

Medicinal plants and phytomedicines are used to treat or prevent illnesses in Sudan: a review

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Author contributions

Abdalbasit Mariod suggested the review conception and design, Ahmed Mohamedain interpreted the review results, Haroon Elrasheid Tahir drafted and prepared the review manuscript. All authors reviewed the results and approved the final version of the manuscript.

Competing interests

The authors declare no conflicts of interest.

Acknowledgments

We thank Prof. Mathew Goss for editing the English text of a draft of this manuscript.

Abbreviations

TM, traditional (folk) medicine; *G. senegalensis*, *Guiera senegalensis*; *C. hartmannianum*, *Combretum hartmannianum*.

Peer review information

Traditional Medicine Research thanks Hui Luo and other anonymous reviewers for their contribution to the peer review of this paper.

Citation

Mariod A, Mohamedain A, Tahir HE. Medicinal plants and phytomedicines are used to treat or prevent illnesses in Sudan: a review. *Tradit Med Res.* 2023;8(1):3. doi: 10.53388/TMR20220323003.

Executive editor: Guang-Ze Ma.

Received: 23 March 2022; Accepted: 30 May 2022; Available online: 21 June 2022.

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Abstract

Traditional medicine is a reliable source for treating many diseases in Sudan. It is widely recognized in Sudan, as no Sudanese house is devoid of medicinal herbs. The Sudanese people and their historical stock of knowledge are distinguished by their knowledge and the many applications of herbs in treatment. This reference paper aims to collect all the available information about the use of medicinal plants in Sudan to treat disease or prevent it. Sudanese medicinal plants include a variety of plants and there are many medicinal applications for these plants in the world. According to the information reached by the paper, there are many therapeutic medical applications of these plants in the treatment of various bacterial infections, including digestive diseases, malaria, diabetes, rheumatic pain, respiratory diseases, jaundice, urinary tract infections, wounds, cancer and various microbial infections, according to the information reached by the paper. This reference is for a few groups of Sudanese medicinal plants such as tamarind, hibiscus, *Acacia nilotica*, *Combretum hartmannianum*, and *Guiera senegalensis*, etc. This review article also showed that these plants contain many biologically active substances as active ingredients, including flavonoids, saponins, alkaloids, stimulants, terpenes, tannins, fatty acids and essential oils. Even though Sudanese people use herbal medicine to treat a wide range of illnesses, more research is needed to show that these plants are safe and effective for people to use. For example, phytochemical analysis, biochemical activity tests and toxicology studies should be done to show that these plants are safe and effective for people to use.

Keywords: medicinal plants; phytomedicines; tamarind; hibiscus; *Acacia nilotica*; *Combretum hartmannianum*; *Guiera senegalensis*

Highlights

- (1) Traditional herbal medicine is used widely to treat diseases in Sudan.
- (2) Tamarind, hibiscus, *Acacia nilotica*, *Combretum hartmannianum*, and *Guiera senegalensis* are an example of plants used to treat different diseases in Sudan.
- (3) These plants are used to treat digestive diseases, malaria, diabetes, rheumatic pain, respiratory diseases, jaundice, urinary tract infections, wounds, and cancer.
- (4) Flavonoids, saponins, alkaloids, stimulants, terpenes, tannins, fatty acids and essential oils are main bioactive compounds found in these plants.

Medical history of objective

Plants have been the basis for medical treatment since prehistoric times in Sudan, since the civilization of Meroe and Napata through the periods of the Sinnar Kingdom and the Sultanates of Darfur, Kordofan and the Nuba Mountains. Herbal medicine or herbal medicine is still widely practiced today in all states of Sudan, especially in the countryside.

Background

Traditional (folk) medicine (TM) was known to human civilizations before B.C.E. and it is a medicine that is passed on to generations of its practitioners who had great experience. The TM practitioners relied on herbs, plants and some spiritual methods. This type of medicine has contributed a great deal to improving human health, especially the provision of primary care services at the community level. This medicine still retains its popularity all over the world [1].

Sudanese traditional medicine is a complete science that includes medicinal herbs and Sudanese spirituality, which usually includes clairvoyants, midwives, and herbalists. Diagnosis is made through spiritual means, then treatment is prescribed which usually consists of herbal remedies which have not only healing powers, but also symbolic and spiritual significance. The Sudanese traditional healer believes that illness does not occur by chance, but through a spiritual or social imbalance [2].

The multiplicity of diseases and their differences created the need for specialization so that the specialist excels in the service he provides and this applies to the folk healer who can be treated in one or more ways, but he is more ingenious in one, which is his main specialty and these are examples of popular specialties: Al-Mutawa: it has other synonyms such as: Al-Faki: the Sheikh: he is usually the imam of the mosque and the religious scholar who has a special religious culture in the countryside and this practices religious treatment such as: reading to the patient and the work of erasing (the eraser) and erasing is a religious treatment by writing some healing verses on a wooden board or paper It is washed with water and the patient drinks it [3]. Al-Kwai: which is treated by cauterization with fire and it is a well-known folk method called "wassem". It is a method commonly used in Arab folk medicine, where the treating doctor protects a piece of metal and put it on the place of pain or on a place determined by the doctor, given that this place in the human body controls the source of pain. Although this type of treatment often comes after using other methods of treatment because of the pain it causes for the patient [4].

The therapeutic use of plants dates to prehistoric times when humans had a good knowledge of the plant kingdom from their surroundings. Forests and meadows are pharmacies that provide human beings with the necessary treatments for their medical use. The simple observation resulted in a crude experimentation with a hint of cleverness to distinguish between harmful and beneficial plants [5]. Therapeutic knowledge has been passed down between generations. Tribal culture has a specific niche layer where shamans (priests) and

herbalists act as healers. It is knowledge, skills and practices based on theories and beliefs. Authentic cultural experiences are used to preserve health and to prevent, diagnose, treat or improve the physical and mental illness conditions of the injured [6].

A group of medicines of plant origin were included in modern pharmacological treatment, as they were known by ancient civilizations and used for thousands of years [7]. The term "herbal medicine" includes herbs and herbal substances, herbal preparations and ready-made herbal products containing active botanicals or other botanical materials or formulations [8].

Herbs are raw plant materials such as leaves, flowers, fruits, seeds, stems, wood, bark, roots or other plant parts, which may be incomplete, fractionated or powdered. These substances include, in addition to herbs, fresh juices and forms of gum, fixed oils, resins and dry herbal powders. This can be prepared in Sudan by following different domestic procedures, such as steaming, roasting or cooking in the oven with honey, alcoholic beverages or other substances [9].

Herbal preparations

Prepared herbal products may include comminuted, powdered, or derivatives of herbal materials, tinctures, and fatty oils. These products are produced by extraction, fractionation, purification, concentration, or other processes involving physical or biological soaking. These products also include lotions that contain herbal substances in alcoholic beverages and/or honey or other substances that are heated to mix with these materials [10].

Herbal treatment in Sudan

The Sudanese have known herbal medicine since ancient times and they also discovered the raw materials of plants in their initial form and extracted from them what cures many endemic diseases that affect humans, and with the accumulation of experience, the Sudanese human beings have a cultural and intellectual legacy in fighting the epidemics that were prevalent in their time. They knew the importance of medicinal herbs and they were widely used in the pharmaceutical industry. However, now, despite the development in the medical field, Sudan is far from inventing medicines or taking advantage of herbal folk medicine due to a lack of research techniques in this area. There is a need to educate and train herbalists as there are no complete scientific statistics on the local patterns of herbs. With the need for laws on herbal treatment in Sudan and the need for doctors to prescribe herbal medicines and help in research [11].

Medicinal plants are used to treat or prevent illnesses in Sudan***Hibiscus sabdariffa* L.**

Hibiscus is a shrubby plant that reaches a height of about two meters and its stems are red. The part used is the sepals that surround the flower and these are, after drying, either dark red or light. Hibiscus is a useful beverage for patients with high blood pressure due to its high content of potassium, which helps stimulate blood circulation, regulate heartbeat and maintain fluid and salt balance in the body. The composition analysis of the dried *Hibiscus sabdariffa* L. sepals reported that the moisture content was 13%, the vitamin C content was 50–100 mg per 100. 5%, nitrates were 41%, ash and salts were 7% and 15%, respectively, while the total acids were 25–30% [12].

Hibiscus is one of the natural herbs rich in potassium, which works with sodium on the balance of salts and fluids in the blood and reduces the risk of fluid retention in the body, as it is a fluid repellent and therefore helps reduce high pressure, regardless of how it is taken, whether "boiled or cold". In both cases, it reduces pressure, not the other way around. Hibiscus is rich in beta-cyanine compounds, which give it this dark red color and have a significant role in lowering blood pressure [13].

A Sudanese study indicated that the hibiscus flower has a low degree of toxicity and its decoction is used in the country to lower blood pressure. Consuming hibiscus daily can help lower systolic and diastolic blood pressure in people with mild to moderate hypertension. The study showed that the anthocyanin pigment, which

gives the hibiscus flower its distinctive color, is generally responsible for the hypotensive activity [14].

Studies have shown that hibiscus offers many benefits for public health, most notably: strengthening the immune system. Fighting free radicals, which threaten body cells with inflammation and damage, which reduces the chances of chronic diseases. Reducing harmful cholesterol and triglycerides in the blood. Strengthening the ability of the liver to purify the body from toxins, reducing the chances of developing cirrhosis and fatty liver. Lose weight and reduce obesity. Prevent cancer because it contains polyphenols. Natural antibiotic, due to its antibacterial properties [15].

Guiera senegalensis (G. senegalensis)

A study by Mariod et al. in the year 2011 showed that the antioxidant activity of phenolic compounds presents in the extracts of both *G. senegalensis* and *Combretum hartmannianum* was significant when compared to the activity of industrial and commercial antioxidants in foods. Also, these extracts were effective in stabilizing the stability of sunflower oil during storage at 70 °C [16].

G. senegalensis is a shrub that grows abundantly in the sandy lands of the Sudanese states of Kordofan and Darfur. Its parts are used as leaves, stems and roots in traditional medicine to treat diseases and wounds. There is a study that showed that the leaf extract had no inhibitory activity against all tested fungal strains. On the other hand, a toxicological test study, which was carried out using brine shrimp, showed that the extract of the opium leaves is apparently not toxic. The phytochemical examination also showed that the extract of gooseberry contains alkaloids, flavonoids, terpenoids, tannins, carbohydrates, proteins, steroids and saponins. The results of this preliminary investigation indicated that the medicinal plant extract is safe to use as a drink to treat various diseases, as has been the case for years in the villages of western Sudan [17]. The common ailment treated by the leaves' extract of *G. senegalensis* is jaundice, which represents more than 51.5% of the conditions treated; and the other 48.5% of the conditions treated include diabetes mellitus, hypertension, cough, arthritis, enteritis, diarrhea and malaria [18].

The ethanolic extract of *G. senegalensis* at a concentration of 13 g/mL caused a 100% cytotoxic effect against Ehrlich ascites carcinoma cells. Moreover, it possessed considerable antioxidant activity against the 2,2-diphenyl-1-picrylhydrazyl radical. The *G. senegalensis* extract was found to contain appreciable amounts of phenolic and flavonoid compounds. *G. senegalensis* possesses sufficient in vitro anticancer and antioxidant activities to warrant further detailed study of its pharm ecology and phytochemistry [19]. *G. senegalensis* ethanolic extract has evidence of reducing hyperthermia in experimental animals and this effect may be correlated to other biological activities of this medicinal plant [20].

Combretum hartmannianum (C. hartmannianum)

Hartmannianum is a shrub or small tree and grows mainly in wooded grassland, high-rainfall savannas and savannah woodland habitats on well-drained alluvial soils. It is a tree that grows in different Sudanese states, e.g., Kordofan, Darfour and Blue Nile, with a branched and intertwined stem, it has smooth white bark, and it has a thin lime green leaf. It breaks (green) early as soon as it rains, and it has a wonderful view. Its branches are used as hammers for building, and its firewood burns smoke to repel insects and mosquitoes [16].

In Sudanese traditional medicine, *C. hartmannianum* is used habitually against a wide range of diseases, including asthma, malaria, fever, jaundice, fungal and bacterial infections, including tuberculosis. Accordingly, some in vitro studies confirm that *C. hartmannianum* extracts are antibacterial. Salih et al.'s study justified the use of *C. hartmannianum* in Sudanese folk medicine against prolonged cough that could be related to tuberculosis infection [21]. The decoction of the tender leaves is used as a disinfectant for the wounds of women during childbirth and firewood is used in a sauna for married women before intimacy, by using thick smoke to be deposited around the woman's body to give it a bright yellow color and a sweet smell. Fadle et al. analyzed the petroleum ether, chloroform, methanol and water

fractions of the fermented wood Nihra of *C. hartmannianum* using chromatographic and spectroscopic analysis [22]. The main fragrance aromatic compound in the petroleum ether Nihra fraction of *C. hartmannianum* was 2-tert-butyl-5-(hydroxymethyl)-4-formylfuran and a terponid compound, according to these authors [23]. Soaked leaves are used in the treatment of skin ulcers, toothaches, wound infections and infections in general. Ointments and tonics were prepared from the leaves, stems and roots for the treatment of acne and skin infections by placing the mentioned plant parts in boiling water for half an hour. The paste prepared in this way covers wounds and treats skin fungal infections [24].

The effect of aqueous extracts, ethyl acetate, chloroform and petroleum ether from *C. hartmannianum* wood was tested to identify the antibacterial activity of *Salmonella*, *Escherichia coli* and *Staphylococcus aureus*. The study showed that ethyl acetate extract has a high ability to inhibit *Salmonella* bacteria. While the activity of other extracts was moderate in inhibiting all bacteria. Thus, this study confirmed the possibility of using *C. hartmannianum* wood as an effective antidote and drug in the treatment of bacterial infections [23].

Tamarindus indica

Another Sudanese drink is Al-Ardeeb, which is the plant known as tamarind in Arab countries. It has black or brown clusters of fruits. Its cultivation is spread in western Sudan, and its juice is extracted after soaking in water for a period, then filtered and drunk. It has a pungent flavor. However, it is the most popular juice among many [25]. Al-Ardib drink "Tamarind" contains 0.1% of tartaric acid, 0.06% of citric acid, 0.08% of acidic potassium salts, as well as a little pectin and tannin and 0.02% of mineral salts, especially phosphorous and magnesium compounds, as well as 30% of sugar and is useful in treating rickets instead of oranges and lemons. The high percentage of acids and mineral salts in tamarind is responsible for its pungent taste and distinctive taste. It is also the main factor in taking Al-Ardeeb as a drink, useful in ridding the blood of excess acidity and expelling the toxins it contains. It fights thirst and is used as a laxative, antacid and a depressant [26]. In a recent study conducted to evaluate the antimalarial activity of the tamarind pulp extracts against *Plasmodium falciparum*, they were extracted with solvents of different polarities. Among the used solvents, the chloroform solvent showed the highest activity, as it contained mainly aliphatic hydrocarbons, acid alcohols and their esters, in addition to sitosterol and aromatics were among the selected components. The results of the study indicated that the antispasmodic activity is due to one or a group of these components [27].

Tamarind is used as a traditional remedy in many countries of the world, including Sudan, where it is used to treat abdominal pain, diarrhea, dysentery, parasitic worm infections, wound healing, malaria, fever, constipation, infections, cell poisoning, gonorrhoea and eye diseases. The Sudanese tamarind fruit contains many chemical compounds. Some studies showed that the tamarind fruit possesses antidiabetic activity, antimicrobial activity, antitoxin activity, antioxidant activity, antimalarial activity, hepatoprotective activity, antipyretic activity and antihypertensive activity [28].

Acacia nilotica

Acacia nilotica is a spiny tree with yellow flowers, fruits like carob and cracked bark yielding a resinous substance. It belongs to the legume family (Fabaceae). Scientific research has shown several potential curative effects of *Acacia nilotica*. *Acacia nilotica* has been used in traditional medicine (since ancient times) to treat many diseases such as cancerous tumors, high blood pressure, diabetes, tuberculosis, diarrhea, asthma, infertility and others. *Acacia-nilotica* leaf extract, like glibenclamide, had a hypoglycaemic and hypolipidaemic impact on alloxan-induced diabetic rats [29]. Some scientific research conducted on rats with diabetes indicated that it contributes to significantly lowering the level of glucose in the blood. Studies conducted on some experimental animals have shown that this herb has a role in lowering cholesterol, triglycerides and low-density

lipoprotein cholesterol, and that it significantly increases high-density lipoprotein cholesterol as well. Studies conducted on some experimental animals have shown that this herb has a role in lowering cholesterol, triglycerides and low-density lipoprotein cholesterol, and that it significantly increases high-density lipoprotein cholesterol as well. According to one study, this herb may inhibit the acetylcholinesterase enzyme, thereby improving memory and alleviating Alzheimer's symptoms [30].

In a study that showed the effectiveness of methanol extract of *Acacia nilotica* as an antibacterial against bacteria that cause various diseases, that study provided the scientific basis that explains its use in Sudanese traditional medicine. The results of the study showed that the extract of pods from the acacia plant was effective against all tested bacteria, even at low concentrations. For a long time, the Sudanese have used *Acacia nilotica* in the treatment of many diseases, such as streptococcus mutans salivary and metabolic syndrome [26]. There are also many studies that have shown the possibility of using *Acacia nilotica* products as compounds against the hepatitis C virus [27]. Efficacy against the COVID-19 virus in several self-reported cases.

Cymbopogon citratus known in Sudan as Al-Muhrib, Al-marhabib or Alhamareeb, it is a perennial herbal plant with a fragrant aroma that often resembles the smell of roses. Useful in relieving gastrointestinal and urinary diseases, as well as in treating menstrual pain, regulating the menstrual cycle in women, relieving postpartum pain, lactation and in some skin diseases. Al-Muhrib oil is useful for tension and headaches [4]. All parts of the plant are used. The plant contains volatile oils, and the most important compounds of this oil are geraniol, which is like lemongrass oil and citral, which is used as a raw material in the manufacture of vitamin A, in addition to converting it into aen perfume. As well as a sterol compound. It also contains flavonoids. It is gentle, opens the plugs and the mouths of the veins, generates urine and menstruation, breaks up stones, dissolves solid tumors in the stomach, liver and kidneys as a drink and as a bandage [4].

It calms toothaches, amalgams, breaks up stones, benefits hemoptysis, analyzes tumors at all, resists toxins, purifies the chest and stomach, and it benefits the kidneys and fixes it. Joint machines: it is beneficial for the muscles and for the benefit of convulsions if you drink from it a quarter of a weight of pepper with pepper and its essential oil will relieve fatigue [31].

Ducrosia anethifolia (Al-Hazza) is a natural herb, which is spread in many places around the world, especially in places with a hot environment. Al-Hazza leaves are one of the most important parts of the plant and they are used in folk medicine. Some clinical trials have shown that the volatile oil of the plant is useful in reducing anxiety and that it does not cause sedation when compared to chemical anti-anxiety drugs [32].

Artemisia absinthium (Al-sheeh) is spread in North Africa, Syria, Iran and Turkey, contains (3%) volatile oil. It is used in folk medicine in the form of a drenched drink for three consecutive days before bedtime to expel worms. Argil: it is a perennial herbaceous plant, its leaves are simple, its small white flowers are collected in tent inflorescences. It is used either as a drink, after adding hot water to the herb or by inhaling the decoction to treat diseases of the respiratory and digestive systems, as well as menstrual and puerperal pain in women [33].

Vitex agnus-castus Mary's herb is known as the palm of Mary, used to treat many women's diseases. In Sudanese folk medicine, it was used during difficult childbirth by placing it on a container with a tight lid, and women chanted some praises and chants that glorify the people of the house, peace be upon them, and believe that this facilitates childbirth, and is also used to increase milk production [4]. *Vitex agnus-castus* is used for the treatment of premenstrual syndrome orally taken, the plant reduces some symptoms of premenstrual syndrome, especially breast pain, constipation, irritability, depressed mood or mood changes, anger and headaches in some women [34].

Medicinal plants and COVID-19

Hardly any Sudanese home these days is free from the use of *Acacia nilotica*, garlic, white onions, gum Arabic, hibiscus, fenugreek, bee honey and black cumin. Most elderly people have become persistent in taking doses of garlic, cumin seeds, and anise twice or more daily, in the morning and in the evening, with a spoonful of honey. Housewives are keen on fumigating homes by burning the *Acacia nilotica* and using it as a disinfectant and sterilizer. It is the fruit of the acacia tree that grows in semi-desert areas in central and southwestern Sudan. Its solution is a natural hand sanitizer as well as a general body sanitizer [35, 36]. Some Sudanese research has proven that the use of different traditional herbs and the way they are prepared and eaten can effectively relieve initial symptoms such as fever, cough and fatigue, as well as reduce the possibility of serious diseases [37]. Mohamed et al. conducted a rapid survey study in Khartoum State, Sudan, on some herbs (*Acacia nilotica*, *Nigella sativa*, *Zingiber officinale*, *Syzygium aromaticum*, *Boswellia carterii*, *Hibiscus sabdariffa*, *Citrus aurantiifolia*, *Camellia sinensis*, *Allium sativum*, *Adansonia digitata*, *Pimpinella anisum*, *Citrus aurantiifolia*) and their relationship to relieving the initial symptoms of the COVID-19 pandemic [37]. A number of 652 people participated in this survey, including those who used these herbs themselves or their relatives during infection with Corona 19, knowing that these people used other additives such as honey and vinegar and sesame oil, olive oil and salt, the results of the survey showed that people who used traditional herbs with different methods of intake effectively reduced the initial symptoms such as fever, cough and fatigue for COVID19 disease, while reducing the possibility of other serious diseases for the infected person.

Phytomedicines in Sudan

Phytomedicine can be defined as herbal medicine with healing properties. Phytomedicine has been in existence since the advent of human civilization. Plants are the effective source of naturally occurring herbs, which are a storehouse of medicinally active phytochemicals, and plant medicine is an inspiring source for the treatment of many diseases. Their accessibility, affordability and most of all, their safety and efficacy have all contributed greatly to the success of their traditional use against some of the most severe forms of neurological disease and the reliability of consumers [38]. The plant *Quercus infectoria* has many therapeutic and medicinal properties, such as being an analgesic, anti-inflammatory, reducing fever, antiseptic for wounds and anti-inflammatory. Strong antibacterial, antiviral and antifungal properties. Its healing properties are because it contains tannin, which is the main compound that makes up 50–70% of the galls of *Quercus Infectoria* [39].

There are widespread traditional uses of Sudanese medicinal herbs and plants, where studies and research have shown to identify the chemistry, composition, and composition of these plants and the most important active compounds in them and to derive drugs from them. The active compounds were extracted and isolated, which were found to have different biological activities. Among those activities were anti-microbial, anti-diabetic, anti-cancer, anti-inflammatory and antioxidant. Thus, the efficacy of extracts and isolated compounds needs to be further investigated for their efficacy and safety using studies in living cells. Therefore, serious consideration should be given to research and projects designed to produce active compounds or biologically active molecules from plant sources [40].

Conclusion

Traditional medicine occupies a very important place in health care in the world in general, in Africa and Sudan in particular. In this review article, it became clear to us that the Sudanese still rely to a large extent on plants and medicinal herbs to treat many diseases, microbes and infections. This review clearly clarified the vast amount of research and studies conducted on the traditional medicinal plants and herbs that exist and are widely spread in most of the Sudanese states and that many of these plants have great therapeutic value, which is why they encouraged their cultivation and trade.

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