

# A Review of the Medicinal and Antimicrobial Properties of *Carissa spinarum* L.

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**Abstract** Medicinal plants have different biological activities and their natural products are an important source of biologically active ingredients. These plants and their secondary metabolic constituents have been used in traditional medicine and they are a source for the synthesis of many important drugs used in modern medicine. Numerous biologically active plant components have been discovered by ethnopharmacological evaluation and the medicinal plants offer the local population with an immediate and accessible therapeutic product used to treat different diseases in animals and humans. *Carissa spinarum* L. belongs to the family *Apocynaceae* and its parts such as root, leaf, and fruits have medicinal properties that are of help to both humans and animals. Different solvents and advanced techniques are employed in the extraction of phytochemical constituents of *Carissa spinarum* to study its potential medicinal applications. The phytochemicals occur naturally in the plant leaves, fruits, stems, bark, seeds, and roots that defend and protect the plant against various diseases. The antimicrobial activities of *Carissa spinarum* revealed a potential antibacterial activity against several bacteria that includes *Staphylococcus aureus*, *Staphylococcus aureus* ATCC 25923, Methicillin-resistant *Staphylococcus aureus* (MRSA), *Bacillus subtilis*, *Salmonella typhi*, *Escherichia coli*, *Escherichia coli* ATCC25922, *Escherichia coli* DSM 1103, *Pseudomonas aeruginosa* ATCC 35032, *Pseudomonas fluorescence*, *Proteus mirabilis*, *Mycoplasma mycoides* and *Streptococcus* species. The current review presents a comprehensive analysis of the medicinal applications of *Carissa spinarum*.

**Keywords:** antibacterial activity, *Carissa spinarum*, drug resistance, medicinal plants, antimicrobial activities

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## 1. Introduction

Plants and their secondary metabolic constituents have been used in traditional medicine and modern medicine and are a source of many important drugs. Medicinal plants are the richest bio-resource of drugs in traditional and modern systems of medicine, nutraceuticals, food supplements, folk medicines, pharmaceutical intermediates, and chemical entities for the development of synthetic drugs [1]. Medicinal plant research has potentiated humans with diverse constituents which can be used as natural preservatives for the inhibition of different pathogens [2]. The ever-growing interest in this area has been instrumental in increasing the research that is being conducted in different countries of the world to use them as a part of traditional medicine [3]. Most traditional medicine applications involve the use of plant materials and could be the only source of treatment for many diseases of humans and livestock. Also, most of the drugs are of plant origin [4,5].

Medicinal herbs have huge potential as a therapeutic aid, as they are used to combat not only multiple diseases but also serve as potential material for maintaining appropriate health conditions [6]. Increased use of traditional medicinal plants is mainly due to the acceptability, accessibility, inadequate coverage of the modern medical system, high cost of modern drugs, and other biomedical benefits [7,8,9,10]. Moreover, people's interest in herbal medicine has grown steadily over the years. This is understood by many aspects such as its diversity, accessibility, low cost, effectiveness, medicinal usefulness, and minimum side effects [11]. Therefore, this manuscript aims to review the medicinal importance and antimicrobial activities of *Carissa spinarum*.

## 2. General Importance of Medicinal Plants

The use of traditional medicinal plants for primary health care has dramatically increased throughout the world [12]. Scientists are in search of new phytochemicals that could be used to develop useful antimicrobials for the

treatment of infectious diseases [13]. Even though plants are rich in a wide variety of secondary metabolites that have anti-microbial properties, very few of them are being explored in the development and synthesis of novel antimicrobials [14].

The phytochemicals find applications in major areas of disease treatment apart from their importance in traditional schemes of medical care at the local level [15]. Medicinal plants have been used in the production of modern drugs. They are used as a source of direct therapeutic agents, as raw materials in the preparation of complex semi-synthetic compounds, and as taxonomic markers in the search of new compounds [16]. The majority of rural areas depend on traditional medicinal plants as their only source of health care due to the lack of adequate clinics, hospitals, volunteer health care professionals, the absence of vehicular/road facilities, and the expensiveness of modern medicines [8].

Most traditional medicines are locally available and cheaper than the standard treatments available in developing countries. As a result, livestock holders can prepare and use homemade remedies with minimum expenses [17]. Due to the shortage of required facilities, traditional medicinal plants are mostly the only option to treat many diseases in such countries [18].

### 3. Biological Activities of Medicinal Plants

Medicinal plants have different biological activities and their natural products are important sources of biologically active ingredients. Major parts of the antimicrobial compounds being discovered are microbial and plant products [19]. These phytochemicals which are produced by plants have different activities against microbes allowing the plants to be investigated and used for the discovery of new antimicrobial drugs [20]. Antimicrobial agents produced by plants are active against animal and human pathogenic microorganisms [21]. The plant crude extract and their fractionation products show antimicrobial activities [22]. Due to the emergence of drug resistance and related problems, much researches have been conducted and vast literature is being accumulated regarding the use of medicinal plant products in traditional medicine [23].

### 4. Bacterial Drug Resistance

The pathogenic bacteria cause serious infectious diseases that frequently result in mortality and morbidity among the population, especially in developing countries [24,25]. Antimicrobial agents are used to controlling and eliminating the effect of infectious diseases. Nevertheless, as resistant pathogens emerge and spread, the efficacy of such antimicrobial agents is reduced. Antibiotic resistance causes significant effects on animal and public health. The occurrence and spread of microbes resistant to most antibiotics (multi-drug resistant), including the major last-resort drugs are showing an increasing trend as evidenced by the available literature [26,27,28]. Currently, there is an increasing demand for pharmaceutical industries to conduct research and develop new drugs,

majorly owing to the continuous emergence of microbial resistance to conventional therapeutic agents [24].

### 5. Description of *Carissa spinarum*

*Carissa spinarum* L. belongs to the family *Apocynaceae*. It has 94 synonyms which are misused, misapplied, invalid, and illegitimate names. The plant is known as 'wild Karanda', or 'bush plum' and is an underutilized wild fruit closely related to *Carissa carandas* L. [29]. *Carissa spinarum* L. is also called as "Magic Shrub" in some of the African countries, as it is considered as a source of treatment for various diseases and ailments [30]. *Carissa spinarum* L. is a small spinous evergreen erect thorny shrub [1,30]. Morphologically it is woody, extremely hard with forked branches, and grows up to a height of 2-3 meters. It is light brown to green in appearance, brown to greenish at the base, and deep brown towards the tip. It can be stripped off longitudinally, exposing the white to light-green wood beneath with 3.2 cm long thorns, [28].

The shrubs of this genus are found in the tropical and subtropical regions of Africa, Asia, and Australia. They are grown as decorative plants in America ranging from Florida to California. The green leaves of the plant are glossy, waxy, and tough oval-shaped, while the white flowers are fragrant [30,31]. The plant also develops oval green berries that emerge from white star-shaped flowers. The berries turn black or dark in color when ripe [28]. Ethnobotanically, the plant has been used as a remedy against numerous diseases, and its fruits are taken as a rich source of vitamin C and iron [29].

### 6. Medicinal Importance of *Carissa spinarum*

The root, leaf, and fruit of *Carissa spinarum* have many medicinal properties that benefit both humans and animals. Different parts of the plant are used for their potential antimicrobial activities [6,31,32]. *Carissa spinarum* was also used to treat chest complaints and is used as an anthelmintic and antimalarial agent [30,33]. The plant extracts were found effective against stomach-ache, diarrhea, and dysentery [30,33,34]. *Carissa spinarum* was used to stop bleeding after the delivery, treat ulcers and muscle cramps, and to clean the worm-infested wounds in animals [28,30,32,33]. The experimental studies have noted that the root extract of the plant had significant wound healing activities as evidenced by the rate of wound contraction and epithelization. The hydroxyproline expressions and histological examinations confirm their potential wound healing properties [1,31,33,34]. The plant extracts of *Carissa spinarum* were used to treat rabies, typhoid fever, syphilis, herpes simplex viruses (HSV I and II), gonorrhea, hepatitis, measles, chickenpox, and polio [30,31,33,34,35]. Other medical applications include fever, skin diseases, cataracts, anemia, constipation, gastric ulcers, asthma, myalgia, infertility, hypertension, and kidney complications [1,6,30,31,32,33,34]. The *Carissa spinarum* plant was also noted to possess anticonvulsant, anticancer, anti-diabetic, and anti-rheumatic activities

[1,6,28,30,31,32,33,34,36]. In-vitro experimental studies have identified that the extracts of the *Carissa spinarum* plant have antiradical and antioxidant activity but are not toxic to shrimp larvae [11].

The plant extracts of *Carissa spinarum* were positively evaluated for its diuretic, anti-inflammatory, hypolipidemic, analgesic, and hepatoprotective activity [6,31,32,33,34,37,38]. It is also used to treat sexual asthenia in males, used as an antidote for snakebites, as a snake repellent, and in the management of chronic pain and joint inflammation [6,31,32,33,34,37,39,40].

The *Carissa spinarum* is considered as a miraculous plant in the management of veterinary ailments [31]. It was also found to show immunomodulatory activities and anti-trypanosomal activity against the Federe strain of *Trypanosoma brucei* subspecies *brucei* [6,40]. Different parts of *Carissa spinarum* plant have been investigated for their antimicrobial activities that include the roots, fruits, stem, and the bark as shown in Table 1 [6,11,28,30,33,35,36,39,40,42,43,44].

**Table 1. Antibacterial activities of *Carissa spinarum* plant**

Parts of the plant studied	Bacteria tested for the activity	Minimum inhibitory concentration	References
Fruits	<i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i> , <i>Salmonella typhi</i> , <i>Escherichia coli</i>	600 µg/ml	[6]
	<i>Escherichia coli</i> ATCC 25922		
Leaves	<i>Pseudomonas aeruginosa</i> ATCC 35032	0.5 mg/mL	[34]
	<i>Proteus mirabilis</i> <i>Staphylococcus aureus</i> ATCC 25923		
Leaves, roots, stems, stembark	<i>Mycoplasma mycoides</i>	0.02 mg/ml	[42]
Root	MRSA, <i>E. coli</i> , <i>Proteus</i> , <i>Pseudomonas fluorescense</i>	6.25 mg/500µl	[43]
Leaf	<i>Escherichia coli</i> DSM 1103		
Root, leaf, and bark	<i>Staphylococcus aureus</i> ATCC 25923	312 µg/ml	[28]
	<i>Escherichia coli</i> , <i>Bacillus subtilis</i> , <i>Staphylococcus aureus</i> , <i>Streptococcus</i> species	125 µg/ml	[33]

ATCC: American Type-culture Collection; MRSA: Methicillin-resistant *Staphylococcus aureus*.

## 7. Solvents and Techniques for the Extraction of *Carissa spinarum*

There are several different solvents and mechanisms by which the plant extracts of *Carissa spinarum* can be obtained. The solvents used include water, chloroform, 70% ethanol, 95% ethanol, nanoemulsion, ethyl acetate, methanol, and dichloromethane. The plant extraction can be done by maceration using ethanol-water mixture,

petroleum ether by Soxhlet extraction, acetone by using Soxhlet extraction, and extraction with n-hexane [1,6,11,28,33,34,35,36,39,41,42,43].

## 8. Phytochemical Constituents of *Carissa spinarum*

The medicinal value of ethnomedicinal plants depends on chemical substances (phytochemical constituents) that brings about a unique biochemical action in humans and animals. Phytochemicals are naturally present in the medicinal plants and their parts including the leaves, fruits, stem, bark, seeds, and roots. These phytochemicals, which may include primary and secondary compounds, play a key role in the plant defense mechanism against injury, and diseases [45]. Many biologically active plant metabolites have been discovered by ethnopharmacological evaluation and these plants may offer the local population with immediate and accessible therapeutic options [45,46,47,48,49]. The medicinal plants and/or herbs offer great possibilities for the discovery of new drugs with antimicrobial activities against various diseases, and microbial infections [6,24,50].

*Carissa spinarum* possesses an extensive range of phytochemicals in its leaves, roots, stem, bark, and fruits that impart enormous medicinal value to the plant [30]. These phytochemicals have a complex structure and form active constituents of herbal drugs which show synergistic antimicrobial action and enhance therapeutic value [6].

The root, leaf, stem, bark, and fruit of the plant, when extracted by different solvents, contain certain major bioactive constituents such as acids, alanine, carindone, carinol, carissone, carinol, citric, digitoxigenin, glucose and galactose, glycine, lupeol, malic, malonic and glycolic acids, oxalic acid, sugars, non-reducing sugars, odoroside H, pectin, phenyl alkaline, and vitamin C.

Other important phytochemical constituents include *carissol* (an epimer of  $\alpha$ -amyrin) anthraquinones, emodin's, lignin's, anthocyanins, gallic tannins, reducing compounds, alkaloids, carbohydrates, cardiac glycosides, and flavonoids [11,28,29,30,33,36,39,41,43].

Additionally, *Carissa spinarum* contains tannins, tartaric acid, and triterpenoids, glycosides, phenolic compounds, reducing sugar, saponins, steroids, and sterols [1,11,28,29,30,33,36,39,40,42]. However, according to previous research, it was observed that the ethanolic root extract of *Carissa spinarum* does not contain alkaloids, coumarins, fatty acids, flavonoids, leucoanthocyanins, saponin, and triterpenoids [41].

## 9. Conclusion

Medicinal plant study provides various sources as natural preservatives for inhibition of different pathogens growth. Most traditional medicine users depend on plant material contents against diseases of animals and humans. The use of traditional medicinal plants for primary health care has been increasing worldwide. Phytochemicals that are produced by plants have different activities against microbes allowing the plants to be investigated and used for the discovery of new antimicrobial drugs.

Antimicrobial agents produced by plants are active against animal and human pathogenic microorganisms. Due to drug resistance problems, many pieces of research have been conducted and vast literature exists on the use of traditional medicine, which somewhat helps to combat the problems. *Carissa spinarum* parts such as root, leaf, and fruit have much medicinal importance to humans and animals. Different parts of the plant are used for antimicrobial activity. The plants and herbs offer great possibilities for the discovery of new conventional drugs with antimicrobial activities against various existing and emerging diseases. *Carissa spinarum* contains an extensive range of phytochemicals in its leaves, roots, barks, as well as fruits that impart enormous medicinal value and antimicrobial properties to the plant which remains to be adequately explored.

## Conflict of Interest

The authors declare that there is no conflict of interest regarding the manuscript.

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