

Original Research Article

Utilization of *Bridelia mollis* as herbal medicine, nutraceutical and functional food in southern Africa: A review

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Abstract

Purpose: To evaluate the functional food, nutraceutical and ethnomedicinal properties of *Bridelia mollis* throughout its geographical range.

Methods: Retrieval of information on the medicinal, nutraceutical and functional food properties of *B. mollis* was undertaken using electronic databases, including PubMed, EThOS, ScienceDirect, SCOPUS, ProQuest, SciFinder, Medline, Open-thesis, OATD and Google Scholar. Pre-electronic literature was sourced from the University library.

Results: Literature search revealed that fresh or dried fruits of *B. mollis* can be commercially processed into new food products and beverages in southern Africa. *Bridelia mollis* is traditionally used as herbal medicine for cough, itching, fever, gastro-intestinal problems, malaria, piles, parasitic worms and wounds. Pharmacological studies on *B. mollis* indicate that the species has antibacterial, antifungal, antileishmanial, antioxidative and antiplasmodial properties.

Conclusion: Detailed studies on the phytochemistry, pharmacological and toxicological properties of *B. mollis* are needed in order to establish the real nutraceutical potential benefits of the species that might improve human health.

Keywords: Antibacterial, Antifungal, Antileishmanial, Antioxidative, Antiplasmodial, *Bridelia mollis*, Phyllanthaceae

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INTRODUCTION

Bridelia mollis Hutch. (Figure 1), family Phyllanthaceae has tremendous potential as herbal medicine, nutraceutical agent and functional food mainly due to its medicinal and nutritional properties. *Bridelia mollis* is native to Malawi, Botswana, Zimbabwe, South Africa, Namibia, Zambia and Mozambique [1-3]. The

fruits are edible, make useful jam and other beverages used by households throughout the geographical range of the species [1,3-9]. The fruit contains a hard seed, surrounded by a thin layer of pulp and its taste and flavour has been compared to that of prune (*Prunus domestica* L.) by Palmer and Pitman [3]. The pressed fruits exude a clear gum which is used to make jam or

juice throughout the distributional range of the species in Southern Africa.

Previous research by Van Wyk [10] showed that the dried and fresh fruits of *B. mollis* can be commercially processed into new food products and beverages such as jam, juice and other processed products. The leaves, fruits and twigs of *B. mollis* are excellent fodder for livestock and game in southern Africa [11,12]. There are several research projects [13-15] attempting to characterize the phytochemical, pharmacological and nutraceutical properties of the species. There has been an increase in the demand for nutraceuticals and functional foods over the years due to the growing concern of society for health and quality of life [16-18]. Rivera *et al* [16] defined functional foods as food sources that have positive physiological properties that are beyond their nutritional uses of providing essential nutrients. While Varzakas *et al* [19] defined nutraceutical as any food source or supplementary diet that provides a concentrated form of a pharmacologically active component of food in a non-food form to improve human health.

Rivera *et al* [16] argued that nutraceutical agents with commercial value can be generated from functional foods which have demonstrated phytochemical and pharmacological properties that are able to protect humans against chronic or infectious diseases. According to the nutraceutical and nutritional therapy theory [17], beneficial nutrients and phytochemical compounds are provided by the nutraceuticals which detoxify the entire human body, supplementing vitamins and essential minerals, resulting in the restoration of a healthy digestion and dietary habit. Research on indigenous edible fruits as possible sources of nutraceuticals is associated with opportunities for using innovative technologies for bioprospecting and the development of pharmaceutical drugs and health products. It is within this context that ethnopharmacological and nutraceutical review of the species was carried out aimed at understanding the medicinal and functional value of *B. mollis*.

METHODS

Information on the food value, ethnomedicinal and nutraceutical properties of *B. mollis* was retrieved from September 2017 to March 2018. Online electronic databases such as Pubmed, EThOS, ScienceDirect, SCOPUS, ProQuest, SciFinder, Medline, Open-thesis, OATD and Google Scholar were used to search for relevant literature. Pre-electronic literature sources

included conference papers, books, scientific articles, book chapters, theses and dissertations obtained from the University of Fort Hare library.



Figure 1: *Bridelia mollis*: a branch showing leaves and fruits (photo: BT Wursten)

The keywords used in the search included “*Bridelia mollis*”, the synonyms of the species “*Bridelia scandens sensu Eyles* and *Bridelia schlechteri* Hutch.” English common names “bushveld bridelia, velvet sweetberry and velvet-leaved bridelia”. The following combination of keywords was used to search for relevant information: “biological properties + *Bridelia mollis*”, “ethnobotany + *Bridelia mollis*”, “ethnomedicinal uses + *Bridelia mollis*”, “ethnopharmacological properties + *Bridelia mollis*”, “food uses or values + *Bridelia mollis*”, “medicinal uses + *Bridelia mollis*”, “nutraceutical properties + *Bridelia mollis*”, “pharmacological properties + *Bridelia mollis*” and “phytochemistry + *Bridelia mollis*”. A total of 44 articles published between 1972 and 2018 were in agreement with the literature search criteria (Figure 1). The sources of data included research articles results published in scientific journals (29), books (seven), theses and dissertations (five), book chapter and website (one each).

FINDINGS AND DISCUSSION

Botanical profile of *Bridelia mollis*

Bridelia mollis Hutch. is a deciduous shrub or a small tree of the Phyllanthaceae family (previously included in the Euphorbiaceae family). The name of the genus, “*Bridelia*” was derived from the name of a Swiss-German muscologist, Samuel Elisée Bridel-Brideri (1761–1828) [3,20,21]. The specific epithet “*mollis*” means “soft”, alluding to the characteristic velvety leaves of the species [2,3,22].

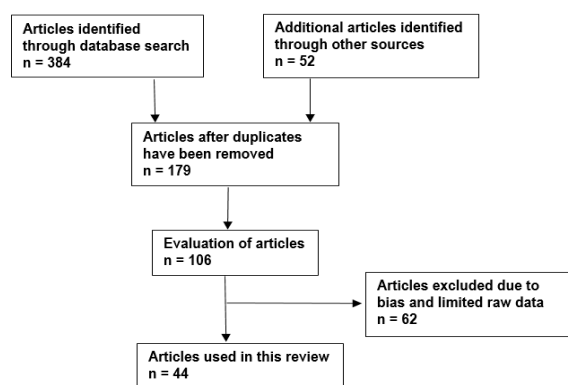


Figure 1: Flow diagram showing literature search results and selection processes

The Phyllanthaceae family was a sub-family of Euphorbiaceae until Hoffmann *et al* [23] separated the two families based on molecular studies using DNA sequence data of nuclear PHYC and plastid atpB, matK, ndhF and rbcL in conjunction with morphological characters. The synonyms of *B. mollis* include *Bridelia scandens sensu Eyles* and *Bridelia schlechteri* Hutch. and English common names include bushveld bridelia, velvet sweetberry and velvet-leaved bridelia.

Globally, the family has 59 genera and 2 000 species [23]. *Bridelia* is a genus of about 60 to 70 species that have been recorded in tropical and subtropical Africa and Asia [21,24,25]. *Bridelia mollis* is a small deciduous tree or shrub growing not more than 8 m in height [3]. *Bridelia mollis* has a small spreading and well-branched crown growing on dark brown to grey stem with rough and longitudinal striations [3,26]. The leaves are alternate, entire, ovate to obovate in shape, light green in colour and densely velvety on both surfaces. The lateral veins on leaves are prominent below and terminating at the leaf margin [1,3,26]. Flowers of *B. mollis* are very

small, occur in tight axillary clusters, greenish-yellow in colour and unisexual on the same tree. The fruit is a subspherical fleshy berry, green when immature, and turning black when mature, edible and made into jam and beverages throughout the distribution of the species [1-9]. The fruits remain on the tree after the leaves have fallen off. The species has been recorded near streams, on rock outcrops and hills and at an altitude ranging from 200 to 1525 m above sea level [1-3,22,26].

Medicinal uses of *Bridelia mollis*

In Botswana, root decoction of *B. mollis* is taken orally as remedy for diarrhoea [27] and the leaves are boiled and the solution rubbed on the body as a soothing lotion [22]. In South Africa, leaf infusion is applied topically for burning sensation, itching and wounds [28]. According to Mabogo [28], leaf root decoction of *B. mollis* is taken orally as emetic, and remedy for dysentery and piles in Venda, the Limpopo province, South Africa.

Research by Bapela [29] showed that root decoction of *B. mollis* is taken orally as remedy for fever, malaria and parasitic worms in South Africa. Research by Arnold and Gulumian [30] and Bapela [29] showed that roots of *B. mollis* are taken orally mixed with roots of *Trichilia emitica* Vahl as remedy for parasitic worms in Venda region of the Limpopo province in South Africa. In Zimbabwe, root decoction of *B. mollis* is taken by mouth as remedy for cough [31] and stomach pains while leaf infusion is applied topically for black blisters or skin blisters [4]. A closely related species, *B. micrantha* (Hochst.) Baill. is also used as herbal medicine against diarrhoea, parasitic worms and wounds in South Africa [20], cough, dysentery, fever and malaria in the Democratic Republic of Congo [32].

Table 1: Medicinal applications of *Bridelia mollis* in southern Africa

Medicinal use	Plant part used	Country	Reference
Burning and itching	Leaves infusion applied topically	South Africa	28
Cough	Root infusion taken orally	Zimbabwe	31
Diarrhoea	Root infusion taken orally	Botswana	27
Dysentery	Leaf infusion taken by mouth	South Africa	28
Emetic	Leaf infusion taken by mouth	South Africa	28
Fever	Root decoction taken by mouth	South Africa	29
Malaria	Root infusion taken by mouth	South Africa	29
Parasitic worms	Roots taken orally mixed with <i>Trichilia emitica</i> Vahl	South Africa	29,30
Parasitic worms	Root infusion taken by mouth	South Africa	29
Piles	Leaf decoction taken orally	South Africa	28
Skin blisters	Leaf infusion applied topically	Zimbabwe	4
Soothing lotion	Leaf decoction rubbed on the body	Botswana	22
Stomach pains	Root decoction taken orally	Zimbabwe	4
Wounds	Leaf infusion applied topically	South Africa	28

Pharmacological properties of *Bridelia mollis*

Traditional uses of *B. mollis* as herbal medicine encouraged researchers to evaluate antibacterial [33], antifungal [34,35], antileishmanial [14,36], antioxidative [13,37], antiplasmodial [38] and cytotoxicity [14,36,38]. Some of the documented biological activities may justify some of the medicinal uses of the species or may provide insight into the therapeutic potential of *B. mollis*.

Antibacterial activity

Shai *et al* [33] assessed antibacterial properties of acetone, dichloromethane and methanolic leaf extracts of *Bradelia mollis* against *Staphylococcus epidermidis*, *Bacillus cereus*, *Citrobacter freundii*, *Enterobacter aerogenes*, *Bacillus stearothermophilus*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiela oxytoca*, *Klebsiela pneumonia*, *Lactobacillus acidophilus*, *Micrococcus luteus*, *Proteus mirabilis*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Serratia marcescens*, *Pseudomonas fluorescens*, *Salmonella typhi*, *Staphylococcus aureus*, and *Streptococcus pyogenes* using serial microplate dilution method with gentamicin as positive control. The extracts exhibited activities with minimum inhibitory concentration (MIC) values ranging from 0.31 mg/mL to >2.5 mg/mL. The average total activity of the extracts ranged from 20.0 mL/g to 313 mL/g [33]. These antibacterial evaluations done so far corroborate use of *B. mollis* as traditional medicine against diarrhoea in Botswana [27], dysentery and wounds in South Africa [28].

Antifungal activity

Samie *et al* [34] assessed antifungal activities of acetone and hexane leaf extracts of *B. mollis* 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 µl) and flourocystosine (10 µl) as positive controls. The hexane extract showed activities against *Cryptococcus neoformans* with 7 mm zone of inhibition which was comparable to 22 mm zone of inhibition exhibited by both controls, nystatin and flourocystosine. The MIC values of hexane and acetone extracts against all the pathogens ranged from 3.75 mg/mL to > 7.5 mg/mL [34]. Mukanganyama *et al* [35] assessed antifungal activities of bark and leaf ethanol extracts of *B. mollis* against *Candida albicans* and *Candida mycoderma* using the agar diffusion assay. The bark extract exhibited activities against *Candida mycoderma* with zone of inhibition of 3.0 mm

[35]. These antifungal properties of *B. mollis* corroborate the traditional uses of the species against fungal and microbial infections.

Antileishmanial activity

Bridelia mollis methanol bark extract exhibited weak antileishmanial activity with IC₅₀ value > 200.0 µg/mL against *Leishmania amazonensis* promastigotes [36]. Bapela *et al* [14] assessed antileishmanial activities of methanol and dichloromethane root extracts of *B. mollis* against *Leishmania donovani*. The dichloromethane extracts exhibited inhibitory activities on the growth of amastigote phases of *Leishmania donovani* with half maximal inhibitory concentration (IC₅₀) values of 1.92 µg/mL with selectivity index value of 27 [14]. Bapela *et al* [39] found that the majority of the non-polar extracts of medicinal herbs used against fever and malaria are characterized by antiplasmodial activities, and therefore, likely to have antileishmanicidal properties as both leishmaniasis and malaria are protozoal infections characterized by similar metabolic systems. Therefore, findings of this research imply that *B. mollis* extracts may have potential as antileishmanial agents.

Antioxidative activity

Ndhlala *et al* [37] assessed antioxidant properties of aqueous and methanolic fruit extracts of *B. mollis* using reducing power, superoxide anion radical scavenging effect, 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay and the inhibition of phospholipids peroxidation using colorimetric technique. The extracts of pulps and peels of the species demonstrated high antioxidant activities. The authors observed high levels of species extracts exceeding 75% superoxide anion scavenging, the peel and pulp exhibited excellent capacities to inhibit lipid peroxidation at higher concentrations.

The degree of polymerization was 9.8 monomer units of catechin per polymer of phenolic acid compounds in the peels and pulps of the species [37]. Chauke *et al* [13] assessed antioxidative properties of acetone leaf extracts of *B. mollis* using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay. The extract exhibited dose-dependent activity with IC₅₀ value of 130.0 µg/mL, which was higher than the ascorbic acid, the standard IC₅₀ value of 25 µg/mL [13]. The documented antioxidant activities of *B. mollis* are probably due to tannins and phenolics that have been isolated from the species [15].

Antiplasmodial activity

Bapela *et al* [38] assessed antiplasmodial properties of dichloromethane and methane root extracts of *B. mollis* using the [3H] hypoxanthine incorporation assay using chloroquine sensitive (NF54) strain of *Plasmodium falciparum* as the test organism. Both dichloromethane and methane extracts exhibited activity with IC₅₀ values of 3.06 µg/mL and 28.5 µg/mL, respectively with selectivity index of 17, which was considered not to be toxic [38]. These findings corroborate the traditional use of *B. mollis* as traditional medicine against fever and malaria in South Africa [29].

Cytotoxicity activity

Bridelia mollis methanol bark extract was not cytotoxic to BALB/c mouse macrophages with half maximal cytotoxic concentration (CC₅₀) value of > 200 µg/mL [36]. Bapela *et al* [38] assessed cytotoxicity activities of dichloromethane and methane root extracts of *B. mollis* against mammalian L-6 rat skeletal myoblast cells with podophyllotoxin as a control. Both dichloromethane and methane extracts demonstrated activities with IC₅₀ values of 51.4 µg/mL and 49.6 µg/mL, respectively with selectivity indices value of 16.8 and 24.6, respectively, which were regarded to be non-toxic to rat skeletal myoblast L6 cells [38].

Bapela *et al* [14] assessed cytotoxicity properties of dichloromethane and methanol leaf extracts of *B. mollis* by assessing the inhibition of mammalian cell growth by cultivating rat skeletal myoblast L6 cells in extracts with concentrations varying from 0.002 to 100.0 µg/mL in 96 well culture plates with podophyllotoxin as a positive control. The methanol and dichloromethane extracts exhibited IC₅₀ values of 49.6 µg/mL and 51.4 µg/mL, respectively which were much higher than IC₅₀ value of 0.007 µg/mL exhibited by podophyllotoxin, the control [14].

Nutritional composition of *Bridelia mollis* leaves and seeds

Seeds of *B. mollis* have nutrients such as fats and proteins and minerals such as Cu, Ca, Fe, Mn, Zn, Mg and P (Table 2). Aganga *et al* [12] isolated phenolics from seeds while Chauke *et al* [13] isolated tannins from leaves of *B. mollis*. Gundidza and Pomerai [15] identified fatty acids such as α-linolenic (41.4%), trans elaidic (21.4 %), linoleic (14.7 %), palmitic (11.5 %) and stearic (8.3 %) from seeds of *B. mollis*. The

essential macronutrients present in *B. mollis* are Ca, Mg and P, with P being a key component of molecular structures such as DNA and RNA, and needed for bone and teeth formation and maintenance in all vertebrates [39]. Calcium is maintained in the bones and required for hormone secretion and muscle contraction while Mg is important to many major processes such as mineralization of bones, synthesis of proteins, enzyme activities, contraction of muscles, nerve function, immunity, and all energy reactions [40].

Trace element present in *B. mollis* include Cu, Fe, Mn and Zn, with Mn playing an important role for stimulating and activating several enzymes [19]. According to Varzakas *et al* [19] Cu is required by the human body in minute quantities as a constituent of redox enzymes while iron is important for hemoglobin formation and oxygen transport with low iron intake and/or bioavailability leading to anemia [41].

Zinc is necessary for the body's enzymatic reactions necessary for cell, protein and DNA synthesis with Zn deficiency leading to delayed growth, dysentery, disturbed neuropsychological performance, pneumonia, and abnormalities of fetuses [42]. Some fatty acids for example α-linolenic are essential for human health as they are characterized by pharmacological properties such as anti-cancer, cardiovascular-protective, anti-inflammatory, neuro-protective, antioxidative and anti-osteoporotic [43]. The phenolic antioxidants which include tannins are known to scavenge radicals in a dose-dependent trend [44]. *Bridelia mollis* has good nutritive value which support its use as food, fodder and herbal medicine.

CONCLUDING REMARKS

The present study presents the medicinal uses, pharmacological activities of *B. mollis*, a plant species characterized by nutraceutical and functional food properties. Preliminary pharmacological assessment of the crude extracts of *B. mollis* seems to support the health claims associated with the species. Detailed studies on the phytochemistry, pharmacological and toxicological properties of the species are required in order to establish the real potential benefits of *B. mollis* as a nutraceutical agent. Further *in vitro*, *in vivo* and clinical studies are needed to establish the safety and practical uses of the species as a nutraceutical agent that might have beneficial effects on improving human health.

Table 2: Nutritional and phytochemical composition of leaves and seeds of *Bridelia mollis*

Nutritional composition	Value	Plant part	Reference	Recommended daily allowance (RDA)
Acid neutral detergent (ADF) (g/100g)	10.5	Seed	12	-
Ash (% dry weight)	2.4	Seed	12	-
Ca (g/100g)	0.31	Seed	12	1000.0
Crude fat (% dry weight)	2.6	Seed	12	300.0
Crude protein (% dry weight)	21.7	Seed	12	34.0
Cu (mg/100g)	9.0	Seed	12	0.9
Dry matter (%)	97.0	Seed	12	-
Fe (mg/100g)	81.0	Seed	12	8.0 - 18.0
In vitro true dry matter digestibility (IVTD) (g/100g)	95.1	Seed	12	-
Mg (g/100g)	0.10	Seed	12	320.0 – 420.0
Mn (mg/100g)	41	Seed	12	1.8 – 2.3
Neutral detergent fibre (NDF) (%)	55.1	Seed	12	-
Phenolic (gallic acid equivalent mg/ml)	39.31	Leaf	13	-
P (g/100g)	0.37	Seed	12	700.0
Tannins (mg/ml gallic acid equivalent)	5.97	Seed	12	-
Zn (mg/100g)	0.17	Seed	12	8.0 – 11.0
Fatty acids				
α-Linolenic acid (%)	41.4	Seed	15	-
Trans elaidic (%)	21.4	Seed	15	-
Linoleic acid (%)	14.7	Seed	15	-
Palmitic (%)	11.5	Seed	15	-
Stearic (%)	8.3	Seed	15	-

DECLARATIONS

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Conflict of Interest

No conflict of interest associated with this work.

Contribution of Authors

The authors declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by them.

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