The aphrodisiac herb *Carpolobia*: A biopharmacological and phytochemical review

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ABSTRACT

Any agent with the ability to provoke sexual desire in an individual is referred to as an aphrodisiac. Aphrodisiac plants are used in the management of erectile dysfunction (ED) in men. One such plant popular in West and Central Africa among the Pygmies of Cameroon, Ipassa of Garbon, and the Yoruba, Ibo, Efik and Ijaw peoples of Nigeria is *Carpolobia*. It is an accepted and commonly utilized herbal booster of libido. It is used to cure male infertility and to boosts libido thereby augmenting male sexual functions or it is used to induce penile erection, and enhance male virility. The chewing stick prepared from the stem and root of either *Carpolobia alba* (CA) or *Carpolobia lutea* (CL) is patronized because it boosts male sexual performance. The genus *Carpolobia* has over 14 species. The leaf essential oil contains a variety of terpenoids, while polyphenols and triterpenoid saponins have been isolated from the root and leaf extracts respectively. Other ethnomedicinal uses include curing of stomach ailments, rheumatism, fever, pains, insanity, dermal infection, venereal diseases; to promote child birth; and as a taeniafuge and vermifuge. In spite of its popularity, no scientific data reviewing the biopharmacological and phytochemical activities of *Carpolobia* exist to our knowledge. The aim of this work is to collate all available published scientific reports in the literature on *Carpolobia* in a review paper. In this review, an overview of the morphology, taxonomy, ethnomedicinal claims, geographical distribution, and structurally elucidated compounds that are secondary metabolites isolated and characterized from *Carpolobia* species is established. The pharmacological assays, phytochemical screenings, and toxicological reports are also reviewed.

Key words: *Carpolobia*, C*arpolobia alba*, *Carpolobia lutea*, ethnopharmacology, phytochemistry

INTRODUCTION

The plant kingdom is an inexhaustible resource, exploited since antiquity for therapeutic remedies. This is possible through the utilization of qualitative ethnobotanical data, which provide ethnopharmacological leads.[1] Most chemical entities from combinatorial and computational chemistry have their origin in molecules from the plant kingdom. Herbal formulations are ubiquitous as health care products and are the most patronized resource in developing countries due to their proven safety, inexpensiveness, efficacy, and availability. Globally, many medicinal plants with PDE-5 inhibitors or aphrodisiac activity have been reported.[2,3] Many plants with aphrodisiac potential have been reviewed in West and Southern Africa.[4,5] One such plant, named in many reports, is *Carpolobia* of the Polygalaceae family, more particularly the two species *Carpolobia alba* (CA) and *Carpolobia lutea* (CL).[6-8]

Polygalaceae, the "milkwort" family, belongs to the order Fabales and has over 800 species distributed in 12-20 genera.[9] Extensive phylogenetic analysis of Fabales has revealed interfamilial relationships and patterns of floral evolution;[10] the roles of biotic and abiotic factors in the evolution of ant dispersal in the milkwort family has been reported.[11] The Polygalaceae family is divided into three tribes: Xanthophylleae, Moutabeae, and Polygalae; Polygalae is the most important because it is a well-researched genus and represents about half of the members of this family. The genus *Polygala* has a cosmopolitan geographical distribution except in New Zealand, Polynesia, and the Antarctic zone; Polygalaceae from West and Southern Africa belong to the genera *Atroxima*, *Polygala*, *Carpolobia*, *Muraltia*, and *Securidaca*.[9] A review of the chemistry and the biological activities of Polygalaceae saponins have been reported.[9]

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CARPOLOBIA

The genus *Carpolobia* is well-known across West and Southern Africa; it has over 14 species. They are *Carpolobia afzeliana*, CA, *Carpolobia caudate*, *Carpolobia conradsiana*, *Carpolobia delvauxii*, *Carpolobia dubia*, *Carpolobia glabrescens*, *Carpolobia goetzei*, *Carpolobia leandriana*, CL, *Carpolobia macrostachya*, *Carpolobia suaveolens*, *Carpolobia versicolor*, and *Carpolobia zenkeri*.[12] Ten of these species are native to tropical West Africa.[12] Of all these species, only two species, CA and CL, have been pharmacologically and phytochemically investigated and reported. CA from natural forest habitat is shown in Figure 1a and the flower is shown in Figure 1b.

Carpolobia is a popular aphrodisiac herbal medicine, and various studies reporting on the plant have described the following activities: curing male sterility; increasing libido; induction of penile erection; enhancement of aphrodisiac prowess; enhancement of virility and male fertility; and augmentation of male sexual functions.[6,8,13-16] Terpenoids from the leaf essential oil of CL,[17] polyphenols from the leaf,[17] and triterpenoid saponins from the root[18] have been isolated.

Biodiversity surveys indicate that CA and CL shrubs are native to West and Central Africa.[14,15,19-23] Among the Pygmies of Cameroon, Ipassa of Garbon; and the Yoruba, Ibo, Efik, and Ijaw peoples of Nigeria, *Carpolobia* is patronized for its effect of boosting libido.[14,15,17] The chewing sticks prepared from the stem and root of CA and CL are expensive because men use them to boost their sexual performance. In addition, the stem bark is used to cure headaches and general pain, and to stave off sleepiness due to fatigue. To release its aphrodisiac power, the root is soaked in water for a week and ingested. Though *Carpolobia* is a popular aphrodisiac, there are no scientific data reviewing reports of its biopharmacological and phytochemical properties.[9]

To execute this review, books, postgraduate theses, graduate dissertations, and peer-reviewed journals were consulted. Besides, systematic database searches of SCOPUS, ScienceDirect, PubMed, Web of Knowledge, Science Citation Index, Google Scholar, and MEDLINE were conducted using keywords such as "aphrodisiacs," "erectile dysfunction," "infertility," "fertility," and "sterility" in relation to "*Carpolobia*," "CA", and "CL" for the last 15 years, and they formed the basis of the current analysis. The aim of this work is to collate all available published scientific reports in the literature on *Carpolobia* in a review paper.

GEOGRAPHICAL DISTRIBUTION

Carpolobia biodiversity is found in the Republic of Sierra Leone, Liberia, Republic of Côte d'Ivoire, the Republic of Ghana (formerly the Gold Coast), Togo, Southern Nigeria, the Republic of Benin (Dahomey), and Cameroon (British Cameroons). CL is a small tree distributed in West and Central tropical Africa. It grows in rainforests and the Guinea Savannah area from Sierra Leone to Cameroon between April and September. CL is called "cattle stick" (English), "*Ikpafum*" (Ibibio), "*Agba*" or "*Angalagala*" (Igbo), and "*Egbo Oshunshun*" (Yoruba) in Nigeria.[24]

Morphology characteristics, and ethnomedicinal and ornamental uses

Morphology

It occurs as a dense overgrowth, an evergreen shrub, or a small tree, up to 5 m high. The leaves are 2-7.5 cm long and 1-2.8 cm broad; branches and midrib densely pubescent; lamina variable in shape, being ovate, ovate-elliptic, oblong or narrowly elliptic, obtuse or rounded, more or less parallel, and rather close. The flower is zygomorphic, often brightly colored. The keel petal is about 16 mm long, 3-4 mm broad, and broader than that of the other petals, while the outer 3 sepals are 2-5 mm long and 3-5 mm broad; they are smaller than the two inner sepals, which are 6-7.5 mm long and 3-6 mm broad. Racemes contain 1-2 flowers. The fruit is freshly yellow or red; the seed is very densely villous, with copious fleshy endosperm.

Ethnomedical uses

The root is reported to have aphrodisiac properties.[25] It has androgenic properties; it is used as an analgesic and to cure rheumatism, fever, insanity, dermal infections, venereal diseases, and sterility; it is used to facilitate child birth; it is also used as a taeniafuge and vermifuge.[16,24,26] The stem bark is dried and taken as snuff to cure migraine headache.[27] The leaf, according to ethnomedicinal reports, has the following uses: anti-inflammatory and antiarthritic,[28] and effective in treating diabetes mellitus, managing fever accompanying diarrhea, headache, leprosy, snakebite, venereal disease, and wounds.[20] The root is used to facilitate childbirth; treat sterility, headache, and worm infestation; and as an aphrodisiac and stimulant.[18] The root of CA is used in traditional medicine as an aphrodisiac and as a vermifuge, and, when mixed with other plants, utilized against miscarriage and poisoning and to preserve one from evil spirits and spells.[18]

Ornamental uses

The stem is used as a chewing stick for oral hygiene.[21] The use of the plant's root and stem in the form of chewing sticks is popular among men due to its aphrodisiac effects in the Efik area of Nigeria. The chewing stick is chewed at night before going to bed. The sapling of the stem makes a good working stick; because of the resilience of the woody stem, it is used by cattle herders to control their cattle heads, and also as material for a sweeping implement ("*indiyan*") in the Efik area of Nigeria.[24]

Phytochemistry, phytochemical screenings, and isolated compounds

The chemical screening of the stem revealed the presence of tannins, saponins, flavonoids, cardiac glycosides, and anthraquinones.[21] Alkaloids in detectable quantity, saponins, and cardenolides were detected in the plant extract.[29] Phytochemical screenings confirmed the presence of tannins, saponins, and flavonoids.[30] The phytochemical screening of the methanolic root of CL revealed the presence of saponins, anthraquinones, flavonoids, cardiac glycosides, simple sugars, and terpenes; it was found to be devoid of alkaloids and tannins.[31,32] The

Figure 1: (a) *Carpolobia lutea*. from forest natural habitat. (b) Flower of *Carpolobia lutea* G. Don(Abstracted from "Aphrodisiacs from Around the World" (juanwhite.com). Original illustration from flower wholesaler trade association

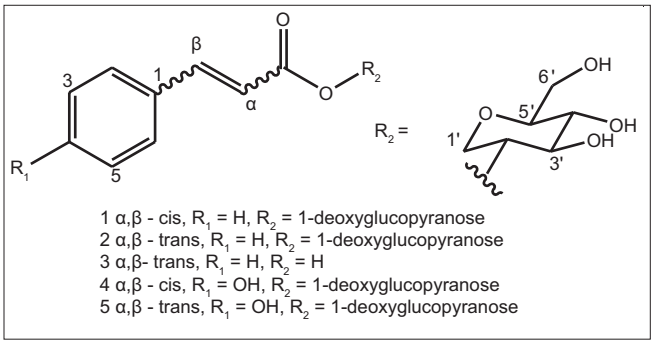

Figure 2: Structures of isolated compounds from *C. lutea* ethyl acetate leaf fraction

preliminary phytochemical screening of CL ethanolic leaf extract revealed alkaloids, saponins, tannins, anthraquinone, cardiac glycosides, and flavonoids.[33] Phytochemical screening of the root methanolic extract revealed the presence of tannins, saponins, flavonoids, cardiac glycosides, anthraquinones, and terpenes; alkaloids were absent.[34]

The hydrodistillation of the leaf using a Clevenger-type apparatus afforded a yield of essential oil (0.06-0.10%), which contained terpenoids, hexahydro farnesyl acetone, (E)-geranyl acetone, (E)-2-decenal, farnesyl acetone, germacrene B, and α-calacorene.[7] Chromatographic fractionation of the ethyl acetate fraction (EAF) afforded two new cinnamonyl 1-deoxy-glucopyranosides (1 and 2) and two new *p*-coumaroyl 1-deoxy-glucopyranosides (4 and 5), besides cinnamic acid (3) [Figure 2].[17] Three new acetylated triterpene saponins were isolated from the roots of CA and CL.[19]

Pharmacological screening

Aphrodisiac activity

Yakubo and Jimoh[6] reported that the aqueous extract of CL root restored sexual function in the case of paroxetine-induced sexual dysfunction in sexually active male rats. The male sexual behavior parameters, that is, frequencies of mounting (MF), intromission (IF), and ejaculation (EF), latencies of mounting (ML), intromission (IL), and ejaculation (EL), and postejaculation interval (PEI), had been completely attenuated by paroxetine but were significantly restored by the aqueous root extract. The low levels of luteinizing hormone, follicle-stimulating hormone, and male hormone (testosterone) in sexually sluggish rats induced by paroxetine were elevated following the subchronic administration of the aqueous root extract of CA by Yakubo and Jimoh.[6] CA aqueous root extract has been reported to boost male reproductive sexual function in rats by increasing testosterone following chronic administration.[8] These findings corroborate the ethnomedicinal use of the root of CA or CL as bedtime chewing sticks.

Fertility, contraceptive, estrogenic, and antiestrogenic activities

The combination of CA plus *Basella alba* extracts was observed to protects against maneb-induced infertility in male rats.[13] Ettebong *et al.*,[32] investigated the contraceptive, estrogenic, and antiestrogenic potentials of the methanolic root extract of CL in rodents and reported a contraceptive effect in both mice and rats for two gestational periods. The investigations of the estrogenic and antiestrogenic properties of the extract revealed that in ovariectomized, immature young rats, the extract showed estrogenic effect (vaginal opening, vaginal cornification, and increased uterine wet weight) in low doses, while the extract showed antiestrogenic effect in high doses. These findings agree with the traditional use of CL in controlling fertility.

Antimicrobial activity

The plant extract was reported to be antimicrobially active against *S. aureus* NCTC 6571, *B. subtilis*, *Escherichia coli* NCTC 9001, *Pseudomonas aeruginosa* NCTC 6570, *Aspergilus niger*, and *Candida albicans* at concentrations of 10-100 mg/mL.[29] Ettebong and Nwafor[31] observed that the methanolic root extract of CL was more active against Gram-positive than Gram-negative bacteria, with the ethyl acetate root extract exhibiting the widest zone of inhibition (21.0 mm), followed by chloroform extract when tested on *E. coli*. No inhibitory effect against *Pseudomonas aeruginosa* or the fungal strains of *Candida albicans* and *Tinea capitis* was observed from the work of Ettebong and Nwafor.[29] The most potent of the extracts they observed was the chloroform extract, with a minimum inhibitory concentration (MIC) of 25 mg/mL for bacteria. Nwidu *et al.*[35] revealed in their study that the MIC of the various fractions and extracts of the leaf, stem, and root when tested; the order of susceptibility of the tested organisms is *B. subtilis* > *C. albicans* > *E. faecalis* > *E. coli* > *S. aureus* = *P. aeruginosa* = *H. pylori*. For *B. subtilis*, the order of activity of MIC of the plant parts is root > stem > leaf.

Antidiarrheal and antiulcer activity

The leaf ethanol extract of CL shows antidiarrheal and antiulcerogenic potential: In particular, dose-dependent gastroprotective and antidiarrheal effects in rodents.[30] The gastroprotective effects of the leaf were more pronounced from the ethyl acetate extract than the *n*-hexane, chloroform, and ethanol leaf fractions of CL,[,33] and the ethyl acetate fraction showed dose-dependent effects in all models of antiulcer activity as investigated in rats with the leaf extract[36] and the stem extract.[37]

Antiparasitic activity

The CL aqueous extract demonstrated *in vitro* antiparasitic effects against *Trypanosoma brucei brucei* (strain 427) (Tbb) and on the promastigotes of *Leishmania mexicana*.[38] In terms of antimalarial activity, it was observed that the best growth inhibition of both strains of *Plasmodium falciparum* resulted from dichloromethane extracts of the leaves and twigs of CL. The cytotoxicity evaluation using the J774 and WI38 cells lines (IC_{50} > 50 g/mL) indicated that CL leaves and twigs were moderately toxic.[39] Okokon *et al.*[40] investigated the antiplasmodial potential of the crude leaf and root extracts and fractions of CL *in vivo* in *Plasmodium berghei berghei*-infected mice. The leaf and root ethanolic extracts of CL showed significant antiplasmodial activities both in the 4-day early infection test and in established infections, with a considerable mean survival time comparable to that of the standard drug, chloroquine. The root extract and fractions also demonstrated promising blood schizontocidal activity in early and established infections. These plant extracts and fractions show considerable antiplasmodial properties, which justify their use in ethnomedicine and can be exploited to control the spread of malaria.

Analgesic, anti-inflammatory, and antipyretic activities

In a phytotherapeutic profile report on some Nigerian herbs, CL was reported to have anti-inflammatory and antiarthritic properties[28] The analgesic properties of the aqueous root extract in rodents produced significant antinociceptive stimuli[17,34] when evaluated using the tail-flick test, acetic acid-induced abdominal constrictions, formalin-induced hind paw licking, and the hot-plate test. The fractions (ethanol, ethyl acetate, chloroform, *n*-hexane) and the crude ethyl acetate extract of CL led to significant inhibition of both phases of formalin-induced pain in mice; a reduction in acetic acid-induced writhing as well as an elevation of the pain threshold in the hot-plate test in mice with effects greater than those produced by indomethacin was observed. Nwidu and Nwafor[41] assessed the anti-inflammatory and antipyretic effects using acute anti-inflammatory and antipyretic models. All the fractions were found to induce significant inhibitory effects on the acute phase of inflammation with formalin, egg albumin, capsaicin-induced edema, and xylene-induced ear edema, as well as in carrageenan-induced paw edema in rats, whereas in the antipyretic model, significant inhibition of pyrexia was observed in 2,4-dinitrophenol but not in yeast-induced-pyrexia or on normal body temperature of the rats.

Antioxidants, ionic, and amino acid profile

Nwidu *et al.*,[42] observed minimal radical-scavenging activity in a spectrophotometric assay using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) of all the leaf and stem fractions investigated. The elemental profile was established by the inductively coupled argon-plasma emission spectrometer and the ionic analyses by potentiometric titration, which revealed the most abundant cations in the aqueous leaf extract to be potassium and phosphorus, while the most abundant anion was phosphate. But higher values of potassium, phosphorus, sulfate in the leaf and a lower amount of sulfate ions were observed in the stem extract.[37] Amino acid analysis by cation-exchange chromatography with automated amino acid analyzer revealed proline, alanine, serine, valine, glycine, glutamate, and lysine in the ethanol fraction, and lysine, phenyl alanine, glycine, and serine in the ethyl acetate fraction, but not in the nonpolar fractions *n*-hexane and chloroform. The ethyl acetate fraction indicated an abundant amount of lysine, phenyl alanine, glycine, and serine compared to the other leaf fractions. The pH of the aqueous leaf extract is 3.17 ± 0.08 and that of the stem extract is 4.06 ± 0.05.[42]

Neuropharmacological evaluations

The ethyl acetate fraction of the leaf extract revealed a dose-dependent, significant prolongation of sleeping time duration but no effect on sleeping time latency; a decrease in locomotor activity and 60% and 40% protection in instances of PTZ- and strychnine-induced convulsions in mice, respectively, were observed. The effects of the chloroform, *n*-hexane, and ethanol fractions were not as significant compared to the ethyl acetate fraction.[43]

Antidiabetic and hypolipidemic effects

The antidiabetic activity of CL ethanolic leaf extract was observed to be comparable to that of glibenclamide. Besides, a considerable decrease in serum total cholesterol, triglycerides, low-density lipoprotein (LDL) cholesterol, and very low-density lipoprotein (VLDL) cholesterol, and an increase in high-density lipoprotein (HDL) cholesterol were reported; the results suggest that the leaf extract of CL has antidiabetic and hypolipidemic effects.[44]

Toxicological evaluations

CA subchronic administration for 60 days indicated no toxicological effects on all parameters evaluated, including reproductive toxicity.[8] The median lethal dose (LD_{50}) of the crude ethanolic leaf extract of CL, as determined by Nwafor and Bassey,[30] is 2449.49 mg/kg body weight. Ettebong *et al.*[32] reported the LD_{50} of the methanolic root extract, using Lorke's method, as 70.7 mg/kg body weight, with signs of toxicity such as excitation, gasping for breath, paw-licking, reduced movement, high respiratory rate, tonic-clonic convulsion, and death. Nwidu *et al.*,[45] reported the acute toxicity (LD_{50}) as 3850.0 mg/kg, 3240.4 mg/kg, and 1414.2 mg/kg for the ethanol fraction, crude ethyl acetate extract, and ethyl acetate leaf fractions, respectively. Nwidu *et al.*[46] estimated the LD_{50} of the ethanolic stem extract as 866.025 mg/kg (i.p.). Taken together, the data from acute toxicity studies indicate the median lethal doses of the root > stem > leaves.[31,33,37] This moderate toxicity may have encouraged the local users in the age-long use of the plant for family planning and for its parasitic effects.[38,40] The subacute and subchronic toxicity reports showed an impingement on biochemical but not hematopoietic parameters.[45,46] These studies on *Carpolobia* are summarized in Tables 1 and 2.

DISCUSSION AND CONCLUSION

Carpolobia enjoys extensive patronage as a herbal resource because of its aphrodisiac potential. The floral part is rich in saponins; a recent study indicated that the root extract has a high amount of saponins (21.02 mg/L) compared to other bioactive phytochemicals such as anthraquinones (5.11 mg/L), alkaloids (2.93 mg/L), flavonoids (1.82 mg/L), tannins (0.91 mg/L), and cardiac glycosides (0.09 mg/L).[6] This report corroborates the isolation and structural elucidation of triterpenoid saponins from both CL and CA by Mitaine-Offer *et al.*[19] However, triterpenoid saponins have been isolated from other members of the Polygalaceae family by Wang *et al.*[47] and reviewed by Lacaille-Dubois and Mittaine-Offer.[9] Though there is no report on the bioactivity-guided isolation of saponin-mediating aphrodisiac activity in *Carpolobia*, for other members of the Polygalaceae family such as *Securidaca longipedunculata*, bioactivity-guided study led to the isolation of xanthones, which mediates the relaxation of the corpus cavernosum, justifying ethnomedicinal usage in the treatment of erectile dysfunction in South Africa.[48]

The reported bioactivities of the saponins were extensively reviewed and the following were found: permeabilization of the cell membrane, stimulation of luteinizing hormone release leading to abortifacient properties, immunomodulatory potential;[49,50] antibacterial properties;[51,52] antioxidant properties,[53,54] antidiabetic properties, and anti-obesity

Table 1: Species of *Carpolobia*, morphology, parts used, and reports of ethnomedicinal uses

Family	Species	Local names	Morphology	English names	Parts used in Trad. medicine	Medicinal uses	Authors
Polygalaceae	*C. alba*	Oshunsun, Oshun	Small tree	-	Stem, bark, and twig	Treatment of sexual dysfunctions	Yakubu *et al.*, 2007
Polygalaceae	*C. lutea*	*Ikpafum*	Shrub/small trees	Cattle stick	Leaves, stem, and root	As stomach medicine	Nwidu and Nwafor, 2009
Polygalaceae	*C. lutea*	-	Shrub tree 5 m high with red flowers	Cattle stick	Root, stem, and leaves	Cure for sterility and used to heal bone fractures	Ndah *et al.*, 2013
Polygalaeae	*C. lutea*	Oziza, Uziza, Angalagala, Egbo oshushun	-	Cattle stick		Treatment for loss of libido induce male erection	Muanya and Odokoya, 2008
Polygalaceae	*C. alba*	Igbo: Agba, Angalagala	-	-	Root	Increases sperm count, enhances fertility	Muanya and Odokoya, 2008
Loganiaceae	*C. alba*	Monono	Small tree	-	Root	As aphrodisiac, increases male sexual function	Betti *et al.*, 2012
Polygalacaeae	*C. alba*	-	Shrub	-	Root, stem, and fruits	Enhances male fertility, virility	Manfo *et al.*, 2011
Polygalaceae	*C. alba*	-	Shrub	-	Leaves	-	Manfo *et al.*, 2011

Table 2: Species of *Carpolobia*, phytochemical and pharmacology reports

Species	Parts	Phytochemical screenings	Pharmacological screenings	Authors
C. lutea	Root	-	Anti-inflammatory and antiarthritic activities	Iwu and Anyanwu, 1982
C. lutea	-	Saponins, cardenolides, and alkaloids	Antimicrobial activity	Idowo *et al.*, 2005
C. lutea	Leaves	Tannins, saponins, and flavonoids	Antidiarrheal and antiulcerogenic activities	Nwafor and Bassey, 2007
C. lutea	Stem	Saponins, flavonoids, cardiac glycosides, and anthraquinones	-	Kayode and Omotoyinbo, 2008
C. lutea	Root	Saponins, anthraquinones, flavonoids, cardiac glycosides, simple sugars, and terpenes	Antimicrobial, contraceptive, estrogenic, and antiestrogenic activities	Ettebong and Nwafor, 2009; Ettebong *et al.*, 2011
C. lutea	Feaves, stem	Alkaloids, saponins, tannins, anthraquinones, cardiac glycosides, and flavonoids	Gastroprotective, antinociceptive anti-inflammatory, and antipyretic activities; neuropharmacological activity; antioxidant and antidiarrheal mechanisms	Nwidu and Nwafor (2009); Nwidu *et al.* 2011 Nwidu and Nwafor 2012; Nwidu *et al.* 2011 Nwidu *et al.*, 2012 a, b Nwidu *et al.*, 2011; Nwidu *et al.*, 2014
C. lutea		Tannins, saponins, flavonoids, cardiac glycosides, anthraquinones, and terpenes	Analgesic activities	Jackson *et al.*, 2011
C. lutea	Leaves	-	Antimalarial and cytotoxic effects	Bero *et al.*, 2009.
C. lutea	Leaf, root	-	Antiplasmodial activities	Okokon *et al.*, 2011
C. lutea	Leaves	Alkaloids, saponins, tannins, anthraquinones, cardiac glycosides, and flavonoids	Acute, subacute, and subchronic toxicity	Nwidu *et al.*, 2012
C. lutea	Root	Saponins, anthraquinones, alkaloids, flavonoids, tannins, and cardiac glycosides	Aphrodisiac effects, effects on male hormones	Yakubu and Jimoh (2014)
C. alba	Root	-	Androgenic activity on testosterone levels, toxicity effects, and protective effects	Manfo *et al.*, 2011 Manfo *et al.*, 2014

properties;[55] protection against gastroenteritic disease;[56] moderate antibacterial activity against the Gram-positive organism *Enterococcus faecalis*;[57] molluscicidal, antifungal, and antiparasitic activities.[58,59] Other therapeutic properties of saponins reported in the literature include: cardioprotective effects against *P. japonicus*,[60] antithrombotic activity against *Dioscorea zingiberensis*[61] and anti-inflammatory and antiulcerogenic properties against the bulbs of *A. ampeloprasum*.[62] Reviews of saponin-mediated effects are observed in some pharmacological reports on *Carpolobia*, but bioactivity-guided studies will be required to fill this gap.

In sum, the pharmacological studies of *Carpolobia* reveal antitrypanosomal and antileishmanial properties[37] antiplasmodial and antimalarial properties,[38,39] contraceptive, estrogenic, and antiestrogenic properties,[13,32] antiulcerogenic and antidiarrheal properties,[30,36,37] gastroprotective effect,[33] antinociceptive properties,[17] anti-inflammatory and antipyretic effects,[41] antidiabetic and hypolipidemic effects,[44] antimicrobial properties,[31,35] antioxidants and amino acid profile,[42] and analgesic activity,[44] which reflects reviews of saponin biological activities. But no aphrodisiac activities,[6,8,13,14] antihemorrhoidal properties,[63] or neuropharmacological effects[43] were seen among the reviewed effects of the saponins.

Polyphenols have been isolated from the leaf extract.[17] However, aphrodisiac activity was revealed with polyphenols isolated from *Mimosa pudica* and *Cydonia oblonga*.[64-66] Recently, several terpenoids have been hydrodistilled from the leaf of CL[7] The reviewed bioactivity of terpenoids encompasses: cancer chemopreventive, antimicrobial, antifungal, antiparasitic, antiviral, anti-allergenic, antileishmanial, antispasmodic, antihyperglycemic, anti-inflammatory, immunomodulatory, insecticidal, and cytotoxic properties.[67-69]

Further studies are needed to ascertain which phytochemicals among the saponins, polyphenols, and terpenoids are responsible for the aphrodisiac and other biological effects of *Carpolobia*. These would lend firm credence to the ethnomedicinal uses of the leaf, stem, and root among the Ibo, Efiks, Ijaw, and Yoruba of Nigeria and the Pygmies of Cameroon.

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