**Review Article**

**Biological Activity and Chemical Composition of *Detarium microcarpum* Guill. and Perr—A Systematic Review**

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Historically, natural products have been the principal source of medications for the treatment of human diseases. Traditional medical practitioners employ *Detarium microcarpum* as a treatment for diabetes, malaria, wounds, inflammation, and even cancer. This study emphasizes the importance of harmonizing *D. microcarpum* research so that results from various sources may be directly compared to reach a scientific conclusion. We searched Google Scholar, Science Direct, Google.com, Wiley, PubMed, Hindawi, and Springer for research papers on *Detarium microcarpum*. This analysis excludes untrustworthy online data, thesis papers, and review publications on *D. microcarpum*. The leaves and stem bark were shown to have high antioxidant, anti-inflammatory, antibacterial, antidiabetic, and anticancer properties. The study also discovered that too much consumption is harmful. Polyphenols and flavonoids were the most commonly reported compounds. However, human safety and efficacy are yet to be fully evaluated, and further well-designed clinical trials are needed to confirm preclinical findings. The leaves and stem bark extracts and isolated compound mechanism of action should be investigated. It is necessary to set a standard dose and ensure its safety.

1. **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 [1]. 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 [2, 3]. Medicinal plants have been used by native peoples for centuries to cure and prevent illness, and they also serve as a source for a wide range of useful pharmaceuticals and other health aids [4]. Due to the rise in infectious diseases and treatment resistance among pathogenic organisms, the search for novel drugs has intensified significantly [5, 6]. Many of the chemical substances found in plants have physiological functions and can be used to treat or prevent disease [7]. Compounds that exhibit biological activity include flavonoids, tannins, saponins, alkaloids, glycosides, and phenolics [8]. Chemical compounds found in plants include a wide variety of physiologically active molecules that can be employed to treat or prevent disease [9]. *Detarium microcarpum* is an African native plant that grows in the wild in several African countries, notably in savannah areas. Because every part of the *D. microcarpum* plant has a therapeutic application, the plant itself is referred to be a miracle plant by the traditional herbalist. Folk medicine relies heavily on its leaves and fruits. The need for new drugs derived from numerous species of medicinal plants is continually growing today [10]. This study aims to bring together the scattered data on the biological impacts of *D. microcarpum* and synthesize it into a cohesive whole, paving the way for a more thorough understanding of the plant and a clearer guidance on how to make the best use of its components. Therefore, traditional applications, taxonomic description, distribution and biological activity, and chemical composition are all documented in the following review.
2. Methodology

Inclusion criteria: we searched for articles on *Detarium microcarpum* using various online databases, including Google Scholar, Science Direct, Google.com, Wiley, PubMed, Hindawi, and Springer and only the articles from reliable web sources were included in this research study. These online databases extract useful information from the original scientific research papers that they index. These biological evaluations, along with a great number of others, were used as key terms in our investigation. Antifungal and antibacterial, anti-inflammatory, herbal, and anticancer treatments were among these. While chemical composition phrases such as chemical content, chemical composition, mineral content, mineral analysis, heavy metal composition, heavy metal analysis, HPLC, HPTLC, GCMS, FTIR, and many others were used. Exclusion criteria: this analysis did not include any data obtained from unreliable web sources and also excluded thesis papers and review articles.

3. Results and Discussion

3.1. Taxonomy, Description, and Distribution. *Detarium microcarpum* is a part of the broader leguminosae family, *Caesalpiniaceae*. It is a tropical African rainforest and savanna tree [11–13]. *Detarium senegalense* sensu auct is a misapplied name to *D. microcarpum*. It happens normally in the drier parts of Africa [14]. *D. microcarpum* can be found in the arid lands of western and central Africa, from Senegal to Sudan, Nigeria, and even Zaire, where it thrives. It may grow to a height of 36 meters and has a big, dense crown. *D. microcarpum* thrives in dry areas of central and western Africa, reaching heights of up to 15 meters. It can reach a height of 25 meters in locations with a lot of rain. The tree's fractured grey bark and dark green 8–12 cm leaves make it easy to identify. The tree grows in dry Savannah areas of Africa [15, 16], and it can be found in Sudan’s Darfur, Blue Nile, and Kordofan states [16]. A grayish-brown color covers the bark, which is rather smooth but is covered in small cracks (Figure 1). From November through March, it produces its berries and nectar which are 4 to 6 cm in diameter, delicious, fibrous, and one seeded [18].

3.2. Chemical Composition. Many natural product chemists are drawn to the study of physiologically active plant-based natural products on a global scale [19]. Various plants have been evaluated for their biological properties, and in certain instances, active compounds have been found and extracted [20]. The biological activity of medicinal plant parts is due to the amalgamation of diverse substances in the plant, known as secondary metabolites [21]. The majority of these are phenolic compounds, tannins, steroids, and alkaloids, which are produced in various areas of the plant and have various roles [21]. Thousands of compounds have been isolated and identified with the application of contemporary scientific procedures. Many of which have served as chemical leads in the creation of chemotherapy medicines for a variety of ailments [22]. In the chemical investigation, ten components representing more than 99% of the fixed oil were discovered (Table 1 and Figure 2). Three fatty acids were discovered (palmitic, linoleic, and oleic acids) Linoleic acid (44.1%) and oleic acid (30.8%), were the predominant components of the oil, and these unsaturated fatty acids, which have been documented to have antimicrobial properties, may be responsible for the activity seen in the seeds [13]. With three strains of *Salmonella*, the results showed that (1) microcarpamide (2) microcarposide, and (3) rhinocerotinoic acid had a moderate effect [37]. The seed hydrocolloids of *D. microcarpum* were found to contain twenty-two chemicals. They are composed of hydrocarbons 20.32, aromatics 2.14, aldehyde 0.49, phenolic 0.37, fatty acids 67.80, esters 5.09, and alcohols 3.80%, respectively, and these make up the majority of their composition of essential oil [23]. The pure compounds produced by bioassay-guided fractionation were evaluated for growth inhibition and acetylcholinesterase inhibition (Table 1). At 100 μg, compound 2 mildly inhibited *C. cucumerinum* development, while compounds 1 and 5 were moderate inhibitors [24]. At 0.1 μg, compound 2 inhibited acetylcholinesterase as well [24]. In addition to being an acaricid (a drug that kills mites or ticks) for use in orchards, hexanedioic acid, a mono (2-ethylhexyl) ester compound, can also be used as an inert ingredient in insecticides, among other applications [35]. Gallic acid, myricetin 3-O-rhamnoside, quercetin 3,7-O-dirhamnoside, quercetin 3-O-glucoside, and quercetin 3-O-rhamnoside were identified as the five possible radical scavengers found in the precolumn DPPH-HPLC experiment [38].

![Figure 1](a) branch (source author), (b) leaves displaying fruit [17], and (c) single leaf (source author).
Table 1: Chemical composition of *Detarium microcarpum*.

| S/ N | Compound                                      | Composition | Part of the plant | Solvent       | Reference |
|------|-----------------------------------------------|-------------|-------------------|---------------|-----------|
| 1    | Cyclohexanone                                 | 1.4         | Seeds             | Petroleum ether | [13]      |
|      | cis-Rose oxide                                | 0.5         |                   |               |           |
|      | Citronellol                                   | 8.7         |                   |               |           |
|      | β-Myrcene                                     | 1.4         |                   |               |           |
|      | Camphor                                       | 0.2         |                   |               |           |
|      | Isoledeene                                    | 1.4         |                   |               |           |
|      | Oleic acid                                    | 30.8        |                   |               |           |
|      | Palmitic acid                                 | 0.2         |                   |               |           |
|      | E-citral                                      | 1.3         |                   |               |           |
|      | Linoleic acid                                 | 44.1        |                   |               |           |
|      | Oleic acid                                    | 30.8        |                   |               |           |
|      | Palmitic acid                                 | 0.2         |                   |               |           |
|      | E-citral                                      | 1.3         |                   |               |           |
|      | Linoleic acid                                 | 44.1        |                   |               |           |
| 2    | Nonane                                        | 6.52        | Seeds             | Chloroform    | [23]      |
|      | 3,5-Di-tert-butylphenol                       | 0.37        |                   |               |           |
|      | 4-Methyldecane                                | 1.27        |                   |               |           |
|      | Isopropylbenzene                              | 1.55        |                   |               |           |
|      | Decane                                        | 7.66        |                   |               |           |
|      | Undecane                                      | 1.44        |                   |               |           |
|      | Hexadecane                                    | 0.60        |                   |               |           |
|      | 3,3-Dimethyl-1-(2-carboxyphenyl) triazene     | 0.59        |                   |               |           |
|      | 2,4-Decadienal                                | 0.49        |                   |               |           |
|      | 2,6,11-Trimethyldecane                        | 1.11        |                   |               |           |
|      | Hexadecanoic acid                             | 9.77        |                   |               |           |
|      | Tetradecanoic acid                            | 2.48        |                   |               |           |
|      | Hexadecane                                    | 1.06        |                   |               |           |
|      | 9-Octadecenoic acid                           | 39.24       |                   |               |           |
|      | Sulfurous acid,2-ethylhexyl isohexyl ester    | 1.49        |                   |               |           |
|      | 9,12,15-Octadeatrienoic acid                  | 6.21        |                   |               |           |
|      | Pentfluoropropionic acid and hexadecyl ester  | 1.33        |                   |               |           |
|      | Octadecanoic acid                             | 8.12        |                   |               |           |
|      | 2,6,10,14,18,22-Tetracosahexaene (squalene)   | 0.66        |                   |               |           |
|      | 2-Methyl-3,13-octadecadienol                  | 3.80        |                   |               |           |
|      | Docosanoic acid                               | 1.98        |                   |               |           |
|      | Sulfurous acid, octadecyl-2-propyl ester      | 2.27        |                   |               |           |
| 3    | 5α, 8-α (2-Oxokolavenic acid (2)               |             | Fruits pulp       | Dichloromethane | [24]      |
|      | 3,4-Dihydroxy clerodan-13E-en 15-oic acid (4)  |             |                   |               |           |
|      | 2-Oxokolavenic acid (3)                       |             |                   |               |           |
|      | 3,4-Epoxy clerodan-13E-en-15-oic acid (1),    |             |                   |               |           |
|      | 3,4-Dihydro clerodan-13z-en-15-oic acid (5)    |             |                   |               |           |
| 4    | Calcium                                       | 17.97       | Fruits pulp (mg/ 100 g) |           | [25]      |
|      | Chromium                                      | 0.44        |                   |               |           |
|      | Cobalt                                        | 0.06        |                   |               |           |
|      | Iron                                          | 78.71       |                   |               |           |
|      | Potassium                                     | 908.1       |                   |               |           |
|      | Copper                                        | 0.59        |                   |               |           |
|      | Iodine 2                                      | 2.77        |                   |               |           |
|      | Manganese                                     | 5.95        |                   |               |           |
|      | Molybdenum                                    | 6.39        |                   |               |           |
|      | Sulphur                                       | 37.24       |                   |               |           |
|      | Magnesium                                     | 113.50      |                   |               |           |
|      | Phosphorous                                   | 204.5       |                   |               |           |
|      | Zinc                                          | 31.7        |                   |               |           |
|      | Sodium                                        | 15.09       |                   |               |           |
|      | Cadmium                                       | 0.03        |                   |               |           |
|      | Nickel                                        | 1.57        |                   |               |           |
|      | Titanium                                      | 0.36        |                   |               |           |
|      | Lanthanum                                     | 0.09        |                   |               |           |
|      | Barium                                        | 0.58        |                   |               |           |
|      | Strontium                                     | 0.25        |                   |               |           |
|      | Lead                                          | 0.002       |                   |               |           |
Table 1: Continued.

| S/N | Compound          | Composition | Part of the plant | Solvent       | Reference |
|-----|------------------|-------------|-------------------|---------------|-----------|
|     | Arsenic          | 0.44        |                   |               |           |
|     | Vitamin B2       | 4.20        | Mg/100 g          |               |           |
|     | Vitamin C        | 55.10       | Mg/100 g          |               |           |
|     | Folic acid       | 0.17        | Mg/100 g          |               |           |
|     | Vitamin E        | 12.44       | Mg/100 g          |               |           |
|     | Ash              | 4.47        |                   |               |           |
|     | Crude fibre      | 12.19       | %                 |               |           |
|     | Crude fat        | 2.23        | %                 |               |           |
|     | Total carbohydrate | 65.8     | %                 |               |           |
|     | Crude protein    | 4.68        | %                 |               |           |
|     | Cyanide          | 0.07        | Mg/100 g          |               |           |
|     | Saponins         | 2.73        | Mg/100 g          |               |           |
|     | Phytates         | 0.41        | Mg/100 g          |               |           |
|     | Tannins          | 0.17        | Mg/100 g          |               |           |
|     | Oxalate          | 1.06        | Mg/100 g          |               |           |
|     | Tannins Present  | Seeds       |                   |               | [26]      |
|     | Flavonoids       |             |                   |               |           |
|     | Alkaloids        |             |                   |               |           |
|     | Fatty acids      |             |                   |               |           |
|     | Saponins         |             |                   |               |           |
|     | Phenol           |             |                   |               |           |
|     | Steroid          |             |                   |               |           |
|     | Protein          | 29.4        | Fruits %          |               | [16]      |
|     | Fat              | 1.59        |                   |               |           |
|     | Moisture         | 5.74        |                   |               |           |
|     | Ash              | 2.6         |                   |               |           |
|     | Fiber            | 19.05       |                   |               |           |
|     | Carbohydrate     | 41.6        |                   |               |           |
|     | Potassium        | 1463.25     | Mg/100 g          |               | [16]      |
|     | Magnesium        | 12.20       |                   |               |           |
|     | Sodium           | 420.50      |                   |               |           |
|     | Calcium          | 136.12      |                   |               |           |
|     | Iron             | 2.73        |                   |               |           |
|     | Zinc             | 0.41        |                   |               |           |
|     | Phosphorous      | 1.05        |                   |               |           |
|     | Manganese        | 2.65        |                   |               |           |
|     | Copper           | 0.35        |                   |               |           |
|     | Nickel           | 0.001       |                   |               |           |
|     | Cobalt           | 2.71        |                   |               |           |
|     | Cadmium          | 0.002       |                   |               |           |
|     | Aluminium        | 1.12        |                   |               |           |
|     | Alkaloids        | 0.37        | Seeds %           |               | [18]      |
|     | Tannins          | 0.47        |                   |               |           |
|     | Saponins         | 1.85        |                   |               |           |
|     | Flavonoids       | 2.28        |                   |               |           |
|     | Phenols          | 0.35        |                   |               |           |
|     | Alkaloids        | 0.72        | Stem bark %       |               |           |
|     | Saponins         | 4.60        |                   |               |           |
|     | Flavonoids       | 5.68        |                   |               |           |
|     | Tannins          | 0.79        |                   |               |           |
|     | Phenols          | 0.67        |                   |               |           |
|     | Magnesium        | 0.32        | Seeds %           |               |           |
|     | Potassium        | 0.30        |                   |               |           |
|     | Calcium          | 1.44        |                   |               |           |
|     | Phosphorus       | 1.0         |                   |               |           |
|     | Sodium           | 0.53        |                   |               |           |
|     | Iron             | 7.11        |                   |               |           |
|     | Zinc             | 5.40        |                   |               |           |
|     | Manganese        | 0.45        |                   |               |           |
| S/ N | Compound       | Composition | Part of the plant | Solvent | Reference |
|------|----------------|-------------|-------------------|---------|-----------|
|      | Potassium      | 0.50        | Stem bark %       |         |           |
|      | Magnesium      | 0.40        |                   |         |           |
|      | Sodium         | 0.40        |                   |         |           |
|      | Calcium        | 1.44        |                   |         |           |
|      | Phosphorous    | 0.54        |                   |         |           |
|      | Manganese      | 0.70        |                   |         |           |
|      | Iron           | 6.97        |                   |         |           |
|      | Zinc           | 6.15        |                   |         |           |
|      | Riboflavin     | 0.62        | Seeds mg/100 g    |         |           |
|      | Ascorbic acid  | 83.6        | Stem bark mg/100 g|         |           |
|      | Thiamin        | 0.14        |                   |         |           |
|      | Niacin         | 2.60        |                   |         |           |
|      | Ascorbic acid  | 24.2        |                   |         |           |
|      | Riboflavin     | 0.67        |                   |         |           |
|      | Niacin         | 8.11        |                   |         |           |
|      | Thiamin        | 0.27        |                   |         |           |
|      | Crude protein  | 20.5        | Seeds %           |         |           |
|      | Fats/oil       | 55.6        |                   |         |           |
|      | Crude fiber    | 10.5        |                   |         |           |
|      | Food energy g/calories | 616 | |         |           |
|      | Ash            | 840         |                   |         |           |
|      | Carbohydrate   | 840         |                   |         |           |
|      | Food energy g/calories | 324.6 | Stem bark % |         |           |
|      | Fats/oil       | 55.6        |                   |         |           |
|      | Crude protein  | 9.6         |                   |         |           |
|      | Ash            | 5           |                   |         |           |
|      | Crude fiber    | 17.8        |                   |         |           |
|      | Carbohydrate   | 63.54       |                   |         |           |
|      | Protein        | 27.1        | Seed %            | [27]    |           |
|      | 3-octanone     | 0.229       | Leaves            | [28]    |           |
|      | Linalol        | 2.098       |                   |         |           |
|      | Myrcene        | 0.064       |                   |         |           |
|      | Bornel         | 0.161       |                   |         |           |
|      | α-Terpineol    | 0.351       |                   |         |           |
|      | α-Cubebeene    | 0.357       |                   |         |           |
|      | Safranal       | 0.407       |                   |         |           |
|      | Geraniol       | 0.227       |                   |         |           |
|      | 1,2-dihydro-trimethyl-naphtalene | 0.339 | |         |           |
|      | α-Copaene      | 1.238       |                   |         |           |
|      | α-Cubebeene    | 0.357       |                   |         |           |
|      | β-bourbonene   | 0.758       |                   |         |           |
|      | β-Copaene      | 0.883       |                   |         |           |
|      | β-bourbonene   | 0.477       |                   |         |           |
|      | β-Caryophyllene| 11.894      |                   |         |           |
|      | Neryl acetone  | 2.452       |                   |         |           |
|      | α-trans-bergamotene | 0.368 | |         |           |
|      | Neryl acetone  | 2.452       |                   |         |           |
|      | γ-muurolene    | 1.589       |                   |         |           |
|      | β-selinene     | 1.108       |                   |         |           |
|      | α-humulene     | 0.605       |                   |         |           |
|      | Germacrene-D   | 0.597       |                   |         |           |
|      | γ-cadinene     | 1.13        |                   |         |           |
|      | α-muurolene    | 1.027       |                   |         |           |
|      | α-calacorene   | 0.73        |                   |         |           |
|      | Internedol     | 1.208       |                   |         |           |
|      | Caryophyllene oxide | 28.186 | |         |           |
|      | Salvia-4 (14)-ene-1-one | 2.243 | |         |           |
|      | Iso-spathulenol | 0.989       |                   |         |           |
Table 1: Continued.

| S/N | Compound | Composition | Part of the plant | Solvent | Reference |
|-----|----------|-------------|-------------------|---------|-----------|
| 1.254 | δ-cadinene | | | | |
| 1.886 | Spathulenol | | | | |
| 4.05 | Humulene-1,2-epoxide | | | | |
| | 1-Naphthaleneacetic-5-carboxy-1,2,3,4,4a,7,8,8a-octahydro-1,2,4a-trimethyl acid | | Bark | Chloroform | [29] |
| | 1-Naphthaleneacetic-7-oxo-1,2,3,4,4a,7,8,8a-octahydro 1,2,4a, stetramethyl acid | | | | |
| | 2-Oxo-kolavenic acid | | | | |
| 4.98 | Moisture (%) | Seed | | | [30] |
| 14.22 | Protein (%) | | | | [30] |
| 2.54 | Ash | | | | |
| 8.43 | Crude fat % | | | | |
| 28.29 | Sodium | Mg/kg | | | |
| 2700 | Calcium | | | | |
| 23900 | Potassium | | | | |
| 700 | Magnesium | | | | |
| 6 | Iron | | | | |
| 0.4 | Zinc | | | | |
| 1.7 | Manganese | | | | |
| 0.2 | Copper | | | | |
| 4.69 | Moisture content (%) | | | | [31] |
| 97.23 | Organic matter content (%) | | | | [31] |
| 35.96 | Protein content (%) | | | | |
| 2.77 | Ash content (%) | | | | |
| 2.14 | Lysine | g/100 g | | | |
| 2.35 | Leucine | | | | |
| 2.13 | Valine | | | | |
| 2.35 | Isoleucine | | | | |
| 2.58 | Phenylalamine | | | | |
| 0.74 | Methionine | | | | |
| 2.17 | Threonine | | | | |
| 5.66 | Arginine | | | | |
| 1.07 | Cystine | | | | |
| 9.78 | Glutamic acid | | | | |
| 4.79 | Aspartic acid | | | | |
| 2.41 | Glycine | | | | |
| 1.13 | Histidine | | | | |
| 1.06 | Tyrosine | | | | |
| 2.09 | Proline | | | | |
| 3.12 | Serine | | | | |
| 2.10 | Alanine | | | | |
| 105 | Potassium | | | | [32] |
| 002 | Sodium | | | | |
| 0.23 | Calcium | | | | |
| 003 | Iron | | | | |
| 001 | Phosphorus | | | | |
| 001 | Sulphur | | | | |
| 5.420 | Iodine | | | | |
| 2.78 | Manganese | | | | |
| 0.96 | Chromium | | | | |
| 0.67 | Molybdenum | | | | |
| 0.035 | Selenium | | | | |
| 0.635 | Zinc | | | | |
| 0.074 | Lead | | | | |
| 0.051 | Arsenic | | | | |
| 0.127 | Copper | | | | |
| 0.362 | Tin | | | | |
| 0.18 | Nickel | | | | |
| 0.753 | Vanadium | | | | |
| S/N | Compound                                                                 | Composition | Part of the plant | Solvent        | Reference |
|-----|--------------------------------------------------------------------------|-------------|-------------------|----------------|-----------|
|     | Bromine                                                                  | 0.023       |                   |                |           |
|     | Cobalt                                                                   | 0.817       |                   |                |           |
|     | Strontium                                                                | 0.083       |                   |                |           |
|     | Rubidium                                                                 | 0.914       |                   |                |           |
|     | Zirconium                                                                | 0.025       |                   |                |           |
|     | Thallium                                                                 | 1.960       |                   |                |           |
|     | Niobium                                                                  | 0.017       |                   |                |           |
|     | Yttrium                                                                  | 0.063       |                   |                |           |
|     | Sitosterol 3-O-(6′-O-palmitoyl-2,3,4-O-triacetyl-beta-D-glycopyranoside) 1,| Bark        | Ethanol           | [33]           |           |
|     | Lupeol                                                                   |             |                   |                |           |
|     | Lup-20 (29)-ene-2alpha,3beta-diol                                        |             |                   |                |           |
|     | Stigmasterol                                                             |             |                   |                |           |
|     | Campesterol                                                              |             |                   |                |           |
|     | L-Quino-1,5-lactone                                                      | Bark        | Ethanol           | [34]           |           |
|     | D-(-)-bornesitol                                                         |             |                   |                |           |
|     | Myo-inositol                                                             |             |                   |                |           |
|     | D-pinitol                                                                |             |                   |                |           |
|     | Sucrose                                                                  |             |                   |                |           |
|     | D-glucose                                                                |             |                   |                |           |
|     | D-Fructose benzoates                                                    |             |                   |                |           |
|     | Hexanedioic acid                                                         | Root        | Ethanol           | [35]           |           |
|     | Mono (2-ethylhexyl) ester                                                |             |                   |                |           |
|     | 1,2-Benzenedicarboxylic acid                                             | Bark        | Ethanol           | [36]           |           |
|     | Mono (2-ethylhexyl) ester                                                |             |                   |                |           |
|     | D-Mannose                                                                |             |                   |                |           |
|     | D-Glucose                                                                |             |                   |                |           |
|     | Labdane diterpenoid                                                      | Root        | Ethanol/water (7:3)| [37]           |           |
|     | Microcarpin (1)                                                          |             |                   |                |           |
|     | Microcarpamide (2)                                                       |             |                   |                |           |
|     | 5-(Carboxymethyl)-5,6,8a-Trimethyl-3,4,4a,5,6,7,8,8a                      |             |                   |                |           |
|     | Octahydronaphthalene-1-carboxylic acid (3), Microcarposide (4),          |             |                   |                |           |
|     | Rhinocerotinoic acid (5), 1,7-Dihydroxy-6-methylxanthone (6), Ursolic acid (7), 3β,23-Dihydroxyxup-20 (29)-en-28-oic acid (8), Alphitolic acid (9), Stigmasterol glucoside (10) | Leaves | Methanol | [38]           |           |
|     | Gallic acid                                                              |             |                   |                |           |
|     | Quercetin 3,7-O-dirhamnoside                                             |             |                   |                |           |
|     | Myricetin 3-O-rhamnoside                                                 |             |                   |                |           |
|     | Quercetin 3-O-glucoside                                                  |             |                   |                |           |
|     | Quercetin 3-O-rhamnoside                                                 |             |                   |                |           |
|     | Iron                                                                     | 218.9       | Stem bark mg/kg    | [39]           |           |
|     | Manganese                                                               | 139         | Stem bark          | 70% Methanol.  | [40]      |
|     | Zinc                                                                     | 48.9        |                   |                |           |
|     | Methyl gallate                                                           |             | Stem bark          | Methanol       | [41]      |
|     | Catechin gallate                                                         |             |                   |                |           |
|     | 3,13E-Clerodien-15-oic acid, 4 (18)                                      | Leaves      | Methanol           | [42]           |           |
|     | 13E-Clerodien-15-oic acid, 18-oxo-3                                       |             |                   |                |           |
|     | 13E-Clerodien-15-oic acid and 2-oxo-3, 13E-Clerodien-15-oic acid         |             |                   |                |           |
|     | Alkaloids                                                                |             | Stem bark          | Methanol       | [43]      |
|     | Flavonoids                                                               |             |                   |                |           |
|     | Glycosides                                                               |             |                   |                |           |
|     | Triterpene                                                               |             |                   |                |           |
nutritional composition of the plant parts was found to be very good for human consumption (Table 1). To sustain normal physiological processes, the human body requires trace amounts of vitamins; therefore, deficiency of vitamins can result in a variety of adverse effects.

### 3.3. Traditional Uses

Ethnomedicinal plants are a major source for novel medication development [46]. Traditional pharmaceutical uses for the plant’s roots, leaves, and bark, as well as its high quality firewood, influenced a variety of regional approaches to management [47]. The Detarium microcarpum is frequently used in traditional medicine to treat numerous ailments, including diarrhoea, bronchitis, fever, meningitis, convulsions, malaria, diabetes, bacterial, and fungal infections [11]. One of Africa’s most important medicinal plants is Leguminosae *D. microcarpum* [11, 34]. It is believed by the Ibo people, who live in the southeastern part of Nigeria, that the “Ofo” plant is a “religious” tree that grows in God’s own compound and represents sincerity and candor, frequently referred to as sweet dattock or tallow [12]. It is also known by its traditional name, Abu Laila, in western Sudan. In Senegal, it is called tamba dala [16, 48]. To prevent infection, wounds can be treated with fresh bark or leaves, and the powder made from boiled bark can be used as a painkiller [49]. An infusion of the bark is reported to be anti-inflammatory, anti-parasitic, and diuretic, while the fruits and leaves are used to treat diarrhoea and syphilis [34]. Roots, stems, bark, leaves, and fruits of this plant have been shown to be effective in treating a wide range of ailments, including diarrhea, tuberculosis, and meningitis [16]. People in Mali use the bark to treat measles, while the roots and leaves are used to treat cramps and diarrhoea in humans and cattle, respectively [49]. For skin diseases, the fruit pulp is used in Burkina Faso, and for dizziness, it is used in Niger Republic and Togo [49]. The fruit, leaves, and seeds of this plant are all edible [16]. The bark’s infusion is said to have antiparasitic, diuretic, and anti-inflammatory properties, while the fruits and leaves are used to cure diarrhoea and syphilis [34]. There are African tribes that use the fruit and leaves as a vegetable and as a seasoning for their food [16, 48]. Diarrhoea and syphilis can be treated with bark infusion, while dysentery and syphilis can be treated with fruits and leaves, respectively [12, 50]. *D. microcarpum* is frequently used as a folk remedy to treat ailments due to its medicinal characteristics; it is used to treat diarrhoea, meningitis, TB, and haemorrhoids. The leaves are consumed as a vegetable and are used as an enema for diarrhoea, an eye wash for conjunctivitis, and a traditional wash for itch [13]. The bark is used to cure anaemia and to expel the placenta that has been retained. In Senegal, it is used to treat bronchitis, pneumonia, and other respiratory ailments using palm wine maceration [13]. The plants are also used in Nigeria for the treatment of cancer [51]. Women in Sudan use the delicious aroma of heated roots as a perfume, and people in the Chad Republic use it to keep mosquitoes away [49]. Because it lights quickly, especially in the presence of moisture, it is also used for firewood and charcoal [49]. The study substantiated the traditional therapeutic efficacy of *D. microcarpum*, indicating its potential as a source of valuable medicine.

| S/N | Compound | Composition | Part of the plant | Solvent | Reference |
|-----|----------|-------------|-------------------|--------|-----------|
| 1   | Saponins | Stem bark   | Methanol          | [43]   |
| 2   | Tannins  | Stem bark   | Ethanol           | [44]   |
| 3   | Indole alkaloid | Stem bark | Ethanol           | [45]   |
| 4   | Quinoline alkaloids | Fruits  | [45]   |
| 5   | Steroids  | Fruits  | [45]   |
| 6   | Tropane alkaloids | Fruits  | [45]   |
| 7   | Flavonoids | Fruits  | [45]   |
| 8   | Terpenoids | Fruits  | [45]   |
| 9   | Microcarposide (1) | Fruits  | [45]   |
| 10  | Lupeol (2) | Fruits  | [45]   |
| 11  | Betulinic acid (3) | Fruits  | [45]   |
| 12  | β-Sitosterol glucoside (4) | Fruits  | [45]   |
| 13  | Methyl gallate (5) | Fruits  | [45]   |
| 14  | Luteolin (6) | Fruits  | [45]   |
| 15  | Epicatechin (7) | Fruits  | [45]   |

Notes: S/N = Serial Number.
3.4. Biological Evaluation. Medicinal plants refer to a wide range of plants, some of which have medicinal properties. *Detarium microcarpum* has been utilized as a medicinal herb for decades in various parts of the world to cure and manage various diseases. The intriguing activity of plant parts has prompted scientists from all around the world to examine the biological potential of the plant’s numerous sections (Tables 2–10). Despite its *invitro* and *invivo* activities, no clinical study has been conducted yet (Figure 3).

3.5. Antioxidants. Oxidative stress is the presence of reactive oxygen species (ROS) and free radicals, both of which are created within normal physiological conditions but become harmful when they are not removed by endogenous systems.

Figure 2: Compounds responsible for the biological activity of the *Detarium microcarpum*: (a) protocatechuic, (b) hexanedioic acid, (c) Lup-20 (29)-ene-2alpha, 3beta-diol, (d) lupeol, (e) stigmasterol, (f) campesterol, (g) myo-inositol, (h) sucrose, (i) vanillic, (j) myricetin 3-O-rhamnoside, (k) quercetin 3-O-glucoside, and (l) methyl gallate.
ROS and free radicals are also referred to as "reactive oxygen species" [97]. Free radicals and reactive oxygen species are produced by the body under normal physiological settings [97]. A chemical molecule is said to be a free radical if it possesses an unpaired electron that is revolving about the molecule’s nucleus’s periphery [98]. The two sources of free radicals in the body are endogenous sources, such as food metabolism and the aging process, and external sources, such as ionizing radiation, tobacco smoking, organic solvents, air pollution, and pesticides [99]. The search for antioxidants from natural sources has attracted a great deal of interest, and scientists are working diligently to identify molecules that could replace synthetic antioxidants. A wide variety of human activities rely on the secondary metabolites produced by the plant’s constituents. It is well-known that these chemical products have a wide range of biological

| S/N | Method                              | Solvents | Part of the plant | Major findings                                                                                                                                                                                                 | Reference |
|-----|------------------------------------|----------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1   | The standard comet assay           | Ethanol  | Fruit pulp        | DNA integrity was unaffected by fruit pulp extract at concentrations of up to 500 μg/mL compared to vehicle. Extract pretreatment reduced the genotoxicity of hydrogen peroxide and methyl methane sulfonate on human lymphocytes. | [52]      |
| 2   | DPPH, FRAP, ABTS, SRASA, DDA, LPM  | Ethanol  | Fruits            | DPPH, deoxyribose degradation, and lipid peroxidation models showed that ethanolic fruit extract had remarkable antioxidant properties with IC50 values of 49.87, 69.06, and 49.36 μg/mL, respectively. IC50 values of 90 μg/mL for hydrogen peroxide and 25 for nitric oxide radical scavenging were obtained for the extract. It is interesting that the extract had a stronger scavenging activity for hydrogen peroxide than gallic acid (IC50 = 90 μg/mL), although the two compounds had similar activity for quenching of nitric oxide radicals at p > 0.05. Significantly improved liver damage and decreased ALT, AST, TBIL, and CBIL values. SML or SMS extracts considerably enhanced glutathione levels in the cell, catalase and superoxide dismutase activities, and greatly lowered reactive thiobarbituric acid components. | [53]      |
| 3   | Lipid peroxidation activity        | Methanol | Leaves            | The ethanolic extract’s ability to neutralize free radicals with an IC50 value of 4.84 mg/mL. The DPPH and ABTS tests had a high degree of correlation (R2 = 0.7), indicating that they were both trustworthy and significant. As a result, the results indicated that each of the six extracts has significant and dose-dependent antioxidant capacity. | [54]      |
| 4   | DPPH, FRAP                          | Essential oil (leaves) |        | Inhibiting the activity of the enzyme acetylcholinesterase responsible for Alzheimer’s disease. At all doses used, extracts considerably outperformed the reference compounds in terms of radical scavenging activity (IC50) at 15 μg/mL. The ethanolic extract’s ability to neutralize free radicals with an IC50 value of 4.84 mg/mL. Both DPPH and ORAC experiments found that the methanolic extract of the leaves had a significant radical scavenging capacity of 937.16 and 2247.63 μmol trolox equivalent/g. | [28]      |
| 5   | Hydrogen peroxide and nitric oxide radical-scavenging assays | Ethanol  | Fruit pulp        | Hydrogen peroxide and n-butanol and m-butanol Stems and bark. At all doses used, extracts considerably outperformed the reference compounds in terms of radical scavenging activity (IC50) at 15 μg/mL. The ethanolic extract’s ability to neutralize free radicals with an IC50 value of 4.84 mg/mL. The DPPH and ABTS tests had a high degree of correlation (R2 = 0.7), indicating that they were both trustworthy and significant. As a result, the results indicated that each of the six extracts has significant and dose-dependent antioxidant capacity. | [55]      |
| 6   | In Vivo                            | Ethyl-acetate and n-butanol | Stem bark | Inhibiting the activity of the enzyme acetylcholinesterase responsible for Alzheimer’s disease. At all doses used, extracts considerably outperformed the reference compounds in terms of radical scavenging activity (IC50) at 15 μg/mL. The ethanolic extract’s ability to neutralize free radicals with an IC50 value of 4.84 mg/mL. Both DPPH and ORAC experiments found that the methanolic extract of the leaves had a significant radical scavenging capacity of 937.16 and 2247.63 μmol trolox equivalent/g. | [24]      |
| 7   | In Vitro                           | Fruits pulp |        | DNA integrity was unaffected by fruit pulp extract at concentrations of up to 500 μg/mL compared to vehicle. Extract pretreatment reduced the genotoxicity of hydrogen peroxide and methyl methane sulfonate on human lymphocytes. DPPH, deoxyribose degradation, and lipid peroxidation models showed that ethanolic fruit extract had remarkable antioxidant properties with IC50 values of 49.87, 69.06, and 49.36 μg/mL, respectively. FeSO4/SNP were found to have an inhibitory effect on lipid peroxidation in the brain, liver, and colon when the extract was used as a pro-oxidant. Malondialdehyde content was significantly increased in the colon. | [52]      |
| 8   | DPPH                               | 70% methanol | Leaf     | Extract pretreatment reduced the genotoxicity of hydrogen peroxide and methyl methane sulfonate on human lymphocytes. DPPH, deoxyribose degradation, and lipid peroxidation models showed that ethanolic fruit extract had remarkable antioxidant properties with IC50 values of 49.87, 69.06, and 49.36 μg/mL, respectively. FeSO4/SNP were found to have an inhibitory effect on lipid peroxidation in the brain, liver, and colon when the extract was used as a pro-oxidant. Malondialdehyde content was significantly increased in the colon. | [53]      |
| 9   | DPPH                               | Ethanol  | Leaves            | Extract pretreatment reduced the genotoxicity of hydrogen peroxide and methyl methane sulfonate on human lymphocytes. DPPH, deoxyribose degradation, and lipid peroxidation models showed that ethanolic fruit extract had remarkable antioxidant properties with IC50 values of 49.87, 69.06, and 49.36 μg/mL, respectively. FeSO4/SNP were found to have an inhibitory effect on lipid peroxidation in the brain, liver, and colon when the extract was used as a pro-oxidant. Malondialdehyde content was significantly increased in the colon. | [52]      |
| 10  | DPPH/ABTS                          | Methanol and aqueous | Stem bark | Extract pretreatment reduced the genotoxicity of hydrogen peroxide and methyl methane sulfonate on human lymphocytes. DPPH, deoxyribose degradation, and lipid peroxidation models showed that ethanolic fruit extract had remarkable antioxidant properties with IC50 values of 49.87, 69.06, and 49.36 μg/mL, respectively. FeSO4/SNP were found to have an inhibitory effect on lipid peroxidation in the brain, liver, and colon when the extract was used as a pro-oxidant. Malondialdehyde content was significantly increased in the colon. | [52]      |
| 11  | DPPH, FRAP, ABTS                   | Methanol | Seeds             | Extract pretreatment reduced the genotoxicity of hydrogen peroxide and methyl methane sulfonate on human lymphocytes. DPPH, deoxyribose degradation, and lipid peroxidation models showed that ethanolic fruit extract had remarkable antioxidant properties with IC50 values of 49.87, 69.06, and 49.36 μg/mL, respectively. FeSO4/SNP were found to have an inhibitory effect on lipid peroxidation in the brain, liver, and colon when the extract was used as a pro-oxidant. Malondialdehyde content was significantly increased in the colon. | [52]      |
| 12  | DPPH, ORAC                         | Methanol | Leaves            | Extract pretreatment reduced the genotoxicity of hydrogen peroxide and methyl methane sulfonate on human lymphocytes. DPPH, deoxyribose degradation, and lipid peroxidation models showed that ethanolic fruit extract had remarkable antioxidant properties with IC50 values of 49.87, 69.06, and 49.36 μg/mL, respectively. FeSO4/SNP were found to have an inhibitory effect on lipid peroxidation in the brain, liver, and colon when the extract was used as a pro-oxidant. Malondialdehyde content was significantly increased in the colon. | [52]      |

Notes: ALT = alanine aminotransferase, AST = aspartate transaminase, S/N = serial number, D. microcarpum = Detarium microcarpum, FRAP = ferric reducing antioxidant power, TBIL = total bilirubin, DPPH = 2,2-diphenyl-1-picrylhydrazyl, 2,2’-azino-bis-3-ethyl-thiazoline-6-sulphonate, SRA-SA = superoxide radical anion scavenging assay, DDA = deoxyribose degradation and LPM = lipid peroxidation models, ABTS = radical cation scavenging assay, ORAC = oxygen radical absorbance capacity, IC50 = the half maximal inhibitory concentration, and TBIL = total bilirubin test.
Hydrogen peroxide was more effectively quenched by the antioxidant potential of D. microcarpum, the antiflammatory activity, all methods showed significant activity (Table 2). In terms of antioxidant properties of D. microcarpum were found to be promising, according to the findings. D. microcarpum could be used to produce neuroprotective. Moreover, the bioactive compounds that were found can be used as good indicators for quality control and should be studied as a potential source of antioxidant-related disorders in the future. Plant extracts or compounds can exert a synergistic effect by chelating metals. When these two types of radicals combine, they form a complex called an antioxidant radical synergist (A:S) in which neither type of radical can catalyse oxidation reactions on its own. The ability of the antioxidant radical to help break down lipid peroxides is inhibited by this chemical association [101]. The number of hydroxyl (OH) groups on the aromatic ring is inversely related to its effectiveness [101]. These compounds may also chelate pro-oxidative metals, depending on the configuration of the OH groups [101].

3.6. Anti-Inflammatory Activity. Inflammation is a multi-faceted phenomenon. It represents the response of the organism to diverse stimuli and is associated with a number of conditions requiring lengthy or recurrent therapy, such as arthritis, asthma, and psoriasis [102]. It is the leading cause of death in the globe [103]. Several medications are used to treat inflammatory diseases, but long-term use can induce gastrointestinal distress, bone marrow depression, and water and salt retention [102, 104]. Research on medicinal plants with anti-inflammatory properties is important. Depending on the experimental model employed,
the leaf and stem bark extracts of *D. microcarpum* were revealed to contain unique anti-inflammatory properties (Table 3). The LD$_{50}$ of the extract in the animal model was 471.2 mg/kg body weight when it was injected intraperitoneally, and ≥5000 mg/kg body weight when it was orally administered [62]. When compared with the usual saline-treated group, the methanolic extract reduced the mean diameter of the rat paw in the carrageenan-induced inflammation [63]. At $p < 0.05$, the results showed that methanol leaf extract had a significant dose-dependent anti-inflammatory effect against egg albumin and formalin-induced inflammation [63]. At the 5th hour, the extract suppressed egg albumin by 26.5 and 29.4% at dosages of 200 and 400 mg/kg, respectively. The percent inhibition of formalin-induced edema was 32.5 for all dosages of 200 and 400 mg/kg [63]. The polyphenolic chemicals found in abundance in the studied extract may be responsible for these effects. Gallic acid had anti-inflammatory, antioxidant, antianaphylactic, antitumor, and antiradiation effects in prior research studies [105, 106]. The anti-inflammatory properties of *D. microcarpum* aqueous extracts, which contain polyphenolic compounds such as vanillic acid, gallic acid, and protocatechuic acid, imply that they are promising herbal remedies for pain and inflammation management [107]. Increased blood flow, increased cellular metabolism, vasodilatation, release of soluble mediators, extravasation of fluids, and cellular influx are all common symptoms of inflammation, and these mechanisms are the

| S/N | Method                  | Solvents          | Part of the plant | Major findings                                                                 | Reference |
|-----|-------------------------|-------------------|-------------------|--------------------------------------------------------------------------------|-----------|
| 1   | Agar-disc               | Ethanol           | Leaves            | *S. aureus* and *S. salmonellae* were found to be resistant to all portions of the leaf extract tested at 15, 30, and 60 μg/mL, respectively. At various doses of 100, 50, 25, and 12 μg/mL, respectively, the stem bark ethanolic extracts showed antibacterial activity against the studied species, with *S. aureus* having the largest zone of inhibition at 21 mm at 100 μg/mL. | [49]      |
| 2   | Agar well diffusion     | Ethanol           | Stem bark         | The stem bark extract were highly active against the test strains, exhibiting substantial efficacy at 25 μg/mL. | [44]      |
| 3   | *Agar disc diffusion*   | Methanol          | Stem bark         | *Salmonella typhi*, *Salmonella enteritidis*, and *Salmonella typhimurium* were all inhibited by the microcarposide with the inhibition zone of 153.4, 76.7, and 76.7 μM, respectively. | [65]      |
| 4   | Microdilution           | Methanol          | Fruits            | Ethanolic root bark extract and the isolated compound rhinocerotinoic acid showed good efficacy in vitro and infected animals at an effective dose of 75 mg/kg. | [45]      |
| 5   | Broth dilution, *In vivo* | Ethanol          | Root bark         | Seeds were found to be significant against all eight tested strains with the highest zone of inhibition against *S. aureus* at 8.8 mm | [66]      |
| 6   | Agar and disc diffusion | Petroleum ether   | Seeds             | The ethanolic bark extract exhibited the highest activity against *Listeria monocytogenes* at 13 mm | [26]      |
| 7   | Ager plate              | Petroleum ether, chloroform, and ethanol | Bark | Catechin gallocate and methyl gallate compound 2 (MIC 200 μg/mL) showed anti-MRSA activity, which is interesting because compounds 1 and 2 also showed anti-MRSA activity. | [33]      |
| 8   | MIC                     | Stem bark         |                   | The dichloromethane extract of *Detarium microcarpum* is the most effective in inhibiting the growth of *Pythium aphanidermatum* at 75%. | [40]      |
| 9   | Ager disk diffusion     | Essential oil     |                   | The extract showed moderate and strong inhibition zones of 12 and 22 mm against all of the tested microbial strains, respectively. | [28]      |
| 10  | Ager well               | n-hexane, ethyl acetate, chloroform, and methanol | Stem bark | Stem bark extract exhibited strong activity against *Staphylococcus* against the zone of inhibition 28 mm | [67]      |
| 11  | MIC                     | Dichloromethane and methanol |                   | The dichloromethane extract of *Detarium microcarpum* is the most effective in inhibiting the growth of *Pythium aphanidermatum* at 75%. | [68]      |
| 12  | Disc diffusion          | Ethanol           | Stem barks and seeds | The greatest inhibitory concentration was 100 mg/mL in *proteus mirabilis*, with an 8-mm inhibition zone. | [69]      |
| 13  | Mic                     | Petroleum ether   | Seed              | The extract exhibited the growth of all tested bacteria significantly | [13]      |
| 14  | Aqueous and methanol    | Seeds             |                   | Highest zone of inhibition was recorded against *E. coli* at 18 mm | [11]      |

Notes: S/N = serial number and MIC = minimum inhibitory concentrations.

Table 4: Antibacterial activity of *D. microcarpum*.
same and are independent of the triggering cause [108]. Arachidonic acid and inflammatory mediators such as cytokines, serotonin, histamine, prostaglandins, and leukotrienes are released from cells in response to the inflammatory agent, which also increases vascular permeability and facilitates leukocyte migration to the site of inflammation [108].

### 3.7. Antibacterial Activity.

Since the beginning of human history, infections have been treated with medicinal plant extracts. Antimicrobial drugs are crucial to lowering the global burden of infectious diseases [109]. However, when resistant organisms evolve and spread, antibiotics lose their potency [110]. This type of bacterial resistance to antimicrobial agents poses a very serious threat to public health,

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### Table 5: Antifungal activity of *D. microcarpum*.

| S/N | Method          | Solvents       | Part of the plant | Major findings                                                                 | Reference |
|-----|-----------------|----------------|-------------------|--------------------------------------------------------------------------------|-----------|
| 1   | Petroleum ether | Seed           |                   | The extract inhibited the growth of all tested fungal significantly               | [13]      |
| 2   | Fruits pulp     | Seed           |                   | Inhibited the growth of the tested fungal strain at 100 μg                        | [24]      |
| 3   | Hexane, methanol| Fruits pulp    |                   | The methanolic stem bark exhibited the highest inhibition against *Microsporum canis* at 10.70 mm. | [70]      |
| 4   | Aqueous         | Fruits pulp    |                   | The extract protects against castor oil-induced diarrhea by 53%, compared to the standard 91%. | [71]      |
| 5   | Aqueous         | Seed           |                   | The aqueous extract alone lowered the contractile amplitude of jejunal tissue dosage independently. Additionally, the aqueous extract lowered the contractile amplitude of an isolated jejunal segment subjected to 0.2 ml of acetylcholine at a concentration of 10 μg/mL. | [72]      |

Notes: S/N = serial number.

### Table 6: Antiparasitic activity of *D. microcarpum*.

| S/N | Method          | Solvents       | Part of the plant | Major findings                                                                 | Reference |
|-----|-----------------|----------------|-------------------|--------------------------------------------------------------------------------|-----------|
| 1   | Antiparasitic   | Methanol       | Stem bark         | For the 200, 400, and 800 mg/kg tested doses, the methanolic stem bark extract had a significant (*p < 0.001*) curative as well as prophylactic impact, and the survival period of mice was significantly (*p < 0.001*) extended in the treated groups. There was no effect of the extract on the biochemical and haematological tests at p > 0.05. When compared to the negative control, the methanolic leaf extract significantly reduced the average % of parasitemia level in the treatment group. At doses of 250, 500, and 1000 mg/kg, the extract cleared parasites at 83.52, 86.65, and 87.21%, respectively. After 14 days of treatment, both doses of the extract administered significantly reduced parasitemia. On the other hand, neither dose of the extract reversed trypanosome-induced anaemia. Similarly, the extract was unable to improve hepatomegaly and splenomegaly caused by trypanosomes. The observed result indicated that the methanolic leaf extract possesses trypano suppressive action, implying that it may be employed as a candidate for the development of medications to treat disorders caused by trypanosomes. The methanolic leaf extract’s of oral LD50 was determined to be greater than 5000 mg/kg. At all doses examined, the extract had substantial curative, suppressive, and preventive effects at p > 0.001. Additionally, the extract increased the survival period of treated mice by up to 19 days when compared to the negative control group. | [42]      |
| 2   | Methanol        | Leaf           |                   |                                                                                   | [73]      |
| 3   | Methanol        | Leaves         |                   |                                                                                   | [74]      |
| 4   | Methanol        | Leaves         |                   |                                                                                   | [75]      |
| 5   | Methanol        | Leaf           |                   |                                                                                   | [76]      |
| 6   | Methanol and aqueous | Stem bark |                   | Both the aqueous and methanolic stem bark extracts inhibited larval mobility in *C. elegans*, Bristol, and *C. elegans* DA1316 with a significant difference at *p < 0.05* compared to the negative control. The observed result indicated that the methanolic leaf extract possesses trypano suppressive action, implying that it may be employed as a candidate for the development of medications to treat disorders caused by trypanosomes. The methanolic leaf extract’s of oral LD50 was determined to be greater than 5000 mg/kg. At all doses examined, the extract had substantial curative, suppressive, and preventive effects at p > 0.001. Additionally, the extract increased the survival period of treated mice by up to 19 days when compared to the negative control group. | [77]      |

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Notes: S/N = serial number.
and the frequency of resistance is increasing worldwide for all types of antibiotics, including the major last-resort medications [110]. Consequently, other antimicrobial antibiotics are urgently required, and this circumstance has prompted evaluation of the therapeutic use of ancient remedies. The agar disc diffusion methods are mostly used to determine if bacteria are responsive to antimicrobial drugs as a qualitative test. The MIC, MBC, broth dilution, and many other methods, refers to the amount of substance required to prevent bacterial growth or the amount bacterial concentration needs to be used. Several studies explored the antibacterial properties of various parts of D. microcarpum using different methods (Table 4). The stem bark ethanolic extracts demonstrated antibacterial activity against the investigated species at dosages of 100, 50, 25, and 12 mg/mL, with S. aureus having the highest

| S/ N | Method | Solvents | Part of the plant | Major findings | Reference |
|------|--------|----------|-------------------|---------------|-----------|
| 1    | Aqueous| dAgNps   | (leaves)          | It was determined that dAgNps suppressed PANC-1 in the cell viability assay, with IC<sub>50</sub> values of 84 μg/mL. There was no substantial health risk associated with the administration of 200 mg·kg<sup>-1</sup> of the methanolic seeds extract, alone or in combination with B. eurycoma and M. pruriens seeds, in the current investigation. | [110] |
| 2    | In Vivo| Aqueous  | Seeds             | The root extract considerably lowered the blood sugar levels of alloxan diabetic rats at (p < 0.05). At 500, 750, and 1000 mg/kg body weight, the methanolic leaf extract significantly reduced blood glucose levels. Compared to diabetic rats administered with the conventional medication (glibenclamide), the extract significantly increased the body weight at (p < 0.05) | [15] |
| 3    | In Vivo| Methanol | Leaf              | On-amyase and -glucosidase IC<sub>50</sub> of leaf extracts at 63 and 158 μg/mL, respectively, were lower than those of acarbose. | [81] |
| 4    | In Vivo| n-Hexane, ethyl acetate, and 70% methanol| Stem bark | The extracts were found to have anti-implantation activity, which supports its usage as a contraceptive in traditional medicine. | [82] |
| 5    | In Vivo| 70% methanol | Leaf | Significant reductions in blood sugar and cholesterol levels were observed with the seed extract. The extract exhibited no influence on haematological or blood chemistry indicators, demonstrating its safety. When compared to glibenclamide, methanol leaf extract (200 and 400 mg/kg body weight) caused a significant dose-dependent drop in blood sugar levels, 20.62 and 40.75%, respectively, and a considerable recovery of body weight in diabetic rats after four hours of administration (57.49%) was observed. | [84] |
| 6    | In Vivo| Aqueous  | Seeds             | The seeds’ extract lowers postprandial blood glucose and insulin levels in humans. | [83] |
| 7    | In Vivo| Methanol | Leaf              | Reduced incremental blood glucose and postprandial glucose levels by a statistically significant amount at p < 0.05. Glucose has a 62% area-under-curve. | [87] |
| 8    | In Vivo| Aqueous  | Seeds             | Reduced incremental blood glucose and postprandial glucose levels by a statistically significant amount at p < 0.05. Glucose has a 62% area-under-curve. | [87] |
| 9    | In Vivo| Gum      |                  |                  | [86] |
| 10   | In Vivo| Methanol | Seed              | The methanolic seed extract lowered alpha-amylase and glucoamylase at 69.3 and 31.1 mg/mL, respectively | [60] |
| 11   | In Vivo| Bread    |                  |                  | [87] |

Notes: S/N = serial number.

and the frequency of resistance is increasing worldwide for all types of antibiotics, including the major last-resort medications [110]. Consequently, other antimicrobial antibiotics are urgently required, and this circumstance has prompted evaluation of the therapeutic use of ancient remedies. The agar disc diffusion methods are mostly used to determine if bacteria are responsive to antimicrobial drugs as a qualitative test. The MIC, MBC, broth dilution, and many other methods, refers to the amount of substance required to prevent bacterial growth or the amount bacterial concentration needs to be used. Several studies explored the antibacterial properties of various parts of D. microcarpum using different methods (Table 4). The stem bark ethanolic extracts demonstrated antibacterial activity against the investigated species at dosages of 100, 50, 25, and 12 mg/mL, with S. aureus having the highest
3.8. Antifungal Activity. Recently, the use of various natural plant compounds to suppress the pathogenic organisms has evolved [8, 110]. Plant products are important sources of therapeutic medications for infectious diseases, and they are reported to have little or no adverse effects when compared to synthetic drugs [113]. Fungal infections cause a wide range of disorders, including aspergillosis, candidiasis, dermatomyositis, and mucormycosis [113]. Plant extracts are frequently employed as a source of medicinal agents, mostly for antifungal purposes. This is due to an increase in the demand for natural products to replace synthetic chemical substances. Antibiotic overuse frequently led to the emergence of resistant strains. Due to this drug resistance, the quest for novel antibiotics is ongoing. In this regard, plants remain as an abundant supply of therapeutic medications. The methanolic stem bark inhibited Microsporum canis the most (10.70 mm) [70]. The contractile amplitude of jejunal tissue was lowered by the aqueous extract alone in a dose-dependent manner. Furthermore, an isolated jejunal segment subjected to 0.2 mL of 10 g/mL acetylcholine had its contractile amplitude reduced by the aqueous extract [72]. Isolated molecules of clerodane diterpenes from the pulp exhibited antifungal action and inhibition of the Alzheimer’s disease-linked enzyme acetylcholinesterase [53]. The extract dramatically increased the growth of all fungal strains examined (Table 5). The plants exhibited a wide spectrum of activities. The presence of secondary metabolites, which inhibited the growth of microbial strains, was linked to the antimicrobial activity of medicinal plant extracts. The activity was caused by a change in the lipid fraction of the microorganism plasma membrane, which altered membrane permeability and allowed intracellular materials to leak [111]. The reported study demonstrates that the crude extracts are antifungal against all strains tested. This research could lead to the identification of new antifungal drugs and new antibiotic compounds.

3.9. Antiparasitic Activity. More than 90 countries with a combined population of 2.4 billion are plagued by malaria [46]. Children under 5 and pregnant women account for the vast majority of the 500 million clinical cases and 1.5–2.7 million annual deaths caused by this disease [114]. African trypanosomiasis, often known as “sleeping sickness” in humans and “nagana” in animals, is a significant infection
Table 10: Toxicity evaluation of *D. microcarpum*.

| S/N | Method | Solvents | Part of the plant | Major findings | Reference |
|-----|--------|----------|-------------------|----------------|-----------|
| 1   | *In Vivo* | Methanol | Leaf             | Toxicological tests have established that a dose of 5000 mg/kg of methanolic leaf extract is safe. According to the study, prolonged use of the extract in the management of medical conditions may have a harmful effect on certain essential organs. | [63] |
| 2   | *In Vivo* | 70% methanol | Stem bark        | It may be concluded that supplementation with aqueous stem bark extract was useful in moderating the changes in liver, kidney, and serum variables of rats exposed to mycotoxins. The methanolic stem bark extract, which reveals that prolonged use of the extract in the therapy of disease conditions may be related to some unfavourable effects on some essential organs. | [89] |
| 3   | *In Vivo* | Aqueous  | Stem bark        | The results of this experiment indicate that the fruit of *D. microcarpum* may have an adverse effect on rats and may include antinutrients that harm its digestion and absorption, resulting in the observed retardation of growth in rats. Increased incorporation of seeds, reduced weight gain and FCR in a linear fashion. Birds fed 10%, 15%, and 20% diets had lower haematological and serum biochemical indices than those fed 5% and control diets at \( p < 0.05 \). Broiler chicks’ blood components were not adversely affected by the inclusion of 5% DSM in their diets. Processed DSM must be added to broiler meals to increase their incorporation levels above 5%. | [92] |
| 5   | *In Vivo* | Aqueous  | Fruit            | Fruit flour was nutritious as a food additive up to 30% without causing clinical indications or death. All treatment groups had a substantial decrease in relative liver weight at \( p < 0.05 \) when compared to the negative control. These findings imply that *Detarium microcarpum* stem bark contains antioxidant phytochemicals and may be useful in the treatment of liver damage. | [88] |
| 6   | *In Vivo* | n-butanol | Stem bark        | The chloroform and ethyl acetate extracts of *D. microcarpum* fruit pulp were the most cytotoxic to normal fibroblasts in a biocompatibility investigation of the fruit pulp. More than 80 percent of cells died when the hexane extract was applied at 500 g/mL, which was the highest concentration that was found to be cytotoxic. The cytotoxic effects of methanol extract were negligible. Human lymphocytes were not harmed by the fruit pulp ethanol extract. The cytotoxicity of hydrogen peroxide and tert-butyl hydroperoxide to human lymphocytes was also dramatically lowered by pretreatment with fruit extracts. In terms of cytoprotective efficacy, both the extract and ascorbic acid were comparable at \( p > 0.05 \). Mice died at concentrations of 2900 mg/Kg and 1600 mg/kg body weight from the methanolic stem bark extract, with an LD\(_{50}\) value of 3,807.89 mg/kg. Experiments with extracts of these plants have yielded a good dose guidance for an ongoing antimalarial study. | [92] |
| 7   | *In Vivo* | Fruits   | Fruits           | The inclusion of the seeds in the diet, had no effect on the haematological and biochemical indices at \( p > 0.05 \). Thus, tallow seed meal can be used in broiler chicken feeds up to 20% without affecting organ weight, haematological, or biochemical indices of broiler chickens. Increased incorporation of seeds, reduced weight gain and FCR in a linear fashion. Birds fed 10%, 15%, and 20% diets had lower haematological and serum biochemical indices than those fed 5% and control diets at \( p < 0.05 \). Broiler chicks’ blood components were not adversely affected by the inclusion of 5% DSM in their diets. Processed DSM must be added to broiler meals to increase their incorporation levels above 5%. | [93] |
| 8   | *In Vivo* | Seeds    | Fruits           | The methanolic stem bark extract, which reveals that prolonged use of the extract in the therapy of disease conditions may be related to some unfavourable effects on some essential organs. | [91] |
| 9   | *In Vivo* | Fruits   | Fruits           | The results show that *Detarium microcarpum* is toxic and thus not safe, especially when administered in large doses without proper monitoring and management. | [43] |
| 10  | BST     | Methanol | Stem bark        | The chloroform and ethyl acetate extracts of *D. microcarpum* fruit pulp were the most cytotoxic to normal fibroblasts in a biocompatibility investigation of the fruit pulp. More than 80 percent of cells died when the hexane extract was applied at 500 g/mL, which was the highest concentration that was found to be cytotoxic. The cytotoxic effects of methanol extract were negligible. Human lymphocytes were not harmed by the fruit pulp ethanol extract. The cytotoxicity of hydrogen peroxide and tert-butyl hydroperoxide to human lymphocytes was also dramatically lowered by pretreatment with fruit extracts. In terms of cytoprotective efficacy, both the extract and ascorbic acid were comparable at \( p > 0.05 \). Mice died at concentrations of 2900 mg/Kg and 1600 mg/kg body weight from the methanolic stem bark extract, with an LD\(_{50}\) value of 3,807.89 mg/kg. Experiments with extracts of these plants have yielded a good dose guidance for an ongoing antimalarial study. | [95] |
that affects both humans and livestock in Africa [115]. The methanolic stem bark extract demonstrated a substantial curative and prophylactic effect at 200, 400, and 800 mg/kg tested doses, and the survival span of mice was considerably extended in the treated groups. At \( p > 0.001 \), the extract had no effect on the biochemical and haematological assays (Table 6). The oral LD\(_{50}\) of the methanolic leaf extract was found to be larger than 5000 mg/kg. The extract demonstrated significant curative, suppressive, and preventive effects at all doses tested at \( p > 0.001 \). Furthermore, compared to the negative control group, the extract enhanced the survival time of the treated mice by up to 19 days [76]. When compared to the negative control, both the aqueous and methanolic stem bark extracts restricted larval movement in \( C.\ elegans \) Bristol and \( C.\ elegans \) DA1316 [77]. However, all studies reviewed revealed that the plant

![Diagram](image-url)

Figure 3: Diagrammatic presentation of how man utilises plants leads to the development of modern drugs and herbal formulations.

Table 10: Continued.

| S/N | Method                     | Solvents                  | Part of the plant | Major findings                                                                 | Reference |
|-----|----------------------------|---------------------------|-------------------|--------------------------------------------------------------------------------|-----------|
| 14  | Brine shrimp lethality test| Dichloromethane and methanol |                  | The methanol extract of \( Detarium microcarpum \), had an \( LC_{50} \) of 1540.00 μg/mL (non-toxic). | [68]      |
| 15  | In Vivo                    | Methanolic                 | Leaf              | The methanolic leaf extract showed that none of the organs showed any histological changes during the monitoring period. | [81]      |
| 16  | In Vivo                    | Ethanol                    | Fruits            | The fruit’s antioxidant molecules scavenging the hydroxyl radical, as well as the peroxy and alkoxy radicals produced by lipid peroxidation had a gene protective impact. | [53]      |
| 17  | In Vivo                    | Methanolic                 | Leaf              | The oral LD\(_{50}\) of the extract was determined to be greater than 5000 mg/kg of body weight. There were no significant differences between the therapy groups when it came to renal function and haematological analysis. | [73]      |

Notes: S/N = serial number.
demonstrated good activity against the tested parasites. It is interesting to note that the different antiparasitic effects of these extracts were related to both their chemical composition and the nature of the promastigote species, and that the different antiparasitic activity of these extracts against the different promastigote species is related to their different chemical compositions [112]. The mechanism of action of these extracts can be inferred from their ability to break the cell membrane and induce cell death in certain cellular targets. In this instance, the contact with the mitochondrial membrane can be suggested as an additional targeted method that induces parasite apoptosis.

3.10. Antidiabetic Activity. Diabetes mellitus is a prominent and widespread disease that affects populations of underdeveloped, developed, and developing nations [110]. This disease is predicted to afflict 25 percent of the world’s population [116]. Diabetes is characterized by improper glucose metabolism, which is connected with low blood insulin levels [116]. The search for novel medications continues as demand grows daily. At \( p < 0.05 \), the root extract significantly reduced blood sugar levels in alloxan diabetic rats [15]. Seed extract was found to lower blood sugar and cholesterol levels significantly. The extract had no effect on haematological or blood chemical signs, indicating that it was completely safe [84]. The alpha-amylase and glucosidase levels in the methanolic seed extract were reduced to 69.3 and 31.1 mg/mL, respectively [60]. In humans, the extract from the seeds decreases the postprandial blood glucose and insulin levels (Table 7). At \( p < 0.05 \), the reduction in incremental blood glucose and postprandial glucose levels was statistically significant [87]. The area-under-curve of glucose was 62% [87]. As a result,
Detarium microcarpum has been studied in vitro and in vivo as a possible source of antidiabetic medicine. The trunk bark contained myo-inositol (4), L-quinol-1,5-lactone (1), D-pinitol (3), D(-)-borsenol (2), sucrose, D-glucose, and D-fructose [34]. Actually, D-pinitol and its derivatives are well known for their helpful effects in cases of insulin resistance. The hypoglycemic effects of D. microcarpum crude extract and compounds are likely achieved by preventing glucose absorption in the small intestine, increasing insulin secretion in the pancreas, thereby preventing glucose production in the liver, or promoting glucose uptake in peripheral tissues via glucose transporters (Figure 4).

3.11. Detarium microcarpum as an Insecticide. The ongoing use of liquid and gaseous insecticides is crucial for keeping insect populations in stored products under control [117]. Although effective, their frequent usage for several decades has disrupted the biological control mechanisms of natural enemies and led to outbreaks of insect pests, widespread development of resistance, unwanted effects on nontarget organisms, and environmental and human health issues [117]. The abundance of bioactive compounds in plants suggests they could be a useful alternative to conventional pesticides (Table 8). It contains the active ingredients such as 3,13E-clerodien-15-oic acid, 4 (18)-clerodien-15-oic acid, 18-oxo-3,13E-clerodien-15-oic acid, and 2-oxo-3,13E-clerodien-15-oic acid. Except for the last, these chemicals have not previously been associated with D. microcarpum. At a concentration of just 1%, all four substances demonstrated significant antifeedant efficacy [41]. More research is needed to confirm whether or not the plant extracts are effective at controlling pesticides.

3.12. Anticancer Activity. Cancer is a disease in which cells divide improperly and uncontrollably. In 2012, there were around 14 million new cancer cases and 8.2 million cancer-related deaths globally [118]. Cancer is the world’s second biggest cause of death, after only cardiovascular disease, and it is a serious public health concern [118]. Cancer incidence and mortality are increasing all over the world [116]. Further biological study of medicinal plants with anticancer properties will help treat and manage the condition. The IC_{50} values for the three plants’ methanol and aqueous extracts inhibiting MCF7 cell growth ranged from 78 to >500 μg/mL. Stem bark extracts had the strongest antioxidant and anti-proliferative properties (Table 9). As a result, anti-breast cancer compounds may be found in the stem bark of these plants [59]. dAgNPs inhibited HeLa cell proliferation with IC_{50} values of 31.5 μg/mL [79]. The chloroform and ethyl acetate extracts were the most effective at inhibiting osteosarcoma cells. Ethyl acetate extract killed all osteosarcoma cells at all dosages, but chloroform extract killed all cells at concentrations of 250 and 500 μg/mL [96]. Apoptosis is inhibited by plant extracts and chemicals (Figure 5), which also improve survival signalling pathways and disrupt proapoptotic intermediates. Bioactive substances have the potential to affect the angiogenesis pathway, which is the growth of blood vessels in the tumor and is a significant step towards metastasis.

3.13. Toxicity Evaluation. Medicinal plants are used throughout the world, particularly in developing countries. This is due to the fact that they are inexpensive and readily available locally. Consumers all throughout the world believe that herbal medicines are always safe since they are natural. Evidence, however, suggests different. If not correctly selected and prepared, they can be highly poisonous. As a result, determining the safety of plant extracts is critical. Many investigations have shown that medicinal plants contain a diverse range of chemicals with biologically beneficial effects. Methanolic leaf extract at a level of 5000 mg/kg has been found to be safe in toxicological tests [63]. At p > 0.05, seeds in the diet showed no effect on haematological or biochemical indices. To summarize, talnig seed meal can be used up to 20% in broiler chicken feed without influencing organ weight, haematological index, or biochemical indices (Table 10). Long-term usage of the methanolic stem bark extract in the treatment of illness conditions has been linked to some negative effects on

Figure 5: Schematic presentation of Detarium microcarpum to target cancer cells. A = Detarium microcarpum; B = crude extract; C = pure compound; D = cancer cell; E = organ with cancer cell; and F = treated human.
Various critical organs [12]. The findings suggest that *D. microcarpum* fruit may have a detrimental effect on rats and may include antinutrients that damage digestion and absorption, resulting in the observed growth retardation in rats [92]. The LC₅₀ of the methanolic extract of the stem bark for brine shrimp larvae was found to be 158.49 g/mL. *Detarium microcarpum* is toxic and thus not safe, according to the findings, especially when given in large dosages without effective monitoring and treatment [95]. The methanolic stem bark extract killed mice at doses of 2900 mg/kg and 1600 mg/kg body weight, with an LD₅₀ of 3,807.89 mg/kg. Experiments with extracts of these plants have given a favourable dose recommendation for an ongoing antimalarial study [43]. According to the conclusions of this study, excessive usage of all sections of *D. microcarpum* extract may have toxicological implications; hence, only small doses should be utilized. Individual compounds should be examined for their toxicity levels, which is the foundation for any drug development or herbal formulation.

4. Conclusion and Future Research

*Detarium microcarpum* has been utilized as an ethno medicine for the treatment of numerous disorders in West Africa and other parts of the world, most notably in Nigeria, Senegal, Sudan, and Mali. Traditional healers treated ailments such as diabetes, malaria, weakness, skin infections, urinary problems, and diarrhea with *D. microcarpum* leaves, bark, roots, and fruits. Preclinical research has been done on antioxidants, antibacterial, antifungal, antiviral, and treatment for a number of other diseases. This analysis also shows that *D. microcarpum* has a lot of chemical compounds (Lup-20(29)-ene-2alpha,3beta-diol, Microcarpin, Linoleic Acid, quercetin 3,7-O-dirhamnoside, myricetin 3-O-rhamnoside, and many others) that could be used to make new drugs in pharmaceutical companies and herbal formulations. The study will pave the way for additional research into the isolation of active secondary metabolites and their mechanisms of action against the diseases in question. In-depth studies are required to fully understand the therapeutic applications of the isolated compounds, including their toxicological profiles, mechanisms of action, and their biological activity clinically.

**Abbreviations**

| ALT: | Alanine aminotransferase |
| AST: | Aspartate transaminase |
| dAgNps: | Silver nanoparticles |
| *D. microcarpum*: | *Detarium microcarpum* |
| FRAP: | Ferric reducing antioxidant power |
| TBL: | Total bilirubin |
| DPPH: | 2,2-diphenyl-1-picrylhydrazyl, 2,20-azino bis-3-ethyl-ethylbenzothiazoline-6-sulphonate |
| SRASA: | Superoxide radical anion scavenging assay |
| DDA: | Deoxyribose degradation |
| LPM: | Lipid peroxidation models |
| ABTS: | Radical cation scavenging assay |
| MIC: | Minimum inhibitory concentrations |
| MBC: | Minimum bacterial concentration |
| HPLC: | High-performance liquid chromatography |
| HPTLC: | High-performance thin-layer chromatography |
| GCMS: | Gas chromatography mass spectrometry |
| FTIR: | Fourier transform infrared |

**Data Availability**

The data supporting the current study are given in the article.

**Conflicts of Interest**

The author declare that, no conflicts of interest.

**Authors’ Contributions**

Mahmoud Dogara Abdulrahman contributed to data search, analysis of the retrieved data, and the drafting of the manuscript.

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