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Antidepressant, antiamnesic activity, and toxicity profile of the ethanolic extract of *Gerbera jamesonii* Adlam flowers

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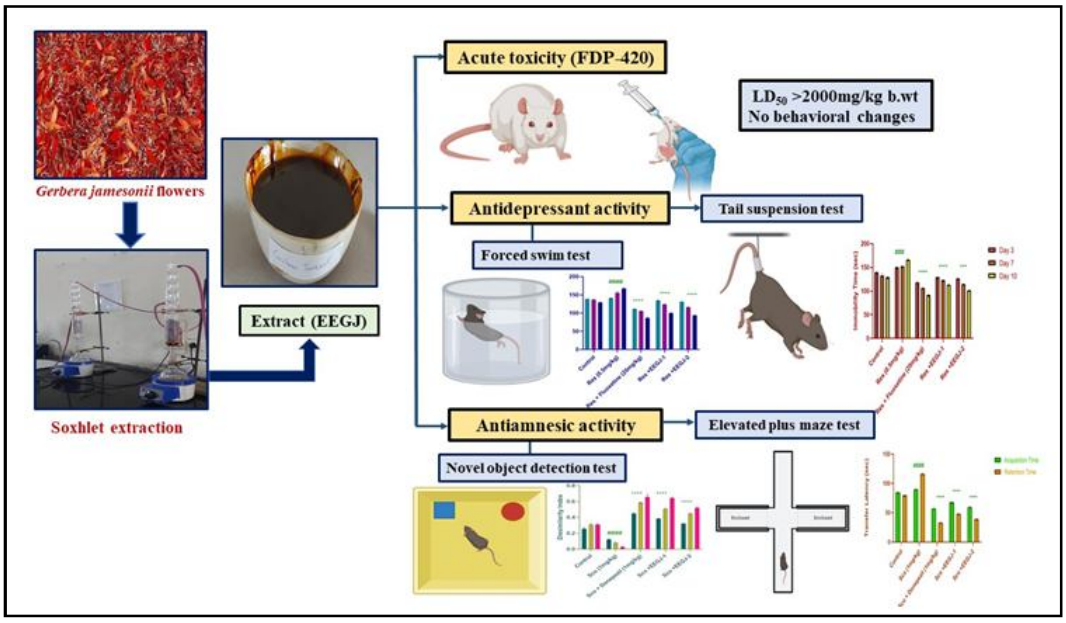
Abstract

The study evaluated the antidepressant, antiamnesic, and toxicity profile of the ethanolic extract of *Gerbera jamesonii* Adlam (EEGJ) flowers. The antidepressant activity of EEGJ (100 and 200 mg/kg, p.o.) was assessed in rats using the tail suspension test (TST) and forced swim test (FST). Antiamnesic effects were evaluated using the elevated plus maze (EPM) test and novel object detection test (NODT). Acute toxicity studies were conducted following OECD-420 guidelines. EEGJ exhibited dose-dependent antidepressant activity, significantly reducing immobility duration ($p<0.001$) compared to reserpine-treated animals in both TST and FST. EEGJ also showed significant antiamnesic effects in scopolamine-induced amnesia models. Treated animals showed improved transfer latencies in the EPM ($p<0.001$ vs. scopolamine) and higher discrimination indices in NODT ($p<0.001$ vs. scopolamine), indicative of enhanced learning and memory. Phytochemical analysis revealed the presence of active constituents such as flavonoids, terpenoids, alkaloids, saponins, and phenols, which are likely responsible for the observed pharmacological effects. The ethanolic extract of *G. jamesonii* flowers demonstrated significant antidepressant and antiamnesic activities with a favourable safety profile. These findings suggest EEGJ's potential as a therapeutic agent for managing depression and memory-related disorders.



1. Introduction

Medicinal plants have been traditionally used to treat several diseases worldwide since the beginning of civilisation. The herbal drugs are also used as household remedies for common ailments by all sections of people either directly as traditional remedies in different indigenous systems of medicine or indirectly in pharmaceutical preparations of modern medicine. Plant-based medicines have grown in popularity because they are highly affordable, accessible, readily available, more

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effective, and have a lower toxicity profile than synthetic drugs (Banu *et al.,* 2024a). Most people prefer whole herbs, leaves, stems, and roots in medicinal practices. But "flowers" also have many medicinal values that cure many ailments. Countless reports of flower extracts show anti-inflammatory, antioxidant, antibacterial anticancer, hepatoprotective activities, *etc*. A few examples like the *jasmine* (*Jasminum sambac*) flower are useful in skin diseases and eye irritation. *Rose* (*Rosa indica*) cures constipation, haematuria, and tuberculosis (Shubhashree *et al.,* 2015; Banu *et al.,* 2024b). Therefore, it seems essential and beneficial to research flowers with a broad range of phytochemicals that may have antidepressant/antiamnesic properties. The Asteraceae family, encompassing around 1600 genera and 2500 species globally, stands as one of the most extensive families among flowering plants. Throughout history, members of the Asteraceae family have played a crucial role in traditional medicine due to their wide array of beneficial applications (Akhtar *et al.,* 2020). Among these, the *G. jamesonii* flower, a member of the Asteraceae family, exhibits diverse biological actions including anticancer, antiproliferative, antioxidant, anti-inflammatory, antiangiogenic, and cholesterol-reducing properties. Traditionally, *G. jamesonii* has been utilised for treating conditions such as cystitis, painful menstruation, and mild urinary tract issues (Negm El-Dein *et al.,* 2023; Naaz *et al.,* 2024). Hence, this study delved into exploring the phytochemical composition, as well as assessing the antidepressant, antiamnesic, and toxicity profile of the ethanolic extract of *G. jamesonii* (EEGJ) flowers.

2. Materials and Methods

2.1 Plant collection and authentication

In February 2023, fully developed *Gerbera jamesonii* Adlam flowers were collected from the Gudimalkapur area in Hyderabad. Their identification and authentication were confirmed by Dr. Vijaya Bhasker Reddy, Assistant Professor in the Department of Botany at Osmania University, under Voucher Specimen Number OUAS-102. A voucher specimen has been deposited in the Department of Botany at Osmania University for future reference.

2.2 Preparation of *G. jamesonii* ethanolic extract

The *G. jamesonii* flowers underwent multiple washes with distilled water to eliminate any impurities. Subsequently, following drying at room temperature, an electric grinder was employed to coarsely powder the flowers. The coarse powder was firmly packed inside the Soxhlet apparatus. 500 ml of 70% ethanol was used as a solvent. The extraction was carried out for 72 h at 60°C. The extract was evaporated until it reached ¼ of its original volume (Naaz *et al.,* 2024; Nayak *et al.,* 2015).

2.3 Preliminary phytochemical analysis

The qualitative analysis was done to investigate the phytochemicals present in the ethanolic extract of *G. jamesonii* (Naaz *et al.,* 2024; Asha and Banu, 2018; Banu *et al.,* 2020).

2.4 Experimental animals

Male swiss albino mice (15-25 g) were used for the acute toxicity study, while wistar rats (150-250 g) were employed for the antidepressant and antiamnesic activity evaluations. These animals were procured from Mahaveer Enterprises and housed under controlled conditions of 27 ± 2°C, 70-80% humidity, and a 12-h light/dark cycle. They were provided with a standard diet and given five days of acclimatization to the laboratory environment before the studies commenced. All procedures adhered strictly to institutional guidelines for animal experimentation as per CCSEA regulations. The study was approved by the Institutional Animal Ethics Committee (RBVRR 1328/04/2023).

2.5 Acute toxicity study

The acute oral toxicity study was conducted following OECD guideline no. 420 using the fixed dose method on male swiss albino mice. The study followed the limit test principle, using a single dose of 2000 mg/kg and five animals per group to assess acute toxicity according to standard protocols. Ten mice were randomly divided into two groups of five: A control group and a treatment group that received 2000 mg/kg body weight of ethanolic extract of *G. jamesonii*. Prior to dosing, all animals were fasted for 2-4 h and weighed. Post-administration, the treatment group was monitored for signs of toxicity over 14 days, with observations made at 0.5, 1, 6, and 24 h during the first 24 h and daily thereafter. Symptoms such as changes in skin, fur, eyes, respiration, behavior, and mortality were recorded. On day 14, the animals were sacrificed, and a gross necropsy was performed to examine internal organs-kidneys, liver, spleen, stomach, brain, heart, and lungs. These organs were cleaned, measured, and inspected for any evidence of organ-specific toxicity. Additionally, hematologic parameters, including haemoglobin levels, neutrophils, lymphocytes, eosinophils, monocytes, basophils, and platelets, were analyzed. This method ensured comprehensive evaluation of both general and organ-specific toxicity, providing a thorough understanding of the safety profile of the ethanolic extract of *G. jamesonii* (Banu *et al.,* 2016; Kengkoom *et al.,* 2012; Asha and Banu, 2018; Worasuttayangkurn *et al.,* 2019; Halim *et al.,* 2011).

2.6 Evaluation of antidepressant activity: Reserpine-induced depression model

2.6.1 Preparation and mode of administration of drugs

All drug solutions are freshly prepared and suspended in saline solution drugs for induction of depression. Reserpine (0.5 mg/kg) was dissolved in saline and administered to rats once daily for 10 days. The most common treatment for hypertension historically was reserpine, an alkaloid derived from the *Rauwolfia* genus, known for its sympatholytic and sedative properties. However, studies and clinical trials have revealed that reserpine's prolonged use is associated with a significant adverse effect, *i.e.,* depression, which tends to worsen over time with continued administration. Reserpine causes monoamine depletion in the brain by blocking vesicular monoamine reuptake. As a result, it is used to induce depression in laboratory animals (Park *et al.,* 2018; Greenwood *et al.,* 2018).

2.6.2 Randomization and grouping

Random assignment involves assigning individuals to groups randomly to ensure unbiased distribution in an experiment. In this study, the animals were categorized by weight and allocated into normal, control, standard, and test groups (Table 1) following the Z rule, *i.e.,* the groups included animals arranged from higher to lower weight.

Table 1: Group classification

S.No.	Groups	No. of rats	Drug treatment
1	Control	06	Distilled water, 1 ml/kg, p.o., daily for 10 days
2	Reserpine-treated	06	Reserpine (0.5 mg/kg,ip) -10 days
3	Fluoxetine-treated	06	Reserpine + Fluoxetine (20 mg/kg, i.p.) -10 days
4	EEGJ-(100 mg/kg)	06	Reserpine +100 mg/kg dose of EEGJ -10 days
5	EEGJ-(200 mg/kg)	06	Reserpine + 200 mg/kg dose of EEGJ -10 days

2.6.3 Experimental procedure

In this experiment, a total of 30 rats were used. The rats were divided into five groups with six animals in each group. Group I received the drinking water and feed and served as normal control. Group II received reserpine (0.5 mg/kg body weight) alone and served as negative control without any drug treatment. Group III received reference drug fluoxetine (20 mg/kg, i.p.) 60 min before each reserpine injection**.** Groups IV and V received ethanolic extract at doses of 100 and 200 mg/kg body weight, respectively for 10 days 60 min before each reserpine injection.

2.6.4 Behavioural studies

2.6.4.1 Tail suspension test

The tail suspension test is a widely used behavioural assay for evaluating a drug's potential antidepressant effects. In this test, rats are suspended 50 cm above the floor using adhesive tape applied 1 cm from the tip of the tail. The rats are observed for a duration of six min, with the entire immobility time recorded. Immobility refers to the absence of purposeful movement, where the animal hangs passively from the suspension hook. During the first 2 min of the test, the rats typically display some initial movement or struggle, after which they become immobile. The test duration is divided into these two distinct phases, with immobility measured in the final 4 min. A reduction in immobility time, compared to control conditions, is interpreted as indicative of antidepressant activity, as it reflects a decrease in behavioural despair.

2.6.4.2 Forced swim test

In the forced swim test (FST), rats are placed in an enclosed water-filled space where escape is impossible. The test lasts for 6 min, but only the final 4 min are used to record the duration of immobility. Immobility is defined as the state where rats remain floating in the water, making minimal movements to keep their heads above the surface. During this period, reduced immobility time is considered indicative of antidepressant-like effects, as it reflects a decrease in behavioural despair. The FST is widely used to assess the effectiveness of potential antidepressant compounds by measuring the rat's tendency to adopt a passive, immobile posture, which is thought to reflect feelings of despair. A reduction in immobility time suggests an improvement in mood and a decrease in depressive-like behaviour (Yankelevitch *et al.,* 2015; Porsolt *et al.,* 2001).

2.7 Evaluation of antiamnesic activity: Scopolamine-induced amnesia model

2.7.1 Drug preparation and administration methods

The drugs were dissolved in saline and prepared freshly drug for induction of amnesia. Scopolamine (1 mg/kg, i.p.) was used to induce amnesia in rats. Scopolamine is an alkaloid with muscarinic antagonist properties, it is also referred to as L-duboisine and hyoscine. It belongs to the class of secondary metabolites found in plants in the Solanaceae (nightshade) family. It acts as a competitive antagonist at muscarinic acetylcholine receptors, particularly at M_1 receptors. Scopolamine has been widely used to induce amnesia in animals. Its effects are attributed to a cholinergic deficit, supporting the theory that acetylcholine is integral to memory functions. In addition to impacting memory and learning, scopolamine also has an impact on a variety of behavioural traits such as locomotor activity, anxiety, and attention (Hsieh *et al.,* 2000; Kulkarni *et al.,* 2010).

2.7.2 Experimental design

The rats were divided into five groups of six each (n=6) as presented in Table 2.

Table 2: Group classification

S.No.	Groups	No. of rats	Drug treatment	Duration
1.	Control	06	Distilled water, 1 ml/kg, p.o.	14 days
2.	Scopolamine-treated	06	Scopolamine (1 mg/kg, i.p.)	14 days
3.	Donepezil-treated	06	Scopolamine (1 mg/kg, i.p.) + donepezil (1 mg/kg, i.p.)	14 days
4.	EEGJ (100 mg/kg)	06	Scopolamine (1 mg/kg, i.p.) + 100 mg/kg EEGJ	14 days
5.	EEGJ (200 mg/kg)	06	Scopolamine (1 mg/kg, i.p.) + 200 mg/kg of EEGJ	14 days

Drugs and vehicles were given to the animals 60 min before the start of the experiment.

2.7.3 Behavioural studies

2.7.3.1 Elevated plus maze

This apparatus has two covered arms (16 cm × 12 cm), two open arms (16 cm × 5 cm) and a central platform (5 cm × 5 cm). The maze has a height of 25 cm from the ground. Each animal was kept away from the platform, at the end of an open arm on the 13th day. The rats were allowed to explore the elevated plus maze, the exploration time of the rat in the maze was observed for the next 5 min, the readings were noted and this was considered as the "Acquisition phase". On the 14th day of the trial, the animals were placed in an elevated plus maze and the exploration time was recorded for the next 5 min, the readings were noted and this was considered as the "Retention phase" (Itoh *et al.,* 1999).

2.7.3.2 Novel object detection test

Before the experiment started, each rat was given two days to get used to the testing apparatus. On the day of the test, after scopolamine was administered, there was a 30-min waiting period before the two trials, each lasting 2 min, began. Two objects (white-coloured) were kept on either side of the setup for the "sample" trial (T_1). The next stage of the experimental procedure was the "choice" experiment (T_2). The old familiar object (F) and the novel object - yellow coloured (N) were the two distinct objects to which the rats were once again exposed in T_2. N was then exchanged for one of the objects (Antunes *et al.,* 2012).

Dissimilarity index =

$$\frac{\text{Novel object exploration time - Familiar object exploration time}}{\text{Total exploration time}} \times 100$$

2.8 Statistical analysis

The data were expressed as mean ± SEM. Statistical analysis was performed using one-way ANOVA, followed by tukey's multiple comparisons test. A $p<0.05$ was considered statistically significant.

3. Results

3.1 Extraction yield of *G. jamesonii*

The extraction yield of *G. jamesonii* was calculated as follows:

$$\text{Extraction yield} = \frac{\text{Weight of the extract}}{\text{Weight of the plant powder}} \times 100$$

Using this formula, the extraction yield was determined to be 42.92%.

3.2 Acute toxicity study

As per, the OECD 420 guidelines the dose of 2000 mg/kg b.wt was selected and administered to mice and was observed for up to 14 days.

Table 3: Acute toxicity studies of EEGJ-Behavioural parameters

Parameters	Control			EEGJ (2000 mg/kg,b.wt)		
	Day 1st	Day 7th	Day 14th	Day 1st	Day 7th	Day 14th
Food and water consumption	N	N	N	N	N	N
Temperature	N	N	N	N	N	N
Breathing	N	N	N	N	N	N
Skin colour	N.C	N.C	N.C	N.C	N.C	N.C
Eye colour	N.C	N.C	N.C	N.C	N.C	N.C
Faeces consistency	N	N	N	N	N	N
Motor coordination	N	N	N	N	N	N
Drowsiness	N.P	N.P	N.P	N. P	N.P	N.P
Coma	N.F	N.F	N.F	N.F	N.F	N.F
Death	N.F	N.F	N.F	N.F	N.F	N.F

Mice in each group were carefully examined for any signs of toxicity for 14 days. N-Normal, N.C-No Change, N.P-Not Present, and N.F-Not found.

Table 4: Effects of EEGJ on body weights

Days	Control	Test
1st Day	30.01 ± 0.20	32.13 ± 0.21 ^{ns}
3rd Day	30.25 ± 0.40	32.56 ± 0.28 ^{ns}
7th Day	29.60 ± 0.27	34.29 ± 0.11 ^{ns}
11th Day	31.02 ± 0.35	35.40 ± 0.21 ^{ns}
14th Day	32.26 ± 0.14	36.85 ± 0.15 ^{ns}

Values are expressed as the mean ± SEM (n = 5; for each group). ns-Not significant.

Table 5: Effects of EEGJ on biochemical parameters

Parameter	Control	Test
Glucose (mg/dl)	145.80 ± 1.59	145.2 ± 1.39 ^{ns}
Bilirubin (mg/dl)	0.132 ± 0.01	0.248 ± 0.06 ^{ns}
Urea (mg/dl)	12.09 ± 0.15	12.054 ± 0.21^{ns}
Creatinine (mg/dl)	0.42 ± 0.21	0.654 ± 0.13 ^{ns}

Values are expressed as the mean ± SEM (n = 5; for each group). ns-Not significant.

Table 6: Effects of EEGJ on haematological parameters

Parameter	Control	Test
Red blood cells (*10/ mm^3)	7.2 ± 0.35	7.8 ± 0.39 ^{ns}
Packed cell volume (%)	40.0 ± 3.4	42.5 ± 2.1 ^{ns}
Haemoglobin (g/dl)	10.3 ± 0.45	12.7 ± 0.27 ^{ns}
White blood cells (*10/ mm^3)	6.4 ± 0.24	6.1 ± 0.15 ^{ns}
Neutrophils (%)	22.7 ± 0.25	22.7 ± 0.26 ^{ns}
Lymphocytes (%)	73.1 ± 0.46	73.4 ± 0.33 ^{ns}
Eosinophils (%)	1.7 ± 0.039	1.9 ± 0.041 ^{ns}
Monocytes (%)	2.3 ± 0.35	1.7 ± 0.24 ^{ns}
Basophils (%)	0.2 ± 0.039	0.3 ± 0.035 ^{ns}

Values are expressed as the mean ± SEM (n = 5; for each group).ns=Not significant.

Table 7: Effects of EEGJ on organ weight after 14 days of acute toxicity studies

Organ	Control	Test
Brain	0.42 ± 0.007	0.40 ± 0.008 ^{ns}
Heart	0.17 ± 0.013	0.18 ± 0.014 ^{ns}
Lungs	0.43 ± 0.15	0.39 ± 0.15 ^{ns}
Liver	1.65 ± 0.40	1.92 ± 0.35 ^{ns}
Spleen	0.11 ± 0.02	0.11 ± 0.016 ^{ns}
Stomach	0.32 ± 0.033	0.41 ± 0.026 ^{ns}
Kidney - Left	0.19 ± 0.027	0.21 ± 0.023 ^{ns}
Right	0.18 ± 0.015	0.24 ± 0.015 ^{ns}

Values are expressed as the mean ± SEM (n = 5; for each group). ns-Not significant.

3.3 Antidepressant activity

3.3.1 Tail suspension test

The data revealed that treatment with reserpine has shown a significant increase in immobility time when contrasted with the normal control group. This indicates a depressive response. Treatment with EEGJ at doses of 100 mg/kg and 200 mg/kg has shown a significant decrease ($p<0.001$) in immobility time when contrasted with the reserpine group in a dose-dependent manner. This indicates that the EEGJ successfully ameliorated depressive-like behaviours in reserpine-treated rats as presented in Table 8.

Table 8: Effect of EEGJ in the tail suspension test

Groups	3rd Day	7th Day	10th Day
Control	140.00 ± 0.44	133.00 ± 1.31	128.00 ± 1.36
Reserpine (0.5 mg/kg)	148.83 ± 0.57##	153.33 ± 0.71###	166.23 ± 0.45###
Fluoxetine (20 mg/kg)	119.16 ± 0.55***	106.23 ± 0.66***	91.400 ± 0.52***
EEGJ (100 mg/kg)	131.33 ± 0.52***	124.16 ± 0.40***	113.43 ± 0.66***
EEGJ (200 mg/kg)	127.60 ± 0.61***	115.83 ± 0.20***	101.40 ± 0.52***

Values are expressed as mean ± SEM. The analysis was done using one-way ANOVA followed by the tukey test. ###$p<0.001$, ##$p<0.01$, compared with normal control, and ***$p<0.001$ compared with reserpine treated group.

3.3.2 Forced swim test

Treatment with reserpine has shown a significant increase in immobility time when contrasted with the normal control group. This indicates a depressive response. Treatment with EEGJ drug at doses of 100 mg/kg and 200 mg/kg has shown a significant decrease ($p<0.001$) in immobility time in a dose-dependent manner when contrasted to the reserpine group. This indicates that the EEGJ possesses antidepressant activity as presented in Table 9.

Table 9: Effect of EEGJ in the forced swim test

Groups	3rd Day	7th Day	10th Day
Control	138.50 ± 0.22	137.16 ± 0.40	129.00 ± 0.44
Reserpine (0.5 mg/kg)	140.83 ± 0.30#	155.66 ± 1.54###	168.83 ± 0.83###
Fluoxetine (20 mg/kg)	112.00 ± 0.46***	104.33 ± 0.80***	89.16 ± 1.24***
EEGJ (100 mg/kg)	135.00 ± 0.56***	124.10 ± 0.41***	100.00 ± 0.68***
EEGJ (200 mg/kg)	131.00 ± 0.56***	116.33 ± 0.55***	93.60 ± 0.32***

Values are expressed as mean ± SEM. The analysis was done using one-way ANOVA followed by the tukey test. ###$p<0.001$, ##$p<0.01$, #$p<0.05$ compared with normal control, and ***$p<0.001$ compared with reserpine treated group.

3.4 Antiamnesic activity

3.4.1 Elevated plus maze

Transfer latencies were significantly ($p<0.001$) increased in the scopolamine-treated rats when contrasted with control and standard during both the acquisition (day 13) and retention (day 14) sessions. Administration of the EEGJ (100 and 200 mg/kg) in scopolamine-treated rats significantly ($p<0.001$) lowered the transfer latencies during both the acquisition and retention trial sessions when compared with the control, scopolamine treated groups. This indicates that the EEGJ possesses antiamnesic activity as presented in Table 10.

Table 10: Effect of EEGJ (100 and 200 mg/kg) on transfer latencies of rats on elevated plus maze following scopolamine-induced amnesia

Groups	Acquisition time	Retention time
Control	84.50 ± 0.5	79.83 ± 0.30
Scopolamine (1 mg/kg)	90.10 ± 0.36#	169.0 .± 0.56###
Donepezil (1 mg/kg)	58.26 ± 0.50***	34.10 ± 0.46***
EEGJ (100 mg/kg)	67.93 ± 0.30***	48.45 ± 0.54***
EEGJ (200 mg/kg)	59.93 ± 0.40***	39.16 ± 0.30***

Values are expressed as mean ± SEM. The analysis was done using one-way ANOVA followed by tukey test. ###$p<0.001$, #$p<0.05$ compared with normal control, and ***$p<0.001$, **$p<0.01$, *$p<0.05$ compared with scopolamine group.

3.4.2 Novel object detection test

Treatment with scopolamine has shown a significant decrease in the dissimilarity index when compared with the normal control group. This indicates an amnesic response. Treatment with EEGJ drug at doses of 100 mg/kg and 200 mg/kg has shown a significant increase in dissimilarity index in a dose-dependent manner when compared to the scopolamine group. The results showed that EEGJ significantly ameliorated the memory deficit seen in scopolamine-treated rats as presented in Table 11.

Table 11: Effect of EEGJ (100 and 200 mg/kg) on dissimilarity index of rats on novel object detection test

Groups	1st Day	7th Day	14th Day
Control	0.35 ± 0.027	0.42 ± 0.023	0.44 ± 0.013
Scopolamine (1 mg/kg)	0.13 ± 0.032###	0.09 ± 0.043###	0.02 ± 0.014###
Donepezil (1 mg/kg)	0.46 ± 0.043***	0.57 ± 0.052***	0.77 ± 0.025***
EEGJ (100 mg/kg)	0.33 ± 0.023***	0.45 ± 0.062***	0.52 ± 0.023***
EEGJ (200 mg/kg)	0.39 ± 0.022***	0.51 ± 0.053***	0.64 ± 0.024***

Values are expressed as mean ± SEM. The analysis was done using one-way ANOVA followed by the tukey test. ###$p<0.0001$ compared with normal control, and ***$p<0.001$ compared with scopolamine group.

4. Discussion

This study examined the antidepressant and antiamnesic activity of ethanolic extract of *G. jamesonii* flowers. The qualitative phytochemical analysis of EEGJ showed the presence of alkaloids, carbohydrates, reducing sugars, saponin, phytosterols, phenolic compounds, and flavonoids. The acute oral toxicity test of EEGJ was carried out with OECD 420 guidelines. During the 14-day experiment, there was no fatality or significant toxic responses at a dose of 2000 mg/kg/p.o. (Jothy *et al.,* 2011). Throughout the 14-day duration, every animal was observed to be in good condition, exhibiting no alterations in their eyes, skin, fur, respiratory, circulatory, nervous systems, motor activity, or behavioural patterns (Porwal *et al.,* 2017). Consequently, it is reasonable to suggest that its oral LD_{50} value be higher than 2000 mg/kg. Gross examination of the vital organs, including the liver, kidney, heart, and pancreas, indicated no treatment-related alterations in the animals following EEGJ administration. Acute toxicity studies' findings demonstrated that the EEGJ did not cause any toxicity symptoms. It is safe to utilize this herb for therapeutic purposes. Depression is a psychiatric condition that has a negative consequence on a person's quality of life. The pathophysiology of depression is mostly thought to be caused by the "depletion of monoamines"(Hasler, 2010). The reserpine-induced depression paradigm has been utilized because reserpine depletes monoamines, including dopamine, serotonin, and norepinephrine. Fluoxetine is a widely used antidepressant that works by blocking serotonin reuptake in presynaptic neurons. FST and TST were the two animal models employed in this investigation. The rationale behind the selection of these models is their affordability and ease of usage (Park *et al.,* 2018; Bakre *et al.,* 2019). At doses of 100 and 200 mg/kg, EEGJ exhibited a significant reduction in immobility time ($p<0.001$) in the rat FST and TST, with a profile comparable to that observed in the reserpine-treated rats. This indicates that the EEGJ significantly ameliorated depression-like behaviour in reserpine-treated rats.

Amnesia is a neurological disorder that impairs memory in individuals. Acetylcholine is the neurotransmitter implicated in memory because cholinergic neurons in the hippocampus mediate memory formation. The scopolamine-induced amnesia model was chosen because of its ability to impair memory by blocking cholinergic neurotransmission. Donepezil inhibits the acetylcholinesterase enzyme in the brain and is used to treat dementia and amnesia (Haam and Yakel 2017; Foyet *et al.,* 2019). The EPM test is used to assess short-term memory and learning. The novel object detection test is used to assess cognition and recognition memory, in rodent models (Yadav *et al.,* 2019). The elevated plus maze is thought to be a reliable behavioural model for memory evaluation. The study included an EPM behavioural learning task to assess the acquisition and retention of spatial memory (Pentkowski *et al.,* 2021). In this study, scopolamine raised the mean transfer delay into the closed arms of the EPM, suggesting a potential impact on memory. On the other hand, treatment with EEGJ at doses of 100 mg/kg and 200 mg/kg significantly decreased ($p<0.001$) the transfer latencies in the retention phase, suggesting an improvement in retention memory. It seems that EEGJ has a cognitive enhancing effect since it can reverse scopolamine-induced amnesia in the EPM test. The NODT is a well-researched method for assessing recognition memory in rats (Lueptow, 2017). The groups that received EEGJ showed a substantial preference for novelty, While the groups treated with scopolamine failed the novelty preference test and showed memory loss, The recognition index was dramatically increased in both the donepezil-treated and extract-treated groups, indicating that the animals were able to maintain their preference for the new object. This suggests that the extract improved the scopolamine-induced memory impairments in object recognition. Based on the behavioural tests, it can be said that EEGJ improved the recognition of memory and its retention. The findings demonstrated that EEGJ effectively improved the rats' scopolamine-induced memory loss.

5. Conclusion

This study showed that the ethanolic extract of *G. jamesonii* possesses anti-depressant and anti-amnesic activities. The qualitative screening revealed the presence of alkaloids, carbohydrates, reducing sugars, saponin, phytosterols, phenolic compounds, and flavonoids. The acute toxicity studies revealed that the extract was safe up to 2000 mg/kg, bd. wt. EEGJ, at all doses, showed dose-dependent antidepressant activity in the TST and FST, EEGJ dose-dependently reduced the duration of immobility ($p<0.001$) compared to reserpine treated animals. Moreover, in learning and memory experimental models, the treated animals reversed scopolamine-induced amnesic effects as evidenced by improved transfer latencies ($p<0.001$ vs scopolamine; elevated plus maze) and discrimination index ($p<0.001$ vs. scopolamine; novel object recognition test). These effects were more pronounced at higher concentrations of ethanolic extract of *G. jamesonii* and reported phytoconstituents might be credited to this phenomenal potential of this flower. Further isolation, characterization and purification of the active constituents and molecular mechanisms behind these effects need to be further explored and investigated in the future to elucidate the exact mechanism of action of *G. jamesonii.*

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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