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African Shea Tree (*Vitellaria paradoxa* C.F. Gaertn*)*: A Review of its Economic Importance, Phytochemistry and Pharmacological Activities

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ABSTRACT

Vitellaria paradoxa (Sapotaceae) is an abundant tree with economic and medicinal value in Nigeria. Several researchers have directed their research interests to *V. paradoxa*, generating substantial information on the plant's financial importance, chemical constituents, and medicinal values. Hence, this study aimed to review the available literature on *V. paradoxa.* The systematic literature search was performed using several search engines (Google, Yahoo, Bing) and electronic databases, including SciFinder, Nexis Uni, ASFA, CAB Abstracts, SID, Scopus, Web of Science, JSTOR, PubMed, AJOL, Google Scholar, and ScienceDirect. Various studies showed that plant parts, including leaves, roots, fruits, and stem barks, harbor metabolites with proven antioxidant, anticancer, and antimicrobial properties. Such compounds include flavonoids, alkaloids, anthocyanins, tannins, saponins, cardiac glycosides, steroids, anthraquinones, phenols, and polyphenols. *V. paradoxa* is also rich in carbohydrates, proteins, dietary fiber, and fatty acids (such as vaccenic, linoleic, linolenic, arachidic, oleic, and stearic acids). Vitamin C. Forty-eight research papers reported a total of 7 activities or usages for the different parts of the plant, of which 31.25% reported phytochemistry, 8.33% reported nutritional composition, 20.83% reported antimicrobial properties, 2.08% reported toxicity, and 4.17% reported anticancer properties. In contrast, 16.67% each reported the antioxidant properties and economic importance of *V. paradoxa*. This review suggests that the plant could be significant in the drug development and economic development of West African countries.

Keywords*:* Economic importance, Metabolites, Pharmacological activities, Sapotaceae, Shea butter, *Vitellaria paradoxa*

INTRODUCTION

Medicinal plants are far-reaching by pharmacological industries as they are imperative in the quest for the development of alternative drugs from natural products (Newman and Cragg, 2014). Products from natural sources contribute to more than half of the approved drugs by the Food and Drug Administration (FDA) (Chavan *et al*., 2018). Notably, medicinal plants have gained exceptional interest in commerce and scientific research (Wink, 2015), due to their wide range of applications in phytopharmaceuticals, cosmetics, traditional medicines, herbal teas, and health foods such as nutraceuticals.

In the past years, efforts have been made to discover alternative therapeutics, especially from plant agents, to counteract resistance among microorganisms (Penesyan *et al*., 2010; Tortorella *et al*., 2018). Herbal medicine is a core component of phytochemistry and phytotherapy, with a direct research focus on the identification, characterization, isolation, purification, and use of active medicinal compounds from plants for the development of new drugs. The most significant elements of plants are their diverse range of secondary metabolites, which are being exploited by chemoinformatics (Lagunin *et al*., 2014) as great potential for drug development (Harvey *et al*., 2015; Mawalagedera *et al*., 2019) and as means of improving the pharmaceutical and health sectors (Pye *et al*., 2017).

Traditionally, medicinal herbs are used against infectious diseases and in the management of various health complications such as cancer, inflammation, hypertension, diabetes, and microbial and cardiovascular diseases (Tao *et al*., 2014). However, recent trends and evidence suggest that they can also be employed for clean energy production, climate resilience, erosion control, food production, and exportation for economic sustenance. Thankfully, Africa is endowed with abundant medicinal plants, a notable example of which is *Vitellaria paradoxa* C. F. Gaertn

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(Sapotaceae), commonly known as the shea butter tree. It is a tree species indigenous to about 21 Sub-Saharan African countries, including Ghana, Cameroon, Senegal, Uganda, Nigeria, Burkina Faso, etc. (Moore, 2008). The tree thrives in different parts of Northern Nigeria including Niger, Kwara, Kebbi, and Kaduna (Yusuf *et al*., 2009).

Botanical description of *Vitellaria paradoxa*

V. paradoxa tree is a naturally regenerating deciduous tree; it reproduces naturally (by seed) and grows slowly but steadily, reaching a height of up to 20 m and a trunk diameter of about 2 m. However, it can grow taller and larger depending on the age, tree management, and climatic conditions. The bark is dark, conspicuously thick, and deeply fissured longitudinally. The older leaves are dense, clustered with scars, and arranged spirally, while the immature leaves are dark green with wavy and bent leaf margins. The white or creamy flowers develop in the axils of scale leaves and bloom during the dry season, providing nectar for honey bees. Fertilized flowers mature into fruits with green skin and pulp that is sweet and high in vitamins. During the rainy season, ripe fruits fall to the ground and are easily harvested. The inner seed or nut has a smooth, thin, brown outer covering that protects the nutritious kernel, which constitutes about 50% of the weight of the fresh fruit (Maranz and Wiesman, 2003). A single tree typically produces 15 to 20 kg of fruit, and altogether, the nuts inside those fruits weigh around 3 – 4 kg and contain 1.5 to 2 kg of fat (National Research Council [NRC], 2006). The tree does not fruit until it is 10 – 15 years old and attains full production at about 20 – 30 years old, after which it continues nut production for about 400 years (Boffa, 2015; Makerere, 1998). *V. paradoxa ssp. paradoxa* found in Central and West Africa grows at 100 – 600 m above sea level, whereas the *ssp. nilotica*, common to Eastern Africa, grows at higher altitudes, around 1200 – 1600 m above sea level.

Geographical Distribution

According to botanists, the genus *Vitellaria* is regarded as monospecific, having two subspecies: *ssp. paradoxa* in Western Africa and *ssp. nilotica* unique to Eastern Africa (Boffa, 2015). The tree, which grows in the West African savannah, also grows in the foothills of the Ethiopian mountains (Adamu *et al*., 2015).

Scientific Classifications

According to an ITIS report, *Vitellaria paradoxa* C.F. Gaertn. (TSN 505960) was classified as;

Taxonomy: *Vitellaria paradoxa* C.F. Gaertn
Kingdom: Plantae – Plants;
Subkingdom: Viridiplantae – green plants
Infrakingdom: Streptophyta – land plants
Division: Tracheophyta – vascular plants
Subdivision: Spermatophyta – seed plants
Class: Magnoliopsida – dicotyledons
Subclass: Asteridae;
Order: Ericales
Family: Sapotaceae
Genus: Vitellaria
Species: *Vitellaria paradoxa* C.F. Gaertn.

Local/Common names

In ethnobotany, proper identification of plants cannot be overemphasized. Below are some of the common names ascribed to shea butter, both local and international.

Traditional names (International)

Arabic: lulu
English: shea nut tree, shea-butter tree, shea tree, bambouk butter tree
French: arbre à beurre, karité, beurre de galam, beurre/graisse de karité
German: schibutter baum, shea butter baum
Swedish: shea smörträd
Spanish: butirospermo, tango, árbol mantequero, karité, carité
Portuguese: carité, cárei
Burkinabe: taãnga
Togolese: somou/yokuti

Traditional names (Local)

Hausa: kadanya/dan karaye
Igbo: okwuma
Yoruba: igi ori/igi emi

Ethnomedicinal Uses

Different parts of the plant have enormous social and economic values, including food and soap processing, healthcare, and medicinal uses (Carette *et al*., 2009; Coulibaly *et al*., 2009; Pousga *et al*., 2007). Being a nut plant, it is reported to be rich in numerous secondary metabolites. The tree also contributes to rural development and promotes land care sustenance. It is used traditionally to treat hemorrhoids, constipation, dysentery, malaria, tooth decay, and diabetes. The butter is used as an emollient in cosmetics, and the woods are used locally as fuel (firewood and charcoal), making local utensils, building poles, and so on, while the fruit pulp provides food for local communities (Boffa, 2015; Elias, 2013; Lovett and Haq, 2000).

Leaves: The leaves are used in vapor baths to treat headaches. Also, the ethanolic leaf extracts are used to treat stomach conditions, including diarrhoea and dysentery.
Fruits: As a food source and laxative (Nacoulma, 1999).
Bark: It is used as an eyewash to protect against the venom of spitting cobras and to treat stomachaches, diarrhoea, and jaundice. The

concoction has also been used to encourage lactation in nursing mothers and to hasten labor.
Root: They are boiled and pounded to heal chronic sores, or they are crushed into a paste and used orally to treat jaundice, diarrhoea, and dysentery (Hall *et al*., 1996).
Kernel: The kernel of the seed (often incorrectly called 'nut') contains a vegetable fat known as shea butter. Shea butter is used to treat skin dryness, inflammation, rashes in youngsters, and dermatitis, soothe skin irritation, and ulcers, in addition to relieving nasal congestion and rheumatic pain (Goreja, 2004; Hall *et al*., 1996; Olaniyan and Oje, 2007).

Numerous studies have ascertained the phytoconstituents and some medicinal values of the different parts of *V. paradoxa*. This review has the goal of collating various reports describing the phytoconstituents, pharmacological activities, and economic importance of different solvent extracts of different parts of *V. paradoxa* available in the open scientific literature.

MATERIALS AND METHODS

Plant Materials

The plant name, *Vitellaria paradoxa* C.F. Gaertn. has been checked (information supplied on 2014-03-26) on http://theplantlist.org and found to be accepted. *V. paradoxa* was harvested from the premises of the Junior Staff Quarters, University of Ilorin, Kwara State, Nigeria. The plant was authenticated at the Herbarium Unit, Department of Plant Biology, and assigned a voucher number, UILH/005/2020/952.

Methodology

A variety of search engines (Google, Yahoo, Bing) and databases, including SciFinder, Nexis Uni, ASFA, CAB Abstracts, Scientific Information Database (SID), Scopus, Web of Science, JSTOR, PubMed, African Journals OnLine (AJOL), Google Scholar, and ScienceDirect. Only publicly available data were used to gather the literature for this review, which included articles, conference papers, and educational magazines. *Vitellaria paradoxa*, the Shea butter tree, medicinal purposes, traditional uses, biological activity, antioxidants, phytochemicals, and other terms evoking interesting topics were utilized as keywords in web searches. When necessary, the results of this search were processed and reported in table or graph formats after being carefully inspected.

RESULTS AND DISCUSSION

This review revealed that different solvent extracts of various parts of *V. paradoxa* have great potential in the management of different types of health conditions, including cancer, numerous microbial infections, skin conditions, etc. These may be attributed to the level of phytoconstituents and the extensive spectrum of usage/pharmacological activities reported (Figure 1).

Phytochemical composition of *Vitellaria paradoxa*

The significant and promising components of medicinal plants are their secondary metabolites, which provide therapeutic effects for humans (Robinson and Zhang, 2011). However, environmental effects are also responsible for variations in the number of phytochemicals present in each species (Thomas, 2000). Ahmadu *et al*. (2006) also stated that the bacteriostatic effect of medicinal plants could largely be due to the presence of metabolites such as saponins, which have been reported to impact physiological activity by lather formation leading to wound and skin healing. Several studies have reported various constituents in different solvent extracts of *V. paradoxa* parts. The leaf has been reported to contain phytochemicals such as phenols and polyphenols, flavonoids, alkaloids, tannins, saponins, cardiac glycosides, and anthocyanins (Fodouop, 2017). Catteau *et al*.. (2015) reported the presence of polyphenols, particularly tannins, in the extract of *V. paradoxa* leaves. Phytochemical screening of the aqueous extract of the leaves of *V. paradoxa* revealed the presence of flavonoids, alkaloids, tannins, phenols and polyphenols, saponins, anthocyanins, steroids, and anthraquinones (Ajijolakewu and Awarun, 2015). Acetone and methanol extracts of *V. paradoxa* fruits were reported to harbor varying levels of phenolic and flavonoid compounds (Lamien-Meda, 2008). The major phenolic constituents are gallic acid, gallocatechin, epigallocatechin, epicatechin, epigallocatechin gallate, and epicatechin gallate (Maranz *et al*., 2003). Shea butter also contains non-glycerides that allow for its use in cosmetic product compositions because cinnamates' triterpene alcohols, particularly lupeol and a/b-amyrin in their esterified forms, have anti-inflammatory properties (Alander and Andersson, 2002; Alander, 2004; Akihisa, 2010). El-Mahmood *et al*.. (2008) revealed the presence of carbohydrates, alkaloids, saponins, tannins, and cardiac glycosides in the stem bark extracts of *V. paradoxa*. The health effects of flavonoids include antioxidant, anti-inflammatory, antiallergic, hepatoprotective, antithrombotic, antiviral, and anticarcinogenic activities (Prior, 2003). Tannins, including corilagin and geranin, show anti-human immunodeficiency syndrome activity by inhibiting reverse transcriptase (Murtaza *et al*., 2015). A chemical analysis of the fat extracted from *V. paradoxa* fruit revealed high levels of UV-B absorbing triterpene esters such as cinnamic acid, tocopherols (vitamin A), and phytosterols. However, lower levels of unsaponifiable such as phytosterols (campesterol, stigmasterol, beta-sitosterol, and

alpha-sitosterol), triterpenes (cinnamic acid esters, alpha- and beta-amyrin, parcel, buytospermol, and lupeol), and hydrocarbons (karitene) were reported (Wiesman *et al*., 2003). The reports on phytoconstituents are significant in that they offer evidence of the worth and ethnomedicinal significance of *V. paradoxa* in phytomedicine.

Nutritional Composition of *Vitellaria paradoxa*

Honfo *et al.* (2014) reported that the pulp of *V. paradoxa* is rich in vitamin C (196.1 mg/100 g). The fat content reported ranged from 43.9% to 58.4%, while fatty acid composition was dominated by oleic (47–62%) and stearic acid (25–38%) (Gwali *et al*., 2012). Other fatty acids present were palmitic, vaccenic, linoleic, linolenic, and arachidic acids. Saponification of the seed oil of *V. paradoxa* by Njoku *et al*. (2000) yielded saturated and unsaturated fatty acids, confirming the solid nature of the oil. The study by Ugese *et al.* (2008) on the nutritional composition of the fruit pulp of *V. paradoxa* from the Savannah region of Nigeria revealed the presence of proteins, carbohydrates, minerals, moisture, fiber, and energy content. Thus, this justifies the incorporation of *V. paradoxa* in complementary food production to alleviate hunger and nutrient deficiency among local dwellers.

Antimicrobial Properties of Vitellaria paradoxa

Antimicrobial resistance refers to the ability of microorganisms to resist the effect of antibiotics. It is a public health issue that impacts the greatest loss to individuals and the social economy (O'Neill, 2016). The antimicrobial potentials of different parts of *V. paradoxa* were demonstrated in several reports (Table 1). According to Ahmadu *et al.* (2006), the ethanolic extract of the seeds, leaves, and stem barks of *V. paradoxa* exhibited bacteriostatic effects against some microorganisms (*S. aureus, E. coli*, and *K. pneumonia*) that are commonly associated with gastrointestinal tract infections, pneumonia, and superficial wound infections in humans. According to El-Mahmood *et al*. (2008), varying degree of antimicrobial activities was exhibited by the ethanolic, acetone, and aqueous extracts of the stem of *V. paradoxa* against *E. coli, K. pneumonia, P. mirabilis, S. dysenteriae*, and *S. typhi*, all of which are pathogenic. A study on the antimicrobial activity of the aqueous and ethanolic extracts of stem bark of *V. paradoxa* against *E. coli, K. pneumonia, P. mirabilis, E. faecalis, S. aureus, S. pyogenes* and *P. aeruginosa* revealed that all the organisms were susceptible to the extracts except *S. pyogenes* and *P. aeruginosa* which were resistant (Ayankunle *et al*., 2012). Additionally, Ndukwe *et al*. (2007) reported that the methanol and petroleum ether extracts of roots, stem bark, and leaves of *V. paradoxa* had antimicrobial effects against *B. cereus, S. aureus, E. coli, P. aeruginosa, K. pneumoniae*, and *S. typhi*.

The findings by Assam *et al*. (2020) suggested that the hydro-ethanolic extract of *V. paradoxa* exhibited remarkable antimycobacterial activity against *Mycobacterium tuberculosis* ($H_{37}R_v$) and *M. tuberculosis* clinical isolate. Its effectiveness against tuberculosis was further substantiated by the relatively low minimum inhibitory and bactericidal concentration value of 78.13 µg/mL against *M. tuberculosis* ($H_{37}R_v$), whereas a slightly higher concentration of 625 µg/mL was obtained for the clinical isolate (Assam *et al*., 2020). Falana *et al*. (2018) reported the i*n vivo* antimicrobial efficacy of different doses of various solvent extracts (water, methanol, *omidun* and sterile *omidun*) of the leaf, root, and bark of *V. paradoxa* against some diarrhoeagenic microorganisms such as enterohaemorrhagic *Escherichia coli* (EHEC-ATCC 43889), enteropathogenic *Escherichia coli* (EPEC-ATCC 43887), *Salmonella typhi*, and *Escherichia coli* (ATCC 25922). These findings suggest that *V. paradoxa* leaves can be suitable for the management of bacterial infections (diarrhoea, typhoid fever) associated with the tested organisms. Dichloromethane and methanol extracts of *V. paradoxa* leaves showed antimicrobial efficacy against *Staphylococcus aureus* MRSA ATCC 33591 (Catteau *et al*., 2015), thereby offering credence to the efficacy of *V. paradoxa* leaves against infection caused by the resistant strain of *S. aureus.*

Furthermore, reports show that *V. paradoxa* is a promising source of antifungal agents that can demonstrate antiseptic properties on skin infections caused by fungus. Studies by Ahmed *et al*. (2009) and Ahmed and Sani (2013) reported fungicidal properties of aqueous and ethanol extracts of *V. paradoxa* bark at higher concentrations against different fungal species (clinical isolates of *A. niger, A. flavus, E. floccosum, M. audouinii* and *T. mentagrophytes*) that are usually implicated in infections such as ringworm and athlete's foot. During the study, a similarity was observed between the low values of the minimum inhibitory concentration and minimum fungicidal concentration, and this indicates a potent fungicidal property of the extract against the test isolates.

Antioxidant properties of *Vitellaria paradoxa*

An antioxidant is any substance that reduces the level of oxidative stress in cells. The connection between oxidative imbalance and various health conditions (such as cancer, aging, diabetes, arthritis, sexual dysfunction, and inflammation) has been documented (Dasgupta and Klein, 2014). However, *V. paradoxa* is a resourceful medicinal plant rich in bioactive compounds such as phenolics, flavonoids, saponins, and triterpenes. These substances are known antioxidants that can support the prevention, detection, and cell repair of diseases associated with oxidative stress through the mechanistic halting of

excess reactive oxygen species and free radical formation in the body (Ojo *et al*., 2021). Maranz *et al*. (2004) assumed that the varying concentration of phenols in shea kernels may be attributed to the level of environmental stress endured by the tree. Lamien-Meda *et al*. (2008) reported the antioxidant properties of acetone and methanol extract of the fruit of *V. paradoxa* using DPPH, FRAP, and ABTS assays. Furthermore, the study by Tagne *et al*. (2014) evaluated the antioxidant activity of 11 plants (including *V. paradoxa*) using 1,1-diphenyl-2-picrylhydrazyl (DPPH) and nitric oxide free radical scavenging models. The methanolic extract of *V. paradoxa* exhibited a significant antioxidant activity that was compared favourably with the reference drug gallic acid in scavenging DPPH free radicals. However, the effect on nitric oxide was relatively lower when compared with the reference drug ascorbic acid (Tagne *et al*., 2014). The myriad of antioxidant activities reported on *V. paradoxa* might not be unconnected to the presence of flavonoids, phenolics, and saponins, all of which have been reported to have antioxidant properties (Honfo *et al*., 2014; Ojo *et al*., 2021).

Anticancer Activities of *Vitellaria paradoxa*

Tagne *et al*. (2014) determined the antiproliferative effects of the crude methanolic extracts of 11 Cameroonian plants, including *C. populnea, E. senegalensis, S. siamea, P. elliotii, C. asiatica, E. speciosa, G. aqualla, L. kerstingii, C. spectabilis, T. macroptera,* and *V. paradoxa*. The plants were evaluated against four malignant cell lines, NCI-H460 (lung cancer), MCF7 (breast cancer), PC3 (prostate cancer), HeLa (cervix cancer), and normal cell 3T3 (mouse cervical cell), using the sulforhodamine-B assay. The trypan blue exclusion method was used with a hemocytometer to determine the viability of the cell lines. The study was conducted using doxorubicin as the positive control. After 48 hours of treatment, *E. senegalensis, C. spectabilis, P. elliotii, T. macroptera,* and *V. paradoxa* exhibited the most cytotoxic effect on the cancerous cells, as evidenced by their lowest 50% growth inhibition values (Table 2). The study by Hollman *et al.* (1996) also suggested a protective role of *V. paradoxa* extracts (due to the presence of a wide variety of flavonoids) in reducing the risk of various conditions, including cancer and cardiovascular diseases.

Toxicological Assay of Vitellaria paradoxa

Essential oils extracted from *V. paradoxa* leaves and stem bark were evaluated for their chemical constituents and toxicity by Aboaba *et al*. (2014) using the brine shrimp lethality test model. A total of 68 and 33 compounds were identified in the essential oils of the leaves and stem bark, respectively. The major compounds identified from the leaves essential oil include linalool, methyl salicylate, β-ionone, nonanal and 1-nonanol whereas major compounds identified in the essential oil from the stem barks include linalool, limonene, n-decane, nonanal, mesitylene, pseudocumene and (E)-geranylacetone. The study concluded that the essential oils from the leaves and stem bark of *V. paradoxa* were moderately toxic, as evidenced by the 50% lethal concentration values of 171.24 and 160.10 µg/ml, respectively (Aboaba *et al*., 2014). Also, silver nanoparticles synthesized from *V. paradoxa* seed extract exerted cytotoxic effects against MCF-7 and HBL100 cancer cell lines (Almudhafar and Al-Hamdani, 2022).

Socio-economic importance of Vitellaria paradoxa

In Africa, shea butter trees have a high economic value due to their fruit production, which has huge domestic and commercialization value, e.g. for making butter by most women (Alhassan, 2020). The pulp of its fruit becomes an important source of food for farmers, while the butter that is extracted from it is commercialized and sold as raw materials for the food, cosmetic, and pharmaceutical industries (Ouédraogo, 2013; Boffa, 2015). The export of shea kernels and butter constitutes a significant contribution to the economy of producing countries due to its high demand in the food and cosmetic industries in developed nations with an annual market value of $30 billion by 2020, and projections suggest continued annual growth of 7 percent until 2030 (Bup *et al*., 2013; Rousseau *et al*., 2015; Sinan *et al*., 2020; Adesope *et al*., 2022). The study by Abujaja *et al*. (2014) established that the production of shea butter is a viable venture that contributes greatly to supporting the livelihood of impoverished rural women in Northern Ghana. Shea production can generate a 33% increase in income per working day for women collectors (from 1.74 – 2.30 USD/day) and increase employment, with an estimate of approximately 260,000 additional jobs by 2032 (Bockel *et al*., 2020). Unfortunately, the sale of dry kernels and shea butter only accounts for roughly 12% of the entire income of the piteous populace in Burkina Faso due to challenges such as climatic factors and land use (Gaisberger *et al*., 2017).

Conclusion

This review provides information for pharmaceutical industries and related policymakers on the nutritional components, chemical composition, and economic importance of *V. paradoxa* tree. The abundance of nutritionally important components such as omega-3 and omega-6 fatty acids, dietary fibre, vitamin C, and minerals as well as the antioxidant potential of shea butter products, makes it a cheap and available option for

food supplementation. The broad spectrum of pharmacological activities of *V. paradoxa* remains untapped, while the few that are already established in the open scientific literature are yet to be fully explored industrially for optimal and cost-effective production. In Nigeria, Shea nuts are usually considered as environmental waste products and occasionally used as fuel or fertilizers, thus failing to capitalize on its proclivity for economic growth. However, with the continuous increase in the demand for Shea products, considerable funding and interest from policymakers on the Shea market would be beneficial for many African countries like Nigeria, which are largely dependent on crude oil as their major export product. Also, with improved monitoring, sponsor and grant allocation, production and exportation of Shea trees (products) could play an integral role in the revival of the critically endangered agricultural sector. The delicate balance between importation and exportation, which has put most West African countries in a trade deficit, might potentially be restored, leading to economic growth and development in these countries and ultimately raising the gross domestic product per capita ratio. Hence, the commercialization of Shea resources could help in the alleviation of poverty, malnutrition, and unemployment in West Africa whilst improving public health and wellness through an increase in drug development and the creation of more job opportunities through the pharmaceutical, nutrition, and agricultural sectors.

Authors' Contribution

All authors contributed to the study's conception and design. **MBF:** Phytochemistry and literature review, **QON:** Conceptualization, literature review, and compiling of manuscript sections, **SSS:** Conceptualization, review of literature for bioactivity, writing **MAD**: co-wrote phytochemistry and pharmacological activity, proofreading, **MRA:** Conceptualizing, co-writing and proofreading. All authors read and approved the final manuscript. **UO:** Literature review, and compiling of manuscript sections.

Conflict of Interest

The authors declare no conflict of interest.

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Table 1: Antimicrobial properties of different solvent extracts of parts of *V. paradoxa*

Plant part	Test pathogen	Solvent used	Reference
Seed, leaf and stem bark	*Staphylococcus aureus, Escherichia coli* and *Klebsiella pneumonia*	Ethanol	[29]
Stem bark	*Escherichia coli, Klebsiella pneumonia, Proteus mirabilis, Shigella dysenterie* and *Salmonella typhi*	Ethanol, acetone and aqueous extracts	[38]
Stem bark	*Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Enterococcus faecalis, Staphylococcus aureus, Pseudomonas aeruginosa* and *Streptococcus pyogenes*	Aqueous and ethanol	[47]
Stem bark	*E. coli* and *P. mirabilis*	Ethanol	Legrand *et al*., 1988
Roots, stem bark and leaves	*Bacillus cereus, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pnuemoniae and Salmonella typhi*	Methanol and petroleum ether	[48]
Leave	*Salmonella typhimurium*	Aqueous	[30]
Leaf, root, bark	*Enterohaemorrhagic Escherichia coli* (EHEC ATCC 43889), Enteropathogenic *Escherichia coli* (EPEC ATCC 43887), *Salmonella*	Water, methanol, *omidun* and sterile *omidun*	[50]

	typhi, and *Escherichia coli* ATCC 25922		
Leaf	*Staphylococcus aureus* MRSA ATCC 33591	Dichloromethane and methanol extracts	[31]
Bark	*Aspergillus niger*, *Aspergillus flavus*, *Epidermophyton floccosum*, *Microsporum audouinii* and *Trichophyton mentagrophytes*	Aqueous	[51]
Bark	*Aspergillus niger*, *Aspergillus flavus*, *Epidermophyton floccosum*, *Microsporum audouinii* and *Trichophyton mentagrophytes*	Aqueous and ethanol	[52]

Table 2: Antiproliferative effect of the methanolic extracts of 11 Cameroonian plants studied

Plant names	Antiproliferative activity showing 50% growth inhibition (µg/ml)				
	NCI H460	MCF–7	PC3	HeLa	3T3
L. kerstingii	>250	>250	>100	>100	>250
C. populnea	>100	>100	>100	>100	>100
C. asiatica	>250	47.00 ± 1.60	45.00 ± 0.81	>100	>250
G. aqualla	>100	87.00 ± 0.73	97.00 ± 0.88	>100	>100
E. speciosa	98.00 ± 0.77	44.00 ± 0.77	> 100	>100	>100
S. siamea	87.00 ± 1.60	97.00 ± 1.30	>100	>100	>100
C. spectabilis	13.00 ± 0.80	20.00 ± 0.80	22.50 ± 0.81	10.30 ± 0.26	6.72 ± 0.05
E. senegalensis	20.00 ± 0.04	13.50 ± 1.04	16.18 ± 1.34	17.86 ± 0.74	28.84 ± 0.10
P. elliotii	24.44 ± 0.90	87.00 ± 1.22	47.00 ± 1.33	66.46 ± 0.37	81.60 ± 0.70
T. macroptera	31.00 ± 1.50	34.00 ± 1.05	42.37 ± 0.31	68.46 ± 0.18	64.42 ± 1.30
V. paradoxa	27.00 ± 0.90	24.00 ± 0.19	67.00 ± 0.09	66.46 ± 0.37	30.67 ± 0.50
Doxorubicin	0.02 ± 0.00	0.22 ± 0.05	0.29 ± 0.12	0.62 ± 0.15	0.70 ± 0.19

Source: Tagne *et al.* [56]

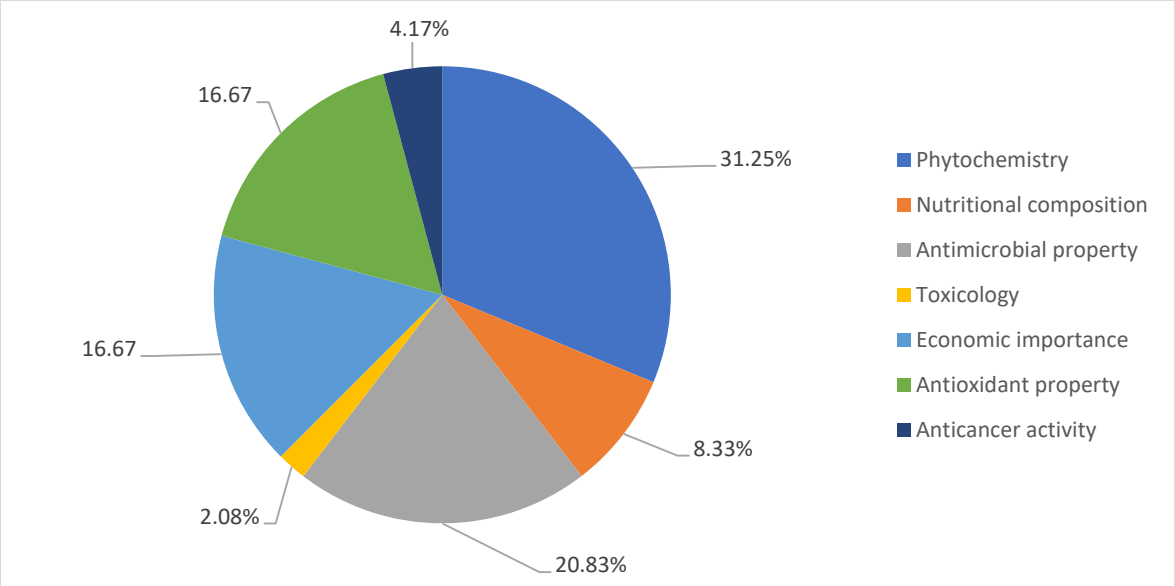

Figure 1: Frequency of the reported pharmacological activities of *V. paradoxa*

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