Effect of the Leaf Extract of Andrographis Paniculata on Cyanide-Induced Toxicity on Wistar Rats

Ossai N F [1*], Kadiri H E [2]
[1-2] Department of Biochemistry, Delta State University, Abraka, Delta State, Nigeria

* Corresponding Author: **Ossai N F**

Article Info

P-ISSN: 3051-3405
E-ISSN: 3051-3413
Impact Factor (RSIF): 8.41
Volume: 02
Issue: 01
Received: 18-11-2025
Accepted: 20-12-2025
Published: 22-01-2026
Page No: 06-13

Abstract
Cyanide is one of the most rapidly lethal poisons known to man and the consumption of plant products with cyanogenic glycosides is a primary source of cyanide poisoning in humans. Its effect on humans is predominantly treated with synthetic antidotes which are costly, of which the use of natural plant extracts presents a cheaper alternative. This study thus investigated the protective effects of *Andrographis paniculate* leaf extracts against cyanide-induced toxicity in rats. Thirty-five male wistar rats were divided into seven groups of five rats. The rats were fed with different formulations Group 1: normal control (was maintained on a standard diet), Group 2: negative control (normal untreated rats + 3mgKCN/kg of cyanide), Group 3:660 mg/kg sodium thiosulphate, Group 4: 100 mg/kg *A. paniculata* leaf extract, Group 5: 200 mg/kg *A. paniculata* leaf extract, Group 6: 3 mg KCN/kg + 100 mg/kg *A. paniculata* leaf extract, Group 7: 3 mg KCN/kg + 200 mg/kg *A. paniculata* leaf extract) and arranged in a completely randomized design with three replicates. Renal markers (Urea, Creatinine, Sodium, Potassium and Chloride electrolytes), liver enzymes (Alanine aminotransferase, Aspartate aminotransferase, aand Alkaline phosphatase), antioxidant status (Superoxide dismutase, malonaldehyde, catalase, and reduced glutathione of the liver and kidneys of the rats were assayed using standard procedures. Data collected were analysed using ANOVA and means were separated using Duncan multiple range test at 5% significant level. The results indicated that cyanide caused significant ($p<0.05$) hepatoxicity and nephrotoxicity, as evidence by elevated levels of the liver enzymes (AST, ALT and ALP) and renal markers (urea and creatinine). Additionally, the extract boosted antioxidant defence as demonstrated by increase activities of superoxide dismutase, catalase and reduced glutathione. Application of 3 mg KCN/kg + 100 mg/kg and and 3 mg KCN/kg + 200 mg/kg *A. paniculata* leaf extract was effective in mitigating the effect of cyanide in wistar rats. The study indicated that ethanolic leaf extract of Andrographis paniculata conferred protection to the kidney and liver of rats against chronic cyanide toxicity by ameliorating renal indices and up regulating antioxidant response.

DOI: https://doi.org/10.54660/IJABRN.2026.2.1.06-13

Keywords: Andrographis paniculate, Cyanide poisoning, Phytoremediation, Toxicity

1. Introduction

Cyanide is a potent and rapidly acting toxic substance, notoriously recognized as a deadly poison. Cyanide occurs in numerous forms in the surroundings as free cyanide, organo-cyanides and metallo-cyanides, and human contact with it effects toxicity (Ogbuagu *et al.*, 2019) [1]. Recently, attention has been on cyanide due to its toxicity to man and animals. Cyanide can occur in various forms such as a toxic gas; hydrogen cyanide, a crystalline salt, potassium cyanide. Human exposure to cyanide may take place through mining, industrial usage, smoke from fire, propulsion motors and tobacco (Parida *et al* 2020) [2]. Exposure to other cyanogenic related compound such as organonitriles, cyanogens and cyanide-containing pesticides also results in cyanide

toxicity (Kadiri *et al*., 2022).

The consumption of plant products containing cyanogenic glycosides is a primary source of cyanide poisoning in humans (Kadiri *et al*., 2020) [7]. Studies have revealed that ingestion of cassava-based food, as well as inhalation of cyanide contaminated air can lead to toxicity (Wood, 2020) [24]. Cyanide (CN) has been recognized as a common environmental pollutant associated with several adverse health consequences such as carcinogenesis, hepatotoxicity, renal impairment as well as disruption of normal endocrine and reproductive functions (Tara *et al*., 2019). Cyanide appears naturally as glycosides in over 2000 plants. Ingesting such plants has been reported to cause acute cyanide toxicity and mortality in live stocks and man (Kadiri *et al*., 2023) [6]. As a result of the increasing use of cassava in animal feeds there is greater exposure to dietary toxins from cyanogenic glycosides (Kadiri and Ohwokevwo., 2022) [3, 5]. Toxicity of cyanogenic plants and their products is primarily associated with the free hydrogen cyanide formed in the plant material due to cyanogenic glycosides hydrolysis (Kadiri *et al*., 2020) [7].

Toxic levels of cyanide may be present in patients who receive prolonged infusions of sodium nitroprusside. (Pruthi *et al.,* 2021) [30], (Zacarias *et al.,* 2020) [25]. Cyanide's main effect is that it inhibits oxidative phosphorylation, a process where oxygen is utilized for the production of essential cellular energy sources in the form of ATP. The utilization of oxygen by the tissue occurs and is followed by the impairment of vital functions. (Pauluhn *et al.,* 2016) [31]. Because early treatment is so important in cyanide toxicity, the most obvious pitfall would be not making the diagnosis early in the course. Some complications that survivors of severe cyanide poisoning may encounter are Parkinson or other forms of neurological sequelae. The basal ganglia are particularly sensitive to cyanide toxicity. Chronic cyanide exposure can lead to vague symptoms such as a headache, abnormal taste, vomiting, chest pain, and anxiety. Treatment of cyanide poisoning has predominantly relied on the use of synthetic medication like thiosulphate; however, similar but cheaper treatment can be obtained from natural plant origin.

Plants exist for thousands of years and have been an essential component of traditional and natural therapeutic frameworks all over the world since ancient times, (Hussen *et al.,* 2023) [29]. Estimated, 80% of people in the third world still primarily obtain their healthcare from medicinal plants, demonstrating the continued usefulness of these plants today (Erukainure *et al*., 2019). Medicinal plants are the primary sources of therapeutic remedies for various ailments. These potential medicinal effects are primarily attributed to their active phytochemical constituents. These effects of plants come from biologically active phytochemicals which include; alkaloids, flavonoids, saponins, terpenoids, steroids, glycosides, tannins, volatile oils, etc. (Das *et al*., 2022) [28]. These phytochemicals are very diverse, in actions as they may be antioxidant, antiviral, anticancer, antibacterial, antifungal and antiparasitic agents, (Kadiri *et al*., 2023) [6].

Andrographis paniculate (Burm, F.) commonly known as the "King of bitter" is a hard herb predominantly used in traditional medicine for decades (Verma *et al*., 2021) [23]. The greatest economic value of this plant resource cultivation is its extensive bioactivities (Gaur *et al.,* 2023) [27], especially its anti-inflammatory properties (Julaton *et al*., 2022) [4], it is also known as a "natural plant antibiotic". The material basis of its anti-inflammatory activity has attracted the comprehensive attention of many research scholars. According to (Kumar *et al.,* 2021), terpenoids and flavonoids, especially diterpenoid lactones, are the main class of compounds responsible for their anti-inflammatory activities, such as andrographolide. *A. paniculata* has been used as an herbal remedy for treating the upper gastrointestinal tract and upper respiratory tract, fever, herpes, diabetes, and other chronic illness, but there is dearth of information on its usage in treating cyanide poisoning. This study thus explores the efficacy of Andrographis leaf and root extracts in wistar rats induced with cyanide poisoning.

Materials and Methods

Experimental location: This experiment was conducted at the Department of Biochemistry, Delta State University, Abraka, Delta State, Nigeria.

Collection of plant and animal materials and identification: Fresh leaves of *Andrographis paniculata* were collected from Warri, Delta State. The studied plant was identified and authenticated at the Department of Botany, Delta State University. thirty-five (35) healthy male Wistar albino rats weighing between 120 and 150g were obtained from the Animal House, Faculty of Basic Medical Science, Delta State University, Abraka. They were acclimatized for one week. The rats were maintained on standard pellets, growers mash (Top feed, Premier feed mills Co. Ltd, Ibadan, Oyo State) and water *ad libitum.*

Extraction of *Andrographis paniculata* leaves: The fresh leave material was washed under running tap to remove dirt and air dried at ambient temperature for fourteen 14 days. The dried leaves were crushed into powdered form using an electric blender. A portion of five hundred grams (500g) of the pulverized the dried leaves of *A. paniculata* was extracted with 2500ml of methanol (99.9%v/v) using cold maceration for 48 hours respectively. The extract was then filtered through cheese cloth with fine pore, the resulting filtrates was then filtered for the second time using Whatman No. 1 filter paper (1mm mesh size) and was then concentrated in a water bath at a constant temperature of 50 °C. The obtained extract was put in a glass container and stored at 4ºC until when required for use.

Experimental design

In the experiment, a total of thirty-five (35) male Wistar rats were used. They were randomly divided into Seven (7) groups containing five (5) rats in each group. All animals were acclimatized for fourteen (14) days before experimental exposure of twenty-eight (28) days.

Group 1: Normal control received normal feed and water only.

Group 2: Cyanide control 3mg KCN/kg b.wt

Group 3: cyanide induced that received 660 mg/kg sodium thiosulphate pentahydrate

Group 4: *A. paniculata* extract 100mg/kg b.wt.

Group 5: *A. paniculata* extract 200mg/kg b.wt.

Group 6: Cyanide induced and received *A. paniculata* extract 100mg/kg b.wt.

Group 7: Cyanide induced and received *A. paniculata* extract 200mg/kg b.wt.

Biochemical assays and phytochemical screaning

Assay for Aspartate Aminotransferase, and Alanine Aminotransferase Activities: The assay for alanine aminotransferase activity was determined by the method of

Reitman and Frankel (1957).

Assay for Alkaline phosphatase Activity: The activity of Alkaline phosphatase standard methods was carried out according to the recommendations of the Deutsche Gesellschaft fur klinische Chemie DGKC (1972).

Estimation of total protein: The method of Tietz (1995) [33] was used for the assay of total protein.

Estimation of albumin: The method for the assay of albumin activity was described by Doumas *et al.* (1971)**.**

Estimation of urea: The method of Weatherburn (1967) [32] was adopted for the determination of serum urea.

Estimation of Creatinine: Estimation of serum Creatinine was done by the method of Bartels and Bohmer, (1972).

Estimation of Sodium: Estimation of serum sodium was done by the methods of Maruna (1958) and Trinder (1951).

Estimation of Chloride: Estimation of serum chloride was done by the methods of Skeggs and Hochestrasser (1964)

Estimation of Potassium: Estimation of serum potassium was done by the methods of Terri and Sesin (1959).

Determination of catalase (CAT) activity: Catalase is determined according to the method of Aebi (1974) by the depletion rate of H_2O_2 at 240 nm in a reaction buffer.

Determination of super oxide dismutase (SOD) activity: This was carried out following the procedure of Misra and Fridovich (1972) [9].

Estimation of lipid peroxidation (LPO): This was estimated following the procedures of Niehius and Samuelsson (1968).

Determination of total reduced glutathione (GSH): This was determined following the procedures of Moron *et al.* (1979).

Qualitative phytochemical screening: Preliminary phytochemical screening of the aqueous leaf extract of *A. paniculata* was carried out using standard methods as described by Borokini and Omotayo (2012), and Njoku to screen for the presence of various chemical constituents.

Test for saponins

The Frothing test was used. 30ml of filtrate was measured and was then vigorously shaken. The samples were observed for the formation of froth.

Test for phlobatanin

Two millitres of the filtrate was then boiled with 2ml of 2% hydrochloric acid solution. A red precipitate indicated the presence of phlobatanin.

Test for cardiac glycosides

The Keller-Killani test was used. Into a test tube, 5ml of the sample and 2ml of glacial acetic acid was added, followed by the addition of one drop of 2% ferric chloride solution. Then 1ml of concentrated sulfuric acid was added. Brown interface, violet ring colour and a greenish ring at the lower part indicated positive for cardiac glycosides.

Test for flavonoids

The shinoda test was used. In a test tube containing 0.5 mL of sample, 10 drops of concentrated HCl and small pieces of magnesium was added and the solution was boiled for 5 mins. The production of reddish-pink colouration indicated the presence of flavonoids.

Test for tannins

Ferric chloride Test was used. To 2.0 mL of sample extract few drops of 5 % aqueous ferric chloride solution was added. The bluish black colour formed disappeared on addition of few millitres of dilute sulphuric acid followed by the formation of a yellowish-brown precipitate, indicating the presence of tannins.

Test for phenol

Ferric chloride test was used. To 1.0 mL of sample extract, 2mL of distilled water was added followed by au few drops of 10 % aqueous ferric chloride solution. Formation of blue colouration indicated the presence of phenols.

Test for steroids

To 2 ml of acetic anhydride was added 0.5ml of sample extract, followed by 2ml of sulphuric acid. The Blue colouration observed indicated a positive test for steroids.

Test for terpenes/terpenoids

The Salkowski test was used and 5ml of the sample was mixed with 2ml of chloroform and 3ml of concentrated sulphuric acid was added to form a layer. Reddish brown colouration indicated the presence of terpenes/terpenoids.

Test for alkaloids

One millilitre of the extract was dissolved in 2ml of 1% concentrated hydrochloric acid and 1ml of Drangendoff's reagent was added. Presence of an orange red precipitate confirms a positive result.

Statistical Analysis: Data collected were analysed using analysis of variance and differences in means were separated using Duncan Multiple Range Test at 5% level of significance.

Results

Biochemical investigation: The finding from the phytochemical analysis of *Andrographis paniculata* leaf extract indicated the presence of Alkaloid, reducing solution, carbohydrate, starch, protein, amino acids, phenolic compound, tannin, terpenoid, triferpenoid, carboxylic acid, lignin, phytosterol, saponin, coumarins, and quinones (Table 1).

Effect of ethanolic leaf extract of Andrographis paniculata on oxidative stress parameters in the liver and kidney of cyanides intoxicated rats.

The result of malonylaldehyde (MDA) levels in the liver and kidney of rats given *Andrographis paniculata* and potassium cyanide shows a significant increase in the cyanide treated rats when compared to the control (Table 2). However, treatment with 100mg and 200mg reduced the cyanide levels non significantly when compared to the control and thiosulphate. Conversely, the GSH level in the cyanide induced oxidative stress of renal and hepatic levels were significantly ($p<0.05$) increased relative to the cyanide control group.

Effect of ethanolic leaf extract of Andrographis paniculata on the SOD and catalase in the liver of cyanide intoxicated rats.

In the Liver SOD, the result shows a significant reduction in the liver of cyanide treated rats when compared with the

control (Table 3). However, treatment with 100mg and 200mg also reduced the cyanide content non significantly when compared to the control and thiosulphate. On the catalase, there was reduction in the cyanide treated rats compared to the control. However, treatment with 100mg and 200mg also reduced the cyanide content non-significantly when compared with the control and thiosulphate respectively. In the Kidney SOD activity, there was a significant decrease in the cyanide treated rats when compared to the control. However, treatment with the 100mg and 200mg increased the SOD significantly when compared to the control and thiosulphate. There was a significant reduction in the catalase of the treated rats when compared to the Control. Also, the 100mg and 200mg increased the SOD significantly when compared to the control and thiosulphate.

Effect of ethanolic extract of Andrographis paniculata on the transaminase enzymes in the liver of Cyanide intoxicated rats.

The result shows that there was significant increase in the AST mean of cyanide treated rats compared to the control (Table 4). Treatment with 100mg and 200mg *Andrographis paniculata* also reduced the AST content significantly compared to the cyanide, but their mean differences with the thiosulphate was not significant. The ALT of the cyanide treated rats increased significantly when compared to the control. However, there were non-significant increase in the 100mg and 200mg *Andrographis paniculata* treatments compared to the control and the thiosulphate. There was non-significant increase in ALP production in the cyanide treated rats compared to the control. Also, there were non-significant increases in the ALP production in the 100mg and200 mg *Andrographis paniculata* treatments when compared with the control and the thiosulphate.

Effect of ethanolic extract on *Andrographis paniculata* on the urea and creatinine activities in the kidney of cyanide intoxicated rats.

The result showed an increase in the urea production in the cyanide treated rats compared to the control (Table 5). However, there were significant mean reduction in the 100mg and 200mg *Andrographis paniculata* treatments compared to the cyanide treatment, while mean difference between the 100mg and 200mg *Andrographis paniculata* treatments and the thiosulphate was not significant. On the creatinine activity, there was increased activity in the cyanide treated rats compared to the control. However, there were significant reduction in the 100mg and 200mg *Andrographis paniculata* treatments relative to the cyanide treatment, while the reduction in the 100 mg and 200 mg *Andrographis paniculata* treatments compared to the thiosulphate was not significant. On the GSH activity, there was a significant reduction in the cyanide treated rats when compared to the control. However, treatment with 100mg and 200mg increased the cyanide content non-significantly when compared with the thiosulphate.

Effect of ethanolic leaf extract of Andrographis paniculata on the Electrolytes in the serum of cyanide intoxicated rats

In the sodium activity, the result shows that there was a significant decrease in cyanide treated rats when compared to the control (Table 6). However, there were a significant mean increase in the 100mg and 200mg treatments relative to the cyanide, but was not significant when compared to thiosulphate. For the potassium, there was a significant reduction in the cyanide treated rats when compared to the control. However, treatment with 100mg and 200mg also reduced the potassium content but non significantly when compared to the control and thiosulphate. The chlorine content shows a significant reduction in the cyanide treated rats when compared with the control. Treatment with 100mg and 200mg increased the chlorine level significantly when compared to the cyanide treated rats but decreased the chlorine content non significantly compared to the control and thiosulphate.

Effect of ethanolic leaf extract of Andrographis paniculata on the levels of Total Protein and Albumin in the serum of cyanide intoxicated rats

The result shows that there was a significant mean reduction in the total protein of cyanide treated rats when compared to the control (Table 7). However, there were significant mean increase in the 100mg and 200mg treatments relative to cyanide treatment, while there was no significant reduction in the 100mg and 200mg treatments when compared to the control and thiosulphate. There was a significant reduction in the albumin of cyanide treated rats when compared to the control. However, there were significant mean increase in the 100mg and 200mg treatments relative to cyanide treatments while there was no significant reduction in the 100mg and 200mg treatment when compared to the control and thiosulphate.

Table 1: Screened phytochemicals from the King of bitters plant

Phytochemical	Observation
Alkaloid	+
Reducing solution	+
Carbohydrate	+
Starch	+
Protein and amino acid	+
Phenolic compound	+
Tannin	+
Terpenoid	+
Triferpenoid	+
Carboxylic acid	+
Lignin	+
Phytosterol	+
Saponin	+
Coumarins	+
Quinones	+

Table 2: Effect of ethanolic leaf extract of *Andrographis paniculata* on oxidative stress parameters in the kidney of cyanides intoxicated rats

Groups	MDA Kidney	MDA Liver	GSH (nmol/mg protein) Kidney	GSH Liver
I	2.950± 0.5 [a]	3.500± 0.2 [a]	35.6± 3.2 [a]	33.5 ±0.2 [a]
II	13.125± 0.8 [b]	6.190 ± 0.6 [b]	14.8± 0.5 [b]	13.7±0.2 [b]
III	4.835± 0.5 [a]	2.615± 0.3 [a]	27.2± 0.2 [a]	26.8 ± 0.5 [c]
IV	2.85± 0.4 [a]	0.615± 0.3 [a]	31.0± 3.2 [a]	30.4 ± 0.2[a]
V	3.04± 0.5 [a]	0.55± 0.2 [a]	30.8± 2.2 [a]	31.5± 0.5[a]
VI	4.32 ± 0.4 [a]	3.58 ± 0.2 [c]	26.5± 0.5 [a]	25.3± 0.5 [c]
VII	4.10 ± 0.6 [a]	3.15 ± 0.2 [c]	28.0± 1.2 [a]	24.7± 0.5 [c]

Values are means ± standard Deviations of triplicate determinations. Values are presented as Mean ± SD. Values on the same column with different superscript differ significantly (P<0.05). I: Control, II: Cyanide 3mg/kg b.wt., III: Cyanide + Thiosulphate 660mg/kg b.wt., IV: Andrographis paniculata 100mgAP, V: Andrographis paniculata 200mgAP, VI: Cyanide + Andrographis paniculata 100mg, VII: Cyanide + Andrographis paniculata 100mg

Table 3: Effect of ethanolic leaf extract of *Andrographis paniculata* on catalase and superoxide dismutase in the liver of cyanide intoxicated rats

Groups	SOD LIV	SOD KID	Catalase LIV	Catalase KID
I	26.81±1.2 [a]	24.01± 0.8[a]	55.7±3.6 [a]	36.07±1.6 [a]
II	9.25±0.8 [b]	5.35±0.8[b]	18.7±3.4 [b]	14.13±1.6 [b]
III	16.63±1.2[c]	18.93±0.8 [c]	38.0±2.2 [c]	26.50±1.2 [c]
IV	24.63±0.8[a]	22.63±2.0 [a]	49.0±2.2 [a]	34.55 ± 1.2 [a]
V	23.90 ±0.8 [a]	21.54 ±2.0 [a]	47.0 ±2.2 [a]	33.95 ±1.2 [a]
VI	14.10 ± 1.0 [c]	14.60±0.6 [c]	37.20± 1.2 [c]	23.48 ± 1.6 [c]
VII	15.82 ± 1.2 [c]	15.50±0.6 [c]	35.75± 1.2 [c]	21.36 ± 1.2 [c]

Values are means ± standard Deviations of triplicate determinations. Values are presented as Mean ± SD. Values on the same column with different superscript differ significantly (P<0.05).). I: Control, II: Cyanide 3mg/kg b.wt., III: Cyanide + Thiosulphate 660mg/kg b.wt., IV: Andrographis paniculata 100mgAP, V: Andrographis paniculata 200mgAP, VI: Cyanide + Andrographis paniculata 100mg, VII: Cyanide + Andrographis paniculata 100mg

Table 4: Effect of ethanolic extract of *Andrographis paniculata* on the transaminase enzymes in the liver of Cyanide intoxicated rats.

Groups	AST	ALT	ALP
1. Control	197.10± 3.5 [a]	147.1± 2.0 [a]	207.0± 7.0 [a]
2. CN	360.3 ± 2.2 [b]	324.00± 2.8 [b]	321.62± 2.2 [b]
3. CN +SCN	277.13 ± 2.8 [c]	241.00± 2.2 [c]	267.0± 3.0 [c]
4. 100mgAP	207.8± 2.5 [a]	151.50± 3.6 [a]	212± 3.0 [a]
5. 200mgAP	202.00± 2.6 [a]	128.0± 2.6 [a]	219 ± 2.2[a]
6. CN +100mgAP	282.00± 1.6[c]	264.2± 2.2 [c]	278.4± 2.2 [c]
7. CN +200mgAP	287.00± 1.6 [c]	269.0± 2.6 [c]	282.8± 2.2 [c]

Values are means ± standard Deviations of triplicate determinations. Values are presented as Mean ± SD. Values on the same column with different superscript differ significantly (P<0.05). I: Control, II: Cyanide 3mg/kg b.wt., III: Cyanide + Thiosulphate 660mg/kg b.wt., IV: Andrographis paniculata 100mgAP, V: Andrographis paniculata 200mgAP, VI: Cyanide + Andrographis paniculata 100mg, VII: Cyanide + Andrographis paniculata 100mg

Table 5: Effect of ethanolic extract of *Andrographis paniculata* on urea and creatinine activities in the kidney function markers of cyanide intoxicated rats

Groups	Urea	Creatinine
I	4.26 ± 2.9 [a]	0.12 ± 0.07 [a]
II	29.21 ± 2.0 [b]	1.58 ± 0.05 [b]
III	11.02 ± 1.8 [c]	0.86± 0.04 [c]
IV	6.48 ± 1.5 [a]	0.16± 0.03 [a]
V	7.95± 1.2 [a]	0.17± 0.02 [a]
VI	13.63 ± 1.5 [c]	0.55± 0.04 [c]
VII	14.03 ± 1.2 [c]	0.61± 0.02 [c]

Values are means ± standard Deviations of triplicate determinations. Values are presented as Mean ± SD. Values on the same column with different superscript differ significantly (P<0.05). I: Control, II: Cyanide 3mg/kg b.wt., III: Cyanide + Thiosulphate 660mg/kg b.wt., IV: Andrographis paniculata 100mgAP, V: Andrographis paniculata 200mgAP, VI: Cyanide + Andrographis paniculata 100mg, VII: Cyanide + Andrographis paniculata 100mg

Table 6: Effect of ethanolic leaf extract of Andrographis paniculata on the Electrolytes in the serum of cyanide intoxicated rats

Groups	Na^+	K^+	Cl^-
1. Control	187.1± 2.5 [a]	3.94± 0.27 [a]	78.19± 5.9 [a]
2. CN	141.09± 3.3 [b]	0.93± 0.25 [b]	49.19± 5.9 [b]
3. CN +SCN	169.16± 2.5 [a]	2.63± 0.40 [c]	68.71± 3.5 [ac]
4. 100mgAP	182.90± 3.5 [a]	3.37± 0.40 [c]	72.67± 2.7 [a]
5. 200mgAP	181.2± 3.5 [a]	3.87± 0.20 [a]	73.70± 3.7 [a]
6. CN +100mgAP	161.2± 3.3[c]	2.82± 0.30 [c]	63.28± 2.7 [c]
7. CN +200mgAP	172.8± 3.5 [c]	2.22± 0.40 [c]	61.82± 3.7 [c]

Values are means ± standard Deviations of triplicate determinations. Values are presented as Mean ± SD. Values on the same column with different superscript differ significantly (P<0.05). I: Control, II: Cyanide 3mg/kg b.wt., III: Cyanide + Thiosulphate 660mg/kg b.wt., IV: Andrographis paniculata 100mgAP, V: Andrographis paniculata 200mgAP, VI: Cyanide + Andrographis paniculata 100mg, VII: Cyanide + Andrographis paniculata 100mg

Table 7: Effect of ethanolic leaf extract of *Andrographis paniculata* on the levels of Total Protein and Albumin in the serum of cyanide intoxicated rats

Groups	Total Protein (g/dl)	Albumin (g/dl)
1. Control	4.90 ± 0.6 a	1.40 ± 0.4 a
2. CN	1.72 ± 0.3 b	0.39 ± 0.2 b
3. CN + SCN	3.53 ± 0.3 a	1.08 ± 0.2 a
4. 100 mg AP	4.04 ± 0.4 a	1.32 ± 0.2 a
5. 200 mg AP	4.12 ± 0.5 a	1.26 ± 0.4 a
6. CN + 100 mg AP	3.12 ± 0.5 a	1.06 ± 0.2 a
7. CN + 200 mg AP	3.05 ± 0.6 a	0.98 ± 0.2 a

Values are means ± standard Deviations of triplicate determinations. Values are presented as Mean ± SD. Values on the same column with different superscript differ significantly.). I: Control, II: Cyanide 3mg/kg b.wt., III: Cyanide + Thiosulphate 660mg/kg b.wt., IV: Andrographis paniculata 100mgAP, V: Andrographis paniculata 200mgAP, VI: Cyanide + Andrographis paniculata 100mg, VII: Cyanide + Andrographis paniculata 100mg

Discussion

Cyanide is a chemical compound readily found in both organic and inorganic substances which poses a toxic threat to animals if consumed. The sources of cyanide spans across medicine, industrial products, and common household products, with the toxic substance widely utilized for poisoning, suicide and acts of terrorism (Jiang, 2023). As a household item, it can be readily found in seeds like bitter almond, apple kernels, loquat kernels, corn, cassava, beans, plum seed where it is synthesized as cyanogenic glucoside (Jiang, 2023; Nyaika *et al*., 2024) [18]. These plants are commonly consumed by different animals, and when the cyanogenic glucoside finds its way to the animal system, it acts through the inactivation of cytochrome oxidase leading to several health problems. This has led humans to frequently carryout preventive measures like proper fermentation, washing, peeling and drying before consuming plants that contains high amount of cyanide above 10 ppm (Kuliahsari *et al*., 2021) [20]. However, in some instances of cyanide poison, its detoxification has also been reliant on organic compounds of plant origin (Latif, 2019) [21].

In this study, *Andrographis paniculata* extract was administered as a remedy to cyanide toxicity due to its reported medicinal abilities in comparison to thiosulphate pentahydrate, a commercially known detoxification compound (Verma *et al*., 2021; (Songvut *et al*., 2023) [16]. The potassium content of the rats fed with 100 mg, and 200 mg *A. paniculata* was similar to the control and the CN + SCN. This can be as a result of the gradual failure of the ATP causing the leak of K+ out of the cells (hyperkalemia) as a result of the cyanic content in the animal tissue. Hence, the CN+SCN,

100 mg and 200 mg *A. paniculata* acts as a restoration to the damaging effect of thiocyanate formation which impedes iodine and amino acid metabolism and intracellular K^+ and Mg^+ retention. This is in line with the report of Ayenitaju and Omokhuale (2023).

The tissues of the rats fed with cyanide + sodium thiosulphate pentahydrate showed higher amount of alaninetaminoransferase (ALT) relative to the control, however it was not significant, while the ones fed with cyanide and 100 mg and 200 mg of *A. paniculata* had the similar amount of the enzyme as the CN + SCN. There have been varied reports on the response of animals to varied dozes of cyanide as a result of its blockage of the cytochrome c oxidase leading to hypoxia. However, majority of the reports indicate increased alanineaminotransferase (Ojeniyi *et al*., 2020) [19]. However, in this study, apart from the rats fed with sodium thiosulphate pentahydrate where the ALT increased with exposure to cyanide above the control, all the *A. paniculata* fed rats recorded lower amount of ALT enzyme in the rats, and this corresponds with the fluctuating findings of different authors on the impact of cyanide exposure to ALT production in animal tissues.

Other factors that dictate the amount or pattern of ALT production in cyanide poisoned rat includes the species of animal used in the trial, the time of assessment after the exposure, the tissue-specific changes, the dozes, and routes of exposure. Hence, since the sodium thiosulphate led to increased ALT production and the *A. paniculata* led to decrease in ALT production, the histopathological becomes important in confirming their detoxification efficacies (Zhang *et al*., 2021) [15].

However, unlike the ALT, the Alkaline Phosphatase (ALP) production was highest in the cyanide fed rats without sodium thiosulphate pentahydrate or *A. paniculata* added. However, the addition of either sodium thiosulphate pentahydrate or *A. paniculata* increased the ALP relative to the control but below the negative control ie cyanide alone. This shows that the cyanide increased the production of ALP by the rats as an immune response to cyanide attack, while the addition of sodium thiosulphate pentahydrate or *A. paniculata* joined in combatting the cyanide poison leading to reduced amount relative to the presence of cyanide alone in the rats system. This is because increased ALP is usually a result cholestasis or a hepatobiliary injury because the ALP is a membrane-bound enzyme that is usually associated with liver and bones. On the other hand, an appreciable decrease in the ALP shows that the liver is having an impaired protein synthesis. Although the AST production also increased in the cyanide fed rats, the higher production rate was not significant, while the CN + SCN, 100 mg and 200 mg *A. paniculata* had higher production rate relative to the control but it was not significant.

On the serum creatinine production, all the treatments produced lower amount relative to the control. Varied reports exists on creatinine production as a result of animal exposure to cyanide with dependence placed on the dosage and animal species exposed, hence, the findings of this study varied from the findings of Tulsawan *et al*. (2005) who reported no significant changes between the control rats and the cyanide exposed ones.

However, this result corresponds with the findings of Ezeanyika (2002) [14] who reported reduction in the serum creatinine and urea production in low dosage application of cyanide to rats. On the urea production, all the treatments exposed to cyanide produced lower amount of urea except the treatment fed with CN. The increased serum urea level could suggest impaired hepatetic urea synthesis, while the gradual reduction could be linked to the normalization effect of the administered *A. paniculata* and the SCN.

The total protein content of the rats fed with cyanide and 100 mg and 200 mg AP was significantly higher than the control and rest of the treatments. Cyanide exposure is known to cause muscle wasting which leads to reduced protein synthesis. On the other hand, in a sub-acute level, cyanides can trigger the upregulation of antioxidants that are proteinous, which shows that the *A. paniculata* which has andrographolide, flavonoids and diterpenes produces an antioxidant repair effect to protect the liver and kidney of the rats under cyanide attack.

The reparative effect was seen in the cyanide fed rats without *A. paniculata* or sodium thiosulfate having the least catalase in the liver, although the catalase amount in the liver and kidney was not significant. However, the Superoxide Dismutase (SOD) content of the liver and kidney of rats fed with SCN, 100 mg and 200 mg *A. paniculata* had similar effect as the controls. This shows the defence mechanism triggered by the introduction of *A. paniculata* and SCN which helps in converting harmful superoxide radicals released to the animal system as a recognition to cyanide attack into less oxygen and hydrogen peroxide (Mohamed *et al*., 2020; (Kadiri and Irene, 2022) [3, 5].

In this study, the presence of biomarkers of oxidative stress and lipid peroxidase Malondialdehide (MDA) was higher in the cyanide relative to the control, while the control had similar production rate as the SCN, 100 and 200 mg AP, which showed the restorative effect of the SCN and *Andrographis* treatments. This showed that the damaging effect of the cyanide triggered oxidative stress in the rat's liver and kidney (Kadiri and Irene, 2022) [3, 5]. However, the amount of MDA in the rats fed with cyanide and *A. paniculata* was closest to the control, which indicates that at the time of assessment, the *A. paniculata* treatment has exerted reparative effect on the kidneys and liver of the cyanide exposed rats. Also, there were no significant differences in the amount of glutathione present in the control and the rest treatments except the treatment were SCN and *A. paniculata* was administered along with cyanide.

The *A. paniculata* (200 mg) was able to exert the above antioxidant due to the presence of different forms of phytochemicals like alkaloid, terpenoid, tannin, coumarins, saponin, carboxylic acid and quinones. The alkaloids are antioxidant that could counteract cyanide-induced neurotoxicity due to its ability to modulate neurotransmission by inducing cytochrome P450 enzyme which enhances detoxification (Nguyen and Dang, 2021) [13]. Terpenoids on the hand helps to protect the mitochondria and liver from oxidative stresses by detoxifying cyanide to thiocyanate (Tholl, 2015; Changyan *et al*., 2023) [12, 11]. Also, due to the protein-precipitating capacity of tannins, it can help to chelate

metals and mop up free radicals developed during cyanide toxicity, hence it reduces the cyanide absorption rate. The coumarines found in *A. paniculata* exhibits both antioxidant and anti-inflammatory role in the rats, thereby aiding enzyme detox activity in the rats, while the saponins and carboxylic acids found enhances endogenous antioxidant defenses, and aids in detoxification (Pal and Saha, 2020).

Conclusion

Cyanide poisoning is an important topic in animal and human life as it could lead to loss of life, and commonly found in organic and inorganic sources. The organic sources can come in plants that human consume daily which makes the awareness very important. However, plant sources like *Andrographis paniculata* possesses unique phytochemicals that can counteract the toxic effect of cyanide when administered in the right dose. The findings of this study had shown that the application of *Andrographis paniculata* at the rate of 100 mg and 200 mg/kg and the application of 3 mg/kg sodium thiosulphate successfully ameliorated the toxic impact of cyanide on the liver and kidney functions of rats *in vitro*.

References

1. Ogbuagu EO, Airaodion AI, Okoronkwu VN, Ogbuagu U, Ekenjoku JA. Cyanide toxicity: the good, the bad and the ugly. Int J Biosci Biotechnol. 2019;11:157–164.
2. Parida PKD, Paul D, Chakravorty D. The natural way forward: molecular dynamics simulation analysis of phytochemicals from Indian medicinal plants as potential inhibitors of SARS-CoV-2 targets. Phytother Res. 2020;34(12):3420–3433.
3. Kadiri HE, Leleji I. Ficus capensis modulates oxidative stress parameters in cyanide induced rats. Sokoto J Med Lab Sci. 2022;7:124–130. doi:10.4314/sokjmls.v7i1.16.
4. Julaton T, Taclendo A, Oyong G, Rempill O, Galvez MC, Vallar E. In silico insights on the pro-inflammatory potential of polycyclic aromatic hydrocarbons and the prospective anti-inflammatory capacity of Andrographis paniculata phytocompounds. Int J Environ Res Public Health. 2022;19(14):8588. doi:10.3390/ijerph19148588.
5. Kadiri HE, Ohwokevwe. Combined effects of cadmium and cyanide contaminated diets on oxidative stress markers in different tissues of rats. Galician Med J. 2022;29(4):1–9.
6. Kadiri HE, Ossai HU. Ameliorative potential of Acalypha wilkesiana leaf extract on cyanide-induced renal damage in Wistar rats. Sci Afr. 2023;19:e01568.
7. Kadiri HE, Okoro IO, Ichipi-Ifukor P. Tetrapleura tetraptera fruit protects against cyanide induced toxicity in rats. Iraqi J Sci. 2020;61(10):2504–2514.
8. Kumar A, Dora J, Singh A, Tripathi R. A review on King of Bitter (Kalmegh). Int J Res Pharm Chem. 2012;2:116–124.
9. Misra HP, Fridovich I. The role of superoxide anion in the autoxidation of epinephrine and a simple assay for superoxide dismutase. J Biol Chem. 1972;247(10):3170–3175.
10. Pal D, Saha S. Coumarins: an important phytochemical with therapeutic potential. In: Natural Products and Their Bioactive Properties. 2020. p. 205–222. doi:10.1007/978-981-15-2361-8_9.
11. Changyan L, Wenjun Z, We L, Jianyu W, Aiqing Y. Advances in the biosynthesis of terpenoids and their ecological functions in plant resistance. Int J Mol Sci. 2023;24(14):11561.
12. Tholl D. Biosynthesis and biological functions of terpenoids in plants. Adv Biochem Eng Biotechnol. 2015;148:1–22. doi:10.1007/10_2014_295.
13. Nguyen TD, Dang TT. Cytochrome P450 enzymes as key drivers of alkaloid chemical diversification in plants. Front Plant Sci. 2021;12:682181. doi:10.3389/fpls.2021.682181.
14. Ezeanyika LU. Comparative effects of scopoletin and cyanide on serum electrolytes, urea, creatinine and some haematological parameters of rats. Glob J Pure Appl Sci. 2002;8:311–313. doi:10.4314/gjpas.v8i3.16013.
15. Zhang M, Dugbartey G, Juriasingani S. Hydrogen sulfide metabolite, sodium thiosulfate: clinical applications and molecular mechanisms. Int J Mol Sci. 2021;22:6452. doi:10.3390/ijms22126452.
16. Songvut P, *et al*. Comparative pharmacokinetics and safety evaluation of Andrographis paniculata extract. Front Pharmacol. 2023;14:1230401. doi:10.3389/fphar.2023.1230401.
17. Mohamed MA, Mahmoud AOD, Lotfi A, Saad A. Effects of fucoidan on hematic indicators in Nile tilapia. Aquaculture. 2020.
18. Nyaika J, Abayomi L, Parmar A, Coast O. Cyanide in cassava: drivers, impacts of climate variability and food security. Food Energy Secur. 2024;13:e573. doi:10.1002/fes3.573.
19. Ojeniyi F, Odewusi-Ehigie A, Ol Ehigie, Ehigie L. Evaluation of enzymatic changes in sublethal cyanide poisoning in Wistar rats. J Plant Biochem Physiol. 2020;7(4):242–248.
20. Kuliahsari D, Sari NI, Estiasih T. Cyanide detoxification methods in food: a review. IOP Conf Ser Earth Environ Sci. 2021;733:012099. doi:10.1088/1755-1315/733/1/012099.
21. Latif S, Zimmermann S, Barati Z, Müller J. Detoxification of cassava leaves by thermal, sodium bicarbonate, enzymatic, and ultrasonic treatments. J Food Sci. 2019;84:1986–1991.
22. Tara HH, *et al*. A review on ingested cyanide: risks, diagnosis and treatment challenges. J Med Toxicol. 2020;15(2):128–133.
23. Verma KKP, Singh A, *et al*. Co-cultivation of Andrographis paniculata with food crops. Ind Crops Prod. 2021.
24. Wood H. Konzo outbreak in Zambia linked to cassava-based diet. Nat Rev Neurol. 2020;16(5):242–243.
25. Zacarias C, *et al*. Occupational exposure to hydrogen cyanide during cassava processing. Cad Saude Publica. 2020;33(7):e00073416.
26. Tietz NW. Clinical guide to laboratory tests. Philadelphia: W.B. Saunders; 1976. p. 487.
27. Gaur P, Khan F, Shanker K. Potential lipase inhibitor from Andrographis paniculata. Ind Crops Prod. 2023;197:116623.

28. Das R, Mitra S, *et al*. Medicinal plants used against hepatic disorders in Bangladesh. J Ethnopharmacol. 2022;282:114588.
29. Hussen EM, Endalew SA. Antioxidant activities of Vernonia amygdalina. BMC Complement Med Ther. 2023;23:146.
30. Pruthi S, Shah S, Gambhir HS. Methemoglobinemia due to drug ingestion. QJM. 2021;110(9):595–599.
31. Pauluhn J, Risk T. Carbon dioxide in combustion toxicology. Toxicol Lett. 2016;262:142–152.
32. Weatherburn MW. Urea concentration estimation in samples. Anal Chem. 1967;39:971.
33. Tietz NW. Clinical guide to laboratory tests. 3rd ed. Philadelphia: W.B. Saunders; 1995. p. 518–519.

How to Cite This Article

Ossai NF, Kadiri HE. Effect of the leaf extract of Andrographis paniculata on cyanide-induced toxicity in Wistar rats. International Journal of Advanced Biochemistry Research Noosphere. 2026;2(1):6–13.
doi:10.54660/IJABRN.2026.2.1.06-13.

Creative Commons (CC) License

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.