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EFFECTS OF WATER MELON RIND EXTRACT AGAINST POTASSIUM BROMATE INDUCED DAMAGE ON THE LIVER AND HAEMATOLOGICAL PARAMETERS OF ADULT WISTAR RATS

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ABSTRACT

Water melon (rind) is popular in traditional medicine and contains numerous bioactive phytochemicals. This study therefore investigated the effect of water melon rind extract against $KBrO_3$ induced damages on the liver and haematological parameters in adult Wistar rats. Thirty adult male Wistar rats were used and randomly divided into 6 groups of 5 animals each. Group A served as control, group B received 100mg/KgBw $KBrO_3$, group C received 1000mg/KgBw of *Citrullus lanatus* (CLRE), group D received 100mg/KgBw $KBrO_3$ and 500mg/KgBw CLRE, group E received 100mg/KgBw $KBrO_3$ and 1000mg/KgBw CLRE and group F received 100mg/KgBw $KBrO_3$ and 1500mg/KgBw CLRE. All administrations lasted for 60 days after which they were sacrificed via cervical dislocation; blood samples and liver collected for analysis. Data were analysed using ANOVA and posthoc LCD and significant at $p \leq 0.05$. The result showed a significant increase in the levels of aspartate transaminase, alanine transaminase and alkaline phosphatase in group B when compared to group A ($p<0.05$). However, administration of CLRE led to a significant decrease in all the markers when compared to group B ($p<0.05$). No significant effect was found in the levels of PCV and HB and on WBC and RBC count in all the treatment groups when compared to group B ($p>0.05$). Histopathological studies showed marked distortion in the histoarchitecture of group B liver when compared to others administered with CLRE. This research therefore reaffirms the deleterious effects of $KBrO_3$ and reveals the protective effect of water melon rind against them.

KEYWORDS: potassium bromate, water melon, haematology, aspartate transaminase, alanine transaminase, alkaline phosphatase.

INTRODUCTION

The prevalence of substandard bakery products and the wide use of potassium bromate in bakeries in Nigeria is a call for concern. Fifteen years after its ban by the National Agency for Food and Drug Administration and Control (NAFDAC), carcinogenic bromate is still in use in bakeries in Nigeria.[1]

The World Health Organisation proclaimed potassium bromate carcinogenic. This was announced in 1992 during its proscription from use as a bread improver. Aside being carcinogenic, bromate has been discovered to induce multiple organ toxicities, resulting in a myriad of diseases which include liver damage, renal failure, haematological derangement, diarrhoea etc. in both humans and experimental animals.[2,3,4] Despite these proven toxic effects, potassium bromate continues to be in use in bakeries in most middle- and low-income countries, including Nigeria (NAFDAC 2003) and this calls for a need to discover natural products for distoxification.[5]

In Nigeria, domestic fruits and plants form the mainstay of traditional health care. Water melon (*Citrullus lanatus*) belongs to the family Cucubitaceae, it is a household fruit in Africa and India.[6] It contains mainly crude proteins, crude fibre, total carbohydrate, amino acids; leucine, isoleucine, arginine, glutamic acid and aspartic acid, bioactive substances such as cucurbitacin, tripterpines, sterols, alkaloids, vitamins and minerals.[7]

The tissue protective effects, free radical scavenging and antioxidant effects of water melon have been widely reported.[8] While lots of research has been done on its fruit content,[6] limited research have being done on the not so popular rind extract and in this research, its effect on potassium bromate induced toxicity on the liver and haematological parameters will be evaluated.

MATERIALS AND METHODS

Materials used includes adult male Wistar rats, standard plastic cage**,** feeding bottles**,** hand gloves, syringes**,** animal weighing balance (BAW-660-M), growers mash**,**

ethanol, plain vacutainer bottles, EDTA bottles, potassium bromate and Fresh rinds of *citrullunus lanatus*.

Study location and ethical considerations

The research work was carried out in the Animal House of the Faculty of Basic Medical Sciences, College of Health Sciences, Nnamdi Azikiwe University, Nnewi campus and ethical approval for the study was obtained from the Nnamdi Azikiwe University-Animal Research Ethics Committee.

Preparation of plant extract

Healthy fruits of *Citrullus lanatus* was sourced from local open markets in Nnewi, and authenticated by a botanist in the Department of Botany, Nnamdi Azikiwe University Awka. *Citrullus lanatus* fruit was sourced and thoroughly washed. The backs were carefully peeled off from the fruits, shed dried, ground and soaked in 70% ethanol. The ethanolic extract was obtained following the modified method of Abd El-Ghany *et al*., (2010). The resulting ethanol extracts was then filtered and concentrated using a rotary evaporator (Heidolph. VV2000, Germany) under reduced pressure at a temperature of 55 degrees centigrade. The residue was lyophilized using a vacuum freeze dryer (Tilburg, Holland; 145Fm-RB). The final extract was then weighed and kept until used.

Study design

A total of thirty (30) healthy male Wistar rats weighing between 150g-250g were used for this study. Prior to commencement of the study, the animals were housed and allowed to acclimatize to the animal house conditions for 2 weeks, housed in standard cages, and fed growers mash and water *ad libitum* for the entire duration of the study. A 12-hours dark-light period was maintained at room temperature throughout the study period. All experimental procedures complied with the commendations provided in the "Guide for the care and use of laboratory Animals" prepared by The National Academy of Sciences and published by the National institute of Health (1985).

The animals were randomly divided into six groups (A-F) of five rats each.

Group A serve as Control group, and received feed and distilled water *ad libitum* only.

Group B received Potassium bromate 100mg/KgBw.

Group C received 1000mg/KgBw of rind extract of *Citrullus lanatus*

Group D received 100mg/KgBw of Potassium bromate and 500mg/KgBw of rind extract of *Citrullus lanatus*

Group E received 100mg/KgBw Potassium bromate and 1000mg/KgBw of rind extract of *Citrullus lanatus*

Group F received 100mg/KgBw of potassium bromate and 1500mg/KgBw of rind extract of *Citrullus lanatus*.

Weight assessment and sample collection

The Wistar rats were weighed at intervals to track changes in body weight. After the end of the experiment, the final weight of the rats were taken and to calculate the weight gained, the difference between the final and the initial weight was calculated. After a 12-hour fasting period, the rats were sacrificed by cervical dislocation. Blood samples were taken via ocular puncture and collected into plain and EDTA blood bottles for both biochemical and haematological analysis. The livers were harvested and immediately placed in 10% formal saline until subjected to histopathological analysis.

Histological studies

For the histological examinations, small pieces of each liver were fixed in 10% neutral phosphate-buffered (pH7.4) formalin, dehydrated, cleared, embedded in paraffin and then sectioned (5 mm in thickness). Sections were stained with haematoxylin and eosin and examined under a light microscope with photomicrographs also taken.

3.11 Haematological examination

The red blood cell (RBC), white blood cell (WBC), packed cell volume (PCV), and haemoglobin concentration (HB) were measured using Mindray (Bc-5390) Auto Haematology Analyser.

Biochemical assay

All serum samples were processed to determine the enzymatic activities of alanine transaminase (ALT), aspartate transaminase (AST) and alkaline phosphatase (ALP) with a spectrophotometric technique by the Olympus AU-2700 auto analyser and presented as IU/L.

Statistical analysis

The data was analysed using the SPSS (Statistical Package for Social Sciences) version 20, and the results presented as (mean ± standard error of mean). Analysis of Variance (ANOVA) test was used for comparison between groups at a significant level ($P \leq 0.05$). The post Hoc LSD was used to analyse the differences between means of the treated and control groups.

RESULTS

Table 1: Effect of *Citrullus lanatus* rind extract on body weight following potassium bromate induced toxicity.

Groups	Initial weight	Final weight	Relative liver weight (g)
	MEAN±SEM	MEAN±SEM	MEAN±SEM
Group A (control)	99.08±7.92	185.60±15.18*	3.47±0.16[a]
Group B (KBrO3 Only)	126.57±2.66	135.20±8.10*	3.90±0.15
Group C (1000mg/kg of CLRE)	113.12±4.09	158.20±8.52*	4.38±0.23 [a]

Group D (100mg/kg of KBrO3 + 500mg/kg of CLRE)	128.88±8.95	155.80±7.60 [a]	3.71±0.16 [a]
Group E (100mg/kg of KBrO3 + 1000mg/kg of CLRE)	121.02±5.03	129.60±7.53 [a]	3.32±0.07*
Group F (100mg/kg of KBrO3 + 1500mg/kg of CLRE)	121.02±5.84	149.00±10.38 [a]	3.25±0.09*

Body weight was analysed using T-test while liver weight was analysed using ANOVA followed by Post-hoc LSD comparison and values were considered significant at $p \leq 0.05$. $p<0.05^{*}$; and $p>0.05$ [a.] CLRE: *Citrullus lanatus* rind extract; SEM: standard error of mean.

Table 2: Effect of *Citrullus lanatus* rind extract on AST, ALT and ALP level following potassium bromate induced toxicity.

Groups	AST (UI/L)	ALT (UI/L)	ALP (UI/L)
	MEAN±SEM	MEAN±SEM	MEAN±SEM
Group A (control)	35.33±1.86*	63.67±4.48*	64.33±1.76*
Group B (KBrO3 Only)	115.67±2.84	188.33±8.74	157.33±10.47
Group C (1000mg/kg of CLRE)	37.33±7.83 [a]	60.00±10.50[a]	52.33±3.71 [a]
Group D (100mg/kg of KBrO3 + 500mg/kg of CLRE)	65.33±5.17*	120.00±6.42*	94.00±5.51*
Group E (100mg/kg of KBrO3 + 1000mg/kg of CLRE)	56.67±3.67 *	102.33±5.04*	81.67±3.17*
Group F (100mg/kg of KBrO3 + 1500mg/kg of CLRE)	49.00±3.05*	86.67±5.61*	72.34±0.67*

Data was analysed using ANOVA followed by Post-hoc LSD comparison and values were considered significant at $p \leq 0.05$. $p<0.05^{*}$ and $p>0.05$ [a.] CLRE: *Citrullus lanatus* rind extract; SEM: standard error of mean.

Table 3: Effect of *Citrullus lanatus* rind extract on RBC, PCV, and haemoglobin level following potassium bromate induced toxicity.

Groups	Red blood cell (x10^12/l)	Pack cell volume (%)	Haemoglobin (g/dl)
	MEAN±SEM	MEAN±SEM	MEAN±SEM
Group A (control)	7.65±0.23[a]	41.00±1.15[a]	14.53±0.34[a]
Group B (KBrO3 Only)	6.95±0.47	39.33±0.88	14.10±0.23
Group C (1000mg/kg of CLRE)	7.32±0.23[a]	40.33±0.88[a]	13.00±0.26[a]
Group D (100mg/kg of KBrO3 + 500mg/kg of CLRE)	7.15±0.62[a]	39.00±1.15[a]	14.26±0.37[a]
Group E (100mg/kg of KBrO3 + 1000mg/kg of CLRE)	7.33±0.10[a]	39.89±1.00[a]	13.77±0.31[a]
Group F (100mg/kg of KBrO3 + 1500mg/kg of CLRE)	7.56±0.42[a]	40.07±0.57[a]	14.03±0.12[a]

Data was analysed using ANOVA followed by Post-hoc LSD comparison and values were considered significant at $p \leq 0.05$. $p<0.05^{*}$; and $p>0.05$ a. CLRE: *Citrullus lanatus* rind extract; SEM: standard error of mean.

Table 4.5: Effect of *Citrullus lanatus* rind extract on lymphocytes, monocytes, eosinophils, neutrophils, white blood cells, and platelet count level following potassium bromate induced toxicity.

Groups	Lymphocytes (%)	Monocytes (%)	Eosinophils (%)	Neutrophils (%)	White blood cell (10^3/ul)	Platelet count (10^3/ul)
	MEAN±SEM	MEAN±SEM	MEAN±SEM	MEAN±SEM	MEAN±SEM	MEAN±SEM
Group A (control)	60.33±5.78[a]	2.33±0.88[a]	1.00±0.00*	36.00±4.72[a]	12.87±2.26 [a]	1233.33±192.28*
Group B (KBrO3 Only)	51.67±2.67	1.58±1.20	4.33±0.33	40.33±3.67	10.37±1.45	681.33±79.43
Group C (1000mg/kg of CLRE)	58.03±2.90[a]	2.20±0.57[a]	2.00±0.88[a]	36.11±0.88[a]	14.43±1.04 [a]	1098.00±140.32[a]
Group D (100mg/kg of KBrO3 + 500mg/kg of CLRE)	56.83±2.96[a]	1.73±0.33[a]	1.00±0.00*	39.73±2.72[a]	10.90±1.04[a]	895.67±253.11[a]
Group E (100mg/kg of KBrO3 + 1000mg/kg of CLRE)	58.00±8.05[a]	2.00±1.00[a]	1.33±0.33*	38.33±11.32[a]	11.03±2.19 [a]	987.33±192.28[a]
Group F (100mg/kg of KBrO3 + 1500mg/kg of CLRE)	61.33±5.36[a]	2.33±0.33[a]	2.00±0.57*	33.33±4.91[a]	12.57±2.24 [a]	1004.67±112.99[a]

Data was analysed using ANOVA followed by Post-hoc LSD comparison and values were considered significant at $p \leq 0.05$. $p<0.05^{*}$ and $p>0.05$ [a]. CLRE: *Citrullus lanatus* rind extract; SEM: standard error of mean.

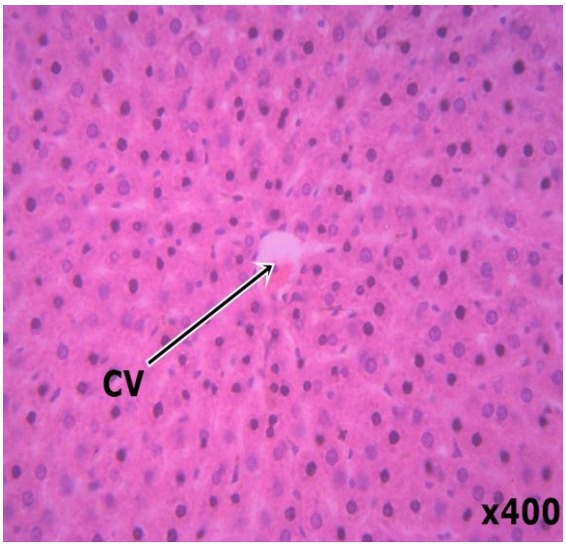

Plate I: Photomicrograph of liver control group (H&E). Photomicrographs show well preserved liver architecture. The portal triads are evenly spaced around a central vein and there is no portal inflammation. CV-Central vein

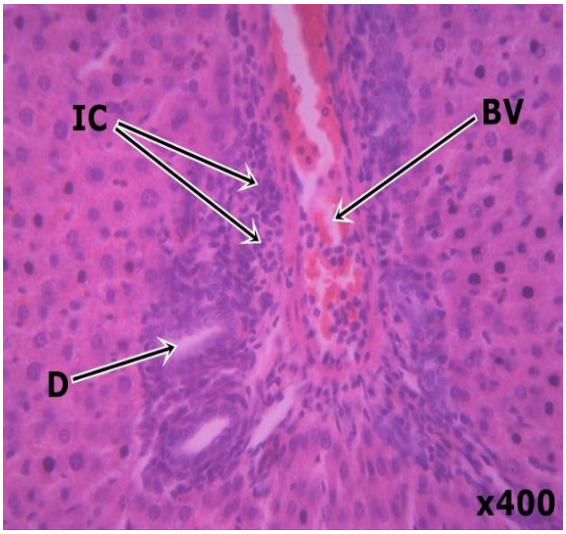

Plate II: Photomicrograph of liver Group B (KBrO3 Only) (H&E). It shows severe portal inflammation without interface, lobular hepatitis, fibrosis or steatosis. D= Hepatic ductile; BV= Blood vessel; IC-=inflammatory cells.

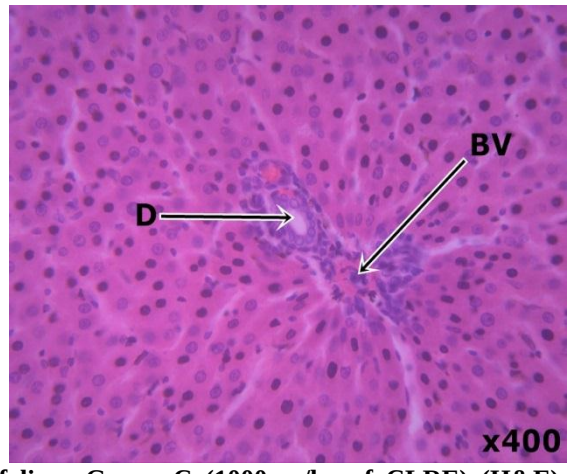

Plate III: Photomicrograph of liver Group C (1000mg/kg of CLRE) (H&E). It shows well preserved liver architecture. The portal triads are evenly spaced around a central vein and there is no portal inflammation. CV= Central vein inflammation. CV-Central vein.

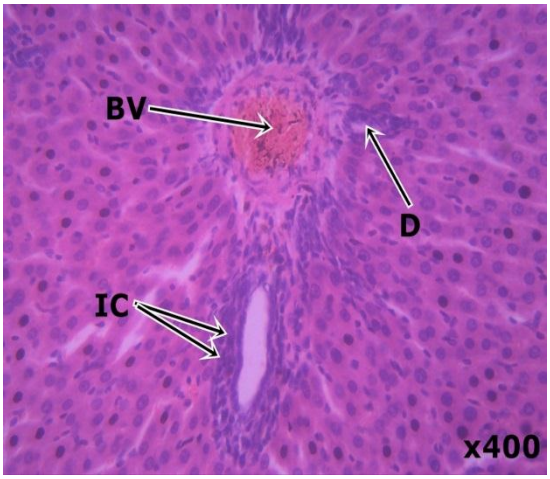

Plate IV: Photomicrograph of liver Group D (100mg/kg of KBrO3 + 500mg/kg of CLRE) (H&E). The portal triads are evenly spaced around a central vein and there is mild portal inflammation without interface, lobular hepatitis, fibrosis or steatosis. D= Hepatic ductile; BV= Blood vessel; IC-=inflammatory cells.

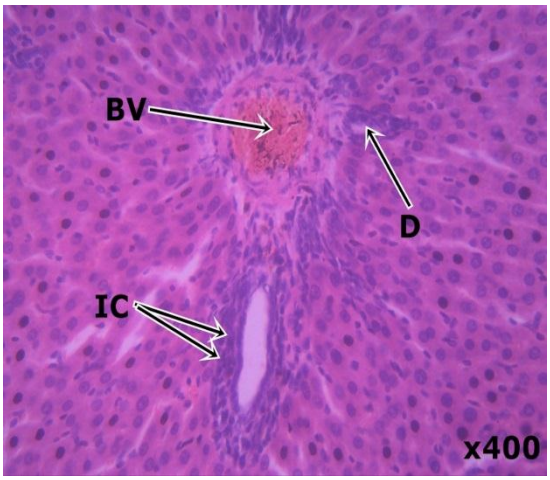

Plate V: Photomicrograph of Group E (100mg/kg of KBrO3 + 1000mg/kg of CLRE) (H&E). The portal triads are evenly spaced around a central vein and there is mild portal inflammation without interface, lobular hepatitis, fibrosis or steatosis. D= Hepatic ductile; BV= Blood vessel; IC-=inflammatory cells.

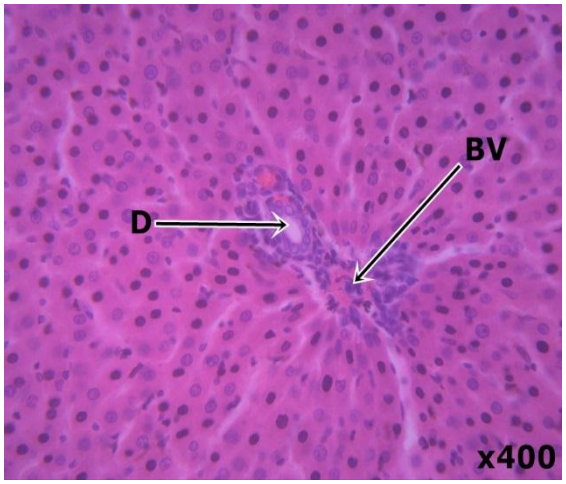

Plate VI: Photomicrograph of liver Group F (100mg/kg of KBrO3 + 1500mg/kg of CLRE) (H&E). The portal triads are evenly spaced around a central vein and there is moderate portal inflammation without interface, lobular hepatitis, fibrosis or steatosis. D= Hepatic ductile; BV= Blood vessel

DISCUSSION

The effects of *Citrullus lanatus* rind extract against potassium bromate induced toxicity on adult Wistar rats was investigated in this study. Its effects (*Citrullus lanatus* rind) on the body and organ weight, liver function test, haematological parameters and histoarchitecture of the liver were evaluated and noted in both controls and treatment groups.

In this study, the significant increase ($p<0.05$) in the body weight in both groups A and C are primarily because the animals are within the growth stage at the beginning of the study as they weigh between 100-130g and the phytoconstituents available in *Citrullus lanatus* rind extract (CLRE) are of beneficial effect as it concerns group C. The non-significant increase ($p>0.05$) in weight in groups B, D, E and F are as a result of the toxic effects of potassium bromate administered despite the animals being within the growth range. It is in line with the assertions of WHO which states that at higher doses of $KBrO_3$, rat growth becomes retarded and the weight significantly reduced. This was probably due to the binding of $KBrO_3$ to the iodine receptors, minimizing iodine uptake by thyroid gland and causing iodine insufficiency leading to growth retardation.[9]

There was an increase in the relative liver weight in group B treated with $KBrO_3$ only when compared to the control (group A). This could be as a result of inflammation, fibrosis or hypertrophy of cells within the organs to compensate for the damaged ones. However, there was a significant decrease ($p<0.05$) in the relative liver weight in groups E and D compared to group B and this is as a result of the therapeutic and antioxidant effect of *Citrullus lanatus* rind extract which has been found to contain flavonoids, alkaloids, phenols and citrulline.[10]

Liver function test of serum aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP) have been used extensively in the evaluation of liver damage due to the release of large quantities of these enzymes into the bloodstream in the advent of hepatotoxicity.[11] This study observed a significant increase ($P < 0.05$) in the activities of these selected liver enzymes when the rats were treated with KBrO3 only in group B compared to group A. This agrees with the works done by Osman *et al*., and Oloyede and Sunmonu, which all showed a significant increase in ALP, ALT and AST activity levels indicating adverse effect on the livers of rats administered potassium bromate.[12,13] This may be attributed to the hepatocellular damage induced by superoxide anions, hydrogen peroxide and hydroxyl radicals, which are all free radicals/oxygen species generated by the toxicity of KBrO3 and causes oxidative stress to the cell membrane resulting in increases in liver enzyme activity. However, administration of varying doses of CLRE as in groups D, E and F protected against KBrO3-induced liver injury. This protective effect is clearly evident from the significant decrease ($p<0.05$) in the elevated marker enzymes AST, ALT and ALP compared to group B and in a dose depended manner. A possible mechanism by which CLRE could exhibit protection against KBrO3-induced hepatotoxicity may be due to the presence of active phytochemicals like polyphenols, flavonoids and terpenoids which have been shown to have great radical scavenging and ameliorative properties.[14]

As observed from the result of this study, there was a non-significant decrease in white blood cell (WBC) count in group B when compared to group A. The decreased in WBC count was in accordance with the work of Thompson and Westfall, who reported a decrease in leucocyte count from 15,500/mm3 to 9,600/mm3 in a two and a half year old boy in a period of two months after swallowing a half glass of neutralizer containing KBrO3.[15] It is also in line with the findings of Mohamed and Saddek and Shehab and Ghadhban.[16,17] The reduction in WBC count could be due to the DNA strand breakage in these cells induced by the oxidative stress associated with KBrO3.[15,18] However, there was a non-significant increase ($p>0.05$) in the WBC counts in groups D, E and F and this could be as a result of the strong antioxidant properties of CLRE which scavenge and eliminate free radicals thereby limiting the toxic effects of KBrO3 on the cells.

The non-significant decrease in red blood cell (RBC), packed cell volume (PCV) and haemoglobin (HB) levels in group B compared to group A are in line with the findings of Mohamed and Saddek and Dhembare and Dale and this may be as a result of oxidative stress, DNA breakage, and damage to the bone marrow and hematopoietic organs occasioned by KBrO3 toxicity.[16,19] Oxidative stress plays a significant role in the damaging of RBCs membrane and contributes to their removal from circulation by macrophages.[20] However, administration of CLRE as in groups D, E and F ameliorated these parameters in a dose-dependent and insignificant manner when compared to group B as a result of the active phytochemicals present in it such as flavonoids and phenols.

Results of histopathological examinations revealed normal histoarchitecture of the rat liver in groups A and C with each section showing hepatic lobule with central vein surrounded by hepatocytes arranged in radially oriented interconnecting cords and separated by normal sized hepatic sinusoids. This is because no toxicity was induced in the groups. This is in contrast to group B histoarchitecture which shows severe portal inflammation and infiltration as a result of $KBrO_3$ toxicity. This concurs with the findings of Dimkpa *et al*., and Enemali *et al*., who noted marked dilated centro-lobular blood sinusoid, degeneration at the periphery of the lobules and congestion of the portal vein with inflammatory cells infiltration at the portal area in KBrO3 induced hepatotoxicity.[21,22] However, administration of varying doses of CLRE led to a marked reduction in the histoarchitectural changes in a dose

dependent manner which is in line with the results of the liver function test as the enzyme biomarkers where seen to be reduced upon administration of CLRE which is rich in flavonoids and phenols.

CONCLUSION

The results of this study taken together revealed that potassium bromate possesses numerous deleterious effects on body and organ weight, histoarchitecture and biochemical composition of the liver and on haematological parameters. However, administration of water melon rind extract was able to salvage the toxicity and damages created by potassium bromate by restoring to normalcy the levels of enzyme biomarkers of liver, ameliorating histopathological changes in the liver and scavenging free radicals and reactive oxygen species which destroys and reduces haematological parameter due to the antioxidants present in the extract.

REFERENCES

1. Emeje MO, Ifiora BI, Ezenyi CJ, Ofuefule SI (2015). Assessment of bread safety in Nigeria: one decade after the ban on the use of potassium bromate, Journal of food processing Technology, 16: 400.
2. Farombi EO, Alabi MC, Akuru TO, (2002). Kolaviron modulates cellular redox status and impairment of membrane protein activities induced by potassium bromate KBr O3 in rats. *Pharmacological Research*, 45: 63-8.
3. Kujawska M, Ignatowicz E, Ewertowska M, Adamska T, Markowski J, Jodynis-Liebert J, (2013). Attenuation of KBr O3-induced renal and hepatic toxicity by cloudy apple juice in rat. *Phytotherapy Research*, 27: 1214–1219.
4. Ahmad MK, Khan AA, Ali SN, Mahmood R, (2015). Chemoprotective effect of taurine on potassium bromate-induced DNA damage, DNA-protein cross-linking and oxidative stress in rat intestine. *PLoS One*. doi: 10.1371/journal.pone.0119137.
5. NAFDAC (2003): Consumer Safety Bulletin Volume2 No. ISSN:1576-3594.
6. Erhirhie EO, Ekene NE (2013). Medicinal values of Citrullus lanatus (Watermelon): Pharmacological Review. *International Journal of Research in Pharmacy and Biological Sciences*, 4(4): 1305-1312.
7. Egbuonu ACC, (2015). Comparative investigation of the proximate and functional properties of watermelon (Citrullus lanatus) rind and seed. *Research Journal of Environmental Toxicology.*
8. Gill N, Bansal R, Garg M, Sood S, Muthuraman A, Bali M, (2010). Evaluation of antioxidant, anti-inflammatory and analgesic potential of Citrullus lanatus seed extract in rodent model. *Internet Journal of Nutrition and Wellness*, 9(2): 1-7.
9. WHO (2007). *Evaluation of certain food additives and contaminants*. Geneva: WHO Press.
10. Nwankwo IU, Onwuakor CE, Nwosu VC, (2014). Phytochemical Analysis and Antibacterial Activities of *Citrullus Lanatus* Seed against some Pathogenic Micro-organisms. *Global Journal of Medical Research*, 14(4): 0975-5888.
11. Jaffar SK, Khasim SM, Prasad MSK, (2020). Protective Effect of *Mimusops elengi L*. on Renal and Hepatic Markers in STZ Induced Diabetic Rats. In: Khasim SM, Long C, Thammasiri, Lutken H. (eds). *Medicinal Plants: Biodiversity, Sustainable Utilization and Conservation*: 509-520.
12. Osman AS, Abu-Risha SE, Bakr SM, EL-Sawi MR, and EL-Kholy WM, (2021). Possible Therapeutic Role of *Ginkgo biloba* Loaded on Gold Nanoparticles against Potassium Bromate-Induced Hepatotoxicity in Rats. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 12(3): 99-118.
13. Oloyede OB and Sunmonu TO, (2009). Potassium bromate content of selected bread samples in Ilorin, Central Nigeria and its effect on some enzymes of rat liver and kidney. *Food and Chemical Toxicology*, 47: 2067-2070.
14. Ogadimma I, Nwafor AC and Samuel B, (2019). Hepatoprotective tendency of Citrullus lanatus rind methanolic extract on liver markers in male Wistar rats. *Asian Journal of Advanced Research and Reports*, 4(1): 1-10.
15. Thompson HC and Westfall SW (1949). Potassium bromate poisoning. Report of a case due to ingestion of a cold wave neutralizer. *Journal of Paediatrics*, 34: 362-364.
16. Mohamed EAK, Saddek EA, (2019). The protective effect of taurine and/or vanillin against renal, testicular and haematological alterations induced by potassium bromate toxicity in rats. *The Journal of Basic and Applied Zoology*, 80(3): 1-11.
17. Shehab ZA and Ghadhban RF, (2021). Effect of Potassium Bromate on Some Hematological and Biochemical Parameters and Protective Role of Vitamin C on Laboratory Rats (*Rattus_Rattus*). *Annals of Romanian Society of Cell Biology*, 25(2): 669 – 674.
18. Parsons JL, Chipman JK, (2000). The role of glutathione in DNA damage by potassium bromate in vitro. *Mutagenesis*, 15: 311–316.
19. Dhembare AJ and Dale PG, (2017). Potassium bromate induced a haematological alteration in European rabbit. *The Journal of Zoology Studies*, 4: 01-05.
20. Mohanty JG, Nagababu E, Rifkind JM, (2014). Red blood cell oxidative stress impairs oxygen delivery and induces red blood cell aging. *Frontiers in Physiology*, 28(5): 84.
21. Dimkpa U, Ukoha U, Anyabolu E, Uchefuna R, Anikeh L, Oji O, Besong E and Emenjo O (2013). Hepatotoxic Effects of Potassium Bromate on Adult Wistar Rats. *Journal of Biology, Agriculture and Healthcare*, 3: 111– 115.

22. Enemali MO, Asogwa ME, Nweze CC, Haruna GS, Ijeomah AU, (2020). Evaluation of the protective effect of Citrullus lanatus (water melon) fruit-parts extract on the liver of Acetaminophen-intoxicated albino rats. *Open Access Library Journal*, 7: e6807.