**Original Research Article**

***Tetrapleura tetraptera* FRUIT EXTRACT INHIBITS ALPHA AMYLASE AND ALPHA GLUCOSIDASE ACTIVITIES IN RATS**

**ABSTRACT**

 Diabetes mellitus is a metabolic disorder posing a serious global health concern, necessitating the need for investigation for alternative management and treatment strategies including phytomedicine. *Tetrapleura tetraptera* (Taub) (family Fabaceae, a medicinal plant used traditionally in the treatment of diabetes was investigated for its inhibitory potential on alpha-amylase and alpha-glucosidase enzymes of rats. The fruit extract of *Tetrapleura tetraptera* (300 - 900 mg/kg)was investigated *in vivo* for inhibitory effect on alpha amylase and alpha glucosidase enzymes using starch, sucrose and maltose as substrates. Acarbose was used as reference drug. Blood glucose levels (BGL) of rats, post administration of the substrate and extract concurrently, were monitored over 3 hours as a parameter to measure the inhibitory potentials of the extract. The fruit extract dose-dependently caused significant (p<0.05) reduction in blood glucose levels of treated rats with the various substrates used. The results suggest that the fruit extract of *Tetrapleura tetraptera* has the potentials to inhibit alpha amylase and alpha glucosidase in rats.

**Keywords:** *Tetrapleura tetraptera;* Anti-diabetic, Enzyme inhibition, Alpha-amylase, Alpha-glucosidase,

**1. INTRODUCTION**

Diabetes mellitus (DM) is one of the most serious metabolic disorder posing a rising health challenges affecting most countries of the world economically and socially. It has been ranked as the 8th deadly diseases responsible for millions of death globally (WHO, 2016). About 700 million people are projected to be affected by the disease by 2045 (Saeedi *et al.*, 2019), necessitating urgent intervention steps aim at preventing the impending deadly situation. The heavy reliance on conventional medicines for the management of the disease has not yielded satisfactory outcome due to economic consequences and associated side effects. Therefore the search for affordable and safe alternative drugs is inevitable and has continued to be one of the areas of active research.

Of late, there has been an increase in the patronage of herbal preparations for the management of DM globally. Some indigenous plants of Nigerian origin used locally for management of diabetes such as *Mammea africana* (Okokon *et al.,* 2007), *Hippocratea africana* (Okokon *et* *al.,* 2010), *Anthocleista djalonensis* (Okokon et al., 2012), *Solenostemon monostachyus* (Okokon *et al*., 2015), *Newbouldia laevis* (Osigwe *et al*., 2015), cornhusk of *Zea mays* (Okokon and Mandu, 2017), *Setaria megaphylla* (Okokon *et al*., 2022a) and *Solanum anomalum* (Okokon *et al.,* 2022b) were investigated by our group and found to be efficacious in the management of diabetes. However, investigation into the mechanism of antidiabetic action has only been conducted on a few of them regarding their effects on alpha amylase and alpha glucosidase activities.

*Tetrapleura tetraptera* (Taub) (family Fabaceae) is a perennial tree that is naturally distributed over a large part of tropical Africa, especially in the rain forest belt of West, Central and East Africa. The four winged fruit with a fragrant, characteristically pungent aromatic odour is used in folkloric medicine for the treatment of various diseases and as spice in the preparation of varieties of white soups by Efiks and Ibibios of Niger Delta region as well as the Eastern region of Nigeria. It is a popular condiment in the culinary practices among the Mbaise people of Imo State of Eastern region for preparation of highly spiced hot watery decoction for women during puerperium. The fruits in addition to its insect repellent property have been reported to be nutritional, molluscicidal, anticonvulsant, analgesic, antiinflammatory, antidiabetic and antimalarial (Adewunmi and Sofowora, 1980; Adewunmi and Marquis, 1981, 1987; Adewunmi, 1984; Adesina and Reisch, 1985; Ekong *et al*., 2025; Nwaiwu and Akah, 1986; Ojewole and Adewunmi, 2004; Ojewole, 2005; Okokon *et al.*, 2007). Other activities include Cytotoxic and antiproliferative (Ozaslan *et al.,* 2016), antioxidant and antibacterial (Koma *et al.*, 2016; Okechukwu *et al.,* 2022), and *in vitro* antiplasmodial (Lekana-Douki *et al.,* 2011). The present study was designed to evaluate the in vivo inhibitory effect of *Tetrapleura tetraptera* fruits extract on alpha amylase and alpha glucosidase enzymes of rats.

**2. Materials and Methods**

**2.1 Plants collection**

The fruits of *Tetrapleura tetraptera* were procured from Itam market, Itu LGA, Akwa Ibom State in November, 2024. The fruits were identified and authenticated as *Tetrapleura tetraptera* by a taxonomist in the Department of Botany and Ecological studies, University of Uyo, Uyo. Nigeria. Herbarium specimen was deposited at the Faculty of Pharmacy Herbarium, University of Uyo, Nigeria.

**2.2 Extraction**

The plant parts (fruits) were washed reduced to smaller pieces and air- dried on laboratory table for 2 weeks. The dried fruits were pulverized using a pestle and mortar. The powdered fruit was macerated in 70% ethanol for 72 hours. The liquid ethanol extract obtained by filtration was evaporated to dryness in a water bath at 60˚C. The yield of the extract was stored in a refrigerator at -4˚C until it was used for the experiment reported in this study.

**2.3 Animals**

Albino wistar rats (125 -142g) of either sex were used for these experiments. The animals were housed in standard cages and were maintained on a standard pelleted feed (Guinea feed) and water *ad libitum.* Permission and approval for animal studies were obtained from the College of Health Sciences Animal Ethics Committee, University of Uyo.

**2.4 In vivo Alpha-amylase and Glucosidase Inhibition Study**

**Alpha-Amylase Inhibitory Study**

Thirty Wistar rats were divided into 6 groups of 5 rats each. The rats in all groups were fasted for 18 h and fasting blood glucose concentration was first taken at 0 min before administration. Group I, as the normal control, received distilled water orally (10 mL/kg). Group II rats were orally administered starch at 2 g/kg body weight (orally with distilled water as vehicle) and distilled water (10 mL/kg) simultaneously. Rats in group III were administered starch (2 g/kg) and the standard drug (acarbose) at 100 mg/kg simultaneously. Based on previously determined LD50 (3240.37 mg/kg) and doses (Okokon *et al.*, 2007), Groups IV, V, and VI were administered with starch (2 g/kg) and *T. tetraptera* fruit extract at 300, 600 and 900 mg/kg respectively. All administrations were done orally and blood glucose concentration was monitored at 30, 60, 90, 120 and 180 min (Gidado *et al.,* 2019,Okokon *et al.*, 2023a).

**Glucosidase Inhibitory Study**

The procedure as described above was used for this study but with sucrose and maltose used as substrates (Okokon *et al.*, 2023a; Okokon *et al.*, 2023b).

**Blood Glucose Determination**

Drops of blood from tip of rats’ tails were dropped on stripes and glucose concentration was measured using a glucometer according to manufacturer’s specifications (Accu-chek, Indiana). The glucometer works using an electrochemical detection system with the following principle; the biosensor system makes use of disposable dry reagent strip based on glucose oxidase method. Each strip has an electrode impregnated with the enzyme glucose oxidase, which react with glucose in the blood sample when dropped on the membrane covering the reagent pad (strip), to produce gluconic acid. During the reaction, in which electric current is generated, an electrochemical mediator transfers electrons to the electrode surface. This electrode sensor measures the current produced when the enzyme converts glucose to gluconic acid. The magnitude of the generated current is proportional to the amount of glucose present in the drop of blood sample, thus giving an accurate reading of the blood glucose concentration (WHO, 2011).

**2.5 Statistical Analysis**

Data obtained from this work were analysed statistically using one –way ANOVA followed by Tukey-Kramer multiple comparison test using Instat Graphpad software, (San Diego, USA). Differences between means were considered significant at 5% level of significance ie p≤ 0.05.

**3. RESULTS**

**3.1 In Vivo Alpha Amylase and Glucosidase Inhibition Assay**

 Treatment of fasted rats with starch (2 g/kg) elevated blood glucose concentrations of the treated animals after 30 min in various proportions. The proportions were as follows: starch (40.18%), extract-treated groups (ranging from 7.92% to 25.76 %), and acarbose-treated groups (17.97%). After 60 minutes, the blood glucose concentrations were lowered with the groups administered with dosages of the extract (300 - 900 mg/kg) having percentage increases ranging from 1.58 to 13.44%. The average blood glucose concentrations of all the groups treated with the extract were lowered to normal level after 120 minutes except that of the lowest dose (300 mg/kg) with BGL of 5.23%. The BGL of all the extract treated groups were reduced to normal at 180 min (Table 1).

Sucrose (2 g/kg) administration to fasted rats caused 51.80% increase in blood glucose level 30 minutes post-administration of the sucrose to the control group. BGL increments of 11.87-35.06 % were also recorded in groups treated with 300,600 and 900 mg/kg of extract. At 60 min, percentage increases in BGL of groups treated with 300, 600, and 900 mg/kg of extract were 22.38, 5.32 and 0 %, respectively. No increment in BGL was recorded in the extract-treated groups from 120 -180 min except in the group treated with the low dose (300 mg/kg) of the extract (3.39 %) (Table 2).

There was a 68.32% increase in blood glucose level 30 min following maltose administration in the control group. However, 17.04 - 43.43 % increases in BGL were observed in the extract-treated groups. At 60 min, groups treated with 300, 600 and 900 mg/kg extract had percentage increments of 21.69, 7.78 and 0%, respectively, while percentage increases of 6.83 and 0.45% were recorded for 300 and 600 mg/kg treated groups at 120 min respectively. At 180 min, no increment in BGL was recorded in any of the extract treated groups (Table 3).

**Table 1.** Effect of ethanol fruit extract of *Tetrapleura tetraptera* on blood glucose level of rat after oral administration of starch load

|  |  |  |
| --- | --- | --- |
| TREATMENT  | DOSE  | BLOOD GLUCOSE LEVEL mg/dL IN MIN |
|  | mg/kg | 0 min | 30 min | 60 min | 120 min | 180 min |
| Control (normal saline) | - | 76.10±5.23 | 78.33±3.42(2.93) | 78.61±4.12(3.29) | 74.45±4.38 | 73.35±3.20 |
| Starch |  | 75.10±1.34 | 105.28±5.23a(40.18) | 94.44±3.65(25.75) | 85.34±2.56(13.63) | 78.43±3.40(4.43) |
| Acarbose | 100 | 72.33±2.69 | 85.33±12.97(17.97) | 80.33±7.21(11.06) | 74.0±1.00(2.30) | 72.33±8.68(0) |
| Extract | 300 | 74.33±3.10 | 93.48±6.12(25.76) | 84.32±3.89a(13.44) | 78.22±4.52a(5.23) | 75.43±2.33a() |
|  | 600 | 75.66±2.56 | 83.48±2.36(10.33) | 80.10±1.55(5.86) | 74.30±2.45b() | 72.56.±3.68a() |
|  | 900 | 74.24±2.38 | 80.12±4.58(7.92) | 75.42±3.16(1.58) | 73.40±2.16a() | 70.22±2.45() |

Data are expressed as MEAN ± SEM, Significant at ap<0.05, bp< 0.01, compared to control (n=6).

Values in parenthesis are percentage increases in blood glucose concentrations compared to 0 min in the same group.

**Table 2.** Effect of ethanol fruit extract of *Tetrapleura tetraptera* on blood glucose level of rat after oral administration of sucrose load

|  |  |  |
| --- | --- | --- |
| TREATMENT  | DOSE  | BLOOD GLUCOSE LEVEL mg/dL IN MIN |
|  | mg/kg | 0 min | 30 min | 60 min | 120 min | 180 min |
| Control (normal saline) | - | 80.20±2.26 | 82.46±3.56(2.81) | 81.49±6.33(1.60) | 82.23±3.28(2.53) | 83.43±1.20(4.02) |
| Sucrose | 2000 | 79.35±5.29 | 120.46±3.28b(51.80) | 125.13±2.33a(57.69) | 110.03±2.14(38.66) | 98.49±3.34(24.12) |
| Acarbose | 100 | 81.66±4.24 | 78.34±3.28 | 74.10±5.20 | 73.28±3.24 | 7522±2.43 |
| Extract | 300 | 78.62±5.28 | 106.19±3.10c(35.06) | 96.22±4.23(22.38) | 81.29±3.18(3.39) | 75.52±2.36 |
|  | 600 | 77.22±3.14 | 89.34±3.36b(15.69) | 81.33±6.18(5.32) | 76.33±2.16() | 70.35±3.26() |
|  | 900 | 76.28±3.34 | 85.34±3.22(11.87) | 75.45±4.13() | 70.12±4.16() | 66.50±2.66() |

Data are expressed as MEAN ± SEM. Significant at ap<0.05, bp< 0.01, compared to control (n=6). Values in parenthesis are

percentage increases in blood glucose concentrations compared to 0 min in the same group.

**Table 3.** Effect of ethanol fruit extract of *Tetrapleura tetraptera* on blood glucose level of rat after oral administration of maltose load

|  |  |  |
| --- | --- | --- |
| TREATMENT | DOSE  | BLOOD GLUCOSE LEVEL mg/dL IN MIN |
|  | mg/kg | 0 min | 30 min | 60 min | 120 min | 180 min |
| Normal Control  | - | 80.23±1.38 | 78.45±2.34 | 81.34±2.30(1.38) | 79.20±5.44() | 82.46±3.16(2.77) |
| Maltose | 2000 | 76.33±5.48 | 128.48±8.26c(68.32) | 120.30±6.78a(57.60) | 110.03±5.49(44.15) | 90.12±6.33(18.06) |
| Acarbose | 100 | 74.23±3.24 | 78.24±3.28(5.40) | 76.33±4.15(2.82) | 74.56±2.45a(0.44) | 70.55±3.22() |
| Extract  | 300 | 73.33±3.56 | 105.18±3.56a(43.43) | 89.24±3.26a(21.69) | 78.34±3.23a(6.83) | 70.24±4.24a() |
|  | 600 | 76.45±5.52 | 95.15±2.54b(24.46) | 82.40±3.86a(7.78) | 76.80±2.65a(0.45) | 72.03±3.45() |
|  | 900 | 75.66±4.16 | 88.56±8.23b(17.04) | 74.34±4.26b() | 70.66±6.77b() | 68.39±4.45a() |

Data are expressed as MEAN ± SEM, Significant at ap<0.05, bp< 0.01, compared to control. (n=6).

Values in parenthesis are percentage increases in blood glucose concentrations compared to 0 min in the same group.

**4. DISCUSSION**

*Tetrapleura tetraptera* fruits are used as spice and medicine in Ibibio traditional medicine in the treatment of diseases such as diabetes among others. This work investigated the effect of *Tetrapleura tetraptera* fruit extract on alpha amylase and alpha glucosidase activities in rats, The extract was found to inhibit increases in blood glucose concentration following starch administration.α-amylases and α-glucosidase enzymes act in synergy to digest dietary polysaccharides such as starch. The polysaccharides are reduced to disaccharides by α-amylase enzyme by breaking the α-bonds of the α-linked polysaccharides. Thereby resulting in disaccharides like maltose, which are also digested by membrane bound α-glucosidase enzymes to monosaccharides (Kalra, 2014; Alongi and Anese, 2018). Inhibitions of these enzymes activities suppress the ingested carbohydrates digestion, with associated insignificant elevation in blood glucose concentrations following carbohydrate meals as was observed in this study. As a target for managing Type 2 diabetes mellitus, some medicinal plants have been investigated for α-amylase and α-glucosidase inhibitory potentials. Previously, we had reported on the α-amylase and α-glucosidase inhibitory potentials of some herbs and vegetables such as *Heinsia crinata, Lasianthera africana,* *Setaria megaphylla*, *Solanum anomalum*  (Okokon et al.*,* 2021; Eweh et al., 2022; Etuk et al.*,* 2023) and *Justicia insularis* (Osigwe *et al.,* 2025) among others.

Similarly, the fruit extract significantly inhibited blood glucose rise when co- administered with maltose and sucrose. Acarbose, the standard drug used in this study significantly suppresses blood glucose rise when co-administered with starch, maltose and sucrose. The results of this study corroborate the reported hypoglycemic activity of the fruit extract of *T. tetraptera* on blood glucose level of hyperglycemic rats (Ojewole and Adewunmi, 2004). The inhibitory activities of this fruit extract maybe linked to its phytochemical constituents such as polyphenols (tannins, flavonoids), saponins, phytate, triterpenoid, coumarinic (scopoletin) and phenolic (caffeic acid, cinnamic acids) compounds and a triterpene glycoside (aridanin) which have been found as the active ingredients (Aladesanmi, 2007)

The presence of these compounds in the extract could have contributed to the observed activity in this study and therefore could represent one of the antidiabetic mechanisms of the fruit extract of *T. tetraptera*.

**5. CONCLUSION**

The findings of this research suggest that the fruit extract of *T. tetraptera* may exhibit anti-diabetic effects by inhibiting the alpha-amylase and alpha-glucosidase enzymes. This activity may be linked to the presence of phytochemical ingredients in the plant.

**Ethical Approval**

Permission and approval for animal studies were obtained from the College of Health Sciences Animal Ethics Committee, University of Uyo. All animal experiments complied with the National Institute of Health Guide for Care and Laboratory Animals (pub. No. 85-23, revised 1985).

 **REFERENCES**

Adesina, S.K., Reisch, J.(1985). A triterpenoid glycoside from the fruit of *Tetrapleura tetraptera* (Taub). *Phytochemistry* 24, 3003–3006.

Adewunmi, C.O., 1984. Water extract of *Tetrapleura tetraptera*: an effective molluscicide for the control of schistosomiasis and fascioliasis in Nigeria. *Journal of Animal Production Research* 4, 73–84.

Adewunmi, C.O., Marquis, V.O., (1987). Evaluation of the effects of environmental factors on the molluscicidal properties of aridan (*Tetrapleura tetraptera*), Lapalapa pupa (*Jatropha gossypyfolia*), Endod (*Phytolacca dodecandra*) and Bayluscide. *Phytotherapy Research* 1, 69–72.

Adewunmi, C.O., Marquis,V.O., (1981). Laboratory evaluation of the molluscidal properties of aridanin, an extract from *Tetrapleura tetraptera* (Mimosaceae) on *Bulinus globosus*. *Journal of Parasitology* 67, 713–716.

Adewunmi, C.O., Sofowora, E.A., (1980). Preliminary screening of some plants extracts for molluscicidal activity. *Planta Medica* 39, 57–65.

Akinboro A, Bakare AA. (2007). Cytotoxic and genotoxic effects of aqueous extracts of five medicinal plants,” *Journal* *of Ethnopharmacology*, 112(3):470–475.

Aladesanmi AJ.(2006) *Tetrapleura tetraptera*: molluscicidal activity and chemical constituents. Afr J Tradit Complement Altern Med. 4(1):23-36.

Albertini RJ, Anderson D, Douglas GR.(2000). IPCS guidelines for the monitoring of genotoxic effects of carcinogens in humans,” *Mutation Research*, 463(2):111–172.

Alongi M and Anese M. (2018). Effect of Coffee Roasting on *in vitro* α-glucosidase activity: inhibition and Mechanism of Action. *Food Res Intl.* 111:480-487.

Ekong MB, Bassey OO, Pessu NA,Kpobari GV, Okuku EI, Bassey RB, Johnson EI, Peter AI, Okokon JE, Akpanabiatu MI.(2025). *Tetrapleura tetraptera* fruit extracts ameliorate pentylenetetrazol induced seizures as well as ensuing cognitive deficit and oxidative stress.  *Metabolic Brain Disease* (2025) 40:143

Etuk IC, Ebong N, Okokon JE (2023). Inhibitory effect of leaf extract and fractions of *Solanum anomalum* on alpha amylase and alpha glucosidase enzymes. *Biology Medicine and Natural Product Chemistry*.21(1):145-150.

Eweh US, Igwe CJ, Effiong GS, Ebong NO, Okokon JE (2022). Evaluation of inhibitory effect of two common vegetables (*Heinsia crinata* and *Lasianthera africana*) on alpha amylase and alpha glucosidase enzymes of rats. *Journal of Current Biomedical Research*.2(5):405-414.

Gidado A, Watafua M, Sa’ad RS, Tagi HS, Abdullahi S. (2019). Alpha-amylase, maltase and sucrase inhibitions by aqueous leaf extracts of *Anacardium occidentale*  (Anacardiaceae) and *Piliostigma reticulatum* (Caesalpiniaceae) in rats. *Trop J Nat Prod Res,* 3(6):210-215.

Kalra S. (2014). Alpha Glucosidase Inhibitors. *The J Pak Med Assoc*. 64(4):474-476.

Koma O, Olawumi O, Godwin E-U, Theophilus O (2016) Phytochemical screening, In-vitro antimicrobial activity and antioxidant characteristics of *Tetrapleura tetraptera* extracts. *Eur J Med Plants* 17(2):1–10.

 Le HTT, Hioku Y, Danova A, Nguyen VK, Duong TH, Kita M, Chavasiri W.(2023). α-Glucosidase inhibition of sesquiterpenoids from the heaertwood of *Mansonia gagei*. *Phytochemistry*. 2023, 213: 113778.

Lekana-Douki JB, Liabagui O, Bongui SL, Zatra JB, Lebibi R, J., Toure-Ndouo FS (2011) In vitro antiplasmodial activity of crude extracts of *Tetrapleura tetraptera* and *Copaifera religiosa. BMC Res Notes* 4(1):506.

Madhu M, Sailaja V, Satyadev T, Satyanarayana MV. (2016). Quantitative phytochemical analysis of selected medicinal plant species by using various organic solvents. *Journal of Pharmacognosy and Phytochemistry*, 5(2): 25 - 29.

Maillard, M., Adewunmi, C.O., Hostettman, K., (1992). A triterpene glycoside from the fruit of *Tetrapleura tetraptera*. *Phytochemistry* 31, 1321–1323.

Morocho V, Sarango D, Cruz-Erazo C, Cumbicus N, Cartuche L, Suárez A. I.(2020). Chemical Constituents of *Croton thurifer* Kunth as α-Glucosidase Inhibitors. *Rec. Nat. Prod.* 14:(1) 31-41.

Nwaiwu, J.I., Akah, P.A. (1986). Anticonvulsant activity of volatile oil from the fruit of *Tetrapleura tetraptera*. *Journal of Ethnopharmacology* 18, 103–107.

Ojewole, J.A., (2005). Analgesic and anticonvulsant properties of *Tetrapleura tetraptera* (Taub) [fabaceae] fruit acqeous extract in mice. *Phytotherapy Research* 19, 1023–1029.

Ojewole, J.A., Adewunmi, C.O. (2004). Antiinflammatory and hypoglycaemic effects of *Tetrapleura tetraptera* (Taub) [fabaceae] fruit acqeous extract in rats. *Journal of Ethnopharmacology* 95, 177–182.

Okechukwu QN, Ugwuona FU, Ofoedu CE, Juchniewicz S, Okpala COR (2022) Chemical composition, antibacterial efficacy, and antioxidant capacity of essential oil and Oleoresin from *Mono-dora myristica* and *Tetrapleura tetrapter*a in Southeast Nigeria. Sci Rep 12(1):19861.

Okokon JE, Anagboso MO, Etim EI, Asor L O. (2023b). Evaluation of inhibitory Effect of *Solenostemon monostachyus* on alpha amylase and alpha glucosidase enzymes of rats. *Journal of Drug Discovery and Research*, *1*(2), 1-7.

Okokon JE, Nwokafor I, Ebong NO. (2023a). In vivo inhibitory effect of *Panicum maximum* root extract on alpha amylase and alpha glucosidase enzymes of rats. *Journal of Current Biomedical Research*. 3(4):1084-1095.

Okokon JE, Udom GJ, Attah G, Bassey AL. (2022c). Alpha amylase and alpha glucosidase inhibitory activities leaf of *Croton zambesicus* fractions in wistar rats. Journal of Current Biomedical Research.2(2):158-165.

Okokon JE, Etuk IC, Thomas P, Drijfhout P, Claridge TM, Li W-W. (2022b). In vivo antihyperglycaemic and antihyperlipidemic activities and chemical constituents of leaf extract and fractions of *Solanum anomalum* in alloxan-induced diabetic rats. *Biomedicine and Pharmacotherapy* 151(2022):113153.

Okokon JE, Davies K, Lekara J, Iwara K, Thomas P, Li W-W. (2022a). Antidiabetic and hypolipidemic activities of solvents fractions of *Setaria megaphylla* and its phytochemical characterisation. *Phytomedicine Plus.* 2(2022):100182.

Okokon JE, Davies K, Lekara J, Iwara K, Kumar H.(2021). Effect of solvents leaf fractions of *Setaria megaphylla* on alpha amylase and alpha glucosidase activities in rats. *Advanced Pharmaceutical Journal.* 6(4):111-115.

Okokon JE, Amazu LU, Nwidu LL. (2015). Antidiabetic and hypolipidemic activities of *Solenostemon monostachyus.* *Journal of Herbal Drugs.* 6(2):83 - 90

Okokon JE, Antia BS, Udobang JA. (2012). Antidiabetic activities of ethanolic extract and fractions of *Anthocleista djalonensis.* *Asian Pacific Journal of Tropical Biomedicine.* 2(6): 461 - 464.

Okokon JE, Nwafor PA, Ekpo E, Okokon P, Udobang J. (2011a). Antidiabetic and hypolipidemic activities of ethanolic root extract of *Croton zambesicus* on alloxan induced diabetic rats. *Asian Journal of Pharmaceutical Research* 1: 493 – 499.

Okokon JE, Antia BS,Umoh EE, Etim EI(2010). Antidiabetic and hypolipidaemic effects of *Hippocratea africana* (Hippocrateaceae) in streptozotocin induced diabetic rats. *Int. Journal of Drug Dev. and Research* 2(3): 501 - 506.

Okokon JE, Antia BS, Osuji L, Udia PM. (2007). Antidiabetic and hypolipidaemic effects of *Mammea africana* (guttiferae) in streptozotocin induced diabetic rats. *Journal of Pharmacology and Toxicology*. 2(3): 278-283.

Okokon JE, Udokpoh AE, Antia BS. (2007). Antimalaria activity of ethanolic extract of *Tetrapleura tetraptera* fruit. *Journal of Ethnopharmacology* 111: 537–540.

Osigwe CC, Okokon JE, Uwaeme UF, (2025). Effect of *Justicia insularis* T. Anderson leaf extract on alpha glucosidase and alpha amylase activities in rats. Journal of Complementary and Alternative Medical Research. 26(4): 101-108

Osigwe CC**,** Akah PA, Nworu CS, Okoye TC, Tchimene MK (2015).Antihyperglycemic studies on the leaf extract and active fractions of *Newbouldia laevis* (Bignoniaceae). Pharmacology & Pharmacy 6: 518 – 532. http://dx.doi.org/10.4236/pp.2015.611054

Ozaslan M, Karagoz ID, Lawal RA, Kilic IH, Cakir AD, Odesanmi OS, Guler I, Ebuehi OAT (2016) Cytotoxic and Anti-proliferative activities of the *Tetrapleura tetraptera* fruit extract on Ehrlich Ascites tumor cells. *Int J Pharmacol* 12:655–662.

Qaisar MN, Chaudhary BA, Sajid MU, Hussain N. (2014). Evaluation of α-glucosidase inhibitory activity of dichloromethane and methanol extracts of *Croton* *bonplandianum* Baill. *Tropical Journal of Pharmaceutical Research.* 13 (11): 1833-1836

Saedi E, Ghein, M, Faiz F, Arami M. (2016). Diabetes mellitus and cognitive impairments. *World Journal of Diabetes*. 7(10). 412 .

Srisongkram, T, Waithong S, Thitimetharoch T, Weerapreeyakul N. (2022). Machine Learning and In Vitro Chemical Screening of Potential \_-Amylase and \_-Glucosidase Inhibitors from Thai Indigenous Plants. *Nutrients* 14, 267.

Tan D, Song Y, Wang J, Gao C, Qin L, Zhao Y, Lu Y, Yang Z, He Y. (2023).Identification of sesquiterpene glycosides from *Dendrobium nobile* and their α-glycosidase and α-amylase inhibitory activities Technol, Campinas. *Food Sci.* 43, e99722, 2023

World Health Organization (2011). Glucose analyser. Core medical equipment information. 2011. www.who.int/medical\_devices/en/index.html. Assessed on 3rd June, 2019.

World Health Organization 2016. *Global Report on Diabetes*. Geneva, 2016.