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Anti-Inflammatory and Hepatoprotective Effects of *Solanium aethiopicum* Leaf Extract in Potassium Bromate Induced Toxicity

***[1]Okon Victoria Edem; [1]Idam Benedict Umagu and [2]Ijioma Solomon Nnah**

[1]Department of Physiology, Faculty of Basic Medical Sciences, Okuku Campus, Cross River State, Nigeria.
[2]Department of Physiology, Abia State University, Uturu, Abia State, Nigeria.
Correspondence: Okon, Victoria Edem; E-mail: okonvictoria40@gmail.com; victoriaokon@unicross.edu.ng; Phone number: 08030946619

ABSTRACT

Potassium bromate (KBr) is a potent oxidizing agent that induces oxidative stress, inflammation, and hepatic injury. This study evaluated the protective effects of *Solanum aethiopicum* leaf extract against KBr-induced alterations in liver function and inflammatory cytokines in Wistar rats. Thirty Wistar rats (140–150 g) were randomly assigned to five groups (n = 6): normal control, KBr (50 mg/kg), KBr + *S. aethiopicum* extract (300 mg/kg), KBr + *S. aethiopicum* extract (600 mg/kg), and KBr + vitamin C (100 mg/kg). Potassium bromate was administered for two weeks before treatment with the extract or vitamin C. Serum liver function indices (total protein, albumin, globulin, ALT, AST, ALP, and total bilirubin) and inflammatory biomarkers (IL-1β and TNF-α) were determined using standard spectrophotometric methods. Data were analyzed using one-way ANOVA followed by Tukey's post hoc test. Potassium bromate significantly disrupted liver function parameters and reduced ($P < 0.05$) IL-1β levels compared with the control, indicating hepatic dysfunction and impaired inflammatory homeostasis. Treatment with *S. aethiopicum* extract significantly restored IL-1β concentrations while maintaining TNF-α levels comparable to the control. The extract also ameliorated KBr-induced alterations in serum proteins and bilirubin. In conclusion, *S. aethiopicum* leaf extract protected against potassium bromate-induced hepatic dysfunction and inflammatory disturbances, supporting its potential as a natural hepatoprotective and immunomodulatory agent. Further studies are recommended to elucidate its underlying mechanisms of action.

Keywords: inflammation, interleukin-1β, tumor necrosis factor-α, potassium bromate, *Solanum aethiopicum*.

INTRODUCTION

In recent years, medicinal plants have attracted considerable attention because of their diverse bioactive compounds and relatively low incidence of adverse effects compared with conventional drugs [1]. Among environmental toxicants implicated in liver injury, potassium bromate ($KBrO_3$) has received significant scientific attention. Potassium bromate is a strong oxidizing agent formerly used as a flour improver and dough conditioner in the baking industry. Although its use has been prohibited or restricted in many countries because of its nephrotoxic, hepatotoxic, genotoxic, and carcinogenic properties, exposure still occurs in some developing countries through contaminated food products and environmental sources. Toxicological studies have demonstrated that potassium bromate

induces excessive production of reactive oxygen species (ROS), resulting in oxidative stress, lipid peroxidation, DNA damage, mitochondrial dysfunction, inflammation, and injury to several organs, particularly the liver and kidneys.

Oxidative stress is recognized as the principal mechanism underlying potassium bromate-induced hepatotoxicity. Excessive generation of reactive oxygen species overwhelms endogenous antioxidant defenses, leading to cellular injury and activation of inflammatory signaling pathways. Activation of these pathways stimulates the release of pro-inflammatory cytokines, including tumour necrosis factor-alpha (TNF-α) and interleukin-1 beta (IL-1β), thereby amplifying inflammatory responses and accelerating hepatocellular damage. Persistent oxidative stress and inflammation ultimately impair liver function, alter serum biochemical markers, and compromise tissue integrity [1].

The growing burden of liver diseases has stimulated renewed interest in medicinal plants as alternative or complementary therapeutic agents. *Solanum aethiopicum L.*, commonly known as African or Ethiopian eggplant, is an important vegetable crop widely cultivated and consumed throughout sub-Saharan Africa. Beyond its nutritional importance, the plant has long been used in traditional medicine for the management of various ailments. Recent phytochemical studies have shown that *S. aethiopicum* contains abundant flavonoids, chlorogenic acid, caffeic acid, phenolic compounds, alkaloids, tannins, saponins, vitamins, and essential minerals. These constituents contribute to its numerous pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, antidiabetic, anti-obesity, nephroprotective, and hepatoprotective effects [2].

Recent reviews have emphasized that flavonoid-rich medicinal plants represent promising candidates for the prevention and management of liver diseases associated with oxidative stress and inflammation [3], [4]. Despite the growing body of evidence supporting the therapeutic potential of medicinal plants, information regarding the protective effects of *Solanum aethiopicum* leaf extract against potassium bromate-induced hepatic dysfunction and inflammatory alterations remains limited. Furthermore, few studies have simultaneously evaluated its effects on liver function indices and key pro-inflammatory cytokines such as IL-1β and TNF-α. Therefore, this study was undertaken to investigate the effects of *Solanum aethiopicum* leaf extract on liver function parameters and inflammatory biomarkers in potassium bromate-induced Wistar rats. The findings are expected to provide scientific evidence supporting the development of *S. aethiopicum* as a natural hepatoprotective and immunomodulatory agent against oxidative stress-mediated liver injury.

MATERIALS AND METHODS

Materials

Ceramic plate, plastic rubber, cage, oral canula, plastic water bottle syringe (1ml, 2ml,5ml, and 10ml) dissecting set, Dettol, distilled water, hand gloves, cotton wool, disinfectant morning fresh, toilet roll, laboratory coat, glass stainer, ceramic crucible, conical flask, chloroform, beakers, desicators, EDTA bottles, plain sample bottles, test tubes, pipette.

Preparation of extract of *Solanium aethiopicum* leaf

The leaves of *Solanium aethiopicum* was collected from Abia State University and air dried at room temperature for a period of 21days until constant weight was obtained. The dried leaves were then pulverized to powdered form by a machine blender and sieved. Thereafter, 400g of the pulverized plant material (*Solanium aethiopicum*) was dissolved in 1200ml of 70% petroleum ether for 72 hours. This was followed with vacuum filtration and extracts was concentrated using an evaporator water bath at 40°C to obtain a solvent free extract, and stored in a refrigerator.

Equipment

Iron cages, Water bottle, Hand gloves, Plate, Digital weighing balance, Sample bottles, Centrifuge, Chloroform, Dissecting set, Sawdust,Paper tape, Garden Egg Leaf Extract, Potassium bromate, Vitamin C, Desiccator, Cotton wool, Syringe (5 ml), Distilled water, Tissue paper, Measuring cylinder, Laboratory coat, Electronic scale, Ethanol, Marker pen, Tween 80, Chloroform, picric acid and normal saline.

Animal experiment

Thirty (30) Wistar rats were obtained from the animal house of the Department of Clinical Physiology, University of Cross River State, Okuku Campus. The animals were allowed to acclimatize for seven days, in a well-ventilated room. They were fed with normal animal feed (rat chow). Good hygiene was maintained by daily cleaning and removal of faeces and spills from their cages and strictly adhered to animal handling precautions and standards.

Experimental design

In the experiment, a total of 25 Wistar rats were used and were divided into 5 groups.

GROUP 1: Normal control (NC), rats were fed with normal chow and distilled water (0.2ml) only.
Group 2: Potassium bromate (50mg/kg)
Group 4: KBr + GEL LD (300mg/kg)
Group 3: KBr + GEL HD (600mg/kg)
Group 5: KBr +Vit C (100mg/kg)
Administration of the extract and Vitamin C was done for 2 weeks after 2 weeks of administration of Potassium bromate. Administration of extracts and duration of treatment lasted for 28 consecutive days. All administrations were done orally using an orogastric tube once daily. The dosages of *S. aethiopicum* extract and vitamin C were determined based on previous literature and preliminary LD_{50} studies [5]. At the end of the experimental period, the rats were anesthetized using light chloroform inhalation. Blood samples were collected via cardiac puncture into EDTA bottles for biochemical analysis.

Administration to the animal

An oropharyngeal cannula was used. The animal was gently held in a supine position and administration was given as designed. 1g of the extract was weighed and dissolved in 2 drops of tween 80 solution then 40mls of water was added to make a solution. Then this was given according to the body weight of the animal. KBr was administered for two weeks before it was discontinued and the extract was administered to the different type of groups except control for another two weeks. Vitamin C was bought from a standard pharmacy (Odonah) Okuku and blended, then administered at 100mg/kg.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Animal Care and Use Committee (IACUC) of [University of Cross River State, Okuku Campus]. All procedures adhered strictly to international guidelines for animal experimentation.

Assay for Tumor necrosis factor alpha (TNF- α) and Interleukin 1 (IL-1) Concentration

Tumor necrosis factor alpha (TNF- α) and Interleukin 1 (IL-1) Concentration was measured using rat TNF-α and IL-1 Elisa kit Catalog No. SG-20127 which was obtained from SinoGeneClon Biotech Co., Ltd. (Hangzhou, China). The developed color was read at 450 nm using a microtiter plate reader. The concentration was then calculated from a standard curve.

Statistical analysis

Data were expressed as Mean ± Standard Error of Mean (SEM). Statistical analysis was performed using one-way Analysis of Variance (ANOVA) followed by Tukey's post hoc test. A p-value < 0.05 was considered statistically significant,

RESULTS

Effect of *Solanum aethiopicum* Leaf Extract on Liver Function Parameters in Potassium Bromate-Induced Wistar Rats

The effects of *Solanum aethiopicum* leaf extract on liver function parameters are presented in Table 3.1. Administration of potassium bromate significantly ($p < 0.05$) increased serum total protein (5.56 ± 0.02 g/dl) and albumin (3.25 ± 0.02 g/dl) compared with the control group (4.59 ± 0.04 and 2.46 ± 0.04 g/dl, respectively). Treatment with low-dose (300 mg/kg) *Solanum aethiopicum* leaf extract reduced total protein (4.37 ± 0.16 g/dl) and albumin (2.19 ± 0.03 g/dl), while high-dose extract (600 mg/kg) produced values of 4.92 ± 0.08 g/dl and 2.82 ± 0.09 g/dl, respectively. Vitamin C treatment resulted in total protein and albumin concentrations of 4.49 ± 0.14 g/dl and 2.21 ± 0.05 g/dl. Serum globulin concentrations showed no significant differences among the control (2.13 ± 0.03 g/dl), potassium bromate (2.30 ± 0.03 g/dl), low-dose extract (2.18 ± 0.16 g/dl), high-dose extract (2.10 ± 0.02 g/dl), and vitamin C-treated groups (2.28 ± 0.10 g/dl).

Serum ALT activity was significantly lower in the potassium bromate group (48.33 ± 1.28 U/L) than in the control group (79.67 ± 0.80 U/L). Administration of low-dose and high-dose *Solanum aethiopicum* increased ALT activities to 85.00 ± 0.84 U/L and 81.00 ± 1.38 U/L, respectively, while vitamin C treatment produced the highest ALT activity (94.67 ± 0.48 U/L). Similarly, AST activity was significantly reduced following potassium bromate administration (62.33 ± 1.28 U/L) compared with the control (69.67 ± 0.80 U/L). Treatment with low-dose extract, high-dose extract, and vitamin C increased AST activities to 85.00 ± 1.58 U/L, 72.67 ± 0.73 U/L, and 117.67 ± 2.46 U/L, respectively.

A similar trend was observed for ALP, where potassium bromates significantly reduced enzyme activity (126.33 ± 2.69 U/L) compared with the control (133.20 ± 6.33 U/L). Treatment with low-dose extract, high-dose extract, and vitamin C significantly increased ALP activities to 165.00 ± 0.95 U/L, 137.00 ± 1.76 U/L, and 278.67 ± 4.61 U/L, respectively. There was no significant difference in total bilirubin between the control (0.80 ± 0.01 mg/dl) and potassium bromate-

treated groups (0.78 ± 0.01 mg/dl). However, bilirubin increased significantly following treatment with low-dose extract (0.93 ± 0.01 mg/dl), high-dose extract (0.85 ± 0.01 mg/dl), and vitamin C (1.30 ± 0.02 mg/dl).

Table 1: Liver function parameters

Groups	Treatment	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	ALT (u/l)	AST (u/l)	ALP (u/l)	Total Bilirubin (mg/dl)
1	Control	4.59±0.04^{a}	2.46±0.04^{b}	2.13±0.03^{a}	79.67±0.80^{b}	69.67±0.80^{b}	133.20±6.33^{ab}	0.80±0.01^{a}
2	KBr	5.56±0.02^{c}	3.25±0.02^{d}	2.30±0.03^{a}	48.33±1.28^{a}	62.33±1.28^{a}	126.33±2.69^{a}	0.78±0.01^{a}
3	KBr + GEL LD	4.37±0.16^{a}	2.19±0.03^{a}	2.18±0.16^{a}	85.00±0.84^{c}	85.00±1.58^{c}	165.00±0.95^{c}	0.93±0.01^{c}
4	KBr+ GEL HD	4.92±0.08^{b}	2.82±0.09^{c}	2.10±0.02^{a}	81.00±1.38^{b}	72.67±0.73^{b}	137.00±1.76^{b}	0.85±0.01^{b}
5	KBr + VIT C	4.49±0.14^{a}	2.21±0.05^{a}	2.28±0.10^{a}	94.67±0.48^{d}	117.67±2.46^{d}	278.67±4.61^{d}	1.30±0.02^{d}

Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.
NOTE: Group I (C) was the normal control, Group 2: Potassium bromate (KBr) (50mg/kg),
Group 3: KBr +HD GEL (600mg/kg), Group 4: KBr +LD GEL (300mg/kg) and Group 5: KBr +Vit C (100mg/kg)

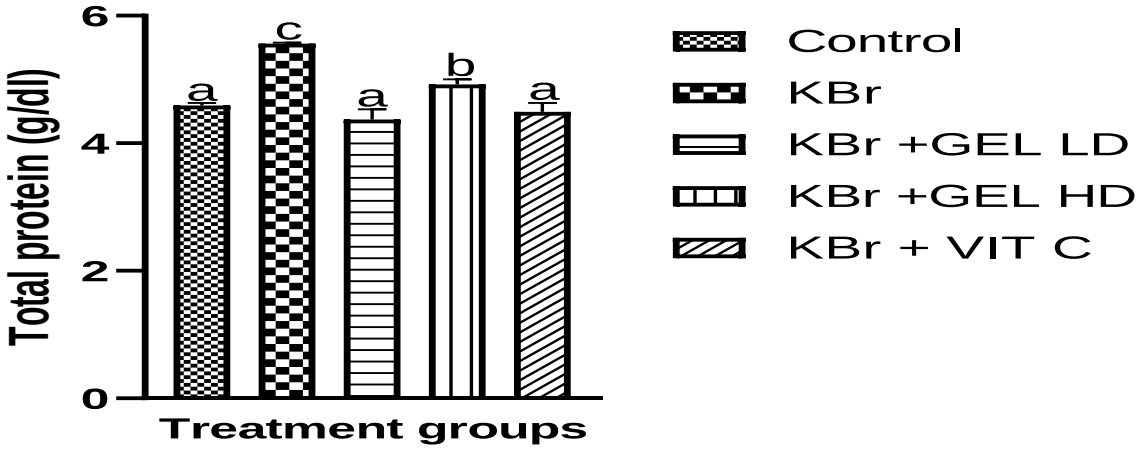

Fig 1: Effect of Solanum aethiopicum leaf extract on total protein among groups
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

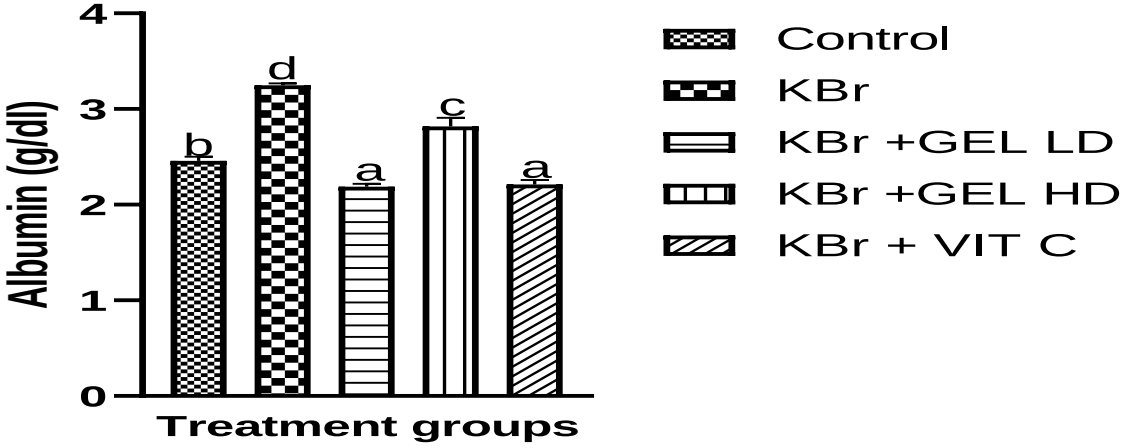

Fig. 2: Effect of Solanum aethiopicum leaf extract on albumin levels
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

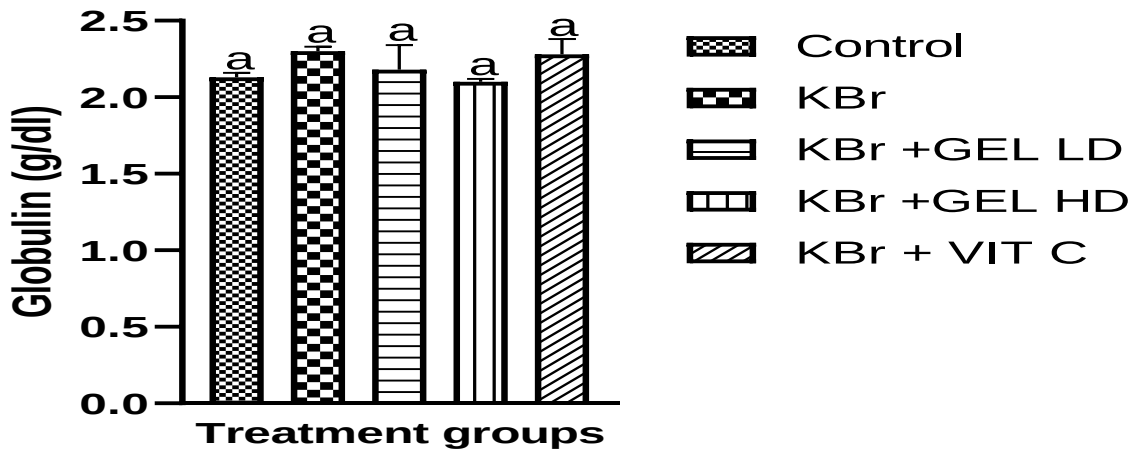

Fig 3: Effect of Solanum aethiopicum leaf extract on globulin levels
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

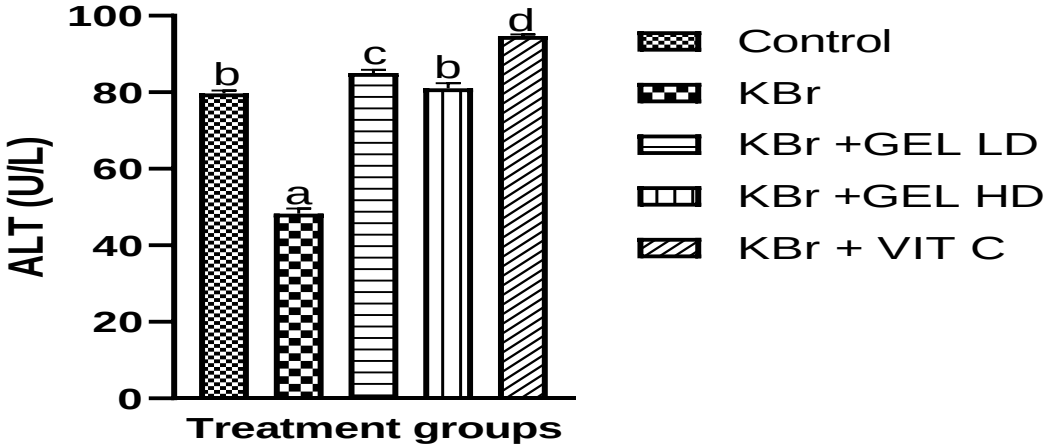

Fig. 4: Effect of Solanum aethiopicum leaf extract on levels of ALT
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

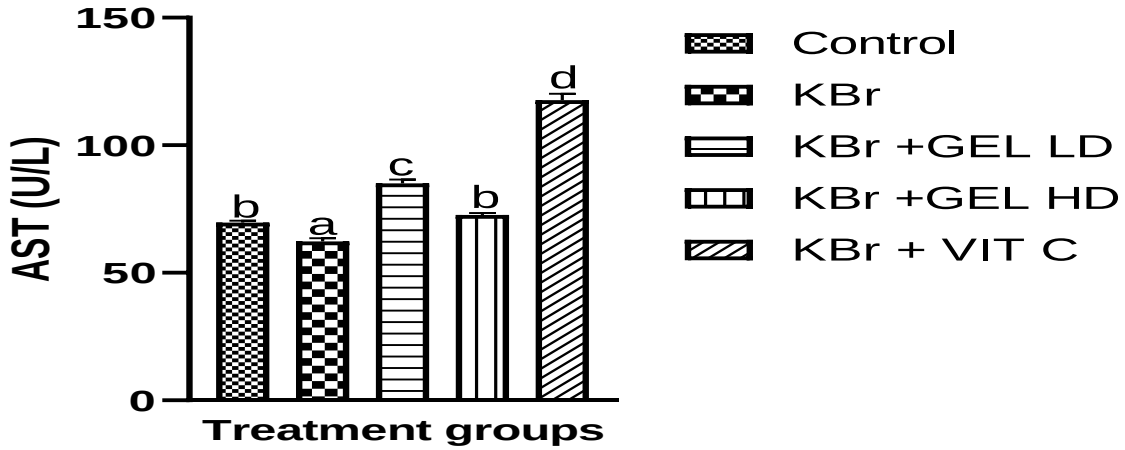

Fig. 5: Effect of Solanum aethiopicum* leaf extract *on levels of AST
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

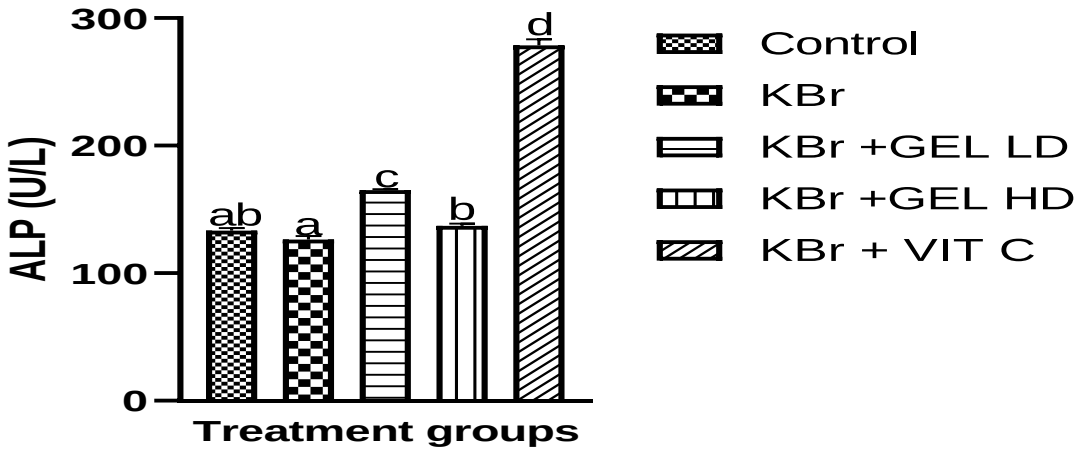

Fig. 6: Effect of Solanum aethiopicum leaf extract on levels of ALP
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

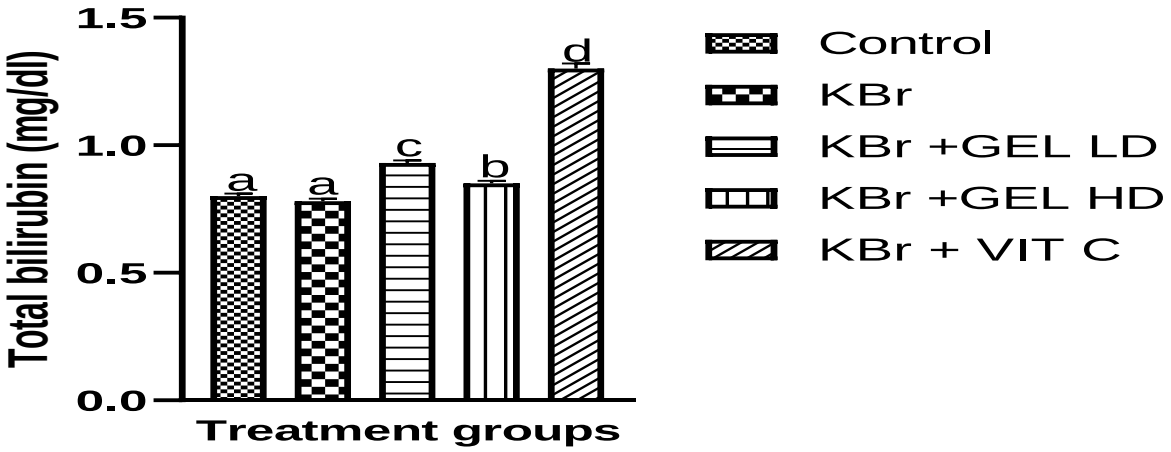

Fig. 7: Effect of Solanum aethiopicum leaf extract on levels of total bilirubin
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

Effect of *Solanum aethiopicum* Leaf Extract on Pro-inflammatory Cytokines in Potassium Bromate-Induced Wistar Rats

The effects of *Solanum aethiopicum* leaf extract on serum IL-1β and TNF-α concentrations are presented in Table 3.2. Administration of potassium bromate significantly ($p < 0.05$) reduced serum IL-1β concentration (5.91 ± 0.09 pg/ml) compared with the control group (6.56 ± 0.08 pg/ml). Treatment with low-dose and high-dose *Solanum treatment* produced the highest IL-1β concentration (8.80 ± 0.19 pg/ml). *Solanium aethiopicum* restored IL-1β concentrations to 6.85 ± 0.03 pg/ml and 6.79 ± 0.08 pg/ml, respectively. Vitamin C

Serum TNF-α concentration was similar between the control (0.07 ± 0.00 pg/ml) and potassium bromate-treated groups (0.07 ± 0.00 pg/ml). Low-dose *Solanum aethiopicum* slightly increased TNF-α to 0.08 ± 0.00 pg/ml, while high-dose extract produced 0.09 ± 0.00 pg/ml. The vitamin C-treated group recorded the highest TNF-α concentration (0.17 ± 0.01 pg/ml), which was significantly higher than all other experimental groups.

Table 2: Result of Pro-inflammatory cytokines of interleukins 1 beta (IL-1β) and tumour necrosis factor - alpha (TNF-α)

Groups	Treatment	IL-1 beta (pg/ml)	TNF-alpha (pg/ml)
1	Control	6.56 ± 0.08^{b}	0.07 ± 0.00^{a}
2	KBr	5.91 ± 0.09^{a}	0.07 ± 0.00^{a}
3	KBr + GEL LD	6.85 ± 0.03^{b}	0.08 ± 0.00^{ab}
4	KBr + GEL HD	6.79 ± 0.08^{b}	0.09 ± 0.00^{b}
5	KBr + VIT C	8.80 ± 0.19^{c}	0.17 ± 0.01^{c}

Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.
NOTE: Group I (C) was the normal control, Group 2: Potassium bromate (KBr) (50mg/kg), Group 3: KBr +HD GEL (600mg/kg), Group 4: KBr +LD GEL (300mg/kg) and Group 5: KBr +Vit C (100mg/kg)

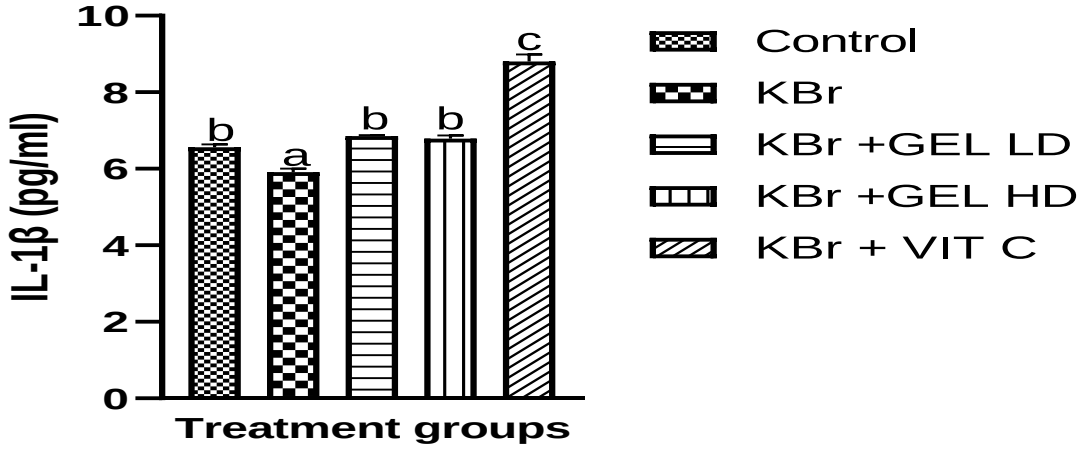

Fig. 8: Effect of Solanum aethiopicum leaf extract on levels of interleukin-1.
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

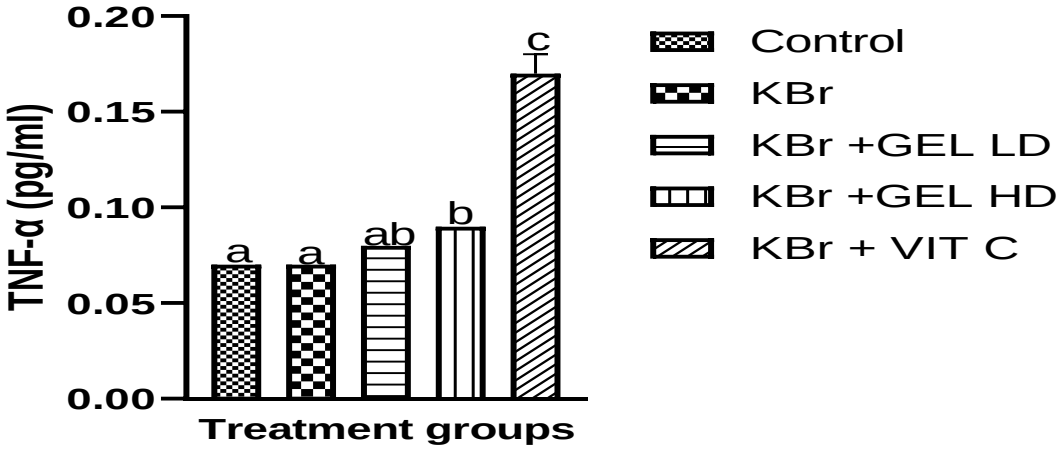

Fig. 9: Effect of Solanum aethiopicum leaf extract on levels of tumor necrosis factor.
Values are mean ± SEM (n=5). Those with different superscripts (a, b, c) along the column are statistically significant at p<0.05 while those with the same superscript are not statistically significant at p≥0.05.

DISCUSSION

The present study investigated the effects of *Solanum aethiopicum* leaf extract on potassium bromate (KBr)-induced alterations in liver function and inflammatory biomarkers in Wistar rats. Potassium bromate is a well-established oxidizing agent that induces excessive generation of reactive oxygen species (ROS), leading to oxidative stress, hepatocellular injury, and dysregulation of inflammatory signaling pathways [5]. The observed changes in liver function parameters and pro-inflammatory cytokines in this study suggest that KBr disrupted hepatic homeostasis, while treatment with Solanum aethiopicum ameliorated many of these alterations, demonstrating its hepatoprotective and immunomodulatory properties [3].

One of the major findings of this study was the alteration of serum proteins following potassium bromate exposure. The significant increase in total protein and albumin observed in the KBr-treated group may reflect an acute adaptive response to oxidative stress, possibly resulting from hemoconcentration or increased synthesis of acute-phase proteins during the early phase of tissue injury. Although chronic liver injury is commonly associated with impaired protein synthesis, early toxic insults may transiently elevate circulating proteins before severe hepatocellular dysfunction develops [1]. Treatment with both low- and high-dose Solanum aethiopicum moderated these changes, bringing protein concentrations closer to those of the control animals. This finding suggests that the extract preserved hepatic synthetic function by limiting oxidative damage to hepatocytes [6]. The relatively unchanged

globulin concentrations across the treatment groups further indicate that immune protein synthesis remained largely unaffected.

The activities of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) also varied among the experimental groups. Although serum transaminases are classical biomarkers of hepatocellular injury, their interpretation should be considered alongside the overall physiological context. The increases observed following treatment with *Solanum aethiopicum* and vitamin C may reflect enhanced hepatocellular metabolic activity or ongoing tissue remodeling during recovery from potassium bromate-induced injury rather than persistent liver damage. Liver regeneration is frequently accompanied by temporary increases in enzyme release before complete restoration of hepatocyte integrity. Furthermore, total bilirubin remained relatively stable in the control and high-dose extract groups, indicating that hepatic excretory function was largely preserved despite exposure to the toxicant [1].

Inflammation plays a central role in potassium bromate-induced toxicity [3]. Surprisingly, potassium bromate significantly reduced IL-1β concentrations compared with the control, while TNF-α remained unchanged. This reduction may indicate suppression of immune-cell function following prolonged oxidative stress, exhaustion of cytokine-producing cells, or the timing of sample collection after the initial inflammatory response had subsided. Similar findings have been described in experimental toxicology studies where sustained oxidative injury eventually compromises normal cytokine secretion despite ongoing tissue damage [5].

Administration of *Solanum aethiopicum* extract effectively restored IL-1β concentrations toward normal values without significantly increasing TNF-α. The restoration of IL-1β to physiological levels suggests that the extract normalized immune function rather than stimulating excessive inflammation. Maintenance of TNF-α close to control values further demonstrates that the extract did not provoke a harmful inflammatory response but instead exerted an immunoregulatory effect. Such balanced modulation of cytokine production is advantageous because excessive suppression or excessive activation of inflammatory mediators may both impair tissue repair [2].

Interestingly, vitamin C treatment produced significantly higher IL-1β and TNF-α concentrations than all other groups. Although vitamin C is widely recognized as a potent antioxidant, it also enhances immune-cell activity and cytokine production during recovery from oxidative injury. Therefore, the elevated cytokine concentrations observed in this group may reflect restoration of immune competence and activation of tissue repair mechanisms rather than persistent pathological inflammation [5].

The beneficial effects of *Solanum aethiopicum* can largely be attributed to its rich phytochemical composition. The leaves contain abundant flavonoids, chlorogenic acid, quercetin derivatives, caffeic acid, and other polyphenolic compounds that possess potent antioxidant and anti-inflammatory properties [2]. Through these complementary mechanisms, the extract limits oxidative injury while maintaining normal inflammatory signaling and hepatic function [7].

CONCLUSION

The findings of this study indicate that *Solanum aethiopicum* leaf extract confers protection against potassium bromate-induced hepatic dysfunction and inflammatory imbalance [8]. The extract preserved liver synthetic and excretory functions, normalized cytokine production, and maintained inflammatory homeostasis without inducing excessive immune activation [9]. Nevertheless, future studies incorporating hepatic histopathology, oxidative stress biomarkers, gene expression analyses, and molecular signaling pathways are recommended to further elucidate the precise mechanisms underlying the hepatoprotective and immunomodulatory actions of *Solanum aethiopicum.*

Declaration of interests

No conflict of interest

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