



A Phytopharmacological Review on a Medicinal Plant: *Cordia africana* Lam

Gashaw Nigussie^{1,*}, Fozia Ibrahim, Sebsib Neway

Armauer Hansen Research Institute, Addis Ababa, Ethiopia

*Author for corresponding: gashawnigussie20@gmail.com

Abstract

Cordia africana lam. (Family of *Boraginaceae*) is a wide spread tree in Tropical Africa. It is a small to medium-sized evergreen tree, 4 to 15 (30) meter high, heavily branched with a spreading, umbrella-shaped or rounded crown. *C. africana*: used for firewood, timber (furniture, beehives, boxes, mortars, church, drums), food (fruit), medicine (bark, roots), fodder (leaves), bee forage, mulch, soil conservation, ornamental, shade. It contains considerable group of phytoconstituents like flavonoids, alkaloids, tannins, terpenoids, saponins, steroids, anthraquinones, carbohydrates and proteins having different activities were screened and isolated from different parts of *Cordia Africana* which possesses pharmacological activities such as antioxidant, cytotoxicity, anti-inflammatory, anthelmintic, antimicrobial, anti-nociceptive, and others which could enhance health. Therefore, this literature review was tailored to widely investigate the ethnobiological, phytochemical compounds and pharmacological assays in attempt to divulge other plausible therapeutic activities.

Keywords: *Cordia africana*, phytoconstituents, Pharmacological Uses, Traditional Medicine

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1. Introduction

Since ancient times, various natural medicines in different dosage forms have been attempted for the management of various diseases. Management of diseases with these agents free of any adverse effects is now also a big challenge for the researchers. There is increasing interest in natural medicine owing to

these reasons. In popular medicine, the plant species of the genus *Cordia* have been tried for the treatment of various illnesses that affect many human systems.

The genus *Cordia* consists of about 250 species in the tropical and subtropical regions of all continents, 10 species are found in Ethiopia. *Cordia africana* is a wide spread tree in tropical Africa. Generally, *Cordia* species (*Boraginaceae*)

contain flavonoids [1], polyphenols [2], anti-androgenic triterpenoids, saponins, sesquiterpenes and cromenes [3]. Antifungal and larvicidal properties of *Cordia* sp. have been referred to the presence of heteroterpenoids, naphthoquinones and naphthoxirene [4]. In the Sudanese traditional medicine, *Cordia africana* (Gumbil) is widely known as a treatment for liver disease, fever and intestinal complaints such as dysentery [5]. The polysaccharide from the fruit pulp of *Cordia africana* consists mainly of galactose, mannose, xylose, arabinose, glucose, rhamnose, galacturonic acid and pharmaceutic acid and about 2.5% protein. Moreover, the wood is moderately durable and moderately resistant to termite and pinhole borer attacks [6]. This plant is locally known as "Wanza" In Ethiopia and used for firewood, timber (furniture, beehives, boxes, mortars, church, and drums), food (fruit), medicine (bark, roots), fodder (leaves), bee forage, soil conservation, ornamental, and shade [7]. Thus objectives of the present review are to provide an overview of the recent status on phytoconstituents and pharmacological uses of plants *Cordia africana*.

2. Classification

It is classified as Kingdom: Plantae; Class: Angiospermae; Subclass: Eudicots; Superorder: Asteridae; Order: Boraginales; Family: *Boraginaceae*; Subfamily: *Cordioideae*; Genus: *Cordia* Species: *Africana*; Scientific name: *Cordia africana* [8].

3. Taxonomy of *Cordia africana*

Cordia africana Lam. (generic name after Valeris Cordus, a German botanist) is a pan tropical genus of about 250 species belonging to *Boraginaceae* Juss. [9], a plant family comprising about 100 genera and 2000 species that are characterized by flowers in helicoid cymes and by coarsely hairy herbage. *Cordia africana* Lam. (Synonym: *Cordia abyssinica* R. Br.) is a tree (rarely shrubby) species.

4. Local Name

In Afrikaans it is called (grootblaarpieringbessie); in Amharic (wanza); in Oromiffa (Waddessa); in Konsogna (Otayita); in Tigrigna (auhi, ekhi, awhi); in Arabic (gambil); in English (Sudan teak), in East African (*cordia*, large-leafed *cordia*); in French (sebestierd' Afrique); in Uganda (mukebu); in Swahili (mringaringa, mringamringa, mukumari, makobokobo); and its Trade name is mukebu, mukumari [10].

5. Geographic Distribution

The origin *Cordia Africana* is Africa. It is widely spreaded in tropical Africa. It is spreading, from Guinea east to Eritrea, Ethiopia and Kenya, and south to Angola, Zimbabwe, Mozambique and northern South Africa. It is also found in Saudi Arabia and Yemen, and has been planted in many tropical countries [11].

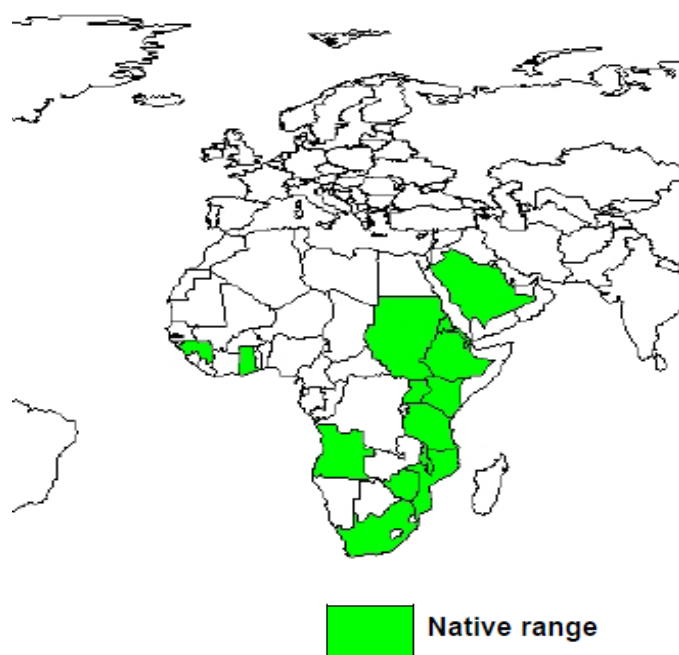


Figure 1. The natural distribution of *Cordia africana*.

6. Botanical Description

Cordia africana Lam. is a multipurpose tree species that belongs to the *Boraginaceae* and is found widely distributed in tropical Africa. *C. africana* is adapted to sufficiently warm areas with an altitude ranging from 900 to 2400 m and a rainfall range of 700 to 2000mm per year. In Ethiopia, it grows in a wide range of agro-ecological zones, though its habitats are mainly montane forest ecosystems. The species serves as timber, coffee-shade tree, agro-forestry crop, honey bee plant and as a draught season food. In Ethiopia, it is widespread in broad leaved Afromontane rain forests, undifferentiated (dry) Afromontane forests and in riverine forests as well as in the western lowlands [12]. Crown umbrella-shaped/rounded, dense, much branched; twigs velvety hairy, becoming glabrous Bole typically curved or crooked [13]. Bark surface smooth in young trees, becoming cracked or longitudinally fissured with age, pale brown to dark brown, inner bark fibrous, whitish, turning grayish to nearly blackish upon exposure [9]. Leaves leathery, simple, alternate, broadly ovate to egg-shaped, rough to feel, dull dark green, rounded to cordate at base, rounded to acuminate at apex, margins entire to slightly toothed, pinnately veined with 5–7 pairs of lateral veins. Buds oval, stalk less, pleated open into flowers that are bisexual, white, sweet scented, shortly pedicel ate or sub sessile, massed in compact panicles covering the crown, with a white mass of attractive flowers; calyx less than 1cm long, strongly ribbed, back of lobes covered with short, soft, brown hairs; corolla lobes crinkled, white, long-exerted, funnel shaped, about 2.5cm long; cymes many flowered. *Cordia africana* begins flowering when a tree is 3-5 years old [14]. It is monocious species with complete flowers (hermaphrodite) and is known to be pollinated predominantly by bees [9]. It can also grow under drier climatic conditions, by minimizing its water consumption through shading its leaves or by closing its stomata [15]. *Cordia africana* has fast growth performance, is cultural and widely used and is adapted to local conditions [16, 17].



(a)



(b)



(c)

Figure 2: various parts of *Cordia Africana* founds in Tropical Africa (a) Fruits, (b) Leaves, and (c) Flower with bee

7. Reproduction of *Cordia africana*

Cordia africana begins flowering when a tree is 3-5 years old [14]. It is monocious species with complete flowers (hermaphrodite) and is known to be pollinated predominantly by bees [18]. In Sudan, flowering occurs in October to December and fruiting from January to April; in Kenya, flowering is from April to June. It is repeated at intervals over several weeks and is evidently activate off by rain showers. After pollination by insects, fruit development takes a period of almost 6 months. In Ethiopia, the tree can be found in flower or in fruit all the year

round, but the main flowering period of the species is from October to March [19]. A flowering tree is spectacular; all the flowers open within a short time and give the tree a white snowy cover [20]. Fruits of *Cordia africana*, are eaten and their seeds dispersed by birds, baboons, monkeys, apes and probably other animals [21].

8. Use in Ethnomedicine

Some literature notes that there is traditional medicinal use of the plant [22-25]. More specifically migraine, broken bones, wounds, gastritis and constipation were noted to be treated with bark, leaf and fruit [26]. In more detailed studies illnesses and plant-parts used and how they are used are described. The fresh, juicy bark is used to tie a broken bone; this splint is changed occasionally with a fresh one until the bone is healed [27, 28]. In Congo the bark is macerated and used to treat madness via nasal application [29]. A decoction made from the bark is used to treat venereal diseases [28] and that of the root to treat bilharzia [27]. In another study sterile branches are ingested to treat problems of urination at night [30]. The wood and root are used as a vermifuges and the ash as skin and mucosae treatment. In Tanzania around Lake Victoria region the root is used to treat tuberculosis, cough and asthma [31]. The leaves and root are used to treat liver diseases, the root is used to treat amoebiasis, and the root and root bark are used to treat stomach ache and diarrhoea [32]. For general body ailment inhalation of the boiled leaf vapours is used [33]. The leaves are used ashed and mixed with butter to treat burns and wounds [27, 34]. The cursed leaf juice is drunk to treat general body ailment, diarrhoea, and tonsillitis and is rubbed into the eye to treat eye infections [34]. The crushed leaf is also applied to wounds for healing [35]. Old wounds are cured using crushed leaves in Tanzania, and intestinal worms are expelled by eating leaves by Masai and Chagga people in East and South Africa [27]. *Cordia africana* is used traditionally to treat stomach ache, toothache, wound and cough [36]. The mature fruits are edible; used to make a sweet drink which can be used as a milk substitute; to make sweets and sweet meats; to make stimulant and alcoholic drinks; and are

sold in the local markets in Northern Ethiopia and Sudan [37, 38].

9. Phytochemistry

The plants of the genus *Cordia* serve as a rich source of phytoconstituents. Various researchers have carried out phytochemical studies resulting in the identification and isolation of secondary metabolites from different parts of *Cordia Africana* [39-44]. Recently the biological active components of the plant reported and characterized from chromatographic separation of the root bark extract of *C. africana* yielded three triterpenoids; oleanolic acid (1), 3- β -lup-20(29)-en-3-ol (2) and stigmast-5,22-dien-3 β -ol (3) a hydroquinone derivative, 2-(2Z)-(3-hydroxy-3,7-dimethylocta-2,6-dienyl)-1,4-benzenediol (4), benzaldehyde derivative, 4-hydroxy-3-methoxy-benzaldehyde (5) and isoflavone, 7-hydroxy-4'-methoxyisoflavone (6). Similarly, the stem bark extract led to re-isolation of 1 and 2 together with terpenoid benzoquinone ubiquinone-8 (7) and an alcohol, 1-octacosanol (8) (Figure 3). From those components compound (1) showed moderate activity against *Enterococcus faecium* (IC₅₀ of 14.44 μ g/mL) and more cell viability of 57.93% against CEM/ADR5000, versus 78.97% for doxorubicin as compared as the standard [45].

10. Pharmacological Uses

10.1 Antimicrobial activity

The increasing incidence of microorganisms becoming resistant to antibiotics has continuously become a scientific community concern. Many scientists around the world are performing research on plants to be able to discover possible antimicrobial compounds. To date, many plant secondary compounds are known to have diverse biological activities. Antimicrobial activity of plants may be attributing to presence of alkaloids, Flavonoids/essential oils, Tannins, Terpenes, quinones. Several phytoconstituents from *Cordia africana* are experimentally proved and used as antimicrobial agent against different microorganisms. Extracts from the leaves of *C. african* were tested against bacteria (*E. coli* and *S. typhimurium*). It was found that

the plant extract showed most active against *E. coli* and *S. typhimurium* with minimum inhibitory concentrations of 16 µg/mL in both cases as well as the fast growing *Mycobacterium* species (*M. smegmatis*, *M. fortuitum* and *M. aurum*) [46]. Extracts from the bark and leaves of *C. Africana* were tested against different bacteria (*S.aureus*, *E.faecalis*, *B.cereus*, *p. aeruginosa*, *E. coli* and *S. typhimurium*) and against three fast growing *Mycobacterium* species strains (*M. smegmatis*, *M. fortuitum* and *M. aurum*). It was found that both the plant extract showed significant antimicrobial activities against all microorganism and zone of

inhibition of extracts was compared with that of standards like ciprofloxacin and both the plant extract were active against *M.fortuitum* with MIC values of 512µg/mL in both cases. Although extract from the leave of *C. Africana* was active against *M. smegmatis*, and *M.aurum* with MIC value of 1024 µg/mL in both cases with that of different standards like Ciprofloxacin and Rifampicin [47]. Studies although showed that the leaf and the fruit extract of *Cordia africana* using the result method gave inhibition zones of growth against the two bacteria (*E. coli* and *Staph. aureus*) far greater than that of the control treatment [8].

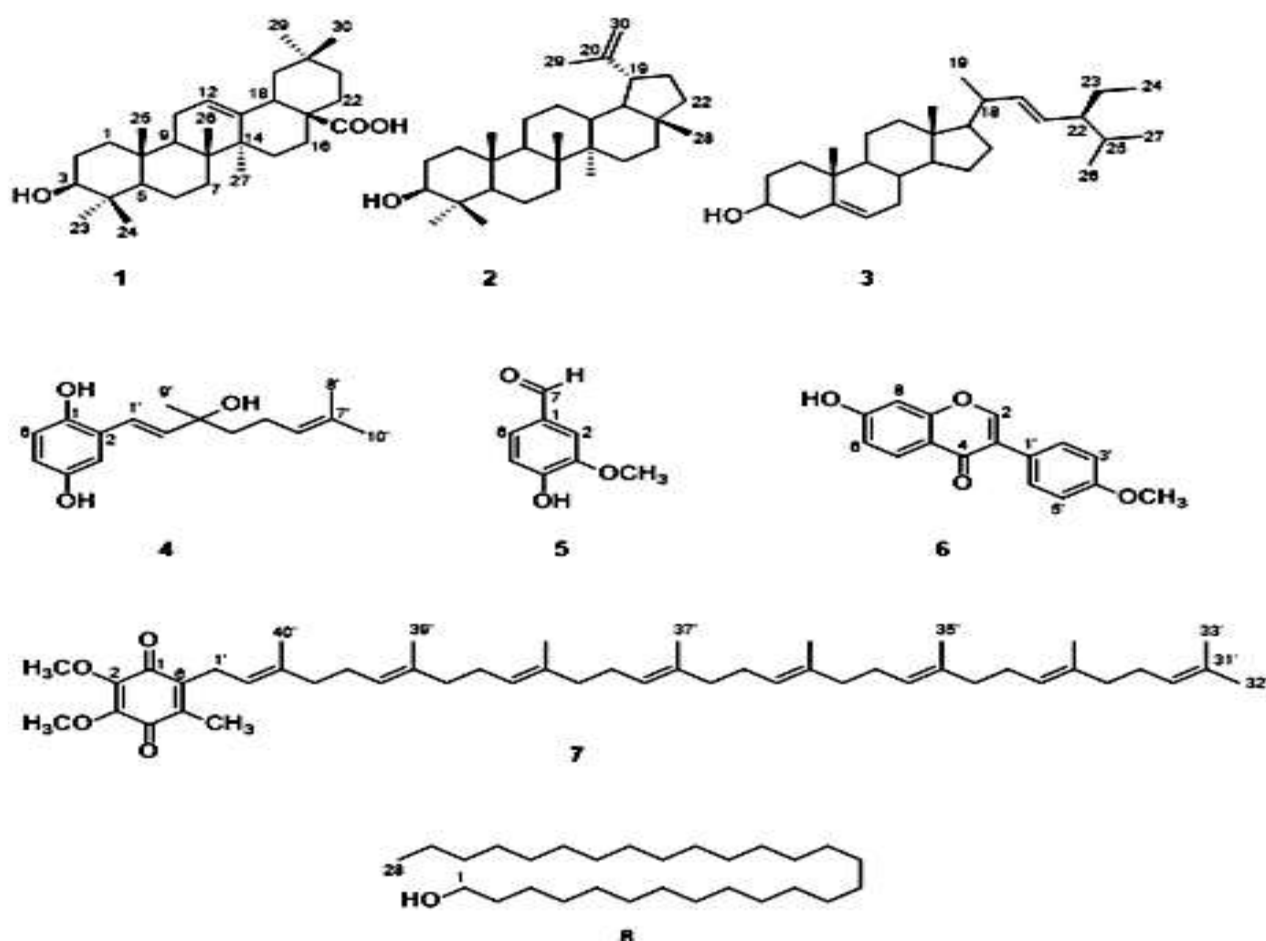


Figure 3: Structures of compounds isolated from the root bark (1-6) and stem bark (7-8) of *Cordia africana* Lam.

10.2 Antimalarial Activity

No single antimalarial drug is effective against all liver and intra-erythrocytic forms of the parasite, which could co-exist in the same patient. As a result, complete elimination of the

parasite infection may require more than one drug during treatment of an established infection [48]. Besides, efforts to develop an effective blood stage vaccine have not met with much success primarily because of antigenic diversity and a poor understanding of

protective host immune responses [49]. The genomic plasticity of the mosquito and the plasmodium parasite has added another dimension for the problem through increasing resistance to drugs, demanding an investment in research and development of newer agents for malaria control [49]. Hence, traditional medicinal plants could be considered as an alternative source of new drugs, as some antimalarial drugs (quinine, artemisinin) in use today were of plant origin [50]. Previous study showed that *In vivo* antimalarial effects of various doses of *C. africana* leave extracts and solvent fractions were determined using the four-day suppression test (both crude and fractions), as well as curative and chemoprophylactic tests (crude extracts). It was found that the crude extract of the plant exhibited significant parasitemia suppression in the four-day suppression (51.19%), curative (57.14%), and prophylactic (46.48%) tests at 600 mg/kg and the n-butanol fraction exhibited the highest chemosuppression (55.62%) at 400 mg/kg, followed by the chloroform fraction (45.04%) at the same dose [51]. There are a number of anti-plasmodial secondary plant metabolites that have shown antimalarial activities belonging to the classes of alkaloids, terpenes, flavonoids, xanthenes, anthraquinones, phenolic compounds, sesquiterpenes and other related compounds [47].

10.3 Antioxidant activity

Free radicals are responsible for many diseases like arthritis, cancer, diabetes mellitus, aging, etc. Herbal antioxidants have gained great importance in recent years as they are utilizing in the management of such diseases due to their ability to neutralize free radicals. As plants are the source of natural antioxidants, much attention has been gain to plants. Currently, there has been an increased interest globally to identify anti-oxidant compound that has potent bioactivities and has low or no side effects [52]. Antioxidant activity of plants may be attributed to presence of phenols, flavones, isoflavones, flavonoids, xanthenes, alkaloids, anthraquinones, phytosterols, steroids, amino acids, anthocyanins, isothiocyanate indoles, coumarins lignans, catechins, and isocatechins [53]. Studies carried out on different parts of *C.*

africana (leaves, stem, park and fruit) were screened to show their antioxidant activity via DPPH assay. The extract of methanol leaves, stem, bark and fruit gave antioxidant activity of 80, 88, 74 and 37%, respectively. Also extract of chloroform leaves and stem gave antioxidant activity of 79 and 78%, respectively. The extract of ethyl acetate leaves and stem gave antioxidant activity of 95 and 91% respectively and extract of water leaves and stem gave antioxidant activity of 82 and 89% respectively [54]. Isa et al., were tested acetone extracts of leaves, bark and ethyl acetate bark extract of *C. africana* for free radical scavenging potential in the management of degenerative disorders such as aging and age-associated oxidative stress related disorders. Activity was evaluated by in-vitro models (ABTS and DPPH model). Both models showed all the extracts had significant ($P < 0.05$) free-radical scavenging activity (IC_{50} ranging from 7.46 ± 0.17 - 104.21 ± 3.37 $\mu\text{g/mL}$) with that of the standards [46]. The ferric reducing antioxidant power (FRAP) and total phenolic content (TP) of the methanol fruit extract of *C. africana* was evaluated and average FRAP value on dry weight basis was 30.8 ± 1.45 mg Trolox equivalent 100 g^{-1} fruit, and the average TP value on dry weight basis 2317.0 ± 104.0 mg gallic acid equivalent 100 g^{-1} fruit. The fruit was also found to have $9.07 \text{ mg } 100 \text{ g}^{-1}$ fruit, which makes it a good source of the vitamin to meet part of the daily requirement. As antioxidants and vitamin C are highly beneficial to general health, the consumption of this fruit should thus be recommended and promoted [55]. Studies showed that antioxidant activities of ethanolic stem bark extract of *C. africana* was significant ($p < 0.001$) decrease in absorbance of DDPH free radical with calculated EC_{50} (the concentration or amount of substance that reduce absorbance by 50%) of 20.12 $\mu\text{g/mL}$, 32.07 $\mu\text{g/mL}$, 40.38 $\mu\text{g/mL}$ for the extract, ascorbic acid and α -tocopherol, respectively. This result shows that the extract, (*in vitro* and in μg concentration) is one and half times (1.5) more potent than ascorbic acid and two (2) times more potent than α -tocopherol acetate [43]. Kahsay Zemichael, et al. evaluated antioxidant potential of ethanolic extract of *C. africana* leaves. In the present study the percentage inhibition of the DPPH radical by the ethanolic extracts of *C. africana* leaves and ascorbic acid at 100 $\mu\text{g/mL}$

was 68% and 79%, while the IC₅₀ values were 66 µg/ml and 47 µg/ml, respectively. The chemical present in the leaves such as Flavonoids, Tannins, Terpenoids, carbohydrates, fixed oils and fats, amino acid and proteins [44].

10.4 Anti-nociceptive

Studies showed that in formalin-induced pain model the ethanolic stem bark extract of *Cordia africana* significantly ($P < 0.05$) reduced pain in the second phase of the test at 3.2 g/kg and 4.8 g/kg oral doses while, in acetic acid-induced abdominal writhings and hot plate-induced pain models, the extract at oral doses of 1.6 g/kg and 3.2 g/kg body weight significantly ($P < 0.05$) reduced abdominal writhes and pain respectively. These results revealed that ethanolic stem bark extract of *Cordia Africana* is relatively orally non-toxic and only slightly toxic via intraperitoneal route. In addition, it possesses significant analgesic activity at 1.6 g/kg, 3.2 g/kg and 4.8 g/kg oral doses. The chemical present in the leaves such as Flavonoids, alkaloids, Triterpenoids, saponins and carbohydrates [42].

10.5 Anti-inflammatory

Studies was carried out carrageenan-induced paw oedema model in rats have demonstrated that the inflammatory effect induced by carrageenan is biphasic in nature; first phase resulting from the rapid production of several inflammatory mediators such as histamine, serotonin and bradykinin and a second phase by the release of prostaglandin and nitric oxide with peak at 3 h. produced by inducible isoforms of cyclo-oxygenase (COX-2) and nitric oxide synthase (NOS), respectively [56]. Results obtained in this model can be used to investigate anti-inflammatory effect of compounds [57]. Studies showed that ethanolic stem bark extract of *C. africana* Lam. at 340 mg/kg dose significantly ($p < 0.05$) reduced the size of induced paw oedema at 2nd, 4th and 5th h. while, at 424 mg/kg dose, it significantly ($p < 0.05$) reduced the size of induced paw oedema at 2nd, 3rd, 4th and 5th h. after carrageenan administration only when compared to negative control, normal saline. However, in comparison to both piroxicam and normal saline, the extract at 509 mg/kg dose, yielded significant ($p < 0.05$) reduction in the size

of induced paw oedema at 2, 3, 4 and 5 h. after carrageenan administration [43].

10.6 Antihelmintic Activities

The *in vitro* tests using free living stages of parasitic nematodes offer a means of evaluating the antihelmintic activity of new plant compounds, as already reported by various authors [58]. Studies was carried out aqueous leaves extract of *C. Africana* showed 95% adult mortality of the parasite *H. contortus* at a concentration of 4mg/ml [59].

10.7 Antidiarrheal

Study was carried out the methanolic extract of the root bark of *Cordia africana* were tested antidiarrheal activity on castor oil induced diarrhea in mice (23–25 g) of either sex. Number of diarrheic defecations, intestinal length traveled by the charcoal meal, and weight of intestinal fluid were taken as important parameters to evaluate the antidiarrheal activity of the plant extract. Reduction in the number of diarrheic drops was observed in groups of mice that received 200 mg/kg ($P < 0.05$) and 400 mg/kg ($P < 0.01$) of the extract compared to the negative controls. The percent inhibition of intestinal fluid accumulation was 26.83%, 46.34%, and 53.66% at the doses of 100, 200, and 400 mg/kg of the extract, respectively. Relative to the negative control group, the mean percent of intestinal length moved by the charcoal meal was decreased by 24.41%, 39.89%, and 51.66% in groups of mice given 100, 200, and 400 mg/kg of the plant extract, respectively. In preliminary phytochemical screening tests, the methanolic extract of *C. africana* was found to contain phenols, flavonoids, terpenoids, and saponins [60].

11. Conclusion

Medicinal herbs have tremendously and uncharacteristically improve the quality of primary health care system in the provision of herbal drugs with no health effects or reactions. *Cordia africana* is native to tropical area of Africa, Saudi Arabia and Yemen. The plant is used as traditionally for curing different disease. In folk medicine, it has been used antimicrobial, antimalarial, anti-inflammatory, antioxidant,

antihelmintic, antinociceptive and antidiarrheal activities. Recently, interests in medicinal plants have been centered on investigation of the pharmacology and phytochemical screening of secondary metabolites to explore their therapeutic potency and boost the production of novel herbal drugs. Bioactive compounds have been isolated, characterized and analyzed in *C. africana* for their pharmacological activities. In attempt to improve the phytochemical and pharmacological studies of *C. africana*, important factors such as mode of propagation, extraction procedures, harvesting time should be monitored and addressed. These will enhance the physicochemical composition and biological activities of the *C. africana* extracts and therefore, boost its economic value and evaluation needs to be carried out on *C. africana* in order to confirm its medicinal uses and development of formulations containing this plant for their practical clinical applications, which can be used for the welfare of mankind.

Conflict of Interest

The authors declare there is no conflict of interest.

References

- [1] Sertié, J.A., et al., *Anti-Inflammatory Activity and Sub-Acute Toxicity of Artemetin*. *Planta medica*, 1990. **56**(01): p. 36-40.
- [2] Marston, A., M.G. Zagorski, and K. Hostettmann, *Antifungal Polyphenols from Cordia goetzei* Gürke. *Helvetica chimica acta*, 1988. **71**(5): p. 1210-1219.
- [3] Santos, R.P.d., et al., *Chemical constituents of Cordia piauhiensis: Boraginaceae*. *Journal of the Brazilian Chemical Society*, 2005. **16**(3B): p. 662-665.
- [4] Ioset, J.-R., et al., *Antifungal and larvicidal meroterpenoid naphthoquinones and a naphthoxirene from the roots of Cordia linnaei*. *Phytochemistry*, 1998. **47**(5): p. 729-734.
- [5] Burkill, H.M., *The useful plants of West Tropical Africa*. Vol. 1. Families AD. 1985: Royal Botanic Gardens.
- [6] Bekele-Tesemma, A. and B. Tengnäs, *Useful trees and shrubs of Ethiopia: identification, propagation, and management for 17 agroclimatic zones*. 2007: RELMA in ICRAF Project, World Agroforestry Centre, Eastern Africa Region
- [7] Zorloni, A., *Evaluation of plants used for the control of animal ectoparasitoses in southern Ethiopia (Oromiya and Somali regions)*, 2008, University of Pretoria.
- [8] Mohammed, F.S.E., *Antibacterial Activity of Leaves and Fruits Extracts Of the Gumbil Tree (Cordia africana L.)*, 2015, University of Gezira.
- [9] Alemayehu, G., Z. Asfaw, and E. Kelbessa, *Cordia africana (Boraginaceae) in Ethiopia: A review of its taxonomy, distribution, ethnobotany and conservation status*. *International Journal of Botany Studies*, 2016. **1**(2): p. 38-46.
- [10] Orwa, C., et al., *Agroforestry Database: a tree reference and selection guide. Version 4*. *Agroforestry Database: a tree reference and selection guide*. Version 4., 2009.
- [11] Gebreegziabher, S.T.-B., *Cordia africana (Lam.) fruit and its uses*. 2016.
- [12] Hawthorne, W., I. Friis 1992. *Forests, and forest trees of northeast tropical Africa. Their natural habitats and distribution patterns in Ethiopia, Djibouti and Somalia*. Royal Botanic Gardens, Kew. Additional Series XV. HMSO, London, iv+ 396 pages. ISBN 0-11-250006-6. Price:£ 37.50 (paperback). *Journal of Tropical Ecology*, 1993. **9**(1): p. 43-44.
- [13] Warfa, A.M., *Cordia (Boraginaceae) in NE tropical Africa and tropical Arabia*, 1988, Acta Universitatis Upsaliensis.
- [14] Negash, L., *Indigenous Trees of Ethiopia: Biology, Uses and Propagation*. Addis Ababa: Department of Biology, Addis Ababa University. Printed: SLU Reprocentralen, Umea (Sweden), 1995.
- [15] Gindaba, J., A. Rozanov, and L. Negash, *Response of seedlings of two Eucalyptus and three deciduous tree species from Ethiopia to severe water stress*. *Forest Ecology and Management*, 2004. **201**(1): p. 119-129.
- [16] Hailu, T., L. Negash, and M. Olsson, *Milletia ferruginea from southern Ethiopia: Impacts on soil fertility and growth of maize*. *Agroforestry Systems*, 2000. **48**(1): p. 9-24.
- [17] MOHAMMED, A.J. and M. INOUE, *Ethiopian Forestry Action Plan. Synopsis report, Ministry of Natural Resources Development and Environmental Protection Ethiopian Forestry Action Plan. Synopsis report, Ministry of Natural Resources Development and Environmental Protection*, 1994. *Journal of forest research*, 2012. **17**(1): p. 30-36.
- [18] Warfa, A.M., *Cordia (Boraginaceae) in NE tropical Africa and tropical Arabia*. 1988.
- [19] Fichtl, R. and A. Adi, *Honeybee flora of Ethiopia*. 1994: Weikersheim (Germany), Margraf Verlag, 1994.
- [20] Bruce, J., *Select Specimens of Natural History, Collected in Travels to Discover the Source of*

- the Nile, in Egypt, Arabia, Abyssinia, and Nubia.: Vol. V. Vol. 5. 1790: for GGJ and J. Robinson, Paternoster-Row.
- [21] Derero, A., Genetic variation in *Cordia africana* Lam. in Ethiopia. 2007: Cuvillier Verlag.
- [22] Birhane, E., et al., Management, use and ecology of medicinal plants in the degraded drylands of Tigray, Northern Ethiopia. *Journal of horticulture and forestry*, 2011. **3**(2): p. 32-41.
- [23] Neba, N.E., Implications of fuel wood yield, availability and harvest in Tubah Mountain Forest, Cameroon. *Global Journal of Human Social Science*, 2010. **10**(3): p. 49-55.
- [24] Smith, W., T.C. Meredith, and T. Johns, Use and conservation of woody vegetation by the Batemi of Ngorongoro district, Tanzania. *Economic Botany*, 1996. **50**(3): p. 290-299.
- [25] Takaoka, S., A comparison of the utility and agronomic traits of indigenous and exotic trees in the Mount Kenya region. *Small-scale Forestry*, 2008. **7**(1): p. 77-85.
- [26] Zenebe, G., M. Zerihun, and Z. Solomon, An ethnobotanical study of medicinal plants in Asgede Tsimbila district, Northwestern Tigray, northern Ethiopia. *Ethnobotany Research and Applications*, 2012. **10**: p. 305-320.
- [27] Jansen, P.C.M., Spices, condiments and medicinal plants in Ethiopia, their taxonomy and agricultural significance. 1981: Pudoc.
- [28] Kokwaro, J., *Medicinal plants of east Africa. Nairobi*, 2009, University of Nairobi Press.
- [29] Chifundera, K., Contribution to the inventory of medicinal plants from the Bushi area, South Kivu Province, Democratic Republic of Congo. *Fitoterapia*, 2001. **72**(4): p. 351-368.
- [30] Yirga, G., Assessment of indigenous knowledge of medicinal plants in Central Zone of Tigray, Northern Ethiopia. *Afr J Plant Sci*, 2010. **4**(1): p. 6-11.
- [31] Otieno, J., et al., Use of ethnobotanical criteria for conservation assessment of plants used for respiratory diseases in Lake Victoria region, Tanzania. *International Journal of Biodiversity and Conservation*, 2011. **3**(11): p. 610-617.
- [32] Giday, M., et al., Medicinal plants of the Shinasha, Agew-awi and Amhara peoples in northwest Ethiopia. *Journal of Ethnopharmacology*, 2007. **110**(3): p. 516-525.
- [33] Teklehaimanot, G. and M. Haile, *Women in backyards: Root crop production and biodiversity management in backyards*. Drylands Coordination Group, Miljøhuset G, 2007. **9**.
- [34] Teklay, A., B. Abera, and M. Giday, An ethnobotanical study of medicinal plants used in Kilte Awulaelo District, Tigray Region of Ethiopia. *Journal of ethnobiology and ethnomedicine*, 2013. **9**(1): p. 65.
- [35] Giday, M., Z. Asfaw, and Z. Woldu, *Medicinal plants of the Meinit ethnic group of Ethiopia: an ethnobotanical study*. *Journal of ethnopharmacology*, 2009. **124**(3): p. 513-521.
- [36] Regassa, R., Diversity and conservation status of some economically valued indigenous medicinal plants in Hawassa College of Teacher Education Campus, Southern Ethiopia. *International Journal of Advanced Research*, 2013. **1**(3): p. 308-328.
- [37] El Tahir, B., *Status of indigenous fruits in Sudan*. Review and appraisal on the status of indigenous fruits in Eastern Africa. A report prepared for IPGRI-SAFORGEN in the framework of AFREA/FORNESSA, 2004.
- [38] Teketay, D. and A. Eshete, *Status of indigenous fruits in Ethiopia*. Review and Appraisal on the Status of Indigenous Fruits in Eastern Africa: A Report Prepared for IPGRI-SAFORGEN in the Framework of AFRENA/FORENESSA, Kenya Forestry Research Institute, Nairobi, Kenya, 2004: p. 3-35.
- [39] Abate, L., Bioactivity profiling of four traditional medicinal plants leave extracts native to Alesaga Forest, Ethiopia. *Chemistry International*, 2019. **5**(4): p. 281-290.
- [40] Abate, L. and T. Mengistu, Phytochemical Screening and Peroxide Value Determination of Methanolic Extract of Four Traditional Medicinal Plants from Debre Tabor Town, Ethiopia. *Journal of Medicinal Plants Research*, 2018. **12**: p. 203-208.
- [41] Mekonnen, A., Y. Degu, and R. Carlson, Appraisal of solvent system effect on bioactivity profiling of *Cordia africana* stem bark extracts. *Chemistry International*, 2020. **6**(1): p. 1-10.
- [42] Tijjani, R., et al., Antinociceptive activities of the ethanolic stem bark extract of *Cordia africana* (Boraginaceae) in rats and mice. *Annals of Biological Sciences*, 2016. **4**(1): p. 6-12.
- [43] Tijjani, R., et al., Anti-inflammatory and antioxidants properties of the ethanolic stem bark extract of *Cordia africana* (Lam.). *Annals of Phytomedicine*, 2015. **4**(2): p. 83-87.
- [44] Zemichael, K., et al., Qualitative phytochemical analysis and 2, 2-diphenyl-1-picrylhydrazyl radical scavenging activity of ethanolic leaves extract of *Cordia africana* L. *Drug Invention Today*, 2019. **11**(6).
- [45] Kamau, R.W., et al., Oleanolic Acid and other Compounds Isolated from *Cordia africana* Lam which Inhibit Vancomycin Resistant Enterococcus. *Pharmacognosy Communications*, 2019. **9**(3).
- [46] Isa, A., et al., 15-lipoxygenase, bacterial inhibitory and cytotoxic activities of *Cordia africana* leaf and stem bark extracts. *Nigerian*

- Journal of Scientific Research, 2014. **13**(2): p. 32.
- [47] Isa, A.I., et al., Evaluation of anti-inflammatory, antibacterial and cytotoxic activities of *Cordia africana* leaf and stem bark extracts. *Bayero Journal of Pure and Applied Sciences*, 2016. **9**(1): p. 228-235.
- [48] Organization, W.H., *World malaria report 2015*. 2016: World Health Organization.
- [49] Zerabruk, S. and G. Yirga, Traditional knowledge of medicinal plants in Gindeberet district, Western Ethiopia. *South African Journal of Botany*, 2012. **78**: p. 165-169.
- [50] Getnet, Z., S. Chandrodyam, and G. Masresha, Studies on traditional medicinal plants in ambagiorgis area of Wogera District, Amhara Regional State, Ethiopia. *Int J Pure Appl Biosci*, 2016. **4**: p. 38-45.
- [51] Wondafrash, D.Z., et al., Antimalarial Activity of *Cordia africana* (Lam.)(Boraginaceae) Leaf Extracts and Solvent Fractions in Plasmodium berghei-Infected Mice. *Evidence-Based Complementary and Alternative Medicine*, 2019. **2019**.
- [52] Khan, S., A. Patel, and K. Bhise, *Antioxidant activity of pomegranate peel powder*. *Journal of Drug Delivery and Therapeutics*, 2017. **7**(2): p. 81-84.
- [53] Ghosh, R. and P. Deb, *A study on antioxidant properties of different bioactive compounds*. *Journal of Drug Delivery and Therapeutics*, 2014. **4**(2): p. 105-115.
- [54] Alhadi, E.A., et al., *Antioxidant and cytotoxicity activity of Cordia africana in Sudan*. *Advancement in Medicinal Plant Research*, 2015. **3**(2): p. 29-32.
- [55] Tewolde-Berhan, S., et al., *Ferric reducing antioxidant power and total phenols in Cordia africana fruit*. *African Journal of Biochemistry Research*, 2013. **7**(11): p. 215-224.
- [56] Seibert, K., et al., Pharmacological and biochemical demonstration of the role of cyclooxygenase 2 in inflammation and pain. *Proceedings of the National Academy of Sciences*, 1994. **91**(25): p. 12013-12017.
- [57] El-Shenawy, S.M., et al., Studies on the anti-inflammatory and anti-nociceptive effects of melatonin in the rat. *Pharmacological research*, 2002. **46**(3): p. 235-243.
- [58] Asase, A., et al., *Ethnobotanical study of some Ghanaian anti-malarial plants*. *Journal of Ethnopharmacology*, 2005. **99**(2): p. 273-279.
- [59] Aleme, H., Y. Awetahegne, and A. Tesfaye, *In vitro antihelmintic activities of four medicinal plants against Haemonchus contortus*. *Scientific Research Journal*, 2015. **3**(4): p. 24-27.
- [60] Asrie, A.B., et al., Antidiarrheal activity of methanolic extract of the root bark of *Cordia africana*. *Journal of experimental pharmacology*, 2016. **8**: p. 53.