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Ethnopharmacology, Biological evaluation and Chemical composition of *Boswellia dalzielii* Hutch: A Review

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ABSTRACT

The Burseraceae family consists of 18 genera and 540 species. *Boswellia dalzielii* is a medicinal plant used in tropical and subtropical areas for the treatment and management of various ailments. Despite the medicinal value of *B. dalzielii,* there is no comprehensive documentation. The study aimed to review the ethnopharmacology, biological evaluation and chemical composition of *B. dalzielii*. Scopus, Web of Science, BioMed Central, Science Direct, PubMed, Springer Link, and Google Scholar were searched to find published articles. The results showed that the leaves, stem bark, and root of *B. dalzielii* have been traditionally used in Nigeria, Cameroon, Burkina Faso, Benin, Sudan, and Guinee for the treatment and management of antirheumatic, antispasmodic, analgesic, antiseptic, hypotensive, malarial mental illness, ulcer, pain, and fever. It is also found that leaves, stem bark, and root have antioxidant, antibacterial, antifungal, and antimalarial properties with stembark having the highest activity. Chemically, it was revealed the leaf has high contents of monoterpenes hydrocarbons with alpha-pinene as the major compound. The species were largely studied *in vitro*, according to the literature survey. A well-designed clinical experiment is required to obtain conclusive evidence on the efficacy of stembark. The standard dose and safety of the stembark should be established.

Keywords: Antimicrobial, Antioxidants, Ethnomedicine, Medicinal plants

INTRODUCTION

Plants have been utilized as medication for centuries, first as traditional mixtures and then as pure active ingredients, with knowledge and expertise passed down from generation to generation (Taylor *et al*., 2001). The use of natural plants for human disease management begins from the earliest civilization of Chinese and Indians (Abdulrahman *et al*., 2018). The present focus and interest in producing medicinal agents have shifted toward the field of phytochemistry. Plants play an important role in human food production. Medicinal and Aromatic Plants (MAP) have long been used as therapeutic medicines and consequently have significant commercial value (Abdulrahman *et al*., 2018). Diverse varieties of the plant have been studied, analyzed, and characterized for their medicinal values based on their major biological compounds present (Taylor *et al*., 2001; Abdulrahman *et al*., 2018). Living things depend relatively on the plants to meet their basic need for survival. All over the globe, 85% of the modern medicines used for healthcare are derived either directly or indirectly from plants. Africa has diverse flora, and scientists have long been interested in studying African medicinal plants (Malterud, 2017). In various West African countries, including Benin, Ghana, Northern Nigeria, Togo, Burkina Faso, Cameroon, and Northern Ivory Coast, it is widely utilized for therapeutic purposes (Adebayo *et al*., 2020). The objective of this review was to provide as much information as possible on ethnopharmacology, taxonomic description, chemical composition, and biological assessment of *B. dalzielii*.

MATERIALS AND METHODS

Search criteria, inclusion, and exclusion criteria

A literature search was carried out in the following databases: Scopus, Web of Science, BioMed Central, Science Direct, PubMed, Springer Link, and Google Scholar. Only published articles were considered, and reviews, research papers, thesis, and abstracts were excluded. Data were subjected to tabulation and graphical presentation (Figure 1).

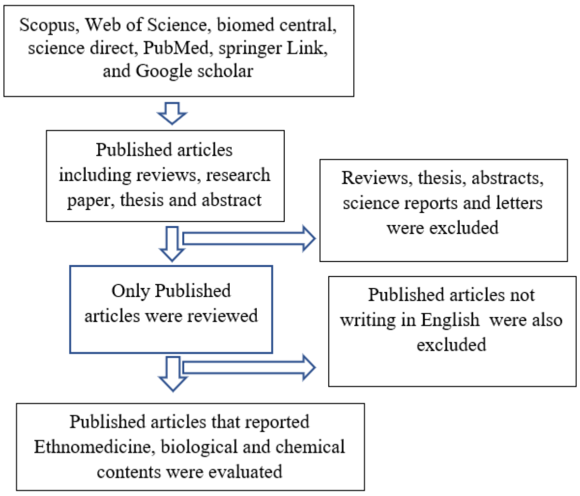

Figure 1: Flow chart of the methodology

RESULTS AND DISCUSSION

On a global scale, science is interested in uncovering patterns of knowledge about natural resources. The results discussed the traditional usage of the different parts of *B. dalzielii* in some West African countries. The origin of *B. dalzielii* and taxonomic description was well explained. The study found that several biological evaluations were carried out on the various parts of the plant using a different assay to validate its efficacy. Similarly, the study found that the majority of the chemical composition analyses were based on the essential oil of the plants and a few studies of phenols and flavonoids. Quantitative and qualitative analysis of the plant was documented based on the phenols, flavonoids, and other chemical components of the plant. Below is the schematic representation of the results and discussion.

Ethnopharmacology

Ethnopharmacology is the interdisciplinary study of biologically active medications used or observed by people in the past (Taylor *et al*., 2001). Plants and their derivatives have been employed since the dawn of time. Several studies on the use of plants in traditional medicine have been published (Ior *et al*., 2017). According to the World Health Organization (WHO), around 80% of the world's population is dependent on traditional medicine, which mostly involves the use of plant extracts (Ior *et al*., 2017). The therapeutic efficacy, accessibility, and low costs of herbal therapy compared to modern treatment, as well as the fact that it is strongly connected with traditional belief, are the key reasons for this reliance (Ouedraogo *et al*., 2020). Traditional medicinal herbs are frequently used in rural places when synthetic medications are unavailable or, if available, are prohibitively expensive (Mahmoud *et al*., 2020). It is a tree species that the local population commonly uses as an ethnomedicine source (Kafuti *et al*., 2018). *Boswellia dalzielii is* locally called in Nigeria as ***Ararrabi, Basamu***, ***Hano.*** Moreover, in Burkina Faso, it is called ***Kumdagneogo,*** Tree Man, Volta, and in Ghana, it is called ***Piangwogu***, while in Ethiopia, it is known as ***Etan*** (Figure 2). It is reported to have traditionally treated different varieties of ailments (Abdulhamid & Sani, 2019; Abubakar *et al*., 2017; Ohemu *et al*., 2014). The plant is considered in Nigeria as the major medication for children's diseases (Table I). This plant is widely used in African traditional medicine to treat diarrhea, malaria, vomiting, infection, and arthritis (Alemika *et al*., 2004; Kafuti *et al*., 2017; Mbiantcha *et al*., 2018). It is used to cure gastrointestinal problems, leprosy, septic sores, skin illnesses, rheumatism, and a wide range of microbiological ailments (Kubmarawa *et al*., 2005; Mamza *et al*., 2018; Olukemi *et al*., 2005; Otitoju *et al*., 2019). The people of Northern Nigeria have long utilized decocted root bark to cure diabetes (Table I) (Yakubu *et al*., 2020). The stem bark secretes a fragrant white gum that is used to fumigate cloth and drive flies, mosquitoes, and other insects out of rooms (Hassan *et al*., 2009). The fresh bark is used as an emetic and to treat giddiness and palpitation symptoms (Nazifi *et al*., 2017). In the northwestern part of Nigeria, the bark part is used in the treatment and management of arthritis (Salihu *et al*., 2018). The raw bark of the root is ingested in Nigeria to treat pain and as a poison antidote (Yakubu *et al*., 2020).

In Burkina Faso, the bark is utilized for the treatment of diabetes (Compaore *et al*., 2020). According to reports, the herb has also been used to cure tooth problems, swellings, bronchitis, and coughs (Balarabe *et al*., 2019; Owolabi *et al*., 2020). A different method of traditionally preparing the plant was reported (Kohoude *et al*., 2017; Sani *et al*., 2021). The extracts and essential oils have long been used as antiseptics in mouthwashes and for cough and asthma treatment (Medugu *et al*., 2020). All parts of the plants are traditionally used in the treatment and management of various ailments in Nigeria, Cameroon, Burkina Faso, Benin, and Guinée (Table I). It is consistent in reporting the usage of the plant parts in the study (Table I).

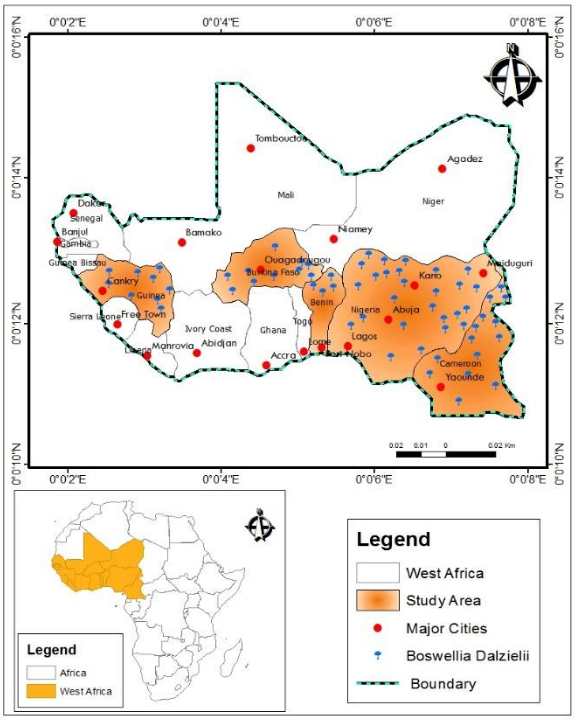

Figure 2. Map of West African countries showing the Distribution of *Boswellia dalzielii*

Origin and Taxonomic Description

The Burseraceae family has 18 genera and 640 species of tropical plants and shrubs. Africa, the Arabian Peninsula, and India are all home to these species (Owolabi *et al*., 2020). Burseraceae is a large family of flowering plants with over 18 genera and 540 species (Mbiantcha *et al*., 2018). The largest group is found in tropical regions and areas such as the desert, savannah, mangrove, and forests (Alemika *et al*., 2004). They are abundant in West Africa's Savannah regions (Fig. 3) (Olukemi *et al*., 2005). This family originated in North America and is widely represented throughout the world. *Boswellia dalzielii* Hutch can be found from western Chad to Mali via Nigeria and Burkina Faso (Owolabi *et al*., 2020). It grows abundantly in the northern Ivory Coast (Ohemu *et al*., 2018). *Boswellia dalzielii* is an aromatic plant that thrives in rocky, shallow, and dry soils (Kohoude *et al*., 2017). It is a tree with a rounded and transparent crown that grows up to 13 meters tall (Fig. 3) (Kohoude *et al*., 2017). It is a tall tree with fragrant white blossoms (about 13 m tall) (Mbiantcha *et al*., 2018). The tree has a smooth bark and peels that are high in non-allergenic resin or essential oils, and some can yield frankincense and myrrh (Mbiantcha *et al*., 2018). It has complex light green and glossy leaves in terminal tufts with narrowly oval laminae with a saw-tooth form. Furthermore, it has a silky pale brown bark that is distinguished by ragged papery plates (Hassan *et al*., 2009; Mbiantcha *et al*., 2017). Flowering and fruiting occur throughout the dry season, usually before the development of the first leaves (Mbiantcha *et al*., 2017). Its natural habitat is savannas with saxicolous woods (Abdulhamid & Sani, 2019).

Figure 3: *Boswellia dalzielii* (Dressler *et al*., 2014)

Biological evaluation

Natural products have gotten a lot of attention recently, not just in terms of health promotion and disease treatment but also in terms of medication discovery and development. Natural products used for drug discovery and development remain as one of the most important opportunities for developing therapies for a variety of disorders.

Table I. Ethnopharmacology of *B. dalzielii* from different countries

S/N	Medicinal uses	Parts of the Plant	Country	References
1	The most utilized plants in the traditional system	Roots	Sudanian Region of Benin	(Imorou, 2020)
2	Stomachache, piles, and worms	Leaf, bark	Nigeria	(Amusa & Jimoh, 2010)
3	Snake-bite, fever, and rheumatism	Bark, root		(Adamu *et al*., 2005)
4	HIV, rabies, chickenpox, and hepatitis	Leaves, bark, and stem	Nigeria	(Ohemu *et al*., 2014)
5	Heat rashes, diarrhea, umbilical cord and complications pile	Stem Bark	Nigeria	(Abubakar *et al*., 2017)
6	Ant sickling	Stem bark	Nigeria	(Sani *et al*.) 2021
7	Malaria	Stem Bark	Nigeria	(Zakariya *et al*., 2021)
8	Maternal ailments	Bark	Nigeria	(Kankara *et al*., 2015)
9	Stomachache and Wound healing	Leaf	Burkina Faso	(Ouedraogo *et al*., 2020)
10	Mental disorders	Stem bark	Burkina Faso	(Nadembega *et al*., 2011)
11	Arthritis	Stem bark	Nigeria	(T. Salihu *et al*., 2018)
12	Ethnoveterinary	Bark	Cameroon	(Djoueche *et al*., 2011)
13	Anti-tuberculosis	Stem bark	Nigeria	(Hassan *et al*., 2017)
14	Mental illness	Stem bark	Nigeria	(Ibrahim *et al*., 2007)
15	Antidiabetic	Root	Nigeria	(Shinkafi *et al*., 2015)
16	Cancer	Bark	Nigeria	(Dogara *et al*., 2021)
17	Inflammatory diseases	Stem-bark	Guinée	(Baldé *et al*., 2015)
18	Many forms of cancers/fibrosis	Stem bark	Nigeria	(Abubakar *et al*., 2007)
19	Antidiarrheal	Bark	Nigeria	(Etuk *et al*., 2009)
20	Pharmaceutics industry cosmetics, incense, perfume, and chewing gum	Leaves/ Bark	Nigeria	(Agbogidi, 2010)
21	Syphilis	Roots bark	Cameroon	(Sharifi *et al*., 2020)
22	Management of hepatic Ailments	Bark	Nigeria	(Kankara *et al*., 2018)
23	Pile and body heat	Stem bark	Nigeria	(Ali *et al*., 2017)
24	Measles, Vaginal Diseases	Bark, root	Nigeria	(Buochuama & Akhabue, 2018)
25	Malarial management	Leaves, Bark, flower	Nigeria	(Dogara *et al*., 2021)
26	Rheumatism, venereal diseases,	Bark, Root	Cameroon	(Talom *et al*., 2018)

Note; S/N = Serial Number

Numerous biological evaluations were carried out on *B. dalzielii,* including antioxidants, anti-inflammatory, antibacterial, antifungal, anticancer, and many more (Table II and Figure 4).

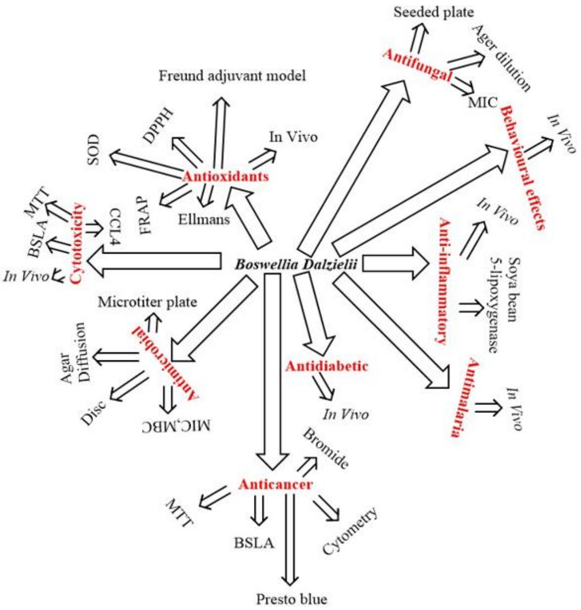

Figure 4. Schematic presentation of documented biological evaluation and their methods of evaluations

Antioxidants

Depending on the plant and its sections, secondary metabolites occur in a range of shapes and functions as antioxidants (Dogara, 2021; Nouri, Salehi, *et al*., 2021). Compounds that can protect cells from the harm produced by free radicals, which are unstable molecules, are known to be antioxidants (Abdulrahman, 2021). The chemicals interact with free radicals, stabilizing them and maybe preventing them from causing system damage (Zarei *et al*., 2021). A variety of methods were used to assess the antioxidant potential of *B. dalzielii* (Table II and Fig. 4). All the evaluated methods are found to be significant (Table II). The methanolic leaves extract demonstrated a high antioxidant activity by radical scavenging activity at 100 mg/L, with an IC_{50} of 6.10 ± 0.01 mg/L (Kohoude *et al*., 2017). The radical scavenging activity of 1 mg of nanoparticles was reduced by 53.73% (Adebayo *et al*., 2020). The maximal reducing power and scavenging activity of ethanolic stembark, respectively, were 18 and 34 μg/mL (Table II). Antioxidant qualities may aid in the treatment of chronic and degenerative diseases. The high flavonoid content of the plant explains its antioxidant properties, which could be used in drug development, as well as its high antioxidant capacity. Quercetin is the most prevalent flavonoid.

Anti-inflammatory

Inflammation is caused by the release of chemical mediators from injured tissues and migratory cells in the majority of cases (Mahmoud & Abba, 2021). Invading pathogens are inactivated or eliminated, irritants are removed, and tissues are prepared for repair (Mahmoud & Abba, 2021). Pain and inflammation are two of the most common side effects of many diseases (Hajhashemi *et al*., 2021). The documented anti-inflammatory evaluation revealed the potential of *B. dalzielii* against inflammation. In both inflammatory and neuropathic pain models, the current study found the methanolic stembark possesses antinociceptive effects (Mbiantcha *et al*., 2017). During the first and second stages of the formalin test, 250 and 500 mg/kg of the administered stembark extract considerably reduced licking and biting behavior in a dose-dependent manner (Mbiantcha *et al*., 2020). It has the potential to be a valuable therapeutic drug for both the prevention and reversal of pathophysiologic pain. Our findings suggest that it could be an effective treatment for preventing and reversing pathophysiologic pain (Table II).

Antibacterial

Antimicrobial resistance is being exacerbated by the creation and spread of drug-resistant bacteria with new resistance mechanisms, putting our capacity to treat common diseases in jeopardy (Abdulrahman *et al*., 2019). The extract's spectral index intensity was determined to be positive against all the tested pathogens (Mamza *et al*., 2018). The antimicrobial evaluation sheds light on the antibacterial potential of the plant parts. This supports its usage in ethnomedicine (Tegasne *et al*., 2020). The extract had a synergistic effect against all of the studied bacterial strains, but the pure component (Incensole) exhibited the strains' growth on average (Table II). Because the ethanolic leaves extract has an MIC of 1.25 mg/mL and the essential oil has an MIC of 1.25 μl/mL, they have antibacterial properties (Bothon & Atindehou, 2019). The methanolic stembark extract spectral intensity index was determined to be 7.27 mm against all pathogens tested. The presence of secondary metabolites in the plant caused the observed sensitivity (Mamza *et al*., 2018). Terpene compounds have been reported to have a strong antibacterial effect on both Gram-negative and

Gram-positive bacteria (Martins *et al*., 2003). The stem bark contains potent phytochemicals that inhibit the growth of the tested clinical isolates, revalidating its utilization in traditional medicine to cure diseases (Balarabe *et al*., 2019; Dogara *et al*., 2021). It also has some active element contents that treat gastrointestinal issues, as traditional medicinal practitioners have indicated (Nwinyi *et al*., 2004). The antibacterial evaluation of *B. dalzielii* revealed drugs could be made from it to treat infections caused by bacteria.

Antifungal

The World Health Organization has emphasized the proper use of natural products and identified plant-based medicines as prime research targets (Biswas *et al*., 2020). Since ancient times, medicinal plants have been widely used to meet mankind's healthcare needs (Dogara *et al*., 2021). Food contamination has become a big concern as the number of outbreaks of food-borne illnesses has increased (Lema *et al*., 2022). To date, there are just a few classes of antifungal medicines, the emergence of resistance to the present medication, and, increasingly, multidrug resistance has a significant impact on patient management (Perlin *et al*., 2017). Due to the shortage of efficient vaccines and the limited supply of existing expensive drugs, scientists working in viral research have taken the initiative to study bioactive leads (Biswas *et al*., 2020). The methanolic stembark extract showed the highest inhibition on *C. albicans* at 100 mg/mL, with a zone of inhibition of 38 mm (Kafuti *et al*., 2017). This indicates its antifungal properties (Owolabi *et al*., 2020). Flavonoids are the major compounds reported in the stembark. Flavonoids are a vast group of polyphenolic chemicals with a benzo—pyrone structure. Because of the current exploratory findings, stembark extract might be a valuable source for the identification and development of novel antifungal active compounds. The plant may be used to make effective antibiotics against fungal infections.

Behavioral Effect

Depression is a long-term mental illness that affects one's emotions, thoughts, behavior, and physical well-being (Fekadu *et al*., 2017). Nature, as it is widely acknowledged, offers the finest answers to all disorders that strike the human body from time to time (Balkrishna & Misra, 2017). The bark extract of *Boswellia dalzielii* has been found to have a central nervous system depressant potential and is employed in traditional mental disorder treatment (Table II). Furthermore, it has antiepileptic properties. There are several chemicals in the stembark, but flavonoids are the most common. Polyphenolic compounds with a benzo—pyrone structure, also known as flavonoids. The findings show that it is widely used in traditional medicine (Medugu *et al*., 2020).

Antimalaria

Malaria is the most common tropical disease in the world (M. Dogara *et al*.). Falciparum malaria has expanded widely as a result of the widespread usage of medications in the affected areas (Mahmoud *et al*., 2020). Moreover, the plant methanolic stembark extract possesses good antimalarial activities at IC_{50} of 1.25 μg/mL (Table II). The stembark contains a number of different compounds, the most common of which are called flavonoids. Polyphenols with a benzo-pyrone structure are called flavonoids.

Antidiabetic

A medicinal plant has restorative ingredients or is a forerunner in the development of drugs (Ahmad *et al*., 2009). Plants with therapeutic capabilities or good pharmacological effects on the animal body are referred to as Medicinal Plants (Ahmad *et al*., 2009). Diabetes mellitus (DM) is one of the most frequent metabolic diseases, with micro and macrovascular complications that lead to a severe sick state and mortality (Aloke *et al*., 2021). After 2 hours, 3 hours, and 6 hours, the blood glucose response was significantly reduced (Bobboi & Olesugun, 2005). The antidiabetic effects of the leaf of *B. dalzielii* enhance when the extract is refined. Alkaloids, flavonoids, tannins, and terpenoids found in the plant may be responsible for their antidiabetic properties in rats (Yakubu *et al*., 2020). Diabetes related disorders may benefit from the plant extract's preventative and therapeutic properties. Clinical trials are important because the investigations on this plant were done *In Vitro* and *In Vivo*.

Anticancer

Natural products have gotten a lot of attention recently, not just in terms of health promotion and disease treatment but also in terms of medication discovery and development. The dichloromethane extract had the highest percent inhibition (65), whereas the rest of the samples were just somewhat anticancer (Table 2). The IC_{50} was 98.12 g/mL, indicating anti-proliferative activity of the ethanolic stembark extract (Otitoju *et al*., 2020).

Table II. Biological evaluation of *B. dalzielii*

	Activity	Parts	Solvents	Methods	Results	References
1	Antioxidant	Essential oil, leaves	Methanol, ethyl acetate, dichloromethane, cyclohexane,	DPPH	Through radical scavenging activity, the methanolic leaves extract at 100 mg/L had a high antioxidant activity with the IC_{50} of 6.10 ± 0.01 mg/L.	(Kohoude *et al.*, 2017)
		Stem bark	Methanol, aqueous	DPPH, FRAP	Maximum antioxidant activity was identified in the aqueous and methanolic extracts with the IC_{50} of 1.58 and 1.99, respectively, based on radical scavenging activity. While the capacity to convert ion was 1 and 1.25 for aqueous and methanolic extracts, respectively.	(Kafuti *et al.*, 2018)
		Leaves	Methanol	In Vivo	Ocular Na^+ and K^+ ATPase activity was increased in the methanolic leaves extract-treated pups, but ocular Mg^{2+} ATPase activity was decreased. It showed a potential for correcting cataracts lenses' osmotic balance	(Onobrudu *et al.*, 2017)
		Stem bark	Methanol	Freund's adjuvant model	It could be a practical means of preventing and/or treating infectious diseases like Anti-arthritic.	(Mbiantcha *et al.*, 2018)
		Essential oil, leaves	Methanol, ethyl acetate, dichloromethane, cyclohexane,	SOD	Cyclohexane leaves extract at a concentration of 100 mg/L exhibited the highest inhibition percentage of 13.96 ± 0.04.	(Kohoude *et al.*, 2017)
		Stem bark	Aqueous nanoparticles	DPPH	The radical scavenging activity was quenched by 1 mg of the stem bark nanoparticles at 53.73%.	(Adebayo *et al.*, 2020)
		Stem bark	Ethanol	DPPH, FRAP	The maximum reducing power and scavenging activities of the ethanolic stem bark were 18 and 34 µg/mL, respectively. It contains antioxidant properties that can help in addressing chronic and degenerative disorders.	(Vedekoi & Selestin, 2020)
		Leaves/ essential oil	Ethanol	DPPH	Even when compared to the standard utilized in the study, the essential oil had stronger radical scavenging activity with IC_{50} of 1.25 µg/mL.	(Bothon & Atindehou, 2019)
		Essential oil, leaves	Methanol, ethyl acetate, dichloromethane, cyclohexane,	Ellman's method	The ethyl acetate extract of the leaves showed the strongest activity of IC_{50} 76.10 mg/L.	(Kohoude *et al.*, 2017)
		Stem Bark	70% Methanol, hexane, ethyl acetate, aqueous	DPPH, FRAP	The stem bark aqueous extract through radical scavenging activity possessed strong antioxidant of IC_{50} value 1.58 µg/mL.	(Alemika *et al.*, 2019)
		Leaves	Methanol	DPPH	The findings revealed that the leaves methanolic extract decreased radical scavenging percentage at concentrations as low as 62.5 µg/mL.	(Ezekiel *et al.*, 2020)

2	Anti-inflammatory	Essential oil, leaves	Methanol, ethyl acetate, dichloromethane, cyclohexane,	Soybean 5-lipoxygenase	The methanolic leaves extract were found with best activity of IC_{50} 28.01 mg/L.	(Kohoude *et al.*, 2017)
		Stem bark	Petroleum ether, methanol	In Vivo	The methanolic stembark extract's median inhibitory concentrations on these spasmogens were assessed to be 4.85 mg/mL. It has antispasmodic properties.	(Hassan *et al.*, 2009)
		Stem bark	Methanol	In Vivo	500 mg/kg of the methanolic stembark exhibited substantial analgesic activity. At p>0.001 0.5 hours after treatment, this activity was considerable, and it remained effective for 8 hours. The current study found antinociceptive properties in both inflammatory and neuropathic pain models.	(Mbiantcha *et al.*, 2017)
		Stem bark	Aqueous	In Vivo	The aqueous stembark extract significantly reduced intestinal propulsion at doses ranging from 25 to 100 mg/kg.	(Nwinyi *et al.*, 2004)
		Stem bark	Methanol	In Vivo	The stembark methanolic extract was shown to be significant 1 and 0.5 hours after the administration of the irritant at concentrations of 250 and 500 mg/kg, respectively, with high inhibition of 83.50 % at a dose of 500 mg/kg.	(Mbiantcha *et al.*, 2018)
		Leaves/bark	Methanol	In Vivo/ In Vitro	In a dose-dependent manner, 250 and 500 mg/kg of the bark extract significantly reduced licking and biting behavior during the first and second phases of the formalin test. Protein denaturation was prevented by 83.59% and 91 % at doses of 500 and 1000 g/mL, respectively, of methanolic bark extract.	(Mbiantcha *et al.*, 2020)
3	Antibacterial	Stem bark, incensole	50% Ethanol, a pure compound	Agar diffusion cup plate method	The stembark ethanolic extract was found to have a synergistic effect against all the tested bacterial strains with the highest inhibition of 16 mm against *E. coli*.	(Alemika *et al.*, 2004)
		Leaves	Ethanol	Agar dilution method	The ethanolic leaves extract demonstrated a synergistic impact against *E. coli* strains with MICs of 0.50 mg/mL.	(Kubmarawa *et al.*, 2007)
		Leaves, essential oil	Ethanol	96 wells microplates	The ethanolic leaves extract exhibited strongest activity with MIC of 1.25 mg/mL against strains of MRSA and *E. faecalis* respectively.	(Bothon & Atindehou, 2019)
		Stembark	Aqueous, methanol	MIC, MBC	At a dosage of 100 mg/mL, the stembark aqueous extract demonstrated activity against all of the test bacterial isolates, with the *Salmonella* species having the largest zone of inhibition of 27.7 mm.	(Aliyu *et al.*, 2021)

		Stem bark	Methanol	Discs method	Against all pathogens examined, the methanolic stembark extract spectral intensity index was found to be 7.27 mm. The observed sensitivity was due to the presence of secondary metabolites in the plant.	(Mamza *et al*., 2018)
		Bark/root	Methanol	MIC, MBC, ager well	The methanolic stembark extract had a significant zone of inhibition against all of the strains tested, with a maximal inhibition of 18.5 mm against *Salmonella paratyhi*, *Bacillus cereus*, and *Escherichia coli*, respectively.	(Talom *et al*., 2018)
		Stem bark	Butanol, methanol, ethyl acetate water, and n-hexane	Agar well	All of the solvents had a significant zone of inhibition, but at a concentration of 100 mg/mL, methanolic stembark extract had the most action against *S. typhiall* (18.5 mm).	(Abdulhamid & Sani, 2019)
		Stem bark	Ethanol	MIC	With a MIC of 12 mg/mL, the methanolic stembark extract was shown to be the most effective against *Klebsiella pneumoniae*.	(Olukemi *et al*., 2005)
		Stem bark	Methanol	Agar well	Methanolic extract of stembark inhibited *E.coli* and *P. aeuroginosa* with an inhibition zone of 6 - 10 mm at a dose of 0.1 mg/2 mL respectively.	(Salihu *et al*., 2020)
		Stem bark	Methanol	MIC, 96 wells	With MIC values of 3.125 mg/mL, methanolic stembark extract inhibited the growth of *E. cloacae, S. pneumonia, S. aureus, P. aeruginosa, and S. typhi,* respectively.	(Tegasne *et al*., 2020)
		Leaves/Essential oil		Agar dilution method	At MICs of 250 and 1000g/mL, the oil inhibited the growth of *B. subtilis* and *S. aureus* respectively.	(Kubmarawa *et al*., 2005)
		Stem bark	Methanol/ aqueous	Ager well	Both methanolic and aqueous stembark extracts demonstrated efficacy against the isolates, with the methanolic stembark extract having stronger activity against *E. coli* (16.67) at a 500 mg/mL concentration.	(Balarabe *et al*., 2019)
		Leaves/Essential oil		MIC	The essential oil's MIC inhibitory against *S. aureus* was 156.3 µg/mL.	(Owolabi *et al*., 2020)
		Stem bark	Aqueous	Agar dilution	The stembark aqueous extract at the concentration of 200 mg/kg has no activity against any of the tested bacterial strains.	(Nwinyi *et al*., 2004)
		Stem bark	Ethanol	Agar well	At 100 mg/mL, the ethanolic stembark extract has a moderate zone of inhibition against *S. aureus* and *P. aeruginosa* at 12 and 10 mm, respectively.	(Ohadoma *et al*., 2016)
4	Antifungal	Bark	Methanol	Seeded plates method	*Candida albicans* growth was inhibited by methanolic bark extract at a dosage of 100 mg/mL, with an inhibition zone of 38 mm.	(Kafuti *et al*., 2017)

		Leaves/Essential oil		Agar dilution method	The oil was shown to have significant antifungal properties with MIC against the tested strain found at 250 and 1000µg/mL, respectively.	(Kubmarawa *et al*., 2005)
		Leaf/essential oil		MIC	It exhibited strong activity with MIC of 78 µg/mL.	(Owolabi *et al*., 2020)
5	Behavioral Effects	Stem bark	Methanol	In Vivo	At concentration of 20, 40, and 80 mg/kg, respectively. The methanolic stembark extract has the ability to depress the central nervous system at $p < 0.001$.	(Nazifi *et al*., 2017)
		Stem bark	Ethanol	In Vivo	Pentylenetetrazol-induced clonic spasm was prevented in 20% of mice by an ethanolic stembark extract at a dosage of 100 mg/kg body weight. Moreover, it reduced the onset of seizure in convulsed mice from 4.40 to 3.75 minutes respectively.	(Medugu *et al*., 2020)
6	Antimalarial	Stem bark	Methanol	In Vivo	The IC_{50} value of 1.25 g/mL for the methanolic stem bark extract showed promising antimalarial activity.	(Salihu *et al*., 2020)
7	Antidiabetic	Stembark	Aqueous	In Vivo	In diabetic rats treated with the stembark aqueous extract (I0mg/I00gm) daily for three weeks, fasting blood glucose levels returned to normal by week two.	(Bobboi & Olesugun, 2005)
		Leaf	Methanol	In Vivo	200 and 400 mg/kg body weight of the leaves methanolic extract were given. At 400 mg/kg body weight, the maximum percentage of glycaemia inhibitions was 71.21 %.	(Yakubu *et al*., 2020)
8	Anticancer	Essential oil, leaves	Methanol, ethyl acetate, dichloromethane, cyclohexane,	MTT assay	The leaves dichloromethane extract demonstrated the highest % inhibition at 65, whereas all other samples were modestly anticancer.	(Kohoude *et al*., 2017)
		Stembark	70 % ethanol	MTT assay	Proliferation and colony formation was inhibited, and the AW8507 cell cycle was halted in the G2/M phase by the ethanolic stembark extract.	Otitoju *et al*., 2019)
		Stembark	Aqueous nanoparticles	Cytometry analysis	At 48 and 72 hours, the IC_{50} inhibitory concentrations of the nanoparticles against Kasumi cell were 49.5 and 13.25 g/mL, respectively. In the S and G2/M phases of the cell cycle, the nanoparticles triggered cell cycle arrest by 5% and 3%, respectively.	(Adebayo *et al*., 2020)
		Stembark	Ethanol	Bromide assay	The stembark ethanolic extract has an anti-proliferative effect with an IC_{50} of 98.12 g/mL.	(Otitoju *et al*., 2020)
		Leaves	Methanol	BSLA	The methanolic extract activity of the leaves was so high that even at 1.0 g/mL, the mortality rate was 68.42%.	(Ezekiel *et al*., 2020)
		Stem bark	Aqueous nanoparticles	Presto Blue assay	Ten of the nanoparticles µg/mL inhibited about 3% of cell	(Adebayo *et al*., 2020)

					development, and there was a drop in the cell number with the increase in the concentration.	
		Stem bark	Methanol		The anti-proliferative properties of the stembark methanolic extract showed the greatest inhibition (90%) at 125 μg/mL.	(Kafuti *et al.*, 2018)
9	Cytotoxicity	Essential oil, leaves	Methanol, ethyl acetate, dichloromethane, cyclohexane,	MTT assay	At a concentration of 50 mg/L, the cytotoxicity of the leaves extracts and essential oil was assessed. The results revealed that, with the exception of the methanolic extract at 23.50%, all other extracts showed good inhibition.	(Kohoude *et al.*, 2017)
		Leaves	Methanolic	Carbon tetrachloride (CCL4) induced hepatotoxicity	Hepatotoxicity was induced using 0.63 mL of CCl4 per kilogram of body weight. Methanolic leaves extract at doses of 100, 200, and 300 mg/kg, respectively were given orally for four weeks. The methanolic extract from the leaves helps to strengthen the liver.	(Onoriose *et al.*, 2012)
		Leaf	Methanol	BSLA	At 1000 and 1 μg/mL concentrations of the methanolic leaves extract, the death rate was 94, 68, and the blank 12.50 %, respectively, implying that the toxicity was caused by the solvents.	(Ezekiel *et al.*, 2020)
		Stem bark	Aqueous	In Vivo	2000 mg/kg of the aqueous stembark extract was administered to the model, but no significant effect was recorded.	(Nwinyi *et al.*, 2004)

Note: S/N = Serial number, DPPH; 1,1-Diphenyl-2-Picryl Hydrazyl (DPPH) Radical Scavenging Activity, FRAP; Ferric Reducing Antioxidant Power (FRAP) Assay MIC; Minimum Inhibitory Concentrations, MBC; Minimum Bactericidal Concentrations, SOD; Superoxide Dismutase, CCL4; carbon tetrachloride

Table III. Chemical Composition of *Boswellia dalzielii* from different countries

	Plant Parts	Compound (Peak area)	Peak area	Country	Reference
1	Leaves	α-Pinene	15.18	Benin	(Kohoude et al., 2017)
		E-isolimonene	0.37		
		Camphene	0.26		
		3-Carene	27.72		
		Myrcene	5.72		
		p-Cymene	9.54		
		Z-b-ocimene	0.28		
		α-Terpinene	0.45		
		β -Phellandrene	8.48		
		E-sabinene hydrate	0.67		
		Isoterpinolene	0.40		
		1S-b-Fenchol	0.19		
		c-Terpinene	0.20		
		E-pinocamphone	0.69		
		Z-chrysanthemol	0.64		
		3-Terpinenol	0.17		
		Terpinen-4-ol	1.41		
		Methyl salicylate	0.52		
		Lavandulol	0.42		
		Z-carveol	0.33		
		β-cyclocitral	0.38		
		Carvenone	0.24		
		α-Cubebene	0.70		
		Undecan-2-one	0.27		
		Cyperene	0.20		
		Isolongifolene	6.15		
		β -Caryophyllene	0.75		
		β -Patchoulene	0.25		
		α-Longipinene	0.23		
		E- α -bergamotene	0.20		
		Italicene	0.17		
		Z- β -farnesene	4.53		
		Z-4,5-muuroladiene	0.24		
		Aromadendrene	0.79		
		β -Santalene	0.91		
		Z- β -guaiene	0.22		
		β -Chamigrene	0.43		
		9-Epicaryophyllene	0.23		
		α -Patchoulene	0.47		
		β -selinene	2.13		
		Viridiflorene	0.16		
		β -Himachalene	0.20		
		E- α -bisabolene	0.12		
		Viridiflorol	0.41		
		Caryophyllene alcohol	0.35		
		Lilial	0.11		
		Widdrol	0.38		
		γ--Eudesmol	0.53		
		1,6-Humulanedien-3-ol	1.61		
		Torreyol-a-cadinol	1.93		

2	Leaves	5,5-Dimethyl-1-vinylbicyclo[2.1.1]hexan	0.5	Nigeria	(Owolabi et al., 2020)
		α-Thujene	0.3		
		Tricyclene	0.1		
		α-Fenchene			
		α-Pinene	20.1		
		Thuja-2,4(10)-diene	1.3		
		Camphene	0.6		
		Sabinene	0.1		
		Myrcene	0.6		
		β-Pinene 0.6			
		3,7,7-Trimethylcyclohepta-1,3,5-triene	0.2		
		α-Phellandrene	0.1		
		3-Ethenyl-1,2- dimethylcyclohexa-1,4-diene	0.3		
		Limonene	0.3		
		p-Cymene	2.6		
		α-Terpinene	0.1		
		p-Menth-1-ene	0.1		
		β-Phellandrene	0.1		
		γ-Terpinene	0.1		
		Terpinolene			
		cis-Linalool oxide (furanoid)			
		1,8-Cineole	0.1		
		p-Cymenene	0.8		
		Nonanal	0.1		
		trans-Linalool oxide (furanoid)			
		Linalool			
		Perillene	0.2		
		trans-Pinocarveol	0.3		
		α-Phellandren-8-ol	0.2		
		Camphor	0.1		
		Pinocarvone	0.5		
		trans-Pinocamphone	0.4		
		Borneol			
		α-Campholenal	1.0		
		Terpinen-4-ol	0.2		
		cis-Pinocamphone	0.5		
		α-Terpineol			
		Methyl salicylate			
		cis-Dihydrocarvone	0.2		
		Myrtenal			
		Verbenone	0.3		
		Cuminaldehyde	0.1		
		Carvone	0.2		
		β-Cyclocitral			
		Phellandral	0.1		
		Carvotanacetone	0.2		
		β-Bourbonene	0.1		
		α-Cubebene	2.1		
		Bornyl acetate	0.3		
		α-Copaene	3.0		
		β-Elemene			

		Cadalene			
		Mustakone			
		Cembrene			
		Eudesm-7(11)-en-4-ol (=Juniper camphor)			
		Pentadecanal			
		α-Phellandrene dimer	0.4		
		α-Pinacene	0.2		
		Phytone			
		Neocembrene	3.3		
		iso-Cembrol	6.8		
		(E, E)-Geranyl linalool			
		Phytol			
		Incensole	27.5		
		Serratol	6.2		
		Toluene			
		6,6-Dimethylhepta-2,4-dien	0.1		
3	Nil	(Z)-Salvene		Nigeria	(DeCarlo et al., 2019)
		Santolina triene			
		5,5-Dimethyl-1-vinylbicyclo [2.1.1]hexane	0.4		
		Tricyclen	0.1		
		α-Thujene	9.8		
		α-Pinene	67.7		
		β-Citronellene	0.1		
		α-Fenchene			
		Camphene	1.3		
		Thuja-2,4 (10)-diene	0.1		
		Sabinene	1.1		
		β-Pinene	1.6		
		Myrcene			
		α-Terpinene			
		3-p-Menthene			
		1,5,8-p-Menthatrien			
		δ-3-Caren			
		o-Cresol methyl ethe			
		α-Phellandrene			
		m-Cymene			
		1,8-Cineole	2.6		
		p-Cymene	0.3		
		β-Phellandrene			
		o-Cymene	0.1		
		Limonene	0.8		
		(Z)-β-Ocimene	0.2		
		(E)-β-Ocimene			
		γ-Terpinene	0.3		
		6,7-Epoxymyrcen			
		cis-Sabinene hydrate			
		p-Cymene	0.1		
		Terpinolene	0.3		
		Perillene			
		α-Pinene oxide			
		Linalool			

		trans-Sabinene hydrate			
		trans-Thujone	0.7		
		cis-Thujone	0.3		
		Myrcenol	0.1		
		α-Campholenal	0.4		
		Chrysanthenone	0.1		
		trans-Sabinol			
		cis-Verbenol			
		rans-Pinocarveol	0.1		
		cis-Limonene oxide			
		trans-Verbeno	1.9		
		α-Phellandren-8-ol	0.1		
		Camphor	4.0		
		Pinocarvone			
		Thuj-3-en-2-one (Umbellulone)			
		trans-Pinocamphone	0.4		
		p-Mentha-1,5-dien-8-ol			
		α-Terpineol	0.8		
		Terpinen-4-ol	0.4		
		Isopinocamphone			
		p-Cymen-8-ol	0.2		
		Verbenone	0.6		
		Myrtenal			
		Cuminal			
		trans-Carveol	0.3		
		Carvone			
		3,5-Dimethoxytoluen			
		Carvotanacetone	0.1		
		Bornyl acetate	0.8		
		Thymol	0.1		
		Carvacrol	0.2		
		α-Copaene			
		(3E)-Cembrene A			
		α-Terpinyl acetate	0.1		
		Serratol			
		Cembrenol			
		Incensyl acetate			
		Incensole	0.2		
		α-pinene	45.7		
		α-phellandrene	2.3		
4	Leaves	α-phellandrene	2.3	Nigeria	(Kubmarawa et al., 2006)
		myrcene	0.7		
		γ-terpinene	11.5		
		trans-sabinene hydrate	4.6		
		p-cymene 0.1	0.1		
		cis-p-menth-2-en-1-ol	2.9		
		pinocarvone	1.9		
		p-cymenene	1.0		
		Myrtenol	1.3		
		Linalool	1.5		
		Crytone 2.0	2.0		
		α-Campholenal	2.7		
		carvone 1.7	1.7		

		Cumin aldehyde	0.5		
		α-ylangene	0.2		
		Isobornyl acetate	0.6		
		β-bourbonene	0.2		
		Cumin alcohol	1.6		
		Carvacrol	0.4		
		β-caryophyllene	1.0		
		α-humulene	0.1		
		δ-muurolene	0.1		
		Trans-α-bergamotene	0.2		
		α-muurolene	0.2		
		α-cadinol	0.3		
		δ-cadinene	0.1		
		germacrene	0.4		
		Caryophyllene oxide	2.3		
5	Oleogum resin	Santolina triene	1.2	Burkina Faso	(DeCarlo 2019)
		5,5-Dimethyl-1-vinylbicyclo [2.1.1] hexane	1.1		
		α-Thujene	1.4		
		Tricyclene	0.2		
		α-Fenchene			
		α-Pinene	39.9		
		Thuja-2, 4(10)-diene	0.8		
		β-Fenchene	0.2		
		Camphene	0.9		
		β-Pinene	1.4		
		Sabinene	1.3		
		Myrcene	1.0		
		trans-p-Mentha-2, 8-diene			
		3, 3, 7-Trimethylcyclohepta-1, 3, 5-triene	0.1		
		δ-2-Carene			
		(E)-2,6-Dimethyl-2, 6-octadiene			
		p-Mentha-1(7), 8-diene			
		α-Phellandrene			
		o-Cresol methyl ether			
		cis-p-Menth-8-ene			
		δ-3-Carene			
		1,5,8-p-Menthatriene	0.4		
		m-Cymene	0.6		
		p-Cymene	0.5		
		p-Menth-1-ene			
		α-Terpinene	0.5		
		β-Phellandrene			
		(Z)-β-Ocimene	0.2		
		1,8-Cineole			
		2-Acetyl-5-methylfuran	0.1		
		(E)-β-Ocimene	0.1		
		cis-Sabinene hydrate			
		o-Cymene	1.2		
		γ-Terpinene	1.9		
		p-Cymenene	0.1		
		6-Camphenone			

Terpinolene	1.2
6,7-Epoxymyrcene	
Perillene	
Rosefuran	
trans-Sabinene hydrate	
α-Pinene oxide	
cis-Thujone	1.2
Linalool	1.3
trans-Thujone	0.6
exo-Fenchol	
E)-2, 4-Dimethylhepta-2, 4-dienal	
Chrysanthenone	0.2
Myrcenol	
cis-Limonene oxide	
cis-p-Menth-2-en-1-ol	
cis-Verbenol	
trans-p-Mentha-2, 8-dien-1-ol	
trans-Sabinol	
α-Campholenal	2.0
Camphor	0.2
trans-Limonene oxide	
α-Phellandren-8-ol	0.7
trans-Pinocarveol	2.4
trans-Verbenol	1.6
Pinocarvone	0.5
p-Mentha-1, 5-dien-8-ol	1.5
trans-Phellandrene epoxid	
trans-Pinocamphone	0.5
Terpinen-4-ol	0.4
p-Cymen-8-ol	0.8
cis-Pinocamphone	
Borneol	
trans-Carveol	0.1
Myrtenal	
Linalyl acetate	
Bornyl acetate	3.4
Verbenone	28
α-Terpineol	1.2
Thymol	
3, 5-Dimethoxytoluene	
Carvone	5.1
α-Cubebene	3.4
α-Copaene	4.8
α-Terpinyl acetate	2.1
(Z)-β-Farnesene	
cis-α-Bergamotene	
Carvacrol	2.2
trans-α-Bergamotene	
α-Himachalene	
β-Caryophyllene	
(3E)-Cembrene	0.1
β-Selinene	
α-Selinene	
α-Humulene	

		m-Camphorene	0.1		
		p-Camphorene			
		Caryophyllene oxide			
		α-Pinacene			
		Incensole + Serratol	0.4		
		Cembrenol	0.1		
6	Leaves	Zerumbone	33.69	Benin	(Bothon & Atindehou, 2019)
		Germacrene	9.08		
		alpha – bourbonene	0.63		
		tau-Muurolol	1.32		
		alpha - cubebene	2.68		
		Alpha - cadinol	0.78		
		Alpha – Humulene	0.97		
		Terpinene – 4 – ol	0.68		
		delta - cadinène	1.64		
		alpha-terpineol	1.02		
		Copaene	2.85		
		Trans beta - caryophyllene	7.45		
		beta - phellandrene	8.19		
		beta - ocimene	1.09		
		alpha-pinene	9.71		
		alpha - phellandrene	11.8		
		delta - 3- carene	0.45		
7		Incensole			(Alemika et al., 2004)
8	Stem bark	Flavonoids, Tannins, Saponins, Glycosides Alkaloids, Steroids Terpenoids, Phenols.		Nigeria	(Abdulhamid & Sani 2019)
9	Stem bark	Total phenolics and total flavonoids	373.9 and 142.2	Nigeria	(Kafuti et al., 2018)
10	Stem bark	Flavonoids, saponin, pseudo tannins, alkaloids		Nigeria	(Aliyu et al., 2021)
11	Stem bark	Diterpenoid	481.20 and 142		(Alemika et al., 2005)
12	Stem bark	Flavonoids, alkaloids, cardiac glycosides, triterpenoids, steroids, saponins, and tannins			(Mbiantcha et al. 2017)
13	Stem bark	Flavonoids, alkaloids, triterpenoids, steroids, saponins, and also gallic acid.			(Mbiantcha et al. 2020)
14	Fresh leaves	Phenolics, flavonoids, tannins			(Kohoude et al., 2017)
15		Tannins, flavones, triterpenoids, steroids, saponins, and alkaloids			(Otitoju et al., 2020)

Cytotoxicity

Medicinal plant use is on the rise all around the world these days (Awang *et al*., 2018). Because of their natural origins and cultural acceptance, medicinal herbs are typically thought to be safe (Kayfi & Abdulrahman, 2021). This belief may lead to their indiscriminate application. Nonetheless, multiple laboratory investigations and clinical reports have discovered that therapeutic plants may have negative effects similar to pharmaceutical medications (Abedini *et al*., 2021). The cytotoxicity of leaves extracts and essential oil was tested at a concentration of 50 mg/L. Except for the methanolic leaves extract, which exhibited a 23.50% inhibition, all other extracts showed good inhibition (Table II). The model received 2000 mg/kg of the aqueous stembark extract; however, there was no discernible effect (Nwinyi *et al*., 2004).

Chemical Composition

Natural compounds have medicinal properties, making them a valuable source of pharmacologically active molecules (Kohoude *et al*., 2017). Its essential oil has long been used for medicinal and religious purposes and is still widely used today (DeCarlo, Johnson, Okeke-Agulu, *et al*., 2019). The chemical evaluation of *B. dalzielii* leaves in Benin reported the plant contents to be dominated by monoterpene hydrocarbons (68.58) of the total contents (Table III) (Kohoude *et al*., 2017). The analysis of the compounds revealed 3-Carene (27.72), α-Pinene (15.18), and p-Cymene (9.54) as the three most dominant compounds in Benin. Similarly, another investigation carried out in the same country showed alpha-phellandrene (11.8), α-Pinene (9.71), and Germacrene (9.08) (Figure 5) (Table III). The dominance of monoterpene hydrocarbons was found in the study carried out in Nigeria (Table III) with the following dominated compounds Incensole (27.5), iso-Cembrol (6.8), Serratol (6.2), α-Pinene (67.7), α-Thujene (9.8) and γ-terpinene (11.5) (Dimas 2006; DeCarlo *et al*., 2019; Owolabi *et al*., 2020). In Burkina Faso, similar terrain was seen with α-Pinene (67.7) (Figure 6) (Abbasi *et al*., 2013). Geographical location and environmental factors are responsible for the differences in chemical composition (Owolabi *et al*., 2020). Alpha-pinene (Figure 5) is a bicyclic monoterpene that functions as an insect repellent in plants (Magalhães *et al*., 2015). Alpha-Pinene is the compound found in both countries' essential oil (Table III). Alpha-Pinene is a food additive made from an organic terpene compound present in plants (Ueno *et al*., 2019). The US Food and Drug Administration has approved it as a safe food ingredient (DeMartino *et al*., 2021). Furthermore, α-pinene has been shown to diminish neuronal activity in several studies (Ueno *et al*., 2019). The compound reduced behavioral abnormalities in mice (Ueno *et al*., 2019). Alpha-pinene-containing essential oils have been utilized to treat a variety of ailments (Mercier *et al*., 2009). These terpenes have a high antibacterial and antifungal effect on both Gram-negative and Gram-positive bacteria (Martins *et al*., 2003). It has gastro-protective properties (Magalhães *et al*., 2015). Alpha- Pinene has been linked to several interesting pharmacological effects, including bronchodilator, broad-spectrum antibacterial, anti-inflammatory, sedative, hypoglycaemic, and antioxidant properties (Magalhães *et al*., 2015). Essential oils containing alpha-pinene have antifungal and antibacterial properties (Kim *et al*., 2015).

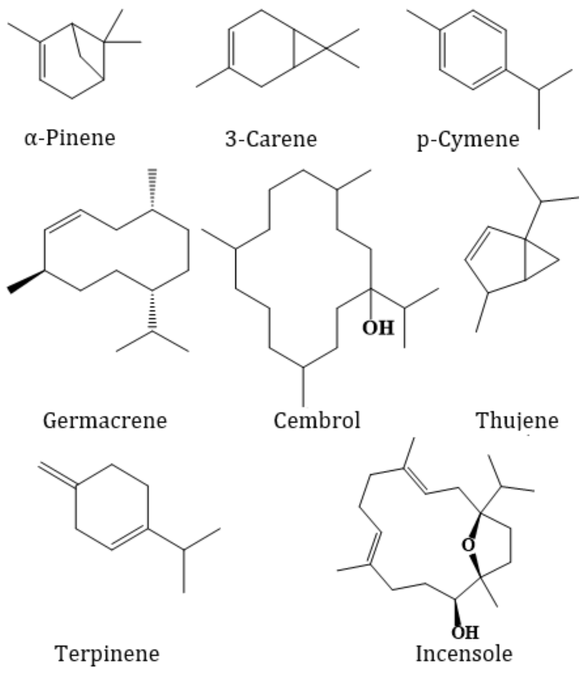

Figure 5. Major compounds in *B. dalzielii*

Usage and Biological Evaluation of *Boswellia dalzielii* Parts (Table I and II)

A medicinal plant has restorative ingredients or is a forerunner in the development of drugs (Ahmad *et al*., 2009). Plants with therapeutic capabilities or good pharmacological effects on the animal body are referred to as Medicinal Plants (Ahmad *et al*., 2009). Overexploitation of natural resources is being caused by population increase, urbanization, and the unregulated gathering of medicinal plants from the wild (Zschocke *et al*., 2000). From the survey and the biological evaluation bark of *B. dalzielii* was the most utilised at 38.6 and 31.4 % respectively (Figure 2). The frequent utilisation of the stembark (54.9%) of the plants in traditional medicinal systems and a large number of pharmacological evaluations present the part of the plant as a promising source of novel drugs for human ailments (Figure 6). Frequent utilisation of the plant parts in west African countries poses a serious challenge to its conservational status.

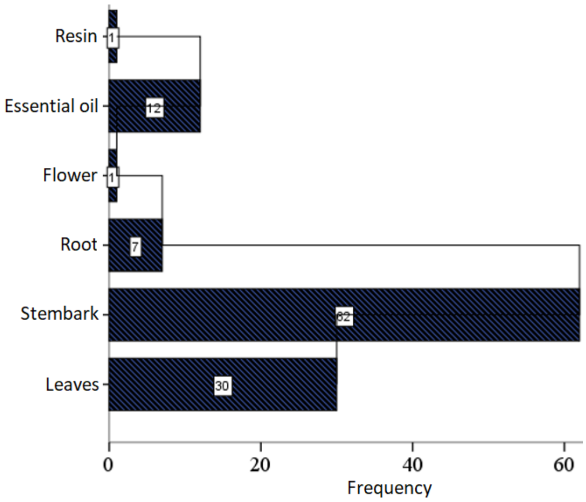

Figure 6: Reported parts of *B. dalzielii* (Table I and 2)

CONCLUSIONS AND RECOMMENDATIONS

Boswellia dalzielii is a popular medicinal plant, locally known in Nigeria as ***Ararrabi, Basamu, Hano,*** and in Burkina Faso as ***Kumdagneogo.*** In Ghana, it is called ***Piangwogu***, while in Ethiopia, it is ***Etan***. The study found traditionally, the plant parts especially stembark are used for the treatment of antirheumatic, antispasmodic, analgesic, antiseptic, hypotensive, malarial mental illness, ulcer, pain, fever, and many several ailments. Preclinical investigations have already been conducted on a variety of biological activities. The stembark was found to have significant biological activity, and this is due to the presence of high contents of aromatic and polyphenol compounds. *B. dalzielii* were largely studied *in vitro*, according to the literature search done. The stem bark of *B. dalzielii* has to be explored further in terms of the mechanism of action of the compound, *in vivo* cytotoxicity and clinical trials to obtain more conclusive evidence about its usefulness.

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