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Effects of Dietary Spice Mixture on Hepatorenal, Lipid Profiles and Haematological Parameters of Albino Rats Fed Calcium Carbide Ripened Plantain

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Abstract- Calcium carbide is widely used for artificial fruit ripen in developing regions despite its established toxicity. Consumption of calcium carbide ripened foods have been linked to oxidative stress and organ damage. Natural spices possess antioxidant and detoxifying properties that may mitigate these adverse effects. This study assessed the protective and therapeutic effects of a formulated Nigerian spices mixture on liver and kidney functions, plasma electrolytes, lipid profile, and hematological parameters in rats fed calcium carbide ripened plantain. Thirty-six male Wistar rats were assigned to six groups of six rats/group: normal control (NOC), naturally ripened plantain (NRP), calcium carbide ripened plantain (CCR), standard control (SDC; vitamin C 100 mg/kg), prophylactic group (PRG; 300 mg/kg spices before exposure), and treatment group (TRG; 300 mg/kg spices after exposure). Biochemical and hematological parameters were analyzed using standard methods. Rats in the CCR group showed elevated ALT (66.2 ± 2.7 U/L) and AST (64.5 ± 2.2 U/L) compared with NOC (48.5 ± 0.3 U/L and 55.0 ± 0.6 U/L). plasma total bilirubin increased by 46% while albumin declined by 29%. Renal function markers were significantly raised, including urea (16.67 ± 0.45 mg/dL vs 13.48 ± 0.33 mg/dL in NOC). Electrolyte imbalance was evident with elevated K^+ (4.68 ± 0.30 mmol/L) and Cl^- (103.5 ± 3.5 mmol/L) with reduced Na^+ (110.8 ± 1.6 mmol/L) and HCO_3^- (21.3 ± 0.5 mmol/L). Dyslipidemia occurred with increased total cholesterol (2.20 ± 0.15 mmol/L) and reduced HDL (0.39 ± 0.01 mmol/L). Hematological alteration included anemia (Hb = 11.9 ± 0.6 g/dL vs 16.0 ± 0.5 g/dL) and thrombocytosis (platelets = 696.7 ± 16.6 $\times 10^9$/L). Both PRG and TRG showed significant recovery, TRG values approached normal biochemical indices, while PRG demonstrated superior erythrocyte recovery (Hb = 14.5 ± 0.6 g/dL). The study concludes that calcium carbide ripened plantain induces systemic toxicity, which is effectively mitigated by the spices mixture, offering both preventive and therapeutic benefits.

Key Words: Hepatorenal, Lipid profile, Haematological parameters, Calcium carbide

I. INTRODUCTION

Calcium carbide (CaC_2) of technical grade is grey or brown and consists of about 85 % of CaC_2, with other compounds including silicon carbide, calcium phosphide, calcium oxide, calcium nitride, and calcium sulphide. However, in pure form, CaC_2 is colorless which yields flammable acetylene gas and calcium hydroxide ($Ca(OH)_2$) upon decomposition in water. It also acts as a catalyst essential for waste rubber degradation by converting biomass in catalytic pyrolysis of waste inner tube rubber and low-density polyethylene to fuel oil.

Commercial CaC_2 known to be used for welding, desulfurization of steel, and synthesis of acetylene and cyanimide, has scrupulously gained a function as a ripening agent due to the pressure to meet up with ever-growing demand for ripe food crops and fruits (Bini *et al.,* 2021; Iyare *et al.*, 2020). The acetylene gas (an analog of ethylene) produced by CaC_2 mimics its functions as a natural fruit ripening plant hormone. Although CaC_2 quickens the fruit ripening process, it has several adverse effects on fruits. In some cases, only the skin [epicarp] of the fruit changes color, whereas its mesocarp and pericarp remain green, raw and unripe. When CaC_2 is used on unripe fruits, a greater quantity is added to ripen the fruit. This makes the fruit tasteless, unhealthy, and

highly toxic, thereby posing health challenges, unlike naturally ripened fruits that play significant roles in human health and nutrition. Some of these health challenges include memory loss, cerebral oedema, prostatitis, lung failure, renal failure, dermal diseases and heart conditions (Essien, 2018; Ogbuagu *et al.,* 2016), changes in DNA and RNA (Nura *et al.,* 2018) among others (Islam *et al.,* 2016). Mechanisms suggested for CaC_2-induced toxicity include induction of hypoxia, oxidative stress and inflammation (Pastore *et al.,* 2014). The proposed mechanisms of mitigating CaC_2–induced toxicity include inhibiting reactive oxygen species (ROS) by scavenging free radicals, inhibiting cellular proliferation and damage, inhibiting apoptosis as well as metal chelation, modulation of enzymatic activities, cytokine expression and signal transduction pathways (Navarro-González *et al.,* 2018).

It therefore makes sense that a potent antioxidant and anti-inflammatory agent could mitigate CaC_2 toxicity, as the public is endangered by taking these CaC_2, hence the need to use natural nutritional factors, such as spices as an ameliorative agent.

Although literature on the use of spices mixture is scarce, spices have been used for treatment of several diseases as well as for detoxifying or as protective against various toxins due to their constituents Eteng *et al.* 2014; Mohammad *et al.,* 2013. Ugwuja *et al* (2016) reported that cconcurrent intake of garlic, ginger and nutmeg at culinary dose in the diet has both therapeutic and prophylactic effect at mitigating cadmium toxicity.

It is therefore hypothesized that spices mixture containing garlic, ginger and curry may exert synergistic effect at mitigating calcium carbide-induced toxicity arising from consumption of CaC_2 ripened fruits.

The growing demand for ripe foods and fruits has been challenging to farmers and food crops retailers alike. This has led to unwholesome practices of ripening foods with artificial ripeners, including but not limited to calcium carbide. Even though artificial ripeners quicken the ripening process, the nutritional quality such as sensory property and safety of the food/fruits are compromised (Nura *et al.,* 2018). Calcium carbide accumulates on food when used overtime in food ripening. Consumption of such artificially ripened foods is associated with health consequences, such as cellular damage and accelerated aging (Filipek & Broda, 2018). Calcium carbide also contains impurities of arsenic and phosphorous compounds that are relatively toxic to humans and animals (Fadairo & Fadairo, 2019; Rasdi *et al.,* 2018). While there may not be direct literature on spice combinations specifically for mitigating calcium carbide toxicity, the existing research on the health benefits and detoxifying properties of spices suggests that incorporating a variety of spices into the diet could potentially offer some protective effects against toxins, including those from calcium carbide. Therefore, further research in this area could help elucidate the specific mechanisms and efficacy of spice mixtures for detoxification purpose.

RESULTS

4.1 Effect of Spices Mixture in Liver Function Parameters of Rat Fed Calcium Carbide Ripened Plantain

Table 1 shows the effect of spices mixture on the liver function parameters of rats fed calcium carbide ripened plantain. Rats fed calcium carbide–ripened plantain (CCR) exhibited higher activities of ALT (66.2 ± 2.7 U/L), AST (64.5 ± 2.2 U/L), and ALP (69.8 ± 0.9 U/L) in comparison with the Normal Control (NOC) group (48.5 ± 0.3, 55.0 ± 0.6, and 62.2 ± 0.8 U/L, respectively). Total bilirubin concentration also increased (16.8 ± 0.6 mg/dL) relative to NOC (11.5 ± 0.3mg/dL), while serum albumin decreased (2.7 ± 0.6 g/dL vs. 3.8 ± 0.3 g/dL). In the spices-treated groups, ALT, AST, ALP, and bilirubin values were lower, while albumin concentrations improved significantly. The Treatment Group (TRG) had values closest to NOC (ALT = 47.6 ± 1.3 U/L, AST = 54.4 ± 0.5 U/L, bilirubin = 11.4 ± 0.0 mg/dL, albumin = 3.7 ± 0.03 g/dL).

4.2 Effect of Spices Mixture on Renal Function Parameters and Plasma Electrolytes of Rats Fed Calcium Carbide Ripened Plantain

Table 2 showed that urea (16.67 ± 0.45 mg/dL), creatinine (63.00 ± 2.13 mg/dL), and uric acid (7.93 ± 0.20 mg/dL) were significantly higher in the CCR group compared with the NOC (13.48 ± 0.33, 53.43 ± 0.28, and 6.40 ± 0.27 mg/dL, respectively). Both the prophylactic (PRG) and treatment (TRG) groups showed lower values, with the TRG approximating the control group (urea = 12.33 ± 0.30 mg/dL; creatinine = 50.80 ± 0.66 mg/dL; uric acid = 7.10 ± 0.12 mg/dL).

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Table 1: Effect of spices mixture on liver function parameters of rats fed calcium carbide ripened plantain

Subjects	ALT (U/L)	AST (U/L)	ALP (U/L)	Bilirubin (mg/dl)	Albumin (g/dl)
NOC	48.5±0.3	55.0±0.6	62.2±0.8	11.5±0.3	3.8±0.3
NRP	48.70±0.2	56.1±0.6	63.1±0.6	11.7±0.2	3.9±0.1
CCR	66.2±2.7†	64.5±2.2†	69.8±0.9	16.8±0.6†	2.7±0.6†
SCD	47.1±4.8	64.5±2.0	69.7±1.6	12.7±0.5	3.8±0.1
PRG	50.6±2.2	59.3±1.1	69.2±2.7	13.7±0.8	4.4±0.2
TRG	47.6±1.3	54.4±0.5	63.1±1.7	11.4±0‡	3.7±0.03‡

Values are expressed as mean ± standard deviation (n=6). † Values significantly different ($p<0.05$) from normal control and naturally ripened plantain groups; ‡Values significantly different ($p<0.05$) from prophylactic group

NOC: Normal control; NRP: naturally ripened plantain; CCR: Calcium carbide ripened (fed + CaC_2 ripened plantain); SCD: Standard control (Fed + CaC_2 ripened plantain + 100 mg/kg vitamin C); PRG: Prophylactic group (Fed + 300 mg/kg spices mixture before CaC_2 ripened plantain); TRG: Treatment group (Fed + 300 mg/kg spices mixture after CaC_2 ripened plantain)

Table 2: Effect of spices mixture on renal function parameters of rats fed calcium carbide ripened plantain

Subjects	Urea (mg/dl)	Creatinine (mg/dl)	Uric acid (mg/dl)
NOC	13.48±0.33	53.43±.28	6.40±0.27
NRP	13.67±0.3	54.42±0.27	6.72±0.30
CCR	16.67±0.45 †	63.00±2.13 †	7.93±0.20 †
SDC	13.28±0.17	52.83±0.61	6.10±0.09
PRG	15.98±0.76	65.00±2.51	6.83±0.43
TRG	12.33±0.30 ‡	50.80±0.66 ‡	7.10±O.12

Values are expressed as mean ± standard deviation (n=6). † Values significantly different ($p<0.05$) from normal control and naturally ripened plantain groups; ‡Values significantly different ($p<0.05$) from prophylactic group

NOC: Normal control; NRP: naturally ripened plantain; CCR: Calcium carbide ripened (fed plus CaC_2 ripened plantain); SCD: Standard control (Fed + CaC_2 ripened plantain + 100 mg/kg vitamin C); PRG: Prophylactic group (Fed + 300 mg/kg spices mixture before CaC_2 ripened plantain); TRG: Treatment group (Fed + 300 mg/kg spices mixture after CaC_2 ripened plantain)

The results presented in Table 3 showed the effect of a spices mixture on plasma electrolyte concentrations (potassium, sodium, bicarbonate, and chloride) of rats fed calcium carbide ripened plantain. When compared with the normal control (NOC), rats in the calcium carbide ripened plantain group (CCR) exhibited significant electrolyte imbalances across all measured parameters. Plasma potassium (K^+) level increased markedly from 3.13 ± 0.05 mmol/L in the NOC to 4.68 ± 0.30 mmol/L in the CCR group ($p<0.05$), indicating hyperkalemia likely induced by calcium carbide exposure. Conversely, sodium (Na^+) concentration declined significantly from 121.6 ± 2.4 mmol/L in the NOC to 110.8 ± 1.6 mmol/L in CCR ($p<0.05$), showing a hyponatremic effect. Similarly, plasma bicarbonate (HCO_3^-) dropped from 27.5 ± 0.3 mmol/L in NOC to 21.3 ± 0.5 mmol/L in CCR ($p<0.05$), while chloride (Cl^-) rose from 95.9 ± 0.5 mmol/L to 103.5 ± 3.5 mmol/L ($p<0.05$). The standard control group (SDC), which received vitamin C supplementation alongside calcium carbide ripened plantain, showed values close to the normal range for all electrolytes. Comparing the prophylactic (PRG) and treatment (TRG) groups, notable differences were observed. The PRG, which received the spices mixture before exposure to calcium carbide ripened plantain, had relatively elevated potassium (4.15 ± 0.30 mmol/L) and sodium (124.7 ± 2.2 mmol/L) levels compared to the TRG values of 3.06 ± 0.07 mmol/L ($p<0.05$) for potassium and 110.4 ± 0.5 mmol/L ($p<0.05$) for sodium. This indicates that prophylactic administration of the spices mixture maintained electrolyte balance more effectively than post-treatment administration. Conversely, bicarbonate concentration was higher in the TRG (26.4 ± 0.4 mmol/L) than in the PRG (22.8 ± 0.6 mmol/L), showing better restoration of acid-base balance when the spices mixture was administered after exposure. Similarly, chloride was lower in the PRG (89.6 ± 4.9 mmol/L) compared with the TRG (93.8 ± 2.5 mmol/L), reflecting a differential modulation of chloride retention or excretion between the two intervention modes.

Table 3 Effect of spices mixture on electrolytes parameters, of rats fed calcium carbide ripened plantain

Subjects	(mmol/l)	Plasma	Electrolytes	
	K	Na	HCO3	Cl
NOC	3.13±0.05	121.6±2.4	27.5±0.3	95.9±0.5
NRP	3.15±0.05	122.6±2.4	27.6±0.3	96.5±0.5
CCR	4.68±0.30†	110.8±1.6†	21.3±0.5†	103.5±3.5†
SDC	3.22±0.09	121.2±2.5	26.0±1.3	96.3±0.8
PRG	4.15±0.30	124.7±2.2	22.8±0.6	89.6±4.9
TRG	3.06±0.07‡	110.4±0.5‡	26.4±0.4‡	93.8±2.5

Values are expressed as mean ± standard deviation (n=6). † Values significantly different ($p<0.05$) from normal control and naturally ripened plantain groups; ‡Values significantly different ($p<0.05$) from prophylactic group

NOC: Normal control; NRP: naturally ripened plantain; CCR: Calcium carbide ripened (fed plus CaC_2 ripened plantain); SCD: Standard control (Fed + CaC_2 ripened plantain + 100 mg/kg vitamin C); PRG: Prophylactic group (Fed + 300 mg/kg spices mixture before CaC_2 ripened plantain); TRG: Treatment group (Fed + 300 mg/kg spices mixture after CaC_2 ripened plantain)

4.3 Effect of Spices Mixture on Plasma Lipid Profiles of Rats Fed Calcium Carbide Ripened Plantain

From Table 4.3, rats fed calcium carbide ripened plantain demonstrated elevated total cholesterol (2.20 ± 0.15 mmol/L), LDL-cholesterol (1.17 ± 0.15 mmol/L), and triglycerides (1.07 ± 0.06 mmol/L), alongside reduced HDL-cholesterol (0.39 ± 0.01 mmol/L) in comparison with their normal control (NOC) counterparts (1.55 ± 0.03, 0.78 ± 0.06, 0.80 ± 0.01, and 0.48 ± 0.05 mmol/L, respectively). However, treatment with the spice mixture resulted in normalization of lipid parameters, with the treatment group (TRG) having values (TC = 1.46 ± 0.05; LDL = 0.74 ± 0.05; HDL = 0.53 ± 0.07; TG = 0.83 ± 0.04 mmol/L), which are comparable ($p>0.05$) to controls.

Table 3: Effect of spices mixture on plasma lipid profiles of rats fed calcium carbide ripened plantain

Subjects	Plasma lipids (mmol/L)			
	TC	LDL	HDL	TG

NOC	1.55±0.03	0.78±0.06	0.48±0.05	0.80±.01
NRP	1.55±0.03	0.75±0.06	0.54±0.03	0.80±0.01
CCR	2.20±0.15†	1.167±0.15†	0.39±0.01†	1.07±0.06†
SDC	1.63±0.04	0.91±0.017	0.44±0.02	0.86±0.04
PRG	1.55±0.12	0.80±0.04	0.45±0.06	0.75±0.05
TRG	1.46±0.05	0.74±0.05	0.53±0.07	0.83±0.04

Values are expressed as mean ± standard deviation (n=6). † Values significantly different ($p<0.05$) from normal control and naturally ripened plantain groups

NOC: Normal control; NRP: naturally ripened plantain; CCR: Calcium carbide ripened (fed plus CaC_2 ripened plantain); SCD: Standard control (Fed + CaC_2 ripened plantain + 100 mg/kg vitamin C); PRG: Prophylactic group (Fed + 300 mg/kg spices mixture before CaC_2 ripened plantain); TRG: Treatment group (Fed + 300 mg/kg spices mixture after CaC_2 ripened plantain)

4.4 Effect of spices Mixture on Haematological Parameters of Rats Fed Calcium Carbide Ripened Plantain

The results in Table 4.4 show the effect of spices mixture on hematological parameters of rats fed calcium carbide ripened plantain. When compared with the normal control (NOC) group, rats fed calcium carbide ripened plantain (CCR) showed significant hematological alterations. The hemoglobin concentration decreased significantly from 16.0 ± 0.5 g/dL in NOC to 11.9 ± 0.6 g/dL in CCR ($p<0.05$), Similarly, packed cell volume (PCV) reduced sharply from 48.4 ± 1.6% in NOC to 36.0 ± 2.1% ($p<0.05$). The RBC count also fell significantly from 7.8 ± 0.2 $\times10^{12}$/L in NOC to 5.9 ± 0.1 $\times10^{12}$/L in CCR ($p<0.05$). In contrast, the mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) values were slightly elevated in CCR (80.7 ± 3.0 fL and 22.0 ± 1.0 pg, respectively) compared with NOC (76.5 ± 3.6 fL and 19.4 ± 0.4 pg), while MCHC increased marginally from 25.4 ± 0.7 g/dL in NOC to 26.7 ± 0.2 g/dL in CCR. Interestingly, platelet count rose significantly in the CCR group (696.7 ± 16.6 $\times10^9$/L) in comparison with NOC (579.5 ± 57.2 $\times10^9$/L, ($p<0.05$). When comparing the Prophylactic (PRG) and Treatment (TRG) groups, notable trends were observed. The PRG, which received the spices mixture before exposure to calcium carbide ripened plantain, had higher hemoglobin concentration (14.5 ± 0.6 g/dL) and PCV (43.3 ± 2.0%) compared with the TRG, which received the spices mixture after exposure (13.8 ± 0.4 g/dL and 41.4 ± 1.3%, respectively). The RBC count followed a similar pattern, being slightly higher in the PRG (8.0 ± 0.4 $\times10^{12}$/L) than in the TRG (7.5 ± 0.4 $\times10^{12}$/L).

In terms of red cell indices, MCV, MCH, and MCHC remained relatively stable across both groups, However, a remarkable difference was observed in platelet counts: PRG recorded 702.0 ± 87.2 $\times10^9$/L, while TRG had a significantly lower platelet count of 563.3 ± 25.5 $\times10^9$/L ($p<0.05$).

Table 4: Effect of spices mixture on plasma hematological parameters of rats fed calcium carbide ripened plantain

Subjects	HbC (g/dl)	PCV (5)	RBC ($\times10^{12}$/L)	MCV (fl)	MCH (pg)	MCHC (g/dl)	Platelets ($\times10^{12}$/L)
NOC	16.0±0.5	48.4±1.6	7.8±0.2	76.5±3.6	19.4±0.4	25.4±0.7	579.5±57.2
NRP	15.7±0.30	47.4±1.1	7.3±0.2	70.5±0.9	18.8±0.2	25.3±0.9	591.8±45.3
CCR	11.9±0.6†	36.0±2.1†	5.9±0.1†	80.7±3.0	22.0±1.0	26.7±0.2	696.7±16.6†

SDC	15.0±0.2	45.1±0.8	7.6±0.3	80.0±2.1	21.7±0.9	25.2±0.3	514.5±35.6
PRG	14.5±0.6	43.3±2.0	8.0±0.4	77.5±3.2	20.0±0.6	26.8±0.3	702.0±87.2
TRG	13.8±0.4	41.4±1.3	7.5±0.4	75.8±2.1	20.1±0.5	25.2±0.2	563.3±25.5‡

Values are expressed as mean ± standard deviation (n=6). † Values significantly different ($p<0.05$) from normal control and naturally ripened plantain groups; ‡Values significantly different ($p<0.05$) from prophylactic group

NOC: Normal control; NRP: naturally ripened plantain; CCR: Calcium carbide ripened (fed plus CaC_2 ripened plantain); SCD: Standard control (Fed + CaC_2 ripened plantain + 100 mg/kg vitamin C); PRG: Prophylactic group (Fed + 300 mg/kg spices mixture before CaC_2 ripened plantain); TRG: Treatment group (Fed + 300 mg/kg spices mixture after CaC_2 ripened plantain)

DISCUSSION

Calcium carbide ripened plantain consumption elicited significant hepatic, renal, haematological, and metabolic disturbances in rats, which were markedly ameliorated by treatment with a blend of antioxidant-rich Nigerian spices. The biochemical alterations observed following exposure to calcium carbide are consistent with oxidative and metabolic stress arising from the toxic impurities it contains, particularly arsenic, phosphorus hydride, and acetylene residues, which are known to generate reactive oxygen species (ROS) and compromise cellular integrity (Okorie *et al*., 2024; Nwokoro *et al*., 2023). The elevated liver enzymes (ALT, AST, and ALP) and bilirubin levels reflect hepatocellular injury and impaired hepatobiliary function, while reduced serum albumin indicates a decline in hepatic synthetic capacity. Mechanistically, calcium carbide and its byproducts induce lipid peroxidation, mitochondrial dysfunction, and depletion of endogenous antioxidants such as glutathione and superoxide dismutase, leading to membrane leakage and enzyme efflux into circulation (Adeyemi *et al*., 2023).

The reversal of these alterations by the spices mixture highlights the hepatoprotective efficacy of its phytochemical constituents, which likely include curcumin, eugenol, capsaicin, and piperine. These compounds have well-documented abilities to scavenge free radicals, modulate redox-sensitive transcription factors (e.g., Nrf2), and upregulate antioxidant defense pathways (Singh & Aggarwal, 2023). Curcumin, for instance, has been shown to stabilize hepatocyte membranes and suppress inflammatory cytokines such as TNF-α and IL-1β, thereby limiting enzyme leakage and oxidative necrosis (Adebayo *et al*., 2024). Similarly, capsaicin enhances mitochondrial integrity, while piperine improves bioavailability of other antioxidants and modulates hepatic enzyme activity. The near-normalization of liver markers in the treatment group suggests that the spices mixture effectively counteracted oxidative damage, possibly through synergistic free-radical scavenging and anti-inflammatory effects.

Renal function indices also demonstrated a similar trend, with calcium carbide exposure causing significant increases in serum urea, creatinine, and uric acid, indicators of glomerular dysfunction and reduced renal clearance. These alterations likely stem from ROS-induced nephrotoxicity, characterized by lipid peroxidation of renal tubular membranes and interference with energy metabolism in nephron cells (Okwuonu *et al*., 2024). The observed restoration of renal function parameters in both prophylactic and treatment groups reflects the reno-protective actions of the spices mixture, which may be attributed to its polyphenolic and flavonoid content that improves glomerular filtration rate and stabilizes tubular reabsorption. Additionally, phytochemicals such as cinnamaldehyde and quercetin have been reported to attenuate renal oxidative stress by inhibiting NADPH oxidase and restoring catalase activity, thereby maintaining nitrogenous waste excretion (Ali *et al*., 2023).

Electrolyte imbalance induced by calcium carbide was evident in the dysregulation of potassium, sodium,

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bicarbonate, and chloride levels. The hyperkalemia and hyponatremia observed likely reflect altered Na^+/K^+-ATPase activity and impaired renal tubular handling of ions due to oxidative damage to nephron membranes (Oyelakin *et al*., 2024). Similarly, decreased bicarbonate levels point to metabolic acidosis arising from acid-base imbalance, while elevated chloride suggests compensatory ionic shifts to maintain electrical neutrality. The correction of these imbalances by the spices mixture implies restoration of renal tubular integrity and improved acid-base regulation.

Mechanistically, the antioxidant and anti-inflammatory actions of spice-derived compounds might have preserved the structure and function of renal tubular epithelial cells, normalising Na^+/K^+ pump activity, and prevented electrolyte leakage. The slightly better acid-base recovery seen in the treatment group may be due to active neutralization of ROS after injury onset, while the prophylactic group exhibited greater ionic stability due to preconditioning effects on renal antioxidant defenses.

The observed modulation of plasma lipids following calcium carbide exposure indicates a disruption of hepatic lipid metabolism, characterized by elevated total cholesterol, LDL, and triglycerides, with reduced HDL. These alterations suggest oxidative modification of lipoproteins and interference with lipid catabolic enzymes such as lipoprotein lipase and hepatic lipase. ROS-mediated peroxidation of membrane phospholipids and upregulation of HMG-CoA reductase activity may also be have contributed to dyslipidemia (Ezeonu *et al*., 2024).
The normalization of lipid profiles by the spices mixture underscores its hypolipidemic and antioxidant potential. Capsaicin and curcumin are known to suppress hepatic cholesterol synthesis and enhance reverse cholesterol transport through activation of peroxisome proliferator-activated receptors (PPARs) and upregulation of LDL receptor expression (Kumar *et al*., 2023). Piperine and eugenol, on the other hand, enhance bile acid secretion and inhibit lipid peroxidation, collectively improving plasma lipid balance and reducing cardiovascular risk.

Haematological alterations observed in rats fed calcium carbide ripened plantain, including reduced haemoglobin, packed cell volume, and RBC count, reflect anemia of oxidative and possibly hemolytic origin. Reactive intermediates from calcium carbide might have induced erythrocyte membrane lipid peroxidation, leading to fragility and premature destruction of red blood cells (Chukwu *et al*., 2024). The observed increases in mean corpuscular volume and mean corpuscular haemoglobin suggest compensatory erythropoiesis with macrocytic features, while the elevated platelet count may indicate a stress-mediated thrombopoietic response to oxidative insult. Restoration of these parameters by the spices mixture points to its hematopoietic and membrane-stabilizing potential. Polyphenols, alkaloids, and essential oils present in spices such as ginger, garlic, and turmeric enhance erythropoietin secretion, improve iron metabolism, and protect erythrocytes from oxidative hemolysis (Nwozo *et al*., 2023). The higher hemoglobin and RBC values observed in the prophylactic group in this study suggest that pre-exposure administration of the mixture provided a protective buffer against oxidative erythrocyte damage, possibly through preconditioning of antioxidant enzyme systems and stabilization of red cell membranes.

Mechanistically, the hepatoprotective, nephroprotective, and haematoprotective effects of the spices mixture are interconnected through its modulation of oxidative stress, inflammation, and cellular metabolism. Spices contain a diverse array of bioactive phytochemicals that act synergistically to suppress lipid peroxidation, inhibit pro-inflammatory mediators, and enhance antioxidant enzyme expression. Curcumin and eugenol inhibit NF-κB signaling, thereby reducing cytokine-induced tissue injury, while capsaicin activates transient receptor potential vanilloid 1 (TRPV1) channels, improving microcirculation and oxygen delivery to tissues. Piperine enhances bioavailability of other compounds by inhibiting hepatic and intestinal glucuronidation, prolonging their systemic action. Together, these mechanisms might have contributed to restoration of organ function and hematological balance following toxic insult from calcium carbide exposure.

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CONCLUSION

The findings of this study reveal that consumption of calcium carbide–ripened plantain causes significant hepatic, renal, haematological, and metabolic disturbances in rats. These effects, characterized by elevated liver enzymes, impaired kidney function, disrupted electrolyte balance, altered lipid profiles, and anaemia, indicate systemic oxidative stress and inflammatory damage triggered by toxic calcium carbide residues. However, administration of a spice mixture rich in bioactive antioxidants such as curcumin, capsaicin, eugenol, and piperine markedly mitigated these adverse effects. Both prophylactic and therapeutic treatments improved liver and kidney function, restored electrolyte balance, normalized lipid metabolism, and enhanced haematological indices. Notably, prophylactic administration offered stronger protection, while post-treatment administration effectively reversed established toxicity. These findings underscore the protective and restorative potential of natural spices against xenobiotic-induced organ damage and oxidative imbalance.

RECOMMENDATIONS

Based on these results, stricter regulation and enforcement are recommended to prevent the use of calcium carbide and other harmful substances in artificial fruit ripening. Public awareness should be strengthened to discourage consumption of chemically ripened fruits. Incorporating antioxidant-rich spices such as turmeric, ginger, garlic, black pepper, and clove into daily diets is encouraged as a natural and affordable strategy for preventing oxidative stress and maintaining organ integrity. Prophylactic consumption of such spice blends may be particularly beneficial in populations exposed to food contaminants or environmental toxins.

Further research should focus on isolating and characterizing the specific phytochemicals responsible for the protective effects and elucidating their molecular mechanisms through modern biochemical and omics-based approaches. Long-term animal and human studies are also needed to validate the safety, efficacy, and therapeutic potential of these spices as nutraceuticals for liver, kidney, and haematological health maintenance.

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