}	23.62 ± 9.64^{c}	0.89 ± 0.58^{a}	Alive/Active
VI	$15.22 \pm 2.61^{b,c}$	$16.07 \pm 2.67^{b,c}$	0.64 ± 0.52^{a}	Alive/Active

Table 3. Anticonvulsant effect of stem juice of M. paradisiaca on PTZ-induced seizures in adult male albino rats (Episode 1)

Data is expressed as mean ± standard deviation (n = 4). Means with different alphabet as superscripts down the column are significantly ($p < 0.05$) different.

- Group I: Normal Control (Saline only)
- Group II: Untreated Control (saline + PTZ)
- Group III: Standard Control (4 mg/kg b.w diazepam) + PTZ
- Group IV: 50% (v/v) MP Stem Juice + PTZ
- Group V: 75% (v/v) MP Stem Juice + PTZ
- Group VI: 100% (v/v) MP Stem Juice + PTZ

Anticonvulsant effect of MP stem juice on PTZ-induced seizure in rats (Episode 2)

Table 4 shows the second seizure episode in which there were variations in clonic seizure latency, duration, as well as the status of the animals at the end of the episode.

The lowest dose of MP stem juice (50% v/v) significantly ($p < 0.05$) increased the latency period (25.82 ± 1.04 min) of clonic seizures in group IV compared to that of group II (12.90 ± 0.92 min). Similarly, 50

% (v/v) of the stem juice caused a significant ($p < 0.05$) increase in the latency period of group IV (25.82 ± 1.04 min) compared to that of group III (12.72 ± 8.75 min).

Moreover, the duration of the clonic seizure was found non-significantly lower in group IV (0.23 ± 0.18 min) and group III (0.36 ± 0.18 min) compared to that of group II (0.67 ± 0.40 min). In addition, groups V and VI received 75% (v/v) and 100% (v/v), respectively of the stem juice did not experience or show any form of seizures.

All the experimental rats in each group were alive and also active, except those in group II that were found with some level of weakness.

Groups	Latency of clonic seizures (min)	Duration of clonic seizures (min)	Status of Animals
I	-	-	Alive/Active
II	12.90 ± 0.92^{b}	0.67 ± 0.40^{b}	Alive/Weak
III	12.72 ± 8.75^{b}	$0.36 \pm 0.18^{a,b}$	Alive/Active
IV	25.82 ± 1.04^{a}	$0.23 \pm 0.18^{a,b}$	Alive/Active
V	NC	NC	Alive/Active
VI	NC	NC	Alive/Active

Table 4. Anticonvulsant effect of MP stem juice on PTZ-induced seizures in adult male albino rats (Episode 2)

Data is expressed as mean ± standard deviation (n = 4). Means with different alphabet as superscripts down the column are significantly ($p < 0.05$) different.

- NC: No convulsion
- Group I: Normal Control (Saline only)
- Group II: Untreated Control (saline + PTZ)
- Group III: Standard Control (4 mg/kg b.w diazepam) + PTZ
- Group IV: 50% (v/v) MP Stem Juice + PTZ

- Group V: 75% (v/v) MP Stem Juice + PTZ
- Group VI: 100% (v/v) MP Stem Juice + PTZ

Anticonvulsant effect of MP stem juice on PTZ-induced seizure in rats (Episode 3)

In Table 5, the third seizure episode is depicted. Only group II rats experienced clonic seizures in this episode. Other groups such as the standard (III) and the test (IV, V, and VI) groups did not encounter any form of epileptic seizures.

The experimental rats in each group were alive and active, except those of group II that survived, but were very weak at the end of this seizure episode.

Groups	Onset of clonic seizure (min)	Duration of clonic seizure (min)	Status of Animals
I	-	-	Alive/Active
II	19.41 ± 1.21	1.32 ± 0.77	Alive/very weak
III	NC	NC	Alive/Active
IV	NC	NC	Alive/Active
V	NC	NC	Alive/Active
VI	NC	NC	Alive/Active

Table 5. Anticonvulsant effect of MP stem juice on PTZ-induced seizures in adult male albino rats (Episode 3)

Data is expressed as mean ± standard deviation (n = 4). Means with different alphabet as superscripts down the column are significantly ($p < 0.05$) different.

- NC: No convulsion
- Group I: Normal Control (Saline only)
- Group II: Untreated Control (saline + PTZ)

- Group III: Standard Control (4 mg/kg b.w diazepam) + PTZ
- Group IV: 50% (v/v) MP Stem Juice + PTZ
- Group V: 75% (v/v) MP Stem Juice + PTZ
- Group VI: 100% (v/v) MP Stem Juice + PTZ

Discussion

In the present study, the anticonvulsant potentials of freshly prepared MP stem juice were evaluated in adult male albino rats and the stem juice at various doses reduced PTZ-induced seizures as evident in the intermittent seizure manifestations (episodes 1, 2, and 3). In the preliminary studies involving the phytochemical screening, the phenolic content which is relatively more abundant, indicates that MP stem juice is a potent anticonvulsant. Moreover, flavonoids which are the second most abundant in the stem juice have proven to be highly phenolic, and have demonstrated strong anticonvulsant properties in other medicinal plants (Tungmunnithum *et al.*, 2018; Celestine *et al.*, 2022; Szwajgier *et al.*, 2017). Other bioactive compounds found in MP stem juice at moderate and trace amounts such as alkaloids, saponins, tannins, and steroids have also been reported in other studies for their anticonvulsant activities (Tungmunnithum *et al.*, 2018; Fisseha *et al.*, 2021; Ugwah-Oguejiofor *et al.*, 2023). A similar observation was made for *n*-butanol (BF) and *n*-hexane residual aqueous fractions (RAF) of *Ipomoea asarifolia* leaf which demonstrated strong anticonvulsant effects against PTZ-induced seizures in experimental mice due to its richness in saponins and flavonoids (Chiroma *et al.*, 2022). Flavonoids, an important class of naturally occurring compounds were reported to have a modulatory role in the treatment of neurodegenerative disorders owing to their phenolic nature since they can disrupt cellular oxidative processes in the nervous system (Panche *et al.*, 2016; Ullah *et al.*, 2020). Some researchers also had it that flavonoids have demonstrated central nervous system (CNS) activities, and intrinsically have a strong affinity for $GABA_A$ receptors and anticonvulsive effects (Uddin *et al.*, 2020). However, these bioactive phytochemicals in the MP stem juice, most especially, flavonoids and phenolics, might have contributed to its anticonvulsant properties.

The acute toxicity test confirmed the safety of MP stem juice as no mortality was recorded up to the highest oral dose of 100% (v/v) of the fresh stem juice in albino mice, suggesting that it is not lethal in mice. In addition, no observable changes were noticed in the behavioural pattern such as posture, mood, or motor activities of the mice. However, no convulsion crises were seen, showing that it is safe to consume, and does not induce convulsion. This study is in consonant with the report of Onyenekwe

et al. (2013) who studied the phytochemicals and effect of *Musa paradisiaca* stem extrude on rat haematological parameters, in which, all four (4) graded doses (25, 50, 75, and 100% v/v) were found safe amongst the tested animals. Presently, no literature has reported or documented any form of lethality for any part of the *Musa paradisiaca* plant.

The results of episode 1 show that medium and high doses of fresh MP stem juice (75 and 100% v/v) remarkably increased the latency periods of tonic/clonic seizures. A similar observation was made in the findings of Mehrzadi *et al.* (2015), who reported a dose-dependent increase in the latency period of strychnine (STR) - and PTZ-induced seizures in mice following the administration of ethanolic extract of *Punica granatum* L. seed. The observed increase in the tonic seizure latency also corresponds with the results of the study that reported a prolongation of the seizure onset in rats administered with 500 mg/kg b.w of both *Cichorium intybus* and *Taaraxacum serotinum* (Rehab *et al.*, 2015). The study also agreed with the findings of Uppala *et al.* (2012), which evaluated the antiepileptic activity of methanolic extract of *Brassica nigra* seeds in mice. Wang *et al.* (2021) demonstrated in their study a notable ameliorative effect on PTZ-induced tonic and clonic convulsions by *Amomum tsaoko* fruit extract. However, this observed increase in the tonic seizure latency period could probably be an indication of a positive interaction of the bioactive compounds in MP stem juice, especially phenolics and flavonoids, with the GABAergic neurotransmission. The marked increase in the tonic seizure latencies detected in groups V and VI as against group III implies that the stem juice exerted a more calming or sedative effect on the CNS than diazepam (standard drug) (Al-Snafi *et al.*, 2019). The duration of clonic seizures was shortened following the administration of the fresh MP stem juice, but not to a reasonable extent. The result of this study also showed that MP stem juice at the doses of 75 and 100% (v/v) increased to a greater extent, the latency period of clonic convulsions, implying that the stem juice might possess neuroprotective effects against glutamate-mediated excitotoxicity as reported for the ethanolic extract of *Bacopa monniera* using different convulsive models (Kaushik *et al.*, 2011). These results provide additional convincing evidence that MP stem juice embodies great anticonvulsant potentialities.

The episode 2 results showed that only the untreated and standard groups (group II and III), as well as the group that received a low dose of the MP stem juice (group IV), experienced seizures, indicating that the stem juice at high dose possesses more anti-seizure or anticonvulsant activities. The result of this finding corresponds with the work of Al-Snafi (2015) which reported a delay of clonic convulsion onset in experimental rodents at low doses of chloroform and aqueous extracts of *Calotropis procera*. It

also agreed with the increased latency of PTZ-induced clonic convulsions in albino mice observed after oral doses of *Otostegia limbata L* extracts (Amin *et al.*, 2022). The observations of this result suggest that the fresh MP stem juice has a particular active compound (s) that confers on it, the ability to delay the onset of clonic seizure. In this episode, at the doses of 75 and 100% (v/v), no clonic seizure was noticed, which suggests that at a higher dose of the MP stem juice, convulsion was prevented and abolished completely. In this episode, all the convulsing rats in each group were alive and active, except the untreated group which showed some levels of weakness indicating the magnitude of neurotoxicity possibly caused by the PTZ.

The result of episode 3 demonstrated that only the untreated group (group II) experienced clonic seizures. The standard (group III) and the test groups (groups IV, V, and VI) neither encountered nor showed any form of seizure; and the experimental rats in the untreated group were alive, but extremely weak after the episode. Based on this, it could be inferred that the fresh MP stem juice had potent anticonvulsant effects just as diazepam. The extreme weakness observed in the convulsing rats in the untreated group shows the extent or level of damage done to the rat's neuronal cells by the PTZ.

Conclusion

The findings of this study have demonstrated that fresh MP stem juice could prevent convulsions by increasing the latencies and decreasing the duration of seizures in PTZ-challenged rats. However, this study provides pharmacological evidence for the folk claim behind the use of *Musa paradisiaca* stem juice to manage epileptic convulsions or seizure disorders.

Abbreviations

- MP *Musa paradisiaca*
- MS *Musa sapientum*
- PTZ Pentylenetetrazole
- PLWE People living with epilepsy
- AEDs Antiepileptic drugs
- CNS Central nervous system
- NC No convulsion

Statements and Declarations

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Author contributions

SCU and CAA conceptualized the research; SCU, VON, IJO, and CAA designed the study and performed the data curation; SCU, IJO, and MOO carried out the experiment; SCU and VON performed the statistical analysis and writing of the original draft; SCU, CAA, VON, OCU, and CPO reviewed and edited the work; TNN, DOO, and YD were involved in the proofreading and all authors were involved in the proofreading and approval of the final manuscript draft.

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Availability of data and materials

The datasets of this study are readily available upon request through the corresponding author, S.C. Ugwuoke

Ethics approval and consent to participate

The experimental animals used in this study were handled in compliance with the National Research Council's Guide for the Care and Use of Laboratory Animals and approved by the Ethical Committee on the Use of Laboratory Animals, Faculty of Biological Sciences, University of Nigeria, Nsukka (Approval ID: UNN/FBS/EC/1090). All necessary permissions to embark on the study plant were duly obtained from the appropriate authority.

Consent for publication

The authors declare no conflict of interest.

Competing interests

The authors declare no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Details

Department of Biochemistry, University of Nigeria, Nsukka, 410001, Enugu, Nigeria

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