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Chemical Composition and Antidiabetic Activity of the Leaves of *Terminalia catappa* Linn. Grown in Dutsin-Ma

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Abstract: The main objective of this study is the investigation of the antidiabetic properties of the leaf of *Terminalia catappa*, a medicinal plant useful for the treatment of various diseases, including diabetes, in northern Nigeria. The plant's leaf, after preparation, was subjected to cold extraction using dichloromethane (DCM) and methanol. *In vitro* antidiabetic ability of *T. catappa* leaf extracts (DCM and methanol) was evaluated by the glucose uptake method using the yeast cell model. Phytochemical screening of both the extracts and Gas chromatography mass spectrometry (GC-MS) of the most active extract (DCM) was carried. *In vitro* antidiabetic activity by glucose uptake of yeast cell assay showed a dose-dependent rise in % of glucose uptake of DCM and methanol extracts of *T. catappa* leaf. Overall, DCM extract revealed the highest (94.00%) glucose uptake at a 50 µg/mL concentration. Eight phytochemicals were present in the plant's extracts: alkaloids, coumarins, flavonoids, steroids, phenols, tannins, saponins, triterpenoids and glycosides. The result of the GC-MS analysis of the dichloromethane extract depicted the presence of 47 compounds. Out of these compounds, a compound, identified as Linoleic acid with (Mol. wt = 278), exhibited the maximum peak area (22.12%), followed by 1,2-Benzenedicarboxylic acid (Mol. wt = 390) and Bis(2-ethylhexyl) phthalate (Mol. wt = 390) having peak areas of 6.85 and 5.55%, respectively. The study revealed the potential antidiabetic activity of leaf extracts of *T. catappa* and this activity may be linked to the presence of the most abundant phytocompounds detected in the plant's leaves.

Keywords: Chemical composition, Antidiabetic, *T. catappa*, Leaf Extracts, Medicinal plant.

Introduction

Diabetes mellitus (DM) is a metabolic disease with characteristic high plasma glucose concentration due to either insulin deficiency and/or impaired insulin activity (Mobasseri et al., 2020). Insulin release and action are affected by numerous factors such as lifestyle activities, genetics and epigenetic predisposition (Mobasseri et al., 2020). About 6.7 million and 416,000 deaths worldwide and in Africa, respectively, were associated with DM, ranking it among the 90th percentile of diseases that cause death in 2021(IDF, 2021). Type 2 diabetes mellitus (T2DM) is the most predominant type of DM, which has constituted a public health challenge by contributing to poor quality of life, morbidity and mortality (Khan et al., 2020; Batubo et al., 2025). In Nigeria and other sub-Saharan African countries, the prevalence of dyslipidemia and diabetes has been on the rise, primarily attributed to urbanization, economic transitions, and dietary shifts towards energy-dense and nutrient-poor foods (Pastakia et al.,2017; Obsa et al., 2021; Ekpor et al., 2024). For instance, a systematic review and meta-analysis among 91320 participants in Nigeria conducted by Adeloye *et al.* reported that the age-adjusted prevalence rates of T2DM in Nigeria among persons aged 20-79 years increased

from 2.0% in 1990 to 5.7% (Adeloye *et al.*, 2017; Iheagwam *et al.*, 2022). Similarly, another systematic review and meta-analysis among 14,650 participants in Nigeria conducted by Uloko *et al.* (2018) reported that the overall pooled prevalence of diabetes Mellitus was 5.77%. Poor adherence or compliance with antidiabetic medications due to side effects has been associated with cardiorenal outcomes (Yesufu, 2020; Denicolo *et al.*, 2021). This increasing burden and poor adherence have heightened the urgency for effective therapeutic interventions that address both conditions simultaneously while being accessible and culturally acceptable to affected populations.

Traditional herbal therapy has consistently remained a widely favoured method of healthcare. While herbal and conventional pharmacological therapies may have some variations, it is possible to assess the effectiveness and safety of herbal medications using traditional experimental techniques. Several distinct herbal extracts have demonstrated efficacy in treating particular medical ailments (Alum *et al.*, 2024a; Alum *et al.*, 2024b; Rizvi *et al.*, 2022).

In our ongoing research for investigation of medicinal plants traditionally used for the treatment of diabetes in northern Nigeria and based on our ethnobotanical survey conducted on plants useful for the treatment of diabetes in Dutsin-Ma, Nigeria, *Terminalia catappa* (*T. catappa*) was chosen for this study. *T. catappa* is a medicinal plant native to tropical regions of Africa, including countries like Nigeria, Ghana, and Cameroon. *T. catappa* leaves are used to treat scabies and other skin diseases. Its other traditional use includes treatment of diarrhea and fever, chronic diseases like diabetes, cancer, human immunodeficiency virus (HIV) and arthritis (Pandya *et al.,* 2013; Khan *et al.,* 2014; Iyekowa, 2023). It is also used in Hausa (northern Nigeria) ethnomedicine in the treatment of hepatitis, asthma and typhoid fever (Ahmadu *et al.,* 2017). The juice obtained from the plant's fresh leaves has been used in the preparation of a medicinal lotion which is effective against scabies, leprosy, stomach ache and headache (Anand *et al.,* 2015).

Materials and Methods

Plant Material

The *Terminalia cattapa* plant leaf was collected from Dutsin-ma, Katsina State, Nigeria, in Month of July, 2024. The plant sample was, thereafter, identified and authenticated in the Department of Biological Sciences, Federal University Dutsin-Ma, Katsina State. A voucher specimen of the plant (No. 32) was deposited in the herbarium for future reference.

Terminalia cattapa plant sample was dried at ambient temperature and then pounded into a coarse powder using a mortar and pestle. Ninety-seven and a half grams (97.5 g) of this powder was exhaustively extracted using 950 ml of DCM for 72 hours and 500 ml of methanol for 72 hours successively, while swirling at time intervals for faster and homogeneous extraction. The extracts were filtered and then concentrated under reduced pressure with a rotary evaporator at 40°C. Extracts obtained were dried at room temperature until they reached a constant weight and then labeled and stored in a desiccator before further analyses.

Phytochemical Screening

The plant extracts obtained were subjected to various tests to detect the presence of alkaloids, steroids, triterpenoids, flavonoids, coumarins, anthraquinones, saponins, tannins, phenols, and glycosides (Radha and Dharanidharan, 2021).

GCMS Analysis

The dichloromethane plant extract was subjected to GC-MS analysis on the instrument GC and MS JEOL GC mate equipped with a secondary electron multiplier. The JEOL GC MATE II GC-MS with data system is a high-resolution, double-focusing instrument. Maximum resolution: 6000 maximum calibrated mass: 1500 Dalton. Source option: Electron impact (EI); Chemical ionization (CI) (Agilent Technologies 6890 N Network GC system for gas chromatography). The column (HP5) was fused silica 50 m x 0.25 mm I.D. Analysis conditions were 20 min at 100m^{0}C, 3 min at 235 ^{0}C for column temperature, 240^{0}C for injector temperature, helium was the carrier gas and the split ratio was 5:4. The sample (1 uL) was evaporated in a splitless injector at 300^{0}C. Run time was 22 min.

***In vitro* Antidiabetic Activity Determination**

A stock solution of 1% glucose was prepared and different dilutions of 10, 20, 30, 40 and 50 µg/mL were prepared in different test tubes. As 1 mL of yeast solution was transferred into each of the test tubes and vortexed. To another set of 5 test tubes containing different dilutions of glucose concentration (10, 20, 30, 40 and 50 µg/mL), 1 mL of yeast solution was added and vortexed and then 1 mL of methanol and DCM extracts were then added to each test tube and incubated in a dark cupboard for 60 min at room temperature. The absorbance was taken at 540 nm using a UV-visible spectrophotometer. The procedure was repeated for each of the extracts and the drug.

The percentage increase in glucose uptake by yeast was calculated using the formula below (Johnson, 2022; Johnson and Okon, 2024).

Increase in glucose uptake % = $\frac{ABScontrol - ABSsample}{ABScontrol}$ x100

Where:

$ABS_{control}$ = Absorbance of the control reaction that does not contain the extract or drug

ABS_{sample} = Absorbance of the test samples

All experiments were carried out in triplicates.

Results and Discussion

Table 1 shows the result of the extraction of *Terminalia catappa* leaf. The result reveals that the dichloromethane extract yielded 17.76 g (18.21%) and the methanol extract yielded 7.73 g (7.92%).

Table 1: Result of Extraction of *Terminalia catappa* Leaf

Solvent	Yield of Extract (g)	Percentage Yield w/w
Dichloromethane	**17.76**	**18.21**
Methanol	**7.73**	**7.92**

These results indicate that the *Terminalia catappa* plant contains abundant phytochemical compounds. It is noteworthy that the highest yield was obtained from the dichloromethane extract, which could be due to the presence of compounds of intermediate polarity such as coumarins, free flavonoids, steroids and terpenoids. Hence, DCM majority of the compounds in the plant's leaves. The methanol extract, being polar, yielded a lower amount of metabolites. The phytochemical screening analysis result of *T. catappa* plant leaf is shown in Table 2. Flavonoids, alkaloids, steroids, triterpenoids, coumarins, phenols, saponins and glycosides were present in the

methanol extract while flavonoids, alkaloids, steroids, triterpenoids, coumarins and phenols were found in the DCM extract. *T. catappa* leaf extracts of different concentrations were assessed for *in vitro* antidiabetic activity by glucose uptake assay using a yeast model. The percentage of glucose uptake by yeast which represents the antidiabetic activity of each of the plant's extracts, is shown in Table 2.

Table 2: Percentage Increase in Glucose Uptake by Yeast for the Extracts and Positive Control

	10 µg/mL	20 µg/mL	30 µg/mL	40 µg/mL	50 µg/mL
Extract	uptake (%)	uptake (%)	uptake (%)	uptake (%)	uptake (%)
DCM	89.4	90.8	92.6	93.0	94.0
Methanol	80.4	82.4	86.3	91.2	93.2
Glibenclamide	60.0	70.2	76.7	83.4	90.5

The plant's extracts examined showed various degrees of percentage increases in the glucose uptake by yeast with all the concentrations used. This showed that all the extracts possessed some level of antidiabetic activity (Table 2). This is in agreement with the information provided by previous researchers on medicinal plants (Eseyin *et al*., 2016; Choudhury *et al*., 2018; Azantsa *et al*., 2019). This corroborates with some *in vivo* studies conducted by Iheagwam *et al* (2022) and Batubo *et al* (2025). DCM extract exhibited the most potent activity (94.0% at 50 µg/mL) compared to methanol extract (Table 4). A dose-dependant rise in the % of glucose uptake with increasing concentration (10–50 µg/mL) of *T. catappa* leaf extracts was observed generally (Table 2).

Table 3: Phytochemical Screening of *Terminalia catappa* Leaf

Constituent	**Test**	**Dichloromethane**	**Methanol**
Alkaloids	Mayer's Reagent Test	+	+
Flavonoids	Acid Test	+	+
Steroids	Alkaline Reagent Test	+	+
Triterpenoids	Acetic Anhydride Test	+	-
Anthraquinones	Bontragers Test	-	-
Saponins	Frothing Test	-	+
Coumarins	Acetic Anhydride Test	+	+
Tannins	Lead Acetate Test	+	+
Glycosides	Libermann's Test	-	+
Phenols	Keller-Killianis	+	+

Key: + = Present - = Absent

These secondary metabolites are reported to possess several biological and therapeutic properties (Boutahiri *et al.*, 2022; Septembre-Malaterre *et al.*, 2022; Saidi *et al.*, 2023). The numerous chemical compounds in plant having medicinal values include alkaloids, flavonoids, saponins, amino acid, carboxylic acid derivatives, anthraquinones, carbohydrates, glycosides, some inorganic compounds, peptidoglycans,

polyphenols and their derivatives and so on. Alkaloids have been investigated for their antidiabetic activity and show free radical scavenging action. Glycosides are mainly involved in the restoration of pancreatic *B* cells and insulin secretion. Flavonoids have numerous medicinal effects including antidiabetic properties and free radical scavenging (Zhang *et al.*, 2022; Septembre-Malaterre *et al.*, 2022). Phenols are used for the treatment of conditions such as cancer, liver cirrhosis, chronic renal disease, chronic obstructive lung disease, diabetes and Alzheimer's disease, which have been linked to antioxidant, anti-inflammatory, anti-allergic, anti-carcinogenic, anti-hypertension and anti-microbial activity (Raj and Singh, 2022; Saidi *et al.*, 2023). Saponins exhibit a biological role and medicinal properties such as hemolytic factor, antibacterial, antifungal, antiviral, cytotoxic and cholesterol-lowering action in animals and humans. Plant steroids possess many interesting medicinal activities like antidiabetic, anti-tumor, immunosuppressive, hepatoprotective, antibacterial, sex hormones, anthelminthic cytotoxic and cardiotonic activities (Saidi *et al.*, 2023). Therefore, the metabolites detected in the course of this study are likely to be linked to the biological activities of *Terminalia catappa*. Fourty-seven (47) compounds were detected by the GC-MS from the plant, Table 4. Linoleic acid Dibutyl phthalate (22.12%), 1,2-benzenedicarboxylic acid (6.85%), Tetrapentacontane (8.78%), Bis(2-ethylhexyl) phthalate (5.55%) and Lup-20(29)-en-3-ol (4.96%), acetate were determined to be the most abundant compounds in the plant's leaf (Table 4).

Table 4: Compounds identified in GC-MS from DCM Extract of *Terminalia catappa* Leaf

Peak	R-Time (min)	Name of Compound	Molecular Formula	Molecular Weight	Peak Area %
1	8.926	Dodacane 4-6 dimethyl	$C_{14}H_{30}$	198	1.24
2	9.996	Octadecane	$C_{18}H_{38}$	254	0.30
3	10.756	2-propenamide, N, N, diethy-2-	$C_8H_{15}No$	141	1.22
4	11.083	Decane-1-iodo	$C_{10}H_{21}I$	268	0.42
5	11.259	Heptadecane-8-methyl	$C_{18}H_{38}$	254	0.38
6	12.654	Trisiloxane Hexamet	$C_6H_{20}OSi_3$	208	0.27
7	4.769	Cyclooctasiloxane, hexadecane	$C_{16}H_{48}O_8Si_8$	592	1.22
8	13.660	Henekosane	$C_{21}H_{44}$	296	3.25
9	13.764	Decane-1-iodo	$C_{10}H_{21}I$	268	0.35
10	14.085	Cyclopropane carboxylic acid, 3	$C_{22}H_{30}O_5$	374	0.47
11	14.825	Heptadecane	$C_{17}H_{36}$	240	0.42
12	15.314	Oxirane, tetradecyl	$C_{16}H_{32}O$	240	0.32
13	17.096	Linoleic acid Dibutyl phthalate	$C_{16}H_{22}O_4$	278	22.12
14	17.171	n-hexadecanoic acid	$C_{16}H_{32}O_2$	256	2.32
15	17.305	Decane-1-iodo	$C_{10}H_{21}I$	268	1.14

16	17.711	Heneicosane	$C_{21}H_{44}$	296	0.44
17	18.492	Cyclooctasiloxane, hexadecane	$C_{16}H_{48}O_8S_{i8}$	592	2.53
18	18.875	12-octadecanoic acid (2,2)	$C_{18}H_{32}O_2$	280	0.66
19	18.967	1-decane-1-2-hexyl	$C_{16}H_{34}O$	242	0.40
20	19.273	Methyl stearate	$C_{19}H_{38}O_2$	298	0.78
21	21.441	Cyclononasiloxane, octadecane	$C_{18}H_{54}O_9Si_9$	666	4.28
22	21.644	4,8,12,16-tetramethyl heptadecane	$C_{21}H_{40}O_2$	324	0.48
23	21.750	1-decanol-1,2-hexyl	$C_{16}H_{34}O$	242	0.67
24	21.909	Decane-1-iodo	$C_{10}H_{21}I$	338	0.35
25	21.992	Hexanadioc acid	$C_{22}H_{42}O_4$	256	0.91
26	22.106	Nonacosane	$C_{29}H_{60}$	284	0.67
27	22.649	Cyclononasiloxane, octadecontane	$C_{18}H_{54}O_9Si_9$	410	4.19
28	22.993	Tetracontane	$C_{40}H_{38}O_4$	390	1.60
29	23.268	Bis(2-ethylhexyl) phthalate	$C_{24}H_{38}O_4$	390	5.55
30	23.407	Oxirane, hexadecyl	$C_{218}H_{36}0$	268	0.90
31	23.590	Tetrapentacontane	$C_{54}H_{11}0$	758	0.21
32	24.870	Pentatracontane	$C_{35}H_{72}$	492	1.57
33	24.957	1,2-benzenedicarboxylic acid	$C_{24}H_{38}O_4$	390	6.85
34	25.156	Lupeol	$C_{30}H_{50}O$	426	2.09
35	25.210	Heptadecane-8-methyl	$C_{18}H_{38}$	254	0.14
36	25.283	Tetracosane	$C_{18}H_{36}O_2$	338	0.87
37	25.400	Octadecanoic acid	$C_{18}H_{36}O_2$	284	0.24
38	25.475	Squalene	$C_{30}H_{50}$	410	0.58
39	25.705	SH-3,5-Epoxynaphth [2,1, -0] ox	$C_{18}H_{30}O_2$	278	2.66
40	25.780	2-Dodecan-1-yl (-) succinic anhy	$C_{16}H_{26}O_3$	266	0.21
41	25.855	Octadecanemethyl	$C_{18}H_{35}N$	265	0.95
42	25.959	Lup-20(29)-en-3-one	$C_{30}H_{48}O$	424	3.28
43	26.079	Dotriacontane	$C_{32}H_{66}$	450	4.94
44	26.301	Tetrapentacontane	$C_{54}H_{110}$	758	8.78
45	26.435	Lup-20(29)-en-3-ol, acetate	$C_{32}H_{52}O_2$	468	4.96
46	26.876	Lanosterol	$C_{30}H_{50}O$	426	0.63
47	27.747	Behenic alcohol	$C_{22}H_{46O}$	326	1.41

The presence of 47 compounds in the plant extract signifies the presence of a vast array of compounds with several medicinal properties. Fatty acids, terpenoids and steroids were documented to have the highest abundance. It was previously reported that all the major compounds detected by the GC-MS have antidiabetic activity. For example, Rayar and Manivannan (2015**)** reported antidiabetic activity of Ethyl Linoleate isolated from *Decalepis hamiltonii* Wight and Arn seed; 1,2-benzenedicarboxylic acid and Lup-20(29)-en-3-ol acetate were also reported to have anti-hyperglycemic effects (Lakshmi *et al*., 2015; Narasimhan *et al*., 2015; Saidi *et al*., 2023).

Conclusion

This study showed that *in vitro* antidiabetic activity by glucose uptake of yeast cell assay is a dose-dependent rise in percentage of glucose uptake of DCM and methanol extracts of *Terminalia catappa* leaf. DCM extract revealed the highest (94.00%) glucose uptake at 50 µg/mL concentration. The antidiabetic activity observed from the *Terminalia catappa* leaf extracts could be linked to the presence of the bioactive phytochemicals detected in the plant's leaf. The activity may be as a result of a synergistic interactions among the metabolites or otherwise. Further, the findings of the study support the traditional usage of *Terminalia catappa* leaves as a natural antidiabetic remedy among the populace of north-western Nigeria. Further studies pertaining isolation of the antidiabetic phytocompounds therein, it's toxicity effects and *in vivo* anti-hyperglycemic activity studies are ongoing.

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