RESEARCH PAPER

To Evaluate the Nephroprotective Effects of Celosia Cristata Whole Plant Extract on Gentamicin-Induced Kidney Damage in Wistar Albino Rats

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ABSTRACT

Background: Gentamicin-induced nephrotoxicity is a major limitation of aminoglycoside therapy and is associated with impaired renal function, oxidative stress, depletion of endogenous antioxidants, and structural damage to renal tissue. *Celosia cristata* has been reported to possess antioxidant and pharmacological properties; however, its nephroprotective potential against gentamicin-induced renal injury requires further investigation. The present study was undertaken to evaluate the nephroprotective effects of *Celosia cristata* whole plant extract in gentamicin-induced kidney damage in Wistar albino rats.

Methodology: The whole plant extract of *Celosia cristata* was subjected to preliminary phytochemical screening to identify major phytoconstituents, followed by acute toxicity evaluation to establish its preliminary safety profile. Nephrotoxicity was induced in Wistar albino rats by administration of gentamicin at 100 mg/kg/day for 8 consecutive days. The extract was administered orally at doses of 200 and 400 mg/kg/day, with a standard drug-treated group included for comparison. Renal function was assessed by measuring serum creatinine, blood urea nitrogen (BUN) and uric acid. Oxidative stress and antioxidant status were evaluated using malondialdehyde (MDA), reduced glutathione (GSH), superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). Histopathological examination of kidney tissues was performed to assess structural changes.

Results: Gentamicin administration produced marked renal dysfunction, as evidenced by elevated serum creatinine, BUN, uric acid, and MDA levels, along with depletion of GSH and significant reductions in SOD, CAT, and GPx activities. Treatment with *C. cristata* whole plant extract attenuated these gentamicin-induced alterations in a dose-dependent manner. The 400 mg/kg dose produced greater improvement, with serum creatinine, BUN, uric acid, and MDA levels approaching normal values and antioxidant parameters showing substantial restoration. Histopathological examination further revealed reduced tubular degeneration, necrosis, inflammatory infiltration, and other structural abnormalities in extract-treated groups.

Conclusion: The findings indicate that *Celosia cristata* whole plant extract possesses promising nephroprotective and antioxidant activity against gentamicin-induced renal injury in Wistar albino rats. The protective effect was more pronounced at the 400 mg/kg dose, suggesting a dose-dependent nephroprotective potential. These effects may be associated with the antioxidant properties of the phytoconstituents present in the extract.

Keywords: *Celosia cristata; Nephroprotective activity; Gentamicin-induced nephrotoxicity; Oxidative stress; Antioxidant activity; Renal injury; Wistar albino rats.*

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1. INTRODUCTION

The kidneys are paired, bean-shaped organs located retroperitoneally on either side of the vertebral column between the levels of T12 and L3 vertebrae. Each kidney measures approximately 10-12 cm in length, 5-7 cm in width and 3 cm in thickness with an average weight of 120-170 g in adults [1].

The kidneys perform several essential physiological functions but their primary function is to filter blood and remove metabolic waste products such as urea, creatinine, uric acid and various drugs and toxins through urine formation. Approximately 180 L of filtrate are produced daily from which nearly 99% is reabsorbed, resulting in the excretion of about 1-2 L of urine per day. The kidneys also regulate body fluid volume and electrolyte balance by controlling the excretion and reabsorption of sodium, potassium, calcium, phosphate, chloride and water, thereby maintaining normal osmolarity and blood pressure [2].

They also function as endocrine organs by secreting renin which regulates blood pressure through the renin–

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angiotensin–aldosterone system (RAAS) and erythropoietin which stimulates red blood cell production. Furthermore, the kidneys activate vitamin D into its biologically active form calcitriol, which is essential for calcium absorption and bone health. Any impairment of these functions due to nephrotoxic agents such as gentamicin can result in electrolyte imbalance, hypertension, anemia and progressive kidney dysfunction [3].

Kidney diseases represent a major global public health challenge because of their increasing prevalence, high mortality and substantial socioeconomic burden. Chronic kidney disease (CKD) and acute kidney injury (AKI) together affect hundreds of millions of people worldwide and are associated with increased risks of cardiovascular disease, end-stage renal disease (ESRD), and premature death [4].

Acute Kidney Injury (AKI) is a clinical syndrome characterized by a sudden decline in kidney function occurring over a period of hours to days. It results in the accumulation of nitrogenous waste products such as urea and creatinine, disturbances in electrolyte and acid–base balance and impaired regulation of body fluid homeostasis [5].

Globally, AKI affects approximately 13–15 million people annually, resulting in nearly 1.7 million deaths each year. More than 85% of AKI cases occur in low- and middle-income countries, were limited healthcare resources delay diagnosis and treatment. In hospitalized patients, AKI develops in approximately 10–15% of admissions, while its incidence increases to 40–60% among critically ill patients admitted to intensive care units (ICUs) [6].

Chronic Kidney Disease (CKD) is a progressive and irreversible disorder characterized by the gradual loss of kidney function over a period of three months or longer [7]. The progression of CKD is associated with persistent oxidative stress, chronic inflammation, glomerulosclerosis, tubular atrophy, interstitial fibrosis and progressive nephron loss leading to irreversible deterioration of renal function [8].

Nephrotoxicity refers to the functional or structural damage to the kidneys developed after their exposure to various drugs, diagnostic techniques and toxins. The effects of these drugs can lead to functional renal disorders which include damage to the glomerular and/or tubular functions of the kidneys, damage to the renal mechanism controlling blood pressure and disruption of kidney's endocrine functions [9]. Toxins which exhibit nephrotoxicity are nephrotoxins. Nephrotoxins include anti-cancer drugs, anti-biotics and heavy metals [10]. Nephrotoxicity is indicated by reduced urine concentration capacity, tubular proteinuria, lysosomal enzymuria, mild glucosuria, decreased ammonium excretion, decrease in GFR, rise in serum BUN and an increase in serum creatinine level along with morphological changes to the kidney tissue [11]. Drug-induced nephrotoxicity, particularly due to aminoglycoside antibiotics such as gentamicin, remains one of the leading causes of hospital-acquired AKI.

Gentamicin is a broad-spectrum aminoglycoside antibiotic widely used for the treatment of severe bacterial infections caused by aerobic Gram-negative microorganisms [12]. Despite its excellent antimicrobial efficacy, the clinical use of gentamicin is significantly limited by its dose-dependent toxicity, particularly nephrotoxicity and ototoxicity [13].

Gentamicin-induced nephrotoxicity is a complex process involving drug accumulation, oxidative stress, inflammation, mitochondrial dysfunction, apoptosis and tubular necrosis. Following systemic administration, approximately 90–95% of gentamicin is eliminated unchanged through glomerular filtration while a small proportion is selectively accumulated within the proximal convoluted tubular epithelial cells of the kidney. Gentamicin enters these cells primarily through megalin- and cubilin-mediated endocytosis resulting in intracellular accumulation within lysosomes. Excessive accumulation eventually disrupts lysosomal membranes, releasing gentamicin into the cytoplasm and initiating cellular injury [14].

One of the primary mechanisms of gentamicin-induced renal damage is the excessive generation of reactive oxygen species (ROS) including superoxide anions, hydroxyl radicals and hydrogen peroxide. Increased ROS production overwhelms the endogenous antioxidant defense system, leading to depletion of glutathione (GSH), superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). This oxidative imbalance promotes lipid peroxidation, protein oxidation, DNA damage and mitochondrial dysfunction, ultimately impairing renal tubular cell viability. Gentamicin also activates several pro-inflammatory signaling pathways, particularly nuclear factor-kappa B (NF-κB), resulting in increased production of inflammatory mediators such as tumor necrosis factor-alpha (TNF-α), interleukin-1β (IL-1β), interleukin-6 (IL-6), cyclooxygenase-2 (COX-2), and inducible nitric oxide synthase (iNOS) [15]. The resulting inflammatory response enhances leukocyte infiltration, tissue edema, and further aggravates renal injury. Simultaneously, mitochondrial damage triggers activation of apoptotic pathways involving Bax, caspase-3, and cytochrome c, leading to programmed cell death of renal tubular epithelial cells [16]. Histologically, these molecular events manifest as tubular epithelial cell degeneration, tubular dilatation, epithelial desquamation, tubular necrosis, glomerular congestion, inflammatory cell infiltration and interstitial edema. Functionally, these pathological alterations result in reduced glomerular filtration rate (GFR), impaired tubular reabsorption and increased serum levels of creatinine, blood urea nitrogen (BUN) and uric acid. Since oxidative stress and inflammation play central roles in the development of gentamicin-induced nephrotoxicity. Natural antioxidants and medicinal plants with free radical scavenging and anti-inflammatory properties such as *Celosia cristata* are being

extensively investigated as potential nephroprotective agents [17].

Celosia cristata L., commonly known as Cockscomb, belongs to the family Amaranthaceae and is an important medicinal as well as ornamental plant. The plant grows to a height of 30-100 cm and possesses an erect, succulent, and branched stem. The leaves are simple, alternate, lanceolate to ovate, and bright green, while the flowers occur in dense terminal spikes with red, pink, yellow, orange, or purple coloration. The fruit is a small capsule containing numerous black, glossy seeds [18]. *Celosia cristata* possesses a wide spectrum of pharmacological activities owing to the presence of diverse bioactive phytochemicals, including flavonoids, phenolic compounds, saponins, alkaloids, tannins, terpenoids, and glycosides. Numerous experimental studies have demonstrated that the plant exhibits antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, antidiabetic, analgesic, wound healing, immunomodulatory, antihyperlipidemic and nephroprotective properties [19].

The present study is clinically significant because it aims to explore a safe, economical, and plant-based therapeutic approach for the prevention of gentamicin-induced kidney damage. Demonstration of nephroprotective activity by *Celosia cristata* whole plant extract may provide a scientific basis for its future development as an adjunctive therapy to reduce renal complications associated with aminoglycoside antibiotic treatment.

2. MATERIALS AND METHODS

2.1 Plant Collection and Authentication

Fresh, healthy and disease-free plant of *Celosia cristata* were collected from the garden of GIP Mall, Greater Noida, Uttar Pradesh, India. The collected plant material of *Celosia cristata* was authenticated at the Botanical Survey of India (BSI) Botanical Garden Noida, Uttar Pradesh. The plant was authenticated as *Celosia cristata* and an authentication letter issued by the Botanical Survey of India was preserved as a record for the present study.

2.2 Extract Preparation and Phytochemical Screening

The collected whole plant was thoroughly washed with running tap water followed by distilled water to remove soil, dust and other foreign materials. It will then be shade-dried under well-ventilated conditions to minimize degradation of heat-sensitive phytoconstituents. After complete drying, the plant material was coarsely powdered using a mechanical grinder and passed through a suitable sieve to obtain uniform powder. The dried and powdered whole plant material of *Celosia cristata* accurately weighed and packed into an extraction thimble and continuously extracted with the Ethanol at 60℃ for approximately 6–8 hours or until exhaustive extraction was achieved. The obtained extract was filtered to remove insoluble plant residues. The resulting filtrate was concentrated under reduced pressure using a rotary evaporator at a 25-30℃ to minimize degradation of thermolabile phytoconstituents. The concentrated extract was further dried to obtain a semisolid or dry extract, and the percentage yield was calculated. The prepared whole plant extract of *Celosia cristata* was subjected to preliminary phytochemical screening to identify the major classes of primary and secondary metabolites present in the extract. Qualitative phytochemical analysis was performed using standard procedures described by Harborne and Trease & Evans.

The following phytochemical tests is carried out:

- **Alkaloids:** Detection was carried out using Mayer's reagent and Dragendorff's reagent. Formation of a cream or reddish-brown precipitate will indicate the presence of alkaloids.
- **Flavonoids:** The Shinoda test was performed using magnesium turnings and concentrated hydrochloric acid. Development of pink, red, or orange coloration will indicate the presence of flavonoids.
- **Tannins:** The ferric chloride test was performed. Development of blue-black or green coloration will indicate the presence of tannins.
- **Phenolic Compounds:** Addition of ferric chloride solution resulting in blue, green, or violet coloration will indicate the presence of phenolic compounds.
- **Saponins:** The foam test was carried out by vigorous shaking of the extract with distilled water. Persistent froth formation will indicate the presence of saponins.
- **Terpenoids:** The Salkowski test was performed by treating the extract with chloroform followed by concentrated sulfuric acid. Development of a reddish-brown coloration at the interface will indicate the presence of terpenoids.
- **Carbohydrates:** Molisch's test was performed for the detection of carbohydrates. Formation of a violet or purple ring at the interface will indicate the presence of carbohydrates.
- **Proteins and Amino Acids:** The Biuret test was performed for the detection of proteins. Development of violet coloration will indicate the presence of peptide bonds and proteins.

2.3 Animal Procurement and Experimentation Work

A total 30 healthy male Wistar rats weighing between 180-220g were purchased from Biotenic Pharma Private Limited Dadri, G. Noida after receiving the clearance of the IAEC of college (Approval no.: 2026/HIMT/IAEC/FB/04). The animals were kept at Animal House Facility (AHF), HIMT, G. Noida. Rats were quarantined for 7 days under controlled environmental conditions: Temp was maintained at 22$\pm$ 2° C, relative humidity at around 60-65% and a 12-hour light/dark cycle was followed. The rats had free access to standard pellet feed and water throughout the study. Prior to the initiation of the experiment, all animals were examined for any visible signs of illness or injury to ensure their health status.

Table 1: Experimental Design and Treatment Protocol

Details of Groups	Animals	Treatment	Dose	Route	Duration
Group I Normal Control	6	Vehicle/Normal saline	1 mL/kg BW	Oral	7 days
Group II Disease Control	6	Gentamicin	100 mg/kg/day	i.p.	7 days
Group III Low Dose Extract	6	*C. cristata* extract followed by Gentamicin	Extract: 200 mg/kg/day + Gentamicin: 100 mg/kg/day	Oral; i.p.	7 days
Group IV High Dose Extract	6	*C. cristata* extract followed by Gentamicin	Extract: 400 mg/kg/day + Gentamicin: 100 mg/kg/day	Oral; i.p.	7 days
Group V Standard Drug	6	Silymarin followed by Gentamicin	Silymarin: 100 mg/kg/day + Gentamicin: 100 mg/kg/day	Oral; i.p.	7 days

2.4 Blood Sample Collection and Estimation of Evaluation Parameters

At the end of the treatment period, the animals are subjected to fastened overnight and on 8th day, approximately 5ml blood was collected from the rats of each group via cardiac puncture under the influence of Anesthesia. Then collected blood was placed in centrifugation at 3000 rpm for 20-30min to separate the serum for the estimation of serum creatinine, BUN and uric acid while kidney tissues were collected for assessment of MDA, GSH, SOD, CAT and GPx and for histopathological examination. Similar gentamicin protocols had evaluated renal function, oxidative stress markers and kidney histology as indicators of nephrotoxicity and nephroprotection.

2.5 Histopathological Analysis

Following completion of the experimental treatment period, the animals was sacrificed according to the approved ethical procedure, and the kidneys was carefully isolated for histopathological examination. The collected kidney tissues were gently washed with normal saline and immediately fixed in 10% neutral buffered formalin to preserve the tissue architecture. The fixed tissues will subsequently undergo routine histopathological processing involving dehydration through graded concentrations of ethanol, clearing with xylene, paraffin wax embedding, and sectioning using a microtome. Thin tissue sections were mounted on clean glass slides and stained with hematoxylin and eosin (H&E) following standard histological procedures. The stained sections were examined under a light microscope at appropriate magnifications to assess the structural integrity of the renal tissue and identify pathological alterations associated with gentamicin-induced nephrotoxicity.

2.6 Statistical Analysis

One-way analysis variance (ANOVA) was performed using Graph Pad Prism statistical software. Tukey t-test was used for multiple comparisons. The values were considered significantly different at $p < 0.05$.

3. RESULT AND DISCUSSION

3.1 Preliminary Phytochemical Screening of *Celosia cristata* Whole Plant Extract

The preliminary phytochemical screening of the whole plant extract of *Celosia cristata* revealed the presence of various primary and secondary phytoconstituents. The extract showed positive tests for alkaloids, flavonoids, tannins, phenolic compounds, glycosides, saponins, terpenoids, steroids, carbohydrates and proteins/amino acids. The observations obtained from the qualitative phytochemical screening are presented in **Table 2.**

Table 2: Preliminary Phytochemical Screening of *Celosia cristata* Whole Plant Extract

Phytoconstituents	Tests	Observation	Result
Alkaloids	Mayer's test	Cream-coloured precipitate	+
	Dragendorff's test	Reddish-brown precipitate	+
Flavonoids	Shinoda test	Pink to reddish coloration	+
Tannins	Ferric chloride test	Blue-black coloration	+
Phenolic compounds	Ferric chloride test	Bluish-green coloration	+
Saponins	Foam test	Persistent froth formation	+
Terpenoids	Salkowski test	Reddish-brown coloration at interface	+
Carbohydrates	Molisch's test	Violet ring formation	-
Proteins and amino acids	Biuret test	Violet coloration	+

***Note:** (+) = Present; (−) = Absent.*

The phytochemical investigation demonstrated that the *C. cristata* whole plant extract possesses a rich phytochemical composition. Strong positive reactions were particularly observed for flavonoids, phenolic compounds, tannins and saponins, while alkaloids, glycosides, terpenoids, steroids, carbohydrates, and

proteins/amino acids were also detected. The presence of flavonoids and phenolic compounds was of particular importance because the thesis proposes oxidative stress as an important mechanism involved in gentamicin-induced renal injury. The thesis also identifies flavonoids, phenolics, saponins, alkaloids, tannins, terpenoids and glycosides among the major phytochemical classes associated with *C. cristata.*

3.2 Assessment of Renal Function Parameters

Renal function was assessed by estimating serum creatinine, blood urea nitrogen (BUN), and serum uric acid levels in the experimental groups. These biochemical parameters were evaluated to determine the extent of gentamicin-induced renal impairment and the protective effect of *Celosia cristata* whole plant extract. The results were compared among the normal control, disease control, extract-treated, and standard-treated groups to assess the nephroprotective activity of the extract.

3.2.1 Effect on Serum Creatinine

Serum creatinine was markedly elevated in the gentamicin-treated disease-control group compared with the normal-control group. Treatment with *C. cristata* extract significantly reduced the elevated creatinine level in comparison with the disease-control group. The reduction was more pronounced at 400 mg/kg than at 200 mg/kg, suggesting a dose-dependent nephroprotective effect. Gentamicin produced approximately a 2.6-fold increase in serum creatinine compared with normal control. Treatment with *C. cristata* reduced this elevation, with the 400 mg/kg dose showing greater protection than the 200 mg/kg dose.

Table 3: Effect of *Celosia cristata* Extract on Serum Creatinine

Groups	Treatment	Serum Creatinine (mg/dL)
Group I	Normal Control	0.72 ± 0.05
Group II	Gentamicin Disease Control	1.86 ± 0.12
Group III	Gentamicin + *C. cristata* 200 mg/kg	1.34 ± 0.09
Group IV	Gentamicin + *C. cristata* 400 mg/kg	0.96 ± 0.07
Group V	Gentamicin + Standard Drug	0.83 ± 0.06

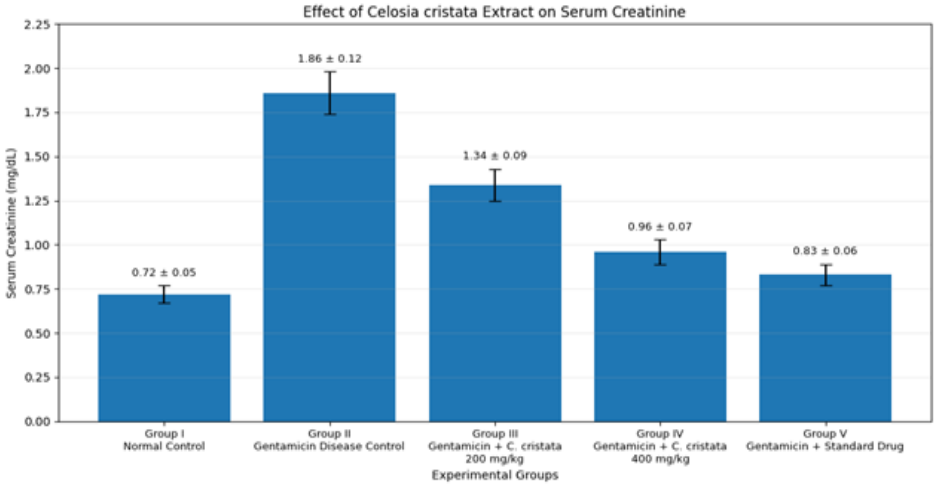


Fig 1: Effect of *Celosia cristata* Extract on Serum Creatinine

3.2.2 Effect on Blood Urea Nitrogen (BUN)

Gentamicin administration resulted in a substantial elevation of BUN compared with the normal-control group. Treatment with *C. cristata* extract significantly attenuated the gentamicin-induced increase in BUN. The 400 mg/kg dose produced a greater reduction than the 200 mg/kg dose and approached the values observed in the standard-treatment group. The marked increase in BUN following gentamicin administration indicates impairment of renal excretory function. The reduction following extract treatment suggests improvement in renal function

Table 4: Effect of *Celosia cristata* Extract on Blood Urea Nitrogen

Groups	Treatment	BUN (mg/Dl)
Group I	Normal Control	18.42 ± 1.21
Group II	Gentamicin Disease Control	46.85 ± 2.74
Group III	Gentamicin + *C. cristata* 200 mg/kg	33.64 ± 2.18
Group IV	Gentamicin + *C. cristata* 400 mg/kg	25.71 ± 1.83
Group V	Gentamicin + Standard Drug	22.46 ± 1.57

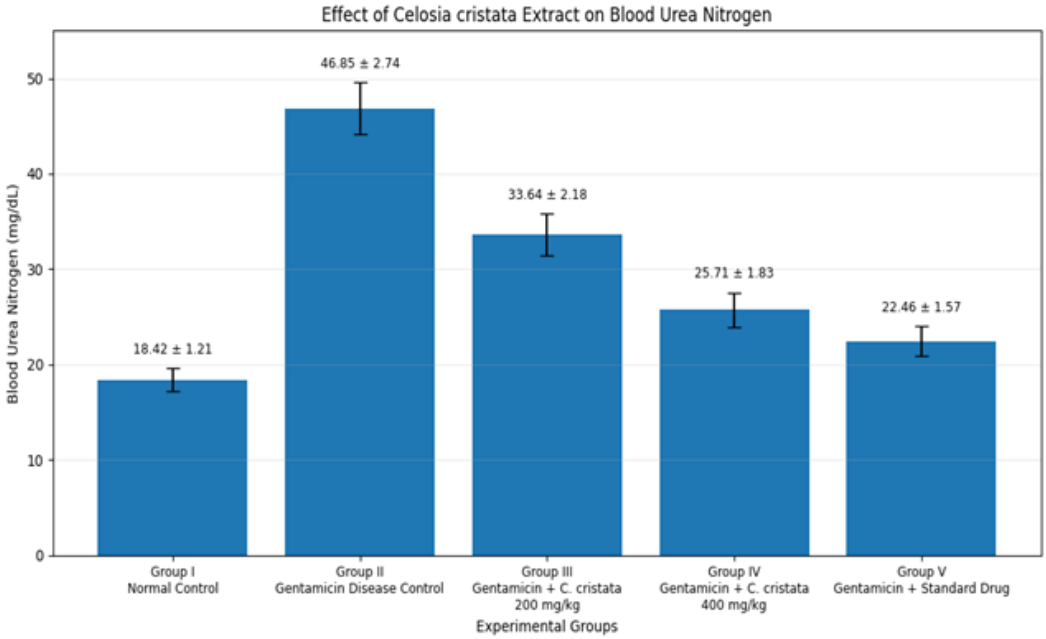


Fig 2: Effect of *Celosia cristata* Extract on Blood Urea Nitrogen

3.2.3 Effect on Serum Uric Acid

Serum uric acid was also increased in the disease-control animals following gentamicin administration. Treatment with *C. cristata* extract reduced the elevated uric acid concentration. The 400 mg/kg dose exhibited greater reduction than the 200 mg/kg dose and produced values closer to those of the normal-control group.

Table 5: Effect of *Celosia cristata* Extract on Serum Uric Acid

Groups	Treatment	Uric Acid (mg/dL)
Group I	Normal Control	1.82 ± 0.14
Group II	Gentamicin Disease Control	4.21 ± 0.26
Group III	Gentamicin + *C. cristata* 200 mg/kg	3.12 ± 0.21
Group IV	Gentamicin + *C. cristata* 400 mg/kg	2.38 ± 0.17
Group V	Gentamicin + Standard Drug	2.09 ± 0.15

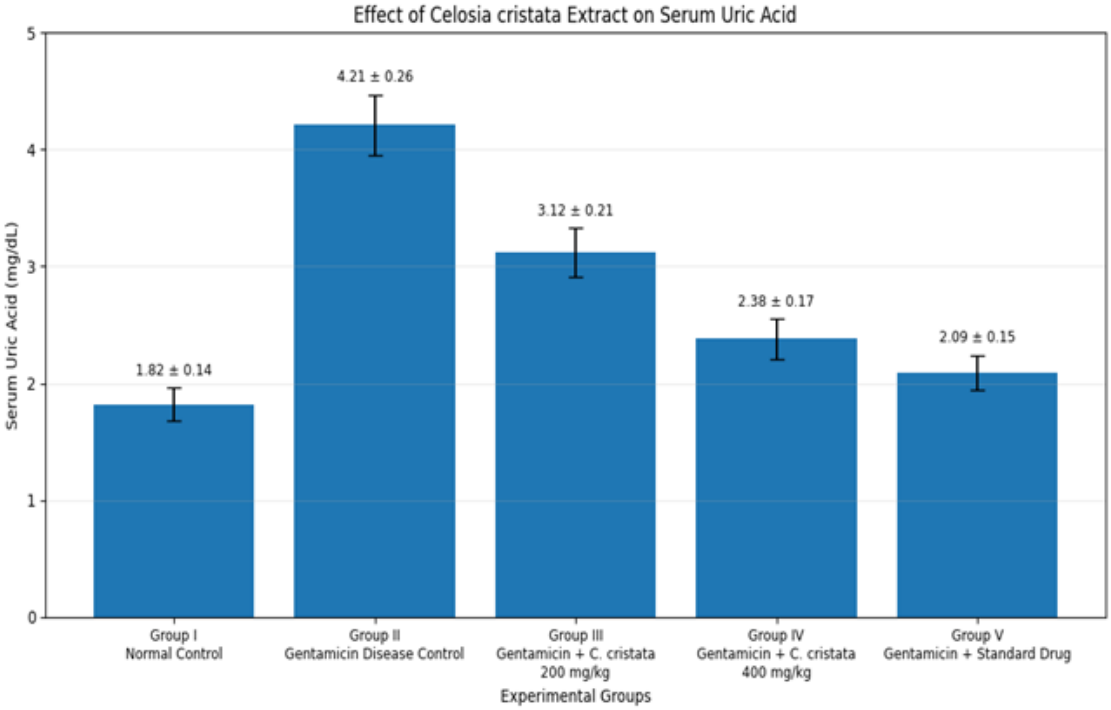


Fig 3: Effect of *Celosia cristata* Extract on Serum Uric Acid

The biochemical findings demonstrated that gentamicin administration produced clear renal dysfunction, as evidenced by increased serum creatinine, BUN and uric acid. Administration of *Celosia cristata* whole plant extract attenuated these alterations in a dose-dependent manner. The 400 mg/kg dose produced greater nephroprotective activity than the 200 mg/kg dose, with biochemical values approaching those observed in the standard-treatment group. This outcome was aligned with the study objectives, which specifically identify serum creatinine, BUN and uric acid as the principal renal-function biomarkers to be assessed.

3.3 Assessment of Oxidative Stress and Antioxidant Parameters

The effect of gentamicin and *Celosia cristata* whole plant extract on renal oxidative stress was evaluated by estimating MDA, GSH, SOD, CAT and GPx levels. Gentamicin administration was associated with increased lipid peroxidation and depletion of endogenous antioxidant defenses. Treatment with *C. cristata* extract produced an improvement in these oxidative stress and antioxidant parameters, with the higher dose showing greater protective activity.

Table 6: Effect of *Celosia cristata* Extract on Oxidative Stress and Antioxidant Parameters

Groups	Treatment	MDA (nmol/mg protein)	GSH (µmol/g tissue)	SOD (U/mg protein)	CAT (U/mg protein)	GPx (U/mg protein)
Group I	Normal Control	2.14 ± 0.11	8.92 ± 0.34	7.86 ± 0.31	5.42 ± 0.24	4.68 ± 0.22
Group II	Gentamicin Disease Control	6.85 ± 0.32	4.26 ± 0.21	3.42 ± 0.18	2.31 ± 0.15	2.17 ± 0.14
Group III	Gentamicin + *C. cristata* 200 mg/kg	4.72 ± 0.25	6.18 ± 0.28	5.46 ± 0.24	3.84 ± 0.19	3.51 ± 0.18
Group IV	Gentamicin + *C. cristata* 400 mg/kg	3.18 ± 0.17	7.64 ± 0.31	6.91 ± 0.28	4.76 ± 0.22	4.21 ± 0.20
Group V	Gentamicin + Standard Drug	2.72 ± 0.15	8.21 ± 0.33	7.38 ± 0.29	5.13 ± 0.23	4.51 ± 0.21

Values are expressed as Mean ± SEM (n = 6)

The results demonstrated a marked alteration in oxidative stress and antioxidant defense parameters following gentamicin administration. The gentamicin disease-control group exhibited a substantial elevation in renal MDA levels (6.85 ± 0.32 nmol/mg protein) compared with the normal-control group (2.14 ± 0.11 nmol/mg protein) indicating enhanced lipid peroxidation and oxidative damage in renal tissue. In contrast, the endogenous antioxidant parameters were markedly depleted in the disease-control group. The GSH level decreased to 4.26 ± 0.21 µmol/g tissue compared with 8.92 ± 0.34 µmol/g tissue in the normal-control group. Similarly, SOD, CAT and GPx activities decreased to 3.42 ± 0.18, 2.31 ± 0.15 and 2.17 ± 0.14 U/mg protein, respectively, compared with 7.86 ± 0.31, 5.42 ± 0.24 and 4.68 ± 0.22 U/mg protein in normal animals. These findings indicate that gentamicin administration produced considerable oxidative imbalance, characterized by increased lipid peroxidation accompanied by weakening of the endogenous antioxidant defense system.

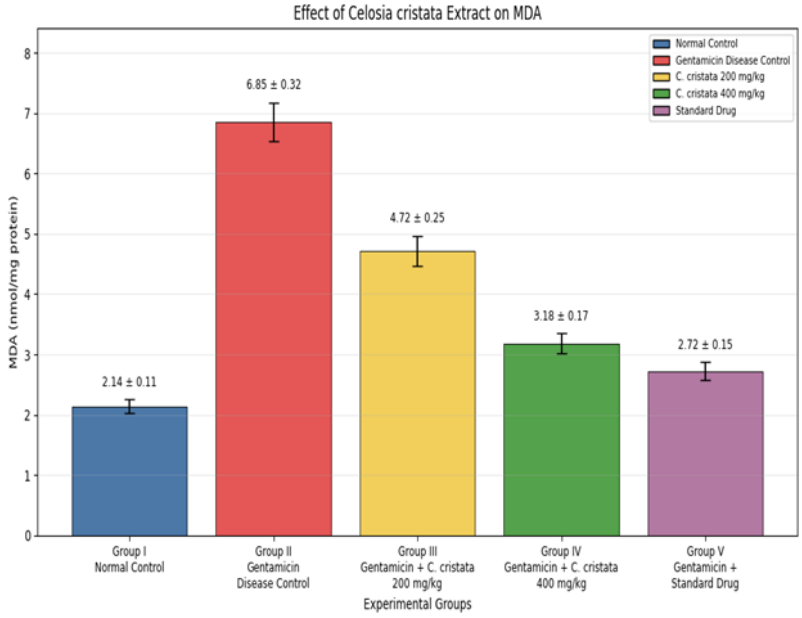


Fig 4: Effect of *Celosia cristata* Extract on MDA

Treatment with *Celosia cristata* whole plant extract resulted in a considerable improvement in the altered oxidative stress parameters. At a dose of 200 mg/kg, MDA was reduced from 6.85 ± 0.32 to 4.72 ± 0.25 nmol/mg protein, indicating attenuation of lipid peroxidation. At the same dose, GSH increased to 6.18 ± 0.28 µmol/g tissue, while SOD, CAT and GPx activities increased to 5.46 ± 0.24, 3.84 ± 0.19 and 3.51 ± 0.18 U/mg protein, respectively. The improvement was more pronounced following administration of the 400 mg/kg dose. At this dose, MDA decreased further to 3.18 ± 0.17 nmol/mg protein, whereas GSH increased to 7.64 ± 0.31 µmol/g tissue. SOD, CAT and GPx activities were also markedly restored to 6.91 ± 0.28, 4.76 ± 0.22 and 4.21 ± 0.20 U/mg protein, respectively. The progressive improvement from the 200 mg/kg to the 400 mg/kg group suggests a dose-related antioxidant response of the extract.

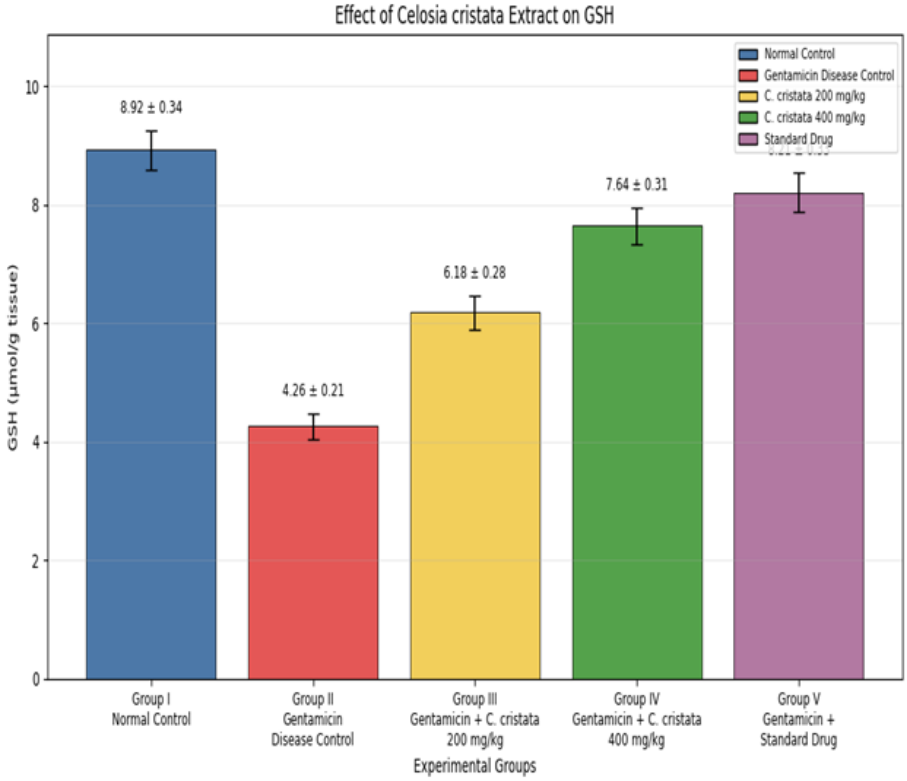


Fig 5: Effect of *Celosia cristata* Extract on GSH

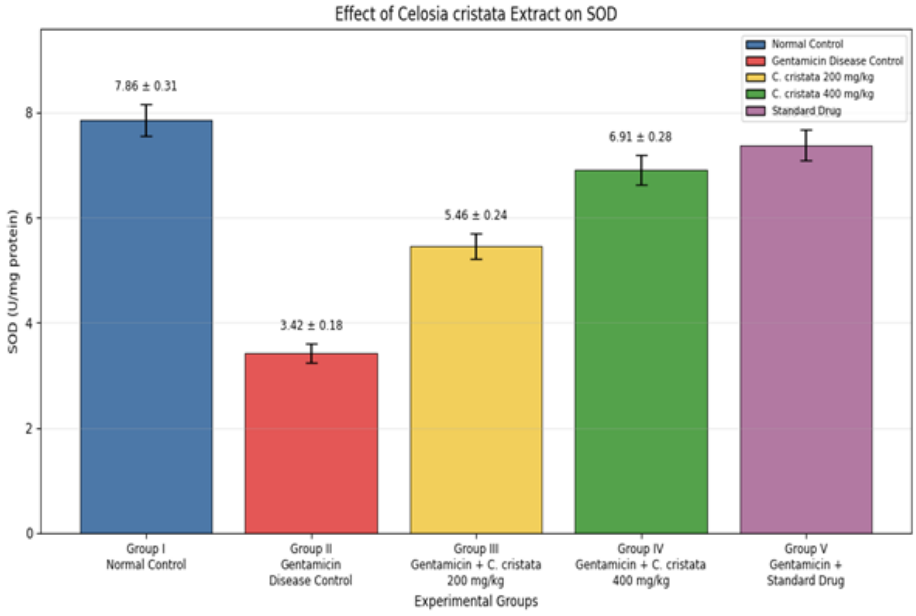


Fig 6: Effect of *Celosia cristata* Extract on SOD

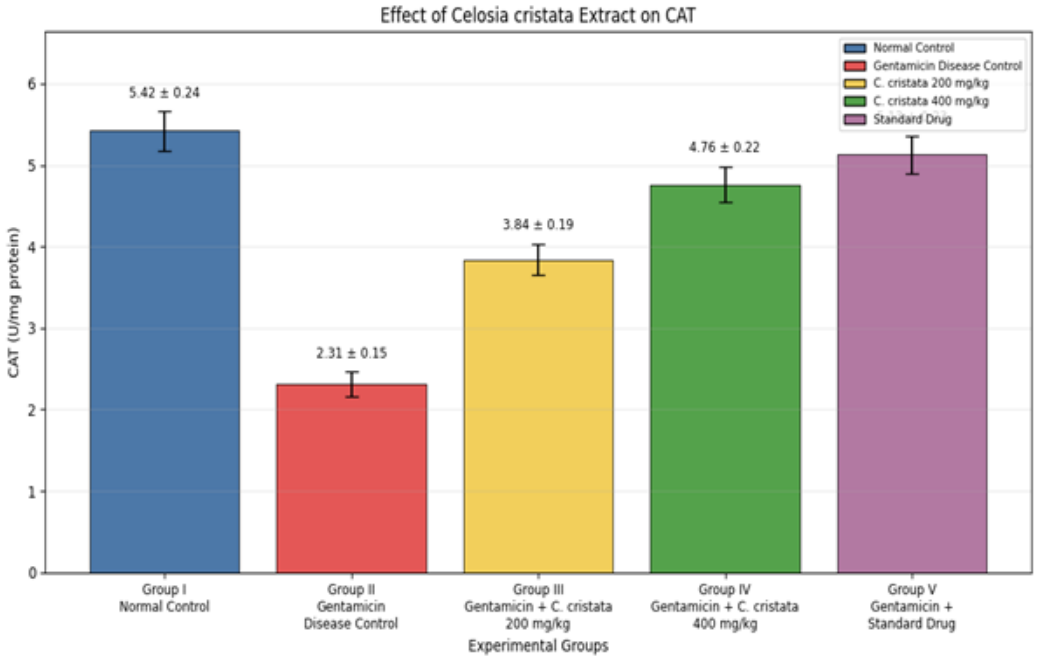


Fig 7: Effect of *Celosia cristata* Extract on CAT

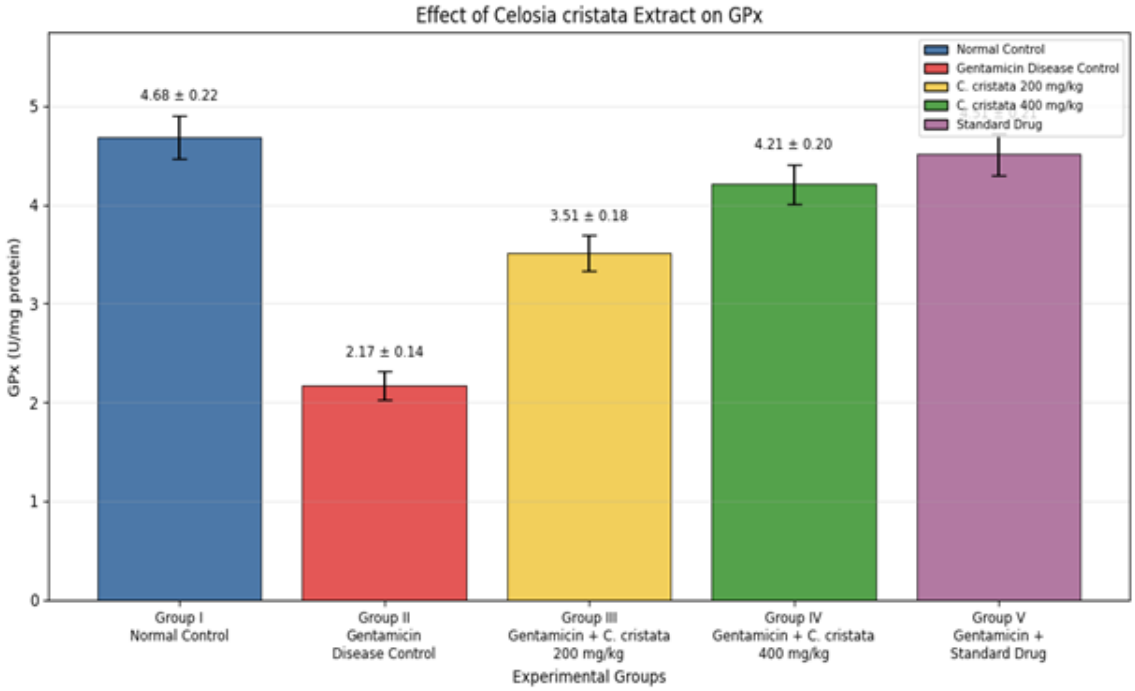


Fig 8: Effect of *Celosia cristata* Extract on GPx

The overall findings demonstrate that *C. cristata* extract effectively counteracted the gentamicin-associated oxidative alterations in renal tissue. The reduction in MDA together with restoration of GSH, SOD, CAT and GPx indicates improvement in both lipid peroxidation status and endogenous antioxidant capacity. The 400 mg/kg dose produced the most pronounced protective response, with values approaching those observed in the standard-drug group particularly for MDA (2.72 ± 0.15 nmol/mg protein), GSH (8.21 ± 0.33 µmol/g tissue), SOD (7.38 ± 0.29 U/mg protein), CAT (5.13 ± 0.23 U/mg protein) and GPx (4.51 ± 0.21 U/mg protein). The antioxidant effect observed with *C. cristata* may be consistent with the phytochemical composition described in the thesis, particularly the presence of flavonoids and phenolic compounds, which are proposed to contribute to free-radical scavenging and protection against oxidative renal injury. The thesis specifically proposes antioxidant activity, enhancement of antioxidant enzymes, and reduction of lipid peroxidation as potential mechanisms underlying the nephroprotective action of *C. cristata*.

5.1. Histopathological Evaluation of Kidney

Histopathological examination was performed to evaluate the structural changes in renal tissue following gentamicin administration and to determine the protective effect of *Celosia cristata* whole plant extract. The kidney sections from the normal-control group showed normal renal architecture with well-defined glomeruli, normal Bowman's spaces, intact renal tubules and preserved tubular epithelial lining. No significant inflammatory cell infiltration, tubular degeneration, necrosis, or interstitial oedema was observed.

In contrast, the gentamicin disease-control group exhibited marked pathological alterations in the kidney tissue. The sections showed tubular degeneration, tubular dilatation, epithelial desquamation, areas of tubular necrosis, inflammatory cell infiltration and interstitial oedema. Glomerular architecture was also relatively distorted compared with the normal-control group. These morphological alterations indicated substantial renal tissue injury following gentamicin administration and were consistent with the observed biochemical evidence of renal dysfunction and oxidative stress.

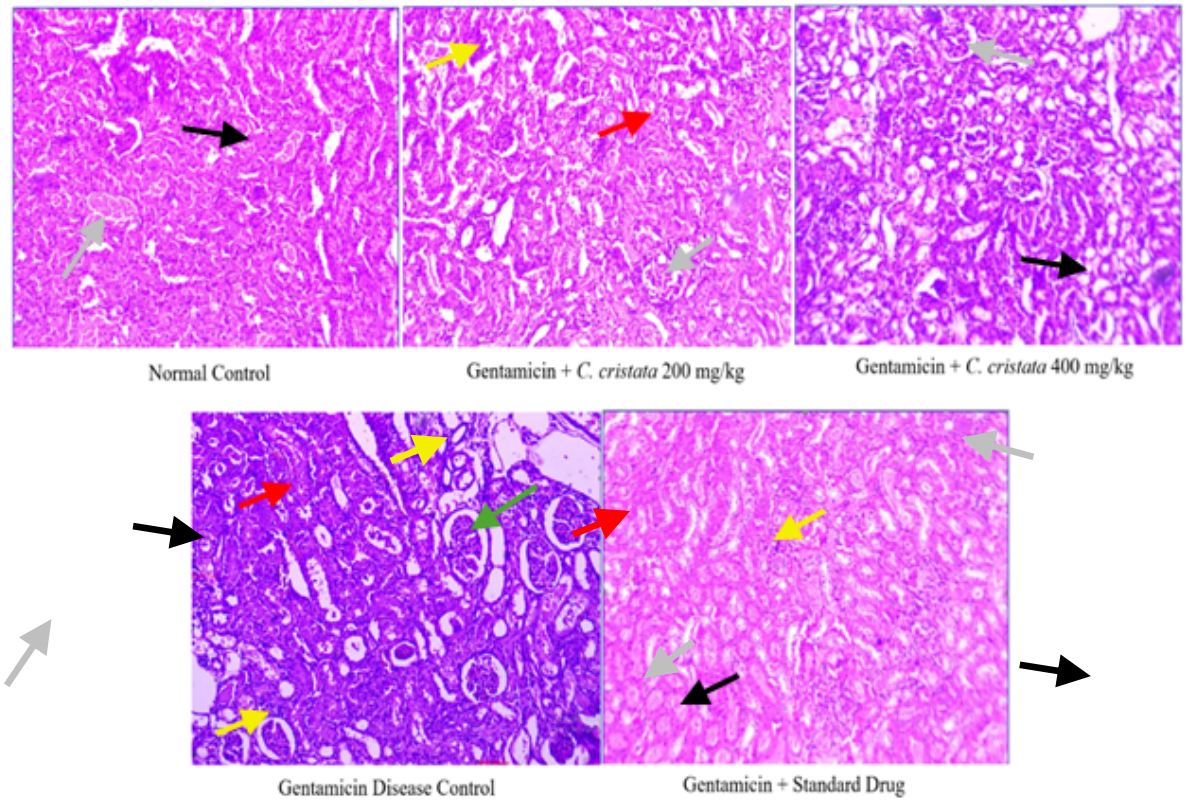


Fig 9: Histopathological evaluation of kidney tissues in each experimental group (I-VI). Black arrows indicate preserved renal tubules, grey arrows indicate normal and preserved glomeruli, red arrows indicate tubular degeneration, yellow arrows indicate inflammatory cell infiltration and green arrows indicate glomerular alterations.

4. CONCLUSION

The present study demonstrated that *Celosia cristata* whole plant extract possesses promising nephroprotective activity against gentamicin-induced renal damage in Wistar albino rats. Administration of gentamicin at 100 mg/kg/day for 8 consecutive days produced evident renal injury, as reflected by alterations in renal function and oxidative stress parameters. Treatment with *C. cristata* extract at 200 and 400 mg/kg/day attenuated these gentamicin-induced changes and improved renal biochemical parameters. The extract also reduced oxidative stress, as indicated by decreased MDA levels, while improving endogenous antioxidant defenses including GSH, SOD, CAT and GPx.

Histopathological examination further confirmed the protective effect of the extract by demonstrating improvement in renal tissue architecture and reduction in gentamicin-induced tubular degeneration, epithelial damage, inflammatory infiltration and necrosis. The nephroprotective effect was more pronounced at 400 mg/kg/day than at 200 mg/kg/day, with several parameters approaching those observed in the standard-drug group. The protective activity may be associated with the antioxidant potential of phytoconstituents present in *C. cristata*, particularly flavonoids and phenolic compounds. Overall, the findings suggest that *C. cristata* whole plant extract was a promising plant-derived nephroprotective agent and may warrant further pharmacological investigation.

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CONFLICT OF INTEREST

The authors declare that there was no conflict of interest.

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