



## ***Maerua edulis* (Gilg & Gilg-Ben.) DeWolf: A review of its ethnomedicinal uses, phytochemistry and pharmacological properties**

Alfred Maroyi\*

Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa

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**ABSTRACT**

*Maerua edulis* (Gilg & Gilg-Ben.) DeWolf is collected from the wild for its edible fruits and also used as traditional medicine. This study is aimed at evaluating the ethnomedicinal uses, phytochemistry and pharmacological properties of *M. edulis*. Results of the current study are based on data derived from several online databases such as Scopus, Google Scholar, PubMed and Science Direct, and pre-electronic sources such as scientific publications, books, dissertations, book chapters and journal articles. This study revealed that the bark, fruit, leaf, root and tuber infusion and decoction of *M. edulis* are mainly used as a thirst quencher and ethnoveterinary medicine, and traditional medicine for eye infections, stomach ache, infertility in women, wounds, fungal infections, rheumatic swellings, cough and tuberculosis and sexually transmitted diseases. Phytochemical compounds identified from the species include agmatine, betaines, cardiac glycosides, fatty acids, flavonoids and quaternary ammonium compounds. Ethnopharmacological research revealed that *M. edulis* extracts and compounds isolated from the species have acaricidal, anthelmintic, antibacterial, antimycobacterial, antifungal, antiproliferative and insecticidal activities. Future research on *M. edulis* should focus on the possible biochemical mechanisms of both the crude extracts and identified phytochemical compounds including toxicological, *in vivo* and clinical studies to corroborate the traditional medicinal applications of the species.

**\*Corresponding Author**

Name: Alfred Maroyi  
 Phone: 0027406022322  
 Email: amaroyi@ufh.ac.za

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**INTRODUCTION**

*Maerua edulis* (Gilg & Gilg-Ben.) DeWolf is a small shrub belonging to the Capparaceae or caper family. The Capparaceae family is a tropical and subtropical taxon of trees, shrubs, herbs and lianas consist-

ing of approximately 417 species (Kers, 2003; Iltis *et al.*, 2011). The genus *Maerua* Forssk has been recorded in tropical and southern Africa, and tropical Asia with about 60 species recorded from the African continent (Hall, 2008; Abreu *et al.*, 2014).

The English common name of *M. edulis* is a blue-leaved bush berry, and the species has been recorded in the Democratic Republic of Congo, Kenya, Malawi, Mozambique, South Africa, Tanzania, Uganda, Zambia and Zimbabwe. Synonyms that are associated with the name *M. edulis* include *Courbonia bussei* Gilg & Gilg-Ben., *C. calothamna* Gilg & Gilg-Ben., *C. camporum* Gilg & Gilg-Ben., *C. decumbens* Brongn., *C. edulis* Gilg & Gilg-Ben., *C. glauca* (Klotzsch) Gilg & Gilg-Ben., *C. prunicarpa* Gilg & Gilg-Ben., *M. camporum* Gilg & Gilg-Ben., *M. decumbens* (Brongn.) DeWolf and *Physantherum glaucum* Klotzsch (Wild, 1960; Elfers *et al.*, 1964). *Maerua edulis* is an evergreen shrub reaching three metres

in height with thick, perennial and swollen tuberous rootstock. The main stem is multi-stemmed with stiff and spreading branches from near the base with young branches covered in a bluish wax layer. The leaves are alternate, simple, fleshy, hairless and entire, broadly lanceolate to ovate in shape and bluish-green in colour.

The leaves have a rounded apex with a bristle-tip and a rounded base. The flowers are bisexual, yellow-green in colour, borne singly in the upper leaf axils. The fruit is a globose or oval capsule, bluish-green at first, turning yellow-orange when ripe. The seeds are discoid, smooth and pale brown. *Maerua edulis* has been recorded in sandy areas, light clay soils and in rocky areas in the riverine thicket in Acacia bushland and woodland, Acacia desert grassland, deciduous or semi-evergreen bushland, bushed grassland, wooded grassland, *Colophospermum mopane* (Benth.) Leonard woodland, often near seasonal rivers or lakes and burnt grassland at an altitude ranging from sea level to 1,850 m above sea level (Dharani, 2019).

The fruits and leaves of *M. edulis* are considered edible throughout the distributional range of the species (Johns and Kokwaro, 1991; Bosch, 2013). The ripe yellow fruits are sweet and widely eaten by children herding livestock, and the fruits are also regarded as a famine food. The fruits are usually eaten fresh, and in some areas, the fruits are boiled first, and the water is thrown away before eating (Bosch, 2013).

The roots of *M. edulis* are eaten during food shortages in Tanzania, but death often occurs when the roots are eaten in excess. The roots of *M. edulis* are widely used in Kenya to purify and reduce the turbidity of water. This evergreen shrub is used as an ornamental plant, live fence, hedge, bee forage and fodder for livestock (Bosch, 2013). *Maerua edulis* is regarded as poisonous, and in Tanzania and Zimbabwe, the leaves, roots and whole plant parts of the species are used as a fish poison. In Tanzania, root powder of *M. edulis* is applied to the funnel of maize (*Zea mays* L.) as a control for stalk borer and to control pests on stored maize (Bosch, 2013).

In Zimbabwe, the leaf extract of *M. edulis* is used as an insecticide. The leaves and roots of *M. edulis* are sold as traditional medicines in the informal herbal medicine markets in the Limpopo province in South Africa. Thus, this review aims to provide an integrated and detailed appraisal of the existing knowledge on the ethnomedicinal uses, phytochemistry and pharmacological properties of *M. edulis* in an attempt to explore the therapeutic and functional potential of this species.

## METHODS

Results of the current study are based on a literature search on the phytochemistry, pharmacological properties and medicinal uses of *M. edulis* using information derived from several internet databases. The databases included Scopus, Google Scholar, PubMed and Science Direct. Other sources of information used included pre-electronic sources such as journal articles, theses, books, book chapters and other scientific articles obtained from the university library.

## RESULTS AND DISCUSSION

### Medicinal uses of *Maerua edulis*

The bark, fruit, leaf, root and tuber infusion and decoction of *M. edulis* are mainly used as a thirst quencher and ethnoveterinary medicine, and traditional medicine for eye infections, stomach ache, infertility in women, wounds, fungal infections, rheumatic swellings, cough and tuberculosis and sexually transmitted diseases (Table 1, Figure 1). Other medicinal applications supported by at two literature reports include the use of bark, fruit, leaf, root and tuber infusion and decoction as an insecticide, pesticide and stimulant, and traditional medicine against allergies, pain and sore joints (Table 1). In Tanzania, the roots of *M. edulis* are mixed with leaves of *Boscia mossambicensis* Klotzsch (family Capparaaceae) as ethnoveterinary medicine against poultry diseases (Komwihangilo *et al.*, 1995). In Zimbabwe, the roots of *M. edulis* are mixed with fruits of *Solanum incanum* L. (family Solanaceae) as ethnoveterinary medicine against ticks (Nyahangare *et al.*, 2015).

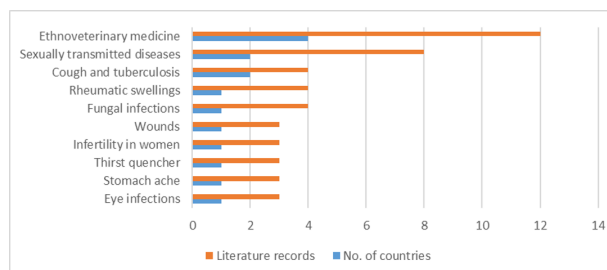


Figure 1: Medicinal applications of *Maerua edulis* derived from literature records

### Nutritional and phytochemistry of *Maerua edulis*

Some researchers identified nutritional elements and phytochemical compounds from the fruits, leaves and roots of *M. edulis* include agmatine, betaines, cardiac glycosides, flavonoids, nutritional compounds, quaternary ammonium compounds

**Table 1: Medicinal uses of *Maerua edulis***

Medicinal use	Plant part	Country	Reference
Allergies	Leaf infusion and decoction applied topically	Tanzania	(Dharani, 2019)
Cough and tuberculosis	Root and tuber infusion and decoction are taken orally	Mozambique and Uganda	(Luo <i>et al.</i> , 2011a; Bosch, 2013)
Eye infections	Bark and roots infusion and decoction applied topically	Tanzania	(Kokwaro, 2009)
Fungal infections	Tuber infusion and decoction applied topically	South Africa	(Samie <i>et al.</i> , 2010; Bosch, 2013)
Infertility in women	Root infusion and decoction are taken orally	Mozambique	(Bosch, 2013; Sithole and Mukanganyama, 2017)
Insecticide	Leaves	Zimbabwe	Bosch (2013)
Laxative	Root infusion and decoction are taken orally	Tanzania	(Dharani, 2019)
Pain	Fruits and leaves infusion and decoction applied topically	Tanzania	(Kokwaro, 2009)
K	Roots	Tanzania	(Bosch, 2013)
Rheumatic swellings	Fruits and leaves infusion and decoction applied topically	Tanzania	(Kokwaro, 2009)
Sexually transmitted diseases (gonorrhoea, syphilis and venereal diseases)	Bark, roots and tubers infusions and decoctions are taken orally	South Africa and Tanzania	(Kokwaro, 2009; Samie <i>et al.</i> , 2010)
Sore joints	Root infusion and decoction applied topically	Kenya	(Kokwaro, 2009)
Stimulant	Root infusion and decoction are taken orally	Tanzania	(Bosch, 2013)
Stomach ache	Root infusion and decoction are taken orally	Mozambique	(Bosch, 2013; Sithole and Mukanganyama, 2017)
Thirst quencher	Roots	Kenya	(Dharani, 2019)
Wounds	Tuber infusion and decoction applied topically	South Africa	(Samie <i>et al.</i> , 2010; Bosch, 2013)
Ethnoveterinary medicine (anthelmintic and ticks)	Leaves and tubers	Kenya, Zambia and Zimbabwe	(Kaposhi, 1992; Nyahangare <i>et al.</i> , 2017)
Poultry diseases	Roots mixed with leaves of <i>Boscia mossambicensis</i> Klotzsch	Tanzania	(Komwihangilo <i>et al.</i> , 1995)
Ticks	Roots mixed with fruits of <i>Solanum incanum</i> L.	Zimbabwe	(Nyahangare <i>et al.</i> , 2015)

**Table 2: Nutritional and phytochemical composition of *Maerua edulis***

Nutritional and chemical compound	Value	Plant part	Reference
3-hydroxyprolinebetaine	-	Aerial parts and whole plant	(McLean <i>et al.</i> , 1996)
3-hydroxystachydrine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
3-hydroxy-1,1-dimethyl pyridinium	-	Aerial parts and whole plant	(McLean <i>et al.</i> , 1996)
4-hydroxy-Z-cinnamoyl-4-aminobutylguanidine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
4-hydroxy-E-cinnamoyl-4-aminobutylguanidine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Cardiac glycosides	-	Leaves	(Kiswii, 2014)
Cinnamoylagmatine hexoside	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Chromium (mg/kg)	2.7 - 5.1	Fruits, leaves and roots	(Njue <i>et al.</i> , 2016)
Crude protein (%)	29.0	Leaves	(Bosch, 2013)
Dry matter digestibility (%)	89.0	Leaves	(Bosch, 2013)
E-cinnamoyl-4-aminobutylguanidine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Feruloylagmatine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Feruloylagmatine hexoside	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Flavonoids	-	Leaves	(Kiswii, 2014)
Glycinebetaine	-	Aerial parts and whole plant	(McLean <i>et al.</i> , 1996)
Hydroxycoumaroylagmatine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Hydroxyferuloyl agmatine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Methoxycinnamoylagmatine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Methylcoumaroylagmatine hexoside	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Methylferuloylagmatine hexoside	-	Leaves	(Stevenson <i>et al.</i> , 2018)
N1-(3,4-Dimethoxy-E-cinnamoylagmatine)	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Non-digestible fibre (%)	31.0	Leaves	(Bosch, 2013)
Prolinebetaine ethyl ester	-	Aerial parts and whole plant	(McLean <i>et al.</i> , 1996)
Prolinebetaine	-	Aerial parts and whole plant	(McLean <i>et al.</i> , 1996)
Selenium ( $\mu\text{g}/\text{kg}$ )	94.8 - 111.4	Fruits, leaves and roots	(Njue <i>et al.</i> , 2016)
Sinapoylagmatine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Sinapoylagmatine hexoside	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Stachydrine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Tetramethylammonium	-	Aerial parts and whole plant	(McLean <i>et al.</i> , 1996)
Vanadium (mg/kg)	5.7 - 9.0	Fruits, leaves and roots	(Nyahangare <i>et al.</i> , 2016)
Z-cinnamoyl-4-aminobutylguanidine	-	Leaves	(Stevenson <i>et al.</i> , 2018)
Zinc (mg/kg)	25.9 - 57.3	Fruits, leaves and roots	(Njue <i>et al.</i> , 2016)

and trace elements (Table 2). Luo *et al.* (2011a) identified linear chain unsaturated fatty acids from the roots of *M. edulis*. Some of these phytochemical compounds may be responsible for the biological activities of the species.

### Pharmacological properties of *Maerua edulis*

The following pharmacological activities have been documented from the leaves, roots and tubers of *M. edulis* and compound isolated from the species: acaricidal, anthelmintic, antibacterial, antimycobacterial, antifungal, antiproliferative and insecticidal activities.

#### Acaricidal activities

Kaposhi (1992) and Kaposi *et al.* (1995) evaluated the acaricidal activities of aqueous extracts of *M. edulis* leaves against *Rhipicephalus appendiculatus* cattle tick larvae. The extracts exhibited activities demonstrating the efficacy of 51.0% against the tested tick larvae (Kaposhi, 1992; Kaposi *et al.*, 1995). Nyahangare *et al.* (2016) evaluated the acaricidal activities of aqueous, hexane and methanol extracts of *M. edulis* leaves against *Rhipicephalus (Boophilus) decoloratus* tick larvae with commercial amitraz-based acaricide (Tickbuster) as a positive control. The highest activity (98.0%) was observed in methanol extract, causing larvae mortality which was comparable to the activities of the positive control (Nyahangare *et al.*, 2016). Nyahangare *et al.* (2017) evaluated the *in vivo* acaricidal activities of crude aqueous extracts of *M. edulis* leaves and tubers at concentrations of 10.0% w/v against cattle ticks with commercial amitraz-based acaricide (Tickbuster) as a positive control. The tuber extract exhibited activities which were comparable to activities exhibited by the amitraz-based acaricide positive control (Nyahangare *et al.*, 2017). Nyahangare *et al.* (2019) evaluated the acaricidal activities of acetone, and crude water extracts of *M. edulis* leaves and tubers with or without liquid soap against *Rhipicephalus (Boophilus) decoloratus* ticks using the Shaw larval immersion test method with commercial amitraz-based acaricide as a positive control. The non-polar fractions of the acetone extract of leaf and tuber caused up to 100.0% mortality of the ticks (Nyahangare *et al.*, 2019).

#### Anthelmintic activities

Gakuya *et al.* (2000) evaluated the anthelmintic activities of the water extract of *M. edulis* tuber against gastro-intestinal nematodes in sheep. The extract demonstrated a 49.0% reduction of worm egg count (Gakuya *et al.*, 2000). Gakuya (2001) and Gakuya *et al.* (2005) evaluated the anthelmintic activities of the water extract of *M. edulis* root

using mice that had been experimentally infected with the intestinal nematode *Heligmosomoides polygyrus*. The mice were administered with extract at a dosage of 5.0 gm/kg, 10.0 gm/kg and 20.0 gm/kg body weight and faecal worm egg count reduction determined after seven days of treatment. The results showed a percentage of faecal *Heligmosomoides polygyrus* egg count reduction of 69.0% to 16.0% (Gakuya, 2001; Gakuya *et al.*, 2005).

#### Antibacterial activities

Maregesi *et al.* (2008) evaluated the antibacterial activities of aqueous, n-hexane and methanol extracts of *M. edulis* roots against *Bacillus cereus*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Salmonella typhimurium* using a liquid dilution method with ampicillin and rifampicin as positive controls. The n-hexane extract exhibited activities against *Bacillus cereus*, *Staphylococcus aureus* and *Klebsiella pneumoniae* with the minimum inhibitory concentration (MIC) values ranging from 500.0 µg/ml to 1000.0 µg/ml against MIC values of 0.1 µg/ml to 0.6 µg/ml exhibited by the positive control (Maregesi *et al.*, 2008). Kowero *et al.* (2016) evaluated the antibacterial activities of chloroform, ethyl acetate and methanol extracts of *M. edulis* leaves against *Salmonella kisarawe*, *Klebsiella oxytoca*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Escherichia coli* and *Salmonella typhi* using microdilution methods with gentamycin as a positive control. The chloroform and ethyl acetate extracts exhibited activities with MIC values ranging from 1.6 mg/mL to 25.0 mg/mL (Kowero *et al.*, 2016).

#### Antimycobacterial activities

Luo *et al.* (2011b,a) evaluated the *in vitro* antimycobacterial activities of n-hexane, dichloromethane, ethyl acetate and 70% ethanol extracts of *M. edulis* roots against *Mycobacterium smegmatis*, *Mycobacterium tuberculosis*, *Mycobacterium avium* and *Mycobacterium Bovis* using the broth microdilution method with isoniazid, kanamycin, puromycin and rifampicin as positive controls. Only n-hexane extract exhibited activities with MIC values ranging from 31.2 µg/mL to 250.0 µg/mL (Luo *et al.*, 2011b,a).

#### Antifungal activities

Maregesi *et al.* (2008) evaluated antifungal activities of aqueous, n-hexane and methanol extracts of *M. edulis* roots against *Aspergillus niger* and *Candida albicans* using a liquid dilution method with flucytosine as a positive control. The aqueous extract exhibited activities against *Candida albicans* with

the MIC value of 1000.0  $\mu\text{g/ml}$  against MIC value of 0.06  $\mu\text{g/ml}$  exhibited by the positive control (Maregesi *et al.*, 2008). Samie *et al.* (2010) evaluated the antifungal activities of acetone and hexane root extracts of *M. edulis* against *Cryptococcus neoformans*, *Candida krusei* and *Candida albicans* isolated from acquired immunodeficiency syndrome (AIDS) patients using agar diffusion and the microdilution methods with nystatin (10.0  $\mu\text{l}$ ) and flourocystosine (10.0  $\mu\text{l}$ ) as positive controls. The extracts exhibited activities against tested pathogens with MIC values ranging from 1.0 mg/ml to 7.5 mg/ml in comparison to MIC values of 0.2  $\mu\text{g/ml}$  to 1.9  $\mu\text{g/ml}$  exhibited by the positive controls (Samie *et al.*, 2010). Kiswii (2014) evaluated the antifungal activities of crude extracts of *M. edulis* leaves against *Aspergillus flavus* using agar well diffusion method with miconazole (10.0 mg/ml) as the positive control. The extract exhibited weak activities with a zone of inhibition of 7.0 mm against the zone of inhibition of 19.4 mm exhibited by the positive control (Kiswii, 2014).

#### Antiproliferative activities

Sithole and Mukanganyama (2017) evaluated the antiproliferative activities of aqueous, acetone, hexane and methanol extracts of *M. edulis* roots against human leukemic Jurkat-T cell line using 1,3-bis (2-chloroethyl)-1-nitrosourea (BCNU) as a reference drug. The methanol extract inhibited the growth of Jurkat-T cells in a dose-dependent manner with half-maximal growth inhibition cell proliferation ( $\text{GI}_{50}$ ) value of 18.5  $\mu\text{g/ml}$  (Sithole and Mukanganyama, 2017).

#### Insecticidal activities

Mazhawidza and Mvumi (2017) evaluated the insecticidal activities of crude aqueous extracts of *M. edulis* leaf against pests of cabbage (*Brassica oleracea* L.), *Plutella xylostella* and rape (*Brassica namus* L.), *Brevicoryne brassicae* with commercial synthetic pesticides used as positive controls. The extracts exhibited activities at a concentration of 5.0% to 20.0% w/v (Mazhawidza and Mvumi, 2017). Stevenson *et al.* (2018) evaluated the insecticidal activities of the crude *M. edulis* leaf extracts and the compounds 4-hydroxy-Z-cinnamoyl-4-aminobutylguanidine, 4-hydroxy-E-cinnamoyl-4-aminobutylguanidine, E-cinnamoyl-4-aminobutylguanidine and Z-cinnamoyl-4-aminobutylguanidine isolated from the species against the cowpea (*Vigna unguiculata* (L.) Walp.) bruchid *Callosobruchus maculatus* at concentrations equivalent to those present in extracts used by smallholder farmers with rotenone as the positive control. The extracts and the compounds exhibited activities against the tested

insect (Stevenson *et al.*, 2018).

#### CONCLUSION

*Maerua edulis* is known to be poisonous, and there is a need for detailed clinical and toxicological evaluations of crude extracts and compounds isolated from the species. Therefore, the widespread use of *M. edulis* as food plant and source of traditional medicines throughout its distributional range suggest that the species is not taken at toxic dosages. But the use of *M. edulis* as food and for the treatment of human diseases and ailments should be treated with caution and rigorous toxicological and clinical studies of the bark, fruits, leaves, roots and tubers, and compounds isolated from the species are necessary.

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#### Conflict of interest

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