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## Qualitative phytochemical analysis of methanol crude extract of *Detarium microcarpum* leaves

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### Abstract

The increasing prevalence of drug-resistant pathogens and limited access to conventional medicine have underscored the need for alternative therapeutic agents derived from natural sources. *Detarium microcarpum*, commonly known as the tallow tree, is widely used in traditional medicine across West and Central Africa. This study presents a qualitative phytochemical analysis of the methanol crude extract of *D. microcarpum* leaves (MEL) to identify its bioactive compounds. Macroscopical evaluation revealed that the leaves are green, ovate, odourless, tasteless, with a glossy surface and a rounded base. Phytochemical screening confirmed the presence of key secondary metabolites, including alkaloids, flavonoids, tannins, saponins, steroids, cardiac glycosides, saponin glycosides, anthraquinones, balsams, volatile oils, and glycosides. These bioactive constituents support the traditional medicinal applications of *D. microcarpum* and highlight its potential for pharmaceutical development. The findings lay a scientific foundation for further pharmacological studies, standardization, and drug formulation to explore its full therapeutic potential.

**Keywords:** *Detarium microcarpum*, therapeutic agents, macroscopical evaluation, phytochemical screening, medicinal plants, bioactive compounds

### Introduction

In recent years, as infectious diseases have spread and harmful organisms have developed resistance to therapy, the quest for new treatments has increased substantially (Abdulrahman *et al.*, 2018) <sup>[1]</sup>. Humans have always drawn inspiration from plants due to their unique medical characteristics. Traditional African medicine relies heavily on the use of medicinal plants for the treatment of a wide variety of illnesses (Kankara *et al.*, 2015; Abubakar *et al.*, 2022) <sup>[2]</sup>. Herbal medicine (also called botanical medicine or phytomedicine) refers to using plant's seeds, berries, roots, leaves, bark, or flowers for medicinal purposes. Traditional medicine refers to health practices, approaches, knowledge and beliefs incorporating plants, animals and mineral based medicines, spiritual therapies, manual techniques and exercises, applied singly or in combination to treat or to diagnose and prevent illnesses or maintain well-being (WHO, 2003) <sup>[24]</sup>. A renewed global interest in the use of herbal medicines even among developed nations has necessitated the need for the standardization of herbal products. The World Health Organization has emphasized the need to ensure the quality of medicinal plant products by using modern control techniques and applying suitable standards. Standardization is necessary to mitigate the incidence of lack of efficacy, poor quality, adverse effects and toxicity (WHO, 1998; WHO, 2007) <sup>[26, 23]</sup>.

The tallow tree, *Detarium microcarpum*, is widely distributed in tropical West Africa's arid Savannah ecosystem. Because every part of the *D. microcarpum* plant has therapeutic applications, the plant itself is referred to as a miracle plant by traditional herbalists (Idris *et al.*, 2021) <sup>[11]</sup>. Folk medicine heavily relies on its leaves and fruits. The need for new drugs derived from numerous species of medicinal plants is continuously growing today (Ashraf *et al.*, 2020) <sup>[4]</sup>.

Plants consist of various kinds of chemical constituents known as phytoconstituents (phytochemical constituents) (Mercy *et al.*, 2017) <sup>[15]</sup>.

The secondary roles that phytoconstituents perform for plants include promoting plant development, protecting them by triggering defense mechanisms, and giving them color, flavor, and odor (Molyneux *et al.*, 2007) <sup>[16]</sup>. In comparison to their synthetic counterparts, natural chemicals and their derivatives have less adverse effects and greater efficacy. These plant-derived components, such as flavonoids, quinine, and terpenoids, perform certain biological functions that enhance therapeutic activities, such as anti-carcinogenic, anti-mutagenic, anti-inflammatory, and antioxidant properties (Batiha and Beshbishy, 2020) <sup>[15]</sup>.

*D. microcarpum* leaves have traditionally been used to treat diabetes mellitus in most regions of Africa (Manukumar *et al.*, 2017) <sup>[13]</sup>. Total phenolic content and radical-scavenging activities have been assessed in *D. microcarpum* methanol extracts (Meda *et al.*, 2017) <sup>[14]</sup>. Silver nanoparticles (AgNPs) have strong antimicrobial and antioxidant activities and have many uses, including catalysis, synergistic oxidation of carbon monoxide, biological research, dye reduction, selective oxidation of benzene, and chemotherapy (Priya *et al.*, 2016) <sup>[19]</sup>. *D. microcarpum* has been used in the synthesis of AgNPs, with an aqueous extract of the plant being applied as a stabilizing and reducing agent. The antioxidant activity of AgNPs stabilized by *D. microcarpum* is between medium and good activity (Labulo *et al.*, 2016) <sup>[12]</sup>. The anti-inflammatory properties of *D. microcarpum* aqueous extracts, which contain polyphenolic compounds such as vanillic acid, gallic acid, and protocatechuic acid, imply that it is a promising herbal remedy for pain and inflammation management (Windmi *et al.*, 2021) <sup>[25]</sup>. Lupeol, betulinic acid,  $\beta$ -sitosterol glucoside, methyl gallate (Feudjou *et al.*, 2020) <sup>[9]</sup>, humulene-1,2-epoxide, caryophyllene oxide,  $\gamma$ -acetylcaryophyllene, salvia-4(14)-ene-1-one, and linalool are some of the main components of the essential oil of *D. microcarpum* leaves, which have antimicrobial properties (Semde *et al.*, 2018) <sup>[20]</sup>. *Detarium microcarpum* flavanones had potent inhibitory effects on HIV-1 and HIV-2 infection in a methanol extract. In order to identify different classes of bioactive constituents present in various parts of the plant for the discovery of drugs, scientists use a process called phytochemical screening. The active components identified from this process can be used for further investigation and research. Depending on the plant species, soil type, and their relationship to microbes, medicinal plants' physiologically active chemical composition varies greatly (Morsy, 2014) <sup>[17]</sup>. These bioactive secondary metabolites produced by medicinal plants have a significant impact on the physiological processes of the microbial communities that are connected with plants as well (Phillipot *et al.*, 2013) <sup>[18]</sup>. The research is significant because:

- It provides empirical evidence on the bioactive constituent present in *D. microcarpum*
- It validates traditional claims on therapeutic activities of the plant.
- It establishes a foundation for future quantitative analyses and pharmacological evaluations that could lead to the development of novel therapeutic formulations.

*Detarium microcarpum* is widely recognized in West African ethnomedicine, but there is paucity of detailed about the phytochemical makeup of its leaves, which have been

hypothesized to contain diverse bioactive phytoconstituents that traditional medicinal efficacy.

*Detarium microcarpum* leaf extracts are rich in nutrients and medicinal properties; therefore, performing phytochemical screening will not only help to identify the components of the leaf extracts and which one predominates over the others, but also be helpful in investigating bioactive agents that can be used in the synthesis of useful drugs, that could be used for treating a variety of diseases and maintaining health.

The aim of the study is determine the phytoconstituents that are present in the methanol crude extract of the leaf (MEL) of *Detarium microcarpum*.

The primary objectives of the study are:

- To extract the bioactive compounds from *D. microcarpum* leaves using the maceration method.
- To conduct a qualitative phytochemical screening of the methanol crude extract of the leaf (MEL) of *D. microcarpum* to determine the presence of key secondary metabolites.

## Materials and Methods

### Materials

#### Equipment/apparatus used

List of the Equipment and Apparatus used

| Equipment          | Manufacturer              |
|--------------------|---------------------------|
| Beaker             | BDH Chemical Limited (UK) |
| Conical flask      | BDH Chemical Limited (UK) |
| Test tube          | BDH Chemical Limited (UK) |
| Filter paper       | BDH Chemical Limited (UK) |
| Cotton wool        | BDH Chemical Limited (UK) |
| Test tube brush    | BDH Chemical Limited (UK) |
| Measuring cylinder | BDH Chemical Limited (UK) |
| Pipette            | BDH Chemical Limited (UK) |
| Weighing balance   | BDH Chemical Limited (UK) |
| Spatula            | BDH Chemical Limited (UK) |
| Water bath         | BDH Chemical Limited (UK) |

### Reagent Used

List of Reagents Used

| Reagents           | Purity (%) | Grade              |
|--------------------|------------|--------------------|
| Methanol           | 90.0       | Industrial grade   |
| Hydrochloric acid  | 95.5       | Laboratory reagent |
| Ferric chloride    | 96.5       | Laboratory reagent |
| Sodium hydroxide   | 97.0       | Laboratory reagent |
| Wagner's reagent   | -          | Laboratory reagent |
| Sulphuric acid     | 95.5       | Laboratory reagent |
| Mayer's reagent    | -          | Laboratory reagent |
| Fehling's solution | -          | Laboratory reagent |
| Ammonia solution   | 95.5       | Laboratory reagent |
| Chloroform         | 95.5       | Laboratory reagent |
| Benzene            | 96.0       | Laboratory reagent |
| Ethanol            | 90.0       | Laboratory reagent |

## Methods

### Sample Collection

Fresh leaves of *Detarium microcarpum* were harvested in September, 2023 from Saki, Nigeria. The plant was identified by Mr. Waliu Olamide Azeez. The leaves were collected using a cleaned plastic container.

### Macroscopical Evaluation

Macroscopical (organoleptic) Analysis: The leaf's size, shape, margin, apex, flavor, color, surface texture, petiole's presence or absence, base, lamina, and venation were all seen and noted (Evans, 2009) <sup>[7, 8]</sup>.

### Sample preparation

The leaves were cleaned, and air dried at room temperature. The dried leaves were crushed into a fine powder and stored in an airtight container after being pulverized using a pestle and mortar.

### Sample Extraction

A total of 5 g of the powdered leaves were macerated in 100 cm<sup>3</sup> of 90% v/v methanol in a conical flask. It was allowed to stand at room temperature for 24 hours while stirring occasionally. The mixture was filtered using Whatman filter paper (No. 1), and the filtrate was allowed to evaporate in a water bath at 30 °C to obtain the methanol extract of the leaf (MEL).

### Percentage Yield

The mass of the dried extract obtained after evaporation = 1.875 g

Mass of the dried powdered leaves used for extraction = 5.000 g

To calculate the percentage yield of the methanol extract, the expression below was used:

$$\text{percentage yield} = \frac{\text{mass of extract}}{\text{mass of sample used}} \times 100$$

$$\text{percentage yield} = \frac{1.875 \text{ g}}{5.000 \text{ g}} \times 100$$

$$\text{percentage yield} = 0.375 \times 100$$

$$\text{percentage yield} = 37.5\%$$

Thus, the percentage yield of the extract was determined to be 37.5%

### Preparation of reagents

All the reagents were prepared using analytical reagent-grade chemicals.

### Wagner's reagent

In a beaker, 2 g of sublimed iodine and 6g of potassium iodide were dissolved in 100 cm<sup>3</sup> of distilled water.

### Ferric chloride solution (5%)

In a 100 cm<sup>3</sup> volumetric flask, 5g of ferric chloride was weighed and dissolved in 50 cm<sup>3</sup> of distilled water, and made up to the mark with distilled water.

### Sodium hydroxide solution (10%)

The reagent was prepared by dissolving 10g of sodium hydroxide pellet in 40 cm<sup>3</sup> of distilled water in a beaker; the solution was then poured into a 100 cm<sup>3</sup> volumetric flask and made up to the mark with distilled water.

### HCl solution (10%)

Exactly 40 cm<sup>3</sup> of distilled was measured and then transfer into 100 cm<sup>3</sup> volumetric flask. 10 cm<sup>3</sup> of concentrated HCl

was added and then made up to the mark with distilled water.

### Ammonium solution (10%)

The reagent was prepared by measuring 10 cm<sup>3</sup> of ammonia, and then transferred it into a 100 cm<sup>3</sup> volumetric flask. 90 cm<sup>3</sup> of distilled water was added, diluting it to the mark indicated on the flask.

### Fehling's solution

Fehling's solution is prepared by combining two separate solutions: Fehling's A, which is a deep blue aqueous solution of copper (II) sulfate, and Fehling's B, which is a colorless solution of aqueous potassium sodium tartrate (also known as Rochelle salt) made strongly alkaline with sodium hydroxide in a 1:1 ratio.

### Mayer's reagent

Two solutions were made, one containing 1.36g of mercury chloride dissolved in 60 cm<sup>3</sup> of distilled water and the other containing 5g of potassium iodide dissolved in 20 cm<sup>3</sup> of distilled water. The two solutions were blended, poured into a 100 cm<sup>3</sup> beaker, and filled up to the mark with distilled water.

### Qualitative phytochemical screening of the extract

The methanol extract was then subjected to qualitative phytochemical screening. Using the methodology described by Evans and Trease (1999) <sup>[7, 8]</sup>; Sofowora (1993) <sup>[21]</sup>; El-Oleye *et al.* (1994) <sup>[6]</sup>, phytochemical screening was done to determine the presence of the following secondary metabolites: alkaloids, tannins, saponins, anthraquinones, glycosides, steroids, saponin glycosides, cardiac glycosides, volatile oils, balsams, and flavonoids.

### Test for Alkaloids

To prepare for the next test, 2 cm<sup>3</sup> of the extract was stirred with 2 cm<sup>3</sup> of 10% aqueous hydrochloric acid. 1 cm<sup>3</sup> of the mixture was treated with a few drops of Wagner's reagent, and the second portion (1 cm<sup>3</sup>) was treated similarly with Mayer's reagent. Turbidity or precipitation with either of these reagents is taken as preliminary evidence for the presence of alkaloids (Harbone, 1998) <sup>[10]</sup>.

### Test for Tannins

To 3 cm<sup>3</sup> of the extract in a test tube, a few drops of 5% FeCl<sub>3</sub> solution were added, and then the test tube was shaken. A dirty green color observed indicates the presence of tannins (Evans and Trease, 1999) <sup>[7, 8]</sup>.

### Test for Flavonoids

The extract (3 cm<sup>3</sup>) was treated with 1 cm<sup>3</sup> of 10% NaOH. According to Evans and Trease (1999) <sup>[7, 8]</sup>, the yellow color observed indicates the presence of flavonoids.

### Test for Saponins

A test tube containing a mixture of 5 cm<sup>3</sup> of the extract and 5 cm<sup>3</sup> of distilled water was forcefully shaken. The development of foams or stable frothing observed indicates the presence of saponins.

### Test for Steroids

A volume of 0.5g of the extract was dissolved in 2 cm<sup>3</sup> of chloroform, and 2 cm<sup>3</sup> of H<sub>2</sub>SO<sub>4</sub> is carefully added to form

the lower layer. A reddish-brown color observed at the interface indicates the presence of a steroidal ring.

#### Test for Anthraquinones

About 0.5g of the extract is shaken with 10 cm<sup>3</sup> of benzene, and 5 cm<sup>3</sup> of 10% ammonia is added. The mixture was shaken, and a pink, red, or violet color was observed, which indicates the presence of anthraquinones.

#### Test for Glycosides

In a test tube, 5 cm<sup>3</sup> of the extract was combined with precisely 2.5 cm<sup>3</sup> of 50% sulfuric acid. After cooling and being neutralized with 10% NaOH, the liquid was boiled in boiling water for 15 minutes. The liquid was then heated while 5 cm<sup>3</sup> of Fehling's solution was added. The brick-red precipitate formed indicates the presence of glycosides.

#### Test for Cardiac glycosides

(Keller-Killiani's Test) 2 cm<sup>3</sup> of a 3.5% ferric chloride solution were added to 1 cm<sup>3</sup> of the extract and left to stand for a minute. A lower layer was created by gently pouring 1 cm<sup>3</sup> of concentrated H<sub>2</sub>SO<sub>4</sub> down the tube's wall. A reddish brown ring formed at the contact indicates the presence of cardiac glycosides.

#### Test for Saponin glycosides

Fehling's solution (2.5 cm<sup>3</sup>) was added to 2.5 cm<sup>3</sup> of the extract. The bluish-green precipitate formed indicates the presence of saponin glycosides (El-Oley *et al.*, 1994)<sup>[6]</sup>.

#### Balsam's Test

The extract (0.2 g) was mixed with an equal volume of 90% ethanol. 2 drops of alcoholic ferric chloride solution were added to the mixture. The dark green color observed indicates the presence of balsams.

#### Test for Volatile oils

The extract (1 cm<sup>3</sup>) was mixed with 1 cm<sup>3</sup> of dilute HCl. The white precipitate formed indicates the presence of volatile oils.

### Results and Discussion

#### Results

**Table 1:** The macroscopy of *Detarium microcarpum* leaf

| Parameter    | Observation |
|--------------|-------------|
| Condition    | Fresh       |
| Colour       | Green       |
| Shape        | Ovate       |
| Size: Length | 5.45 cm     |
| Margin       | Entire      |
| Venation     | Reticulate  |
| Petiole      | Short       |
| Surface      | Glossy      |
| Phyllotaxy   | Alternate   |
| Odour        | Odourless   |
| Taste        | Neutral     |

#### Percentage Yield

**Table 2:** Percentage yield of the extract

| Extract/solvent  | Percentage yield (%) |
|------------------|----------------------|
| Methanol extract | 37.5                 |

#### Results of the Phytochemical Screening

The phytochemical screening performed on the methanol extract of *Detarium microcarpum* leaves revealed the presence of all targeted phytoconstituents.

**Table 3:** The results summary

| TESTS              | RESULTS |
|--------------------|---------|
| Alkaloids          | +       |
| Tannins            | +       |
| Flavonoids         | +       |
| Saponins           | +       |
| Cardiac glycosides | +       |
| Anthraquinones     | +       |
| Glycosides         | +       |
| Saponin glycosides | +       |
| Balsams            | +       |
| Volatile oils      | +       |
| Steroids           | +       |

KEY: + = Present

#### Discussion

The macroscopical evaluation of *Detarium microcarpum* leaves revealed significant morphological characteristics, including an ovate shape, glossy green surface, entire margin, and a rounded base. These observations are consistent with the findings of Idris *et al.* (2021)<sup>[11]</sup>, who described *D. microcarpum* leaves as green, odorless, tasteless, with a thickly glabrescent surface and ovate to elliptical shape.

The phytochemical screening of the methanol crude extract confirmed the presence of various secondary metabolites, including alkaloids, flavonoids, tannins, saponins, steroids, cardiac glycosides, saponin glycosides, anthraquinones, balsams, volatile oils, and glycosides (Table 3). These bioactive compounds contribute to the plant's diverse pharmacological properties. Previous studies by Ugwoke *et al.* (2017)<sup>[22]</sup> and Semde *et al.* (2018)<sup>[20]</sup> similarly reported the presence of flavonoids, tannins, saponins, and steroids in the methanol extract of *D. microcarpum* leaves. Flavonoids and tannins are well known for their strong antioxidant and anti-inflammatory properties, while saponins and alkaloids exhibit antimicrobial and immunomodulatory effects (Evans & Trease, 1999; Idris *et al.*, 2021)<sup>[7, 8, 11]</sup>.

The percentage yield of the methanol crude extract was determined to be 37.5% (Table 2). This is comparable to the yield obtained in previous studies on methanol extracts of medicinal plants, suggesting that methanol is an efficient solvent for extracting the bioactive compounds present in *D. microcarpum* (Meda *et al.*, 2017)<sup>[14]</sup>. The high presence of flavonoids and glycosides may contribute to the plant's potential as a source of therapeutic agents, particularly in antioxidant and cardiovascular treatments (Morsy, 2014; Batiha & Beshbishy, 2020)<sup>[5]</sup>.

The presence of volatile oils and balsams suggests antimicrobial and anti-inflammatory properties, aligning with the findings of Semde *et al.* (2018)<sup>[20]</sup>, who characterized the essential oils of *D. microcarpum* and found antimicrobial activity against several pathogens. The detection of cardiac glycosides indicates potential cardiovascular benefits, supporting the traditional use of the

plant in managing heart-related ailments (Feudjou *et al.*, 2020) [9].

The study's results align with previous phytochemical studies, further validating the medicinal properties of *D. microcarpum*. The combination of alkaloids, flavonoids, saponins, tannins, and steroids suggests that the methanol extract could serve as a promising candidate for future drug development. However, while this qualitative analysis provides valuable insights, further quantitative phytochemical analysis, pharmacological evaluations, and toxicity studies are essential to confirm the efficacy and safety of *D. microcarpum* extracts (WHO, 2007; Labulo *et al.*, 2016) [23, 12].

To fully explore the potential of *D. microcarpum*, advanced analytical techniques such as High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), and Nuclear Magnetic Resonance (NMR) spectroscopy should be employed to isolate and characterize individual bioactive compounds (Priya *et al.*, 2016) [19]. Additionally, in-vitro and in-vivo studies will be required to establish bioavailability, pharmacodynamics, and toxicity levels before developing standardized herbal formulations (Windmi *et al.*, 2021) [25].

### Conclusion

This study has demonstrated that the methanol crude extract of *Detarium microcarpum* leaves contains a diverse range of bioactive phytochemicals, including alkaloids, flavonoids, tannins, saponins, steroids, cardiac glycosides, saponin glycosides, anthraquinones, balsams, volatile oils, and glycosides. These findings validate the traditional medicinal use of *D. microcarpum* and suggest its potential as a source of therapeutic compounds. The presence of these bioactive constituents indicates possible pharmacological applications, particularly in antimicrobial, anti-inflammatory, and antioxidant therapies. While this study provides qualitative insights into the phytochemical composition of the plant, further research is necessary to conduct quantitative analysis, isolate and characterize individual compounds, and evaluate their pharmacological efficacy and safety. This work lays the groundwork for future studies aimed at developing standardized herbal formulations and exploring the potential of *D. microcarpum* in drug discovery.

### Recommendation

Based on the findings of this study, several recommendations for further research can be proposed to deepen the understanding of *Detarium microcarpum* leaves and their potential applications:

**Quantitative phytochemical Analysis:** To determine the concentration of each bioactive compound and correlate this with biological activities.

**Pharmacological Evaluation:** *In-vitro* and *in-vivo* studies to assess antimicrobial, anti-inflammatory, anticancer and anti-diabetic potentials. This will be essential to confirm the therapeutic efficacy and safety of the extract.

**Isolation and Characterization:** Advanced techniques such as HPLC, GC-MS, and NMR spectroscopy should be employed to isolate and structurally characterize the

individual bioactive compounds responsible for the observed medicinal properties.

**Toxicity and Safety Studies:** Systematic toxicological assessments should be used to establish safe dosage levels for human and animal use.

**Standardization Protocols:** Development of standardized extraction and formulation protocols to ensure batch-to-batch consistency in future drug development.

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### Conflicts of interest

The authors declare no conflicts of interest

### References

1. Abdulrahman MD, Ali AM, Fatimah H, Khandaker MM, Mat N. Traditional medicinal knowledge of Malays in Terengganu, Peninsular Malaysia. *Malayan Nature Journal*. 2018;70(3):349-364.
2. Abubakar IB, Kankara SS, Malami I, *et al.* Traditional medicinal plants used for treating emerging and re-emerging viral diseases in northern Nigeria. *European Journal of Integrative Medicine*. 2022;49:102094.
3. Akinsanmi AO, Johnson OT, Longdet IY, Aguiyi JC. *in vitro* evaluation of free radical scavenging, Fe<sup>2+</sup> and SNP-induced lipid peroxidation (rat brain) activities of methanolic extracts from three (3) northern Nigerian plant leaves. *Journal of Tropical Life Science*. 2019;9(1):71-78.
4. Arif AM. Phytochemicals as potential anticancer drugs (2020). Time to ponder nature's bounty. *BioMed Research International*. 2020;2020:8602879 (7 pages). <https://doi.org/10.1155/2020/8602879>
5. Batiha GE, Beshbishy AM. Gas chromatography-mass spectrometry analysis, phytochemical screening and anti-protozoal effects of the methanolic *Viola tricolor* and acetonic *Laurus nobilis* extracts. *BMC Complementary Medicine and Therapies*. 2020;20:87. <https://doi.org/10.1186/s12906-020-2848-2>
6. El-Oley MM, Farid JA, Abdulfatah AA. Experimental phytochemistry laboratory manual. Riyadh: College of Pharmacy, King Saud University; 1994. p. 3-61.
7. Evans WC. Trease and Evans pharmacognosy. 16th ed. London: W.B. Saunders Ltd.; 2009. p. 191-393.
8. Evans WC. Trease and Evans pharmacognosy. 14th ed. New York: W.B. Saunders Company Ltd.; 1999. p. 1-340.
9. Feudjou WF, Mbock AM, Ouahou MBW, *et al.* Antibacterial isovaleronitrile diglycoside from *Detarium microcarpum* Guill. Perr. (Fabaceae). *Natural Product Communications*. 2020;15(7):1-4. doi:10.1177/1934578X20936939
10. Harborne JB. Phytochemical methods: A guide to modern techniques of plant analysis. 3rd ed. New York: Chapman and Hall; 1998. p. 88-381.

11. Masa'ud AI, Ibrahim H, Ambi A, Tanko Y. Phytochemical and pharmacognostic studies of the leaf of *Detarium microcarpum*. Journal of Current Biomedical Research. 2021;1(3):27-38. <https://journals.unizik.edu.ng/jcbr/article/view/841>
12. Labulo AH, Adesuji ET, Dedeke OA, Bodede OS, Oseghale CO, Adegoke OA. A dual-purpose silver nanoparticles biosynthesized using aqueous leaf extract of *Detarium microcarpum*: An under-utilized species. Talanta. 2016;160:735-744.
13. Manukumar HM, Kumar JS, Chandrasekhar B, Raghava S, Umesha S. Evidences for diabetes and insulin mimetic activity of medicinal plants: Present status and future prospects. Critical Reviews in Food Science and Nutrition. 2017;57(12):2712-2729.
14. Meda NR, Fraisse D, Gnoula C, Vivier M, Felgines C, Senejoux F. Characterization of antioxidants from *Detarium microcarpum* Guill. et Perr. leaves using HPLC-DAD coupled with pre-column DPPH assay. European Food Research and Technology. 2017;243(9):1659-1666.
15. Mercy AG, Light WF, Gospel SA. Qualitative and quantitative phytochemical screening of some plants used in ethnomedicine in the Niger Delta region of Nigeria. Journal of Food and Nutrition Sciences. 2017;5(5):198-205. <https://doi.org/10.11648/j.jfns.20170505.16>
16. Molyneux RJ, Lee ST, Gardener LE, Panter KE. Phytochemicals: The good, the bad, and the ugly? Phytochemistry. 2007;68(22-24):2973-2985. <https://doi.org/10.1016/j.phytochem.2007.09.004>
17. Morsy NM. Phytochemical analysis of biologically active constituents of medicinal plants. Main Group Chemistry. 2014;13:7-21. doi:10.3233/MGC-130117
18. Philippot L, Raaijmakers JM, Lemanceau P, van der Putten WH. Going back to the roots: The microbial ecology of the rhizosphere. Nature Reviews Microbiology. 2013;11:789-799. doi:10.1038/nrmicro3109
19. Priya RS, Geetha D, Ramesh PS. Antioxidant activity of chemically synthesized AgNPs and biosynthesized *Pongamia pinnata* leaf extract mediated AgNPs-A comparative study. Ecotoxicology and Environmental Safety. 2016;134:308-318.
20. Semde Z, Koudou J, Zongo C, Somda MK, Figueredo G, Ganou L, Ouagadougou B. Chemical composition, antioxidant and antimicrobial activities of the essential oil of *Detarium microcarpum* Guill. and Perr. leaves from Burkina Faso. International Journal of Pharmaceutical Sciences and Research. 2018;9:956-964.
21. Sofowora A. Medicinal plants and traditional medicine in Africa. Ibadan: Spectrum Books Ltd.; 1993. p. 289.
22. Ugwoke CEC, Okolo C, Tchimine KM, Ezugwu CO, Anze SPG. Evaluation of pharmacognostic and phytochemical constituents of *Detarium microcarpum* Guill and Perr (Fabaceae). World Applied Sciences Journal. 2017;35(4):615-620.
23. World Health Organization (WHO). WHO guidelines for assessing quality of herbal medicines with reference to contaminants and residues. Geneva: WHO; 2007.
24. World Health Organization (WHO). Resolution-Promotion and development of training and research in traditional medicine. WHO Document No. WHA; 2003. p. 40-49.
25. Windmi K, Roland N, Amadou T, et al. Polyphenols quantification and antioxidant activity of methanolic and aqueous extracts from eight medicinal plants used to manage avian diseases in Burkina Faso. Journal of Medicinal Plants Research. 2021;15(5):226-231.
26. World Health Organization (WHO). Quality control methods for medicinal plant materials. Geneva: WHO; 1998. ISBN: 92 4 154510.