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Evaluation of nephroprotective activity of methanolic extract of santalum album leaves

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Abstract
The present study designed to evaluate the protective effect of leaves extract (methanol) of Santalum album Linn. plant against cisplatin-induced nephropathy and gentamycin induced nephropathy in rats. Cisplatin and gentamycin administered rats (toxic control group) had encountered acute kidney dysfunction as evidenced by elevation in serum urea and creatinine, decreased urine output and body weight with multiple histological damages. Treatment with the methanol extract of Santalum album leaves at the dose level of 400 mg/kg b.w. for 14 days and 21 respectively (SAME400 group) significantly lowered the serum level of creatinine and urea, decreased urine creatinine and albumin with a significant weight gain, and increased urine output when compared with the toxic group. The histological damages in the Santalum album -treated group were minimal in contrast to the toxic rats. The statistical significance of the nephroprotective activity of Santalum album - treated group and the polyherbal drug cystone (standard group)-treated group (both the groups were compared against toxic control) were found to gain same level of significance ($P<0.001$) against the toxic group.

Keywords: santalum album, nephroprotective, nephropathy, polyherbal

Introduction

Traditional medicine is “the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, used in the maintenance of health and in the prevention, diagnosis, improvement or treatment of physical and mental illness”. The pharmacological treatment of disease began long ago with the use of herbs. Methods of folk healing throughout the world commonly used herbs as part of their tradition [1, 2].

In some cases, the active principles of plant-derived products have been isolated and characterized, and their mechanisms of action are understood. It is also a function of the traditionally-held belief that the synergistic combination of several active principles in some herbal preparations is responsible for their beneficial effects [3, 4].

Santalum album Linn, belonging to the family Santalaceae is one of the most precious trees in the world. Commonly known as White sandalwood (English), Safed Chandan (Hindi) and Srigandha (Sanskrit), acclaimed as one of the oldest known perfumery materials having more than 2000 years of incessant history, sandalwood has retained its eminence as admired perfumery stuff from antiquity down to modern times. It is generally accepted that sandal is indigenous to peninsular India as its history of recorded occurrence dates back to at least 2500 years. Sandal tree grows under different edaphic and eco-climatic conditions, adapts very well in terms of growth, heartwood and oil content. The finest wood grows in driest region particularly on red or stony ground while on rocky ground the tree often remains small but gives the highest yield of oil. The heartwood is moderately hard, heavy, durable, yellow or brown in appearance, with an oily texture and is an exquisite material for carving intricate designs. The carved images of gods and mythological figures have a high demand in the market. A wide variety of articles such as boxes, cabinet panels, jewel cases, combs, picture frames, hand fans, pen holders, card cases, letter openers and bookmarks are made from sandalwood. The heartwood constitutes the central part of the tree and is valued for its fragrance. The bark and outer wood (sapwood) or other parts of the tree however, have no fragrance. The plant has been mainly exploited for sandalwood oil obtained by steam distillation of its heartwood [5, 6, 7].

Santalum album is mainly grown for its timber and fragrant oil. The timber weighing 870 kg/cubic m is durable and strong. Its close grained heartwood is used for ornamental and carving work. The wood has been used as a fuel but is generally considered too valuable for this purpose. Sandalwood oil distilled from the heartwood is a pale yellow to yellow viscous liquid, with sweet, fragrant, persistent, spicy, warm, woody, animalic, milky and nutty notes. It is extensively used in perfumery, cosmetics, aromatherapy and pharmaceutical industry. Being good fixatives, it is highly valued in perfumery and toiletry industry, especially for certain delicate scents that are extremely rare and fragile. No composition of the heavy or oriental type of perfume is complete without an ample dose of sandalwood oil. Most Indian attars use sandal oil as the base because of its inherent capacity to absorb most of the ethereal notes of other whole herbs or flowers, as it can enhance their perfumery status and stability. The oil is used as a flavoring substance in food products such as frozen dairy desserts, candy, pan masala, baked food, gelatin, puddings and also in alcoholic and non- alcoholic beverages. US Food and Drug Administration, Flavor and Extract Manufacturers Association Council of Europe and Joint FAO/WHO Expert Committee have approved sandalwood oil for use as food additives [8, 9, 10].

The kidneys are a pair of bean-shaped organs on either side of your spine, below your ribs and behind your belly. Each kidney is about 4 or 5 inches long, roughly the size of a large fist.

The kidneys' job is to filter your blood. They remove wastes, control the body's fluid balance, and keep the right

levels of electrolytes. Blood comes into the kidney, waste gets removed, and salt, water, and minerals are adjusted, if needed. The filtered blood goes back into the body. Waste gets turned into urine, which collects in the kidney's pelvis - a funnel-shaped structure that drains down a tube called the ureter to the bladder.

Each kidney has around a million tiny filters called nephrons. You could have only 10% of your kidneys working, and you may not notice any symptoms or problems. If blood stops flowing into a kidney, part or all of it could die. That can lead to kidney failure.

Nephropathy is widely encountered among the people of entire world irrespective of the age, racial, environmental, and geographical variability. The etiology behind this complication is broad ranging from substance-induced to various metabolic and physiological disturbances, paneling nephropathy amongst the 10 leading causes of death across the world [11, 12, 13].

Nephrotoxicity is one of the most common kidney problems and occurs when body is exposed to a drug or toxin. A number of therapeutic agents can adversely affect the kidney, resulting in acute renal failure, chronic interstitial nephritis and nephritic syndrome because there is an increasing number of potent therapeutic drugs like aminoglycoside antibiotics, NSAID's, chemotherapeutic agents have been added to the therapeutic arsenal in recent years. Exposure to chemical reagents like ethylene glycol, carbon tetrachloride, sodium oxalate and heavy metals such as lead, mercury, cadmium and arsenic also induces nephrotoxicity. Prompt recognition of the disease and cessation of responsible drugs are usually the only necessary therapy. Nephroprotective agents are the substances which possess protective activity against Nephrotoxicity. Medicinal plants have curative properties due to the presence of various complex chemical substances. Coadministration of various medicinal plants possessing nephroprotective activity along with different nephrotoxic agents which may attenuate its toxicity. The term renal failure primarily denotes failure of the excretory function of kidney, leading to retention of nitrogenous waste products of metabolism in the blood. In addition to this, there is a failure of regulation of fluid and electrolyte balance along with endocrine dysfunction. The renal failure is fundamentally categorized into acute and chronic renal failure [14, 15, 16].

Acute renal failure (ARF) refers to the sudden and usually reversible loss of renal function which develops over a period of days or weeks. There are many causes for acute renal failure which mainly includes acute tubular necrosis that commonly accounts for 85% of incidence. Mostly acute tubular necrosis occurs either due to ischemia or toxins. The toxins may be exogenous or endogenous. The exogenous agents are radio contrast agents, cyclosporine, antibiotics, chemotherapeutic agents, organic solvents, acetaminophen and illegal abortifacients5, 6. Chronic renal failure (CRF) is an irreversible deterioration in the renal function which classically develops over a period of years, leading to loss of excretory metabolic and endocrine functions. Various causes of renal failure has been recognized like hypertension, diabetes mellitus, antineoplastic agents like cyclophosphamide, vincristine and cisplatin etc [17, 18].

Certain Indian Medicinal plants have been reported to exhibit protective effect of renal tissues against injuries [5]. Medicinal plants used for the treatment of kidney disorders by tribal practitioners and traditional medicine systems have been shown to possess promising nephroprotective activities. This reveals that evaluation of herbal drugs is still needed to explore its benefits in the treatment of kidney disorders. This present study of nephroprotective activity of Santalum album linn will assure the research for better and cost effective nephroprotection.

Methodology

Material Selection

Animal Selection

Swiss albino male rats of wistar strain weighing 200-250g were used for the study. The mice and rats were inbred in the central animal house, under suitable conditions of housing, temperature, ventilation and nutrition were used for antidepressant activity. They were kept in clean dry cages week before the beginning of the experiment to acclimatize with the experimental conditions. The animals were fed with standard pelleted diet (Lipton India Ltd., Mumbai) and distilled water ad libitum was maintained at 21^0C-23^0C under a constant 12hrs light and dark cycle.

The animal care and experimental protocols were in accordance with Institutional Animal ethics committee constituted as per the direction of the committee for the purpose of control and supervision of experiments on animals CPCSEA /IAEC

Housing

Mice as well as albino rats were housed in groups of six in each clean cage. The bedding material of the cages was removed and replaced thrice a week with fresh materials as often as necessary to keep the animals clean and dry. Bedding materials used in sufficient amount to keep animals dry between cage changes without coming into contact with watering tubes. Drinking tubes were examined routinely to ensure their proper function.

Chemicals used

Table 1: Chemicals used for the study

Sl no	Chemicals	Supplier
1.	Methanol	HiMedia Laboratories Pvt. Ltd. Nashik
2.	Sodium CMC	HiMedia Laboratories Pvt. Ltd. Nashik
3.	phenyl benzoquinone	Central Drug House Ltd, New Delhi
4.	Gentamycin	Central Drug House Ltd, New Delhi
5.	Cisplatin	HiMedia Laboratories Pvt. Ltd. Nashik
6.	Cystone Syrup	Himalaya Drug Company., Bangalore, India

Plant material

The bundle of leaves of Santalum album Linn. belongs to family Santalaceae was collected from young matured plant collected from local region of Mangalore district in the month of November and December and the annexure of the same is enclosed. It is preserved in the departmental library for future reference.

Extraction and preparation of test sample

After authentication fresh plant materials were collected in bulk, washed under running tap water to remove adherents, shade dried, and pulverized in a mechanical grinder to get coarse powder of Santalum album leaves. Coarse powder of the air-dried leaves was subjected to successive solvent extraction method using methanol in a soxhlet extraction unit till exhaustion to get methanolic extract. The extract

will be filtered through a cotton plug followed by Whattman filter paper No.1 and then concentrated by using a rotary evaporator at low temperature. The extract will be preserved in airtight containers and kept at 4-5°C until further use. The extract will be suspended in 0.5% w/v of sodium CMC in a normal saline solution to prepare the test doses.

Phytochemical Screening [58]

Each extract was subjected to phytochemical screening and the preliminary chemical examination of methanol extract revealed the presence of steroids, flavonoids, tannins, coumarins, carbohydrates and reducing sugars.

Dose Fixation

A dose of 200mg/kg and 400mg/kg were chosen as per the previous work.

Nephroprotective activity [59, 60, 61]

Nephroprotective activity of Santalum album leaf extract for cisplatin induced nephrotoxicity by blood serum analysis

Table 2: Details of test group selected for the Nephroprotective activity of Santalum album leaf extract for cisplatin induced nephrotoxicity by blood serum analysis**.**

Group	Description
Group I	Control animals. received oral dose of 0.5% sodium CMC (1 ml each)
Group II	Cisplatin induced rats (3 mg/kg body weight)
Group III	Nephrotoxic rats treated with plant extract (200mg/kg bwt).
Group IV	Nephrotoxic rats treated with plant extract at (400mg/kg bwt).
Group V	Control animals treated with plant extract (200mg/kg bwt).
Group VI	Control animals treated with plant extract (400mg/kg bwt).

Total 30 Wistar rats were divided randomly into five groups of six animals each. The test drug was fed orally for 21days. A single intraperitoneal (i.p) injection of cisplatin (3 mg/kg body weight) was given on the 18th day. The experiment was terminated in overnight fasted rats at the end of 21days.Blood samples were collected from the test animals under anesthesia (Anaesthetic ether) by cardiac puncture before sacrifice and serum parameters including creatinine, urea, albumin, and total protein were estimated. The rats were sacrificed by cervical dislocation after giving mild anesthesia using Chloroform. Blood was collected and serum was separated which was used for various parameters (Urea, uric acid, creatinine, cholesterol and protein).The biochemical estimations were done in a Biochemical-semi-auto analyzer (Ebra-chem-5- plus, V2. West Germany) by standard procedures using commercial kits (Ecolin: Merck specialties, India).

Nephroprotective activity of Santalum album leaf extract for cisplatin induced nephrotoxicity by urine analysis

Table 3: Details of test group selected for the Nephroprotective activity of Santalum album leaf extract for cisplatin induced nephrotoxicity by urine analysis

Group	Description
Group I	Control animals, received oral dose of 0.5% sodium CMC (1 ml each)
Group II	Cisplatin induced rats (3 mg/kg body weight)
Group III	Standard group received standard polyherbal drug cystone (5 ml/kg; p.o.)
Group IV	Nephrotoxic rats treated with plant extract (400mg/kg bwt).
Group V	Nephrotoxic animals treated with plant extract (200mg/kg b.w).

Total 30 Wistar rats were divided randomly into five groups of six animals each. Group I (normal control) received oral dose of 0.5% sodium CMC (1 ml each) for 14 days. Group II (toxic control) received single dose of cisplatin (3 mg/kg of body weight; i.p.) on day 1. Group III (standard group) received standard polyherbal drug cystone (5 ml/kg; p.o.) (Cystone Syrup, Himalaya Drug Company., Bangalore, India) for 14 days with single dose of cisplatin (7 mg/kg of body weight; i.p.) on day 1, group IV (SAME 200) and group V (SAME 400) received methanolic extract 200 and 400 mg/kg b.w. once in a day for 14 days respectively along with the single dose of cisplatin (3 mg/kg of body weight; i.p.) on day 1. The treatment duration was considered for 14 days.Urine was collected over 24 h on 14th day by keeping the test animals in individual metabolic cages. The volume of collected urine samples was measured followed by estimation of biochemical parameters, namely urine creatinine and urine albumin. The biochemical estimations were done in a Biochemical-semi-auto analyzer (Ebra-chem-5-plus, V2. West Germany) by standard procedures using commercial kits (Ecolin: Merck specialties, India).

Statistics

Data obtained in the experiment were expressed in terms of mean ± SEM. Statistical significance of data was assessed by analysis of variance (one-way ANOVA) followed by a comparison between different groups using "Tukey-Kramer" multiple comparison test. The significance level was set at $P<0.05$. The toxic control group was compared with the normal control group and all other treatment groups were compared with the toxic control group.

Nephroprotective activity of Santalum album leaf extract for gentamycin induced nephrotoxicity by blood serum analysis

Table 4: Details of test group selected for the nephroprotective activity of Santalum album leaf extract for gentamycin induced nephrotoxicity by blood serum analysis

Group	Description
Group I	Control animals. received oral dose of 0.5% sodium CMC (1 ml each)
Group II	Gentamycin induced rats (Gentamycin 80 mg/kg)
Group III	Nephrotoxic rats treated with plant extract (200mg/kg b.w).
Group IV	Nephrotoxic rats treated with plant extract at (400mg/kg b.w).
Group V	Control animals treated with plant extract (200mg/kg b.w).
Group VI	Control animals treated with plant extract (400mg/kg b.w).

Total 30 Wistar rats were divided randomly into five groups of six animals each. The test drug was fed orally for 14days. A single intraperitoneal injection of gentamycin (80 mg/kg b.w) was given on the 2nd day. The experiment was terminated in overnight fasted rats at the end of 14days.
Blood samples were collected from the test animals under anesthesia (anesthetic ether) by cardiac puncture before sacrifice and serum parameters including creatinine, urea, albumin, and total protein were estimated. The rats were sacrificed by cervical dislocation after giving mild anesthesia using Chloroform. Blood was collected and serum was separated which was used for various parameters (Urea, uric acid, creatinine, cholesterol and protein).
The biochemical estimations were done in a Biochemical-semi-auto analyzer (Ebra-chem-5- plus, V2. West Germany) by standard procedures using commercial kits (Ecolin: Merck specialties, India).

Nephroprotective activity of Santalum album leaf extract for gentamycin induced nephrotoxicity by urine analysis

Table 5: Details of test group selected for the Nephroprotective activity of Santalum album leaf extract for gentamycin induced nephrotoxicity by urine analysis

Group	Description
Group I	Control animals, received oral dose of 0.5% sodium CMC (1 ml each)
Group II	Gentamycin induced rats (80 mg/kg b.w)
Group III	Standard group, received standard polyherbal drug cystone (5 ml/kg; p.o.)
Group IV	Nephrotoxic rats treated with plant extract (400mg/kg b.w).
Group V	Nephrotoxic animals treated with plant extract (200mg/kg b.w).

Total 30 Wistar rats were divided randomly into five groups of six animals each. Group I (normal control) received oral dose of 0.5% sodium CMC (1 ml each) for 14 days. Group II (toxic control) received single dose of gentamycin (80 mg/kg of body weight; i.p.) on day 1. Group III (standard group) received standard polyherbal drug cystone (5 ml/kg; p.o.) (Cystone Syrup, Himalaya Drug Company., Bangalore, India) for 14 days with single dose of gentamycin (80 mg/kg of body weight; i.p.) on day 1, group IV (SAME 200) and group V (SAME 400) received methanolic extract 200 and 400 mg/kg b.w. once in a day for 14 daysrespectively along with the single dose of gentamycin (80 mg/kg of body weight; i.p.) on day 1. The treatment duration was considered for 14 days.Urine was collected over 24 h on 14th day by keeping the test animals in individual metabolic cages. The volume of collected urine samples was measured followed by estimation of biochemical parameters, namely urine creatinine and urine albumin. The biochemical estimations were done in a Biochemical-semi-auto analyzer (Ebra-chem-5-plus, V2. West Germany) by standard procedures using commercial kits (Ecolin: Merck specialties, India).

Statistics
Data obtained in the experiment were expressed in terms of mean ± SEM. Statistical significance of data was assessed by analysis of variance (one-way ANOVA) followed by a comparison between different groups using "Tukey-Kramer" multiple comparison test. The significance level was set at $P<0.05$. The toxic control group was compared with the normal control group and all other treatment groups were compared with the toxic control group.

Histopathological examination [62][63]
The kidneys were removed from the rats before sacrifice and organs were fixed using a formosal solution (10% v/v of formaldehyde in normal saline), embedded with paraffin wax followed by preparation of tissue sections using a microtome for histopathology study. For that small L.S of the tissue was made and used under light ocular microscope.

Results and Discussion
The methanolic extract of Santalum album leaves was prepared and the nephroprotective activity was evaluated.

Phytochemical Screening

Table 6: Phytochemical screening of methanolic extract of *santalum album* leaves

SL. No	Name of the Test	Observation	Conclusion
		Same	
I.	Tests for Steroids Salkowski reaction Liebermann Burchard test	 + +	Steroids were present in methanolic extract.
II.	Tests for Saponins Foam test Haemolytic test	 - -	Saponins were absent in methanolic extract.
III.	Tests for Tannins and Phenolic Compounds Lead acetate test 5% Fe Cl_3 test Bromine water test Acetic acid solution test Potassium dichromate test	 - - - - -	Tannins were absent in methanolic extract.
V.	Tests for Flavonoids Shinoda test Lead acetate test Alkaline solution Ferric chloride test	 + + + +	Flavanoids were present in aqueous extract.
VI.	Tests for Reducing Sugars Fehling's test Benedict's test	 + +	Reducing sugars were present in methanolic extract.

The above observations concluded that the methanol extract of *Santalum album* contain volatile oil, steroids, phenolic compounds and flavonoids as active constituents (Table 6)

Nephroprotective Activity [59, 60, 63]

Nephroprotective activity of Santalum album leaf extract for cisplatin induced nephrotoxicity by blood serum analysis

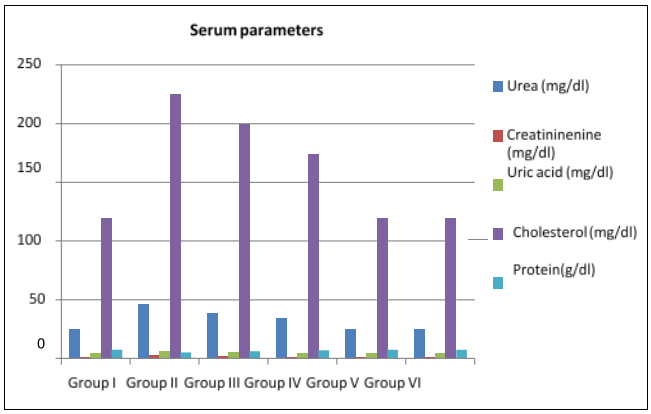


Fig 1: Concentration of urea, uric acid, creatinine, cholesterol and protein in serum of control and experimental groups (cisplatin induced nephrotoxicity)

A. Variation in Urea, Creatinine and Uric Acid Levels in Rat Serum

As shown in the fig 1, urea, creatinine and uric acid levels were elevated in cisplatin induced renal toxicity when compared to group Ị normal rats. Oral administration of methanolic extract of Santalum album significantly reduced urea, creatinine and uric acid levels in rats affected by nephropathy. There was no significant change in the above parameters in the rats treated with plant extract alone and is also similar to control group. However maximum protection (activity) was offered by the 400mg/kg of Santalum album pretreatment.

B. Changes in Cholesterol and Protein

The change in the level of cholesterol and protein in both the control and experimental animals were shown in fig 1. The levels of serum cholesterol and serum protein were increased and decreased respectively in cisplatin induced nephrotoxicity as compared with normal rats. Treatment with methanol extract of Santalum album at the doses of 200mg/kg and 400mg/kg reduced and increased the levels of cholesterol and protein respectively, which is comparable to normal rats.

Concentration of SGOT, SGPT and ALP in serum of control and experimental groups. (cisplatin induced nephrotoxicity)

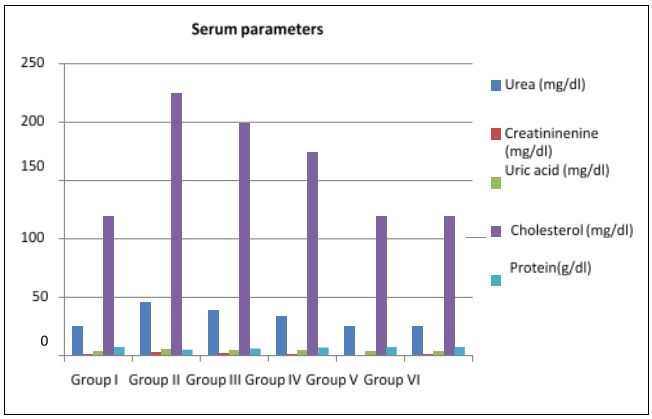


Fig 2: Concentration of SGOT, SGPT and ALP in serum of control and experimental groups. (cisplatin induced nephrotoxicity)

C. Level of SGOT, SGPT and ALP

The enzymes SGOT, SGPT and ALP were increased significantly in cisplatin induced rats as shown in fig 2.

The *Santalum album* treatment significantly reversed the levels of above enzymes when compared to cisplatin induced renal toxicity. The *Santalum album* treatment alone did not have significant effect on the levels of the above mentioned enzymes.

Nephroprotective activity of santalum album leaf extract for cisplatin induced nephrotoxicity by urine analysis

The results as cited in fig 2 includes change in body weight, urine volume along with the urine biochemistry data. Cisplatin administration-induced renal injury was prominent as evidenced by significantly depressed renal functions, body weight, and urine volume as compared to the normal control group.

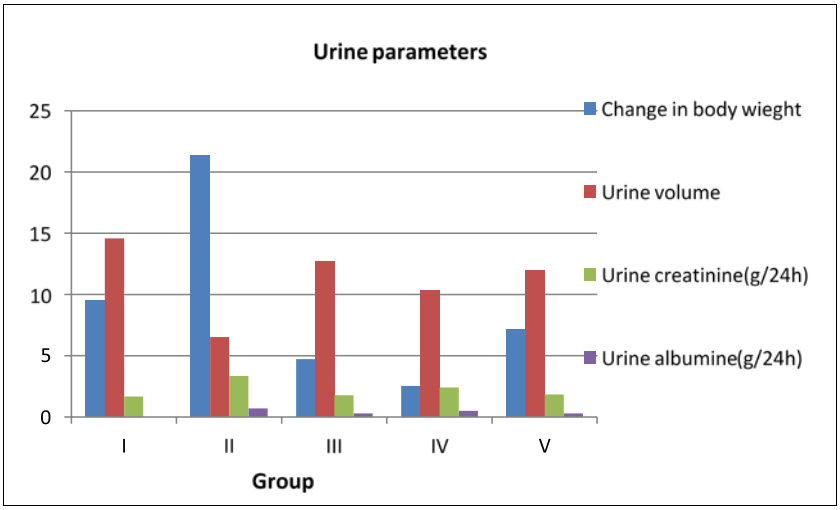


Fig 3: Urine parameters studied for the nephroprotective effect of the methanol extract of *Santalum album* (cisplatin induced nephrotoxicity)

The SAME 400 group (*Santalum album* methanolic extract 400 mg/kg treated rat group) showed significant (P<0.001) elevation in body weight (7.15 ± 1.25) with a significant (P<0.05) increase in urine volume output (11.95 ± 1.25). However, the urine creatinine (1.85 ± 0.0025) and albumin (0.30 ± 0.08) decreased significantly (P<0.01) as compared with the toxic control group.

Nephroprotective activity of santalum album leaf extract for gentamycin induced nephrotoxicity by blood serum analysis

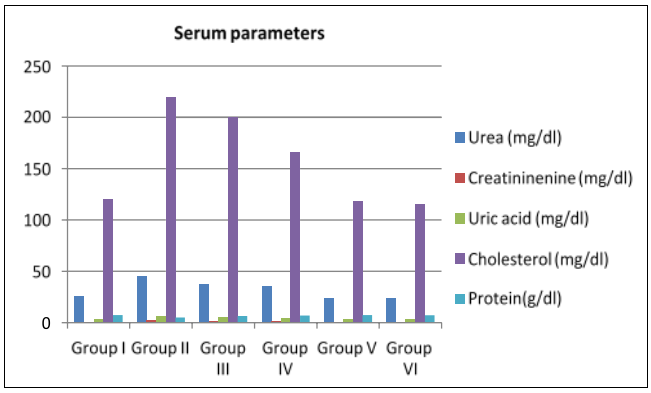


Fig 4: Concentration of urea, uric acid, creatinine, cholesterol and protein in serum of control and experimental groups (gentamycin induced nephrotoxicity)

Values are expressed as mean ±S.D. Values are taken as a mean of six individual experiments. Values not sharing a common superscript letter differ significantly (DMRT).

A. Variation in Urea, Creatinine and Uric Acid Levels in Rat Serum

As shown in the fig 4, urea, creatinine and uric acid levels were elevated in gentamycin induced renal toxicity when compared to group Ⅰ normal rats. Oral administration of methanolic extract of *Santalum album* significantly reduced urea, creatinine and uric acid levels in rats affected by nephropathy. There was no significant change in the above parameters in the rats treated with plant extract alone and is also similar to control group. However maximum protection (activity) was offered by the 400mg/kg of *Santalum album* pretreatment.

B. Changes in Cholesterol and Protein

The change in the level of cholesterol and protein in both the control and experimental animals were shown in fig 4. The levels of serum cholesterol and serum protein were increased and decreased respectively in gentamycin induced nephrotoxicity as compared with normal rats. Treatment with methanol extract of *Santalum album* at the doses of 200mg/kg and 400mg/kg reduced and increased the levels of cholesterol and protein respectively, which is comparable to normal rats.

Concentration of SGOT, SGPT and ALP in serum of control and experimental groups (gentamycin induced nephrotoxicity)

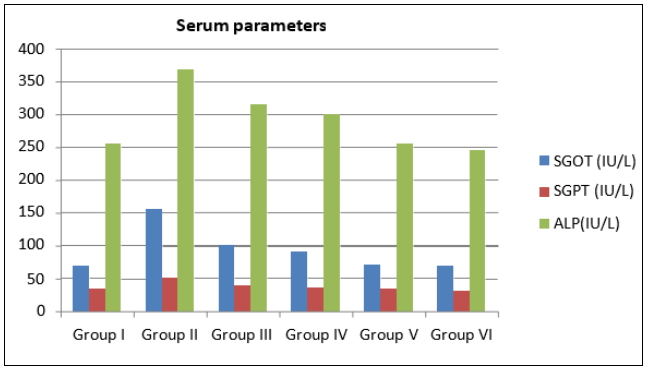


Fig 5: Concentration of SGOT, SGPT and ALP in serum of control and experimental groups (gentamycin induced nephrotoxicity)

C. Level of SGOT, SGPT and ALP

The enzymes SGOT, SGPT and ALP were increased significantly in gentamycin induced rats as shown in fig 5. The *Santalum album* treatment significantly reversed the levels of above enzymes when compared to gentamycin induced renal toxicity. The *Santalum album* treatment alone did not have significant effect on the levels of the above mentioned enzymes.

Nephroprotective activity of santalum album leaf extract for gentamycin induced nephrotoxicity by urine analysis

The results as cited in fig 5 includes change in body weight, urine volume along with the urine biochemistry data. Cisplatin administration-induced renal injury was prominent as evidenced by significantly depressed renal functions, body weight, and urine volume as compared to the normal control group.

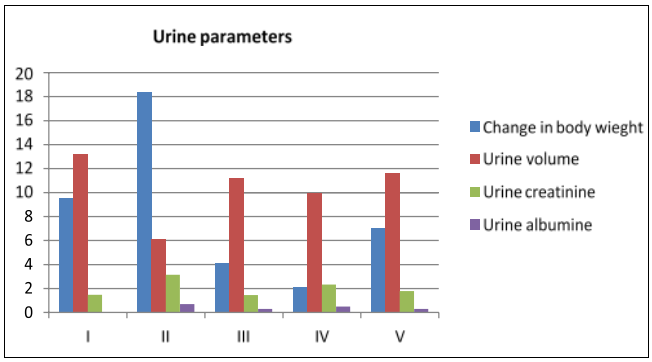


Fig 6: Urine parameters studied for the nephroprotective effect of the methanol extract of *Santalum album* (gentamycin induced nephrotoxicity)

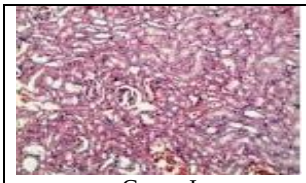
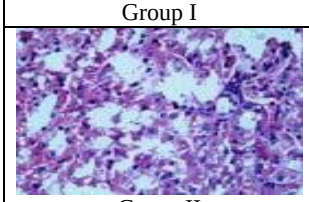
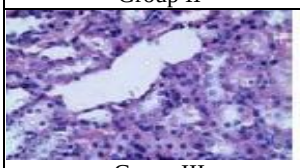
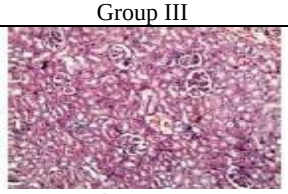
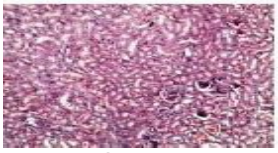
The SAME 400 group (methanolic extract 400 mg/kg treated rat group) showed significant (P<0.001) elevation in body weight (7.02±1.2) with a significant (P<0.05) increase in urine volume output (11.64±1.24). However, the urine creatinine (1.79±0.002) and albumin (0.30± 0.18) decreased significantly (P<0.01)as compared with the toxic control group.

Histopathological examination [62, 63]

The histological features and the photomicrographs of tissue sections are presented in table. The histopathology of tissue sections suggest that the toxic control group had encountered vast histological damages as evidenced by the glomerular and tubular congestion with abnormal Bowman's

capsule, blood vessel congestion, epithelial cell desquamation, and presence of tubular cast with few inflamatory cells. The histological features of the SAME 400 group showed minimal cellular damage in contrast to the toxic control group. The SAME 400 group showed normal glomerular and tubular arrangements with normal Bowmen's capsule. Congestion of blood vessels was minimal and tubular cast were not present.

Table 7: Histopathological examination of albino rats administered *Santalum album* leaf extract (gentamycin induced nephrotoxicity)

 Group I	Kidney of control animal showing normal histology.
 Group II	Kidney of gentamycin intoxicated rats showing focal renal tubular atropy
 Group III	Kidney of nephrotoxic animal treated with SAME 200 showing normal histology.
 Group IV	Kidney of nephrotoxic animal treated with SAME 400 showing normal histology.
 Group V	Kidney of normal animal treated with SAME 200 showing normal histology.
 Group VI	Kidney of normal animal treated with SAME 200 showing normal histology.

Conclusion

The study was taken up to evaluate methanolic extract of Santalum album leaves for nephroprotective activity.

Phytochemical screening of methanolic extract concluded that the methanol extract of Santalum album leaves contain volatile oil, steroids, phenolic compounds and flavonoids as active constituents.

The acute toxicity study conducted for aqueous extracts indicated that they are safe up to 1000 mg/kg body weight.

Methanolic extract of Santalum album leaves produced significant nephroprotective activity in both cisplatin and gentamycin induced nephrotoxicity in albino rat.

The histological damages in the Santalum album -treated group were minimal in contrast to the toxic rats.

In conclusion, the findings reported in the study indicate that the oral administration of Santalum album to mercuric chloride intoxicated rats exhibited significant nephroprotective effect. Although promising results have been obtained, more concerted efforts are still needed for the isolation, characterization and biological evaluation for the active principles of the extract.

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