Science World Journal Vol. 21(No 2) 2026 https://dx.doi.org/10.4314/swj.v21i2.35
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University

EFFECT OF A POLYHERBAL AQUEOUS EXTRACT ON HAEMATOLOGICAL INDICES OF ALLOXAN-INDUCED DIABETIC WISTAR RATS

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ABSTRACT
This study investigated the effect of a polyherbal formulation on haematological parameters in alloxan-induced Wistar rats. Forty Wistar rats were randomly assigned into eight groups (5 rats each) designated: normal control; test control (diabetes induced, untreated); T-100mg, T-200mg, and T-300mg (diabetes induced and treated with 100, 200, and 300 mg/kg of the polyherbal extract respectively); TC-100mg, TC-200mg, and TC-300mg (treatment control groups non-induced, but administered 100, 200, and 300 mg/kg of the polyherbal extract respectively). Diabetes was induced through a single intraperitoneal injection of a freshly prepared alloxan solution. The polyherbal aqueous extract was prepared from a combination of five selected herbs and orally administered for two weeks. Rats were anaesthetised, their blood was collected in EDTA sample bottles, and haematological indices were analysed. Differences in values were considered significant at $p<0.05$. The polyherbal extract improved white blood cell, lymphocyte, and platelet counts, haematocrit, plateletcrit, and haemoglobin concentrations in diabetic rats, especially with T-100mg and T-300mg. Elevated red blood cell counts were observed in all treated groups. The highest granulocyte and mid-sized cells count, and red cell distribution width were recorded in T-300mg. Hence, the polyherbal aqueous extract can help correct haematological abnormalities associated with diabetes.

Keywords: Haematological indices, Anaemia, Diabetes mellitus, Polyherbal formulation, Alloxan.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder typified by persistent hyperglycaemia owing to a deficiency in insulin secretion or action (Radha *et al.,* 2024). Cases of diabetes mellitus (DM) are rapidly increasing globally, with about 1.31 billion persons projected to have diabetes by the year 2050 (GBD, 2023). This disease is reported to be more prevalent in low- and middle-income countries, where access to adequate healthcare and resources for managing the condition is limited (Sugandh *et al.,* 2023).

Haematology is the branch of medicine focused on studying the blood and blood-forming organs, and diagnosing blood disorders and diseases such as clotting disorders, anaemia, and leukaemia. Furthermore, haematopoiesis is the production of blood cells to maintain a steady blood supply. These blood cells include red blood cells, which supply oxygen to body tissues, white blood cells, which fight infections, and platelets, which help clot blood during injuries. Haematopoiesis may be affected by various factors, including exposure to certain substances, environmental pollutants, acute and chronic diseases (Essiet *et al.,* 2020). Diabetes has been linked to alterations in haematological status as chronic hyperglycaemia can lead to impairment of erythropoietin production by the kidneys, which may disrupt erythropoiesis (red blood cell or erythrocyte production) and cause anaemia in diabetic individuals (Shittu *et al.,* 2016; Taderegew *et al.,* 2020).

Currently, several conventional/synthetic medications, such as insulin, sulfonylureas, metformin, glinides, and biguanides, are used to treat DM (Dhankhar *et al.,* 2023). However, certain limitations, including high costs, side effects like dizziness, weight gain, hypoglycaemia, headache, cardiopathy, liver injury, and lactic acidosis, as well as low accessibility, have been attributed to some of these medications (Ojuade *et al.,* 2021; Dhankhar *et al.,* 2023; Yedjou *et al.,* 2023; Radha *et al.,* 2024). Hence, it is necessary to explore other therapeutic solutions to these problems.

Plants are rich in bioactive compounds, including flavonoids and other nutrients, that possess numerous pharmacological properties, enabling them to play crucial roles in the treatment of diabetes mellitus and its related complications with little or no side effects (Shevante *et al.,* 2023; Radha *et al.,* 2024). Studies have shown that extracts from herbs and spices such as *Dioscorea bulbifera* bulb (Eke *et al.,* 2025), *Allium sativum* (Anyanwu *et al.,* 2023), *Garcinia kola* seeds (Joshua *et al.,* 2022), *Lasianthera africana* leaves (Essiet *et al.,* 2020), *Zingiber officinale* (Ani *et al.,* 2022; Iwuji *et al.,* 2023), *Hibiscus sabdariffa* and *Piper nigrum* (Ani *et al.,* 2022), *Cymbopogon citratus* (Ale *et al.,* 2023), *Salacia lehmbachii* leaves (Akuodor *et al.,* 2021), *Curcuma longa* (Attamah *et al.,* 2021; Sivaranjani *et al.,* 2021), and cinnamon (Sivaranjani *et al.,* 2021), among many others, can restore normal haematological status in diabetic conditions and may possess anti-hyperglycaemic potentials. Therefore, this study investigated the effect of a polyherbal aqueous extract prepared from five distinct herbs (Garcinia kola, Allium sativum, Zingiber officinale, Cymbopogon citratus, and Curcuma longa) on haematological parameters in alloxan-induced diabetic Wistar rats.

MATERIALS AND METHODS

Procurement of Plant Materials and Preparation of Aqueous Extract

Fresh samples of *Garcinia kola* seeds, *Allium sativum* bulbs, *Zingiber officinale* rhizomes, *Cymbopogon citratus* leaves, and *Curcuma longa* rhizomes were obtained from Rumuokoro market in Port Harcourt, Nigeria, and taken to the Biochemistry Research Laboratory of the University of Port Harcourt. The samples were washed with clean water, cut into small pieces, and dried completely in the oven at 30 °C. Each dried sample of *G. kola*, *A. sativum*, *Z. officinale*, *C. citratus*, and *C. longa* was ground into a

fine powder using an electric blender, weighed separately, and mixed in the ratios 6:9:6:5:10, respectively. The mixture was macerated in hot (boiled) distilled water for 48 hours amidst frequent stirring, according to the method of Ikewuchi *et al.* (2021). The mixture was sieved through a muslin cloth, and the filtrate was freeze-dried to obtain the solid extract, which was then stored in an airtight container for animal treatment.

Procurement of Experimental Animals and Handling

All experimental procedures, including animal handling and care, were approved by the University of Port Harcourt Research Ethics Committee (Reference Number: UPH/CEREMAD/REC/MM117/053), and conducted in accordance with established ethical guidelines for the care and use of laboratory animals in research (National Research Council, 2011). Wistar rats were procured from an animal house and kept in clean, well-ventilated wooden cages secured with stainless-steel wire mesh at the Department of Nutrition and Food Science, Faculty of Agriculture, University of Port Harcourt, throughout the experimental period. They were allowed 2 weeks of acclimatization before the study commenced. The rats were gently handled and housed in a clean environment under standard laboratory conditions (12-hour light/dark cycle and room temperature). They were fed a steady supply of standard rat chow and clean water, and monitored daily for behaviour, food intake, and any signs of distress throughout the experimental period.

Experimental Design

Forty (40) Wistar rats weighing 95-102 g were randomly assigned into eight groups (5 rats per group) as shown in Table 1.

Table 1: Experimental Design

Group Number	Designation/ID	Treatment Mode
1	Normal Control	No diabetes induced, received only water
2	Test Control	Diabetes induced without treatment
3	Treatment 1 (T-100mg)	Diabetes induced and treated with 100 mg/kg of extract
4	Treatment 2 (T-200mg)	Diabetes induced and treated with 200 mg/kg of extract
5	Treatment 3 (T-300mg)	Diabetes induced and treated with 300 mg/kg of extract
6	Treatment Control 1 (TC-100mg)	No diabetes induced, but treated with 100 mg/kg of extract
7	Treatment Control 2 (TC-200mg)	No diabetes induced, but treated with 200 mg/kg of extract
8	Treatment Control 3 (TC-300mg)	No diabetes induced, but treated with 300 mg/kg of extract

Induction of Diabetes

The experimental rats were fasted overnight. Then, their baseline fasting blood glucose (FBG) levels were measured early in the morning using an Accu-Chek® glucometer and test strips. Diabetes was induced through a single intraperitoneal injection of a freshly prepared alloxan solution (160 mg/kg body weight in normal saline) according to Putri *et al.* (2020). Elevated FBG levels were detected in the animals after 48 hours of induction, upon measurement. Their FBG levels were measured again at 96 hours after induction to confirm hyperglycaemia before the commencement of treatment. Rats with FBG levels above 6.1 mmol/L were regarded as hyperglycaemic and selected for the study (Ojiako *et al.,* 2015).

Treatment with the Polyherbal Aqueous Extract

Different dose concentrations (100, 200, and 300 mg/kg body weight) of the polyherbal aqueous extract were prepared by weighing and reconstituting the extract in distilled water, then administered to the experimental animals according to each animal's weight and treatment group. The extract was administered through oral gavage daily for 2 weeks. Body weights and fasting blood glucose levels were also measured weekly.

Collection of Blood Samples

At the end of the treatment, the rats were anaesthetised using chloroform. Then, their blood was collected into ethylenediaminetetraacetic acid (EDTA) sample bottles for the haematological assay.

Determination of Haematological Indices

Haematological indices were determined using Mindray Auto Haematology Analyzer Model: BC-11 (Shenzhen Mindray Bio-medical Electronics Co., Ltd. China) at the Biochemistry Research Laboratory of the University of Port Harcourt.

The lysing reagent and diluents (Mindray haematology reagent kit) were placed at the instrument level and the electronic sensors: yellow for lysing reagent and red for the diluents were checked to know the level of the reagents. The analyser was powered on and left to complete the background check; once completed, it was ready for use in the analysis. Then, forty pre-diluted tubes were filled with diluent reagent from the M[16] Haematological Analyser using the dispense function. The diluent was discarded, and the tubes were filled again. Then, 1 mL of each sample was added to each tube. The tubes were tilted, one after another, for 20 seconds each to ensure a proper mixture of diluents and sample.

The new sample button on the main screen of the haematological analyser was clicked on to begin sample identification. The sample identification number was entered and saved. The aspiration needle was gently inserted into the sample tube, and the whole-blood start plate was "powered on" to initiate aspiration immediately. At the sound of a beep, the sample was removed. Then, 45 seconds later, the results were displayed on the sample menu and recorded.

Data Analysis

Data were analysed using Microsoft Excel (Data Analysis Add-in). All data were expressed as mean ± standard error of the mean (SEM), and were analysed using one-way Analysis of Variance (ANOVA) and Duncan's multiple range test to compare means and determine significant differences. Values were considered statistically significant at $p < 0.05$.

RESULTS

Effect of the Polyherbal Aqueous Extract on White Cell Indices

The lymphocytes count (absolute values) of the test control, T-200mg, and all the treatment control groups (TC-100mg, TC-200mg, and TC-300mg) were significantly ($p < 0.05$) lower than the normal control. However, there was no significant difference ($p > 0.05$) between T-100mg and T-300mg and the normal control group, as shown in Table 2. Only the percentage lymphocyte count in T-300mg was significantly lower ($p < 0.05$) than that of the normal

control, while the other groups did not differ significantly. There was no significant difference ($p > 0.05$) in white blood cell count, granulocyte count (absolute value), and mid-sized cell count among all experimental groups. T-300mg had the highest granulocyte count among all groups for both absolute and percentage values; however, the difference was not significant ($p > 0.05$) for absolute values, whereas the percentage value was significantly higher than the normal control ($p < 0.05$). Likewise, T-300mg recorded the highest mid-sized cell count among all groups for both absolute and percentage values; however, the differences were not significant ($p > 0.05$) for either.

Table 2: Effect of the Polyherbal Aqueous Extract on White Cell Indices in Alloxan-Induced Rats

Treatments	White blood cell count (10^9/L)	Lymphocytes count		Granulocytes count		Mid-sized cells count	
		Absolute value (10^9/L)	Percent (%)	Absolute value (10^9/L)	Percent (%)	Absolute value (10^9/L)	Percent (%)
Normal control	13.475 ± 2.761^{a}	12.350 ± 2.629^{a}	0.909 ± 0.019^{a}	0.475 ± 0.118^{a}	0.037 ± 0.010^{b}	0.650 ± 0.119^{a}	0.055 ± 0.009^{a}
Test control	6.933 ± 1.387^{a}	5.700 ± 1.418^{b}	0.810 ± 0.043^{a,b}	0.700 ± 0.200^{a}	0.101 ± 0.029^{a,b}	0.533 ± 0.033^{a}	0.089 ± 0.017^{a}
T-100mg	9.667 ± 1.922^{a}	7.667 ± 1.539^{a,b}	0.794 ± 0.049^{a,b}	1.267 ± 0.448^{a}	0.129 ± 0.037^{a,b}	0.733 ± 0.120^{a}	0.077 ± 0.014^{a}
T-200mg	5.767 ± 1.431^{a}	4.800 ± 1.332^{b}	0.815 ± 0.037^{a,b}	0.633 ± 0.120^{a}	0.119 ± 0.031^{a,b}	0.333 ± 0.033^{a}	0.066 ± 0.008^{a}
T-300mg	12.633 ± 7.133^{a}	7.667 ± 3.012^{a,b}	0.734 ± 0.122^{b}	3.433 ± 3.085^{a}	0.171 ± 0.096^{a}	1.533 ± 1.133^{a}	0.095 ± 0.026^{a}
TC-100mg	6.025 ± 2.255^{a}	5.275 ± 2.095^{b}	0.863 ± 0.015^{a,b}	0.375 ± 0.085^{a}	0.071 ± 0.009^{a,b}	0.375 ± 0.085^{a}	0.067 ± 0.009^{a}
TC-200mg	6.700 ± 1.520^{a}	5.450 ± 1.255^{b}	0.816 ± 0.029^{a,b}	0.775 ± 0.229^{a}	0.110 ± 0.021^{a,b}	0.475 ± 0.085^{a}	0.074 ± 0.011^{a}
TC-300mg	7.150 ± 1.507^{a}	6.075 ± 1.295^{b}	0.849 ± 0.010^{a,b}	0.600 ± 0.108^{a}	0.080 ± 0.007^{a,b}	0.475 ± 0.118^{a}	0.071 ± 0.004^{a}

*Data are expressed as mean ± SEM; n = 5 animals per group; values in the same column with different superscript letters differ significantly at $p < 0.05$; normal control - only distilled water; test control - diabetes induced and untreated; T-100mg, T-200mg, and T-300mg - treatment groups induced and treated with 100 mg/kg, 200 mg/kg, and 300 mg/kg of the polyherbal extract respectively; TC-100mg, TC-200mg, and TC-300mg - treatment control groups non-induced, but administered 100 mg/kg, 200 mg/kg, and 300 mg/kg of the extract respectively.

Effect of the Polyherbal Aqueous Extract on Red Cell Indices

As presented in Table 3, there was no significant ($p > 0.05$) difference in the red blood cell count and mean cell haemoglobin values among all the experimental groups. However, all the treatment groups had higher red blood cell count than the normal and test control groups. Higher haemoglobin concentrations and haematocrit values were observed in T-100mg, T-200mg, T-300mg, TC-100mg and TC-200mg than those in the normal and test control groups. However, the difference was not significant ($p > 0.05$). Whereas, T-100mg had the highest haemoglobin concentration and haematocrit value of all the groups which were significantly ($p < 0.05$) higher than those of TC-300mg that recorded the lowest values among all the groups.

The mean corpuscular volume of T-200mg and all treatment control groups did not differ significantly from the normal control, whereas that of the test control (T-100mg) and T-300mg was significantly ($p < 0.05$) lower than that of the normal control group. There was no significant ($p > 0.05$) difference between the mean cell haemoglobin concentrations of the treatment groups, TC-100mg, and TC-300mg, and that of the normal control group. Also, no significant ($p > 0.05$) difference was observed in the mean cell haemoglobin concentrations among all the treatment and treatment control groups. Meanwhile, the test control group had the highest mean cell haemoglobin concentration among all groups, which was significantly higher ($p < 0.05$) than that of the normal control.

The lowest red cell distribution width (absolute values) was recorded in TC-300mg. The test control values were significantly ($p < 0.05$) lower than those of T-300mg, which had the highest red cell distribution width among all groups. However, the values recorded in all treatment and treatment control groups did not differ significantly from those of the normal control group ($p > 0.05$). Similarly, T-300mg had the highest red cell distribution width percentage, which was significantly ($p < 0.05$) higher than those of all other groups except T-100mg and T-200mg, with TC-300mg having the lowest value among all groups.

Table 3: Effect of the Polyherbal Aqueous Extract on Red Cell Indices in Alloxan-Induced Rats

Parameters		Normal control	Test control	T-100mg	T-200mg	T-300mg	TC-100mg	TC-200mg	TC-300mg
Red blood cell count (10^{12}/L)		6.998 ± 0.334^{a}	7.710 ± 0.902^{a}	8.925 ± 0.915^{a}	8.283 ± 0.742^{a}	7.820 ± 0.380^{a}	7.863 ± 0.666^{a}	8.083 ± 0.370^{a}	7.113 ± 0.167^{a}
Haemoglobin concentration (g/L)		142.750 ± 4.211^{a,b}	149.667 ± 15.070^{a,b}	181 ± 13^{a}	167 ± 13.317^{a,b}	171.667 ± 19.936^{a,b}	160.250 ± 15.612^{a,b}	162.250 ± 5.662^{a,b}	140 ± 4.243^{b}
Haematocrit (%)		0.419 ± 0.013^{a,b}	0.422 ± 0.046^{a,b}	0.514 ± 0.032^{a}	0.483 ± 0.042^{a,b}	0.492 ± 0.045^{a,b}	0.458 ± 0.039^{a,b}	0.459 ± 0.014^{a,b}	0.407 ± 0.011^{b}
Mean corpuscular volume (fL)		59.975 ± 1.437^{a}	54.900 ± 1.193^{b,c,d,e,f,g}	54.700 ± 1.453^{b,c,d,e,f,g}	58.400 ± 0.379^{a,b}	55.467 ± 1.834^{b,c,d,e,f}	58.300 ± 0.969^{a,b,c}	56.975 ± 1.601^{a,b,c,d,e}	57.150 ± 0.900^{a,b,c,d}
Mean cell haemoglobin (pg)		20.450 ± 0.452^{a}	19.500 ± 0.666^{a}	19.167 ± 0.353^{a}	20.233 ± 0.219^{a}	19.267 ± 0.260^{a}	20.375 ± 0.335^{a}	20.125 ± 0.539^{a}	19.700 ± 0.354^{a}
Mean cell haemoglobin concentration (g/L)		340.750 ± 1.601^{b}	355.333 ± 4.372^{a}	351.333 ± 4.410^{a,b}	346 ± 2.082^{a,b}	348 ± 7.937^{a,b}	349.250 ± 4.802^{a,b}	353.500 ± 1.500^{a}	344.250 ± 1.109^{a,b}
Red cell distribution width	Absolute value (fL)	25.750 ± 0.624^{a,b}	24.100 ± 0.794^{b}	25.167 ± 0.348^{a,b}	26.333 ± 1.053^{a,b}	27.967 ± 2.776^{a}	26.375 ± 0.484^{a,b}	24.725 ± 0.624^{a,b}	23.900 ± 0.248^{b}
	Percent (%)	0.133 ± 0.001^{b}	0.135 ± 0.004^{b}	0.142 ± 0.004^{a,b}	0.139 ± 0.006^{a,b}	0.155 ± 0.013^{a}	0.140 ± 0.003^{b}	0.134 ± 0.001^{b}	0.129 ± 0.002^{b}

*Data are expressed as mean ± SEM; n = 5 animals per group; values in the same row with different superscript letters differ significantly at $p < 0.05$; normal control - only distilled water; test control - diabetes induced and untreated; T-100mg, T-200mg, and T-300mg - treatment groups induced and treated with 100 mg/kg, 200 mg/kg, and 300 mg/kg of the polyherbal extract respectively; TC-100mg, TC-200mg, and TC-300mg - treatment control groups non-induced, but administered 100 mg/kg, 200 mg/kg, and 300 mg/kg of the extract respectively; g/L - grams per litre; fL - femtolitre; pg - picogram.

Effect of the Polyherbal Aqueous Extract on Platelet Indices

There was no significant ($p > 0.05$) difference in platelet count and plateletcrit values among all the groups, as shown in Table 4. T-100mg had the highest platelet count and plateletcrit among all treated diabetic groups, which were close to the values obtained for the normal control group. The mean platelet volume, platelet distribution width, and platelet-larger cell ratio in all treatment and treatment control groups did not differ significantly ($p > 0.05$) from those of the normal control. The test control group had the highest mean platelet volume, which was significantly ($p < 0.05$) higher than the values recorded for T-100mg and TC-200mg. The platelet distribution width was also highest in the test control group and was significantly higher ($p < 0.05$) than those for T-100mg and TC-300mg. Likewise, the platelet-to-larger cell ratio was highest in the test control group and was significantly higher ($p < 0.05$) than the values recorded for T-100mg, TC-200mg, and TC-300mg.

Table 4: Effect of the Polyherbal Aqueous Extract on Platelet Indices in Alloxan-Induced Rats

Treatments	Platelet count (10^{9}/L)	Mean platelet volume (fL)	Platelet distribution width (fL)	Plateletcrit (mL/L)	Platelet-larger cell ratio
Normal control	811.750 ± 22.422^{a}	6.775 ± 0.085^{a,b}	14.650 ± 0.050^{a,b}	5.483 ± 0.126^{a}	0.079 ± 0.005^{a,b}
Test control	514.667 ± 158.980^{a}	6.900 ± 0.058^{a}	14.767 ± 0.067^{a}	3.537 ± 1.078^{a}	0.096 ± 0.004^{a}
T-100mg	794.667 ± 48.571^{a}	6.500 ± 0.115^{b}	14.533 ± 0.120^{b}	5.153 ± 0.366^{a}	0.068 ± 0.009^{b}
T-200mg	488.333 ± 166.085^{a}	6.667 ± 0.088^{a,b}	14.633 ± 0.088^{a,b}	3.243 ± 1.070^{a}	0.082 ± 0.008^{a,b}
T-300mg	651.333 ± 121.477^{a}	6.733 ± 0.186^{a,b}	14.600 ± 0.058^{a,b}	4.357 ± 0.714^{a}	0.084 ± 0.011^{a,b}
TC-100mg	746 ± 117.295^{a}	6.825 ± 0.075^{a,b}	14.675 ± 0.025^{a,b}	5.100 ± 0.855^{a}	0.086 ± 0.002^{a,b}
TC-200mg	789.250 ± 113.440^{a}	6.550 ± 0.050^{b}	14.600 ± 0.041^{a,b}	5.180 ± 0.751^{a}	0.074 ± 0.003^{b}
TC-300mg	585.750 ± 47.531^{a}	6.675 ± 0.125^{a,b}	14.525 ± 0.063^{b}	3.893 ± 0.292^{a}	0.073 ± 0.006^{b}

*Data are expressed as mean ± SEM; n = 5 animals per group; values in the same column with different superscript letters differ significantly at $p < 0.05$; normal control - only distilled water; test control - diabetes induced and untreated; T-100mg, T-200mg, and T-300mg - treatment groups induced and treated with 100 mg/kg, 200 mg/kg, and 300 mg/kg of the polyherbal extract respectively; TC-100mg, TC-200mg, and TC-300mg - treatment control groups non-induced, but administered 100 mg/kg, 200 mg/kg, and 300 mg/kg of the extract respectively; fL - femtolitre.

DISCUSSION

Measurement of haematological indices is essential for providing information on the physiological status of the blood cells, and for diagnosing blood-related disorders such as anaemia, haemophilia,

and leukaemia, among others. In this study, the polyherbal aqueous extract improved white blood cell (WBC) and lymphocytes counts in the alloxan-induced diabetic rats especially those that received 100 mg/kg and 300 mg/kg doses of the extract. Additionally, treatment with 300 mg/kg of the polyherbal extract increased the counts of granulocytes and mid-sized cells in the diabetic rats. WBCs and lymphocytes are crucial for fighting against foreign substances in living organisms (Oladejo & Osukoya, 2021). The results of the present study suggest that the polyherbal extract may possess immune-enhancing properties. This is consistent with findings from previous research. Shevante *et al.* (2023) found that a polyherbal extract of *Sesbania grandiflora* leaves and *Beta vulgaris* root increased WBCs and lymphocytes in diabetic rats. Elevated WBCs were also observed in alloxan-induced diabetic Wistar rats treated with the ethanol extract of Garcinia kola (Joshua et al., 2022) and a combination of *Carica papaya* and *Newbouldia laevis* leaves extract (Oji *et al.,* 2022). Moreover, increased WBCs and lymphocytes counts were detected in diabetic Wistar rats administered extracts of *Salacia lehmbachii* (Akuodor *et al.,* 2021), *Allium sativum* (Anyanwu *et al.,* 2023), and *Cymbopogon citratus* (Ale *et al.,* 2023).

Diabetes mellitus has been linked with a higher risk of anaemia, and this is attributed to the increased nonenzymatic glycosylation of red blood cell membrane proteins, which undergo oxidation and lipid peroxidation to cause haemolysis of red blood cells, thereby leading to decreased levels of red blood cells and haemoglobin in hyperglycaemic conditions (Shittu *et al.,* 2016; Joshua *et al.,* 2022). The red blood cells (RBCs) supply oxygen to the body's tissues through the blood, while haemoglobin is the oxygen-carrying protein in RBCs. Therefore, the availability of sufficient functional RBCs and haemoglobin is vital for adequate tissue oxygenation. Insufficient levels of functional RBCs in the body can lead to weakness, fatigue, and anaemia (Cleveland Clinic, 2025a). Haematocrit (also known as HCT, packed cell volume, or PCV) is the percentage volume of RBCs in whole blood. It is also useful for diagnosing anaemia (Cleveland Clinic, 2025b). In the present study, an elevated RBC count was observed in all diabetic rat groups treated with the polyherbal aqueous extract compared with the untreated groups. The results also indicate that the polyherbal extract increased haemoglobin concentrations and haematocrit values across all treatment groups, particularly in those receiving the 100 mg/kg and 300 mg/kg doses. Mean cell haemoglobin concentrations (MCHC) in all treatment groups were close to those in healthy animals. Moreover, the polyherbal extract markedly increased the red cell distribution width (RCDW) in treated diabetic rats, especially in those administered a 300 mg/kg dose of the extract. These findings suggest that the polyherbal extract may attenuate anaemia in diabetes.

The results from this study are similar to those of some previous related studies. For instance, a polyherbal extract comprising *Hibiscus sabdariffa*, *Zingiber officinale*, and Piper nigrum was found to improve haemoglobin and PCV levels (Ani *et al.,* 2022). Shevante *et al.* (2023) reported a significant increase in RBC count, haemoglobin concentration, and PCV, mean cell haemoglobin (MCH), and MCHC in diabetic rats administered with 200 mg/kg and 400 mg/kg of a polyherbal extract of *Sesbania grandiflora* leaves and *Beta vulgaris* root. Oji *et al.* (2022) observed that treatment with a combined extract of *Carica papaya* and *Newbouldia laevis* leaves improved RBC count, haemoglobin concentration, and PCV in alloxan-induced diabetic rats. Anyanwu *et al.* (2023) also observed that *Allium sativum* extract increased the haemoglobin concentration, PCV, and RBC count in alloxan-induced diabetic rats. Shittu *et al.* (2016) reported a significant increase in RBC count, haemoglobin concentration, and PCV in alloxan-induced diabetic rats treated with an aqueous extract of *Ocimum gratissimum* leaves. RBC count was also restored in diabetic rats by an ethanol extract of *Garcinia kola* in a previous study (Joshua *et al.,* 2022). Ethanolic extract of Dioscorea bulbifera bulb improved red cell indices (RBC count, haemoglobin concentration, PCV, MCH, and MCHC) in alloxan-induced rats treated with 100, 200, and 400 mg/kg of the extract (Eke *et al.,* 2025). Furthermore, improved RBC, haemoglobin, and PCV levels were recorded in diabetic rats administered *Zingiber officinale* extract (Iwuji *et al.,* 2023), and *Curcuma longa* extract (Attamah *et al.,* 2021). Increased RBCs and PCV were noted in alloxan-induced diabetic Wistar rats treated with *Cymbopogon citratus* extract (Ale *et al.,* 2023); while, RBC, haemoglobin, PCV, MCH, MCHC, and RCDW were increased in those that received *Salacia lehmbachii* leaf extract (Akuodor *et al.,* 2021).

Administration of the polyherbal aqueous extract in the present study improved the mean corpuscular volume (MCV) in diabetic rats treated with a 200 mg/kg dose of the extract and in all non-diabetic treated rats (treatment control), compared with the diabetic untreated (test control) group. This is discordant with Shevante *et al.* (2023), who reported decreased MCV in diabetic rats treated with polyherbal extracts at 200 mg/kg and 400 mg/kg. However, it aligns with the findings of Akuodor *et al.* (2021) and Eke *et al.* (2025), who reported increased MCV values in their studies.

The present study revealed that treatment with the polyherbal aqueous extract, particularly at 100 mg/kg and 300 mg/kg, improved platelet count and plateletcrit values in diabetic rats. The polyherbal extract also maintained mean platelet volume, platelet distribution width, and platelet-to-large-cell ratio in all treated rats at values similar to those in normal control rats. This indicates that the extract can stimulate the production of blood-clotting factors. Similar findings were observed in other diabetic rats upon treatment with extracts of *Salacia lehmbachii* leaves (Akuodor *et al.,* 2021), *Hibiscus sabdariffa*, *Zingiber officinale,* and *Piper nigrum* (Ani *et al.,* 2022), and also *Sesbania grandiflora* leaves and *Beta vulgaris* root (Shevante *et al.,* 2023).

Conclusion

The results from this study suggest that the polyherbal aqueous extract of *G. kola*, *A. sativum*, *Z. officinale*, *C. citratus*, and *C. longa* improves the haematological status of diabetic rats by restoring their white cell, red cell, and platelet indices. Therefore, this underscores the potential of the polyherbal extract in managing haematological abnormalities associated with diabetes. Further studies may be conducted to identify and isolate the specific bioactive components of the polyherbal extract responsible for the observed findings, as well as their mechanisms of action.

Acknowledgements

We thank Prof. M.O. Ifeanacho of the Department of Nutrition and Food Science, Faculty of Agriculture, University of Port Harcourt, for providing a conducive environment for the animal experiment. We also appreciate the lab technologists at the Biochemistry Research Laboratory of the University of Port Harcourt for their

assistance during the laboratory analysis.

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