Ameliorative Effects of *Vernonia amygdalina* and *Celosia argentea* Leaf Extracts on Potassium Bromate-Induced Biochemical Alterations in Male Wistar Rats

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Abstract

This study investigated the effects of potassium bromate (PB), a widely used food preservative, on kidney and liver function in Wistar rats, as well as the potential ameliorative properties of bitter leaf (*Vernonia amygdalina*) and Lagos spinach leaf (*Celosia argentea*) extracts. Adult male Wistar rats were divided into four groups: control, PB-treated, PB + bitter leaf extract-treated, and PB + Lagos spinach leaf extract-treated. Kidney and liver function parameters were evaluated to assess the toxic effects of PB and the therapeutic efficacy of the extracts.

PB-treated rats showed non-significant decreases in kidney function parameters such as urea (35.19 ± 0.79 mg/dL), creatinine (1.12 ± 0.09 mg/dL), and sodium (65.14 ± 1.82 mEq/L), alongside an increase in potassium (2.63 ± 0.07 mEq/L) and chloride (51.73 ± 3.41 mEq/L). Similarly, liver function parameters showed minor reductions, except for lactate dehydrogenase (LDH), which significantly decreased to 10.32 ± 2.06 U/L. Bitter leaf extract treatment caused further reductions in most parameters, with no significant change in alanine aminotransferase (ALT) (4.00 ± 0.00 UI). Conversely, Lagos spinach leaf extract treatment improved kidney and liver function, with elevated urea (40.10 ± 0.91 mg/dL), creatinine (1.14 ± 0.02 mg/dL), and LDH (15.60 ± 1.92 U/L).

These results highlight the toxic impact of PB on kidney and liver function and demonstrate the protective roles of bitter leaf and Lagos spinach leaf extracts. Lagos spinach leaf extract showed superior restorative effects, making it a promising natural therapy for PB-induced organ damage.

Keywords: Bitter leaf, kidney function, Liver function, Lagos spinach leaf, Potassium bromate, wistar rats.

1. Introduction

Potassium bromate ($KBrO_3$) is a widely used chemical in the food industry, primarily as a flour improver and dough conditioner. Despite its industrial benefits, potassium bromate has been identified as a potent oxidizing agent with significant toxicological effects. When ingested, it undergoes metabolic transformations that result in the generation of reactive oxygen species (ROS), leading to oxidative stress and cellular damage (Abdel-Daim *et al*., 2022). Oxidative stress is the primary mechanism through which potassium bromate exerts its toxic effects. Exposure leads to an imbalance between ROS production and the antioxidant defense system, resulting in lipid peroxidation, protein oxidation, and DNA damage—effects confirmed in mice and rat models (Abdel-Daim *et al*., 2022; Ebhohimen *et al*., 2020).

Nephrotoxicity is evidenced by elevated serum creatinine and urea, glutathione depletion, and structural kidney damage, including tubular degeneration and glomerular atrophy (Ebhohimen *et al*., 2020).
Hepatotoxicity is characterized by elevated ALT and AST, as well as oxidative-stress–driven cellular damage (Abdel-Daim *et al*., 2022; Ebhohimen *et al*., 2020). The resultant oxidative stress not only disrupts cellular integrity but also adversely affects vital organs such as the liver and kidneys, as evidenced by increased levels of biochemical markers of organ dysfunction (Ahmad *et al*., 2020). Consequently, potassium bromate has been banned in many countries due to its harmful effects; however, it is still employed in some regions, warranting further investigation into mitigating strategies.

In the quest for mitigating potassium bromate-induced toxicity, attention has turned to natural antioxidants, which have the potential to counteract oxidative stress and restore physiological balance. *Vernonia amygdalina*, commonly known as bitter leaf, is a medicinal plant widely utilized in African traditional medicine. It is rich in bioactive compounds such as flavonoids, saponins, and phenolic acids, which are renowned for their antioxidant properties. *Vernonia amygdalina* can enhance the activities of endogenous antioxidant enzymes, reduce lipid peroxidation, and promote cellular repair mechanisms (Erasto *et al*., 2007; Farombi *et al*., 2015).

Similarly, *Celosia argentea*, known locally as Lagos spinach, is a leafy vegetable with established nutritional and medicinal benefits. It contains a high concentration of phenolic compounds, which contribute to its strong antioxidative capabilities. Literature that *Celosia argentea* can scavenge free radicals, enhance antioxidant enzyme activities, and protect tissues against oxidative damage (Iwalewa *et al*., 2016). Thus the combined use of these two plants will present an exciting research for the toxicological challenges posed by potassium bromate.

2.0 Materials and Methods

2.1 Test substance and potassium bromate preparation

Potassium bromate ($KBrO_3$, CAS No. 7758-01-2, 99.5% purity) was sourced from MOLYCHEM Co., Mumbai, India. A stock solution was prepared by dissolving potassium bromate in distilled water at a concentration of 90 mg/kg body weight, with vortexing to ensure homogeneity (Ibezute and Marcus-Abdul, 2025). This dosage was derived based on the LD50 for rats (157 mg/kg body weight), ensuring sub-lethal exposure.

2.2 Collection and preparation of plant extract

Fresh leaves of *Vernonia amygdalina* and *Celosia argentea* were collected and authenticated as described in Ibezute and Marcus-Abdul (2025). The leaves were dried, powdered, and subjected to aqueous extraction using standard procedures. The resulting extract was freeze-dried to obtain a solid form and reconstituted in distilled water at doses of 150 mg/kg (*Vernonia amygdalina*) and 100 mg/kg (*Celosia argentea*).

2.3 **Acclimatization and Housing of Male Wistar Rats**

Male wistar rats, aged between 6 and 7 weeks and weighing 125g to 150g, were sourced from the Animal Research Unit at the University of Benin, Nigeria. The rats were acclimatized in standard laboratory conditions for two weeks, in wooden cages equipped with wire mesh lids. They were maintained in an environment with a temperature of 22 ± 2°C, a 12-hour light/dark cycle, and a relative humidity of 50 ± 5%. During this period, the rats had unrestricted access to standard rodent chow (Bendel Livestock Feeds Ltd, Ewu, Nigeria) and distilled water. Their body weights were monitored at the start and end of the acclimatization phase. At the end of acclimatization, the rats were assigned randomly to four experimental groups:

- **Group A (C)**: Control
- **Group B (PB)**: Potassium Bromate
- **Group C (PB + BTL)**: Potassium Bromate + *Vernonia amygdalina*
- **Group D (PB + SHK)**: Potassium Bromate + *Celosia argentea*

The Potassium Bromate solution was prepared at a concentration of 90 mg/kg body weight in distilled water. The plant extracts were administered in doses of 150mg/kg (*Vernonia amygdalina*) and 100mg/kg (*Celosia argentea*). Treatment continued for 60 days with a dose given every 48 hours. At the end of the treatment period, the surviving rats were fasted overnight, anesthetized, and sacrificed. Blood was drawn from the inferior vena cava for biochemical assessments, and the serum was separated and stored at -80°C.

2.4 **Biochemical Analysis**

Serum biochemical parameters, including urea, creatinine and serum electrolytes, were assessed to evaluate kidney function. Liver function markers such as Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP) and Lactate Dehydrogenase (LDH) were also measured. In the kidney and liver tissues, biomarkers of oxidative stress such as hydrogen peroxide, MDA, SOD, CAT, GPx, GSH, TAC, and vitamin C were analyzed. The testes were processed by homogenizing in a cold buffer solution (0.1 M phosphate buffer, pH 7.4),

followed by centrifugation at 10,000 × g for 15 minutes at 4°C to isolate the supernatant for biochemical analysis. Assays for oxidative stress and enzymatic parameters were conducted colorimetrically using commercially available diagnostic kits from Human Gesellschaft für Biochemica und Diagnostica mbH, Wiesbaden, Germany**.** Absorbance readings were obtained using a Model SP-300 UV/VIS spectrophotometer (OPTIMA Inc., Tokyo, Japan)**.** All results were normalized to protein concentrations in the homogenates, determined by the Bradford method, to ensure reliable quantification.

2.5 **Statistical Analysis**

The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 25 and Microsoft Excel. Results were presented as means ± standard error (SE). To determine significant differences between groups, one-way analysis of variance (ANOVA) was performed. Post-hoc analysis was carried out using the Duncan Multiple Range Test to compare specific group means. Statistical significance was accepted at $p < 0.05$.

3.0 Results

The study investigates oxidative stress and antioxidant responses in liver and kidney tissues of wistar rats exposed to potassium bromate (PB) and the effects of potential abatements with bitter leaf (BTL) and Lagos spinach leaf (SHK). The findings, as illustrated in Figure 1, show elevated hydrogen peroxide (H_2O_2) levels under PB exposure, with the liver and kidney recording 80.00µg/mL and 70.00µg/mL, respectively, compared to control values of 60.00µg/mL and 50.00µg/mL. BTL treatment reduced these levels slightly to 75.00µg/mL (liver) and 70.00µg/mL (kidney), while SHK demonstrated a more pronounced reduction to 65.00µg/mL (liver) and 60.00µg/mL (kidney).

The effects on lipid peroxidation, represented by malondialdehyde (MDA) levels in Figure 2, indicate baseline concentrations of 0.50mol/g in the liver and 0.40mol/g in the kidney for the control group. Exposure to PB lowered MDA levels to 0.30mol/g (liver) and 0.20mol/g (kidney). Treatment with BTL restored these values to 0.50mol/g (liver) and 0.40mol/g (kidney), while SHK

caused a significant increase in liver MDA to 0.80mol/g, indicating heightened lipid peroxidation, with kidney levels stabilizing at 0.30mol/g. Glutathione peroxidase (GPx) activity, shown in Figure 3, highlights suppressed antioxidant defense under PB exposure, with liver levels decreasing from 6.00U/g in the control to 4.00U/g, and kidney levels reducing from 3.00U/g to 2.00U/g. BTL partially restored GPx to 5.00U/g (liver) and 3.00U/g (kidney), while SHK elicited a marked improvement, increasing liver GPx to 8.00U/g and maintaining kidney levels at 3.00U/g.

The catalase (CAT) activity data in Figure 4 reflected similar trends. The control liver and kidney CAT levels were 1.50U/g and 0.80U/g, respectively, but PB exposure reduced these to 1.00U/g (liver) and 0.60U/g (kidney). BTL treatment led to slight improvements (1.20U/g liver, 0.70U/g kidney), while SHK demonstrated greater efficacy, restoring CAT levels to 1.80U/g (liver) and 0.90U/g (kidney). Superoxide dismutase (SOD) activity, depicted in Figure 5, decreased under PB exposure. Liver SOD dropped from 2.50U/g in the control to 2.00U/g, and kidney SOD fell from 1.50U/g to 1.00U/g. SHK significantly improved SOD activity, restoring levels to 3.00U/g (liver) and 1.50U/g (kidney). BTL provided moderate improvements, raising SOD activity to 2.30U/g (liver) and 1.20U/g (kidney). Vitamin C concentrations (Figure 6) increased under PB exposure, possibly as a compensatory response. Liver levels rose from 30.00µg/mL (control) to 40.00µg/mL, while kidney concentrations surged from 25.00µg/mL to 70.00µg/mL. BTL further elevated liver levels to 60.00µg/mL but reduced kidney levels to 40.00µg/mL. SHK normalized vitamin C levels, restoring liver and kidney concentrations to 30.00µg/mL and 25.00µg/mL, respectively.

Glutathione reductase (GR) concentrations, as shown in Figure 7, were elevated under PB exposure, with liver levels rising from 30.00µg/mL (control) to 35.00µg/mL and kidney levels increasing from 40.00µg/mL to 45.00µg/mL. BTL treatment further elevated these to 40.00µg/mL (Liver) and 50.00µg/mL (kidney). However, SHK mitigated the elevation, reducing liver GR to 28.00µg/mL and maintaining kidney levels at 40.00µg/mL. Protein concentrations (Figure 8) showed minor increases under PB exposure, with liver levels rising from 0.60g/dL (control) to 0.80g/dL and kidney levels increasing from 1.3g/dL to 1.4g/dL. BTL treatment did not significantly alter these levels, but SHK caused a slight reduction in liver protein to 0.50g/dL and a notable increase in kidney protein to 1.80g/dL, marking the highest observed value in the kidney.

Total antioxidant capacity (TAC) levels (Figure 9) decreased significantly under PB exposure, with liver TAC dropping from 100.00µg/mL (control) to 60.00µg/mL and kidney TAC reducing from 80.00µg/mL to 50.00µg/mL. BTL restored TAC to 90.00µg/mL (Liver) and 100.00µg/mL (Kidney), while SHK improved liver TAC to 80.00µg/mL and Kidney TAC to 110.00µg/mL, the highest recorded value.

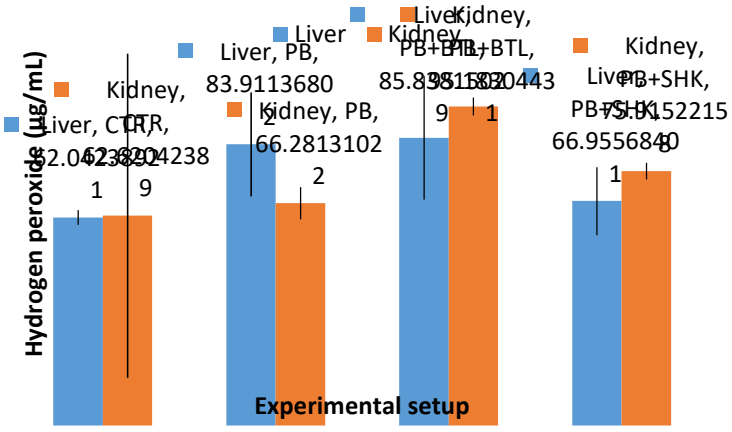

Figure 1: Hydrogen peroxide in the liver and kidney of wistar rats given potassium bromate food preservatives and possible abatements

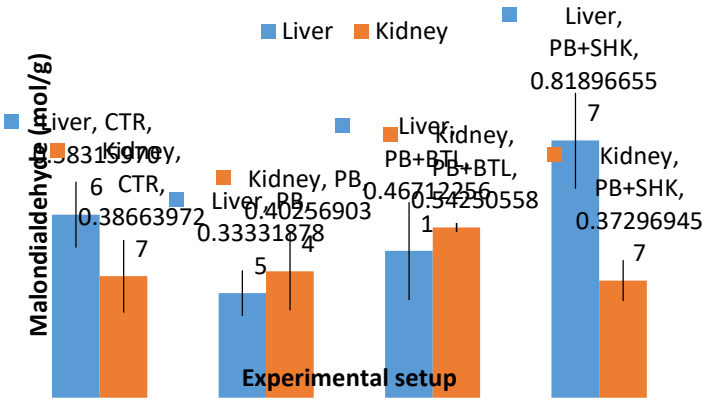

Figure 2: MDA in the liver and Kidney of wistar rats given potassium bromate food preservatives and possible abatements

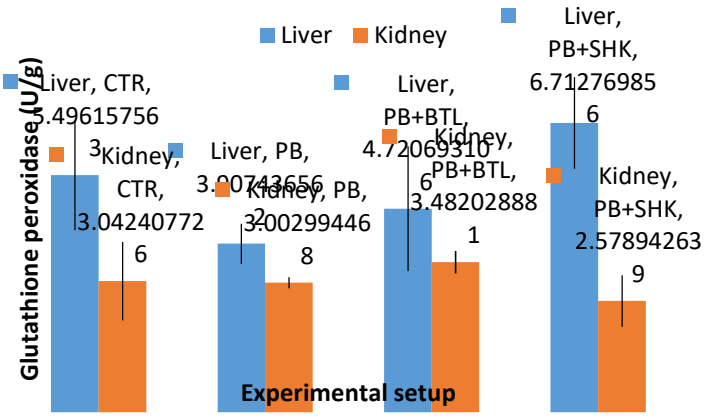

Figure 3: Glutathione peroxidase in the liver and kidney tissues of wistar rats given potassium bromate food preservatives and possible abatements

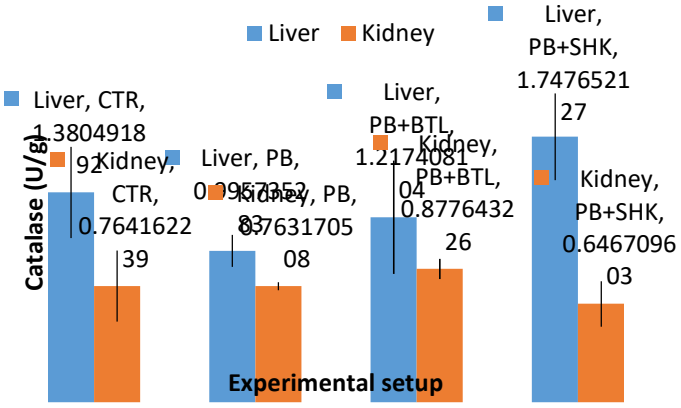

Figure 4: Catalase concentration in the liver and kidney of wistar rats given potassium bromate food preservatives and possible abatements

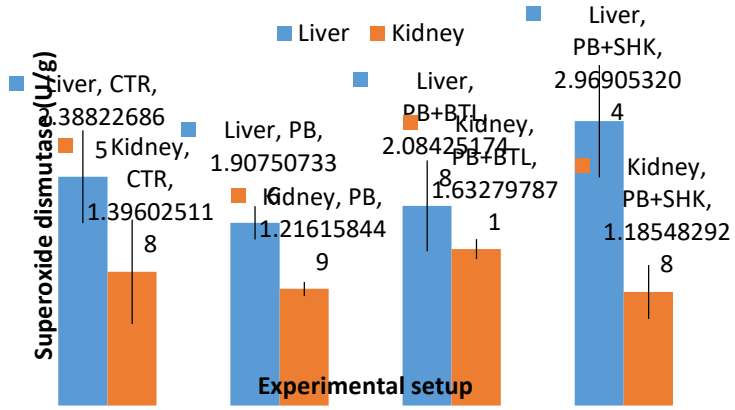

Figure 5: Superoxide dismutase in the liver and kidney of wistar rats given potassium bromate food preservatives and possible abatements

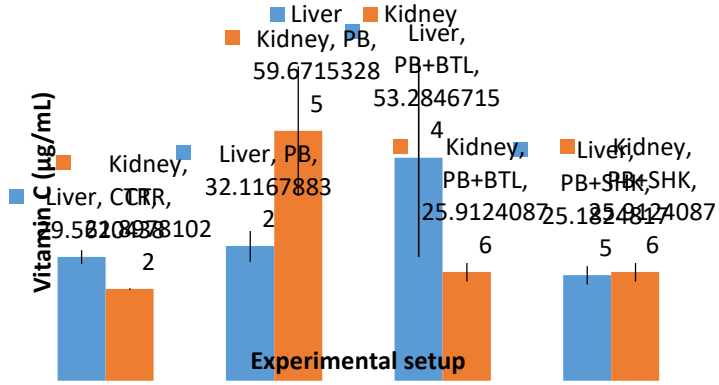

Figure 6: Vitamin C concentration in the Liver and kidney of wistar rats given potassium bromate food preservatives and possible abatements

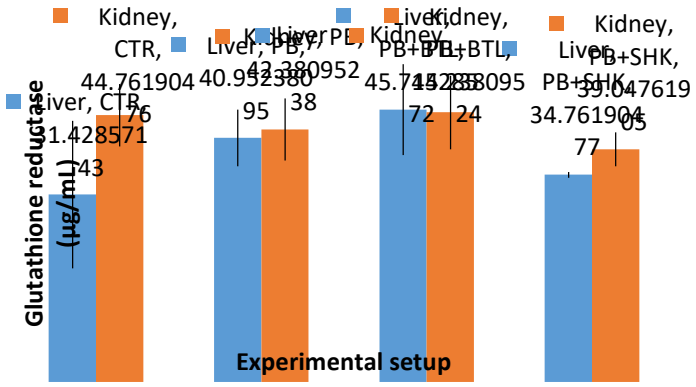

Figure 7: Glutathione reductase concentration in the liver and kidney of wistar rats given potassium bromate food preservatives and possible abatements

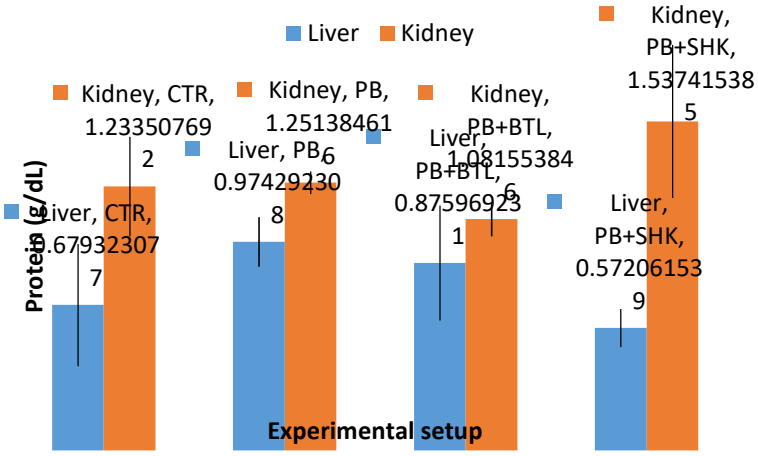

Figure 8: Protein concentration in the liver and kidney of wistar rats given potassium bromate food preservatives and possible abatements

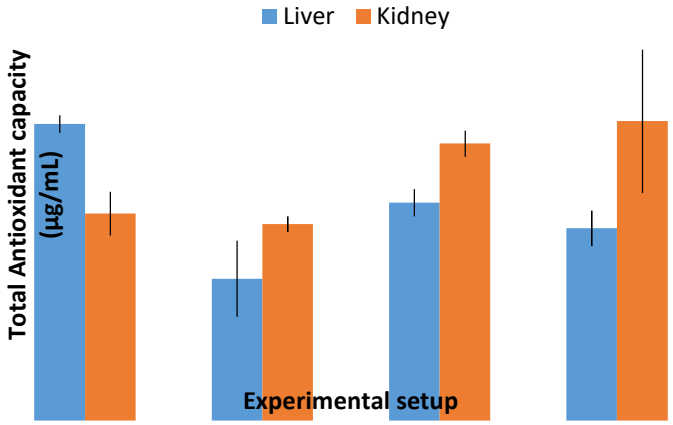

Figure 9: Total antioxidant capacity in the liver and kidney of wistar rats given potassium bromate food preservatives and possible abatements

The impact of kidney function parameters of wistar rats given potassium bromate food preservative and possible abatements is shown in Table 1. The wistar rats given potassium bromate displayed a non-significant decrease in urea, (35.19±0.79 mg/dL), creatinine (1.12±0.09 mg/dL) and sodium (65.14±1.82 mEq/L) with an increase in potassium (2.63±0.07mEq/L) and chlorine (51.73±3.41 mEq/L). Similar trend was noticed in wistar rats given potassium bromate and treated with bitter extract as a further decrease was recorded in creatinine, and a further increase in chloride. However, a reversal in trend occurred as there was an elevation in urea potassium ion level and sodium ion level. in the wistar rats given potassium bromate and treated with SHK leaf extracts, a further reversal was seen with an upsurge in urea (1.14±0.02 mg/dL), creatinine (1.14±0.02 mg/dL) and chloride (64.30±0.89mEq/L) and a decline in potassium (1.83±0.30 mEq/L) and sodium (63.58±4.93mEq/L).

Table 1: Kidney function parameters of wistar rats given potassium bromate food preservatives and possible abatements

	Experimental Setup				P-Value
	CTR	PB	PB+BTL	PB+SHK	
Urea (mg/dL)	35.98±1.59	35.19±0.79	35.58±0.13	40.34±2.51	P>0.05
Creatinine (mg/dL)	1.17±0.03	1.12±0.09	0.99±0.00	1.14±0.02	P>0.05
Potassium (mEq/L)	2.12±0.00	2.63±0.07	2.10±0.07	1.83±0.30	P>0.05
Sodium (mEq/L)	67.47±1.30	65.14±1.82	76.30±1.56	63.58±4.93	P>0.05
Chloride (mEq/L)	51.73±3.41	58.50±2.35	63.20±4.03	64.30±0.89	P<0.05

The impact of liver function parameters of wistar rats given potassium bromate food preservative and possible abatements is shown in Table 2. The wistar rats given potassium bromate displayed a non-significant decrease in a liver function parameter except in LDH (10.32±2.06 U/L) with showed a decrease in value when compared with the control. A reversal in trend was noticed in the group of wistar rats given potassium bromate and treated with bitter leaf extract as there was a reduction in all liver function parameter with no significant in ALT (4.00±0.00 UI). In the wistar rats given potassium bromate and treated with SHK leaf extract, a further reversal was recorded. There was an elevation in all liver function parameters with no significant difference in ALT (4.00±0.00UI).

Table 2: Liver function parameters of wistar rats given potassium bromate food preservatives and possible abatements

	Experimental Setup				**P-Value**
	CTR	**PB**	**PB+BTL**	**PB+SHK**	
Aspartate Aminotransferase (UI)	16.00±0.00	24.00±17.00	7.00±0.00	10.00±3.00	P<0.05
Alanine Aminotransferase (UI)	8.00±2.00	4.00±0.00	4.00±0.00	4.00±0.00	P<0.05
Alkaline Phosphatase (UI)	27.69±1.42	29.19±2.40	26.42±1.27	28.44±0.45	P>0.05
Lactate Dehydrogenase (U/L)	8.25±2.06	10.32±2.06	8.25±0.00	12.38±0.00	P<0.05

Discussion

This study highlights significant findings on oxidative stress and antioxidant responses in liver and kidney tissues of wistar rats exposed to potassium bromate (PB), a known environmental toxicant. PB exposure was associated with increased oxidative stress markers, including elevated hydrogen peroxide (H_2O_2) levels, lipid peroxidation, and diminished antioxidant enzyme activities. The study also evaluated the mitigating effects of bitter leaf (BTL) and Lagos spinach leaf (SHK) extracts, with SHK showing superior efficacy in most parameters. These findings emphasize the interplay between oxidative stress and natural antioxidant defenses, underscoring the therapeutic potential of phytochemicals in addressing toxicant-induced damage. PB exposure significantly raised H_2O_2 levels in liver and kidney tissues, reflecting increased production of reactive oxygen species (ROS), consistent with its ability to generate free radicals (Akinmoladun *et al*., 2020). ROS accumulation leads to oxidative damage in vital organs, disrupting cellular integrity. While BTL moderately reduced H_2O_2 levels, SHK provided a more pronounced decrease, attributed to its richer antioxidant phytochemical profile, including flavonoids and phenolic compounds, which effectively neutralize ROS (Oboh *et al*., 2018).

Unexpectedly, PB-exposed groups showed suppressed malondialdehyde (MDA) levels, which could indicate compensatory metabolic adaptations under oxidative stress. BTL treatment normalized MDA levels, in line with previous studies highlighting its antioxidant activity (Adewole *et al*., 2021). In contrast, SHK treatment elevated MDA levels in the liver, possibly due to pro-oxidant effects of certain SHK metabolites under specific conditions, warranting further investigation. PB exposure also reduced antioxidant enzyme activities, including glutathione peroxidase (GPx), catalase (CAT), and superoxide dismutase (SOD), corroborating findings that PB impairs antioxidant defenses (Oyewo *et al*., 2019). BTL and SHK restored these activities, with SHK demonstrating superior effects, likely due to its higher concentrations of micronutrients such as selenium and zinc, which enhance enzymatic efficiency (Nwaichi *et al*., 2022).

Vitamin C levels were elevated in PB-exposed groups, likely as an adaptive response to oxidative stress, given its role as a non-enzymatic antioxidant (Ajibola *et al*., 2020). BTL increased vitamin C levels further, while SHK normalized them, reflecting different impacts on antioxidant reserve dynamics. Similarly, glutathione reductase (GR) levels were elevated in response to oxidative stress, and SHK's ability to reduce GR levels, particularly in the liver, suggests its efficacy in mitigating oxidative burden and lowering the demand for glutathione recycling. Total antioxidant capacity (TAC) was reduced under PB exposure, consistent with the depletion of antioxidant reserves. Both BTL and SHK improved TAC levels, with SHK achieving the highest recorded values, particularly in kidney tissues. This underscores SHK's potent antioxidant properties, linked to its polyphenolic content and synergistic phytochemical interactions (Adebayo *et al*., 2021).

The study highlights significant alterations in kidney function parameters in wistar rats exposed to potassium bromate (PB) as a food preservative, alongside the modulatory effects of bitter leaf (BTL) and Lagos spinach (SHK) extracts. PB exposure resulted in a non-significant decrease in urea, creatinine, and sodium levels, accompanied by increased potassium and chloride levels. These disruptions reflect early-stage kidney dysfunction, possibly due to PB-induced oxidative stress and lipid peroxidation, impairing renal tubular function and disrupting electrolyte homeostasis (Yadav *et al*., 2020; Akinrinmade *et al*., 2019). The nephrotoxic effects of PB are well-documented, primarily attributed to its generation of reactive oxygen species (ROS), which cause oxidative damage to renal tissues (Ibrahim *et al*., 2017). Consistent with previous reports, this study observed disrupted nitrogenous waste clearance and electrolyte imbalances in PB-exposed rats.

Treatment with BTL extract led to partial recovery in sodium and potassium levels, suggesting its antioxidant properties may mitigate oxidative damage and enhance renal clearance mechanisms (Odukoya *et al*., 2018). However, persistent increases in chloride levels and limited improvement in potassium indicate incomplete restoration of tubular function. Conversely, SHK extract demonstrated a more pronounced restorative effect, reversing PB-induced alterations by significantly elevating urea, creatinine, and chloride levels while improving sodium and potassium balance. These effects are likely due to SHK's rich antioxidant profile, which combats free radical-

mediated damage more effectively than BTL (Ajiboye *et al*., 2019). Both extracts corroborate earlier findings on the nephroprotective potential of plant-based antioxidants. BTL's phytochemicals, such as flavonoids and phenolics, enhance antioxidant defenses, while SHK's carotenoids and polyphenols reduce oxidative stress and inflammation, promoting improved renal function (Odukoya *et al*., 2018; Ajiboye *et al*., 2019). Notably, SHK exhibited superior efficacy, particularly in restoring electrolyte balance. However, discrepancies in BTL's performance, such as its limited effect on chloride levels, may stem from differences in dosage, preparation, or experimental conditions, warranting further investigation.

The study provides valuable insights into the effects of potassium bromate (PB) on liver function parameters in wistar rats and the protective roles of bitter leaf (BTL) and Laos spinach leaf (SHK) extracts. PB exposure caused a non-significant reduction in liver function parameters, with lactate dehydrogenase (LDH) levels declining compared to the control. This reduction may reflect PB-induced oxidative damage to hepatocytes, as LDH is an enzyme released during tissue injury (Ibrahim *et al*., 2017). However, the lack of significant changes in other liver enzymes suggests the onset of liver dysfunction, with compensatory mechanisms likely still active to maintain homeostasis. PB is a well-documented hepatotoxic agent, known to induce oxidative stress, lipid peroxidation, and mitochondrial dysfunction in liver tissues (Yadav *et al*., 2020). The observed trends align with earlier reports linking PB exposure to diminished hepatic function due to reactive oxygen species (ROS)-mediated hepatocyte damage (Akinrinmade *et al*., 2019).

In PB-exposed rats treated with BTL extract, reductions in all liver function parameters were observed, though ALT levels remained unchanged. BTL's antioxidant compounds, such as flavonoids and polyphenols, likely mitigate oxidative stress and enhance liver repair mechanisms (Odukoya *et al*., 2018). However, the unchanged ALT levels indicate an incomplete or dose-dependent protective effect of BTL. Conversely, SHK-treated rats exhibited elevations in liver function parameters, suggesting a more robust restorative effect. SHK's bioactive compounds, including carotenoids and polyphenols, may stabilize hepatocyte membranes and enhance enzyme release, indicating improved hepatic recovery (Ajiboye *et al*., 2019).

The hepatoprotective effects of both extracts corroborate earlier findings on the therapeutic potential of plant-based antioxidants. BTL has been shown to prevent hepatic inflammation and enzyme leakage, while SHK's superior antioxidative properties further enhance membrane integrity and liver function (Odukoya *et al*., 2018; Ajiboye *et al*., 2019). This study extends current knowledge by comparing the relative efficacy of these extracts in mitigating PB-induced hepatotoxicity. Notably, SHK demonstrated a greater capacity to restore liver enzyme levels, highlighting its superior hepatoprotective potential. However, deviations from prior findings, such as the non-significant changes in ALT levels with BTL treatment, may result from differences in extract preparation, dosage, or experimental design. Further research is needed to explore these variations and optimize the therapeutic use of these plant-based remedies.

4. Conclusion

This study has demonstrated the adverse effects of potassium bromate (PB) on kidney and liver function in wistar rats, as evidenced by altered biochemical parameters. The findings from this study underscore the therapeutic potential of Lagos spinach leaf extract as a natural remedy for mitigating PB-induced nephrotoxicity and hepatotoxicity. While both extracts hold promise as protective agents, the pronounced efficacy of Lagos spinach leaf extract highlights its potential as a more effective treatment option. Further studies are recommended to explore the underlying mechanisms of action and to assess the long-term safety and effectiveness of these plant extracts in clinical applications.

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