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Review

Peltophorum africanum Sond [Mosetlha]: A review of its ethnomedicinal uses, toxicology, phytochemistry and pharmacological activities

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A variety of ethnotherapeutic properties and pharmacological actions have been attributed to *Peltophorum africanum* Sond which belongs to the family Fabaceae. Besides being used in indigenous ethnoveterinary medicine, *P. africanum* is also traditionally used to treat a variety of human infections including sexually transmitted infections, diarrhoea, wounds, stomach disorders and erectile dysfunction. Reports from literature indicate that the plant possess a variety of compounds belonging to variety of classes, including flavonoids, cardiac glycosides, steroids, and condensed tannins. Additionally, research reveals that different parts of this plant possess antibacterial, antifungal, antiviral, antioxidant and anthelmintic activity. In this current review, a comprehensive account of phytochemical constituents, toxicology and traditional ethnomedicinal uses of *P. africanum,* are presented along with the pharmacological activities.

Key words: *Peltophorum africanum* Sond, ethnomedicine, phytochemistry, pharmacology, sexually transmitted infections.

INTRODUCTION

Peltophorum africanum Sond. is an important commercial, ethnomedicinal and ornamental plant in Africa, belonging to the family Fabaceae. In South Africa, it is known locally as “Mosetlha” amongst Sotho tribes which are mostly located in the northern part of the country. Besides occurring in the wooded grasslands, woodlands, and along margins of vleis in well drained soils, *P. africanum* is distributed continuously from Democratic Republic of Congo to North of Kwazulu Natal in South Africa (Venter and Venter, 2009). It is a tree with a dense rounded to spreading crown, greyish stem, fern-like stipules and clustered fruits. The flowers are yellow, in an erect terminal raceme, while pods are flat and winged (van Wyk and van Wyk, 1997). The wood is soft, with black heartwood (Coates, 2005). Although, not palatable all year long (Berlin et al., 1988), leaves of *P. africanum* had reasonable amount of minerals including phosphorus, calcium, magnesium, sodium, potassium, manganese, copper, selenium and cobalt (Aganga and Mesho, 2008), hence used as a fodder for domestic animals in remote areas.

The leaves of this plant are also known to contain low levels of acid detergent fibre, lignin and insoluble nitrogen (Lukhele and van Ryssen, 2000). Fruit is eaten by humans and animals and has high vitamin C content (Pooley, 1993). Plants belonging to genus *Peltophorum* are well known for their antimicrobial activity (Jagessar et al., 2007; Raj et al., 2012; Yadav and Khan, 2012), antioxidant properties (Chew et al., 2011) and are less toxic at low concentrations (Ahmed et al., 2012).

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Table 1. Some medicinal uses of *Peltophorum africanum* Sond.

Country	Plant part used	Uses	Reference
Botswana	Bark/Root	Ethnoveterinay	Moreki (2012), Moreki et al. (2012).
	Bark/Root	Asthma and early cancer	Setshogo and Mbereki (2010)
	Stem bark	Treatment of wounds	Motlhanka and Nthoiwa (2013)
	Leaves	Ethnoveterinary	Motlhanka and Nthoiwa (2013)
Namibia	Bark/Root	Diarrhoea, wounds, back pains, infertility, abdominal disorder	Chinsembu et al. (2011)
Zimbabwe	Stem bark/root	Venereal diseases	van Wyk and Gericke (2007)
	Whole plant	Psychoactive purposes	Sobiecki (2002)
	Bark/leaves/root	Syphilis, diarrhoea,headache toothache, sore eyes	(Chinemana et al. (1985), Maroyi (2011), Maroyi (2013)
	Roots	Used as sudorific	Gelfand (1985)
South Africa	Roots	Wounds, respiratory infections, infertility, sexually transmitted infections	Moeng (2010), De Wet et al. (2012), Abdillahi and van Staden (2013)
	Roots/stem bark	Colic, cough, painful tooth, joints, backache, stomach disorders, sore eyes and fever	Coates Palgrave (2005), Iwalelwa et al. (2007)
	Stem bark	Colds, sores, blisters and ulcers in the oral cavity, eye sickness, venereal diseases, HIV/AIDS	Mabogo (1990), Semenya et al. (2013)
	Stem bark/root	Ethnoveterinary	van der Merwe et al. (2001), McGaw and Eloff (2008)
	Entire plant	Treatment of menorrhagia and infertility	Mabogo (1990), Steenkamp (2003)
	Stem bark	Erectile dysfunction	Semenya and Potgieter (2013)
	Leaves	Ritual body covering	Mabogo (1990)
Swaziland	Root/bark	Stomach cramps and menorrhagia	Amusan et al. (2002)

According to Tshisikhawe et al. (2012) and Rasethe et al. (2013), *P. africanum* is highly available in Limpopo Province, South Africa, and is used for medicinal purposes and as source of firewood.

ETHNOMEDICINAL USES

Uses of *P. africanum* in folk medicines from different African countries are documented (Table 1), and suggests that most frequently used plant parts are roots and stem bark. The stem bark may be ground into powder and mixed with ground bark of *Sclerocarrya birrea* (A. Rich.) Hochst. subspecies *caffra* (Sond) for the treatment of early cancer (Setshogo and Mbereki, 2011). Bark and root specimen may be used in the treatment of domestic animal infections (Moreki, 2012), while the root is used to promote the fertility of cattle (Moreki et al., 2012). According to Motlhanka and Nthoiwa (2013), pulverised stem bark extract may be drunk to treat wounds, while a decoction from the leaves (Figure 1) may be used in the retention of placenta in livestock. The bark and roots decoction may be drunk to treat wounds, acute pains, infertility, joint and back pains, abdominal disorders, diarrhoea, dysentery and depression (Chinsembu et al., 2011).

The stem bark and roots extracts are used in the treatment of venereal or sexually transmitted infections, diarrhoea, toothache, sore eyes (van Wyk and Gericke, 2007; Maroyi, 2011; Maroyi, 2013), while whole plant may be used as a body wash for madness (Sobiecki, 2002). According to Chinemana et al. (1985), the bark may be soaked in water and the resulting liquid may be taken three times a day to treat diarrhoea or taken as long as necessary to treat headache.

Decoctions made from the roots boiled with those of *Bridelia cathartica* Bertol. F. and an *Ochna* species, are taken for infertility (Hutchings, 1996). Both roots and stem bark may be either chewed or boiled and used on the treatment of colic, cough, painful tooth, joints, backache and severe fever (Iwalewa et al., 2007). Moreover, the infusion of the bark may be taken orally to relieve variety of stomach disorders and the steam from a hot decoction may be applied to sore eyes (Coates, 2005).

According to Semenya et al. (2013), the root HIV/AIDS and related opportunistic infections. The roots may also be used in the treatment of infertility (Abdillahi and Van Staden, 2013).

Figure 1. Leaves and flowers of *Peltophorum africanum*.

Moreover, stem bark was also reported to be used in the treatment of sore throat, sores, ulcers and blisters in the oral cavity, while leaves are used for ritual body covering and the entire plant is used for treatment of menorrhagia and infertility (Mabogo, 1990; Steenkamp, 2003). The stem bark may be used as a tonic while root bark may be used to treat diarrhoea in animals (Van der Merwe et al., 2001; McGaw and Eloff, 2008). Pounded stem bark may be taken orally with warm water to treat erectile dysfunction, mostly in men (Semenya and Potgieter, 2013). Besides being used to treat sexually transmitted infections, a handful of roots may be chopped and boiled in 2 L of water and one cup of resulting concoction may be taken three times to treat sores (De Wet et al., 2012).

According to Amusan et al. (2002), about 30 g each from roots and stem bark may be ground into powder, added to 1 L of warm water and the resulting concoction may be taken twice daily to treat stomach cramps. About 50 g of bark may be boiled into 1 L of water and a cup of the resulting concoction may be taken thrice daily to treat menorrhagia until cured. The leaves, stem bark or root extract may be taken to treat syphilis and other related sexually transmitted infections while root extract may be used to wash infected eye and also as a remedy for toothache (Van Wyk and Gericke, 2007; Maroyi, 2011, 2013).

PHYTOCHEMISTRY

Various compounds have been isolated from different plant parts of *P. africanum*. Condensed flavonoids and affluence of familiar pyrano[3,2-c][2] benzopyran-6-(2H)-ones were isolated from heartwood (Bam et al., 1988), while Theo et al. (2009) reported the presence of betulinic acid and its biological activity. Compounds such as 11-O-(E)-p-coumaroyl bergenin, bergenin and norbergenin were isolated form ethanol extract of stem bark (Mebe and Makuhunga, 1992). Flavonoids found in leaves include kaempferol galactoside, myricetin, quercetin and rutin (Hutchings, 1996). High total phenolic content, flavonoids, gallotannins and condensed tannins have also been reported from methanol extract of stem bark (Bessong et al., 2005; Mulaudzi et al., 2011). Methanol extracts of both roots and bark possess higher quantities of compounds belonging to classes such as flavonoids, cardiac glycosides, saponins, steroids, anthraquinones and tannins, while leaves contains tannins and saponins at higher concentrations (Cooper et al., 1988; Iwalewa et al., 2007; Okeleye, 2011), suggesting that majority of compounds or active ingredients may be embedded into roots and bark. Evans et al. (1985) isolated naturally occurring sulphate ester known as trans-4-hydroxypipecolic acid-4-sulphate from the seeds. Figure 2 presents some major compounds isolated from various parts of *P. africanum*.

The ethyl acetate extract fraction of the stem bark revealed the presence of benzoic acid, azelaic acid, bis(trimethylsilyl) ester, 3-methoxy-4[(trimethylsilyl) oxy], trimethylsilyl 3,5-dimethoxy-4-(trimethylsilyloxy) benzoate, cinnamic acid, hexadecanoic acid, ferulic acid, Octadecanoic acid, Lanost-8-en-3-one, hexacosanoic acid, 3-Oxo-9b-lanosta-7-en-26-, 23-0lide and Hop-22(29)-en-3.beta-ol (Okeleye et al., 2013).

PHARMACOLOGICAL ACTIVITIES

Antibacterial activity

Recently, aqueous and organic (1:1 dichloromethane: methanol) extracts were evaluated for antibacterial activity against agents of sexually transmitted infections (Naidoo et al., 2013). Aqueous extracts exhibited a notable minimum inhibitory concentration (MIC) of 0.50 mg/ml against both *Gardnerella vaginalis* and *Neisseria gonorrhoea*. Furthermore, organic extracts showed a MIC of 0.04 and 0.25 mg/ml against *Ureaplasma urealytica* and *N. gonorrhoea*, respectively. Methanol extracts of the stem bark exhibited a MIC of 0.50 and 2.0 mg/ml against *Staphylococcus epidermidis* and *Staphylococcus aureus*, respectively, while water extracts exhibited a MIC of 3.61 mg/ml against both *S. epidermidis* and *S. aureus* organisms (Steenkamp et al., 2007a). In contrast, Mongalo et al. (2009) reported a MIC of stem bark water extracts to be >12.5 mg/ml against both organisms.

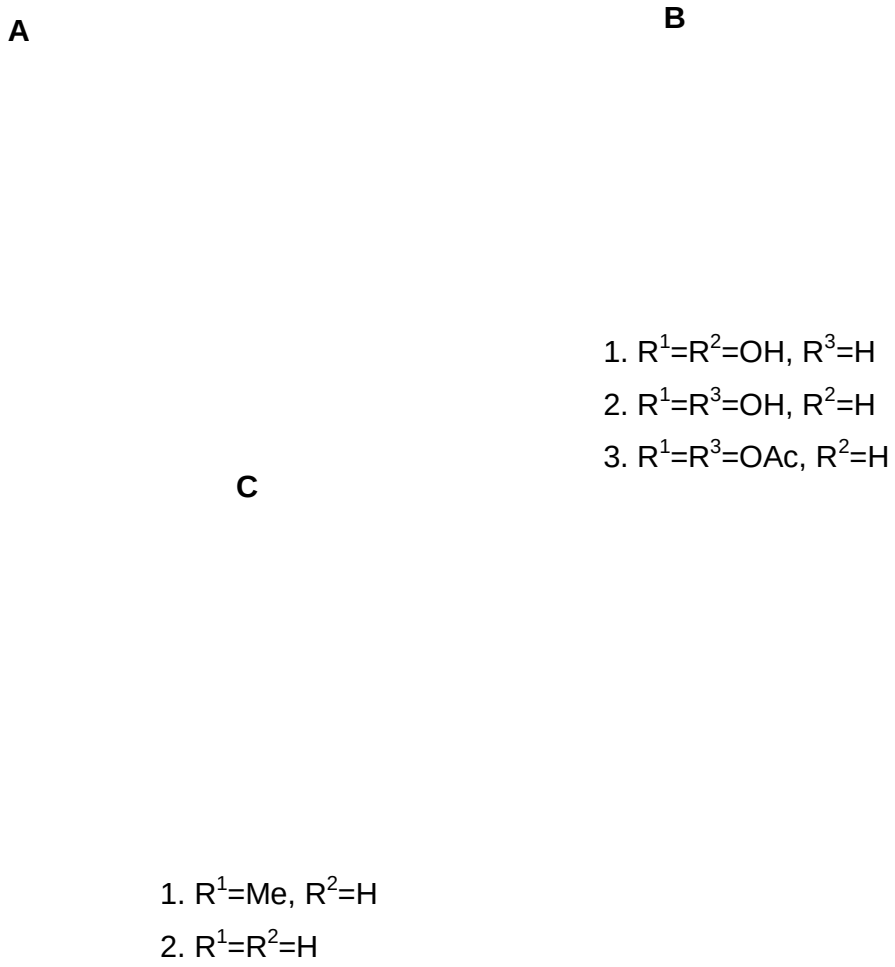

Figure 2. Structures of major constituents from *P. africanum*. (a) Betulinic acid (Theo et al., 2009), (b1) 6-2-metano-6H,12H-dibenzo[*b,f*][1,5]-dioxin, (b2) Cyanomaclurin, (b3) Cyanomaclurin tetraacetate (Bam et al.,1988), (c1) bergenin, (c2) norbergenin (Mebe and Makuhunga, 1992).

Differences in such activities may be due to locality or area of collection and environmental conditions, age of the plant and season of collection.

The water extracts from stem bark exhibited a MIC of 0.39 and 0.78 mg/ml against clinical isolates of *Bacillus subtilis* and *Enterococcus faecalis*, respectively, while methanol extracts from stem bark showed a MIC of 1.56 mg/ml against clinical isolate of *S. aureus* (Mongalo, 2013). Furthermore, both acetone and ethanol extracts from stem bark exhibited a MIC of 2.08 mg/ml against clinical isolate of *Shigella flexineri*. Elsewhere, the methanol extracts of stem bark exhibited a MIC of 1.5 mg/ml against *Serratia marscens*, *S. flexineri* and *Bacillus cereus*, while methanol extracts of the root exhibited a MIC of 1.5 mg/ml against clinical isolates of *E. faecalis* and *Pseudomonas aeruginosa* (Samie et al., 2005). The ethanol extracts of both roots and the stem bark exhibited a MIC of 0.63 mg/ml against *Escherichia coli*, while acetone extracts of both root and leaf showed a MIC of 0.16 mg/ml against *S. aureus*, *E. faecalis* and *P. aeruginosa* (Bizimenyera et al., 2005).

The ethyl acetate extracts of stem showed the zone of inhibition of growth of about 20 mm against nine clinical isolates of *Helicobacter pylori* (Okeleye et al., 2010). Besides demonstrating zones of inhibition ranging from 16.5 to 21.5 mm against *P. aeruginosa*, *Plesiomonas shigelloides*, *Streptococcus pyogenes*, *Aeromonas hyrdophila*, *S. aureus*, *Shigella sonnei* and *Salmonella typhimurium* at a concentration of 50 mg/ml, ethyl acetate extract of the stem bark exhibited a MIC of 1.25 mg/ml against both *S. sonnei* and *S. typhimurium,* a minimum lethal concentration (MLC) of 1.25 mg/ml against *P. aeruginosa* and a MLC/MIC_{index} of 2 mg/ml against *P. aeruginosa, P. shigelloides, A. hyrdophila* and *S. typhimurium*, rendering the extract both bactericidal and bacteriostatic in activity (Okeleye et al., 2013). Petroleum ether extracts of stem bark exhibited a 56% of inhibition against *N. gonorrhoea,* one of the major causative agents of a curable sexually transmitted infection, while dichloro-methane extracts of the same plant part exhibited a MIC

of 1.56 mg/ml against *Klebsiella pneumoniae* (Mulaudzi et al., 2011).

The acetone extracts of stem bark exhibited a MIC >100 µg/ml against two strains of *Mycobacterium tuberculosis* (Green et al., 2010), while Obi et al. (2003) reported ethanol extracts to possess zones of inhibition ranging from 10 to 16 mm against Gram negative bacterial strains such as *S. typhi*, *S. sonnei*, *E. coli*, *Campylobacter jejuni* and *A. hydrophila*. The methanol extracts of the leaf exhibited a MIC of 1.56 mg/ml against five *Staphylococcus* species (isolated from HIV positive patients) which were resistant to oxallin, amoxillin, ampicillin and other antibiotics, while methanol extracts of the stem bark showed a MIC of 0.78 mg/ml against four of those *Staphylococcus* spp. (Iweriebor et al., 2013). The reported antibacterial activities may well explain the use of this plant in the treatment of a variety of bacterial infections in Africa.

Antifungal activity

The dichloromethane extracts of the stem bark exhibited a MIC and a minimum fungal concentration (MFC) of 3.125 mg/ml, while water extracts exhibited a MIC of 1.56 mg/ml against *Candida albicans* (Mulaudzi et al., 2011). Petroleum ether extracts exhibited a MIC and a MFC of 6.25 mg/ml against *C. albicans* (Mulaudzi, 2012). Steenkamp et al. (2007) also reported activity of water and methanol extracts against both clinical isolates and ATCC strains of *C. albicans*. Elsewhere, the acetone extracts of stem bark was reported inactive against *C. albicans* and *C. krusei*, while inhibiting *Cryptococcus neoformans* yield zone of inhibition of 18 mm (Samie et al., 2010), suggesting that inactive compound(s) against *C. albicans* may be insoluble in acetone. Acetone extracts from the stem bark exhibited zone of inhibition of 12 mm, a MIC of 1.9 mg/ml and a MFC of 3.75 mg/ml against *Fusarium graminearum* (Samie and Mashau, 2013).

Anti-HIV activity

Gallotannins isolated from methanol extracts of both root and stem bark of *P. africanum* inhibit both RNA-dependent-DNA polymerase activity of HIV-1 reverse transcriptase and ribonuclease H activity of ribonuclease (Chinsembu and Hedimbi, 2009, 2010; Kanta et al., 2011), while catechin derived from stem bark inhibited 3'-end processing activity of HIV-1 by 65% at 100 µM, but had no activity against HIV-1 reverse transcriptase (Bessong and Obi, 2006). Water and methanol extracts of stem bark exhibited remarkable and potent IC_{50} of 0.1 and 0.05 mg/ml, respectively against HIV-1 reverse transcriptase compared to Kaletra which was used as a reference drug (Mulaudzi et al., 2011). Betulinic acid also exhibited potent anti HIV-1 activity with IC_{50} of 0.04 µg/ml, while the ethyl acetate fraction of the stem bark extracts inhibited virus replication in MAGI CCR5+ cells at IC_{50} of 1.8 µg/ml (Theo et al., 2009). Gallotannin isolated from roots and stem bark methanol extracts exhibited strong inhibition of RNA-directed DNA polymerase (RDDP) activity of HIV-1 reverse transcriptase (RT) and RNase H activity with an IC_{50} of 6.0 and 5.0 µM, respectively, while bergenin and catechin did not inhibit the RDDP and RNase activity of HIV-1 RT at a concentration of 100 µM (Bessong et al., 2005).

Anthelmintic activity

Although, acetone extracts of the root bark was found safe for consumption, it was not found effective against *Haemonchus contortus* and *Trichostrongylus colubriformis* in sheep at three different doses of 50, 500 and 750 mg/kg (Bizimenyera et al., 2008). However, the acetone extracts of root, stem bark and leaf reportedly possess complete ovicidal and larvicidal activities against *T. colubriformis*, with a notable effective dose value (EC_{50}) of 0.28 mg/ml which was exhibited by root extract in both egg hatch and larval development trials (Bizimenyera et al., 2006). The acetone extracts of root, stem bark and leaf also possessed ovicidal and larvicidal activity against *H. contortus*, with notable complete lyses of larva at a concentration of 5 and 25 mg/ml (Bizimenyera et al., 2006a). The water extracts from both the stem and leaf showed an effect at a concentration of 0.5 mg/ml after 24 h against cestodes of *Hymanolepsis diminuta*, while the water extracts from both root bark had effect against *H. diminuta* at a concentration of 25.4 mg/ml after 1 h (MΦlgaard et al., 2001).

Antioxidant and glucosidase activity

Mongalo et al. (2009) reported methanol stem extracts to have good antioxidant activity, with IC_{50} of 0.50 and 0.26 mg/100 ml against DPPH and ABTS, respectively. Acetone extracts of the leaf exhibited IC_{50} of 0.03 mg/ml against DPPH (Shai et al., 2011), while acetone extracts of both roots and bark exhibited DPPH inhibition, yielding EC_{50} of 3.28 and 4.37 µg/ml, respectively as compared to 5.04 µg/ml exhibited by L-ascorbic acid which was used as a standard (Bizimenyera et al., 2007). Acetone extracts obtained from *P. africanum* leaves exhibited IC_{50} of 0.04 mg/ml against yeast α-glucosidase and inhibition activity with IC_{50} >2.5 mg/ml against mammalian (rat) α-glucosidase (Shai et al., 2011).

TOXICOLOGY

The acetone extracts from roots, stem bark and leaves

did not show toxicity in the brine shrimp and the Vero monkey kidney cell line assays, at a concentration of 5 mg/ml, each yielding LC_{50} >1000 µg/ml (Bizimenyera, 2007). Elsewhere, the root acetone extracts exhibited a less toxic effect on Vero cells with a mean value (IC_{50}) of 137.2 µg/ml (Samie et al., 2009). There were no abnormalities or signs of toxicity in the lambs that were given a maximum dosage rate of 750 mg/kg. Moreover, the aqueous and methanol extracts from root and stem bark were reported to be nontoxic at maximum concentration of 400 µg/ml (Bessong et al., 2005). These results may well validate that some extracts from *P. africanum* may be safe for consumption as there were no lethality reports both *in vivo* and *in vitro*. In contrast, Okeleye et al. (2013) reported 96% ethyl acetate extract to possess some degree of toxicity at concentrations ranging from 5 to 1000 µg/ml, especially after 72 h on a human Chang liver cell lines.

CONCLUSION

Ethnobotanical surveys have led to biological screening of *P. africanum.* According to the literature cited, the plant may be used in the treatment of a variety of infections including venereal diseases, stomach cramps, diarrhoea, infertility, menorrhagia, erectile dysfunction, opportunistic infections associated with HIV/AIDS, wounds and fever. *P. africanum* possess variety of compounds, mostly flavonoids, which may well explain the antimicrobial, antioxidant, α-glucosidase and anthelmintic properties, thus validating the use of the plant in African traditional medicine. Increasing human population and resistance of a variety of infectious microorganisms may well result in unsustainable harvesting and collection of potent medicinal plants. Therefore, there is a need to consider strict protection of *P. africanum* in core conservation areas, with a good cooperation between indigenous traditional herbalists, traditional healers, local governments, any relevant stakeholders and conservation biologists in various countries. Although betulinic acid possess anti HIV activity, there is a need to investigate the biological properties of some individual compounds isolated from *P. africanum*.

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