NEUROPROTECTIVE EFFECT OF EMBLICA OFFICINALIS EXTRACT ON ACRYLAMIDE-INDUCED NEUROTOXICITY IN RATS: BEHAVIORAL AND PHYSIOLOGICAL INSIGHTS

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ABSTRACT

Introduction: Acryamide (ACR) is a neurotoxin that is produced during the high-temperature treatment of food containing carbohydrates, such as potato chips, French fries, cookies and biscuits, causing oxidative stress, neuronal damage, and behavioral dysfunction. Emblica officinalis (Amla), which is a good source of vitamin C, minerals, amino acids, and polyphenols, has antioxidant, anti-inflammatory, hypolipidemic, anti-diabetic, hepatoprotective, and neuroprotective effects.

Objective: This study evaluates neuroprotective properties of the Emblica officinalis fruit extract against neurotoxicity induced by ACR in rats using behavioral measures.

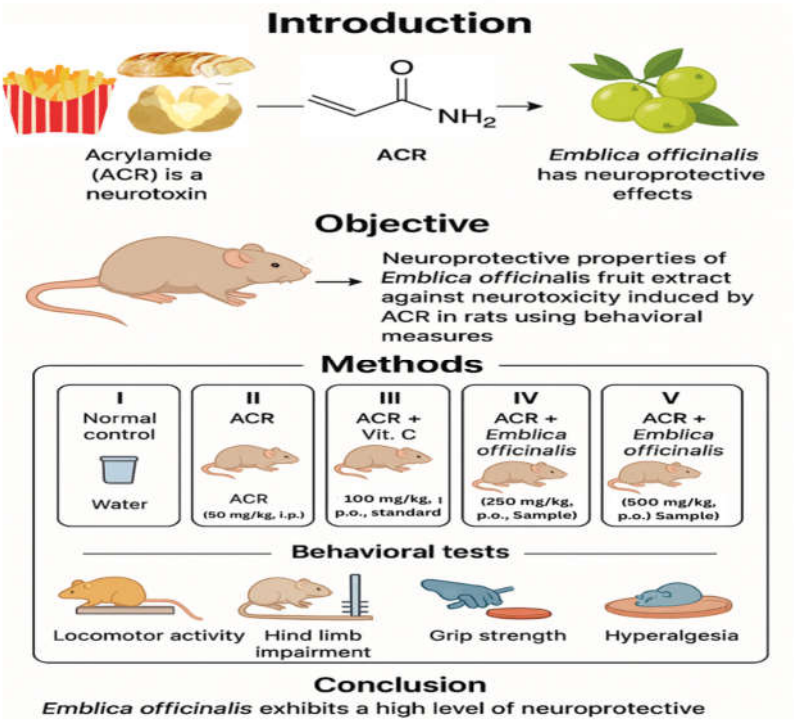
Methods: Wistar rats were divided into five groups (n=6). Group I (normal control) received water; Group II received ACR (50 mg/kg, i.p.); Group III received ACR + Vitamin C (100 mg/kg, p.o., standard); Group IV received ACR + Emblica officinalis (250 mg/kg, p.o.); Group V received ACR + Emblica officinalis (500 mg/kg, p.o.). Behavioral tests—locomotor activity, hind limb impairment (narrow beam test), grip strength, and hyperalgesia (hot plate test)—were conducted on day 7. Data were analyzed using one-way ANOVA followed by Tukey's test.

Results: Compared to controls, ACR treatment was significant in reducing locomotor activity ($p<0.001$), increasing hind limb impairment ($p<0.001$), decreasing grip strength ($p<0.001$) and causing hyperalgesia (reduced latency to hind paw licking, $p<0.001$). The effects of Emblica officinalis co-administration were dose-dependent in reversing these effects with the 500 mg/kg dose returning levels to almost normal, similar to Vitamin C.

Conclusion: Emblica officinalis exhibits a high level of neuroprotective properties against ACR-induced neurotoxicity, implying that the plant might be used as a therapeutic agent to reduce neuronal damage by ACR in the diet.

Keywords: Acrylamide, Neurotoxicity, Emblica officinalis, Oxidative Stress, Neuroprotection, Behavioral Assessment.

Graphical Abstract:



1. INTRODUCTION

1.1 Neurotoxicity:

Nervous system toxicology has become a hot topic in recent years because it is susceptible to chemical damage and due to its role in affecting the population. Neurodegenerative diseases are incurable, progressive diseases associated with brain trauma, such as the Alzheimer disease (AD), Parkinson disease (PD), stroke, and

amyotrophic lateral sclerosis (ALS), are linked to selective neuronal death in particular brain areas. There is no curative treatment of the most frequent types of AD or PD.

AD is characterized by gradual neuronal loss in the hippocampus and cortex, and has such symptoms as memory loss, cognitive defect, and behavioural impairments. Its aetiology is uncertain because of the complex pathogenesis, although neurotoxicity of misfolded 8 -amyloid (A8) and phosphorylated tau proteins is evidenced. No recovery cure exists.

PD is associated with progressive dysfunction of the dopaminergic neurons in the substantia nigra pars compacta and striatal nerve fibres. It is an age-related condition which is characterized by bradykinesia, tremor and postural instability. Oxidative stress plays a crucial role, which produces reactive oxygen species (ROS) and changes the mitochondrial activity. DA oxidative stress leads to macromolecular damage, whereas mitochondrial dysfunction leads to the increase and death of cells in the presence of ROS. This is worsened by neuroinflammation including nitric oxide and superoxide release by microglia. The pathophysiology of oxidative stress is explained by gene mutations in the family PD proteins.

Moreover, neuroinflammatory responses also include the release of nitric oxide and superoxide by microglia accompanied by aggravation of alpha-synuclein, neuromelanin, and matrix metalloproteinase-3. Research on proteins associated with PD demonstrates that cellular dysfunction is related to oxidative stress [1].

1.2 Acrylamide:

Acryamide (ACR) formula C3H5NO, a molecular weight of 71.08 is an odorless crystalline solid at room temperature. The monomeric form is water-soluble and toxic and finds applications in labs in electrophoresis and industries as water management, cosmetics, ore processing, and in dye synthesis. ACR develops on cooked foods that are heated at high temperature which has led to the interest in dietary neurotoxicity. Being classified as possibly carcinogenic to humans (IARC, 1994), it has neurotoxicity, genotoxicity, carcinogenicity, mutagenicity, and reproductive toxicity [2].

1.2.1 Physicochemical properties of Acrylamide (ACR):

- Chemical name: Acrylamide
- IUPAC name: Prop-2-enamide
- Molecular weight: 71.08
- Chemical formulae: C3H5NO

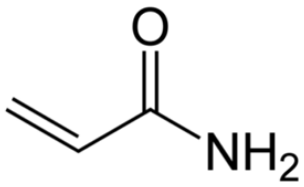


Figure 1: Structure of Acrylamide

- Solubility: Soluble in water (2155 g/L at 30°C) and polar solvents (acetone, methanol, ethanol); insoluble in non-polar (carbon tetrachloride).
- Density: 1.122 g/L (25°C).
- Boiling point: 125°C at 3.3 kPa.
- Melting point: 84.5°C.

1.2.2 Source of Ingestion

(a) Dietary Exposure:

Figure 2: Dietary Sources of Acrylamide

High-carbohydrate thermally processed foods like biscuits, cookies, French fries, and potato chips contain ACR. No ACR in boiled foods, but highest in fried/grilled potato/grain dishes at ≥180°C. Formation involves pyrolytic asparagine fragments from Maillard-active precursors. Smoking and coffee are key sources. Residual ACR in water is concerning; EU limit 0.1 µg/L.

Table 1: Acrylamide levels in various diets

Category	Samples Tested	Samples Positive	Mean	SD	Min	Max
Soybean paste	4	4	13.70	8.39	4.08	24.40
Processed meat	6	6	23.62	20.10	2.31	49.06
Rice roll and noodle	11	9	23.22	15.19	9.12	52.09
Cooked meat	5	5	25.03	21.97	2.71	78.57
Sauted nut	8	7	225.14	19.09	4.04	54.66
Roasted bread	5	5	36.72	26.54	10.50	67.19
Wafer biscuit	6	5	44.92	33.86	10.36	86.76
Roasted rice cake	6	6	68.34	65.75	16.82	196.46
Pancake	8	7	70.33	127.86	1.88	352.90
Roasted biscuit	24	23	97.57	103.71	0.41	484.17
Crisp	11	9	137.91	119.68	17.39	398.23
Fried flour snack	8	8	131.73	122.75	39.12	432.92
Fried rice crust	8	8	201.51	122.62	100.46	491.76
Fried prawn strips	4	4	341.40	122.95	166.25	439.44
Fried potato	9	9	604.41	1,327.87	58.40	4,126.26
Total	123	115	94.16	54.74	0.41	4,126.26

(b) Occupational Exposure:

ACR manufactures polyacrylamide to treat water and food containers, which causes indirect exposure. Monomeric ACR causes neuropathies in humans/animals; polymer is benign. Sub chronic exposures lead to ataxia, gait problems, muscle weakness, skin problems, numbness. Fumes irritate to skin/eyes, paralyze the brain. Neurotoxicity in humans is replicated in animals (rats, guinea pigs, etc.) exposed to it daily (0.5-50mg/kg) [3].

1.3 Biotransformation of Acrylamide (Table 2)

ADME Phase	**Details**
Absorption	ACR rapidly absorbed via skin, mucosa (inhaled), or orally; hydrosolubility enables uniform body diffusion.
Distribution	Unaffected by dose/method; highest in erythrocytes, low in nervous system, crosses placenta easily.
Metabolism	Blood half-life ~2 hours; tissues initial 5 hours, terminal 8 days; no accumulation. CYP2E1 oxidizes 50% to glycidamide (DNA-reactive); varies with polymorphisms (50% in wild-type mice, none in null). Glycidamide broken by epoxide hydrolase or GSH.
Excretion	Same as metabolism: blood half-life ~2 hours; tissues initial 5 hours, terminal 8 days; no accumulation. Glycidamide processed by epoxide hydrolase or GSH.

1.4 Mechanism of Acrylamide

The acrylonitrile is formed in high temperature food processing (high temperature of at least 120 C) such as baking, frying, or roasting. Neither is a natural ingredient but occurs principally via the Maillard reaction of asparagine and reducing sugars (glucose/fructose). Acrolein is also a minor pathway of lipids.

Maillard Reaction Pathway (Primary):

- Condensation: Asparagine condenses with a reactive carbonyl from reducing sugar, forming unstable Schiff bases.
- Amadori Rearrangement: At acidic pH, Schiff bases rearrange to Amadori compounds.
- Enolization and Fragmentation: Amadori products undergo enolization to form reductones and deoxyosones, leading to melanoidins (brown color/scent).
- Strecker Degradation: Dicarbonyls decarboxylate to Strecker aldehydes, promoting acrylamide.
- Alternative Decarboxylation: Schiff base decarboxylates to azomethine ylide; hydrolysis yields 3-aminopropionamide, which decomposes to acrylamide.

Acrolein Pathway (Minor):

- Pyrolysis of Glycerols/Lipids: High heat breaks down glycerols (from fats/oils) to acrolein (2-propenal).
- Oxidation: Acrolein oxidizes to acrylic acid.
- Ammoniation: Acrylic acid reacts with ammonia (from Strecker degradation or aspartic acid) to form acrylamide.

Other sources: Proteinogenic amino acids (cysteine/serine via pyruvic acid), aspartic acid, β-alanine, carnosine; in meat, lipid degradation yields acrolein [4].

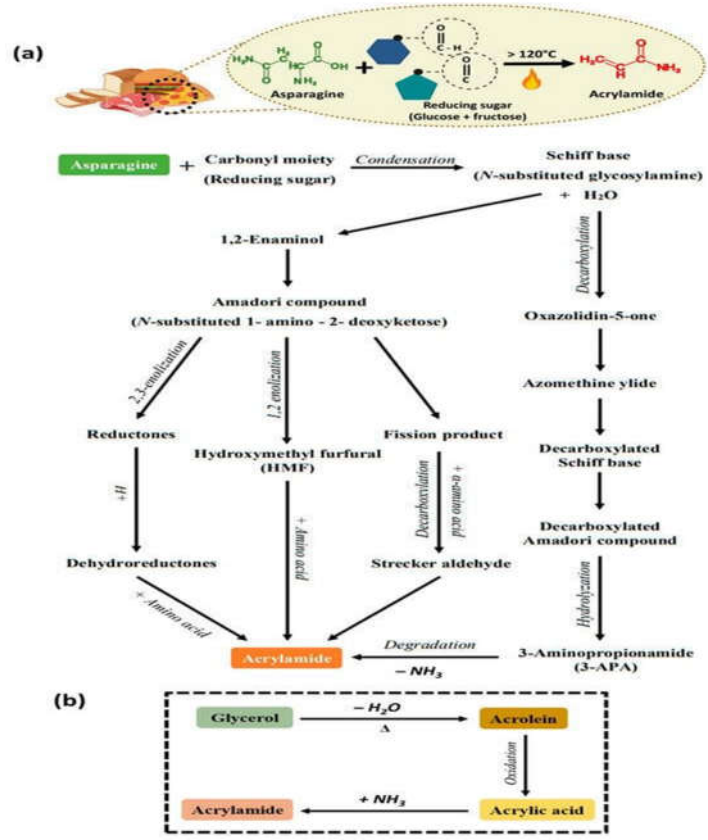


Figure 3: (a) Conversion of asparagine to acrylamide and the overall mechanism of acrylamide formation via the Maillard reaction. (b) Formation of acrylamide via the acrolein pathway.

1.5 Neurotoxicity of Acrylamide:

The neurotoxicity induced by acrylamide (ACR) may be achieved via unknown pathways like the interaction of nucleic acid, distortion of neurotransmitter, membrane damage, and lipoperoxidation. Central/peripheral nerve disease, with paranodal distal axonal swelling (neurofilaments, tubulovesicular profiles, degenerating mitochondria), but no proximal axonal degeneration is seen in sub chronic exposure. Sensory, and later, autonomic/motor are the first axons affected. Cavanagh dying-back (poor transport of axons by components) and Schaumburg/Spencer direct axonal injury (multifocal swelling through large-diameter axons) are some theories, and Sickles, kinesin inhibition to disrupt axonal transport. According to LoPachin exhibits nerve defects by blocking the release of neurotransmitters by adducing cysteine. Among them are oxidative stress (ROS, decreased GSH) and Purkinje cell injury (membrane-fusion/tubulovesicular damage). Dose based neurotoxicity, not necessarily critical degeneration is cumulative [5].

1.6 Emblica officinalis:

In Ayurveda, Emblica officinalis (EO, Amla, Phyllanthus emblica, Indian gooseberry) is revered as the first tree. Euphorbiaceae family; medium deciduous tree (8-18m) native to tropical SE Asia, habitats: India, Pakistan, Bangladesh, Sri Lanka, China, Mascarene Islands, Malaysia Properties: Antitussive, immunomodulatory, neuroprotective, gastroprotective, cytoprotective, analgesic, antipyretic; improves cognition, lowers cholesterol, treats eyes. Antioxidant/neuroprotective shown in neurodegenerative models. Protects against chemical neurotoxicity, but not studied for ACR in mice [6].

1.6.1 Phytochemistry of Emblica officinalis

Table 3: Properties, functions, and some common sources of bioactive compounds isolated

Compound names	Molecular formula	Molecular weight	BP/ MP	Biological activity	Common sources	References
Chebulinic acid	C41H32O27	956.67 gm/mol	1460°C at 760 mmHg (BP)	Antioxidant activity, Antisecretory and cryo-protective activity	Phyllanthus emblica, Terminalia arborea, and T. chebula	[7]
Chebulagic acid	C41H30O27	954.66 gm/mol	1610.6°C at 760mmHg (BP)	Antispasmodic action	E. officinalis, Terminalia Chebula, T. citrine, T. catappa	[8]
Emblicanin-A	C34H22O22	<1000 gm/mol	Not confirmed	Antioxidant activity	E. officinalis	[9]
Emblicanin-B	C34H22O22	<1000 gm/mol	Not confirmed	Antioxidant activity	E. officinalis	[10]
Gallic acid	C7H6O5	170.12 gm/mol	252° C (MP)	Radioprotective effect, chemopreventive effect, anti-carcinogenic, antioxidative, antimutagenic, antiallergic and anti-inflammatory activities	E. officinalis; T chebula; T bellerica, C sinensis L., Arctostaphylos uva-ursiL., C avellana, O biennis, V viniferaL.	[11]
Ellagic acid	C14H6O8	302 gm/mol	≥350 °C (MP)	Radioprotective and chemopreventive effect, antityrosinase Activity, antioxidant, antiproliferative, and antiatherogenic Properties, estrogenic/antiestrogenic Activity	E. officinalis, Castanea sativa, Eucalyptus camaldulensis, Juglans regia	[12]
Quercetin	C15H10O7	302.24 gm/mol	316.5 °C (MP)	Radioprotective, chemopreventive, hepato protective effect	E. officinalis	[13]
Phyllantine	C14H17NO3	247.29 gm/mol	Not confirmed	Not confirmed	E. officinalis	[14]
Phyllantidine	C13H15NO3	233.2631 gm/mol	Not confirmed	Neuropharmacological activity (CNS activity)	E. officinalis, P. discoides; Seurinega suffruticosa	[15]
Punigluconin	C34H26O23	802.556 gm/mol	1448.6°C at 760	Antioxidant activity	E. officinalis	[16]

Compound names	Molecular formula	Molecular weight	BP/ MP	Biological activity	Common sources	References
			mmHg (BP)			
Pedunculagin	C34H24O22	784.54 gm/mol	1578.039 °C at 760 mmHg (BP)	Antitumor activity, Antioxidant activity	E. officinalis	[17]

1.7 Aim and Objectives

1.7.1 Aim

To evaluate the Neuroprotective effect of Emblica officinalis fruit extract on Acrylamide induced neurotoxicity in rats.

1.7.2 Objective

The main objective of the study was to evaluate the Neuroprotective effect of Emblica Officinalis fruit extract on Acrylamide induced neurotoxicity in rats altered behavioral studies [18].

- Hind limb impairment.
- Grip strength.
- Hyperalgesia.
- Locomotor activity.

1.7.3 Need of Study

- Acrylamide is obtained from thermally processed carbohydrate rich foods like potato chips, French fries, cookies, biscuits.
- Amla is highly nutritious and is an important dietary source of vitamin C, minerals, and amino acids.
- Emblica officinalis extracts have also been reported to possess hypolipidemic, anti-obesity, anti-diabetic, anti-cancer, hepatoprotective and anti-inflammatory activities.

So, we have chosen Emblica officinalis as a treatment for ACR induced neurotoxicity in rats.

2. MATERIALS & METHODS

2.1. Study Design:

To evaluate the neuroprotective effect of Emblica officinalis fruit extract on acrylamide-induced neurotoxicity in rats.

2.2. Chemicals:

- Acrylamide (ACR) 25g obtained from Bl chemical products.
- Vitamin C tablets 500mg manufactured by ABBOTT HEALTHCARE PVT LTD procured from local medical store.
- Emblica officinalis procured from local vendor; other chemicals obtained locally.

2.3. Experimental Animals

Male Wistar rats purchased from National Institute of Nutrition (Table 4), Hyderabad (Teena bio labs PVT. Limited 177/PO/cb/99/CPCSEA). Housed individually in standard clean, transparent polypropylene cages with free access to food and water; 12:12hr dark/light cycle. Acclimatized for one week and divided into groups. Procedures per CPCSEA guidelines (320/CPCSCEA dated 03-01-2001). Approved by IAEC (287/R/S/2000/CCSEA dated 20.07.2022), Sarojini Naidu Vanita Pharmacy Maha Vidyalaya, Hyderabad.

2.4. Experimental Design

- Total animals: 30
- Sex: Male
- Strain: Wistar rats
- Body weight: 100-200g
- Groups: 5
- Induction: ACR
- Treatment: Emblica officinalis fruit extract
- Standard: Vitamin C
- Housed in controlled conditions (22±2°C; 12hr light/12hr dark cycle)

Table 4: Grouping of animals

Grouping	Dosage	No. of animals	Route of Administration
I. Control	Water	6	Oral
II. Acrylamide	50 mg/kg	6	I.P
III. Acrylamide + Vitamin C	50 mg/kg + 100 mg/kg	6	I.P & Oral
IV. Acrylamide + Emblica officinalis fruit extract	50 mg/kg + 250 mg/kg	6	I.P & Oral
V. Acrylamide + Emblica officinalis fruit extract	50 mg/kg + 500 mg/kg	6	I.P & Oral

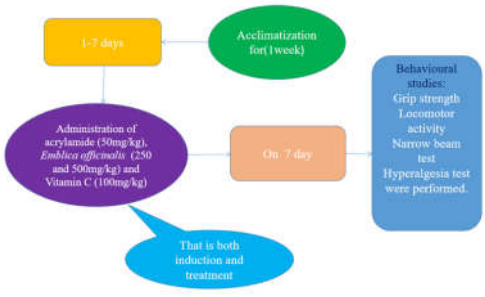


Figure 4: Experimental design

Study began with one-week acclimatization, followed by 7th day protocol: ACR 50 mg/kg, Emblica officinalis 250/500 mg/kg, Vitamin C 100 mg/kg. Included toxicity induction and intervention. Behavioral assessments on 7th day: grip strength (neuromuscular function), locomotor activity (movement/energy), narrow beam test (motor coordination/balance), hyperalgesia test (pain sensitivity/nociception). Provided insights into Emblica officinalis protective effects against ACR neurotoxicity [19].

2.4. Preparation of Emblica officinalis Fruit Extract

Fruits cut into pieces, seeds removed, sun-dried. Dried powder extracted with 99% ethanol using Soxhlet apparatus below 60°C for 24 hours. Solvent evaporated under vacuum to semisolid mass. Stored as stock in refrigerator, diluted with distilled water as needed [20].

Figure 5: Soxhlet extraction of Emblica officinalis fruit

2.5. Behavioural Studies

2.5.1 Narrow Beam Test

Measures rear limb deficits. Animals trained to walk across 180 cm wooden beam (split into three 60 cm segments: 1,2,3), 100 cm above floor, from platform to home cage. Foot slips onto underhanging ledge noted.

- Score 0 – Rat traverse through the beam without falling.
- Score 1 – Rat fell off in the third segment.
- Score 2 – Rat fell in second segment.
- Score 3 – Rat fell in first segment.
- Score 4 – Rat fell even to sit/ balance the beam.

Each rat was tested three times. The averages of scores for three trials per rat were taken.

Figure 6: Narrow Beam Test

2.5.2 Grip Strength (Motor Coordination)

Assesses muscular coordination, motor dysfunction, balance requiring unmodified central function using Rota rod at 10 cycles/min, 180s cutoff. Three repetitions at 60-min intervals; averaged times compared.

2.5.3 Hyperalgesia

Eddy's Hot Plate measures thermal sensitivity (central/peripheral mechanisms). Animal on hot plate at 45 ± 1°C; 12s cutoff to prevent injury. Latency to paw licking/jump as pain threshold indicator.

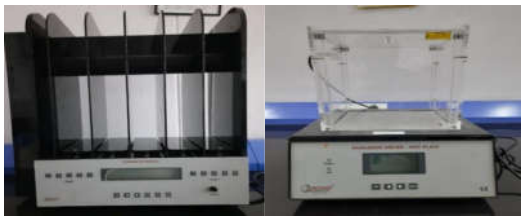


Figure 7: Rotarod apparatus & Eddy's hot plate

2.5.4 Locomotor Activity

Tracks movements for treatment-induced sleep/wake disruptions as general toxicity gauge. Using Actophotometer (light beam cuts count movement); 300s cutoff, locomotor score recorded.

Figure 8: Actophotometer

2.5.6 Statistical Analysis

Data expressed as Mean ± SEM were analyzed by one way analysis of variance (ANOVA) followed by Tukey's test as a post hoc by using Graph Pad prism software (8.4.3 version). p values less than 0.001 were considered as statistically significant [21].

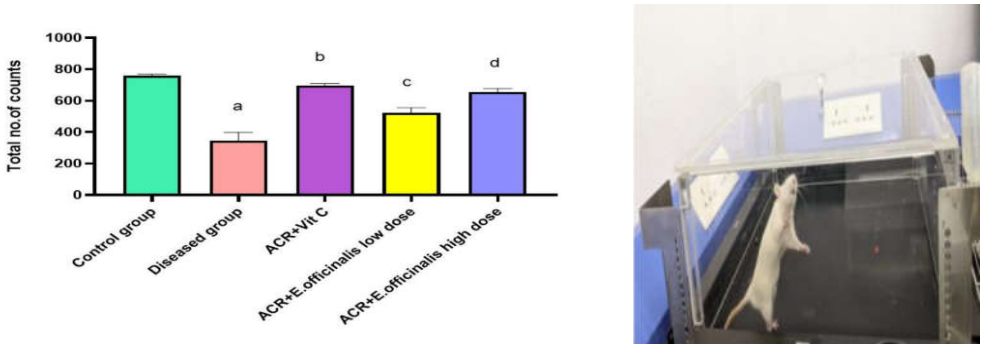
3. RESULTS

3.1 Effect of Emblica officinalis on Locomotor Activity in Acrylamide-Induced Neurotoxic Rats

Locomotor activity tracks animal movement for treatment-induced sleep/wake disturbances, indexing general toxicity. ACR group showed significant ($p<0.001$) decrease vs. normal control. Emblica officinalis reversed this decrease vs. ACR control and standard ($p<0.001$). Results in Table 5.

Table 5: Effect of Emblica officinalis on Acrylamide-Induced Altered Locomotor Score

S.No	Groups	Total no of counts (5 min) - 7 days
1	Control (water)	758.3±6.173
2	Acrylamide (50mg/kg)	346.3±29.79
3	Acrylamide (50mg/kg) + Vitamin C (100mg/kg)	697±6.807
4	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (250mg/kg)	524.0±18.25
5	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (500mg/kg)	654.3±13.17



Graph 1: Graphical Representation of Emblica officinalis Effect on Acrylamide-Induced Altered Locomotor Score

Data as Mean ± SEM; one-way ANOVA followed by Tukey's test.

a $p<0.001$, b $p\leq0.001$ vs. Normal Control.

c $p<0.001$, d $p<0.001$ vs. ACR group.

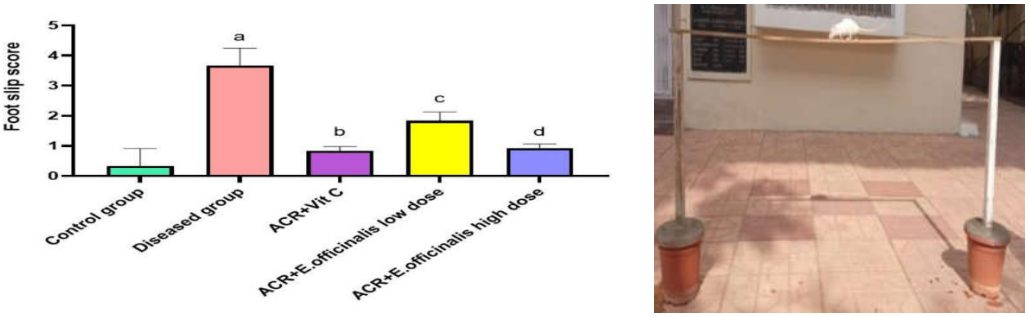
c $p<0.001$, d $p\leq0.001$ vs. Standard group.

3.2 Effect of Emblica officinalis on Hind Limb Impairment in Acrylamide-Induced Neurotoxic Rats

Narrow beam test detects motor skills, coordination, balance, and hind limb impairment. ACR increased impairment on day 7 vs. control. Emblica officinalis (250mg/kg) reduced it vs. ACR; 500mg/kg restored to normal like Vitamin C. Results in Table 6.

Table 6: Effect of Emblica officinalis on Acrylamide-Induced Altered Hind Limb Impairment in Rats

S.No	Groups	Foot slip score - 7 days
1	Control (water)	0.333±0.333
2	Acrylamide (50mg/kg)	3.667±0.333
3	Acrylamide (50mg/kg) + Vitamin C (100mg/kg)	0.8333±0.08333
4	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (250mg/kg)	1.833±0.333
5	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (500mg/kg)	0.9167±0.333



Graph 2: Graphical Representation of Emblica officinalis Effect on Acrylamide-Induced Altered Hind Limb Impairment in Rats

Data as Mean ± SEM; one-way ANOVA followed by Tukey's test.

a $p<0.001$, b $p\leq0.001$ vs. Normal Control.

c p<0.001, d p<0.001 vs. ACR group.

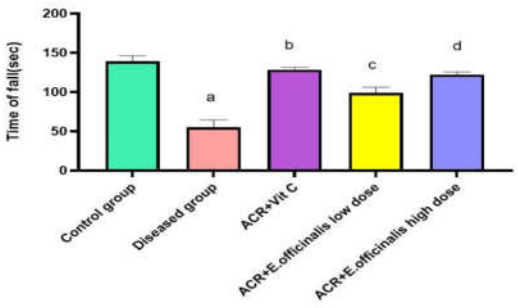
c p<0.001, d p≤0.001 vs. Standard group.

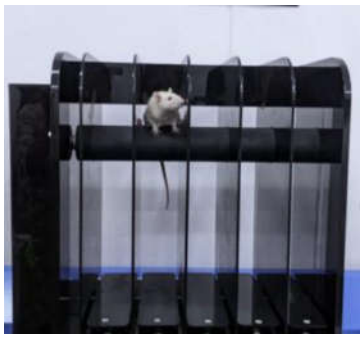
5.1.3 Effect of Emblica officinalis on Grip Strength in Acrylamide-Induced Neurotoxic Rats

Rota rod assesses motor clumsiness; time on rod measures balance, coordination, condition, and motor planning. ACR decreased latency to fall (p<0.001) vs. control. Emblica officinalis (250mg/kg) increased latency; 500mg/kg restored to normal like Vitamin C (p<0.001). Results in Table 7.

Table 7: Effect of Emblica officinalis on Acrylamide-Induced Altered Grip Strength in Rats

S.No	Groups	Time of fall (sec) - 7 days
1	Control (water)	139±4.041
2	Acrylamide (50mg/kg)	55±5.508
3	Acrylamide (50mg/kg) + Vitamin C (100mg/kg)	128.3±1.764
4	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (250mg/kg)	98.67±4.333
5	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (500mg/kg)	122±2.082





Graph 3: Graphical Representation of Emblica officinalis Effect on Grip Strength in Acrylamide-Induced Neurotoxic Rats

Data as Mean ± SEM; one-way ANOVA followed by Tukey's test.

a p<0.001, b p≤0.001 vs. Normal Control.

c p<0.001, d p<0.001 vs. ACR group.

c p<0.001, d p≤0.001 vs. Standard group.

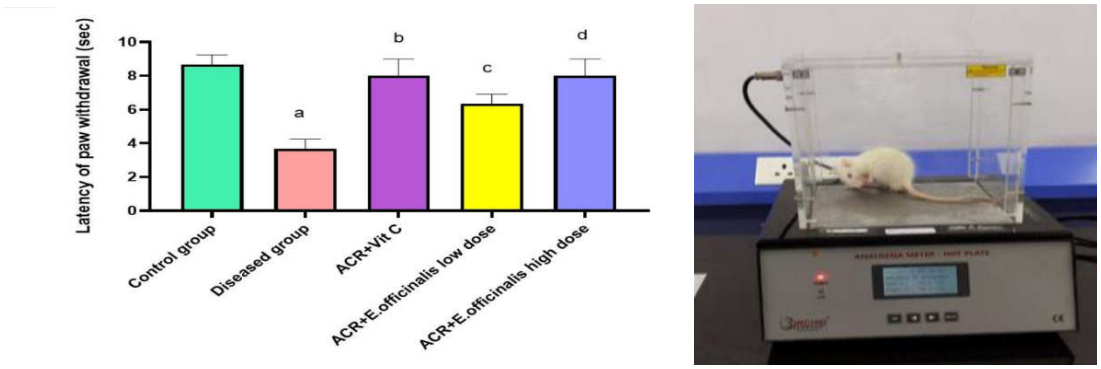
5.1.4 Effect of Emblica officinalis on Hyperalgesia in Acrylamide-Induced Neurotoxic Rats

Eddy's Hot Plate (45±1°C) assesses pain sensitivity. ACR reduced paw licking latency vs. control. Emblica officinalis (250mg/kg) increased latency; 500mg/kg matched normal and Vitamin C. Results in Table 8.

Table 8: Effect of Emblica officinalis on Altered Hyperalgesia (45°C) in Acrylamide-Induced Neurotoxic

S.No	Groups	Latency of paw withdrawal (12s) - 7 days
1	Control (water)	8.667±0.333
2	Acrylamide (50mg/kg)	3.667±0.333

S.No	Groups	Latency of paw withdrawal (12s) - 7 days
3	Acrylamide (50mg/kg) + Vitamin C (100mg/kg)	8.0±0.5774
4	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (250mg/kg)	6.333±0.333
5	Acrylamide (50mg/kg) + Emblica officinalis fruit extract (500mg/kg)	8.0±0.5774



Graph 4: Graphical Representation of Emblica officinalis Effect on Altered Hyperalgesia in Acrylamide-Induced Neurotoxic Rats

Data as Mean ± SEM; one-way ANOVA followed by Tukey's test.

a $p<0.001$, b $p\leq0.001$ vs. Normal Control.

c $p<0.001$, d $p<0.001$ vs. ACR group.

c $p<0.001$, d $p\leq0.001$ vs. Standard group.

4. DISCUSSION

Studies in laboratory rats have shown that acrylamide (ACR) has substantial neurotoxicity due to oxidative stress and can be used as a model to assess neuroprotective agents that are antioxidant. The purpose of the present study was to assess the ability of Emblica officinalis to mitigate ACR-induced neurophysiological deficits. The present study found behavioural deficits expected based on previous studies. In the narrow beam test, ACR resulted in substantial hind limb impairment and diminished motor functions. In the narrow beam test, Emblica officinalis (especially with 500 mg/kg) remarkably prevented the injury associated with ACR, restoring function to near-normal levels akin to standard Vitamin C (in highest dosage form), with 250 mg/kg function levels being much less than either higher dosage group. In the Rota rod test, ACR impaired motor coordination in rats. This could possibly be due to ACR selectively impacting peripheral and central nerves terminals. That is, ACR administration was found to impair motor coordination with Emblica officinalis treatment restoring reduced results due to ACR intoxication compared to healthy control measures. An examination of thermal hyperalgesia showed that ACR produced a marked reduction in hind paw licking latency [22].

However, treatment with Emblica officinalis significantly increased latencies and the increasing latencies across the treatments appeared to mimic a control and a Vitamin C treated group. Locomotor activity, being a critical measure of ACR-induced neurotoxicity was diminished through ACR intoxication. An assessment of locomotor activity for treated rats suggested improved mobility compared to ACR intoxicated rats and showing environmental features would influence locomotor patterns. While it is unclear precisely how Emblica officinalis is able to mitigate ACR-induced neurotoxicity in rats, these benefits were likely facilitated due to, in part, Emblica officinalis' antioxidant properties to provide sufficiently sustained protection against ACR in intoxicated rats [23].

CONCLUSION

The current research provides evidence that Emblica officinalis treatment has a significant neuroprotective impact on acrylamide-induced neurotoxicity in rats, as demonstrated by improvements in hind limb impairment, locomotor activity, pain threshold, and grip strength. Importantly, the high dose of Emblica officinalis (500 mg/kg) appeared to be the most effective, returning the same parameters to normal levels and yielding results comparable to standard Vitamin C. Furthermore, the high dose of Emblica officinalis (500 mg/kg) was more successful than the low dose (250 mg/kg) in terms of managing neurotoxicity.

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Ethical Statement

All experimental procedures involving animals were conducted in accordance with the guidelines of the Institutional Animal Ethics Committee (IAEC) and approved as per the norms of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Government of India.

Competing Interests

The authors declare no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Authors' Contribution

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A V Vasanthi (Co-author 2): Writing – Review & Editing, Data Curation & Critical Reviews

B Medha Gayatri (Co-author 2): Formal Analysis & Review

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