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Research Article

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# Corchorus Olitorius Leaves Affect Nutrient Utilization and Improve Biochemical Indices of Alloxan Induced Diabetic Wistar Rats

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***Abstract***

*The effective management of type 2 diabetes depends on the ability to improve insulin utilization, regulate blood glucose, and control hyperlipidaemia. Performance of Corchorus olitorius leaves in these three areas was evaluated using alloxan induced diabetic Wistar rats. Nutrient composition of C. olitorius leaves was determined using standard AOAC methods; alpha-amylase inhibitor content of the leaves was determined after extraction with four solvent systems. Some bioactive compounds in C. olitorius were identified with GC-MS. Diets were formulated to contain 0-20% C. olitorius and fed to alloxan-induced diabetic rats for 70 days. Indices of nutritional quality, biochemical indices and histopathology of the pancreas were compared in the experimental animals. Water and 99% ethanol were the best solvents for extracting alpha amylase inhibitor from C. olitorius leaves. 9-octadecanoic acid (Z), benzoic acid,2 phenyl ester, 9-octadeceneZ-methylester and hexadecenoic acids were major bioactive compounds identified in C. olitorius leaves by GC-MS. Formulated diets containing C. olitorius decreased feed intake, body mass gain, glycosylated haemoglobin (HBA1c), fasting blood glucose (FBG), total cholesterol (TC), triglycerides (TGs) in a concentration dependent manner. HDL-C (good cholesterol) increased. C. olitorius caused the regeneration of the pancreas of the alloxan -induced diabetic rats. Corchorus olitorius leaves is effective for the control of hyperglycaemia and hyperlipidaemia.*

**Keywords:** Corchorus Olitorius Leaves, Glycosylated Haemoglobin, Nutritional and Biochemical Indices, Histopathology, Hyperlipidemia, Hyperglycaemia.

## List of Abbreviations

**AD**: Apparent Digestibility
**BMG**: Body Mass Gain
**BV**: Biological Value
**CO**: Corchorus Olitorius
**EFN**: Endogenous Fecal Nitrogen
**EUN**: Endogenous Urinary Nitrogen
**FBG**: Fasting Blood Glucose
**FI**: Feed Intake
**FER**: Feed Efficiency Ratio
**HbA1c**: Haemoglobin A1c
**HDL-C**: High Density Lipoprotein Cholesterol
**LDL-C**: Low-Density Lipoprotein Cholesterol
**PER**: Protein Efficiency Ratio
**TD**: True Digestibility
**NPU**: Net Protein Utilization
**% NR**: % Nitrogen Retention
**TC**: Total Cholesterol
**TG**: Triglyceride

## 1. Introduction

Diabetes is a class of metabolic disorders which is caused by decreased pancreatic function where secretion and function of insulin is either limited, impaired or stopped altogether [1]. It is a non-communicable disease that ranks high as a global health problem and is a risk factor that can lead to the malfunction of other organs and systems in the body if not well managed. It was estimated that 425 million people aged 20-79 years were sick of diabetes mellitus in 2017 and it is projected that the number will rise to 629 million by 2045 [2]. Diabetes has been rising more rapidly in low- and middle-income countries than in high income countries [3]. Type 2 diabetes is the most common type of diabetes as it is occurring increasingly and frequently even in children [3]. It is well known that diabetes mellitus is a metabolic, endocrine

disorder and is directly connected to carbohydrate, lipid and protein metabolism and as such, nutrition therapy forms an integral part of diabetes management [4]. While type 2 diabetes requires the administration of insulin, type 2 diabetes may be managed with oral drugs and the diet [5]. Ojimelukwe and Amaechi (2019) reported the importance of Vernonia amygdalina and other plant products in the management of type 2 diabetes [6]. Nutrition and diet are the mainstay in type 2 diabetes prevention and management of the complications associated with it.

C. olitorius (Family Malvaceae) is a tropical herb that is upright branching and slightly woody [7]. It is an annual/perennial crop that grows to a height of 3.5m and the edible parts include leaves, seeds and shoots. The leaves are reported to be demulcent, diuretic, febrifuge, tonic and can be used to cure chronic cystitis/gonorrhea and dysuria [8, 9]. C. olitorius is called by many vernacular names such as 'Jew's mallow', 'Krinkrin', 'Tossa jute', 'Bush Okra' and 'West African Sorrel' [10]. It is consumed fresh, raw or cooked in soups or as potherb [9]. It is a leafy mucilaginous vegetable and in Nigeria, the leaves are cooked to form a slimy sticky sauce comparable to okra [11]. The leaves can be sundried, milled into flour and stored for a significant time and the dried product can be used for tea and as a soup thickener [12]. It is rich in fiber and helps to control blood pressure, cholesterol build up, and prevents heart disease [11].

Treatment of diabetes requires diet and physical activity as well as lowering blood glucose and other risk factors that damage blood vessels [3]. Clinical studies have most times recommended the use of natural or herbal cure for diabetes rather than depending primarily on drugs because of side effects [13]. It is in view of this that Corchorus olitorius leaves (wild jute, bush okra) was investigated for its potential effects on nutrient utilization and biochemical parameters as well as the histopathology of the pancreas of alloxan induced diabetic Wistar rats.

## 2. Methods

**2.1 Plant Collection and Preparation:** Fresh Corchorus olitorus leaves were procured from Abakpa Market, Abakaliki Ebonyi State, Nigeria. They were picked, washed and drained to remove water before air drying under the shade for 6 days at 25±2°C. The air-dried leaves were pulverized and stored in clean, dry airtight container and labeled prior to use.

### 2.2 Determination of Alpha Amylase Inhibitory Activity

Alpha amylase inhibitor (AAI) in the dried C. olitorius leaves was extracted using different solvents namely water, chloroform, ethylacetate, absolute ethanol and 70% ethanol using cold maceration method described by Jeremy and Whiteman (2003) [12]. The extract was concentrated using a rotary evaporator at a maximum temperature of 40oC and then dried. AAI in each extract was determined by the dinitrosalicylic acid method of Bernfeld (1955) to estimate the inhibition of degradation of starch to maltose [14]. The α-amylase inhibitory activity was calculated as percentage inhibition: % Inhibition = Absorption of control-Absorption of extract/Absorption of control x 100. One-unit releases one micromole of β-maltose per min at 25°C and pH 4.8.

### 2.3 Gas Chromatography-Mass Spectrometry Analysis

Bioactive compounds from ethanol extract of Corchorus olitorius leaves was analyzed using gas chromatography-mass spectrometry (QP 2010 plus, Shimadzu, Japan) equipped with flame ionization detector (FID). Helium was used as carrier gas at a flow rate of 3.0ml/min. The column temperature was programmed from 70 to 280oC at the rate of 5oC/min. Injector and detector temperatures were set at 250oC and 260oC, respectively. All quantifications were carried out using a built-in-data handling programme provided by the manufacturer of the gas chromatogram. Interpretation of mass spectrum was conducted using the database of the National Institute Standard and Technology (NIST) version 2.0, 2009 library.

### 2.4 Diet Formulation

A standard diet containing 83% corn starch, 10% casein, 2% soybean oil, 3% rice bran for fiber and 2% vitamin and mineral mix was prepared. The dried pulverized Corchorus olitorius leaves was incorporated at different concentrations of 2.5%, 5.0%, 10.0 and 20% per 100g of standard diet.

### 2.5 Experimental Animals

Weanling albino Wistar Rats (22-26 days old) of both sexes with average initial body weight of 40+2grams were used for the experiments. The rats were obtained from the Department of Veterinary Medicine, University of Nigeria, Nsukka. They were housed in stainless steel metabolism cages maintained at an ambient temperature of 28+2°C and a natural light-dark cycle. All the experimental animals were acclimatized for 14 days on the standard diet in accordance with the recommendation in the guide for the care and use of laboratory animals [15]. The experimental protocol was approved by the Institutional Ethics Committee.

### 2.6 Proximate Analysis of the Formulated Diets

Proximate composition of the various diet samples was analyzed by the methods described by AOAC (2005) [16].

### 2.7 Induction of Diabetes

Diabetes was induced by intra-peritoneal injection of alloxan monohydrate (5,5-dihydroxyl pyrimidine-2,4,6-trione) (160mg/kg). After 72 h, fasting blood glucose levels of the rats were determined with a glucometer (Accu-check active Germany). Animals with blood glucose levels of ≥250 mg/dL were considered diabetic.

### 2.8 Experimental Design

The method described by Pellet and Young (1980) was adopted [17]. Six (6) normoglycemic and 36 diabetic rats were used for the experiment. The normoglycemic rats were assigned group A and diabetic rats were randomly assigned to 5 groups (B-F) of 6 rats each and housed in metabolic cages. Groups A and B received standard feed excluding C. olitorius leaves while groups C-F received feed containing 2.5%, 5.0%, 10.0% and 20% C. olitorius

leaves respectively. The rats were fed ad libitum for 70 consecutive days. At first, the animals were used for growth study for a total of 35days to monitor the response of the various animal groups to the different treatments. After 35days of growth study (weaning period), the same group of animals were continuously fed the various treatment diets for another 35days giving a total of 70days. Daily feed and water intake were recorded while body weight was recorded at weekly intervals. Faecal droppings and urine voided for the last 7days of weaning period were collected continuously. The faeces were oven dried at 60ºC while urine was preserved in 1ml of 0.1N HCl in brown bottles to eliminate microbial growth and prevent nitrogen losses. The urine samples were stored in a deep freezer prior to nitrogen determination. After the 70th day of feeding, the rats were fasted for 16h and blood samples were collected via ocular puncture into EDTA and plain bottles for whole blood and serum preparations respectively. Thereafter, the rats were sacrificed by cervical dislocation, immediately laparotomised and pancreas were excised and preserved in 10% formalin solution for histopathological study.

### 2.9 Evaluation of Nutritional Indices

Nitrogen content of both urine and faecal samples were analyzed using the Kjeldahl method described by James (1985) [18]. Protein efficiency ratio (PER), feed efficiency ratio (FER), apparent digestibility (AD), True digestibility (TD), Biological Value (BV) and Net protein utilization (NPU) were calculated.

### 2.10 Biochemical Analysis

Fasting blood glucose (FBG) was determined using a glucometer (Accu-Check, Germany). Glycosylated haemoglobin (HbAlc) was analysed by the method of Trivelli et al (1971), using a glycohaemoglobin test kit (Teco Diagnistics, USA) [19]. Serum total cholesterol, triglycerides, high density lipoproteins were analyzed using their various diagnostic test kits (Randox Laboratory, UK). Serum low density-lipoproteins was calculated using the equation promulgated by Friedwald et al. (1972) as [20].

$$\text{LDL Cholesterol (mg/dl)} = \text{Total cholesterol} - \left(\frac{\text{Triglycerides}}{5}\right) - \text{HDL-Cholesterol}$$

### 2.11 Histopathology

Excised pancreas of the rats was fixed in 10% formal saline for 24h. They were washed in ascending grades of ethanol, cleared with xylene, embedded in paraffin wax, sectioned with a microtome and stained with hematoxylin and eosin (H and E) and mounted on Canada Balsam (Sigma-Aldrich, St Louis, Mo) [21]. All the sections were examined under a light microscope using 100 and 400 magnifications. Photomicrographs of lessons were taken with an Olympus photo microscope (Olympus Scientific Equipment, Ashburn, VA).

### 2.12 Statistical Analysis

One-way analysis of variance (ANOVA) followed by Duncan's Post hoc test was used to separate differences of data collected for the various parameter analyzed. Data obtained were expressed as mean ± standard deviation and differences in means were significantly different ($p<0.05$). Statistical analysis was determined using SPSS Statistical Software version 20.

## 3. Results and Discussion

### 3.1 Alpha Amylase Inhibitory Activity

The percentage alpha amylase inhibitory activities of whole C. olitorius leaf extracts from different solvents are presented in Figure 1. Results showed α-amylase inhibitor activities in both polar and non-polar solvents with the highest activity in 99% ethanol and lowest activity in 70% ethanol. α-amylase inhibitory activities exhibited by C.olitorius leaves in different solvents depicts the presence of compounds which inhibit α-amylase and they were affected by solvent media. Methanol extract of the leaves was reported to inhibit both α-amylase and α-glucosidase enzymes and has antioxidant effects [22, 23]. One therapeutic target for delaying oligosaccharide digestion to absorbable monosaccharides in the intestinal brush border is through the inhibition of pancreatic α-amylase and results in reduced postprandial hyperglycemia [24]. Many other botanicals such as Salacia reticulata contain inhibitors of starch degradation that delay the build-op pf glucose in the blood [25]. The in-vitro inhibition of α-amylase activity of C.olitorius leaf extracts indicated they possess bioactive molecules which have potential effects in delaying carbohydrate digestion. Plants that have α-amylase or α-glucosidase inhibitory potentials closely follow the action of acarbose [26]. Hence, with this identified mechanism, it can be deduced that Corchorus olitorius leaves has potential therapeutic benefit in managing diabetes mellitus. Although whole shade dried leaves (not extracts) were used in the present research, Mohammed et al., 2019 found water extracts of C [27]. olitorius effective in the control of hyperglycaemia and dyslipidaemia.

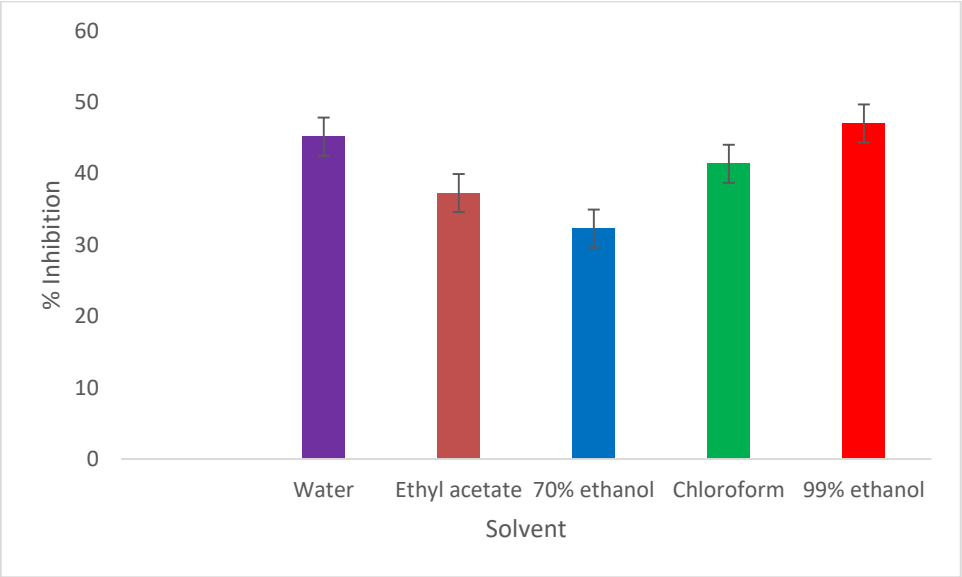


**Figure 1:** Alpha Amylase Inhibitory Activities of Different Extracts of Cochorus Olitorius

### 3.2 Gas Chromatography-Mass Spectrometry Results of Ethanol Extract of Corchorus Olitorius Leaves

Table 1 shows results of gas chromatography-mass spectrometry analysis of ethanol extract of Corchorus oiltorius leaves. Results indicated the presence of 9 compounds. The predominant compounds include benzoic acid phenyl ethyl ester (15.54%), hexadecanoic acid (12.29%), octadecenoic (Z)-methyl ester (13.06%) and 9-octadecenoic (Z) (48.45%). The respective compounds have been reported to have various beneficial biological activities. Hexadecanoic acid, octadecenoic (Z)-methyl ester and 9-octadecenoic acid are polyunsaturated fatty acids while benzoic-acid 2-phenyl ethyl ester is an essential oil and classified as a flavoring agent and occurs as a volatile compound in foods. On the contrary, 2-Dodecenal was found to be the major component alongside other compounds namely 2-methy-1-penten-4yn-3-ol, 2,4-Decadienal and ethanone were found in appreciable quantities [28]. Hexadecanoic acid and 9-Octadecenoic acid methyl ester have been reported to exhibit both antioxidant and hypocholesterolemic activities, while oleic acid has anti-inflammatory and hypocholesterolemic activities [29, 30]. Lipid peroxidation and oxidative stress are closely related in inducing elevated blood sugar levels [31]. Polyunsaturated fatty acids have antioxidant potentials and are important in preventing lipid peroxidation. The presence of these compounds in C. olitorius leaves are responsible for its nutritional and health benefits. C. olitorius is rich in micro and macronutrients, as well as a wide range of bioactive compounds such as glycosides, phenolics, flavonoids, tannins, saponins, sterols, triterpenoids, ionones, fatty acids, and carbohydrates [32]. Identifying volatile compounds through GC-MS in this study complements previous research efforts which had revealed the identities of phytochemicals in C. olitorius [33, 34]. Phenols, flavonoids, quercetin, corchoinoside A, folic acid and ascorbic acid have been found in significant amounts in C. olitorius [35].

| z | Retention Time (mins) | Identity of Compound | Concentration (%) | Molecular Weight | Molecular Formula |
|---|---|---|---|---|---|
| 1 | 16.33 | Benzoic acid, 2-phenyl ethyl ester | 15.54 | 226 | $C_{15}H_{14}O_2$ |
| 2 | 21.33 | 1,6.10-Dodecatrien-3-ol-1,7,11-trimethyl (E)+/- trans Nerolidiol | 0.26 | 222 | $C_{15}H_{26}O$ |
| 3 | 24.73 | 3.7,11,15-tetramethyl-2-hexadecen-1-ol | 2.38 | 296 | $C_{20}H_{40}O$ |
| 4 | 25.71 | Hexadecanoic acid methyl ester | 3.05 | 270 | $C_{17}H_{34}O_2$ |
| 5 | 26.32 | Hexadecanoic acid | 12.29 | 256 | $C_{16}H_{32}O_2$ |
| 6 | 27.46 | 9-Octadecenoic (Z)-methyl ester | 13.06 | 296 | $C_{19}H_{36}O_2$ |
| 7 | 27.62 | Octadecanoic acid methyl ester | 0.06 | 298 | $C_{19}H_{38}O_2$ |
| 8 | 28.06 | 9-Octadecenoic acid (Z) | 48.45 | 282 | $C_{18}H_{34}O_2$ |
| 9 | 30.73 | 9,12-Octadecadienoyl chloride | 4.37 | 298 | $C_{18}H_{31}ClO$ |

**Table 1: Bioactive Compounds Identified by Gc-Ms in the Ethanol Extract of Corchorus Olitorius Leaves.**

### 3.3 Proximate Composition of Standard Diet and Diets Containing Different Quantities of Corchorus Olitorius Leaves

Incorporation of C. olitorius leaves resulted to a concentration dependent significant ($p<0.05$) increase in the moisture, ash, crude fiber, fat and crude protein content of the ration when compared with the standard ration (Table 2). Carbohydrate content of rations containing C. olitorius leaves significantly ($p<0.05$) decreased in a concentration dependent manner when compared with carbohydrate content of the standard ration. This agrees with the findings of Ranawara et al. (2016) who reported that the addition of vegetables (broccoli, carrot, tomato, beetroot) respectively to wheat flour in the production of bread resulted to an increase in moisture, protein, fat contents while total carbohydrate decreased when compared with carbohydrate content of plain bread made from wheat flour alone [31]. Similarly, El-Khatib and Muhieddine (2019) also reported an increase in fiber and other nutrients content of bread to which pumpkin flour was added while carbohydrate decreased when compared with plain bread [36]. Idris et al. (2009) reported C [37]. olitorius leaves to be a good source of minerals, lipids, protein and carbohydrates which are important as energy source in human and animal nutrition.

| Parameter | Standard diet | 2.5% CO | 5% CO | 10% CO | 20% CO |
|---|---|---|---|---|---|
| Moisture | $6.52^{d}\pm0.18$ | $6.98^{d}\pm0.16$ | $7.73^{c}\pm0.09$ | $9.64^{b}\pm0.06$ | $11.08^{a}\pm0.14$ |
| Ash | $2.58^{c}\pm0.13$ | $2.79^{b}\pm0.02$ | $2.83^{b}\pm0.04$ | $3.82^{a}\pm0.05$ | $3.91^{a}\pm0.12$ |
| Crude Fiber | $2.60^{d}\pm0.07$ | $2.85^{d}\pm0.12$ | $3.82^{c}\pm0.12$ | $4.75^{b}\pm0.05$ | $5.50^{a}\pm0.15$ |
| Fat | $2.68^{d}\pm0.04$ | $3.39^{c}\pm0.09$ | $3.84^{c}\pm0.04$ | $4.05^{b}\pm0.06$ | $5.85^{a}\pm0.05$ |
| Crude Protein | $16.95^{e}\pm0.05$ | $19.38^{d}\pm0.13$ | $21.60^{c}\pm0.15$ | $23.56^{b}\pm0.13$ | $25.71^{a}\pm0.37$ |
| Carbohydrate | $56.97^{c}\pm0.16$ | $65.11^{a}\pm0.31$ | $60.17^{b}\pm0.22$ | $54.18^{d}\pm0.10$ | $47.95^{e}\pm0.39$ |

**Table 2: Proximate Composition of Standard Ration and Rations Containing Corchorus Olitorius Leaves at Varied Concentration.**

### 3.4 Effect of Corchorus Oiltorius Leaves on Nutrient Utilization in the Experimental Animals

The effect of the incorporation of C. olitorius leaves on nutrient utilization of diabetic rats compared with normoglycemic and diabetic rats fed standard rations (i.e rations not containing C. olitorius leaves) is shown in Table 3 Results indicated varied responses. C. olitorius leaf supplemented diets resulted to a significant ($p<0.05$) decrease in feed intake (FI), body mass gain (BMG), protein efficiency ratio (PER), endogenous fecal nitrogen (EFN), endogenous urinary nitrogen (EUN), %nitrogen retention (%NR), apparent digestibility (AD) and net protein utilization (NPU) of treated diabetic groups when compared with normoglycemic and diabetic groups fed plain standard diets. Feed intake (FI) was relatively higher in diabetic untreated and diabetic rats fed 2.5% C. olitorius leaves. A similar finding was reported by Aluwong et al. (2016) where FI of alloxan-induced diabetic rats increased when compared with the diabetic treated group [38]. The higher FI observed in the diabetic untreated and 2.5% C. olitorius leaves treated group could be attributed to the deficiency and/or absence of insulin, which induces impairment in glucose transport resulting to energy deficiency in cells hence, increased feeding to compensate for the energy deficiency [39].

Normoglycemic animals fed standard diets had a significantly ($p<0.05$) high PER, FER, %NR, AD, TD and NPU than the diabetic untreated and diabetic treated groups. Zhang et al. (2013) reported a decrease in NPU as dietary fiber concentration increased; this could be attributed to decreased bioavailability of amino acids

[39]. There were no significant differences ($p<0.05$) in BMG of normoglycemic and diabetic untreated groups despite the high feed intake of the diabetic untreated group. This could be attributed to reduction of catabolic processes in the diabetic untreated group [38]. BMG significantly ($p<0.05$) decreased in a concentration dependent manner in the diabetic treated groups. Gomaa et al. (2018) reported that C. olitorius leaf extract significantly reduced weight gain and visceral white adipose tissue [40]. Weight increase is a major risk factor in the development of diet related diseases such as cardiovascular diseases, stroke, type diabetes and certain cancers [41]. Increase in vegetable consumption results in weight loss [42].

| Parameter | Normal Control | Diabetic Control | 2.5% CO | 5% CO | 10% CO | 20% CO |
|---|---|---|---|---|---|---|
| FI (g) | $282.38^{bc}\pm38.8$ | $330.68^{a}\pm25.9$ | $332.05^{a}\pm14.2$ | $302.38^{b}\pm10.4$ | $260.23^{c}\pm6.7$ | $190.30^{d}\pm6.2$ |
| PI (g) | $47.84^{d}\pm6.6$ | $56.02^{c}\pm4.4$ | $64.59^{a}\pm2.7$ | $65.40^{a}\pm2.3$ | $61.23^{b}\pm1.6$ | $48.93^{d}\pm1.6$ |
| BMG (g) | $87.57^{b}\pm10.4$ | $80.23^{b}\pm2.8$ | $109.72^{a}\pm6.8$ | $85.47^{b}\pm10.9$ | $60.30^{c}\pm7.5$ | $38.68^{d}\pm3.4$ |
| PER | $1.85^{a}\pm0.1$ | $1.44^{c}\pm0.1$ | $1.71^{b}\pm0.1$ | $1.30^{d}\pm0.1$ | $0.98^{e}\pm0.1$ | $0.79^{f}\pm0.1$ |
| FER | $0.31^{a}\pm0.0$ | $0.24^{c}\pm0.0$ | $0.33^{a}\pm0.0$ | $0.28^{b}\pm0.0$ | $0.23^{c}\pm0.0$ | $0.20^{d}\pm0.0$ |
| NI (mg) | $1297.76^{c}\pm178.2$ | $1519.77^{b}\pm118.8$ | $1752.05^{a}\pm74.6$ | $1773.55^{a}\pm62.0$ | $1661.25^{a}\pm42.6$ | $1327.42^{c}\pm43.2$ |
| FN (mg) | $108.22^{e}\pm24.9$ | $155.64^{d}\pm16.5$ | $167.31^{d}\pm7.2$ | $191.93^{c}\pm8.6$ | $227.10^{b}\pm9.7$ | $277.92^{a}\pm12.3$ |
| UN (mg) | $41.10b^{c}\pm3.5$ | $38.97^{c}\pm0.1$ | $62.07^{a}\pm1.4$ | $62.86^{a}\pm0.8$ | $58.85^{a}\pm0.4$ | $44.37^{b}\pm4.7$ |
| EFN (mg) | $39.19^{c}\pm4.4$ | $35.49^{c}\pm1.3$ | $53.36^{a}\pm3.0$ | $44.85^{b}\pm4.9$ | $35.58^{c}\pm3.4$ | $28.20^{d}\pm1.6$ |
| EUN (mg) | $11.93^{c}\pm1.75$ | $10.45^{c}\pm0.5$ | $17.71^{a}\pm1.1$ | $14.20^{b}\pm1.9$ | $10.48^{c}\pm1.4$ | $7.54^{d}\pm0.6$ |
| NR | $1148.78^{c}\pm153.2$ | $1325.16^{b}\pm102.6$ | $1522.67^{a}\pm74.6$ | $1519.60^{a}\pm53.4$ | $1375.31^{b}\pm34.0$ | $1005.13^{d}\pm31.2$ |
| NR% | $88.56^{a}\pm0.4$ | $87.20^{b}\pm0.2$ | $86.89^{b}\pm0.7$ | $85.64^{c}\pm0.2$ | $82.79^{d}\pm0.3$ | $75.73^{e}\pm0.2$ |
| AD% | $91.77^{a}\pm0.8$ | $88.11^{cd}\pm4.3$ | $90.44^{ab}\pm0.6$ | $89.19^{bc}\pm0.2$ | $86.33^{d}\pm0.3$ | $79.07^{e}\pm0.3$ |
| TD | $88.74^{a}\pm0.7$ | $87.43^{c}\pm0.3$ | $87.39^{b}\pm0.6$ | $86.67^{d}\pm0.3$ | $83.54^{e}\pm1.3$ | $76.95^{f}\pm0.3$ |
| BV | $95.30^{b}\pm0.5$ | $96.26^{a}\pm0.3$ | $94.79^{c}\pm0.2$ | $94.99^{c}\pm0.0$ | $95.04^{bc}\pm0.1$ | $94.87^{c}\pm0.2$ |
| NPU | $84.56^{a}\pm0.4$ | $84.17^{a}\pm0.3$ | $82.83=\pm0.7$ | $82.32^{c}\pm0.3$ | $81.02^{d}\pm2.6$ | $73.04^{e}\pm0.3$ |

**Table 3: Effect of Corchorus Olitorius Leaves on Nutrient Utilization in Normoglycemic and Diabetic Rats.**

### 3.5 Effects of Corchorus Olitorius Leaves on Biochemical Parameters of Diabetic Rats.

Table 4 shows results on biochemical parameters of normoglycemic, diabetic and diabetic treated rats. Haemoglobin A1c (HbA1c) and fasting blood glucose (FBG) were significantly ($p<0.05$) higher in the diabetic untreated group while it decreased in the diabetic treated group in a concentration dependent manner. High HbA1c and FBG in diabetic condition due to the administration of alloxan is attributed to the damage to pancreatic beta cells resulting to deregulation of blood glucose, hence resulting to an increase in blood glucose concentration and the generation of reactive oxygen species [43, 44]. Tabesh et al. (2013) found out that the consumption of vegetables and fruits generate antioxidants which defend and help reduce HBA1c in diabetic patients [45]. Therefore, the gradual reduction in HBA1c observed in the diabetic treated groups could be attributed to the presence of antioxidants and other bioactive compounds in C. olitorius leaves and these could ameliorate oxidative reactions.

With respect to the lipid profile, it was observed that total cholesterol (TC), triglyceride (TG) and low-density lipoprotein cholesterol (LDL-C) were higher in the diabetic untreated and group fed 2.5% C. olitorius leaves. The increase in TC and TGs could be attributed to reduced lipoprotein lipase activity secondary to decreased serum insulin levels because of the diabetic condition [38]. High density lipoprotein cholesterol (HDL-C) significantly ($p<0.05$) increased in a concentration dependent manner in the diabetic treated group while it was quite low in the diabetic untreated as well as the group fed 2.5% C. olitorius leaves. The reduction in HDL-C may be attributed mainly to low density lipoprotein which favor the hydrolysis of stored triglycerides in the adipocytes thereby discharging them into the circulation resulting to a decrease in serum HDL-C concentrations. Low, high density lipoprotein cholesterol and increased triglyceride concentration predisposes individuals to dyslipidaemia and may put up likelihood of cardiovascular disease [46]. The reduction observed in our findings for serum lipids with an increase in serum HDL-C in the diabetic treated groups fed whole C. olitorius leaves agrees with the findings of Gomaa et al. (2018) who reported that that the leaf extract was effective in preventing hyperlipidaemia and decreased serum glucose [40]. Airaodion et al. (2019) and Yahani and Adoteyi, 2018) had observed similar results with C. olitorius leaves [47, 48].

| Parameter | Normal Control | Diabetic Control | 2.5% CO | 5%CO | 10%CO | 20%CO |
|---|---|---|---|---|---|---|
| HBA1c (%) | $4.05^{d}\pm0.1$ | $10.65^{a}\pm2.0$ | $7.95^{b}\pm0.98$ | $6.98^{b}\pm0.5$ | $6.53^{bc}\pm0.9$ | $5.30^{cd}\pm0.4$ |
| FBG (mg/dl) | $93.17^{d}\pm12.8$ | $212.50^{a}\pm35.9$ | $161.17^{b}\pm9.1$ | $128.17^{c}\pm3.3$ | $118.67^{c}\pm2.6$ | $98.33^{d}\pm7.7$ |
| TC (mg/dl) | $165.39^{d}\pm14.18$ | $251.28^{a}\pm13.5$ | $246.80^{a}\pm1.4$ | $206.80^{b}\pm10.4$ | $188.46^{c}\pm16.3$ | $162.31^{d}\pm9.8$ |
| TG (mg/dl) | $117.82^{e}\pm6.7$ | $195.77^{a}\pm5.9$ | $177.63^{b}\pm16.7$ | $144.23^{c}\pm5.3$ | $132.92^{d}\pm11.0$ | $113.85^{e}\pm3.7$ |
| HDL-C (mg/dl) | $54.14^{ab}\pm6.4$ | $27.44^{d}\pm8.3$ | $24.36^{d}\pm1.0$ | $42.12^{c}\pm4.2$ | $50.23^{bc}\pm9.6$ | $61.93^{a}\pm5.2$ |
| LDL-C (mg/dl) | $86.44^{d}\pm12.0$ | $184.69^{a}\pm14.3$ | $186.91^{a}\pm8.1$ | $135.83^{b}\pm13.0$ | $112.05^{c}\pm17.2$ | $77.57^{d}\pm13.8$ |

**Table 4: Effects of Corchorus Olitorius Leaves on Biochemical Parameters of Normoglycemic and Diabetic Rats.**

### 3.6 Histopathology

Photomicrograph sections of Pancreas of Rats after 70days feeding with Corchorus olitorius leaves are shown in Figure 2. The diabetic untreated group showed loss of islet cells and necrosis of acini. Alloxan monohydrate caused considerable damage to pancreatic beta cells as shown by the histopathological assay. Corchorus olitorius leaves gradually regenerated the islet and acini cells in a concentration dependent manner in the diabetic treated groups. Nduka et al. (2020) had similar observations [49].

**Figure 2: Photomicrograph Sections (H and E X 400) of the Pancreas of Normoglycemic Diabetic (Untreated and Treated) Wistar Rats.**

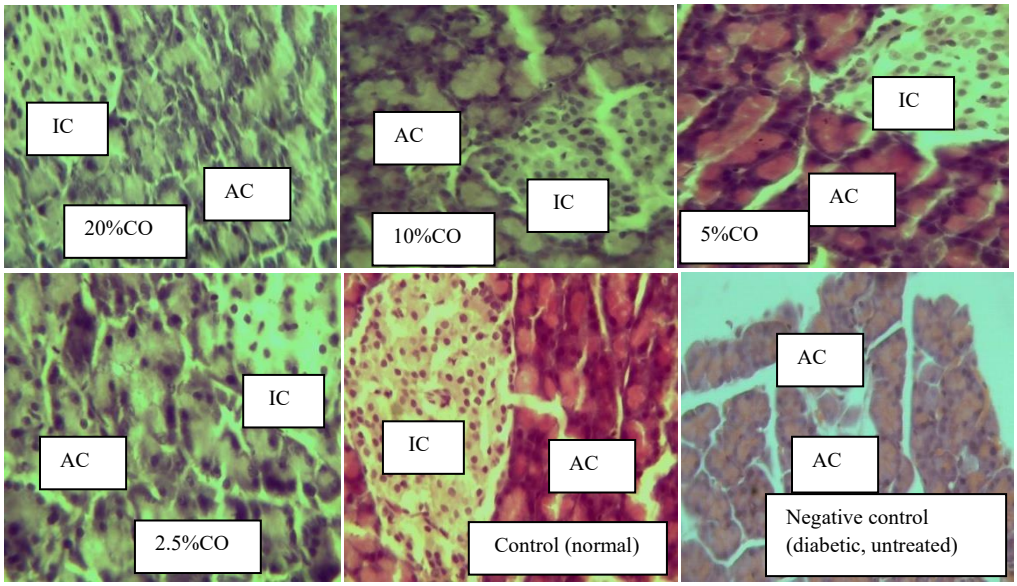


**Figure 2:** Photomicrograph sections (H and E x 400) of Pancreas of normoglycemic (control), diabetic untreated (negative control) and diabetic treated (2.5%CO, 5%CO, 10%CO and 20%CO) groups. CO= Cochorus olitorius: AC = Acini: IC = Islet cells.

## 4. Conclusion

Corchorus olitorius leaves exhibited alpha amylase inhibition activities; hypoglycemic and hypolipidemic activities and reversed pancreatic damage in alloxan-induced diabetic rats. It had varied effects on nutritional indices at various concentrations. Corchorus olitorius leaves at 10% inclusion significantly improved biochemical parameters but at an inclusion rate of 2.5% it had better effects on nutrient utilization. Both the results of its content of poly unsaturated fatty acids and cholesterol lowering potentials suggest that it could be more effective in the prevention of dyslipidaemia.


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## Author Contributions

PO conceptualized the research. NO carried out the work. The two authors drafted and edited the manuscript. All authors approved the manuscript.


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## Conflict of Interests

The authors declare that there are no conflicts of interest.

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