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Musa cavendish ameliorates isoproterenol-induced renal and hepatic injury in Wistar rats

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ABSTRACT

Introduction
Isoproterenol (ISP) treatment is an established model for inducing myocardial infarction (MI). In acute MI, compromised renal function may result from preexisting kidney disease, acute renal failure, or the effects of pharmaceuticals and contrast agents used during diagnostic or therapeutic procedures, which are reflected by changes in biochemical indices.

Purpose
Musa cavendish (MC), commonly known as banana, is a staple food in many regions worldwide. MC has demonstrated ameliorative effects against hepato-renal damage caused by various pathologies. This study aimed to investigate the effects of *Musa cavendish* on isoproterenol-induced renal and hepatic injury in Wistar rats.

Methods
Wistar rats were divided into six groups. Groups 4 to 6 received MC at doses of 100, 200, and 400 mg/kg, respectively, for 30 days. Groups 2 to 6 were also administered ISP (85 mg/kg) on days 29 and 30.

Results
Results showed significant reductions in sodium, bicarbonate, and chloride levels, as well as elevations in urea and creatinine, which were reversed in the MC treatment groups. Additionally, increases in potassium, alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), albumin, and both direct and total bilirubin observed in the control groups were also reversed following MC treatment.

Conclusion
In conclusion, *Musa cavendish* ameliorates isoproterenol-induced renal and hepatic injury in Wistar rats.

INTRODUCTION

An established model for the induction of myocardial infarction (MI) is treatment with isoproterenol (ISP). Isoproterenol, a non-selective β-adrenergic agonist, is known to produce MI when administered at doses above therapeutic levels (up to 85 mg/kg; Huang et al., 2018). Following treatment, ISP induces heightened lipid peroxidation, depletion of antioxidants, production of inflammatory cytokines, intracellular Ca^{2+} overload, and apoptosis, ultimately resulting in myocardial necrosis (Boarescu et al., 2019). Continuous activation of β-adrenergic receptors by isoproterenol induces oxidative stress, myocardial inflammation, thrombosis, platelet aggregation, and calcium overload, which finally leads to myocardial infarction (Garg & Khanna, 2014). The expression of β-adrenergic receptors has been noted in various kidney subunits, including proximal tubules, glomeruli, and podocytes, and these receptors are involved in Na^+-ATPase activity and transcellular Na^+ transport through protein kinase C activation (Arif & Nihalani, 2019). Compromised renal function is a risk factor for cardiovascular disease and a negative prognostic indicator in patients with existing cardiovascular disease. In acute myocardial infarction, compromised renal function may arise from preexisting kidney disease, acute renal failure, and the influence of pharmaceuticals and contrast agents utilised during diagnostic or therapeutic interventions; this is often made evident by changes in biochemical indices (Lekston et al., 2009). Moreover, Zhou et al. (2022) used ISP to construct a kidney injury model and studied the ameliorative effects of sophocarpine on ISP-induced kidney injury. The model demonstrated that inflammatory cytokines such as IL-1β, IL-6, TNF-α, MCP-1, and NLRP3 increased following ISP challenge. Furthermore, at the doses of ISP used for MI induction, hepatic injury was also observed. Zhou et al. (2022) reported increased serum AST and total protein levels in rats treated with ISP at 3.0 mg/kg.

Similarly, Zhang et al. (2024) assessed the detrimental effects of ISP on major organs and the potential reversibility of these adverse effects in mice. They found that ISP doses of 0.2 mg/kg and 3.0 mg/kg caused liver damage, with the higher dose producing more severe injuries.

Musa cavendish, commonly known as banana, is a staple food in many regions of the world. *Musa cavendish* peels have demonstrated nephroprotective properties and glucose-lowering effects in alloxan-induced diabetic rats (Navghare & Dhawale, 2016). Additionally, *Musa cavendish* has ameliorated hepato-renal damage and exerted anti-inflammatory and anti-apoptotic effects in metal mixture–mediated hepatic nephropathy via activation of Nrf2/Hmox-1 and inhibition of the NF-κB pathway (Eddie-Amadi et al., 2022).

Despite the availability of drugs such as propranolol for the management of myocardial infarction, there remains a need for other readily available and accessible alternatives. This study, therefore, aimed to investigate the effects of *Musa cavendish* on isoproterenol-induced renal and hepatic injury in Wistar rats, highlighting its potential benefits in human studies to combat the rising incidence and prevalence of myocardial infarction.

METHOD

Experimental Animals

Healthy adult male Wistar rats aged 12–15 weeks and weighing 220–280 g were randomly selected for the study. The animals were sourced from the Animal House of the Pharmacology Department at Delta State University, Abraka, Delta State, Nigeria. The rats underwent a 14-day acclimatization period under controlled temperature and relative humidity, with a 12:12 light–dark cycle. They were provided with standard animal pellet feed and clean water ad libitum.

Ethical Considerations

All animal handling and experiments adhered to the guidelines established by the National Institute of Health Guide for the Care and Use of Laboratory Animals and were approved by the ethical committee of the Faculty of Basic Medical Sciences, Delta State University, Abraka (Ethical clearance No: RBC/FBMC/DELSU/24/648).

Plant Extraction

The pulp of *Musa cavendish* (MC) was separated from the bark, washed, rinsed, and diced. The diced samples were dried at room temperature until a consistent weight was achieved. The dried Musa pulp was crushed into powder and stored in an airtight plastic container at room temperature. The powdered pulp was dissolved in distilled

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water and allowed to stand for 72 hours at room temperature, stirred regularly with a glass rod, and then filtered using Whatman No. 1 filter paper to obtain the crude aqueous extract of *Musa cavendish*. The filtrate was concentrated using a lyophilizer and stored in the refrigerator when not in use.

Research Design

This study employed an experimental design. Rats were divided into six groups receiving the following treatments:

- Group 1: Distilled water (normal control)
- Group 2: ISP + distilled water (negative control)
- Group 3: ISP + propranolol (PRO) + distilled water (positive control)
- Group 4: ISP + MC (100 mg/kg)
- Group 5: ISP + MC (200 mg/kg)
- Group 6: ISP + MC (400 mg/kg)

(Doses: distilled water 10 mg/kg orally; ISP 85 mg/kg subcutaneously; PRO 0.5 mg/kg; MC doses as above)

Measurement of Renal Indices

Renal indices were measured using established protocols: creatinine (Heinegård & Tiderström, 1973), urea (Tobacco, 1979), sodium (Maruna, 1958), potassium (Berry et al., 1989), calcium (Leary et al., 1992), serum bicarbonate (Forrester et al., 1976), and chloride (Skeggs & Hochstrasser, 1964).

Determination of Liver Enzymes

Alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) were measured as described by Reitman and Frankel (1957), while total protein (TP) concentration was determined following Weichselbaum (1946).

Statistical Analysis

Data were presented as mean ± SEM. Results were analysed using one-way analysis of variance (ANOVA), followed by Student's Newman–Keuls post hoc test to determine the source of significant main effects, using GraphPad InStat® Biostatistics software. Statistical significance was set at $p < 0.05$.

RESULTS

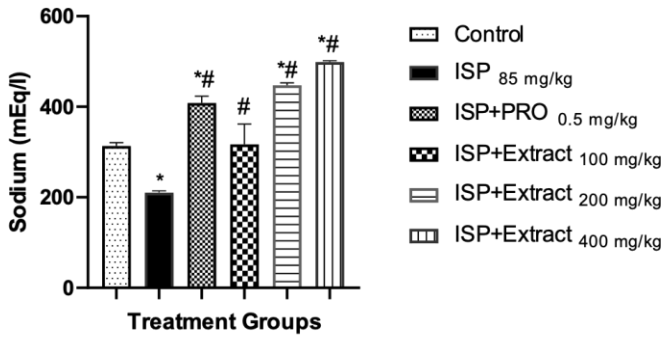
Effects of Aqueous MC Extract on Renal Indices in Isoproterenol-Induced Myocardial Infarction

Figures 1 to **5** and **Table 1** reflect the renal biochemical changes caused by ISP-induced myocardial infarction in Wistar rats and the role of *Musa cavendish* in reversing or preventing these changes.

Effects of Aqueous MC Extract on Serum Sodium Concentration

Figure 1 shows a significant decrease ($p < 0.05$) in serum sodium concentration in the ISP group compared to the normal control group. Marked and significant elevations ($p < 0.05$) were observed in the treatment groups administered MC at 100, 200, and 400 mg/kg when compared with the ISP control group. Furthermore, compared to the normal control group, the MC extract treatment groups at 200 and 400 mg/kg demonstrated a significant increase ($p < 0.05$) in sodium concentration.

Figure 1:
Effects of aqueous MC extract treatment on serum sodium concentration in isoproterenol-induced myocardial infarction

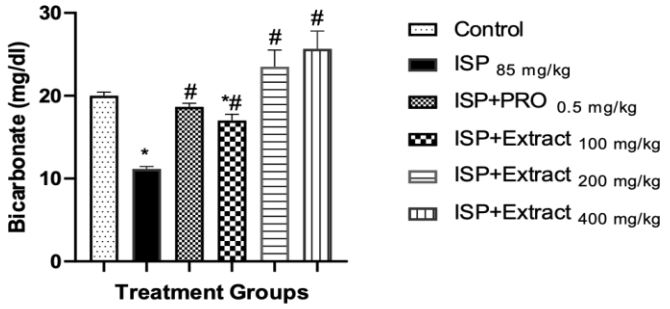


All values are expressed as mean ± standard error of the mean (SEM); $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Serum Bicarbonate Concentration

Figure 2 shows a significant decrease ($p < 0.05$) in serum bicarbonate concentration in the ISP group compared to the normal control group, and a marked and significant elevation ($p < 0.05$) in the treatment group administered MC extract at 100 mg/kg compared to the ISP control group.

Figure 2:
Effects of aqueous MC extract treatment on serum bicarbonate concentration in isoproterenol-induced myocardial infarction



All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Serum Potassium and Calcium Concentrations

Table 1 shows a significant decrease ($p < 0.05$) in serum potassium concentration in the ISP group compared to the normal control group. The treatment group administered MC extract at 100 mg/kg demonstrated a marked and significant elevation ($p < 0.05$) in serum potassium concentration compared with the ISP control group.

Serum calcium was significantly elevated in the MI control group compared to the normal control. Treatment groups at 100, 200, and 400 mg/kg also showed elevated calcium compared to the negative control group, with only the 200 and 400 mg/kg groups exhibiting statistically significant elevations ($p < 0.05$).

Table 1:
Effects of Aqueous MC Extract on Serum Potassium and Calcium Concentrations

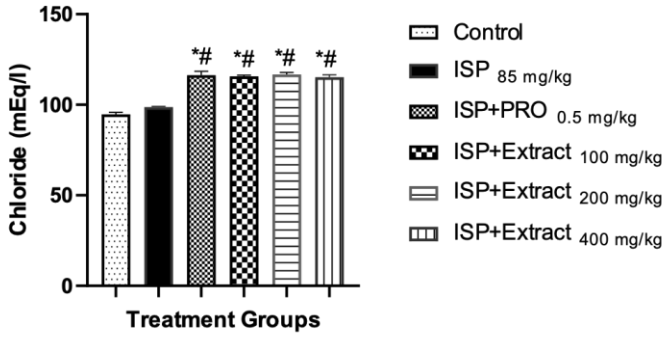
Group	K^+ (mEq/L)	Ca^{2+} (mEq/L)
Control	3.90 ± 0.09	4.07 ± 0.52
ISP	2.35 ± 0.05*	5.90 ± 0.09*
ISP + PRO 5 mg/kg	3.80 ± 0.41#	6.77 ± 0.74*
ISP + Extract 100 mg/kg	3.57 ± 0.28#	6.30 ± 1.34*
ISP + Extract 200 mg/kg	3.70 ± 0.77#	8.23 ± 0.67*#
ISP + Extract 400 mg/kg	4.55 ± 0.10#	8.47 ± 0.45*#

All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ compared to normal control; # = $p < 0.05$ compared to MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC); K^+ = Potassium ion; Ca^{2+} = Calcium ion

Effects of Aqueous MC Extract on Serum Chloride Concentration

Figure 3 shows no significant difference in serum chloride concentration between the ISP and normal control groups. However, the treatment groups administered MC extract at 100, 200, and 400 mg/kg demonstrated marked and significant elevations ($p < 0.05$) in serum chloride compared with both the normal control and ISP control groups.

Figure 3:
Effects of aqueous MC extract treatment on serum chloride concentration in isoproterenol-induced myocardial infarction

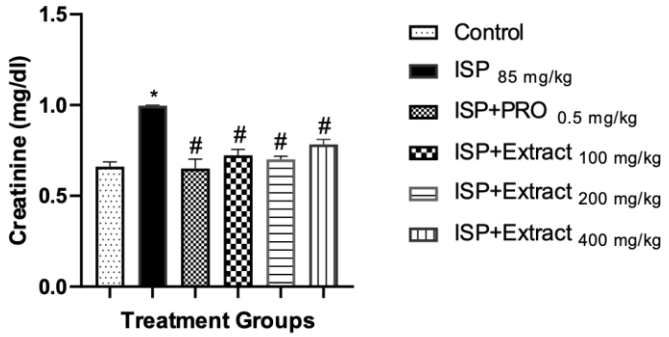


All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Serum Creatinine Concentration

Figure 4 shows a significant increase ($p < 0.05$) in serum creatinine concentration in the ISP group compared to the normal control group. The treatment groups administered MC extract at 100, 200, and 400 mg/kg demonstrated marked and significant reductions ($p < 0.05$) in serum creatinine compared to the ISP control group.

Figure 4:
Effects of aqueous MC extract treatment on serum creatinine concentration in isoproterenol-induced myocardial infarction



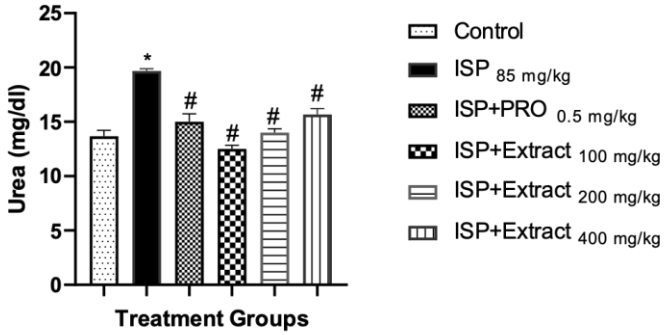
All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Serum Urea Concentration

Figure 5 shows a significant increase ($p < 0.05$) in serum

urea concentration in the ISP group compared to the normal control group. The treatment groups administered MC extract at 100, 200, and 400 mg/kg demonstrated significant reductions ($p < 0.05$) in serum urea compared with the ISP control group.

Figure 5:
Effects of aqueous MC extract treatment on serum urea concentration in isoproterenol-induced myocardial infarction



All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

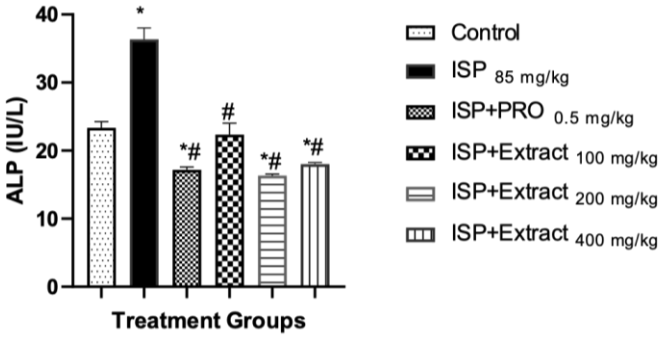
Effects of Aqueous MC Extract on Liver Indices in Isoproterenol-Induced Myocardial Infarction

Figures 6 to **12** show biochemical changes in the liver caused by ISP-induced myocardial infarction in Wistar rats and the role of *Musa cavendish* in reversing or preventing these changes.

Effects of Aqueous MC Extract on Alkaline Phosphatase (ALP)

Figure 6 shows a significant increase ($p < 0.05$) in serum ALP concentration in the ISP group compared to the normal control group. Treatment groups administered MC extract at 100, 200, and 400 mg/kg showed significant decreases ($p < 0.05$) in serum ALP compared to the ISP control group. Only the 200 and 400 mg/kg groups were significantly reduced ($p < 0.05$) compared to the normal control group.

Figure 6:
Effects of aqueous MC extract treatment on serum ALP concentration in isoproterenol-induced myocardial infarction

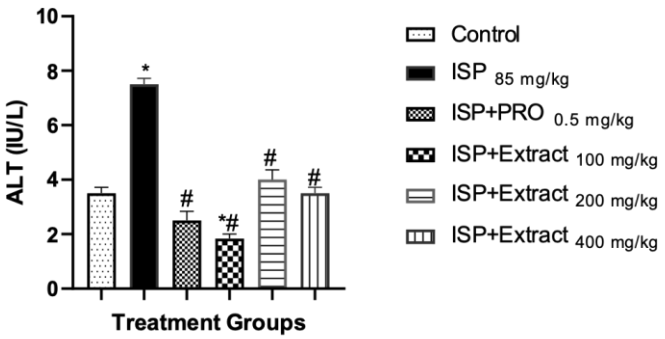


All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Alanine Transaminase (ALT)

Figure 7 shows a significant increase ($p < 0.05$) in serum ALT concentration in the ISP group compared to the normal control group. Treatment groups administered MC extract at 100, 200, and 400 mg/kg demonstrated significant decreases ($p < 0.05$) in serum ALT compared to the ISP control group. The 100 mg/kg MC extract group also showed a significant decrease ($p < 0.05$) compared to the normal control.

Figure 7:
Effects of aqueous MC extract treatment on serum ALT concentration in isoproterenol-induced myocardial infarction



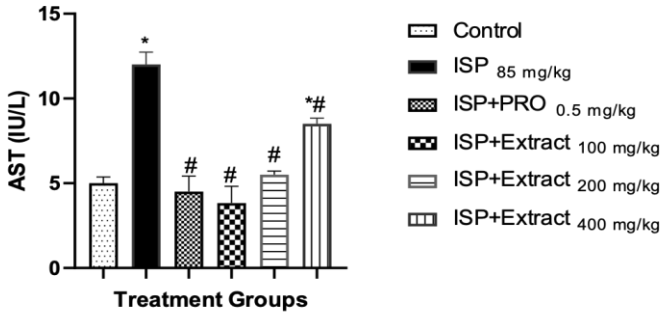
All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Aspartate Aminotransferase (AST)

Figure 8 shows a significant increase ($p < 0.05$) in serum AST concentration in the ISP group compared to the normal control group. Treatment groups administered MC extract at 100, 200, and 400 mg/kg demonstrated significant

decreases ($p < 0.05$) in serum AST compared to the ISP control group. The 400 mg/kg MC extract group also showed a significant increase ($p < 0.05$) compared to the normal control.

Figure 8:
Effects of aqueous MC extract treatment on serum AST concentration in isoproterenol-induced myocardial infarction

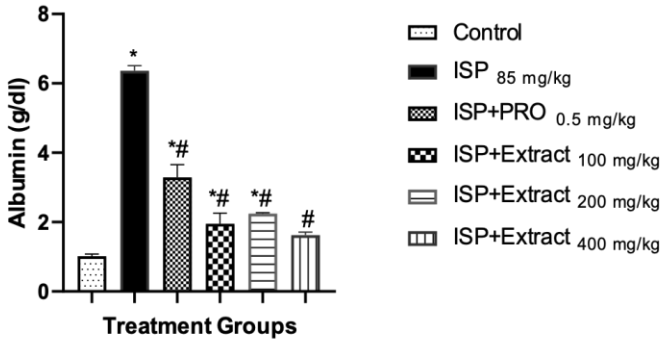


All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Albumin

Figure 9 shows a significant increase ($p < 0.05$) in serum albumin concentration in the ISP group compared to the normal control group. Treatment groups administered MC extract at 100, 200, and 400 mg/kg demonstrated significant decreases ($p < 0.05$) in serum albumin compared to the ISP control group. The 400 mg/kg MC extract group also showed a significant increase ($p < 0.05$) compared to the normal control.

Figure 9:
Effects of aqueous MC extract treatment on serum albumin concentration in isoproterenol-induced myocardial infarction

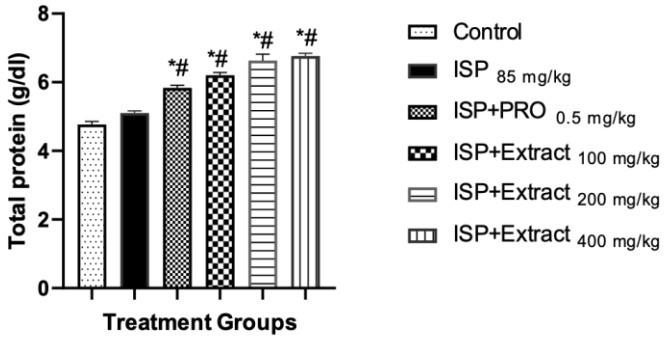


All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Total Protein

Figure 10 shows no significant change ($p > 0.05$) in total protein concentration between the ISP and normal control groups. Treatment groups administered MC extract at 100, 200, and 400 mg/kg showed significant increases ($p < 0.05$) in total protein compared to both ISP and normal control groups.

Figure 10:
Effects of aqueous MC extract treatment on total protein in isoproterenol-induced myocardial infarction

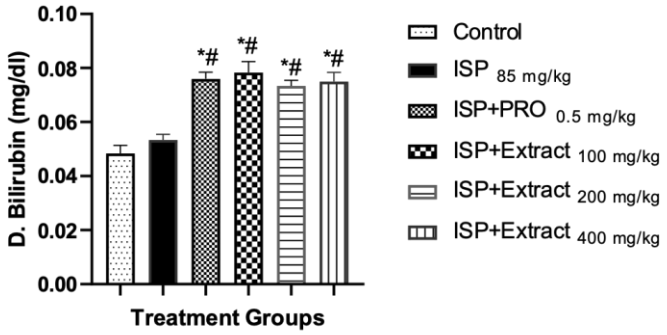


All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC)

Effects of Aqueous MC Extract on Direct Bilirubin Concentration

Figure 11 shows no significant increase ($p > 0.05$) in direct bilirubin concentration in the ISP group compared to the normal control group. Treatment groups administered MC extract at 100, 200, and 400 mg/kg showed significant increases ($p < 0.05$) in direct bilirubin compared to both ISP and normal control groups.

Figure 11:
Effects of aqueous MC extract treatment on serum direct bilirubin concentration in isoproterenol-induced myocardial *infarction*

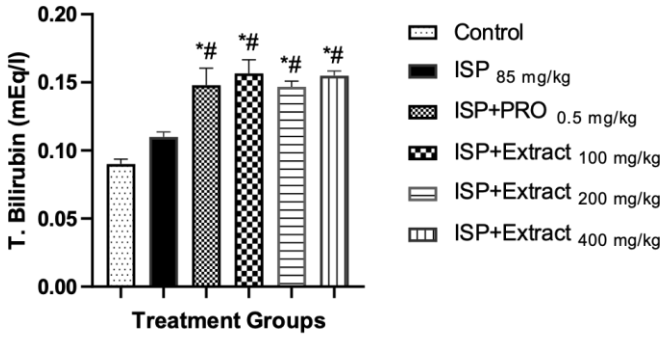


All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC); D. bilirubin = Direct bilirubin

Effects of Aqueous MC Extract on Total Bilirubin Concentration

Figure 12 shows no significant increase ($p > 0.05$) in total bilirubin concentration in the ISP group compared to the normal control group. Treatment groups administered MC extract at 100, 200, and 400 mg/kg showed significant increases ($p < 0.05$) in total bilirubin compared to both ISP and normal control groups.

Figure 12:
Effects of aqueous MC extract treatment on serum total bilirubin concentration in isoproterenol-induced myocardial infarction



All values are expressed as mean ± SEM; $n = 6$; * = $p < 0.05$ when compared with normal control; # = $p < 0.05$ when compared with MI control. Control = Normal control; ISP = Isoproterenol; PRO = Propranolol; Extract = *Musa cavendish* (MC); T. bilirubin = Total bilirubin

DISCUSSION

Effects on Renal Indices

Potassium

The results of potassium in this study reveal significant implications for the protective and therapeutic role of *Musa cavendish* in isoproterenol-induced myocardial infarction. It has often been postulated anecdotally that banana holds significant potential in maintaining normal body potassium levels as well as managing hypokalemia. Quan et al. (2024), who studied the effect of banana intake on serum potassium levels in patients undergoing maintenance haemodialysis, concluded that consuming approximately 250 g of bananas at the start of haemodialysis does not lead to hyperkalemia. However, it can effectively reduce the incidence of hypokalemia and arrhythmias, and prevent a rapid decline in serum potassium levels during haemodialysis. Both hypokalemia and hyperkalemia are variably found at presentation in myocardial infarction (MI) and have been the basis of research into the role of potassium in both the occurrence and severity of MI. The clinical study by Ravn et al. (2020) reviewed the prevalence of MI patients with potassium disturbances at presentation and found more hypokalemic cases (20.8%) than hyperkalemic cases (1.6%), with most being normokalemic (77.6%). Moreover, potassium disturbances were found to lead to a higher frequency of ventricular arrhythmia and cardiac arrest (Ravn et al., 2020).

Furthermore, numerous pharmacological agents and strategies have been used for cardiac protection and reduction of infarct size in patients with MI. Aside from agents or devices that can restore and maintain reperfusion, only beta-blockers have been shown to have cardioprotective effects (Hammerman et al., 1984). This plays a significant therapeutic role in MI, especially in patients with a high circulating adrenergic concentration, as replicated by induction of MI with isoproterenol, a non-selective sympathomimetic catecholamine (Ma et al., 2023). This study found a non-significant reduction in serum potassium in the negative control group compared to the normal control, consistent with existing knowledge on the effects of isoproterenol on serum potassium (Brembilla-Perrot et al., 1993; Dhalla et al., 2024). Dhalla et al. (2024) further describe the mechanism by which this hypokalemic effect is achieved as depression of the sodium-potassium ATPase (Na^+/K^+ ATPase) pump. The opposing effects of beta blockers such as propranolol on isoproterenol and consequently on serum potassium, as reported by other authors, were also evident in this study. The effects of *Musa cavendish* on serum potassium in isoproterenol-induced myocardial infarction are as presented in **Table 1** and are similar to the prophylactic effects of *Costus* and selenium nanoparticles on serum potassium in isoproterenol-induced MI documented by Abbas et al. (2022).

Calcium

This study showed a significant increase in serum calcium in the MI control group compared to the normal control animals. Furthermore, the treatment groups (200 mg/kg and 400 mg/kg) also demonstrated significant increases in serum calcium compared to the 100 mg/kg treatment group as well as the positive and negative control groups. These patterns differ from those reported by Abbas et al. (2022), who found that while isoproterenol-only treated animals had a significant increase in serum calcium, treatment with *Costus* or selenium nanoparticles caused a decrease in serum calcium. This discrepancy may be

explained by the fact that *Musa cavendish* has been shown to contain a high concentration of dietary calcium and, according to Keivani et al. (2020), causes an increase in measured serum calcium. However, this does not bode well for the possible preventive or therapeutic effects of *Musa cavendish* on isoproterenol-induced myocardial infarction, as high serum calcium concentrations are associated with increased cardiovascular disease risk (Bolland et al., 2010; Larsson et al., 2017) and increased mortality in MI (Shiyovich et al., 2018).

Urea and Creatinine

This study found a significant increase in serum urea and creatinine in animals treated with isoproterenol, which was alleviated in the *Musa cavendish* treatment groups, but not in a dose-dependent manner. Lobo Filho et al. (2011) and Subashini and Rajadurai (2011) similarly found increases in serum urea, but only Subashini and Rajadurai (2011) reported creatinine results comparable to those in this study.

Effects on Liver Biomarkers

In the absence of structural liver diseases, elevated liver enzymes may result from hepatic hypoperfusion due to low cardiac output ("shock liver") or from elevated central venous filling pressures due to right ventricular failure with passive liver congestion (Alvarez & Mukherjee, 2011). Both conditions may arise from decompensated chronic heart failure or acute heart failure following myocardial infarction. Thus, elevated liver enzymes and cardiac performance are tightly linked, with increases in aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), total bilirubin (TB), and gamma-glutamyl transferase (GGT). In shock liver, transaminase elevations are usually markedly higher compared to congestive liver damage (Huseynov et al., 2016). In this study, ALP values were significantly reduced in the 200 mg/kg and 400 mg/kg treatment groups compared to the normal control, but there was no significant difference compared to the negative control. The variance in ALP concentration changes between this study and that by Huseynov et al. (2016) may be due to methodology; shock liver typically develops over a longer period than allowed in this study's protocol.

Effects on ALP, AST, and ALT

Serum AST is mainly found in the liver, cardiac muscle, and other tissues, whereas serum ALT is primarily found in the liver (Kalra et al., 2018). Increased ALP is associated with poor clinical outcomes in patients with ST-elevation myocardial infarction (STEMI); elevated ALP levels at presentation—even within the upper limit of normal—are independently associated with a higher risk of major adverse events after primary percutaneous coronary intervention (PCI) for STEMI (Tonelli et al., 2009). These enzymes are sensitive indicators of liver cell injury but are also useful in diagnosing and prognosticating diseases such as MI (Djakpo et al., 2020). This study found a significant increase in ALP, AST, and ALT in the ISP treatment group compared to the normal control, with a corresponding significant difference in the *Musa cavendish* treatment groups compared to the negative control. These results align with findings by Tonelli et al. (2009), Subashini and Rajadurai (2011), and Abbas et al. (2022), further validating the study's protocols and demonstrating a protective effect of *Musa cavendish* on isoproterenol-induced myocardial injury. The significant difference in the AST/ALT ratio between the *Musa cavendish* treatment groups and the ISP treatment groups also suggests that *Musa cavendish* may play an instrumental role in limiting mortality and morbidity from MI.

Effects on Albumin

Albumin is the most abundant plasma protein and plays a regulatory role in body fluid distribution, acid-base physiology, and binding of essential components in the bloodstream (Sheinenzon et al., 2021). This study showed a statistically significant increase ($p < 0.05$) in albumin levels in groups 3 to 6 compared to the normal control; this increase was preserved only in group 6 when compared to the negative control. This finding aligns with other studies showing that low serum albumin concentrations are associated with first incident acute myocardial infarction (AMI) in a dose–response manner across age groups and sexes in the Chinese Han population. A meta-analysis demonstrated that a 4 g/L difference in serum albumin predicted a 50% increased risk of coronary artery disease (CAD). The adjusted risk ratios for MI were 1.49 (95% CI, 1.01–2.21) for men and 2.12 (1.06–4.27) for women, comparing those in the bottom third to those in the top third of serum albumin levels (He et al., 2016; Xia et al., 2018).

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Effects on Serum Bilirubin

Direct and total bilirubin levels in groups 3 to 6 were significantly higher than those in groups 1 and 2 ($p < 0.05$). This corresponds with findings by Keivani et al. (2019), who reported significant increases in total bilirubin after administration of *Musa cavendish*. Additionally, the high amounts of unsaturated fatty acids (linolenic, linoleic, and oleic acids) in banana pulp correlate with bilirubin concentrations (Oliveira et al., 2008). Serum bilirubin is a marker of heme oxygenase activity and has been suggested as a predictor of thrombus burden in AMI patients. Hamur et al. (2015) found that patients with high thrombus burden had higher total bilirubin levels. Bilirubin is also an important endogenous antioxidant; physiologically increased total bilirubin is associated with reduced risk of first myocardial infarction but is linked to increased risk of major adverse cardiac events (MACEs) in stable CAD patients. These findings correspond with the index study results, showing serum bilirubin peaks 21 hours after coronary intervention (Okuhara et al., 2010; Yao et al., 2015). This suggests a protective role of *Musa cavendish* in isoproterenol-induced MI. However, the use of serum total bilirubin levels to predict MACEs and long-term mortality remains conflicting (Shen, 2019).

Limitations

This study utilised isoproterenol to induce hepato-renal damage resulting from both direct toxicity of the drug and indirect effects on the heart, specifically myocardial infarction. The inability to differentiate between direct and indirect impacts is a limitation. Isoproterenol is not used clinically; nonetheless, the indirect consequences are pertinent as myocardial infarction results in hepato-renal impairment. Therefore, further studies are needed to determine whether the hepato-renal damage induced by isoproterenol is direct or indirect. Additionally, imaging and histological studies were not conducted due to logistical and financial constraints, which are recommended for future research.

CONCLUSION

Whereas isoproterenol induces significant and extensive hepato-renal damage, *Musa cavendish* appears protective of renal impairment, as demonstrated by decreased urea, creatinine, and electrolyte levels. Changes in liver indices following *Musa cavendish* administration also indicate amelioration of isoproterenol-induced damage. Although there was a significant calcium increase in rats treated with isoproterenol that was not reversed by *Musa cavendish*, this did not counteract the ameliorative effects on hepato-renal damage. There are documented severe affectations of renal and hepatic tissues in patients with acute myocardial infarction, similar to those simulated by isoproterenol in this study.

Recommendations

Despite the limitations of this study, the findings suggest that *Musa cavendish* (MC) may offer protective benefits against the hepato-renal complications associated with myocardial infarction. It is therefore recommended that further research be conducted to explore the translational potential of MC in human subjects who are at risk of developing myocardial infarction. Dietary supplementation with MC could represent an affordable, accessible, and cost-effective preventive strategy for mitigating myocardial infarction-related complications in high-risk individuals.

Ethical Approval: Ethical approval was obtained prior to the commencement of the experiment (Ethical clearance No: RBC/FBMC/DELSU/24/648).

Conflicts of Interest: None declared.

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REFERENCES

Abbas, M. M., Abdelmonem, H. A., & Mahmoud, A. H. (2022). Prophylactic effect of *Costus* and selenium nanoparticles in isoproterenol induced myocardial infarction in rats. *The Egyptian Journal of Hospital Medicine, 89*(1), 4817–4823.

Alvarez, A. M., & Mukherjee, D. (2011). Liver abnormalities in cardiac diseases and heart failure. *International Journal of Angiology, 20*(3), 135–142.

Arif, E., & Nihalani, D. (2019). Beta2-adrenergic receptor in kidney biology: A current prospective. *Nephrology, 24*(5), 497–503.

Berry, M., Mazzachi, R., Pejakovic, M., & Peake, M. (1989). Enzymatic determination of potassium in serum. *Clinical Chemistry, 35*(5), 817–820.

Boarescu, P. M., Boarescu, I., Bocşan, I. C., Pop, R. M., Gheban, D., Bulboacă, A. E., ... & Bolboacă, S. D. (2019). Curcumin nanoparticles protect against isoproterenol induced myocardial infarction by alleviating myocardial tissue oxidative stress, electrocardiogram, and biological changes. *Molecules, 24*(15), 2802.

Bolland, M. J., Avenell, A., Baron, J. A., Grey, A., MacLennan, G. S., Gamble, G. D., & Reid, I. R. (2010). Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: Meta-analysis. *BMJ, 341*, c3691.

Brembilla-Perrot, B., de la Chaise, A. T., Le Van, D., & Beurrier, D. (1993). Effect of isoproterenol on serum potassium and magnesium. *European Heart Journal, 14*(5), 677–681.

Dhalla, N. S., Elimban, V., & Adameova, A. D. (2024). Role of Na+-K+ ATPase alterations in the development of heart failure. *International Journal of Molecular Sciences, 25*(19), 10807.

Djakpo, D. K., Wang, Z. Q., & Shrestha, M. (2020). The significance of transaminase ratio (AST/ALT) in acute myocardial infarction. *Archives of Medical Science - Atherosclerotic Diseases, 5*(1), 279–283.

Eddie-Amadi, B. F., Ezejiofor, A. N., Orish, C. N., Rovira, J., Allison, T. A., & Orisakwe, O. E. (2022). Banana peel ameliorated hepato-renal damage and exerted anti-inflammatory and anti-apoptotic effects in metal mixture mediated hepatic nephropathy by activation of Nrf2/Hmox-1 and inhibition of Nfkb pathway. *Food and Chemical Toxicology, 170*, 113471.

Forrester, R. L., Wataji, L. J., Silverman, D. A., & Pierre, K. J. (1976). Enzymatic method for the determination of CO2 in serum. *Clinical Chemistry, 22*, 243.

Garg, M., & Khanna, D. (2014). Exploration of pharmacological interventions to prevent isoproterenol-induced myocardial infarction in experimental models. *Therapeutic Advances in Cardiovascular Disease, 8*(4), 155–169.

Hammerman, H., Kloner, R. A., Briggs, L. L., & Braunwald, E. (1984). Enhancement of salvage of reperfused myocardium by early beta-adrenergic blockade (timolol). *Journal of the American College of Cardiology, 3*(6), 1438–1443.

Hamur, H., Duman, H., Bakirci, E. M., Kucuksu, Z., Demirelli, S., Kalkan, K., & Degirmenci, H. (2016). Bilirubin levels and thrombus burden in patients with ST-segment elevation myocardial infarction. *Angiology, 67*(6), 565–570.

He, Y. M., Yang, Q., Yang, X. J., Zhao, X., Xu, H. F., & Qian, Y. X. (2016). Serum albumin concentrations, effect modifiers and first incident acute myocardial infarction: A cross-sectional study of 1552 cases and 6680 controls. *Clinica Chimica Acta, 454*, 49–56.

Heinegard, D., & Tiderstrom, G. (1973). Determination of serum creatinine by a direct colorimetric method. *Clinica Chimica Acta, 43*, 305.

Huang, H., Geng, Q., Yao, H., Shen, Z., Wu, Z., Miao, X., & Shi, P. (2018). Protective effect of scutellarin on myocardial infarction induced by isoprenaline in rats. *Iranian Journal of Basic Medical Sciences, 21*(3), 267.

Huseynov, A., Baumann, S., Becher, T., Koepp, J., Lang, S., Jabbour, C., ... & Akin, I. (2016). Liver and cholestatic parameters as prognostic biomarkers of in-hospital MACE in patients with STEMI. *European Journal of Clinical Investigation, 46*(8), 721–729.

Kalra, A., Yetiskul, E., Wehrle, C. J., & Tuma, F. (2018). Physiology, liver.

Keivani Rad, N., Mohri, M., Seifi, H. A., & Haghparast, A. (2020). The effects of administration of different parts of banana (*Musa cavendish*) fruit extracts and peel powder on the oxidative/antioxidative characteristics and some mineral concentrations in neonatal dairy calves. *Iranian Journal of Veterinary Science and Technology, 12*(1), 37–45.

Larsson, S. C., Burgess, S., & Michaëlsson, K. (2017). Association of genetic variants related to serum calcium levels with coronary artery disease and myocardial infarction. *JAMA, 318*(4), 371–380.

Leary, N., Pembroke, A., & Duggan, P. (1992). Single stable reagent (Arsenazo III) for optically robust measurement of calcium in serum and plasma. *Clinical Chemistry, 38*(6), 904–908.

Lekston, A., Kurek, A., & Tynior, B. (2009). Impaired renal function in acute myocardial infarction. *Cardiology Journal, 16*(5), 400–406.

Lobo Filho, H. G., Ferreira, N. L., Sousa, R. B. D., Carvalho, E. R. D., Lobo, P. L. D., & Lobo Filho, J. G. (2011). Experimental model of myocardial infarction induced by isoproterenol in rats. *Brazilian Journal of Cardiovascular Surgery, 26*, 469–476.

Ma, G., Ma, K., Li, M., Liang, R., Guo, Z., Xiao, Y., ... & Liang, W. (2023). The mechanism of isoproterenol hydrochloride-induced cardiac arrhythmia and the effect of propranolol through the CaMKII pathway.

Maruna, R. F. L. (1958). Colorimetric determination of sodium in human serum and plasma. *Clinica Chimica Acta, 2*, 581.

Navghare, V., & Dhawale, S. (2016). Suppression of type-II diabetes with dyslipidemia and nephropathy by peels of *Musa cavendish* fruit. *Indian Journal of Clinical Biochemistry, 31*, 380–389.

Okuhara, K., Kisaka, T., Ozono, R., Kurisu, S., Inoue, I., Soga, J., ... & Yoshizumi, M. (2010). Change in bilirubin level following acute myocardial infarction is an index for heme oxygenase activation. *Southern Medical Journal, 103*(9), 876–881.

Oliveira, L., Freire, C. S., Silvestre, A. J., & Cordeiro, N. (2008). Lipophilic extracts from banana fruit residues: A source of valuable phytosterols. *Journal of Agricultural and Food Chemistry, 56*(20), 9520–9524.

Quan, Z., Li, C., Zhao, L., Cui, D., Liu, S., Yin, Y., ... & Fu, X. (2024). Effect of banana intake on serum potassium level in patients undergoing maintenance hemodialysis: A randomized controlled trial. *International Journal of Nursing Sciences, 11*(2), 197–204.

Ravn Jacobsen, M., Jabbari, R., Glinge, C., Kjær Stampe, N., Butt, J. H., Blanche, P., ... & Engstrøm, T. (2020). Potassium disturbances and risk of ventricular fibrillation among patients with ST-segment–elevation myocardial infarction. *Journal of the American Heart Association, 9*(4), e014160.

Reitman, S., & Frankel, S. (1957). A colorimetric method for the determination of serum glutamic oxalacetic and glutamic pyruvic transaminases. *American Journal of Clinical Pathology, 28*, 56–63.

Sheinenzon, A., Shehadeh, M., Michelis, R., Shaoul, E., & Ronen, O. (2021). Serum albumin levels and inflammation. *International Journal of Biological Macromolecules, 184*, 857–862.

Shen, H., Zeng, C., Wu, X., Liu, S., & Chen, X. (2019). Prognostic value of total bilirubin in patients with acute myocardial infarction: A meta-analysis. *Medicine, 98*(3), e13920.

Shiyovich, A., Plakht, Y., & Gilutz, H. (2018). Serum calcium levels independently predict in-hospital mortality in patients with acute myocardial infarction. *Nutrition, Metabolism and Cardiovascular Diseases, 28*(5), 510–516.

Skeggs, L. T., & Hochstrasser, H. C. (1964). Thiocyanate (colorimetric) method of chloride estimation. *Clinical Chemistry, 10*, 918.

Subashini, R., & Rajadurai, M. (2011). Evaluation of cardioprotective efficacy of *Nelumbo nucifera* leaf extract on isoproterenol-induced myocardial infarction in Wistar rats. *International Journal of Pharma and Biosciences, 2*, 285–294.

Tobacco, A. (1979). Quantitative enzymatic colorimetric determination of urea. *Clinical Chemistry, 25*, 336.

Tonelli, M., Curhan, G., Pfeffer, M., Sacks, F., Thadhani, R., Melamed, M. L., ... & Muntner, P. (2009). Relation between alkaline phosphatase, serum phosphate, and all-cause or cardiovascular mortality. *Circulation, 120*(18), 1784–1792.

Weichselbaum, C. T. (1946). An accurate and rapid method for the determination of proteins in small amounts of blood serum and plasma. *American Journal of Clinical Pathology, 16*(3), 40–49.

Xia, M., Zhang, C., Gu, J., Chen, J., Wang, L. C., Lu, Y., ... & Yang, X. J. (2018). Impact of serum albumin levels on long-term all-cause, cardiovascular, and cardiac mortality in patients with first-onset acute myocardial infarction. *Clinica Chimica Acta, 477*, 89–93.

Yao, H. M., Shen, D. L., Zhao, X. Y., Wang, X. F., Sun, T. W., Zhang, J. Y., ... & Zhao, L. S. (2015). Prognostic value of total bilirubin in patients with angina pectoris

undergoing percutaneous coronary intervention. *International Journal of Clinical and Experimental Medicine, 8*(9), 15930.

Zhang, X. T., Zhang, X., Wang, M. W., Zhang, C., Weng, R., Xu, X., ... & Gao, J. P. (2024). Multiple organs injury and myocardial energy metabolism disorders induced by isoproterenol. *Toxicology, 503*, 153752.

Zhou, W., Fu, Y., & Xu, J. S. (2022). Sophocarpine alleviates isoproterenol-induced kidney injury by suppressing inflammation, apoptosis, oxidative stress and fibrosis. *Molecules, 27*(22), 7868.