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HEPATORENAL PROTECTIVE FUNCTIONS OF COCONUT WATER IN ALLOXAN-INDUCED TYPE 1 DIABETES MELLITUS

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Abstract

Coconut water is a natural product reported to contain antioxidant compounds with beneficial health effects. This study aimed to evaluate the antidiabetic effect of mature coconut water on some biochemical parameters of liver and kidney functions, and histological architecture of the pancreas in alloxan-induced diabetic rats. Twenty-four (24) Wistar rats were randomly divided into four groups, (n=6). Group I (negative control) rats were fed with rat chow and drinking water *ad libitum* and did not receive alloxan. Group II (positive control) received a single intraperitoneal dose of 150mg/kg body weight of alloxan to induce type 1 diabetes mellitus. Groups III and IV received a single intraperitoneal dose of 150mg/kg body weight of alloxan and were treated with 1ml/kg of mature coconut water for 3 weeks and 2mg/kg of glibenclamide for 3 weeks respectively by oral administration. On day 21, blood samples were collected for liver and kidney function tests. Liver function tests for Group II showed elevated aspartate transaminase (AST), alkaline phosphatase (ALP), albumin, total protein, total bilirubin, and low alanine aminotransferase (ALT) (p<0.05). When compared with Group II, Group III showed elevated liver function parameters except ALT that was reduced (p<0.05). Group IV showed elevated AST, total bilirubin, and reduced ALT, ALP, albumin, and total protein (p<0.05). Kidney function tests showed that rats in Group II had significantly high creatinine, urea, bicarbonate, potassium, and sodium (p<0.05). Group III had lowered creatinine, potassium levels, but with elevated urea, bicarbonate, and sodium levels (p<0.05). Group IV had lowered creatinine, urea, bicarbonate, potassium levels, but with elevated sodium levels (p<0.05). This study indicates that mature coconut water can be included in the treatment regimen for diabetes mellitus due to its hepatorenal protective functions.

Keywords: *Hepatorenal, hepatoreno-protective, biomarkers, coconut water, alloxan, diabetes mellitus*

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Introduction

Diabetes mellitus is an endocrine metabolic disorder resulting from a defect in insulin secretion, insulin action or both in the extracellular fluid [21, 44, 59]. Insulin defects, in turn lead to severe hyperglycemia with impaired metabolism of glucose and other energy-yielding fuels such as lipids and protein [22, 24, 45]. As diabetes progresses, tissue or vascular damage ensues leading to severe complications like cerebrovascular accident, myocardial infarction, nephropathy, retinopathy, blindness, and diabetic foot [54, 56, 60]. It is shown that elevated level of total cholesterol, triglyceride, high concentration of low density lipoprotein cholesterol (LDL-C) as well as low concentration of high density lipoprotein cholesterol (HDL-C) in diabetes mellitus is associated with cardiovascular disorders [27, 30, 35, 36, 38, 47].

Gametes are ova and sperm cells which are haploid and have one copy of each type of chromosome i.e. 1–22 X or 1–22 Y [34]. Genetics (family history) has been implicated in the pathogenesis of diabetes mellitus. Based on pathogenesis, clinical features, and immunological parameters, diabetes mellitus is classified into primary, secondary and gestational diabetes. The primary diabetes is further subdivided into Type 1 diabetes mellitus, also called Insulin Dependent Diabetes Mellitus (IDDM), caused by lack of insulin secretion; and Type 2 diabetes mellitus, also called Non-Insulin Dependent Diabetes Mellitus (NIDDM), initially caused by decreased

sensitivity of target tissues to the metabolic effects of insulin [18, 39, 70].

Type 1 diabetes mellitus is present in patients who have little or no endogenous insulin secretory capacity and who therefore require insulin therapy for survival [18, 29, 45, 64, 65]. It is characterized by the presence of islet cell antibody or insulin antibody, this antibody and other ill-defined factors lead to the destruction of the beta cells. Viral infections may also be involved in the destruction of the beta cells, although heredity also plays a major role in determining the susceptibility of the beta cells to destruction by these two implicated factors [18]. Therefore, the trace amount of beta cells left is insufficient to produce the insulin necessary for the metabolism of glucose and other energy-yielding fuel such as lipids and proteins [70].

The activities of liver damage markers including serum alanine transaminase (ALT), aspartate transaminase (AST) and alkaline phosphatase (ALP) are increased in untreated diabetic patients as reported by Arkkila, *et al.* [5]. Reports show that the liver is one of the main organs affected by diabetes mellitus and this progressive disease may elevate the danger of both chronic liver disorders and hepatocellular damage [11, 59]. Diabetic nephropathy and renal dysfunction are diabetes-related complications [25, 26, 29, 31, 37, 61, 63] and approximately 20% to 40% of patients with diabetes mellitus develop nephropathy [4]. Meanwhile, plasma levels of urea and creatinine increase in diabetic hyperglycemia, and they are known markers for renal impairment [17, 62, 67].

The pharmacological management of diabetes mellitus with synthetic drugs provides good glycemic control [23, 28, 32, 66]. However, the long-term use of these drugs is associated with undesirable side effects [46], which had led to the ongoing search for herbal drugs acclaimed to possess no or less side effect [51]. Studies have shown that the coconut plant possesses antidiabetic potential [1, 40]. Available evidence indicates that coconut water is an isotonic beverage which contains the same balance of electrolyte level as that of blood serum and was used to give emergency plasma transfusion to injured soldiers during wars [12].

Major free radicals that are of physiological significance are superoxide anion, hydroxyl radical, and hydroperoxyl radical, while non-radical is hydrogen peroxide [33]. A report from Bruce in 2020 showed that coconut water contains 95.3% water, 0.005% nitrogen, 0.56% phosphoric acid, 0.25% potassium, 0.69% calcium oxide, 0.59% magnesium oxide, 0.5% iron, 0.8% reducing sugar, and total sugar of 2.08% [10]. Coconut fruit contains polyphenols [7], and it is confirmed that these polyphenolic compounds have hypoglycemic activity and prevent the development of diabetic complications [13, 20]. It was suggested that coconut water exhibits properties which may be beneficial in the management of diabetes mellitus because it also contains bioactive components such as phenol, flavonoid, tannin, catechin, etc that possess cardioprotective, hepatoprotective, hypolipidemic and antihypertensive effects in experimental animals [9]. Hence, coconut water is one of the herbal products which holds therapeutic effects in the treatment of various diseases.

Globally, the prevalence of diabetes mellitus is becoming worrisome with complications in several systems of the body. Efforts have been in top gear to ensure the herbal solution is being initiated in the management of diabetes mellitus. Continuous applications of some bioactive molecules from plants by pharmaceutical companies have also increased the growing strength of herbal medicine within Nigeria in particular and within Africa in general [15]. As it has been stated that most of the synthetic drugs currently used in the management of diabetes mellitus exhibit adverse side effects [46], this study therefore aims to investigate the protective effects of the administration of coconut water on the biochemical parameters of the liver and kidneys of Wistar rats with alloxan-induced type 1 diabetes mellitus.

Materials and Methods

Chemicals and drugs

Alloxan, a Sigma-Aldrich product, was purchased at GSO Store while Glibenclamide was purchased at OCTOVIA Pharmaceutical Store, both in Abakaliki, Ebonyi State, Nigeria.

Experimental animals

Twenty-four (24) adult male Wistar rats weighing between 120g and 160g were purchased from the animal house of the Anatomy Department, Ebonyi State University (EBSU), Abakaliki, Nigeria. These rats were housed and allowed to acclimatize for 14 days in well-ventilated cages under controlled environmental condition of temperature (25±5°C), relative humidity (50±5%), and 12 hours light/dark cycle as described by [16, 57, 58]. They were fed with standard commercial rat feeds and water *ad libitum*.

Collection of coconut water

Coconut water was obtained from coconut fruits purchased from Eke Imoha Market in Ezza, Ezza South Local Government Area, Ebonyi State, Nigeria. The coconut fruits were identified and authenticated in the Department of Crop Science, EBSU. The coconut water collected was stored in an airtight container and stored in the refrigerator to prevent fermentation.

Induction of type 1 diabetes mellitus

Experimental type 1 diabetes mellitus was induced following an overnight fast with a single intraperitoneal injection of 150mg/kg body weight of alloxan monohydrate, freshly prepared in 40ml formosaline [49]. Hyperglycemia was confirmed 72 hours after injection by measuring the tail venous blood glucose level with a glucometer (ACCU-CHEK, Germany). Only animals with fasting blood glucose levels ≥200mg/dl were selected for the study.

Experimental design

The 24 adult male Wistar rats were randomly grouped into four sets of six rats each, (n=6).

- Group I: negative control (no type 1 diabetes mellitus induction; received clean drinking water and rat feed)
- Group II: positive control (type 1 diabetes mellitus induced with a single intraperitoneal dose of 150mg/kg body weight of alloxan with no treatment)
- Group III: type 1 diabetes mellitus induced with a single intraperitoneal dose of 150mg/kg body weight of alloxan but treated with oral administration of mature coconut water (1 ml/kg body weight of rats)
- Group IV: type 1 diabetes mellitus induced with a single intraperitoneal dose of 150mg/kg body weight of alloxan but treated with oral administration of glibenclamide

(2mg/kg of body weight) [8]. Oral administration was done with oral gavage for 21 days.

Animal sacrifice and sample collection

After 3 weeks of administration, the animals were anesthetized with diethyl ether and blood samples were collected through orbital puncture into plane tubes for biochemical analyses.

Biochemical analyses

The blood samples were allowed to clot in plain bottles first, then the sera were separated and centrifuged (3,000 rpm) for 15 minutes to obtain pure serum with no blood clot. The sera were biochemically analyzed to determine liver function and renal function parameters.

Liver function tests

- Alanine transminase (ALT), aspartate transaminase (AST), and total bilirubin were estimated according to the method of Reitman and Frankel (1957) using Randox test kits [53].
- Alkaline phosphatase (ALP) estimation was done based on colorimetric method using enzyme kits described by King and King (1954) [42].
- Albumin was estimated based on bromocresol green method using Agappe Diagnostics Albumin Kit [14].
- Total protein was estimated using Biuret reaction [69].

Renal function tests

- Serum creatinine was estimated using Jaffe's method.
- Urea was estimated by modified Berthelot method [68].
- Electrolytes (bicarbonate, potassium, and sodium) were estimated using Randox test kits.

Statistical analyses

All data obtained were expressed as mean±SD (standard deviation). The results were analyzed by one-way analysis of variance (ANOVA) and Tukey's post hoc test was used for data comparison. $p<0.05$ was taken to be statistically significant using SPSS version 20.

Ethical approval

This experiment was conducted according to the ethical standards and protocols approved by the Research Committee, Faculty of Basic Medical Sciences, College of Medicine, Ebonyi State University with approval reference number: MPC 1707.

Results

The findings in this study are presented in the following tables 1-4, with data expressed in mean±standard deviation (SD).

Table 1 shows the values of the liver function parameters which include alanine transaminase (ALT), aspartate transaminase (AST), total bilirubin, alkaline phosphatase (ALP), albumin, and total protein. The non-diabetic rats in Group I (negative control) had normal levels of ALT (9.37±1.69iu/l), AST (9.57±1.52iu/l), total bilirubin (1.17±0.15mg/dl), ALP (4.33±0.21iu/l), albumin (2.33±0.15mg/dl), and total protein (2.63±0.42g/dl). The untreated diabetic rats in Group II had low levels of ALT (6.40±0.70iu/l) but high levels of AST (14.20±1.61iu/l), total bilirubin (2.47±0.12mg/dl), ALP (7.99±1.23iu/l), albumin (3.73±0.15mg/dl), and total protein (5.37±0.49g/dl). The levels of these parameters in the diabetic rats in Group III were equally high except for ALT which was low, even after the administration of coconut water. Diabetic rats in Group IV treated with glibenclamide had lowered levels of ALT, ALP, albumin, and total protein, but high levels of AST and total bilirubin.

Table 1. Descriptive statistics of liver function parameters of healthy, untreated diabetic, and diabetic Wistar rats treated with coconut water and glibenclamide

GROUPS	ALT (iu/l)	AST (iu/l)	Total bilirubin (mg/dl)	ALP (iu/l)	Albumin (mg/dl)	T. protein (g/dl)
GI	9.37±1.69	9.57±1.52	1.17±0.15	4.33±0.21	2.33±0.15	2.63±0.42
GII	6.40±0.70	14.20±1.61	2.47±0.12	7.99±1.23	3.73±0.15	5.37±0.49
GIII	3.63±0.45	20.90±0.87	4.52±0.58	11.48±1.06	5.33±0.57	6.67±0.21
GIV	3.43±0.75	19.87±1.00	4.22±0.59	5.40±0.85	2.53±0.21	4.03±0.57

Source: Fieldwork, 2022 $p<0.05$

Table 2 shows the values of the renal function parameters which include creatinine, urea, bicarbonate, potassium, and sodium. The rats in Group I had normal levels of creatinine (0.50±0.10mg/dl), urea (23.03±1.01mg/dl), bicarbonate (12.33±0.70mmol/l), potassium (1.70±0.30mmol/l), and sodium (128.43±2.11mmol/l). The levels of the renal parameters were high in Group 2: creatinine (1.51±0.38mg/dl), urea (29.87±0.95mg/dl), bicarbonate (25.87±0.72mmol/l), potassium (4.57±0.54mmol/l), and sodium (145.07±3.71mmol/l). Rats in Group III treated with coconut water, had lowered creatinine (0.90±0.10mg/dl) and potassium (3.20±0.48mmol/l) levels, but high urea (33.20±1.57mg/dl), bicarbonate (30.30±1.51mmol/l) and sodium (170.90±2.34mmol/l) levels. Treatment with glibenclamide as seen in Group IV shows lowered creatinine, urea, bicarbonate, and potassium, but elevated sodium level.

Table 2. Descriptive statistics of renal function parameters of healthy, untreated diabetic, and diabetic Wistar rats treated with coconut water and glibenclamide

Groups	Creatinine (mg/dl)	Urea (mg/dl)	Bicarbonate (mmol/l)	Potassium (mmol/l)	Sodium (mmol/l)
GI	0.50±0.10	23.03±1.01	12.33±0.70	1.70±0.30	128.43±2.11
GII	1.51±0.38	29.87±0.95	25.87±0.72	4.57±0.54	145.07±3.71
GIII	0.90±0.10	33.20±1.57	30.30±1.51	3.20±0.48	170.90±2.34
GIV	0.90±0.00	26.93±0.45	22.57±0.55	1.37±0.64	159.37±8.77

Source: Fieldwork, 2022 $p<0.05$

Table 3 shows the statistical comparison between the levels of liver function parameters among these groups of rats. The levels of ALT, AST, total bilirubin, ALP, albumin, and total protein were significantly elevated ($p>0.05$) in the diabetic rats in Group II when compared with the healthy rats in Group I. Diabetic rats treated with coconut water and glibenclamide in groups III and IV respectively had significantly reduced ($p=0.005$) ALT levels when compared with Group I, but significantly elevated levels of AST, total bilirubin, ALP, and total protein ($p<0.05$).

The level of albumin in Group III was significantly elevated ($p=0.001$) when compared with Group I, but the difference between the albumin levels in groups IV and I was not significant ($p=0.251$). Comparing the levels of these parameters in the treated groups (III and IV) and untreated group (II), the ALT level in group III (treated with coconut water) was significantly lower ($p=0.005$), while other parameters in the same group were significantly higher ($p<0.05$). ALT, ALP, albumin, and total protein levels in Group IV (treated with glibenclamide) were significantly lower ($p<0.05$), while AST and total bilirubin were significantly higher ($p<0.05$).

In the comparison of these parameters between treatment of alloxan-induced type 1 diabetes mellitus with coconut water and glibenclamide, there was no significant difference ($p>0.05$) between ALT, AST, and total bilirubin levels. ALP, albumin, and total protein levels were significantly lower ($p<0.05$) after treatment with glibenclamide.

Table 3. Multiple comparisons of parameters of liver function tests in healthy, untreated diabetic, and diabetic Wistar rats treated with coconut water and glibenclamide

Groups	ALT (iu/l)	AST (iu/l)	T. bilirubin (mg/dl)	ALP (iu/l)	ALBUMIN mg/dl)	T. protein (g/dl)
GI	9.37±1.69	9.57±1.52	1.17±0.15	4.33±0.21	2.33±0.15	2.63±0.42
GII	6.40±0.700	14.20±1.61	2.47±0.12	7.99±1.23	3.73±0.15	5.37±0.49
p-value	**0.049**	**0.022**	**0.001**	**0.007**	**0.001**	**0.002**
GI	9.37±1.69	9.57±1.2	1.17±0.15	4.33±0.21	2.33±0.15	2.63±0.42
GIII	3.63±0.45	20.90±0.87	4.52±0.58	11.48±1.06	5.33±0.57	6.67±0.21
p-value	**0.005**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
GI	9.37±1.69	9.57±1.52	1.17±0.15	4.33±0.21	2.33±0.15	2.63±0.42
GIV	3.43±0.75	19.87±1.00	4.22±0.59	5.40±0.85	2.53±0.21	4.03±0.42
p-value	**0.005**	**0.001**	**0.001**	**0.11**	**0.251**	**0.03**
GII	6.40±0.70	14.20±1.61	2.47±0.15	7.99±1.23	3.73±0.15	5.37±0.49
GIII	3.63±0.45	20.90±0.87	5.33±0.57	11.48±1.06	5.33±0.57	6.67±0.21
p-value	**0.005**	**0.003**	**0.001**	**0.02**	**0.009**	**0.014**
GII	6.40±0.70	14.20±1.61	2.47±0.15	7.99±1.23	3.73±0.15	5.37±0.49
GIV	3.43±0.75	19.87±1.00	4.23±0.59	5.40±0.85	2.53±0.21	4.03±0.57
p-value	**0.007**	**0.007**	**0.008**	**0.040**	**0.001**	**0.037**
GIII	3.63±0.45	20.90±0.87	4.52±0.58	11.48±1.06	5.33±0.57	6.67±0.21
GIV	3.43±0.75	19.87±1.00	4.22±0.59	5.40±0.85	2.53±0.21	4.03±0.57
p-value	**0.713**	**0.249**	**0.001**	**0.001**	**0.001**	**0.202**

Source: Fieldwork, 2022 $p<0.05$

Table 4 shows the statistical comparison between the renal function parameters levels among the groups of rats. The levels of creatinine, urea, bicarbonate, potassium, and sodium were significantly elevated ($p>0.05$) in the diabetic rats in Group II when compared with the negative control rats in Group I. Diabetic rats treated with coconut water and glibenclamide in groups III and IV respectively had significantly higher ($p<0.05$) levels of these parameters when compared with Group I, except potassium level in Group IV that was insignificantly lower ($p>0.05$). The comparisons of these parameters in the untreated group and treated groups show that

treatment of type 1 diabetes mellitus with coconut water significantly reduced potassium (p=0.030), significantly increased urea, bicarbonate, and sodium (p<0.05), but there was no significant reduction in creatinine level (p=0.055).

On the other hand, treatment with glibenclamide shows a significant reduction in urea, bicarbonate, and potassium levels (p<0.05), a significant elevation in sodium level, and an insignificant reduction in creatinine level (p=0.05). Levels of creatinine and sodium after treatment with coconut water and glibenclamide showed no significant difference (p>0.05), but treatment with glibenclamide presented significantly lower levels of urea, bicarbonate and potassium (p<0.05) when compared with the results after treatment with coconut water.

Table 4. Multiple comparisons of parameters of renal function tests in healthy, untreated diabetic and diabetic Wistar rats treated with coconut water and glibenclamide

Groups	Creatinine (mg/dl)	Urea (mg/dl)	Bicarbonate (mmol/l)	Potassium (mmol/l)	Sodium (mmol/l)
GI	0.50±0.10	23.03±1.01	12.33±0.70	1.70±0.30	128.43±2.11
GII	1.51±0.38	29.87±0.95	25.87±0.72	4.57±0.54	145.07±3.71
p-value	**0.011**	**0.001**	**0.001**	**0.001**	**0.003**
GI	0.50±0.10	23.03±1.01	12.33±0.70	1.70±0.30	128.43±2.11
GIII	0.90±0.10	33.20±1.57	30.30±1.51	3.20±0.48	170.90±2.34
p-value	**0.008**	**0.001**	**0.001**	**0.010**	**0.001**
GI	0.50±0.10	23.03±1.01	12.33±0.70	1.70±0.30	128.43±2.11
GIV	0.90±0.00	26.93±0.45	22.57±0.55	1.37±0.64	159.37±8.77
p-value	**0.002**	**0.004**	**0.001**	**0.461**	**0.004**
GII	1.51±0.38	29.87±0.95	25.87±0.72	4.57±0.54	145.07±3.71
GIII	0.90±0.10	33.20±1.57	30.30±1.51	3.20±0.48	170.90±2.34
p-value	**0.055**	**0.035**	**0.010**	**0.030**	**0.001**
GII	1.51±0.38	29.87±0.95	25.87±0.72	4.57±0.54	145.07±3.71
GIV	0.90±0.00	26.93±0.45	22.57±0.55	1.37±0.64	159.37±8.77
p-value	**0.050**	**0.008**	**0.003**	**0.003**	**0.060**
GIII	0.90±0.10	32.20±1.57	30.30±1.51	3.20±0.48	170.90±2.34
GIV	0.90±0.00	26.93±0.45	22.57±0.55	1.37±0.64	159.37±8.77
p-value	**1.00**	**0.003**	**0.001**	**0.017**	**0.093**

Source: Fieldwork, 2022 p<0.05

Discussion

Diabetes mellitus has been reported to play a role in the activation and progression of liver damage, and this progressive syndrome is an independent risk factor for the development of chronic liver disorder [19]. It is worth noting that alanine transaminase (ALT) and aspartate transaminase (AST) are transaminase enzymes that speed up amino transfer reactions and play a vital role in amino acids catabolism and biosynthesis [6]. ALT localized in the hepatocytes is more sensitive in indicating hepatic damage when compared to AST, which can be found in other organs aside the liver. These enzymes together with alkaline phosphatase (ALP which is found in the liver and other organs), total bilirubin, albumin, and total protein are biomarkers of hepatic injury as stated by Ahmadvand, *et al* [2] and Udeh, *et al* [58]. ALP is a hydrolase enzyme which acts as a non-specific phosphomonoesterase to hydrolyse phosphate esters [41]. Bilirubin is a waste product greatly found in the blood as a result of hemolysis. An increase in the level of total bilirubin suggests an excessive hemolysis, inefficiency of the hepatocytes to process the bilirubin volume or an obstruction within the liver or in the bile duct during bilirubin excretion [58]. Albumin is the most abundant plasma protein that maintains osmotic pressure and transports bilirubin.

As noted in studies by Ikwuka, *et al,* positive correlative relationships exist between asymptomatic hyperuricemia, increased albuminuria and a decrease in glomerular filtration rate (GFR), dyslipidemia, systolic blood pressure (SBP), glycated hemoglobin (HbA_1C), inflammatory processes and kidney damage, which indicate the heterogeneity of renal pathogenicity and a higher risk of cardiovascular disease in diabetes mellitus [25, 26, 30, 35, 36, 38, 39].

In addition, these biomarkers of liver damage in the diabetic untreated rats spiked significantly (p<0.05) as was seen in the study of Preetha, *et al* [52]. This increase is due to alloxan toxicity to the liver causing leakage of the enzymes from the liver into the bloodstream. Further hepatic findings indicate that treatment of diabetic rats with coconut water could significantly reduce only ALT level (p<0.05), whereas other liver parameters were significantly elevated (p<0.05). These findings are contrary to the report of Prakasam, *et al* [50] and Sivajothi, *et al* [55] who reported that there was a decline in total protein and serum albumin in diabetic rats. The study of Preetha, *et al* found that coconut water caused a decline in ALP

level [52]. On the other hand, glibenclamide proved to protect the liver better, as it caused a significant reduction in ALT, ALP, albumin, and total protein levels (p<0.05), but significantly elevated AST and total bilirubin levels (p<0.05).

Literature indicates that diabetes mellitus is also associated with complications in the renal system and patients with diabetes experience major long-term complications such as nephropathy [26, 31, 37, 39, 62, 67] and diabetic nephropathy is one of the leading causes of end-stage renal disease globally [43]. The results of this research establish that there is a significant increase in the plasma levels of creatinine, urea, bicarbonate, potassium, and sodium (p<0.05) due to experimentally induced-type 1 diabetes mellitus, a finding similar to a report by Ali, *et al* [3] and Nwangwa [48]. Creatinine is naturally found in chordates and its main function is to recycle adenosine triphosphate (ATP) in muscle and brain tissues. If the kidneys fail to naturally filter creatinine out in urine, its level in blood increases, same as with urea, bicarbonate, potassium and sodium, which are indicators of kidney damage [57, 61, 62, 67]. Bicarbonate can also be a predictor of acidosis, potassium a predictor of heart disease, and sodium an indicator of dehydration and hypertension.

This study further shows that the administration of coconut water in treating induced type 1 diabetes mellitus insignificantly reduces plasma creatinine (p>0.05), significantly reduces potassium (p<0.05), but significantly increases urea, bicarbonate, and sodium (p<0.05), a finding opposing Nwangwa's study where coconut water significantly reduced all the parameters (p<0.05) [48]. This opposition can be linked to the little dose of coconut water administered in the present study as against the *ad libitum* consumption in Nwangwa's study. However, treatment with glibenclamide significantly reduced urea, bicarbonate, and potassium (p<0.05), insignificantly reduced creatinine (p>0.05), and insignificantly increased sodium (p>0.05).

Therefore, these findings indicate that the consumption of little quantity of coconut water has mild protective function on kidneys of diabetic rats whereas glibenclamide protects the kidneys better, although the consumption of higher quantity of coconut water could do more hepatorenoprotective function.

Conclusion

Coconut water has hepatorenal protective effects in alloxan-induced type 1 diabetes mellitus and this hepatorenal protective effects are directly proportional to the quantity of coconut water consumed. Prospects for further research include investigating insulin levels after treatment with coconut water, and also a study focusing on histological examination of the pancreatic islets of Langerhans to examine the recovery of beta cells after treatment with both coconut water and glibenclamide.

Conflict of Interest

The authors guarantee responsibility for every information published in this manuscript, as well as the absence of a conflict of interest and the absence of their financial interest in conducting this study and writing this manuscript. This manuscript was written from an original research work and has never been published, neither is it under consideration for publication elsewhere.

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Author Contribution

All authors contributed in different aspects of the research.

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