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Ethno medicinal uses, phytochemistry and anti-malarial effect of *Croton macrostachyus* (Bisana): A review

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Abstract
Background: *Croton macrostachyus* Hochst. ex Del. which belongs to the family Euphorbiaceae, has been utilized as a remedy for malaria, abdominal pain, gonorrhea, wounds, ringworm infestation, hemorrhoids, ascariasis, epilepsy, rabies venereal diseases, cough, rheumatism, liver problem and other ailments in Ethiopian traditional medicines.
Objective: The aim of this review article to explore and compile the ethno medicinal uses, phytochemistry and anti-malarial activity of this plant.
Methodology: A comprehensive and systematic literature search on the following databases: Google Scholar, PubMed, Science Direct and Scopus were undertaken using the key words: *Croton macrostachyus*, ethnomedicine, phytochemistry and pharmacology so as to document this article.
Results: Next to leaf, bark is reported as remedy for a vast number of ailments among the various plant parts, in Ethiopian traditional medicine. Preliminary phytochemical qualitative tests on the different solvent crude extracts of the plant parts revealed the presence of phenolic compounds, tannins, terpenoids, alkaloids saponins, free anthraquinones, phytosterols, polyphenols and Wthanoides. Further fractionation and characterization approaches on the most biologically active crude extracts led to the isolation of many secondary metabolites from the given medicinal plant. Cyclohexane die oxides such as crotepoxide, lupeol and betulin, *cis*-clerodane, crotomacrine, 3β-Acetoxy tetraxer-14-en-28-oic acid, trachylina-19-oic acid, trachylina-18-oic acid are among the isolated compounds from various parts of *Croton macrostachyus*.
Conclusion: The present review paper has attempted to explore ethno medicinal uses, phytochemical constituents and the anti-malarial activity of one of the croton species, *Croton macrostachyus* which is native to Ethiopia and other Eastern African countries. This plant is used in Ethiopian folklore medicine for the treatment of malaria, gonorrhea, diabetes, wounds, fungal infections, helminthes and others.

Keywords: *Croton macrostachyus*, ethno medicine, phytochemistry, pharmacology, anti-malarial activity

Introduction
Malaria is a mosquito borne infectious tropical disease and the leading cause of morbidity and mortality in most developing Sub-Saharan African countries. About 78% of malaria cases occurs in the African region, followed by Southeast Asia (15%) and Eastern Mediterranean regions (5%). However it is preventable and curable, malaria remains one of the major global public health problems [1], in Ethiopia. The disease has still remained highly endemic despite the considerable achievement in delivering effective prevention and treatment interventions in recent times [2, 3]. Another challenge to the global community is that the emergence of Multi-drug resistant strains of malaria causing parasites to the available anti-malarial drugs which make the control and treatment of the disease difficult [4, 5]. Due to recurring problems of drug resistance, natural plant products are the main sources of biologically active compounds and have potential for the development of novel antimalarial drugs [4, 6].
Natural products have been playing a dominant role in drug discovery efforts for treatment of human and livestock diseases [7]. They have been important sources of different drugs currently available to treat severe *Plasmodium falciparum* malaria [8]. Artemisinin and quinine are two of the plant based anti-malarial drugs that have been developed respectively from *Artemisia annua* L. and bark of *Cinchona pubescens* Vahl [9, 10]. Medicinal plants have been used to treat malaria for thousands of years and have always been considered to be the source

of modern antimalarial drugs. Recently, herbal products are being used worldwide as home remedies and in a variety of healthcare settings [11, 12].

More than 1200 plant species from 160 families exist for treatment of malaria and fever in various countries [13]. *Croton macrostcyus* is one of these plant species which is used for the treatment of malaria and other ailments in Ethiopian traditional medicine. There exist many scientific reports on the traditional uses, phytochemistry and pharmacological activities of this plant. However, no review has ever made on this medicinal plant and the lack of scientific review motivated us to make a thorough review on its traditional uses, phytochemistry and pharmacological activities.

Vernacular Names of *Croton macrostachyus*

Croton macrostachyus, known as Broad-leaved croton in English, is named by various vernacular names in the different areas of Ethiopia.

Bissana (Amharic), Bekenisa (Oromifa), Makanissa, Badessa, Alaleh, Dogoma (G), Wush, Masincho (Sidama), Ambuk, Tambuk, Tambush, Berberi-islami (Tigrigna) [14].

Botanical Description and Distribution of *Croton macrostachyus*

The genus *Croton*, with just *a*bout 1,300 species of herbs, shrubs and trees and belonging to the Euphorbiaceae family and crotonoideae subfamily, is widely found throughout the tropical and subtropical regions of the world [15-17]. Tropical America, India, and Africa are the major centers of the croton species distribution. Great variety is reported in Madagascar, West Indies and Southern Brazil [18, 19].

Croton macrostachyus Hochst (Euphorbiaceae) commonly grows on forest edges along rivers, around lakes, woodlands, wooded grasslands, in moist or dry evergreen forests and along roadsides [20, 21]. It is a deciduous tree of East Africa having medium size mainly wide spreadbetween 200-2500 m in mountainous forests and savannah of the tropical regions and evergreen bushland areas that receive between 700-2000 mm rainfalls annually [22, 23]. *Croton macrostachyus* Delil is shrub or deciduous tree that grows up to 30 m high at an altitude of 200-2500 m a.s.l and is broadly found in Eritrea, Ethiopia, Somali, Madagascar, Kenya, Sudan, Tanzania, Uganda, and Nigeria Angola Guinea, Liberia, Malawi, Zambia and Zimbabwe [15, 24-26]. The plant is crown rounded and opens with large spreading branches and has large green leaves that turn orange before falling, with more or less furry texture and slightly toothed margin. It has creamy to yellow-white flowers on separate shoots but has green and grey fruits respectively at younger and maturation stages [27].

Ethno medicinal uses *Croton macrostachyus*

Croton plants have been used widely in folk medicine all over the world [25]. Several croton species have a long role in the traditional use of medicinal plants worldwide including Africa, Asia and South America [16], for the treatment of various diseases such as malaria, hypertension, cancer, constipation, diabetes, digestive problems, inflammation, dysentery, external wounds, fever, leukemia, balsamic, narcotic, rheumatism, leprosy, bronchitis, diarrhea, intestinal worms, psoriasis, urtcaria, hypercholesterolemia, weight loss and ulcers [20, 28-30].

Croton macrostachyus has widely utilized for the management of a large number of public health and live stock problems in Ethiopian traditional medicines. Different parts of this plant have been used as a remedy for malaria, abdominal pain, gonorrhea, wounds, ringworm infestation, hemorrhoids, ascariasis, venereal diseases, cough and rheumatism [20, 31-34]. An ethno botanical study in the Shinasha, Agew-awi and Amhara, Chilga District, and Tigray region, for example, indicated that the bark, seed, root and leaves of this plant are utilized for the management of rabies, splenomegaly, ovine pasteurellosis, epilepsy, anti-termite, hyper-blurbia [20, 35, 36].

For instance the fruit and decoction of the roots are used for the treatment of venereal diseases and the seeds are used to induce abortion [14]. The leaves are used for the treatment of malaria, constipation, tetanus, epilepsy, skin cancer and TB etc. in Ethiopia [33, 37, 38], whereas the bark of *Croton macrostachyus* is also used for the treatment of tapeworm infection syphilis, and asthma in humans [39]. The seed is used by the local population of the Bonga area of Southern Ethiopia for treatment of tapeworm infection in humans [40]. Roots are used as a remedy for helminthiasis, malaria, venereal diseases and diabetic mellitus [29]. The latex/ sap of the plants is employed for treating ringworm, wound, constipation [33, 41, 42]. A summary on the wide ethnobotanical utilization of the different parts of *Croton macrostachyus* (Del.) is given in Table 1.

Table 1: Medicinal uses of the different plant parts of the plant in Ethiopia

Plant part	Ethno medicinal uses/ ailments treated:	References
Leaf	Diarrhea, malaria, ascariasis, internal worms, chiffea, wound, gonorrhea, black leg, clotting, blood clot, stomachache, tetanus, Epilepsy, Skin cancer. Ring worm, scabies, febrile illness, head ache, infection (Arraba iddaa), liver problem, hook worm, Tinea corporis (robi), Biduu, Qurumbaa, STI in males, Mitch/Fever, Leeches, poisoning, Tuberculosis	[20, 33, 37, 38, 41-47]
Leaf/bark	Malaria	[20]
Root	Malaria, evil eye	[20, 47]
Leaf/Stem bark	Wound	[20]
Stem	liver problem, ascariasis	[37]
Root bark	Rabies	[20]
Bark	Rabies, gonohrhea, wound, ascaries, black leg, tape worm, Jaundice, stomachache, STI in males, Heart disease, elephantiasis, abdominal Problem	[41, 42, 45-47]
Shoot	Malaria	[43]
Latex /Sap	Ringworm, wound, constipation	[33, 37, 41, 42]
Seed	Abortion	[14]

Phytochemistry of *Croton macrostachyus*

Qualitative Phytochemical Analysis: General Phytochemical tests are useful in the preliminary screening of the biologically active chemical compounds in medicinal plants despite limitations in specific tests [48], and are also carried out in order to establish associations between pharmacology and chemistry of the plants [49]. Phytochemical studies indicated that the Croton plants are endowed with

many classes of secondary metabolites mainly alkaloids, flavonoids, terpenoids and essential oils such as mono and sesquiterpenoids [25, 29]. Of these, terpenoids are the predominant secondary metabolite constituents in the genus chiefly diterpenoids, which belongs to the neoclerodane, clerodane, kaurane, phorbol, labdane and trachylobane skeletal types [23, 29]. Further fractionation of the biologically active crude extracts of the plant parts of many croton species has afforded the isolation and characterization of specific compounds which belong mainly to the groups of alkaloids, flavonoids and terpenoids [30, 50].

Secondary metabolites from *Croton macrostachyus*: Preliminary phytochemical screening showed the existence of secondary metabolites such as phenolic compounds, tannins, terpenoids, alkaloids, saponins, free anthraquinones, phytosterols, polyphenols and wthanoides [36, 51-53]. The detailed major secondary metabolites contained in the different types of solvent extracts/ fractions of the plant parts are indicated in Table 2.

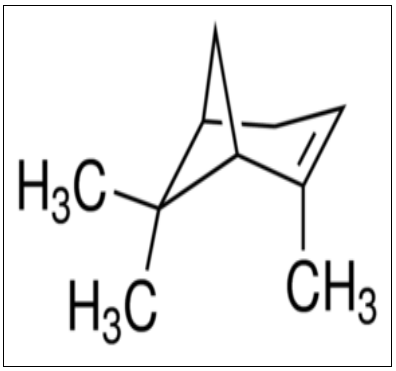
Table 2: *Croton macrostachyus'* phytochemical constituents

Plant part used	Type of extract/fraction	Phytoconstitutents in each extract	Reference
Berries	Pet ether Chloroform Methanol	Terpenes withanoids, steroids *Polyphenols* alkaloids, saponins, polyphenols, flavonoids	[53]
Root bark	Pet ether Chloroform Methanol	Terpenes, withanoids, steroids, alkaloids, polyphenols, flavonoids	[53]
stem bark	Pet ether Chloroform Methanol	Coumarins, Withanoids, steroids Flavonoides, terpenes, Alkaloids, saponins, Polyphenols	[53]
Root	Methanol	Phenolic compounds, tannins, terpenoids, alkaloids saponins	[36]
Fruit	Methanol	phenolic compounds, tannins, terpenoids, alkaloids saponins	[36]
Leaf	Ethanol, Water, methanol, Chloroform fraction	Flavonoids, saponins, free anthraquinones, phytosterols, polyphenols, tannins, alkaloids steroids, terpenoids; cardiac glycosides	[15, 51, 54, 55 26, 53]
Seed	Aqueous, Methanol (80%)	*Polyphenols, Flavonoids, Alkaloides Phytosteroides and Wthanoides*	[52]

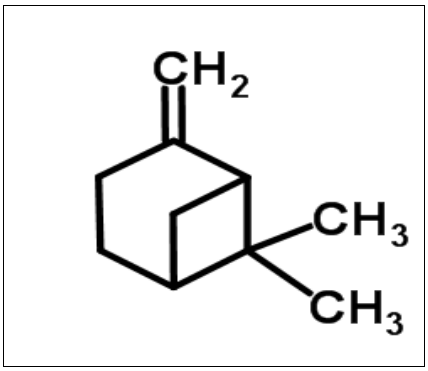
Isolated/Identified Compounds from *Croton macrostachyus*

Further fractionation and characterization approaches on the most biologically active crude extracts led to the isolation of many secondary metabolites from the given medicinal plant. Cyclohexane diepoxides such as crotepoxide, lupeol and betulin, *cis*-clerodane, crotomacrine, 3β-Acetoxy tetraxer-14-en-28-oic acid, trachylina-19-oic acid, trachylina-18-oic acid are among the isolated compounds from various parts of *Croton macrostachyus*.

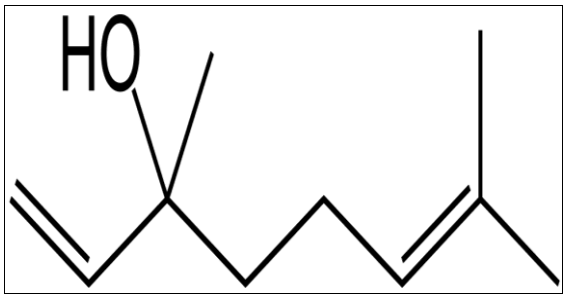
Results of GC/MS analysis revealed that 31 compounds accounting for 98.4 % of the total oil were identified from the essential oils of Croton macrostachys. A GC/MS quantitative study based on the peak area also indicated that the benzyl benzoate comprised 51.46 % of the oil of Croton macrostachys followed by γ-muurolene (11.98 %), linalool (10.06 %) and α-farnesene (3.21 %). The oil contained phenololic esters (51.46 %), sesquiterpene hydrocarbons (17.57 %), oxygenated monoterpene (10.81 %), oxygenated sesqueterpenes (8.58 %) and monoterpene hydrocarbons (1.09%).[53] Some of the identified constituent essential oils from *Croton macrostachyus* include Heptyl acetate, α-Terpineol, 4-Terpineol, Isocaryophyllene, γ-Muurolene, α-Farnesene, α-Cadinol and Benzyl benzoate, Alpha-pinene, β-Pinene, Linalool, and others. Their respective chemical structures are shown in Figure 1.



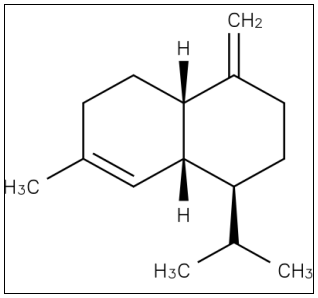
Alpha-pinene



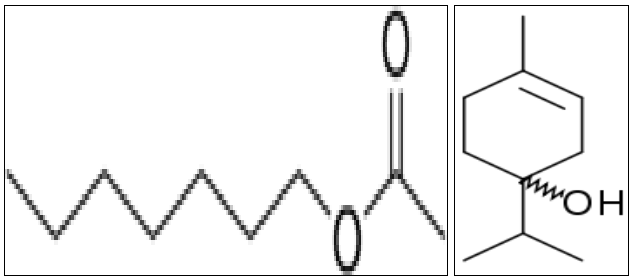
β-Pinene



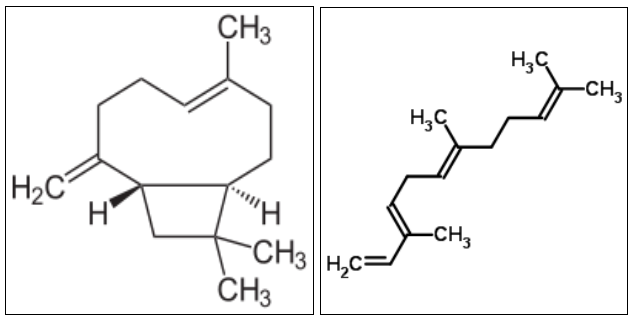
Linalool



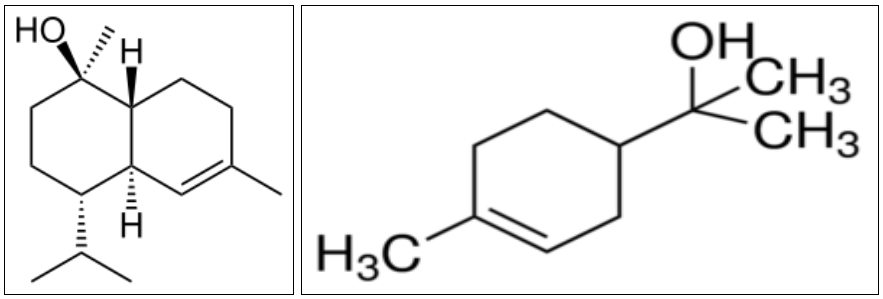
γ-Muurolene



Heptyl acetate 4-Terpineol



Isocaryophyllene α-Farnesene



α-Cadinol α-Terpineol

Fig 1: Chemical structures for identified constituents from Essential oils of *Croton macrostachyus*.

A study [54] isolated two compounds using Silica gel column chromatographic separation of the crude ethanolic leaf extract and complete characterization of one the compounds using NMR and IR spectroscopy provides the structure shown in Figure 2 below. With previous spectroscopic data and comparison with literature, the compound was found to be a pentacyclic triterpeniod. He also isolated a compound with pale yellow crystalline powder with Rf value of 0.58 (40% ethyl acetate in chloroform as eluent). This compound has a total of around sixty carbon atoms peaks of which one carbonyl carbon multiple aromatic and aliphatic carbons but its structure was not elucidated from spectroscopic data obtained.

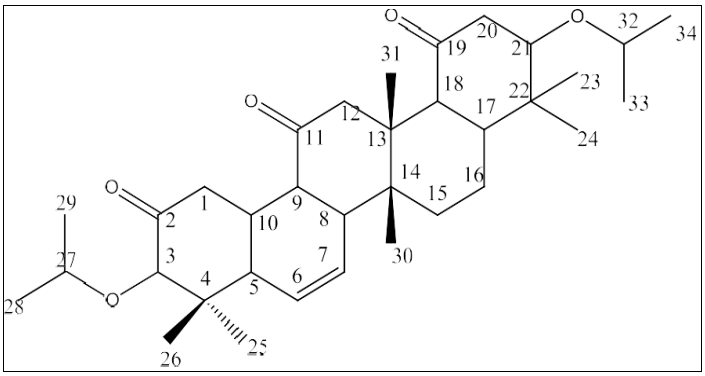


Fig 2: Structure of compound 1

Large of compounds were isolated from the different parts of this medicinal plant. A compound, Crotepoxide, was isolated from the berries of *Croton macrostachyus* by subjecting its chloroform extract to column chromatography separation using an eluting solvent mixture of chloroform and ethyl acetate. This compound has anti-leishmanial activity. The isolated compound was characterized using different spectroscopic techniques and was found to depict the structure in Figure 3, below [56].

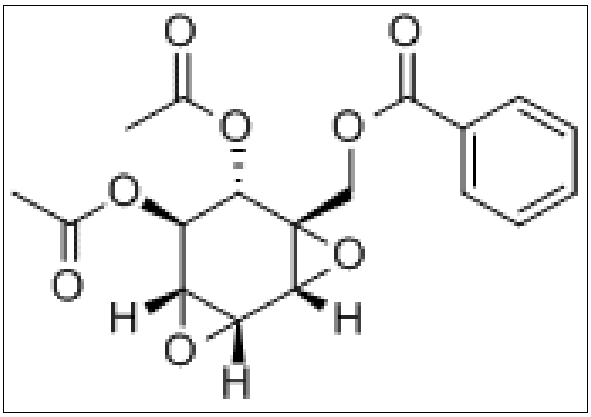
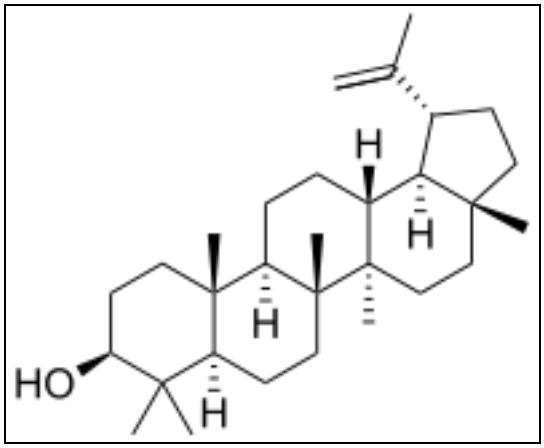
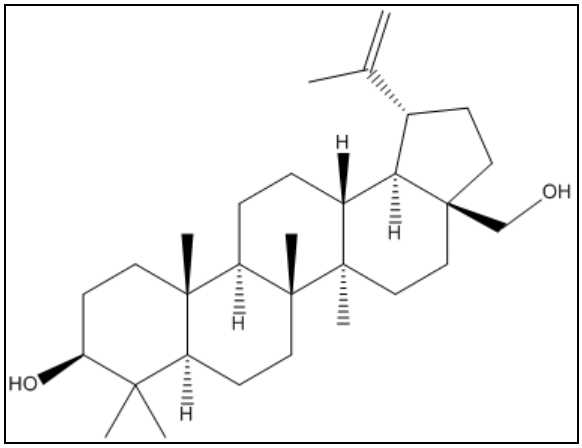


Fig 3: The chemical structure of crotepoxide.

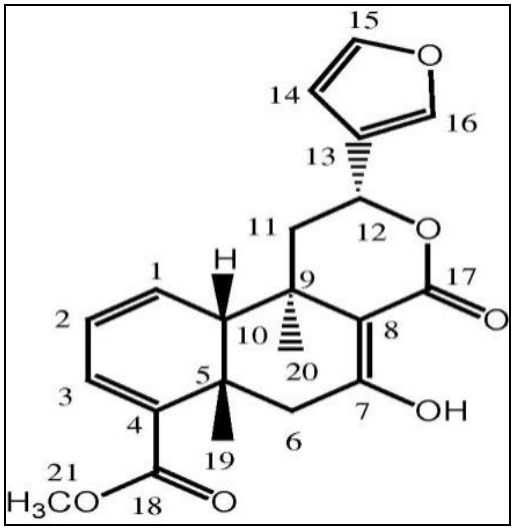
Crotomacrine and Crotepoxide from the fruits or berries [56, 57], Lupeol from the root bark and other compound such as 3α, 18, 19-trihydroxy trachylobane, Trachyloban-19-oic acid; Neoclerodan-5, 10-en-19, 6β, 20, 12-diolide, Trachyloban-18-oic acid, 3α, 19-dihydroxy trachylobane etc… from the root are some of the terpene compounds which had been isolated from *Croton macrostachyus* (Bisana) [22, 58]. Following are the proposed chemical structures for some of the isolated compounds from the various parts of the plant (Figure 4).



Lupeol



Betulin



Crotomacrine

Fig 4: Proposed structures for some isolated compounds of *Croton macrostachys*

A phytochemical investigation on the dichloromethane (DCM) stem bark extract of *Croton macrostachyus* has afforded the isolation and characterization of two terpenoid compounds for the first time [29]. A similar study also revealed the presence of a triterpenelupeol from Ethylacetate extract as well as its fraction in the stem bark of the plant [16]. This compound has proven to have broad antimicrobial activity against several major human pathogens such as E.coli, S.typhi, K.pneumoniae, and C.albicans with a novel finding against E.aerogenes and L. monocytogenes. Some compounds isolated from the different parts of *Croton macrostachyus* are shown the Table 3.

Table 4: List of chemical constituents isolated from *Croton macrostachyus*

Sources	compound name	Reference
Stem bark	CM-1(Not stated)	[29]
Stem bark	CM-2 (Not stated)	[29]
Root	Neoclerodan-5,10-en-19,6β, 20, 12-diolide 3β-acetoxy tetraxer-14-en-28-oic acid Trachyloban-19-oic acid Trachyloban-18-oic acid 3α, 18,19-trihydroxy trachylobane 3α, 19-dihydroxy trachylobane	[22]
Root bark	Lupeol	[58]
Fruits	Crotomacrine	[57]
Fruits	Crotepoxide	[57]
Leaves	Methyl laurate	[27]
Leaves	Creptoxide	[27]
Leaves	CM-3 [figure 2]	[54]
Berries	Creptoxide	[59]
leaves	Crotomachlin	[50]
	Crotepoxide, Crotomacrine, Floridoline, Hardwickiic 12-Oxo-hardwickiic acid	[50]

CM-1: Compound 1, CM-2: Compound 2, CM-3: Compound 3

Pharmacological Properties of croton marostachyus

A survey of many published papers in peer-reviewed journals revealed that the various plant parts of *Croton macrostachyus* in different extracting solvents (in crude extract / fraction forms) have been evaluated in animal models and found to possess diverse medicinal properties that can support its ethno medicinal uses. A number of pharmacological studies confirmed the anthelmintic activity of the aqueous and 80% methanol crude extracts of the plant seeds on the egg and adult stage of *H. contortus* [60], the analgesic and anti-inflammatory effect of the aqueous and methylene chloride/methanol stem bark extracts [61], antimicrobial and antifungal activities of methanol and dichloromethane extracts of the leaves and stem [62, 63], antibacterial activities [64] and antileishmanial activities [53] of the essential oils of the plant. There also existed study reports that stated larvicidal activity [65], molluscicidal activities [66-68], antimicrobial[69] and anticonvulsant [70], mitogenic activity on human lymphocytes and mice spleen lymphocyts [71] of various crude extracts of *Croton macrostachyus*. The plant could significantly have delayed diarrheal onset, decreased stool frequency and weight of feces and also shown a decline in the weight and volume of intestinal contents with its chloroform and methanol fractions at at a dose of 300, 400, 500 mg/kg 400 & 500 mg/kg respectively. Moreover, the fractions produced a significant anti-motility effect in castor oil induced diarrhea mice model [15]. These and other pharmacological activity evaluation reports that support many of the traditional claims and uses of the plant in the ethno medical systems of different countries of the world are illustrated in Table 4./D.

Table 4: List of the Medicinal activities of the plant materials

Plant parts	Therapeutic activity	Resulting effect	Reference
Leaf	larvicidal	Methanol leaf extract exhibited larvicidal activity against late third instar larvae of An. arabiensis	[65]
Stem bark	Antimicrobial	The methanol, ethyl acetate, butanol extracts stem bark, the isolated compound, lupeol show promising antimicrobial agent against several important human pathogens, with the highest scale seen in the ethyl acetate extract	[16]
Root	Anti-diabetic activity	The hydro alcoholic root extract had shown a significant blood glucose lowering effect and improved glucose tolerance after administration of oral glucose solution	[72]
Leaf	Anti-diabetic activity	Treatment of diabetic mice with doses of the leaf extract resulted in significantly (p<0.05) lower levels of fasting blood glucose. The effects of the leaf extract were comparable with the conventional drugs.	[73]
Leaf	Antibacterial activity	The methanol and ethanol leaf extracts antibacterial activity while the aqueous extracts were comparatively ineffective.	[74]
Leaf	Antibacterial activity	The extracts of ethanol, methanol and chloroform showed antibacterial activity against all studied bacterial strains with the highest antibacterial inhibition was observed in crude chloroform extract	[75]
Leaf	wound healing potential	The methanolic extract enhanced wound healing significantly in rats.	[51]
Leaf	Anti-diarrheal activity	Both the chloroform and methanol fractions produced significant anti-diarrheal activity on castor oil induced diarrhea at all tested doses, but the aqueous fraction did not	[15]
Leaves	Against-gonorrhoeae and Mycobacterium tuberculosis	The hydroalcoholic extract has shown promising activity against Neisseria gonorrhoeae and Mycobacterium tuberculosis	[76, 77]
berries	Anti-leishmanial activities	Crotepoxide, isolated from the DCM berries extract using CC is less active as compared to the reference antileishmanial drugs (amphotericin B and miltefosine).	[59]
Stem bark	Anti-nociceptive, anti-		[78, 79]

	inflammatory activities		
	analgesic and anti-inflammatory	The aqueous and methylene chloride/methanol extractsshowed promising activities	
bark	anti-convulsant and sedative	decoction	[70]
seed	Anthelmintic activity	Both aqueous and 80% methanol extracts produced complete egg hatch inhibition at concentration less than or equal to 2 mg/ml. Show significant activity on the egg and adult stage of *H. contortus*.	[60]
Leaf and fruit	Anti-oxidant activity	Methanol extract of leaves and benzene and methanol extracts of fruits exhibited a noteworthy DPPH radical scavenging activity compared to standard. Ascorbic acid.	[80]
Root	Anti-oxidant activity	The methanol extract had the highest antioxidant property compared to other fractions.	[81]

Toxicity/ safety data

An acute toxicity study reported the absence of any detectable signs of toxicity such as hair erection, lacrimation, diarrhea, loss of appetite, tremors, and salivation. It also revealed no recorded death of the test mice, at the limit dose of 2000 mg/kg of the 80% methanolic fruit and root extracts within the first day and the next fourteen days of the experiment [36]. Similarly, the aqueous and methanol leaf extracts of the plant showed no gross physical and behavioral changes including, [rigidity, sleep, diarrhea, depression, abnormal secretion and hair erection for 24 hours] and mortality within the first 24 h as well as for the following 14 days [4]. This suggests that LD_{50} of the extract is greater than 2 g/kg [4, 8, 36].

In another sub-acute toxicity study, no mortality was observed in methanol and water extracts at a dose of 2000mg/ kg of body weight. There was also no significant difference observed on hematological parameters of PCV and Hb and in the body weight of animals treated with both extracts and control group [4]. Thus, all the above studies declare the nontoxic nature of this medicinal plant.

Anti-malarial activity profiles

The leaf, fruits, root and bark of *Croton macrostachyus* are reported to treat malaria in Ethiopia ethno medicine [20, 28, 54]. Accordingly, Crude extracts as well as fractions of the stated parts of the plant in various extracting solvents, have been investigated both *in vitro* and *in vivo* for their antimalarial activities.

An *in vitro* anti-malarial study by Sorsa *et al*. [82] indicated that *C. macrostachyus* has shown a substantial anti- malarial activities against *P. falciparum* with IC_{50} value 0.94 µgm/mL with methanol extracts of its fruits. Another *in vitro* study conducted on Croton zambesicus which is taxonomically related to *Croton macrostachyus* in Cameroon showed a remarkable antiplasmodial activity on *P. falciparu* [83]. Moreover, *Croton macrostachyus* was also screened for its larvicidal activity against late third instar larvae of *Anopheles arabiensis* with $LC5_0$ and LC_{90} values of 89.25 and 224.98 ppm respectively [65].

An *In vivo* antimalarial study showed a significant suppressive effect of methanol extract of *Croton macrostachyus* fruit against *P. berghei* [84]. An *invivo* antiplasmodial activity study by [36] demonstrated that both the 80% methanol root extract and fruit extract of *Croton macrostachyus* suppressed dose dependently *P. berghei* parasitaemia significantly (P<0.001) in rodent model with a maximum inhibition in the root extract treated mice (89%), followed by the fruit extract(87%)< at the highest dose of 600mg/kg body weight. Both extracts, at all doses, showed a significant increase in the survival time despite the better suppressive activity and greater survival time of root extract. Furthermore, both types of extracts prevented the reduction in body weight and in rectal temperature at doses all doses, but increase in body weight by fruit extract is not a function of concentration. However, neither of the extracts prevented the reduction of PCV significantly, compared to the negative controls. The fruit extract and the root extract from dose range of 200 to 600 mg/kg body weight, respectively produced 36 to 83% and 43 to 88% inhibition of parasitemia in the curative test.

Moreover, the methanol and aqueous extracts of *Croton macrostachyus* leaves resulted in chemo suppressive effect in a dose dependent manner in Plasmodium berghei infected mice while the mice treated with chloroquine was totally free from the parasites on the last day in the entire experiments. Without significantly improving survival time, Both the crude aqueous and methanol extracts of *Croton macrostachyus* significantly suppressed (P<0.05) parasitaemia at all dose levels compared to the negative control groups. The aqueous extracts, however, had better parasitaemia suppression (P<0.05) than the methanol extract. Further PCV and body weight measurements on day 4 also revealed that significant reduction in PCV(p<0.05) and insignificant change($p > 0.05$) in body weight were seen for all groups for the methanol and aqueous leaf extracts of *Croton macrostachyus* as compared with day 0 [4].

A similar study also revealed that C. macrostachyus crude leaf extract and solvent fractions of aqueous, methanol, and chloroform showed 44 to 91 and 12 to 76% parasitemia suppressive effect respectively, in P. berghei-infected mice in a 4-day suppression test. The inhibitory activity was dose-dependent (200, 400, and 600 mg/kg body weight for all extract), with potency being lower than chloroquine (100% suppression) [8]. Similarly, the curative effect of the crude extract and chloroform fraction was in the range of 39 to 83 and 66 to 82%, respectively, for all the three dosage regimens in this study. The crude extract as well significantly prevented body weight loss and temperature reduction, however, it did not affect PCV of the experimental mice as compared to the control group. Besides, all doses of the chloroform fraction significantly prevented the reduction in rectal temperature and packed cell volume (PCV) reduction.

Conclusion

The present review paper has attempted to explore ethnomedicinal uses, phytochemical constituents and the anti-malarial activity of one of the croton species, croton macrotachyus which is native to Ethiopia and other Eastern African countries. This plant is used in Ethiopian folklore medicine for the treatment of malaria, gonorrhea, diabetes, wounds, fungal infections, helminthes and others.

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