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The Ameliorative Effects of Leaf Extract of *Senna occidentalis* on *Cannabis sativa*-Induced Lung and Renal Damages in Adults Male Wistar Rats

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ABSTRACT **Original Research Article**

Background: Respiratory diseases remain a major public health concern worldwide while its burden has increased considerably due to environmental pollution, occupational hazards, smoking and substance abuse. *Cannabis sativa*, has increasingly been associated with respiratory health concerns. Despite increasing knowledge regarding the harmful effects of *Cannabis* smoke and the medicinal properties of *Senna occidentalis*, there remains limited information on the specific ameliorative effects of *Senna occidentalis* leaf extract on cannabis-induced lung damage. This paper seeks to evaluates these effects in adult male Wistar rats.

Methodology: A total of thirty-six adult male Wistar rats weighing between 200g to 250g were used for this study. The experimental rats purchased from an animal housewere housed in well-ventilated cages and allowed to acclimatize for 7 days in the Animal house. The animals were maintained under standard conditions of 12 hours of light/dark cycle at a temperature of 27^0C-30^0C. The animals were fed with rat feeds bought from Top Feed Ltd, Nigeria and were allowed access to drinking water. Fresh leaves of *Senna occidentalis* were procured from a natural habitat, during the study period. The leaves were carefully selected to ensure they were healthy, mature and free from insect infestation, disease or physical damage. Extraneous materials such as soil particles, twigs and other plant debris were removed before transportation to the laboratory in clean, sterile polyethylene bags. The plant material was authenticated, given a voucher specimen number and deposited in the herbarium for future reference.

Result: The *Cannabis sativa* smoke produced marked pulmonary and renal injury through oxidative stress mechanisms, while treatment with *Senna occidentalis* leaf extract significantly attenuated these adverse effects in a dose-dependent manner. Histological examination of lung tissues revealed that the normal control group maintained normal pulmonary architecture characterized by intact alveolar sacs, thin alveolar septa, patent bronchioles, and the absence of inflammatory cell infiltration. Conversely, rats exposed solely to *Cannabis sativa* smoke exhibited severe pulmonary lesions including thickening of alveolar septa, inflammatory cell infiltration, pulmonary vascular congestion, edema, degeneration of bronchiolar epithelium, distortion of alveolar spaces and widespread disruption of normal lung.

Conclusion: We conclude that exposure to *Cannabis sativa* smoke produces significant pulmonary and renal toxicity through mechanisms involving oxidative stress, lipid peroxidation, inflammation and structural tissue degeneration. Administration of *Senna occidentalis* leaf extract significantly attenuated these pathological alterations in a dose-dependent manner, thereby demonstrating its potent antioxidant and tissue-protective properties.

Keywords: Cigarette Smoke, Wistar Rats, *Cannabis Sativa*, Histological Effects, *Senna occidental.*

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Introduction

The lungs are essential organs of the respiratory system responsible for the exchange of oxygen and carbon dioxide between the body and the external environment. Through the process of respiration, oxygen is supplied to tissues for cellular metabolism while carbon dioxide, a metabolic waste product is removed from the body. Extensive exposure to inhaled substances also makes the lungs particularly susceptible to injury from environmental pollutants, toxic chemicals, cigarette smoke, recreational drugs and other airborne contaminants (Xiong *et al*., 2024). Respiratory diseases remain a major public health concern worldwide. The burden of respiratory disorders has increased considerably due to environmental pollution, occupational hazards, smoking and substance abuse. Respiratory diseases remain a major public health concern worldwide. The burden of respiratory disorders has increased considerably due to environmental pollution, occupational hazards, smoking and substance abuse. Exposure to toxic substances can initiate inflammatory responses and oxidative stress, leading to structural and functional alterations in pulmonary tissues. Such alterations may include thickening of alveolar walls, infiltration of inflammatory cells, degeneration of epithelial cells, fibrosis and destruction of normal lung architecture. These pathological changes can compromise respiratory function and reduce the overall quality of life (Addissouky *et al*., 2024). One of the substances increasingly associated with respiratory health concerns is *Cannabis sativa*. (*C. sativa*) *Cannabis sativa* is an annual herbaceous plant belonging to the family *Cannabaceae.* The plant contains numerous biologically active compounds known as cannabinoids, the most prominent of which are delta-9-tetrahydrocannabinol (THC) and cannabidiol (CBD). THC is primarily responsible for the psychoactive effects of cannabis, while CBD possesses several therapeutic properties, including anti-inflammatory and anticonvulsant effects (Arlen *et al*., 2025). *Cannabis sativa* smoke contains many of the same toxic and carcinogenic compounds found in tobacco smoke, including carbon monoxide, tar, ammonia, hydrogen cyanide, volatile organic compounds and polycyclic aromatic hydrocarbons (Sanz-Pérez *et al*., 2026). Experimental and clinical studies have demonstrated that cannabis smoke can induce oxidative stress and inflammatory responses in the lungs, resulting in tissue damage and disruption of normal pulmonary architecture (Arlen *et al.,* 2025). Oxidative stress is recognized as one of the major mechanisms involved in smoke-induced lung injury. It occurs when the production of reactive oxygen species (ROS) exceeds the antioxidant capacity of the body's defense system. Reactive oxygen species are highly reactive molecules capable of damaging cellular lipids, proteins and nucleic acids. Excessive oxidative stress can initiate lipid peroxidation, mitochondrial dysfunction, DNA damage and cellular apoptosis, ultimately leading to tissue degeneration and organ dysfunction (Addissouky *et al*., 2024). Recent studies have reported significant histological changes in lung tissues following exposure to cannabis smoke. These changes include alveolar congestion, thickening of interalveolar septa, inflammatory cell infiltration, epithelial degeneration, edema and disruption of normal alveolar architecture. Such alterations may adversely affect pulmonary function and increase susceptibility to respiratory diseases (Sanz-Pérez *et al*., 2026).

Beyond gas exchange, the respiratory system performs numerous additional physiological functions. It contributes to acid-base regulation by modulating carbon dioxide elimination, thereby influencing blood hydrogen ion concentration. The lungs also play important roles in immune defense through mucociliary clearance, secretion of antimicrobial substances, and activation of immune cells such as alveolar macrophages. Furthermore, the respiratory tract filters inhaled particles, humidifies inspired air, and warms it to body temperature before it reaches the delicate alveolar structures. These protective mechanisms minimize pulmonary injury and reduce susceptibility to respiratory infections (Kumar *et al*., 2023).

Medicinal plants have been used for centuries in the management of numerous diseases. They are valuable sources of natural compounds with antioxidant, anti-inflammatory, antimicrobial and cytoprotective properties. The growing burden of chronic diseases and concerns regarding the side effects of synthetic drugs has renewed scientific interest in plant-based therapies. Numerous studies have demonstrated that phytochemicals obtained from medicinal plants can effectively neutralize free radicals, suppress inflammation and enhance tissue repair processes (Zaman *et al*., 2024). One medicinal plant that has attracted considerable attention is *Senna occidentalis*, formerly known as *Cassia occidentalis*. The plant belongs to the family Fabaceae and is widely distributed throughout tropical and subtropical regions, including Africa, Asia and South America. In Nigeria, *Senna occidentalis* grows abundantly in farmlands, roadsides and waste areas and has long been utilized in traditional medicine.

Meanwhile, exposure to these harmful substances promotes oxidative stress, inflammation, epithelial injury, and structural remodeling of pulmonary tissues. Consequently, respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, lung cancer, and acute respiratory distress syndrome remain major causes of morbidity and mortality worldwide. According to the World Health Organization, respiratory diseases continue to represent a substantial global health burden, particularly in low- and middle-income countries where environmental pollution and tobacco use remain prevalent (WHO, 2023).

Traditionally, different parts of *Senna occidentalis*, including the leaves, roots, seeds and stem bark, have been used in the treatment of fever, malaria, liver disorders, skin infections, gastrointestinal disturbances, inflammation and respiratory ailments. The widespread medicinal use of the plant has stimulated scientific investigations into its phytochemical composition and pharmacological activities. Phytochemical analyses of *Senna occidentalis* leaves have revealed the presence of several biologically active compounds, including flavonoids, tannins, alkaloids, anthraquinones, phenolic compounds, glycosides and saponins. These phytochemicals possess potent antioxidant and anti-inflammatory properties that may contribute to the therapeutic effects of the plant (Adefegha *et al*., 2020).

Despite the documented medicinal properties of *Senna occidentalis*, there is limited information regarding its effectiveness in ameliorating lung damage specifically induced by *Cannabis sativa*. Most available studies have focused on the effects of cannabis on other organ systems such as the nervous, cardiovascular and reproductive systems, while relatively few investigations have examined its histopathological effects on the lungs. Furthermore, studies evaluating the potential therapeutic role of *Senna occidentalis* in reversing cannabis-induced pulmonary damage remain scarce.

The paucity of scientific data in this area creates a significant knowledge gap regarding the possible protective and restorative effects of *Senna occidentalis* on pulmonary tissues exposed to *cannabis* smoke. Without adequate experimental evidence, the therapeutic potential of this medicinal plant cannot be fully established or utilized in the management of smoke-induced respiratory injury. Therefore, there is a need to investigate the histological changes associated with *Cannabis sativa*-induced lung damage and to determine if the administration of *Senna occidentalis* leaf-extract can ameliorate such alterations. This study is designed to address this gap by evaluating the ameliorative effects of leaf extract of *Senna occidentalis* on cannabis-induced lung damage in adult male Wistar rats. The findings of this study may contribute to the development of affordable plant-based therapeutic strategies for the prevention and management of pulmonary injuries associated with *cannabis* exposure and other inhaled toxic substances.

Study Materials

Biological Materials, Animal Housing and Care

A total of thirty-six adult male Wistar rats weighing between 200g to 250g were used for this study. The experimental rats were purchased from the animal house, Department of Anatomy, Faculty of Basic Medical Sciences of Ebonyi State University, Abakakili. The experimental animals were housed in well-ventilated cages and were allowed to acclimatize for 7 days in the Animal house. The animals were maintained under standard conditions of 12 hours of light/dark cycle at a temperature of 27^0C-30^0C. The animals were fed with rat feeds bought from Top Feed Ltd, Nigeria and were allowed access to drinking water.

Equipment and instruments includes**:** Gloves**,** Notebooks and pen, Weighing balance with a scale of 0.1g measurement and Syringes and needles.

Ethical Consideration and Reporting Compliance

Ethical approval number was obtained from the Research Ethics and Animal Handling Committee is: EBSU/REC/MPC/2503/37. All efforts were made to minimize animal suffering and reduce the number of animals used.

Study Methodology

Plants Procurement and Authentication

A. Fresh leaves of *Senna occidentalis* were procured from a natural habitat within study area during the study period. The leaves were carefully selected to ensure they were healthy, mature and free from insect infestation, disease or physical damage. Extraneous materials such as soil particles, twigs and other plant debris were removed before transportation to the laboratory in clean, sterile polyethylene bags. The plant material was authenticated by a qualified taxonomist. Following authentication, a voucher specimen was prepared and deposited in the herbarium for future reference, where it was assigned a voucher specimen number.

Plate 1: *Senna occidentalis* Plant

B. *Cannabis sativa* used for this study was obtained from a legal authorized source in compliance with Nigerian laws governing the use of controlled substances for research. Procurement was carried out after obtaining approval from the Institutional Animal Research Ethics Committee. Relevant documentation (National Institute on Drug Abuse [NIDA], 2024; United Nations Office on Drugs and Crime [UNODC], 2023) confirming the lawful acquisition of the plant material was maintained throughout the study. The plant material was also authenticated where its botanical identity was conferred as *Cannabis sativa*. A voucher specimen was prepared and deposited in the departmental herbarium for future reference and a voucher number was assigned. Following authentication, the plant material was stored in a secure, dry, well-ventilated environment under controlled conditions until required for the experimental procedures. Appropriate records of receipt, storage, use and disposal were maintained throughout the study in accordance with institutional guidelines for handling controlled research materials.

Plate 2: *Cannabis sativa* Plant

Administration of *Cannabis sativa* Smoke Using a Standardized Whole-Body Exposure Chamber

The administration of *Cannabis sativa* smoke was carried out using a standardized whole-body smoke exposure chamber constructed from transparent material. The chamber measured approximately 60 cm × 40 cm × 40 cm and was fitted with an inlet for smoke delivery, an outlet connected to an exhaust system and adjustable ventilation ports to maintain adequate oxygen supply throughout the exposure period.

A standardized quantity of the dried leaves was combusted in a smoke-generating unit located outside the exposure chamber. The smoke produced was conveyed into the chamber through a heat-resistant silicone tube, allowing it to cool slightly before entering the chamber. The smoke was evenly distributed within the chamber to ensure uniform exposure of all experimental animals.

The rats assigned to the experimental groups (B-F) were placed inside the chamber and exposed to *Cannabis sativa* smoke once daily for 20 minutes. During each exposure session, airflow into the chamber was regulated to maintain adequate oxygenation and to prevent excessive accumulation of carbon dioxide and smoke. Following each exposure, the chamber was thoroughly ventilated with fresh air before the animals were returned to their respective cages.

Animals in the control group (Group A) were placed in the same chamber for an equivalent period but were exposed only to filtered room air. Throughout the experimental period, all animals were monitored daily for clinical signs of respiratory distress, changes in behaviour, food and water intake, body weight and the exposure environment was maintained in accordance with institutional animal welfare guidelines. The exposure chamber was cleaned and disinfected after each session to prevent contamination and ensure consistent experimental conditions.

Processing of the *Senna occidentalis* Leaves

After authentication, the leaves were thoroughly washed with clean running water to remove adhering dirt and contaminants, followed by rinsing with distilled water. The leaves were air-dried under shade at room temperature (25–30°C) for approximately 2 weeks until a constant weight was obtained. The dried leaves were pulverized into a fine powder using a mortar and pestle and stored in clean, airtight amber containers at room temperature until extraction.

Extraction of *Senna occidentalis* Leaves

The powdered leaf material (1kg) was macerated in 70% ethanol at a ratio of 1:5 (w/v), by soaking the powder in 5 L of 70% ethanol in a clean glass container. The mixture was stirred intermittently and allowed to stand for 72 hours at room temperature to facilitate extraction of the phytochemical constituents. After maceration, the mixture was filtered first through a double layer of sterile muslin cloth to remove coarse particles and then through Whatman No. 1 filter paper to obtain a clear filtrate. The extraction process was repeated twice using fresh solvent to maximize extraction efficiency, and the filtrates were pooled together.

Concentration of the Extract of *Senna occidentalis*

The combined filtrate was concentrated under reduced pressure using a rotary evaporator maintained at 40–45°C to remove the ethanol. The concentrated extract was further evaporated to dryness in a thermostatically controlled water bath maintained at 40°C until a semi-solid mass was obtained.

The percentage yield of the extract was determined using the formula:

Percentage yield (%) = (Weight of dried extract / Weight of powdered leaves) × 100

The concentrated extract was transferred into sterile amber-colored bottles, properly labelled, and stored at 4°C in a refrigerator until required for administration.

Preparation of Stock Solution of *Senna occidentalis*

Before administration, the crude extract was reconstituted in distilled water to prepare a stock solution. 10g of the dried extract was dissolved in distilled water and the final volume adjusted to 100 mL, producing a stock concentration of 100 mg/mL. From this stock solution, the required experimental doses (200 mg/kg, 400 mg/kg, and 600 mg/kg body weight) were prepared freshly each day before administration.

The volume administered to each rat was calculated according to its body weight using the formula:

Volume (mL) = (Dose (mg/kg) × Body weight (kg)) / Stock concentration (mg/mL) for a 250g (0.25 kg) rat using a 100 mg/mL stock solution:
200 mg/kg: (200 × 0.25)/100 = 0.50 mL
400 mg/kg: (400 × 0.25)/100 = 1.00 mL
600 mg/kg: (600 × 0.25)/100 = 1.50 mL
The extract was administered orally once daily using a sterile oral gavage throughout the treatment period.

Phytochemical Analysis of *Senna occidentalis* Leaf Extract

Test for Alkaloids: Dragendorff's reagent was added to 2 ml of the extract. Formation of an orange precipitate indicated the presence of alkaloids.

Test for Flavonoids: 2 ml of the extract was treated with dilute ammonia and concentrated sulfuric acid. Development of a yellow coloration confirmed flavonoids.

Test for Tannins: Ferric chloride solution was added to 2 ml of the extract. A greenish-black coloration indicated tannins.

Test for Saponins: 2 ml of the extract was vigorously shaken with distilled water. Persistent frothing confirmed saponins.

Test for Phenols: Ferric chloride solution was added to 2 ml of the extract. This produced a deep bluish-green coloration indicating phenolic compounds.

Test for Terpenoids: Using Salkowski's test, concentrated sulphuric acid was added to 2 ml of the extract and this yielded a reddish-brown interface confirming terpenoids

Experimental Design Involving 36 Rats Divided into 6 Groups (A-F)

Group A received only feed and water.
Group B was exposed to 0.5g of smoked Cannabis sativa.
Group C was exposed to 0.5g of cannabis sativa and subsequently treated with 200mg/kg of Senna occidentalis leaf extract.
Group D was exposed to 0.5g of cannabis sativa and subsequently treated with 400mg/kg of Senna occidentalis leaf extract.
Group E was exposed to 0.5g of cannabis sativa and subsequently treated with 600mg/kg of Senna occidentals leaf extract.
Group F was exposed to 0.5g of cannabis sativa and subsequently treated with 100mg/kg of Vitamin E.

Table 1: Experimental design showing *Cannbis sativa* (CS) exposure and treatment with *Senna occidentalis* (SO) and standard drug, Vitamin E

Groups	Description	Exposure	Administration	Number of rats	Duration (days)
A	Normal control	no exposure	water + feed	6	35
B	Negative control	*Cannabis sativa*	0.5g *Cannabis sativa*	6	21
C	Experimental Group 1	*Cannabis sativa* + *Senna occidentalis* extract	0.5g CS + 200mg/kg SO	6	35
D	Experimental Group 2	*Cannabis sativa* + *Senna occidentalis* extract	0.5g CS + 400mg/kg SO	6	35
E	Experimental Group 3	*Cannabis sativa* + *Senna occidentalis* extract	0.5g CS + 600mg/kg SO	6	35
F	Standard control	*Cannabis sativa* + Vitamin E	0.5g CS + 100mg Vit E	6	35

Field work, 2025

Animal Sacrifice and Sample Collection

At the end of 35 days of the study, the animals were sacrificed using cervical dislocation. blood samples were collected from the lateral tail vein for biochemical analysis. The organs (kidney and lung) were harvested and fixed in 10% formal saline for histological studies.

Histological Analysis

At the end of the experiment that lasted for 35 days, rats were anaesthetized with ether followed by quick cervical dislocation. The lung and the kidney tissues were harvested and placed in a new formaldehyde solution for 24 hours before being dehydrated using ethanol (70% for 24 hours, 90% for 1 hour and 95% for 1 hour). Then cleared in xylene and embedded in paraffin wax. Tissue sections were made using a rotary microtome at 5µm. Sections from the kidney from each group was stained with haematoxylin and eosin, a routine histology stain. Examination of slides and photomicrography was done using X400 magnification while a digital camera attached to the microscope was used to capture the photomicrographs.

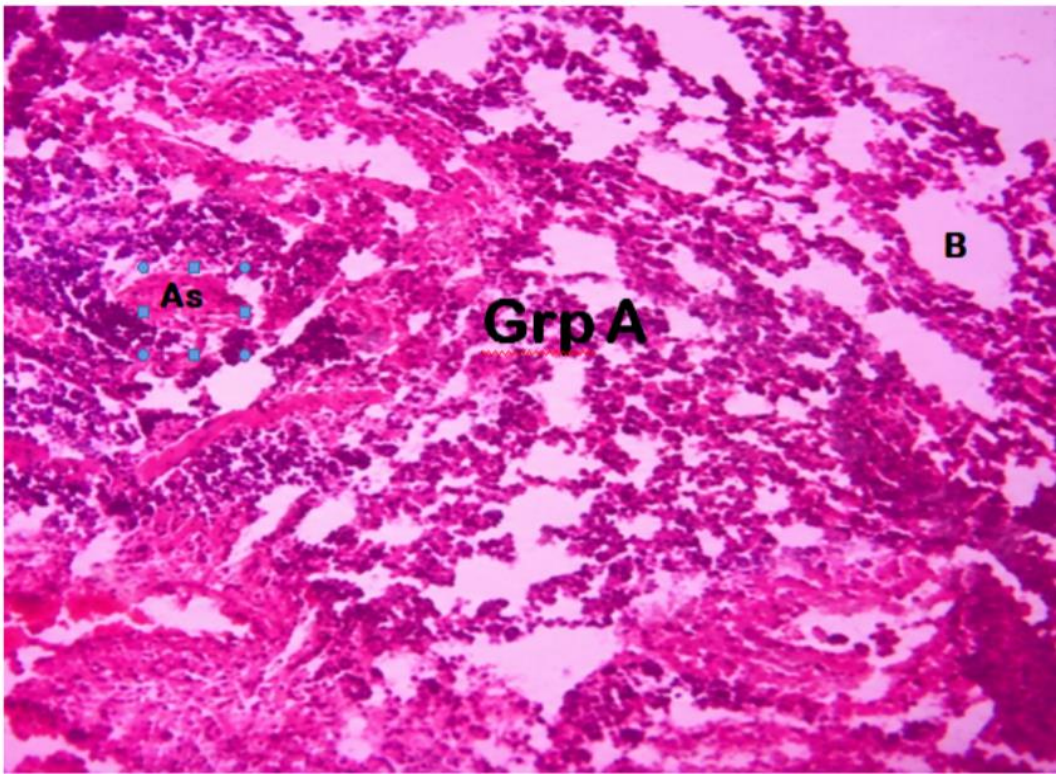
Data Presentation

The experimental data obtained was analyzed using Graph Pad prism version 9.0.1.5 and results were presented in a tabular form as Mean ± SD. A 1-Way Analysis of Variance (ANOVA) established the significance differences between means. Multiple comparisons of Turkey's Post Hoc Test were adopted to check the significance level at $P \leq 0.05$.

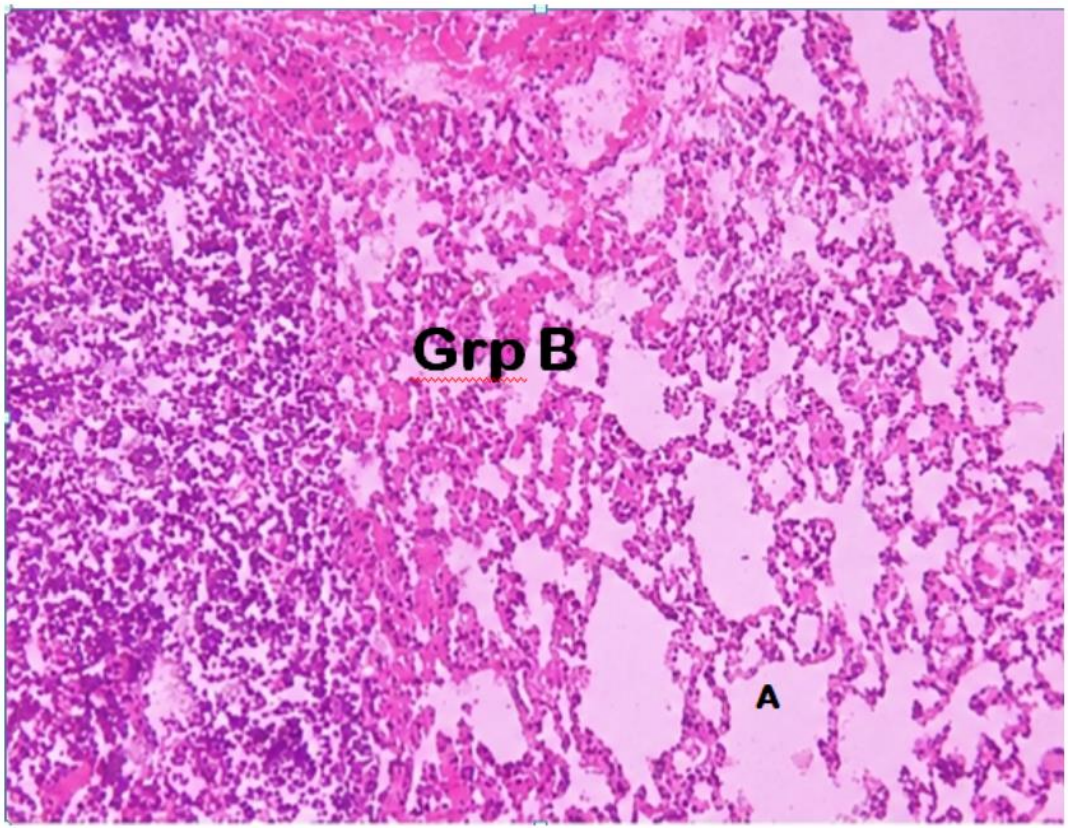
Results

Histological Observations in the Lungs across all Experimental Groups

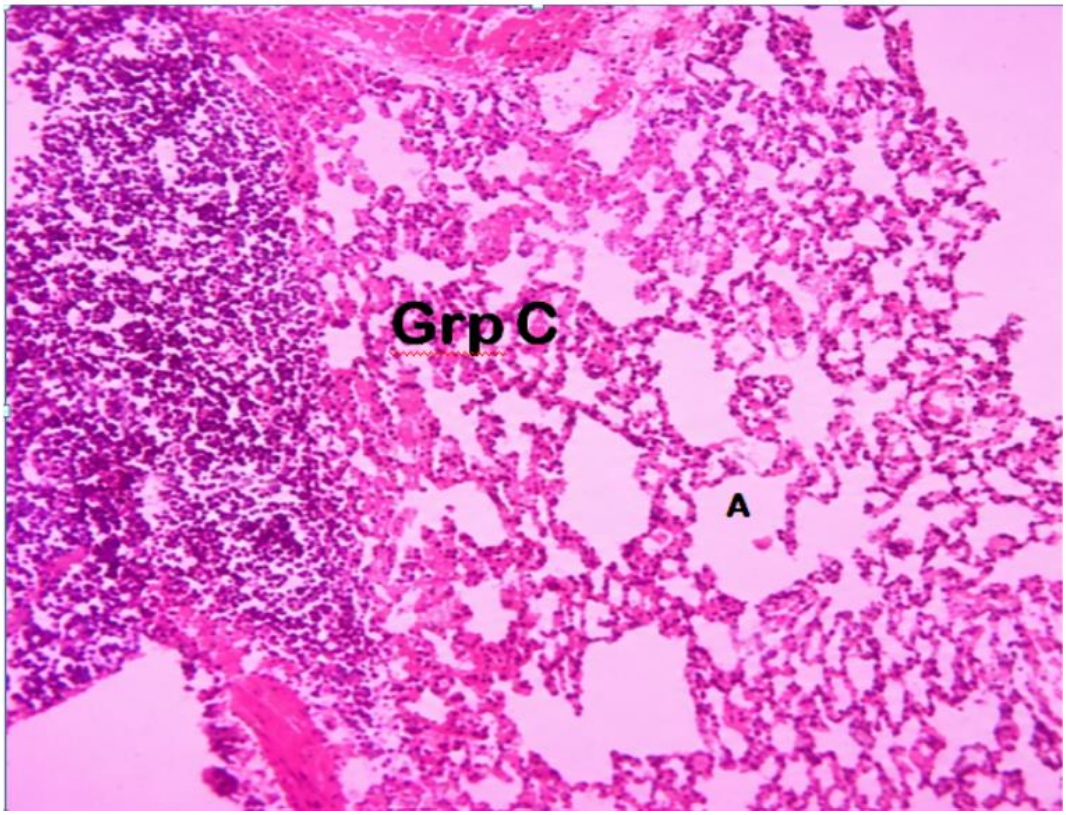
A. Normal Control (Group A): This group received only feed and water. Intact alveolar sacs (As), thin alveolar septa, patent bronchioles, normal bronchial (B) epithelium and absence of inflammatory cell infiltration, edema, hemorrhage.



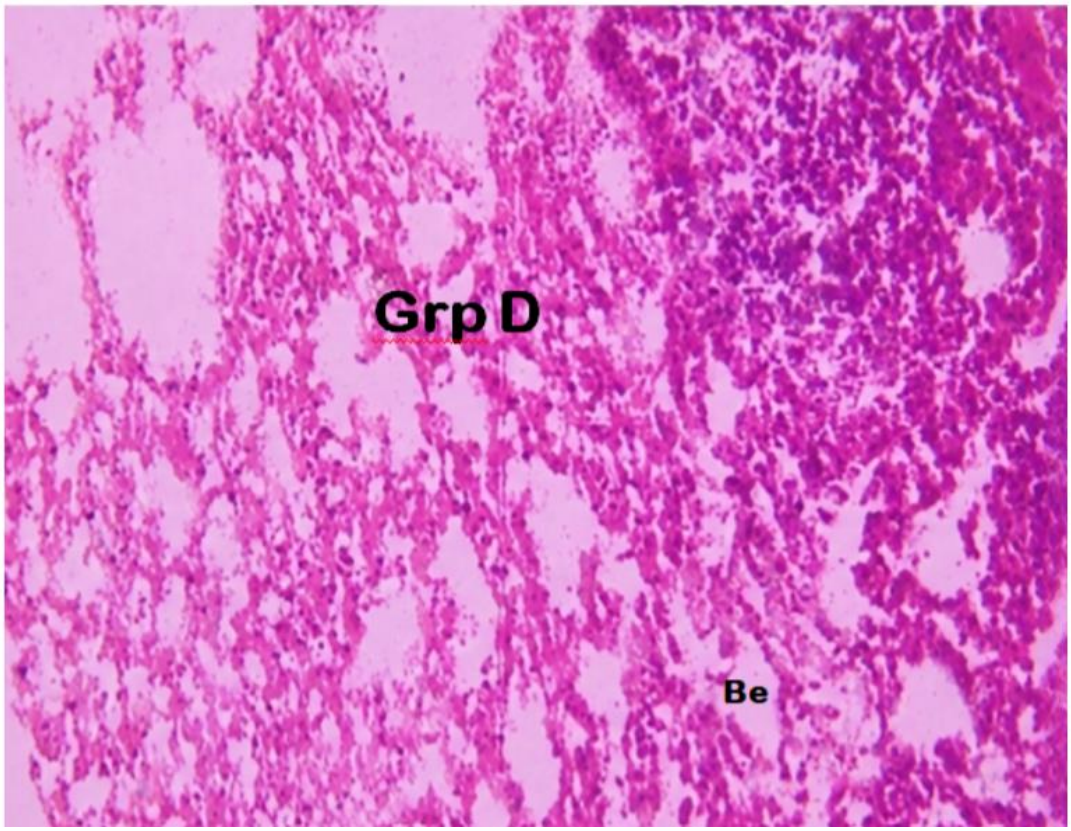
B. Negative group (Group B): This group was exposed to smoked *Cannabis sativa* only with no treatment. Thickened alveolar septa, collapsed and enlarged alveoli (A), severe inflammatory cell infiltration, congestion of pulmonary blood vessels, interstitial edema, hemorrhage, degeneration of bronchiolar epithelium and possible early fibrosis.



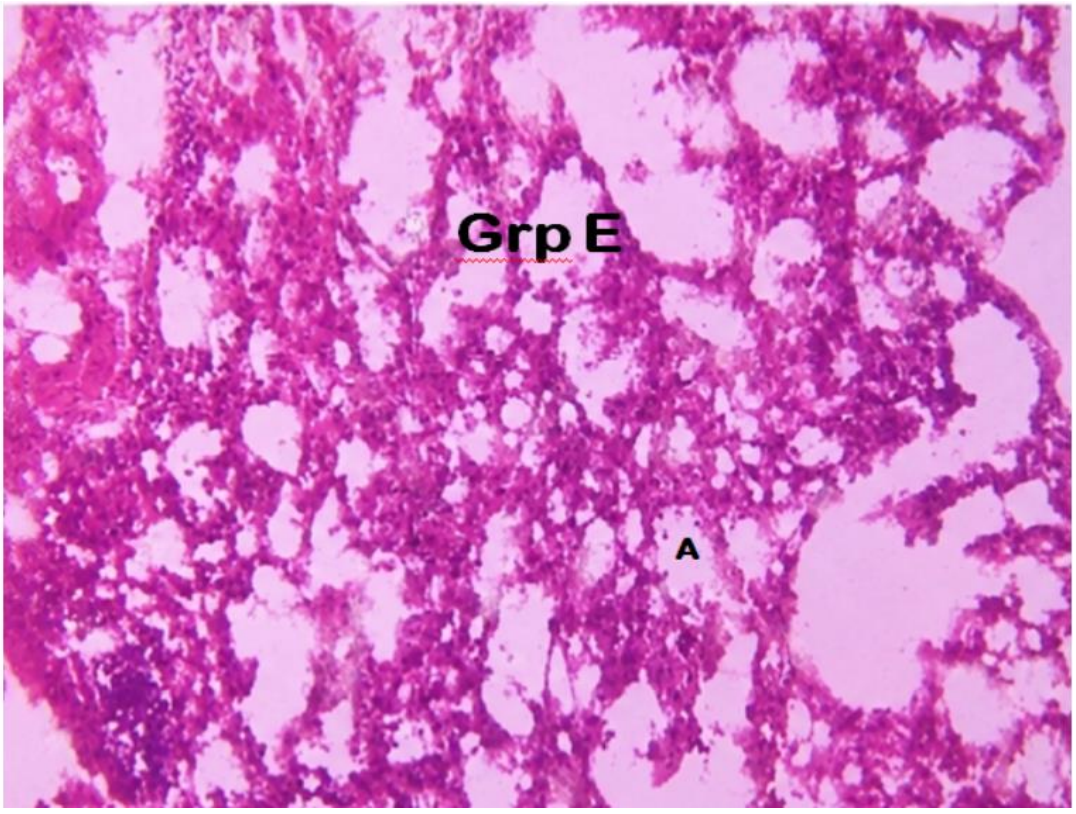
C. Experimental group 1 (Group C): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 200mg/kg of *Senna occidentalis* leaf extract. Reduced inflammatory cell infiltration, mild septal thickening, slight congestion, partial restoration of alveolar architecture and reduced edema.



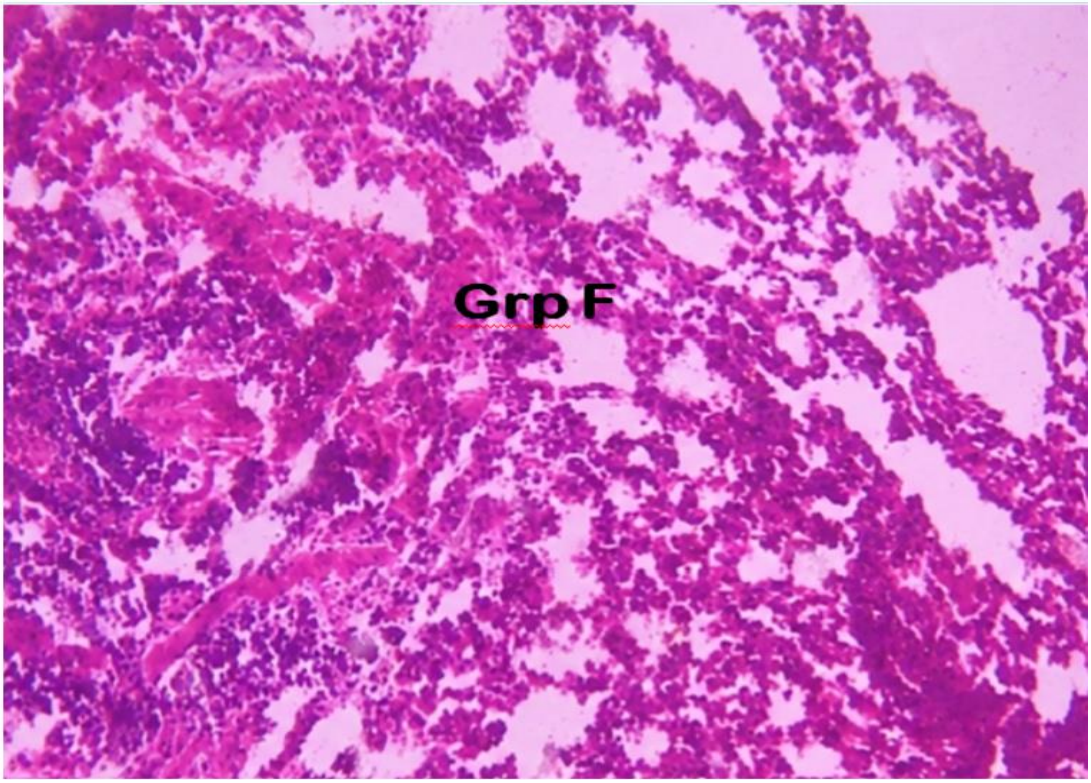
D. Experimental group 2 (Group D): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 400mg/kg of *Senna occidentalis* leaf extract. Better preservation of alveolar spaces, mild inflammatory infiltration, minimal vascular congestion, reduced septal thickening and improved bronchiolar epithelial (Be) integrity.



E. Experimental group 3 (Group E): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 600mg/kg of *Senna occidentalis* leaf extract. Intact alveolar sacs, thin alveolar septa, minimal or absent inflammatory infiltrates, no edema and restoration of normal bronchiolar architecture.

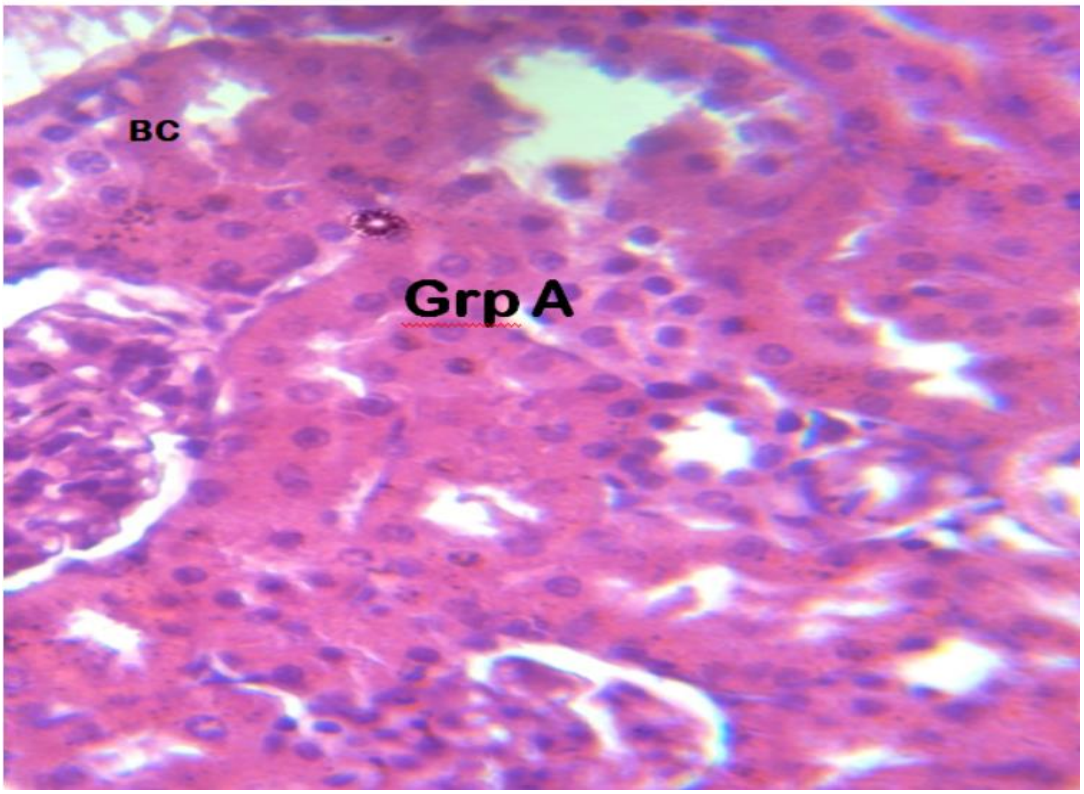


F. Positive group (Group F): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 100mg/kg of Vitamin E. Mild inflammatory infiltration, minimal congestion, preserved alveolar architecture, reduced oxidative tissue injury and limited septal thickening.

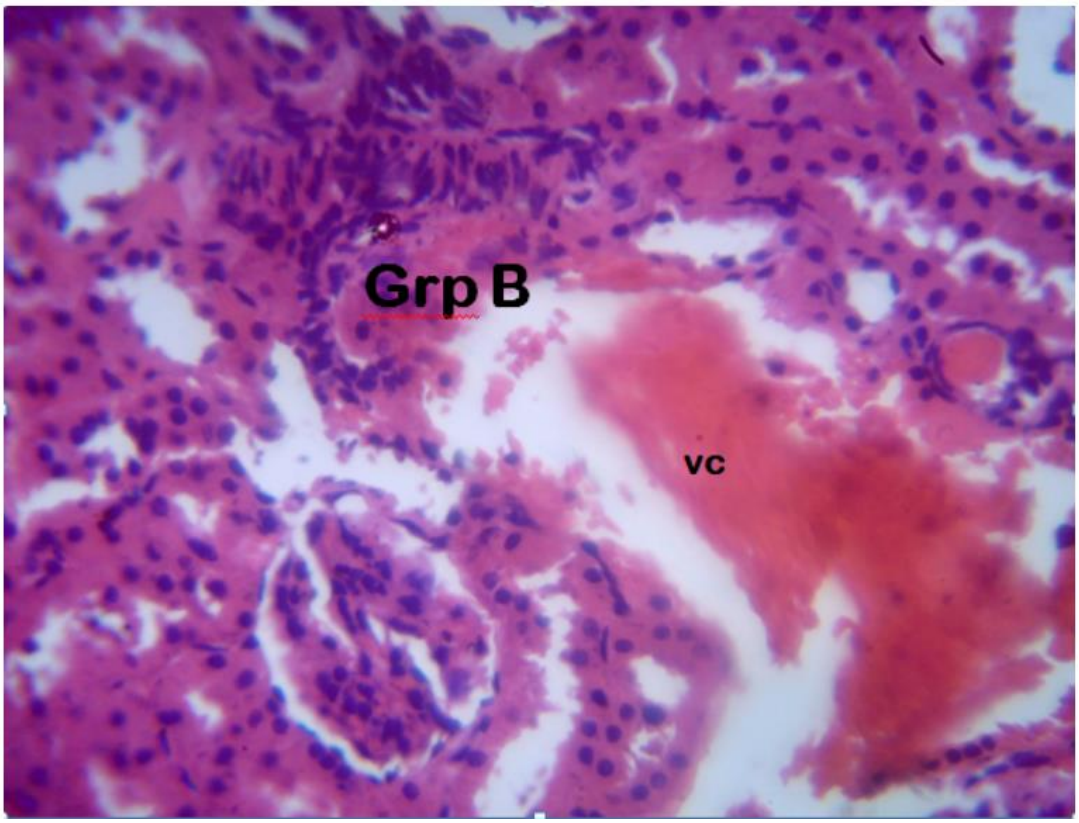


Histological Observations in the Kidneys across all Experimental Groups

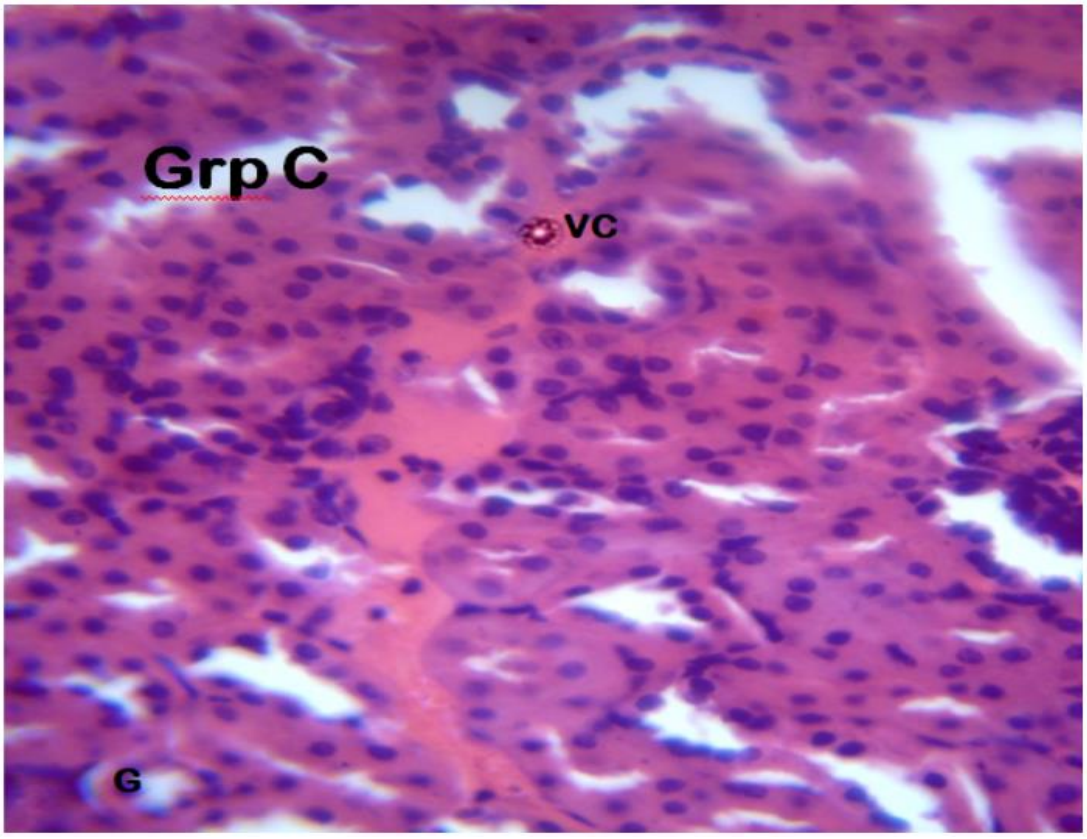
A. Normal Control (Group A): This group received only feed and water. Well-defined renal corpuscles, intact glomeruli, normal Bowman's capsules (BC) and urinary spaces, normal proximal and distal convoluted tubules, and no evidence of inflammation, tubular degeneration.



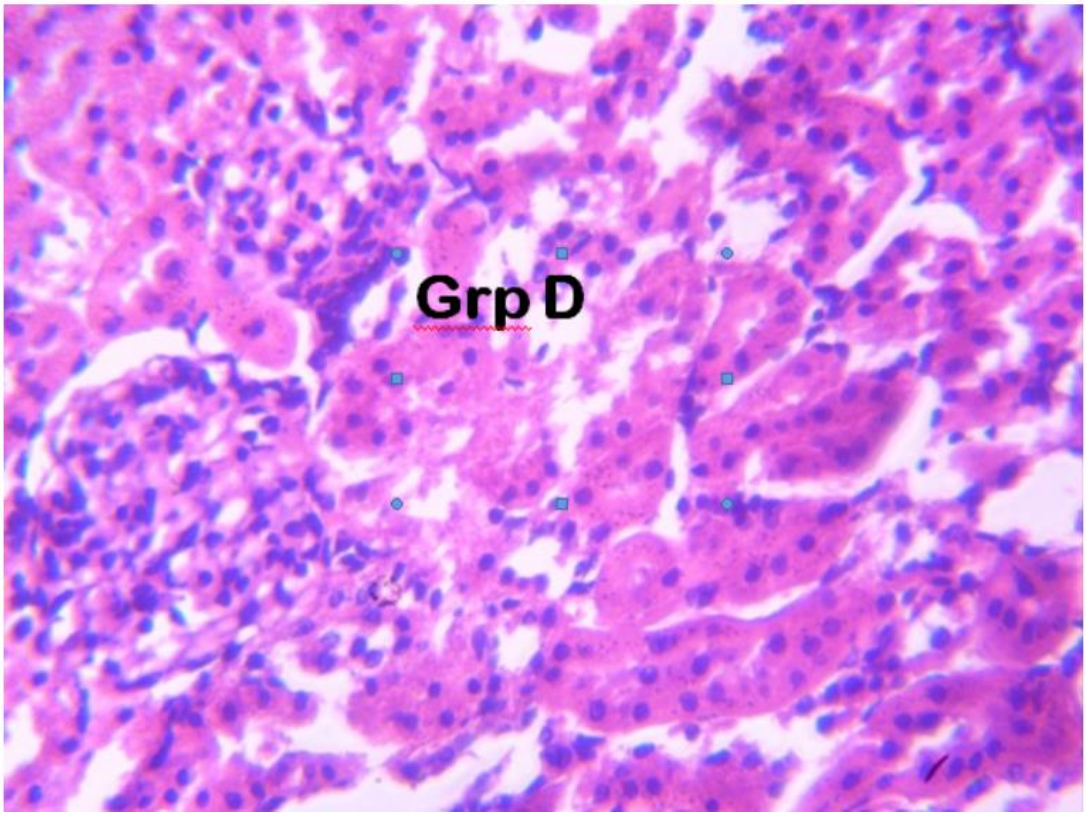
B. Negative group (Group B): This group was exposed to smoked *Cannabis sativa* only with no treatment. Distorted renal architecture, glomerular shrinkage (glomerular atrophy), widened Bowman's space, tubular epithelial degeneration and necrosis, tubular dilatation, vascular congestion (VC), interstitial edema, inflammatory cell infiltration and occasional tubular casts.



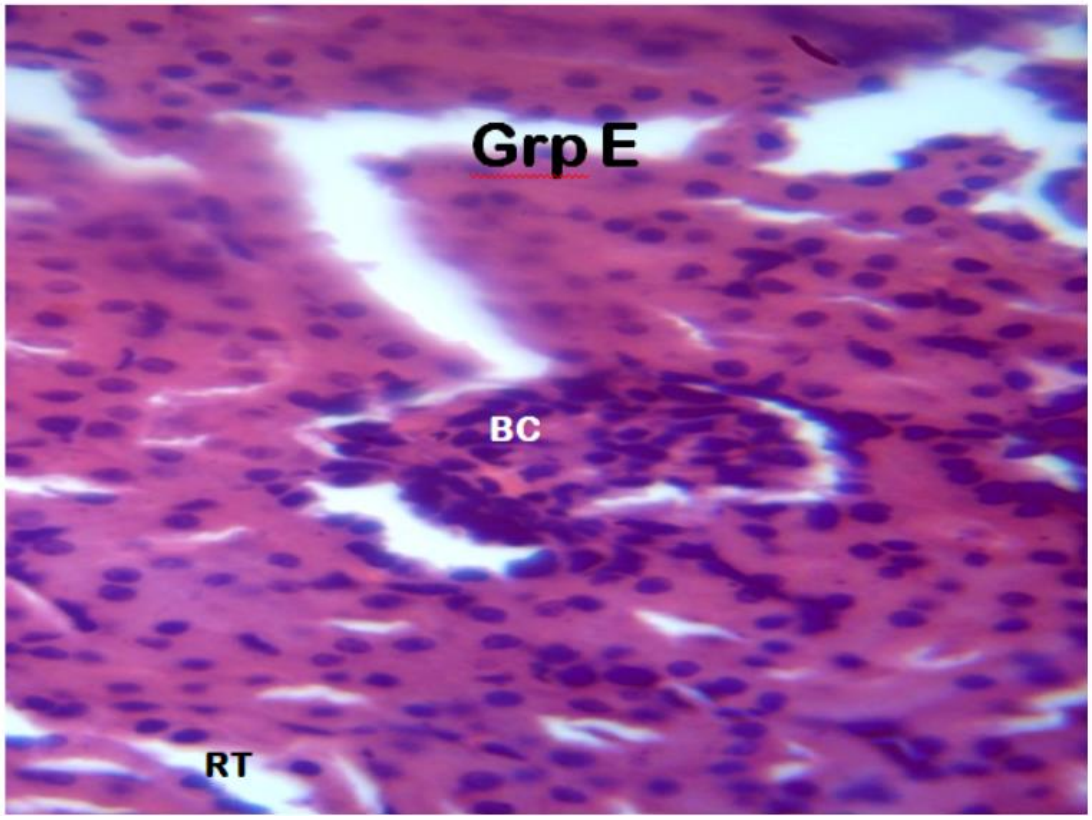
C. Experimental group 1 (Group C): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 200mg/kg of *Senna occidentalis* leaf extract. Reduced tubular degeneration, mild glomerular distortion (G), slight vascular congestion (VC), mild inflammatory cell infiltration and partial restoration of renal architecture.



D. Experimental group 2 (Group D): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 400mg/kg of *Senna occidentalis* leaf extract. Moderate renoprotection with preservation of most glomeruli, mild tubular epithelial degeneration, minimal inflammatory infiltration, reduced vascular congestion, and improved tubular organization.



E. Experimental group 3 (Group E): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 600mg/kg of *Senna occidentalis* leaf extract. Near-normal renal histology with intact glomeruli and Bowman's capsules (BC), well-preserved renal tubules (RT), minimal or no inflammatory infiltration, absence of tubular necrosis, and normal cortical architecture. This group is expected to show the greatest protective effect among the extract-treated groups.



F. Positive group (Group F): This group was exposed to smoked *Cannabis sativa* and subsequently treated with 100mg/kg of Vitamin E. Marked attenuation of renal injury with preserved glomerular architecture, mild tubular degeneration, minimal congestion and inflammation, reduced oxidative damage, and substantial restoration of normal renal histology.

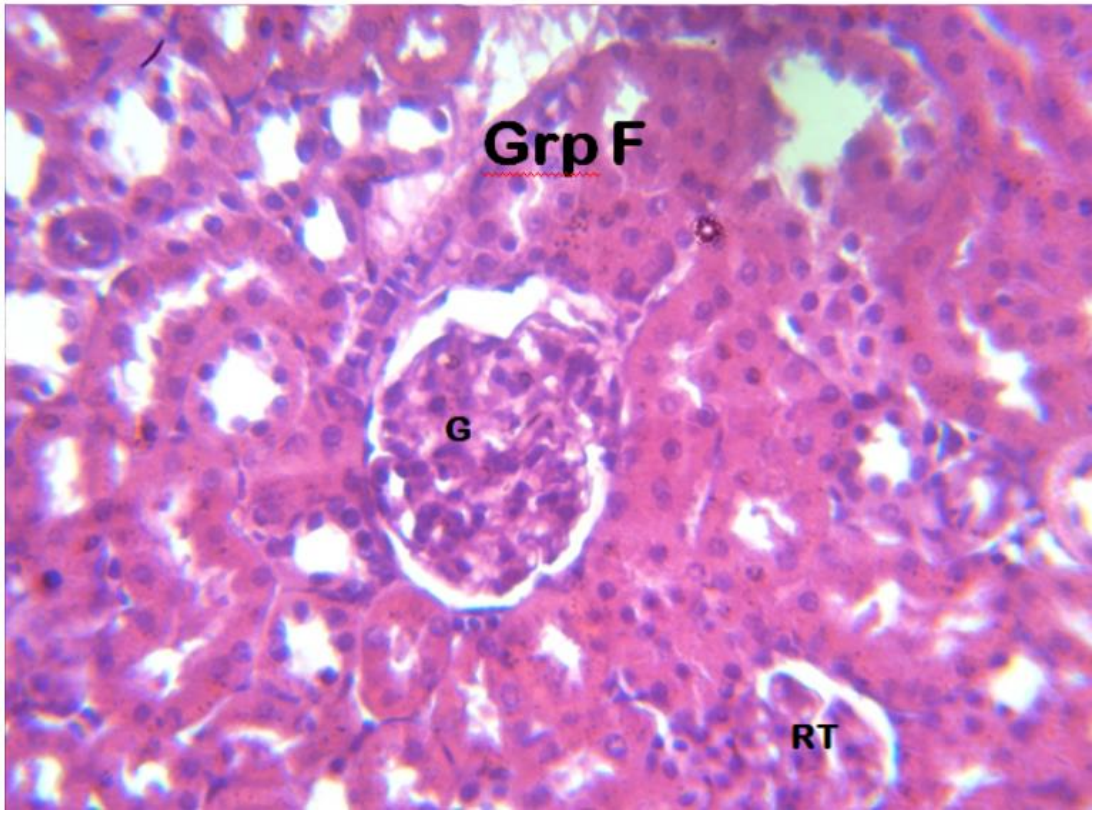


Table 2: Phytochemical Analysis of *Senna occidentalis* extract

From the table showing the phytochemical analysis of *Senna occidentalis* leaf extract, it shows that flavonoids and phenolic compounds are highly present in the extract while tannins, saponins and terpenoids are slightly present.

Phytochemical	**Result**
Alkaloids	Present
Flavonoids	Highly present
Phenols	Highly present
Tannins	Moderately present
Saponins	Moderately present
Terpenoids	Moderately present
Steroids	Present
Glycosides	Present

Table 3: Effects of *Senna occidentalis* Leaf Extract on Pulmonary Oxidative Stress Biomarkers in *Cannabis sativa*-Induced Wistar Albino Rats

Group	**MDA (nmol/mg protein)**	**SOD (U/mg protein)**	**CAT (U/mg protein)**	**GPx (U/mg protein)**	**GSH (µ/mg tissue)**
A	1.85±0.18a	15.82±1.21a	68.45±4.32a	10.84±0.91a	8.72±0.61a
B	5,94±0.42e	6.14±0.62e	29.56±2.84e	4.12±0.48e	3.18±0.34e
C	4.62±0.36d	8.85±0.76d	41.38±3.15d	6.24±0.56d	4.91±0.42d
D	3.41±0.28c	11.82±0.95c	52.76±3.87c	8.14±0.73c	6.53±0.48c
E	2.34±0.22b	14.56±1.08ab	63.24±4.15ab	10.18±0.84ab	8.04±0.57ab
F	1..61±0.24b	13.82±1.02b	60.47±3.98b	9.96±0.79b	7.71±0.52b

Values are expressed as Mean ± SD (n = 6). Means within the same column bearing different superscript letters (a–e) differ significantly at $P < 0.05$ using one-way ANOVA followed by Tukey's post hoc test.

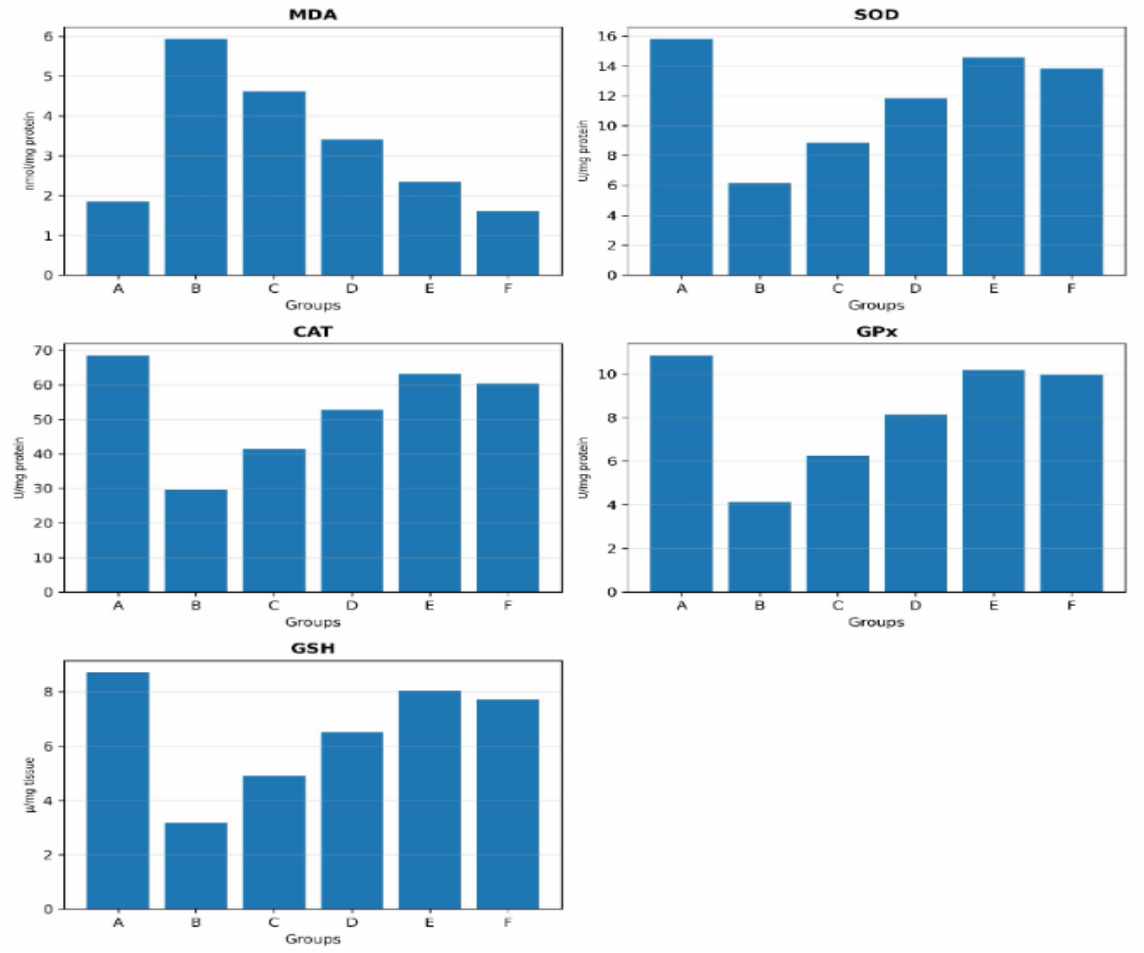


Figure 1: Effects of *Senna occidentalis* Leaf Extract on Pulmonary Oxidative Stress Biomarkers in *Cannabis sativa*-Induced Wistar Albino Rats.

Table 3 and figure 1 presents the effects of *Cannabis sativa* smoke exposure and treatment with varying doses of *Senna occidentalis* leaf extract on selected oxidative stress biomarkers in the experimental animals. The biomarkers assessed were malondialdehyde (MDA), superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and reduced glutathione (GSH). Data are expressed as Mean ± SD, while values bearing different superscript letters within the same column are significantly different at $P < 0.05$.

The normal control group (Group A) exhibited the lowest MDA level (1.85 ± 0.18 nmol/mg protein), indicating minimal lipid peroxidation under normal physiological conditions. This group also recorded the highest antioxidant enzyme activities, including SOD (15.82 ± 1.21 U/mg protein), CAT (68.45 ± 4.32 U/mg protein), GPx (10.84 ± 0.91 U/mg protein) and GSH (8.72 ± 0.61 µ/mg tissue), reflecting an intact endogenous antioxidant defense system.

The untreated *Cannabis sativa*-exposed group (Group B) demonstrated the highest MDA concentration (5.94 ± 0.42 nmol/mg protein), which was significantly higher than all other groups ($P < 0.05$). This marked increase indicates severe lipid peroxidation and oxidative damage induced by *cannabis* smoke exposure. Concurrently, Group B showed the lowest activities of SOD (6.14 ± 0.62 U/mg protein), CAT (29.56 ± 2.84 U/mg protein), GPx (4.12 ± 0.48 U/mg protein) and GSH (3.18 ± 0.34 µ/mg tissue), suggesting profound depletion of endogenous antioxidant defenses due to excessive production of reactive oxygen species.

Animals treated with *Senna occidentalis* leaf extract showed dose-dependent improvements in oxidative stress indices. Group C exhibited partial reductions in MDA (4.62 ± 0.36 nmol/mg protein) and corresponding increases in antioxidant enzyme activities, indicating that the extract effectively reduced oxidative stress. Group D demonstrated greater improvement, with MDA declining further to 3.41 ± 0.28 nmol/mg protein, while SOD, CAT, GPx, and GSH values increased. Group E recorded the lowest MDA value among the treated groups (2.34 ± 0.22 nmol/mg protein) and high antioxidant enzyme activities, indicating the strongest protective effect against cannabis-induced oxidative damage. Although some antioxidant parameters remained slightly below those of the normal control, Group F exhibited substantial restoration of the antioxidant defense system.

Treatment with Vitamin E (Group F) ameliorated the oxidative damage caused by *cannabis* exposure. MDA concentration decreased to 1.61 ± 0.24 nmol/mg protein, while SOD, CAT, GPx, and GSH activities decreased significantly compared with the untreated group ($P < 0.05$). However, these values remained significantly different from those of the normal control, indicating only partial restoration of antioxidant capacity.

Table 4: Effects of *Senna occidentalis* Leaf Extract on Renal Oxidative Stress Biomarkers in *Cannabis sativa*-Induced Wistar Albino Rats

Group	MDA (nmol/mg protein)	SOD (U/mg protein)	CAT (U/mg protein)	GPx (U/mg protein)	GSH (µmol/g tissue)
A	1.72±0.16a	16.45±1.14a	72.38±4.28a	11.26±0.82a	8.94±0.63a
B	6.12±0.45e	5.82±0.58e	27.86±2.67e	3.86±0.42e	2.96±0.31e
C	4.85±0.37d	8.46±0.71d	40.24±3.12d	5.98±0.51d	4.62±0.39d
D	3.54±0.29c	11.58±0.88c	53.41±3.69c	8.12±0.65c	6.41±0.46c
E	2.21±0.20b	15.08±1.02ab	67.18±4.06ab	10.62±0.78ab	8.31±0.58ab
F	1.46±0.23b	14.36±0.97b	64.52±3.84b	10.08±0.72b	7.92±0.54b

Values are presented as Mean ± SD (n = 6). Means within the same column with different superscript letters (a–e) are significantly different at $P < 0.05$ using one-way ANOVA followed by Tukey's multiple comparison test.

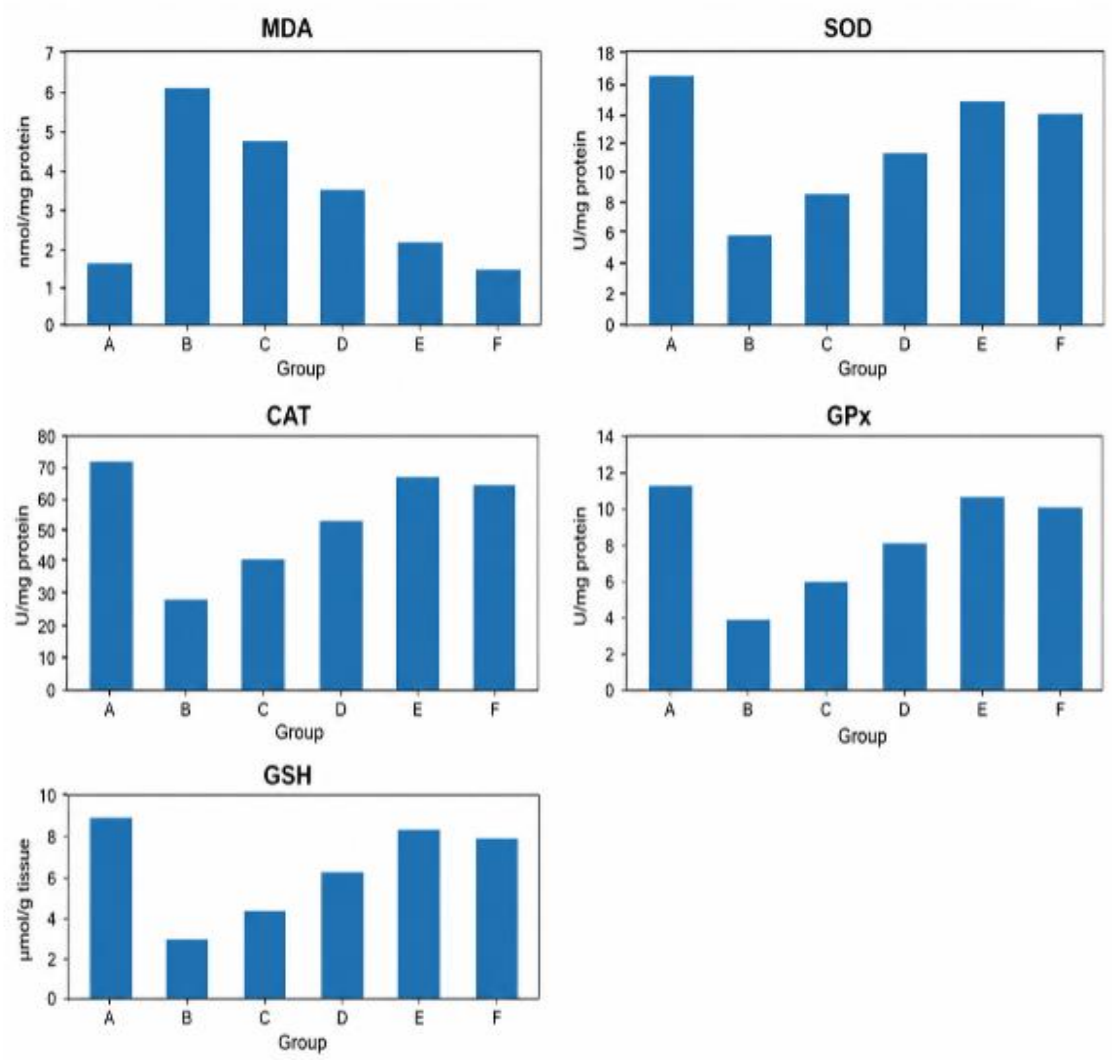


Figure 2: Effects of *Senna occidentalis* Leaf Extract on Renal Oxidative Stress Biomarkers in *Cannabis sativa*-Induced Wistar Albino Rats

The bar charts (Figure 2), illustrate the effects of *Senna occidentalis* leaf extract on selected renal oxidative stress biomarkers in *Cannabis sativa*-induced Wistar albino rats. The biomarkers assessed were malondialdehyde (MDA), superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and reduced glutathione (GSH). Group A served as the normal control, Group B was exposed to *Cannabis sativa* without treatment, Groups C, D and E received 200, 400 and 600 mg/kg of Senna occidentalis leaf extract, respectively, while Group F received Vitamin E.

The MDA bar chart shows that Group B recorded the highest level of lipid peroxidation, indicating severe oxidative damage to the renal tissues following *Cannabis sativa* exposure. Treatment with *Senna occidentalis* leaf extract progressively reduced MDA levels in Groups C, D, and E, demonstrating a dose-dependent protective effect. The 600 mg/kg dose (Group E) produced values very close to those of the normal control, while the Vitamin E-treated group (Group F) exhibited the lowest MDA level among the treated groups, confirming its potent antioxidant activity.

The SOD bar chart demonstrates that *Cannabis sativa* exposure markedly depleted superoxide dismutase activity in Group B compared with the control group. Administration of *Senna occidentalis* significantly restored SOD activity in a dose-dependent manner, with the 600 mg/kg dose producing the greatest improvement among the extract-treated groups. Vitamin E also markedly increased SOD activity, confirming its effectiveness in scavenging reactive oxygen species and protecting renal tissues against oxidative injury.

Similarly, the CAT bar chart reveals a pronounced reduction in catalase activity in the untreated *Cannabis sativa* group. Catalase is an important antioxidant enzyme responsible for degrading hydrogen peroxide into water and oxygen. The progressive increase in CAT activity observed in Groups C, D and E indicates that *Senna occidentalis* enhanced the renal antioxidant defense system. The highest extract dose produced catalase activity approaching that of the normal control, while Vitamin E also restored catalase activity substantially.

The GPx bar chart follows the same trend. Group B exhibited the lowest glutathione peroxidase activity, reflecting impaired enzymatic antioxidant defense following oxidative stress. Administration of *Senna occidentalis* increased GPx activity in a dose-dependent fashion, with the 600 mg/kg treatment showing the greatest improvement among the extract-treated animals. Vitamin E also significantly enhanced GPx activity, demonstrating its established antioxidant potential.

The GSH bar chart further confirms these findings. Reduced glutathione concentrations were markedly depleted in Group B due to excessive oxidative stress induced by *Cannabis sativa*. Treatment with *Senna occidentalis* restored GSH levels progressively as the dose increased, indicating enhanced intracellular antioxidant capacity. The 600 mg/kg dose produced values close to the normal control, while Vitamin E similarly restored GSH concentrations to near-normal levels.

Table 5: Effects of *Senna occidentalis* Leaf Extract on Renal Function Indices in *Cannabis sativa*-Induced Wistar Albino Rats

Group	Urea (nmol/L)	Creatinine (µmol/L)	Uric Acid (mg/dL)	Na+ (nmol/L)	K+ (nmol/L)	Cl- (nmol/L)	HCO3- (nmol/L)
A	5.48±0.42a	52.43±4.12a	2.82±0.21a	142.85±3.21a	4.12±0.25a	102.68±2.84a	24.72±1.43a
B	12.84±0.88e	118.76±8.54e	6.82±0.46e	129.42±3.68e	4.54±0.41e	91.34±3.26e	17.86±1.28e
C	10.38±0.74d	97.82±6.73d	5.34±0.38d	133.83±3.42d	5.82±0.36d	95.62±3.08d	20.34±1.36d
D	8.16±0.63c	79.46±5.86c	4.18±0.31c	137.52±3.27c	5.12±0.31c	98.84±2.91c	22.48±1.24c
E	6.24±0.51b	60.82±4.68b	3.18±0.24b	141.16±3.06ab	4.38±0.28b	101.46±2.73ab	24.061.37ab
F	5.10±0.54b	64.14±4.92b	3.42±0.26b	140.22±3.12b	4.58±0.29b	100.84±2.81b	23.64±1.31b

Values are expressed as Mean ± SD (n = 6). Means with different superscript letters (a–e) within the same column are significantly different at $P < 0.05$ using one-way ANOVA followed by Tukey's post hoc multiple comparison test.

Group A (Normal Control): Exhibited normal renal function with low serum urea, creatinine and uric acid levels, alongside normal electrolyte concentrations.

Group B (*Cannabis sativa*): Showed significant elevations in serum urea, creatinine, uric acid, and potassium, with significant reductions in sodium, chloride, and bicarbonate levels, indicating impaired renal filtration and electrolyte imbalance due to cannabis-induced nephrotoxicity.

Groups C–E (*Senna occidentalis*): Demonstrated dose-dependent improvement in renal function. Increasing doses of the extract progressively reduced urea, creatinine, uric acid, and potassium while restoring sodium, chloride, and bicarbonate concentrations toward normal values.

Group E (600 mg/kg): Produced the greatest renoprotective effect among the extract-treated groups, with renal function indices approaching those of the normal control.

Group F (Vitamin E): Also showed marked improvement in renal function indices, with effects comparable to, though slightly less pronounced than, the highest dose of Senna occidentalis leaf extract.

Discussion

The present study investigated the ameliorative effects of *Senna occidentalis* leaf extract against *Cannabis sativa*-induced pulmonary and renal toxicity in Wistar albino rats. The findings demonstrated that exposure to cannabis smoke resulted in significant structural and biochemical alterations in the lungs and kidneys, whereas treatment with *Senna occidentalis* leaf extract produced dose-dependent protection. The protective effects of the extract were evidenced by improvements in pulmonary and renal histology, restoration of antioxidant enzyme activities, reduction in lipid peroxidation, and normalization of renal function indices. Vitamin E, used as the standard antioxidant, also markedly attenuated cannabis-induced tissue damage, although the highest dose of *Senna occidentalis* produced comparable protective effects.

The histological examination of the lungs showed that the normal control group maintained intact pulmonary architecture characterized by thin alveolar septa, patent alveolar spaces, intact bronchioles, and absence of inflammatory infiltration. In contrast, rats exposed solely to *Cannabis sativa* smoke exhibited severe pulmonary lesions including thickened alveolar septa, inflammatory cell infiltration, vascular congestion, pulmonary edema, degeneration of bronchiolar epithelium, and distortion of alveolar architecture. These observations suggest that cannabis smoke induces significant pulmonary injury through oxidative stress and inflammatory mechanisms. Combustion of cannabis produces numerous reactive oxygen species (ROS), carbon monoxide, tar, and particulate matter capable of damaging pulmonary tissues. The resulting oxidative stress initiates inflammatory cascades, increases vascular permeability, and promotes destruction of alveolar epithelial cells. These findings are consistent with previous reports that chronic cannabis smoke exposure causes pulmonary inflammation, oxidative injury, epithelial remodeling, and emphysematous changes (Adefegha *et al*., 2020).

Histological examination of renal tissues also revealed marked cannabis-induced nephrotoxicity. Kidneys from the untreated cannabis group demonstrated distorted glomeruli, widened Bowman's spaces, tubular epithelial degeneration, tubular necrosis, vascular congestion, interstitial edema and inflammatory cell infiltration. These lesions indicate

impairment of renal filtration and tubular function following *Cannabis* smoke exposure. Oxidative stress generated by cannabis smoke promotes lipid peroxidation of renal cell membranes, mitochondrial dysfunction, inflammatory cytokine production, and apoptosis, resulting in progressive renal injury. Similar renal histopathological alterations have been reported following exposure to various smoke-derived toxicants and oxidative stress-inducing agents (Adebayo *et al*., 2021; Adefegha *et al*., 2020).

Assessment of pulmonary oxidative stress biomarkers further confirmed the involvement of oxidative stress in Cannabis-induced toxicity. *Cannabis* exposure significantly elevated pulmonary malondialdehyde (MDA), indicating increased lipid peroxidation of pulmonary cell membranes. Elevated MDA reflects excessive production of reactive oxygen species exceeding the capacity of endogenous antioxidant defenses. Similar increases in MDA have consistently been reported in experimental models of smoke-induced lung injury (Adefegha *et al*., 2020). Concurrently, cannabis exposure significantly reduced the activities of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and reduced glutathione (GSH), demonstrating severe depletion of pulmonary antioxidant defenses.

Treatment with *Senna occidentalis* leaf extract significantly reversed these biochemical alterations in a dose-dependent manner. Progressive reductions in pulmonary MDA levels accompanied by significant restoration of SOD, CAT, GPx and GSH activities indicate that the extract effectively attenuated oxidative stress. The highest dose of the extract restored antioxidant biomarkers to values approaching those of the normal control and vitamin E groups. These findings strongly suggest that *Senna occidentalis* possesses potent free radical-scavenging activity capable of preventing lipid peroxidation while preserving endogenous antioxidant enzyme systems. The antioxidant activity of the extract is most likely attributable to its high flavonoid and phenolic content, which directly neutralize reactive oxygen species and activate endogenous antioxidant pathways, including the nuclear factor erythroid 2-related factor 2 (Nrf2) signaling pathway (Adefegha *et al*., 2020; Gulcin, 2020).

Similarly, renal oxidative stress biomarkers demonstrated severe oxidative injury following cannabis exposure. Significant elevation of renal MDA together with marked reductions in SOD, CAT, GPx, and GSH confirmed the occurrence of oxidative nephrotoxicity. The kidneys are particularly susceptible to oxidative damage because of their high metabolic activity and abundant mitochondrial content. Excessive ROS production damages glomerular and tubular membranes, impairs mitochondrial respiration and promotes inflammatory responses, ultimately resulting in renal dysfunction. These observations are consistent with previous studies demonstrating that oxidative stress is a central mechanism underlying toxicant-induced nephrotoxicity (Adefegha *et al*., 2020).

Evaluation of renal function indices provided additional evidence of *Cannabis*-induced nephrotoxicity. Rats exposed solely to cannabis exhibited significant elevations in serum urea, creatinine and uric acid concentrations together with disturbances in electrolyte balance, including reduced sodium, chloride and bicarbonate levels and increased potassium concentration. Elevated serum urea and creatinine are well-established indicators of impaired glomerular filtration, while electrolyte imbalance reflects tubular dysfunction. These biochemical alterations correspond closely with the renal histological lesions observed in the untreated cannabis group and indicate substantial impairment of renal function.

Overall, the findings of this study demonstrate that *Cannabis sativa* smoke induces significant pulmonary and renal toxicity through mechanisms involving oxidative stress, inflammation, lipid peroxidation and tissue degeneration. Treatment with *Senna occidentalis* leaf extract effectively attenuated these pathological changes in a dose-dependent manner, with the 600 mg/kg dose producing the greatest protective effect. The comparable efficacy observed between the highest dose of the extract and vitamin E further supports the potent antioxidant potential of *Senna occidentalis*. These findings suggest that *Senna occidentalis* leaf extract may serve as a promising natural therapeutic agent for the prevention or management of oxidative stress-mediated pulmonary and renal injuries associated with cannabis smoke exposure.

Summary and Conclusion

The present study was undertaken to evaluate the ameliorative effects of *Senna occidentalis* leaf extract on *Cannabis sativa*-induced lung and renal damage in Wistar albino rats.

The results of this study demonstrate that *Senna occidentalis* leaf extract possesses considerable antioxidant, anti-inflammatory and tissue-protective properties. The extract effectively attenuated cannabis-induced pulmonary and renal damage in a dose-dependent manner, with the 600 mg/kg dose exhibiting the greatest therapeutic efficacy. The comparable protective effects observed between the highest dose of the extract and vitamin E further support the potential of *Senna occidentalis* as a promising natural therapeutic agent for the prevention or management of oxidative stress-mediated lung and kidney injury associated with exposure to Cannabis sativa smoke. These findings contribute valuable scientific evidence supporting the medicinal potential of *Senna occidentalis* and provide a basis for future studies aimed at isolating its active constituents, elucidating its molecular mechanisms of action, and evaluating its safety and efficacy in clinical settings. The findings of this study clearly demonstrate that exposure to *Cannabis sativa* smoke produces significant pulmonary and renal toxicity through mechanisms involving oxidative stress, lipid peroxidation, inflammation and structural tissue degeneration. Conversely, administration of *Senna occidentalis* leaf extract significantly attenuated these pathological alterations in a dose-dependent

manner, thereby demonstrating its potent antioxidant and tissue-protective properties. One of the most important findings of the present study is the consistent dose-dependent response observed across all evaluated parameters. Histological observations, oxidative stress biomarkers and renal function indices all demonstrated progressive improvement with increasing doses of *Senna occidentalis* leaf extract. Among the treatment groups, the 600 mg/kg dose consistently produced the greatest protective effect, with results approaching those of the normal control and the vitamin E-treated group. This finding suggests that the therapeutic efficacy of the extract is concentration dependent and supports the selection of higher doses for future preclinical investigations, provided safety is established.

The findings of this study therefore provide strong experimental evidence that oxidative stress plays a central role in the pathogenesis of *Cannabis*-induced pulmonary and renal toxicity. More importantly, the study demonstrates that *Senna occidentalis* leaf extract effectively attenuates these pathological processes by enhancing antioxidant defenses and preserving tissue integrity. The comparable effectiveness observed between the highest dose of the extract and vitamin E further supports the antioxidant potential of *Senna occidentalis* and highlights its promise as a natural therapeutic agent.

In conclusion, this study establishes that exposure to *Cannabis sativa* smoke induces significant oxidative damage, histopathological alterations and functional impairment in the lungs and kidneys of Wistar albino rats. Administration of *Senna occidentalis* leaf extract significantly ameliorated these adverse effects by reducing oxidative stress, restoring antioxidant enzyme activities, improving renal function indices and preserving the normal histological architecture of pulmonary and renal tissues. The protective effects were dose dependent, with the 600 mg/kg dose producing the greatest therapeutic benefit.

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References

1. Addissouky, T. A., El Sayed, I. E. T., Ali, M. M. A., Wang, Y., El Baz, A., Elarabany, N. and Khalil, A. A. (2024). Oxidative stress and inflammation: Elucidating mechanisms of smoking-attributable pathology for therapeutic targeting. Bulletin of the National Research Centre, 48(16), 1–15. https://doi.org/10.1186/s42269-024-01174-6
2. Adebayo, A. H., Abolaji, A. O. and Kela, R. (2021). Oxidative stress-mediated nephrotoxicity and antioxidant interventions in experimental animal models. Toxicology Reports, 8, 1013–1025.
3. Adefegha, S. A., Oboh, G. and Oyeleye, S. I. (2020). Phenolic compounds as natural antioxidants and their protective roles against oxidative stress. Journal of Food Biochemistry, 44(10), e13386.
4. Arlen, M. T., Patterson, S. J., Page, M. K., Liu, R., Caruana, V., Wilson, E. T., Laporte, S. A., Goniewicz, M. L., Harris, C. S., Eidelman, D. H. and Baglole, C. J. (2025). Cannabis vaping elicits transcriptomic and metabolomic changes involved in inflammatory, oxidative stress, and cancer pathways in human bronchial epithelial cells. American *Journal of Physiology-Lung Cellular and Molecular Physiology*, 328(3), L385–L402. https://doi.org/10.1152/ajplung.00131.2024
5. ARRIVE Guidelines. (2020). ARRIVE 2.0: Updated Guidelines for Reporting Animal Research. PLOS Biology, 18(7), e3000410.
6. Kumar, P., Meena, M., Verma, R. and Sharma, S. (2023). Phytochemistry and pharmacological potential of Cannabis sativa: A comprehensive review. *Journal of Ethnopharmacology*, 317, 116824.
7. Kumar, V., Abbas, A. K. and Aster, J. C. (2023). Robbins & Cotran pathologic basis of disease (11th ed.). Elsevier.
8. National Institute on Drug Abuse. (2024). Cannabis (Marihuana) Research Reports. U. S Department of Health and Human Services.
9. Sanz-Pérez, A., Pérez, T. and González-Burgos, E. (2026). Preclinical evidence of cannabis-induced oxidative stress: A systematic review and meta-analysis. Regulatory Toxicology and Pharmacology, 168, 106067. https://doi.org/10.1016/j.yrtph.2026.106067
10. United Nations Office on Drugs and Crime. (2023). World Drug Report 2023. United Nations.
11. World Health Organization. (2023). Global health estimates: Leading causes of death and disability. Geneva: World Health Organization.
12. World Health Organization. (2023). WHO global report on traditional and complementary medicine. World Health Organization.
13. World Health Organization. (2024). Global health estimates 2024. World Health Organization.
14. Xiong, J., Xie, L., Huang, Y., Zhu, J., Hong, Z., Qian, H. and Liu, J. (2024). Therapeutic effects of melatonin on the lungs of rats exposed to passive smoking. Respiratory Research, **25**(411), 1–14. https://doi.org/10.1186/s12931-024-03042-3
15. Zaman, S., Ahmed, A., Khan, R. and Ibrahim, M. (2024). Cenchrusciliaris L. ameliorates cigarette-smoke induced acute lung injury by reducing inflammation and oxidative stress. South *African Journal of Botany*, 171, 216–227. https://doi.org/10.1016/j.sajb.2024.05.057