

**Effect of Ethanol Extract of *Amaranthus Viridis* (Inine) on Potassium-Bromide-Induced Haematotoxicity in Wistar Rats**

Innocent I. Ujah¹, Godwin S. Alor², Cosmas E. Achikanu¹, Onuabuchi N. Ani¹, Chukwunonso A. Nsude¹, Uchenna B. Alozieuwa³, Jane I. Ugochukwu⁴, Ebere I. Akpata¹, Justice C. Ude¹, Kenekchukwu C. Onyishi⁵, Innocent O. Okpako⁶, Chukwuemeka O. kechukwu⁷, Obiora E. Nneji¹, Chikezie K. Ogbu¹, Chinenye A. Anieke¹ and Onyebuchi P. Ogbodo¹

¹Department of Applied Biochemistry, Faculty of Biological Sciences, Enugu State University of Science & Technology, Enugu State, Nigeria.

²Department of Biochemistry, College of Natural Sciences, Michael Okpara University of Agriculture Umudike, Nigeria.

³Department of Biochemistry, Faculty of Natural & Applied Sciences, Veritas University Abuja, Nigeria.

⁴Department of Pharmaceutical Microbiology and Biotechnology, Faculty of Pharmaceutical Sciences, Enugu State University of Science and Technology, Enugu State, Nigeria.

⁵Department of Pharmacognosy, Faculty of Pharmaceutical Sciences, Enugu State University of Science and Technology, Enugu State, Nigeria.

⁶Department of Molecular Biology and Biotechnology, Pan African University Institute for Basic Sciences, Technology and Innovation, Nairobi, Kenya.

⁷Department of Food Science and Technology, Enugu State University of Science & Technology, Enugu State, Nigeria

ARTICLE INFO**Article history:**

Received 23 December 2024

Revised 31 December 2024

Accepted 04 January 2025

Published online 01 April 2025

ABSTRACT

Potassium Bromate (KBrO₃) is an oxidative agent capable of causing hematological alterations and other toxic effects. *Amaranthus Viridis* (Inine) is a medicinal plant traditionally used for various therapeutic purposes. This study investigated the ameliorative effect of ethanol extract of *Amaranthus viridis* (Inine) on the haematological parameters in potassium bromate (KBrO₃) intoxicated Albino Rats. Thirty (30) rats divided into six (6) groups consisting of five rats each, group one as the normal control, group two as the negative control (50 mg/kg of KBrO₃ only), group three Vitamin C (100 mg/kg) + 50 mg/kg of KBrO₃ and group four to six (200 mg/kg, 400 mg/kg, and 800 mg/kg) respectively. KBrO₃ exposure significantly altered some haematological indices in the rats indicating a haematotoxic effects. The results showed a dose-dependent improvement in several haematological parameters upon coadministration of *Amaranthus viridis* occurred. The red blood cell count (RBC), packed cell volume (PCV), haemoglobin concentration (Hb), and white blood cell count (WBC) exhibited notable recovery in comparison to the KBrO₃-treated group. Platelet count (PLT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) also demonstrated positive alterations in response to the extract. The group receiving the highest dose of the leaf extract (800 mg/kg) alongside KBrO₃ displayed the most significant improvement in the aforementioned parameters, indicating a potential dose-dependent protective effect against KBrO₃-induced haematotoxicity. These findings suggest the potential therapeutic efficacy of *Amaranthus viridis* extract in mitigating KBrO₃-induced hematological alterations.

Keywords: Ethanol Extract, *Amaranthus viridis*, Potassium Bromate (KBrO₃), Haematological Parameters, Albino Rats.

Copyright: © 2025 Ujah *et al.* This is an open-access article distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

Potassium bromate (KBrO₃) is a potent oxidizing agent used in various industries, particularly in bread-making processes, despite its well-documented adverse health effects¹. Its exposure has been linked to renal damage, gastrointestinal disturbances, haematological alterations characterized by disruptions in red blood cell (RBC), white blood cell (WBC), and platelet counts along with changes in hemoglobin levels, haematocrit, and other crucial indices². Such haematotoxic effects have prompted the exploration of potential interventions to mitigate KBrO₃-induced damage.

*Corresponding author. Email: Justice C. Ude, j.chinecherem@yahoo.com
Tel: +2347014217837

Citation: Ujah II, Alor GS, Achikanu CE, Ani ON, Nsude CA, Alozieuwa UB, Ugochukwu JI, Akpata EI, Ude JC, Onyishi KC, Okpako IO, Okechukwu CO, Nneji OE, Ogbu CK, Anieke CA, Ogbodo OP. Effect of Ethanol Extract of *Amaranthus Viridis* (Inine) on Potassium-Bromide-Induced Haematotoxicity in Wistar Rats. Trop J Nat Prod Res. 2025; 9(3): 1274 - 1279 <https://doi.org/10.26538/tjnpr/v9i3.52>

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria

Amaranthus viridis, commonly known as "Inine" or slender amaranth, has gained attention due to its rich phytochemical composition, including flavonoids, polyphenols, and vitamins^{3,4}. The medicinal properties of amaranthus species have been extensively studied, these properties are antioxidant, anti-inflammatory, and cytoprotective attributes³. Ethnopharmacological studies have reported the traditional use of *Amaranthus viridis* in treating various ailments, suggesting its potential therapeutic value in addressing health issues^{5,6}. Haematological parameters serve as crucial indicators of an organism's physiological state, reflecting alterations in response to xenobiotic exposure, including toxic substances like KBrO₃^{7,8}. While numerous studies have delved into the toxicological effects of KBrO₃, limited research has investigated potential interventions, such as herbal extracts, to reverse its haematotoxic effects. Previous research has highlighted the antioxidant and cytoprotective properties of various plant extracts in mitigating chemical-induced toxicities^{9,10}. Thus, exploring the potential ameliorative effects of *Amaranthus viridis* extract on haematological parameters affected by KBrO₃ toxicity holds promise for developing novel therapeutic strategies. Several studies have underscored the importance of phytochemical compounds in combating oxidative stress and cellular damage induced by toxic agents¹¹. The specific constituents within *Amaranthus viridis* extract, such as flavonoids and polyphenols, may exert protective effects through scavenging free radicals, modulating oxidative pathways, and

enhancing endogenous antioxidant defenses^{12,13}. Through *in vivo* experiments, this research seeks to assess the protective potential of *Amaranthus viridis* extract against KBrO₃-induced haematotoxicity, focusing on key haematological indices including RBC count, PCV, Hb concentration, WBC count, platelet count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). In this context, this study will contribute to the existing knowledge by elucidating the potential protective role of *Amaranthus Viridis* extract against KBrO₃-induced hematotoxicity, paving the way for future investigations into its underlying mechanisms and potential clinical applications. .

Materials and Methods

Sample Collection and Preparation of Plant Material

Fresh stems of *Amaranthus viridis* (green leaf) were collected from Umudike in Ikwoano Local Government Area of Abia State on the 8th of May 2024 and were authenticated at the Department of Forestry, College of Natural Resources and Environmental Management, Michael Okpara University of Agriculture, Umudike. The collected stems were chopped into smaller particles and air dried under shade on a laboratory bench over a period of 48 days before being pulverized into powder using a blender. The crude extract was prepared from the powdered material. The cold maceration technique was adopted in the preparation of plant extract. A quantity, 500 g of the powdered material was macerated in 2 litres of ethanol for 48 hours and was thereafter filtered with a Whatman filter paper. The filtrate was then concentrated to dryness in a laboratory oven at low temperature (40 °C) to obtain a dark green pasty extract which weighed (26.89 g) and represented a 5.38% extract yield. The process was repeated until sufficient quantity of extract for the entire study was obtained.

Percentage yields in both cases were calculated using the formula:

$$\% \text{ yield} = \frac{Q}{W} \times \frac{100}{1}$$

Where Q is weight of extract obtained after extraction and W is weight of pulverized plant material macerated in methanol. The extract was preserved in the refrigerator at low temperature until use.

Acute toxicity studies

For the acute toxicity evaluation of both the crude extract and potassium bromate, the new¹⁴ method used by¹⁵ was adopted with modifications.

Acute toxicity evaluation of potassium bromate

Two stages were involved in the test. In the first stage, 9 Wistar rats were assigned to 3 groups (A, B and C) of 3 rats each were administered 10, 100 and 200 mg/kg of the extract respectively. The animals were thereafter monitored for the manifestations of toxicity signs and deaths within 24 hours. With zero mortality recorded, the study proceeded to the second phase which also involved the use of 9 rats assigned to 3 groups (A-C). Single oral treatment doses assigned to the groups were 400, 600 and 800 mg/kg respectively. The animals were again monitored for toxicity signs and deaths within 24 hours.

Acute toxicity value for the test agent was then calculated from the number of deaths recorded across the groups using Lorke's formula stated as:

$$LD50 = \sqrt{(A \times B)}$$

A= Maximum dose that produced no mortality

B= Minimum dose that killed all animals in a group

Acute toxicity evaluation of green leaf extract

In this case three stages of tests were involved. In the first stage, 9 Wistar rats assigned to 3 groups (A, B and C) of 3 rats each were administered 10, 100 and 1000 mg/kg of the extract respectively. The animals were thereafter monitored for the manifestations of toxicity signs and deaths within 24 hours. With zero mortality recorded, the study proceeded to the second phase which also involved the use of 9 rats assigned to 3 groups (A-C). Single oral treatment doses assigned to the groups were 1600, 2900 and 5000 mg/kg respectively. The animals were again monitored for toxicity signs and deaths within 24 hours. When no mortality was still observed, the highest dose (5000 mg/kg)

used was repeated on another set of 3 rats during the confirmatory test stage and were monitored for mortalities within 24 hours and a further 7 days.

Acute toxicity value for the test agent was then calculated from the number of deaths recorded across the groups using Lorke's formula stated as:

$$LD50 = \sqrt{(A \times B)}$$

A= Maximum dose that produced no mortality

B= Minimum dose that killed all animals in a group

Experimental design for the evaluation of the effect of the crude extract of green leaf on potassium bromate induced toxicity in rats

Thirty (30) adult male Wistar rats assigned to 6 groups of 5 rats each were treated according to the order below:

Group 1: Normal control

Group 2: Negative control (50 mg/kg of KBrO₃ only)

Group 3: Green leaf extract (200 mg/kg) + 50 mg/kg of KBrO₃

Group 4: Green leaf extract (400 mg/kg) + 50 mg/kg of KBrO₃

Group 5: Green leaf extract (800 mg/kg) + 50 mg/kg of KBrO₃

Group 6: Vitamin C (100 mg/kg) + 50 mg/kg of KBrO₃

All treatments were via the oral route and lasted for 14 days. Body weights were taken at the beginning and at the end of the treatment (days 1 and 14) using an electronic balance (DJ-A1000, China). At the end of the period, animals were sacrificed and blood and tissue samples were collected for the various haematological and biochemical analysis carried out.

Determination of haematological parameters

Haematological analysis of the blood samples was performed in an automated haematology analyzer (BC-2300 model, Mindray Medical Co., China) with the procedure carried as specified by the producer. The parameters which were evaluated included: red blood cells count (RBC), haemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV); mean corpuscular haemoglobin (MCH); mean corpuscular haemoglobin concentration (MCHC); platelets (PLT); (WBC) counts were obtained at once for each blood sample.

Principles of Haematological Analyzer

The haematological parameters were determined using the automated haematology analyzer according to the methods by¹⁶, modified by^{17,18} following the procedure outlined by the producer;

Procedure

To analyze a whole blood sample, the sample was presented to the diluent dispenser and the diluent key was pressed to aspirate 20μL of the sample into the dispenser. A diluted sample (about 1:300) was dispensed when the diluent key was pressed again. The sample was thoroughly mixed and presented under the suction nozzle, then the count key was pressed to aspirate into the analyzer for analysis and the result was displayed on the screen after few seconds.

Statistical analysis

Statistical Package for Social Sciences (SPSS, Version 20.0, IBM SPSS Inc, Chicago, IL) was used for data analysis. Level of significance was calculated by One Way Analysis of Variance (ANOVA). Data were analyzed using Duncan Multiple Range Test and complemented with Student's t test for post-hoc test for comparisons of the means of the various doses and fractions. All data were expressed as mean ± standard deviation. P ≤ 0.05 values or less were considered to indicate statistically significant difference between the test and control groups as well as among test groups for measured value.

Results and Discussion

Acute toxicity evaluation of the extract

No mortality was recorded in any group at all stages of the acute toxicity test, even at 5000 mg/kg. All animals instead retained their physical activities and showed no signs of toxicity (Tables 1A & 1B). The results of the phase 1 acute toxicity for potassium bromate showed there was no acute toxicity or mortality in animals at doses up to 200 mg/kg (Table 2A). For the phase 2 acute toxicity of potassium bromate, there was toxicity in

the animals at doses above 260 mg/kg, with a lethal dose (LD₁₀₀) of 600 mg/kg (Table 2B). Hence, the conclusion that acute toxicity value was greater than 5000 mg/kg in accordance with established international protocols for acute toxicity testing.

Table 1A: Phase 1 Acute Toxicity Evaluation of the Extract

Group	Dose (mg/kg)	No. of death	Observation
1	10	0/3	Animals were active and physically balanced
2	100	0/3	Animals were active and physically balanced
3	1000	0/3	Animals were active and physically balanced

Table 1B: Phase 2 Acute Toxicity Evaluation of the Extract

Group	Dose (mg/kg)	No. of death	Observation
1	1600	0/3	Animals were active and physically balanced
2	2900	0/3	Animals were active and physically balanced
3	5000	0/3	Animals were calm and physically inactive for a moment but soon regained physical activity.

Conclusion

LD₅₀ > 5000 mg/kg extract may be safe for oral use.

Acute toxicity evaluation of potassium bromate

The acute toxicity evaluation of Potassium Bromate was conducted in two phases. In Phase 1, doses of 10, 100, and 200 mg/kg were administered, resulting in no deaths and normal physical activity in the animals. However, in Phase 2, higher doses of 260, 400, and 600 mg/kg were given, leading to increased mortality rates, with 1/3, 2/3, and 3/3 of the animals dying, respectively. As the dose increased, the animals became progressively calm, physically inactive, and eventually deceased.

Table 2a: Phase 1 Acute Toxicity Evaluation of Potassium Bromate

Group	Dose (mg/kg)	No. of death	Observation
1	10	0/3	Animals were active and physically balanced
2	100	0/3	Animals were active and physically balanced
3	200	0/3	Animals were active and physically balanced

Effects of the Extract On Haematological Parameters in Potassium Bromate Treated Rats

The effects of *Amaranthus* leaf extract on haematological parameters in potassium bromate-treated rats were investigated and shown in table 3. The results showed that potassium bromate (100 mg/kg) significantly altered haematological parameters, including reduced RBC, PCV, Hb, WBC, and PLT counts. However, co-administration of vitamin C (100 mg/kg) or *Amaranthus* leaf extract (200-800 mg/kg) with potassium bromate (50 mg/kg) mitigated these alterations, with the extract showing a dose-dependent protective effect. The highest dose of *Amaranthus* leaf extract (800 mg/kg) almost restored the haematological parameters to normal levels, indicating its potential to counteract the haematotoxic effects of potassium bromate.

Table 2b: Phase 2 Acute Toxicity Evaluation of Potassium Bromate

Group	Dose (mg/kg)	No. of death	Observation
1	260	1/3	Animals were calm and physically inactive for a moment but soon regained physical activity.
2	400	2/3	Animals were calm and physically inactive
3	600	3/3	Animals were inactive/deceased.

Acute toxicity values calculated using Lorke's formula stated as:

$$LD_{50} = \sqrt{A \times B}$$

A= Maximum dose that produced no mortality

B= Minimum dose that killed all animals in a group

$$LD_{50} = \sqrt{200 \times 600}$$

$$= 346.41 \text{ mg/kg body weight}$$

The data presented in Table 3 illustrated the effect of different treatments, particularly *Amaranthus viridis* extract in varying doses, on several crucial haematological parameters in rats subjected to potassium bromate (KBrO₃) toxicity. This comprehensive analysis provides insights into the potential protective role of *Amaranthus Viridis* extract against KBrO₃-induced hematotoxicity, shedding light reversal of KBrO₃-induced reductions in red blood cell (RBC) count, packed cell volume (PCV), haemoglobin (Hb) concentration, white blood cell (WBC) count, platelet count (PLT), mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC)^{19,20}. However, the administration of *Amaranthus viridis* extract showed a dose-dependent restoration of RBC counts towards normal control levels, suggesting its protective effect against KBrO₃-induced anaemic effect²¹. Studies have shown that antioxidant-rich plant extracts can mitigate haematotoxic effects. Previous research highlighted that flavonoids in plant extracts protected against oxidative damage to blood cells²². Similar protective effects of plant extracts on haematological parameters have been observed²³. PCV is significantly reduced by KBrO₃ exposure, indicating anaemia or reduced erythropoiesis²⁴. *Amaranthus viridis* extract restored PCV, demonstrating its potential in protecting against anemia induced by oxidative stress²⁵. Similar protective effects on PCV have been reported by other researchers. For instance,²⁶ noted that plant-derived antioxidants help maintain haematocrit levels under oxidative stress conditions. KBrO₃ significantly reduces Hb concentration, indicating impaired oxygen transport capacity. *Amaranthus viridis* extract showed a dose-dependent increase in Hb levels, suggesting its role in enhancing erythropoiesis and haemoglobin synthesis. Protective effects on Hb levels have been reported by²⁷, who demonstrated that plant extracts with antioxidant properties can improve haemoglobin concentrations in

oxidative stress models. KBrO₃ exposure causes a slight decrease in WBC count, possibly indicating an impaired immune response^[28].

Amaranthus viridis extract normalize WBC counts, indicating its potential immunomodulatory effects.

Table 3: Effects of the Extract on Haematological Parameters in Potassium Bromate Treated Rats

Treatment	RBC ($\times 10^6/\text{mm}^3$)	PCV (%)	Hb (g/dl)	WBC ($\times 10^3/\text{m}^3$)	PLT ($\times 10^3/\text{mm}^3$)	MCV (fl)	MCH (pg)	MCHC (g/dl)
Control	7.17 \pm 0.17 ^f	45.00 \pm 1.00 ^e	15.60 \pm 0.53 ^e	8.57 \pm 0.28 ^b	248.33 \pm 7.51 ^c	62.76 \pm 0.38 ^a	21.75 \pm 0.23 ^a	34.66 \pm 0.52 ^b
KBrO₃ (100 mg/kg)	4.18 \pm 0.16 ^a	29.00 \pm 1.73 ^a	9.53 \pm 0.25 ^a	7.93 \pm 0.20 ^a	228.67 \pm 2.52 ^a	69.35 \pm 2.31 ^d	22.81 \pm 0.29 ^b	32.93 \pm 1.41 ^a
Vit. C (100 mg/kg) + KBrO₃ (50 mg/kg)	4.91 \pm 0.04 ^b	32.33 \pm 0.58 ^b	10.93 \pm 0.25 ^a	8.06 \pm 0.50 ^{ab}	239.00 \pm 4.58 ^{abc}	65.85 \pm 0.76 ^{bc}	22.27 \pm 0.43 ^{ab}	33.81 \pm 0.33 ^{ab}
<i>Amaranthus</i> leaf extract (200 mg/kg) + KBrO₃ (50 mg/kg)	5.72 \pm 0.20 ^c	38.33 \pm 1.55 ^c	12.83 \pm 0.45 ^c	8.17 \pm 0.08 ^{ab}	240.00 \pm 4.58 ^{bc}	66.99 \pm 0.33 ^c	22.43 \pm 0.41 ^{ab}	33.48 \pm 0.64 ^{ab}
<i>Amaranthus</i> leaf extract (400 mg/kg) + KBrO₃ (50 mg/kg)	6.25 \pm 0.12 ^d	41.67 \pm 0.58 ^d	13.93 \pm 0.35 ^d	8.26 \pm 0.19 ^{ab}	234.67 \pm 8.33 ^{ab}	66.64 \pm 0.75 ^c	22.28 \pm 0.13 ^{ab}	33.44 \pm 0.53 ^{ab}
<i>Amaranthus</i> leaf extract (800 mg/kg) + KBrO₃ (50 mg/kg)	6.76 \pm 0.28 ^e	43.33 \pm 0.58 ^{de}	14.57 \pm 0.32 ^d	8.51 \pm 0.29 ^b	238.67 \pm 4.51 ^{abc}	64.12 \pm 1.98 ^a	21.56 \pm 1.10 ^a	33.62 \pm 0.72 ^{ab}

Values are presented as mean \pm standard deviation of replicated determination (n = 3). Means in the same column bearing different letter superscripts are statistically significantly different.

Similar findings where plant extracts with anti-inflammatory properties normalized WBC counts in inflammatory models have been reported²⁹. KBrO₃ significantly reduces PLT count, which may impair blood coagulation. The extract significantly normalized PLT counts, indicating its possible role in maintaining haemostasis. Similar results were found by ³⁰, who reported that plant extracts could improve platelet counts and functionality in models of induced thrombocytopenia. KBrO₃ increases MCV, suggesting the presence of macrocytic anaemia. The extract shows a trend towards reducing MCV, indicating its potential in normalizing red blood cell size. Similar trends were observed by ³¹, who found that antioxidant compounds could mitigate increases in MCV associated with oxidative stress. KBrO₃ slightly increased MCH, suggesting changes in haemoglobin content per cell. The extract normalized MCH values, indicating its role in maintaining haemoglobin synthesis and incorporation³². Dietary bioactive compounds could normalize MCH levels under stress conditions, supporting these findings. KBrO₃ significantly reduced MCHC, suggesting hypochromic anaemia³³. The extract shows a trend towards normalizing MCHC, indicating its role in ensuring adequate haemoglobin content in red blood cells. Plant extracts with high antioxidant activity have been shown to normalize MCHC levels in oxidative stress models, aligning with these results³⁴.

Conclusion

The study demonstrates that ethanol extract of *Amaranthus viridis* significantly ameliorates haematological disturbances caused by potassium bromate intoxication in albino rats. This protective effect is evidenced by the restoration of RBC count, PCV, Hb levels, WBC count, PLT count, MCV, MCH, and MCHC towards normal values, highlighting its potential as a therapeutic agent against KBrO₃-induced haematotoxicity.

Conflict of Interest

The authors declare no conflict of interest.

Author's Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgement

The authors would like to extend their gratitude to Department of Applied Biochemistry and Enugu State University of Science and Technology for their support and contributions to this research. We would also like to thank our colleagues and peers who reviewed and provided feedback on this manuscript.

References

- Shanmugavel V, Santhi KK, Kurup AH, Kalakandan S, Anandharaj A, Rawson A. Potassium bromate: Effects on bread components, health, environment and method of analysis: A review. *Food Chem.* 2020;311:125964. doi: 10.1016/j.foodchem.2019.125964
- Radwan SA, El Wessemy AM, Abdel-Aziz BF, Abdel-Baky ES. Study the protective effect of vitamin E against potassium bromate toxicity on some hematological, renal, and hepatic functions in male rats. *Bull Pharm Sci Assiut Univ.* 2022;45(2):903-913. https://journals.ekb.eg/article_271769_5c2707f8713ac7ab7906b5da4a4ce8cc.pdf
- Abdel-Alim ME, Serag MS, Moussa HR, Elgendy MA, Mohesien MT, Salim NS. Phytochemical screening and antioxidant Potential of *Lotus corniculatus* and *Amaranthus viridis*. *Egypt J Bot.* 2023;63(2):665-681. https://journals.ekb.eg/article_290445_cb808804721c16742187ad86a5e37b51.pdf
- Soriano-García M, Aguirre-Díaz IS. Nutritional functional value and therapeutic utilization of *Amaranth*. In: Nutritional value of *Amaranth*. IntechOpen; 2019.
- Sunday EA, Gift WP, Boobondah WJ. Phytochemistry and antioxidant activity of *Amaranthus viridis* L (Green leaf). *World J Adv Res Rev.* 2021;12(2):306-314. doi: 10.30574/wjarr.2021.12.2.0468
- Attah AF, Fagbemi AA, Olubiye O, Dada-Adegbola H, Oluwadotun A, Elujoba A, Babalola CP. Therapeutic potentials of antiviral plants used in traditional African medicine with COVID-19 in focus: a Nigerian perspective. *Front Pharmacol.* 2021;12:596855.
- Singh NN, Srivastava AK. Haematological parameters as bioindicators of insecticide exposure in teleosts. *Ecotoxicology.* 2010;19(4):838-854. doi: 10.1007/s10646-010-0465-4. <https://link.springer.com/article/10.1007/s10646-010-0465-4>
- Nwachukwu DA, Uchendu IK, Nwafor GO, Ogbonna CC, Kwaor IA, Onyishi JC, et al. The Effects of Flauzifop-p-butyl on Behavioural Changes, Acetylcholinesterase, serum biochemical parameters, and haematological indices in albino rats. *Trop J Nat Prod Res.* 2024;8(10). doi:10.26538/tjnpr/v8i10.25
- Ben Saad H, Nasri I, Elweij A, Krayem N, Jarraya R, Kallel C, Amara IB. A mineral and antioxidant-rich extract from the red marine algae *Alsidium corallinum* exhibits cytoprotective effects against potassium bromate-induced erythrocyte oxidative damages in mice. *Biol Trace Elem Res.* 2014;160(1):85-96. doi: 10.1007/s12011-014-0025-5
- Ogbiko C, Eboka JC, Igbe I, Usman DM. Anti-Ulcer activity of methanol extract of *Plantago rugelii* Decne. (Plantaginaceae). *Trop J Nat Prod Res.* 2017;1(2):84-88. <https://www.tjnpr.org/>
- Engwa GA. Free radicals and the role of plant phytochemicals as antioxidants against oxidative stress-related diseases. *Phytochemicals: source of antioxidants and role in disease prevention. BoD-Books on Dem.* 2018;7:49-74. doi: 10.5772/intechopen.76719
- Park SJ, Sharma A, Lee HJ. A review of recent studies on the antioxidant activities of a third-millennium food: *Amaranthus spp.* *Antioxidants.* 2020;9(12):1236. <https://doi.org/10.3390/antiox9121236>
- Netshimbupfe MH, Berner J, Van Der Kooy F, Oladimeji O, Gouws C. The importance and use of *Amaranthus* for crop diversification in the SADC region. *S Afr J Bot.* 2023;152:192-202. <https://doi.org/10.1016/j.sajb.2022.11.039>
- Lorke D. A new approach to practical acute toxicity testing. *Arch Toxicol.* 1983;54(4):275-287. <https://link.springer.com/article/10.1007/bf01234480>
- Orieke UA, Udegbunam SO, Akunne TC, Okoye FBC, Eze GI. Evaluation of acute and subacute toxicity of methanolic leaf extract of *Cassia alata* in rats. *Toxicol Rep.* 2019;6:830-835.
- Dacie JV, Lewis SM. *Practical Haematology*. 7th ed. London: Churchill Livingstone; 1991.
- Chabra G. Automated hematology analyzers: recent trends and applications. *J Lab Phys.* 2018;10(1):015-016. https://www.thieme-connect.com/products/ejournals/pdf/10.4103/jlp.jlp_124_17.pdf
- Bain BJ, Bates I, Laffan MA. Dacie and Lewis *Practical Haematology*. 11th ed. London: Elsevier Churchill Livingstone; 2012.
- Emmanuel AM, Roger KK, Toussaint DG, Koffi K. Acute and subacute toxicity of the aqueous extract of *Amaranthus viridis* (Amaranthaceae) leaves in rats. *J Phytopharmacol.* 2018;7(4):366-372. https://phytopharmajournal.com/assets/pdf_files/Vol7_Issue4_03.pdf
- Jiménez-Aguilar DM, Grusak MA. Minerals, vitamin C, phenolics, flavonoids and antioxidant activity of *Amaranthus* leafy vegetables. *J Food Compos Anal.* 2017;58:33-39. <https://doi.org/10.1016/j.jfca.2017.01.005>
- Mofunanya AAJ, Ekpien EE, Ikwa EO, Owolabi AT. Impact of Telfairia mosaic virus on medicinal and economic potentials of *Amaranthus viridis* L. *Asian J. Res Bot.* 2021;5(4):15-25. <http://archive.sdpublishers.com/id/eprint/198>
- Kumar A, Pandey AK. Chemistry and biological activities of flavonoids: an overview. *Sci World J.* 2013;162750. doi: 10.1155/2013/162750
- Sayadi MH, Fahoul N, Kharkan J, Khairieh M. Investigating the protective effects of *Elaeagnus angustifolia* fruit extract on hematological parameters and damage of different tissues of male mice exposed to graphene oxide nanoparticles. *Nano Select.* 2023;4(9-10):559-583. doi: 10.1002/nano.202300070
- Ugwu NI, Uche CL, Airaodion AI, Ogbenna AA, Chikezie K, Okite UP, et al. Impact of *Corchorus olitorius* Leaf Extract on Potassium Bromate-Induced Haematological Parameters Derangement in Rats. *Trop J Nat Prod Res.* 2024;8(7). doi:10.26538/tjnpr/v8i7.24
- Maurya NK, Arya P. *Amaranthus* grain nutritional benefits: A review. *J. Pharmacogn Phytochem.* 2018;7(2):2258-2262. <https://www.phytojournal.com/archives?year=2018&vol=7&issue=2&ArticleId=3826&si=false>
- Alam MA, Subhan N, Hossain H. Hydroxycinnamic acid derivatives: a potential class of natural compounds for the management of lipid metabolism and obesity. *Nutr Metab.* 2016;13:27. doi: 10.1186/s12986-016-0080-3
- Akbari B, Baghaei-Yazdi N, Bahmaie M, Mahdavi Abhari F. The role of plant-derived natural antioxidants in reduction of oxidative stress. *BioFactors.* 2022;48(3):611-633. doi: 10.1002/biof.1831
- Miah MA, Mondol PP, Rahman MM, Rahman MH, Mustari A, Begum JA. Effects of Gestational Exposure to Potassium Bromate as Food Additive on Reproductive and Immunological Parameters in Mouse Offspring. *J Sci Technol Res.* 2024;6(1):109-116. <https://doi.org/10.3329/jscitr.v6i1.77382>
- Shakeri F, Soukhtanloo M, Boskabady MH. The effect of hydro-ethanolic extract of *Curcuma longa* rhizome and curcumin on total and differential WBC and serum oxidant, antioxidant biomarkers in rat model of asthma. *Iran J Basic Med Sci.* 2017;20(2):155. doi: 10.22038/ijbms.2017.8241

30. Manasa K, Soumya R, Vani R. Phytochemicals as potential therapeutics for thrombocytopenia. *J Thromb Thrombolysis*. 2016;41(3):436-440. doi: 10.1007/s11239-015-1257-8
31. Ali SH, Obaid QA, Khairi GA. Lemon juice antioxidant activity against oxidative stress. *Baghdad Sci. J.* 2020;17(1 Suppl):0207.
[https://dx.doi.org/10.21123/bsj.2020.17.1\(Suppl.\).0207](https://dx.doi.org/10.21123/bsj.2020.17.1(Suppl.).0207)
32. Gandhi P, Samarth RM, Peter K. Bioactive compounds of amaranth (Genus *Amaranthus*). In: *Bioactive compounds underutilized vegetables legumes*. 2020;1-37.
https://link.springer.com/referenceworkentry/10.1007/978-3-030-44578-2_3-1
33. Islam MJ, Kunzmann A, Henjes J, Slater MJ. Can dietary manipulation mitigate extreme warm stress in fish? The case of European seabass, *Dicentrarchus labrax*. *Aquaculture*. 2021;545:737153. doi: 10.1016/j.aquaculture.2021.737153
34. Kunnaja P, Chansakaow S, Wittayapraparat A, Yusuk P, Sireeratawong S. In vitro antioxidant activity of *Litsea martabanica* root extract and its hepatoprotective effect on chlorpyrifos-induced toxicity in rats. *Molecules*. 2021;26(7):1906. doi: 10.3390/molecules26071906