Alfred Maroyi et al /J. Pharm. Sci. & Res. Vol. 11(8), 2019, 3055-3060

ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Boscia salicifolia: review of its botany, medicinal uses, phytochemistry and biological activities

Alfred Maroyi
Medicinal Plants and Economic Development (MPED) Research Centre, Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa

Abstract

Boscia salicifolia is a small to medium-sized deciduous tree widely used as herbal medicine in the Sahel and sub-Saharan Africa. The current study critically reviewed the botany, medicinal uses, phytochemistry and pharmacological activities of *B. salicifolia*. Literature on botany, medicinal uses, phytochemical and biological activities of *B. salicifolia* was collected from multiple internet sources including Elsevier, Google Scholar, SciFinder, Web of Science, Pubmed, BMC, Science Direct and Scopus. Complementary information was gathered from pre-electronic sources such as books, book chapters, theses, scientific reports and journal articles obtained from the University library. This study revealed that the species is used as an anthelmintic or dewormer and herbal medicine for parasitic diseases, eye problems, fertility, fever and malaria, gastro-intestinal problems, headache, skin diseases, sores and wounds, swellings, toothache and ethnoveterinary medicine. Ethnopharmacological research identified alkaloids, anthraquinones, flavonoids, saponins, tannins and several glycosides of the flavonols rhamnocitrin and rhamnetin from the leaves of *B. salicifolia*. The crude extracts of the species exhibited anthelmintic, antibacterial, antiplasmodial, antioxidant, uterotonic and cytotoxicity activities. *Boscia salicifolia* should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological activities.

Keywords: *Boscia salicifolia*, Capparaceae, Capparidaceae, herbal medicine, indigenous knowledge, Sahel, sub-Saharan Africa

INTRODUCTION

Boscia salicifolia Oliv. is a small to medium-sized deciduous tree belonging to the Capparaceae or Capparidaceae or caper family. The Capparaceae family contains 33 genera and approximately 700 species distributed in tropical and subtropical regions of the world.[1-3] *Boscia* Lam. is a genus of shrubs or small trees consisting of 37 species, mostly in tropical and southern Africa, a few in Madagascar, one confined to Arabia, mostly in semi-arid or seasonally dry areas.[2,4-7] Several *Boscia* species are used as herbal medicines in tropical Africa and these include *B. albitrunca* (Burch.) Gilg & Gilg-Ben., *B. angustifolia*, *B. coriacea* Graells, *B. foetida* Schinz, *B. longifolia* Hadj-Moust., *B. madagascariensis* (DC.) Hadj-Moust., *B. mossambicensis* Klotzsch., *B. plantefolii* Hadj-Moust., *B. salicifolia* Oliv. and *B. senegalensis* Lam.[8-10] Iwu[8] argued that the medicinal properties of *Boscia* species could be attributed to alkaloids, flavonoids, sesquiterpenes and their glycosides, sulphur compounds and lipids that are associated with the genus. *Boscia angustifolia* is regarded as a multipurpose species in the Sahel and sub-Saharan Africa used as human food, animal food, construction materials, firewood, source of charcoal, used to enhance soil fertility, soil or water conservation, reclaiming degraded sites, ethnoveterinary medicines, herbal medicines, shade, ornamental, source of bee forage and arrow poison.[11-24] Research by Bello et al.[25] showed that *B. salicifolia* is locally threatened in the Sudan Savanna in Katsina State, northwestern Nigeria and the authors categorized the species as Critically Endangered (CRB2ab(i,iv,v). On an IUCN Red List Categories and Criteria, a species is categorized as CRB2ab(i,iv,v) when the species is facing an extremely high risk of extinction in the wild based on area of occupancy estimated to be less 10km^2, and there is evidence of continuing decline based on observations or inferred from extent of occurrence, number of locations or subpopulations and/or number of mature *B. salicifolia* individuals.[25] In some countries in the Sahel and sub-Saharan Africa, fruits of *B. salicifolia* are eaten, seeds are eaten after cooking, leaves are eaten as leafy vegetables or an ingredient in soups, bark is pounded and put into soups or the root is roasted and eaten.[10,12,17,20,22,23] Therefore, in some countries, *B. salicifolia* is conserved for use as famine or emergency food when forests or woodlands are cleared for agricultural purposes. It is within this context that this review was undertaken aimed at reviewing the botany, medicinal uses, phytochemistry and biological activities of *B. salicifolia* so as to provide baseline data required in evaluating the therapeutic potential of the species.

Botanical profile of *Boscia salicifolia*

The genus name *Boscia* Lam. is in honour of a French naturalist, botanist, zoologist and horticulturist Louis Auguste Guillaume Bosc (1759-1828).[26] The species name "*salicifolia*" means "leaves like a willow, Salix L. species".[27] *Boscia salicifolia* is commonly referred to as "willow-leaved shepherd's tree" in English.[28,29] Synonyms associated with *B. salicifolia* include *B. powellii* Sprague & M.L. Green and *B. stylosa* Gilg & Bened.[4-6,27] *Boscia salicifolia* is a small to medium-sized deciduous tree growing up to 15 m in height.[4-6,30] The bole is often short but massive, often twisted with dark grey bark, often rough, becoming scaly to cracked, inner bark yellow with a rounded crown but often flattened with dropping branches. The leaves are alternate, spirally arranged, seldom in groups of two or more, narrowly ovate or narrowly elliptical to linear in shape. The leaves are leathery, dull green above and below, fine-haired below

when mature, apex tapering and bristle-tipped. The flowers are small, occur in axillary racemes or panicles and yellowish green in colour. The fruit is a berry, which is spherical in shape, hairless and yellowish in colour. *Boscia salicifolia* is widespread and occurs from Mauritania, Senegal and Gambia eastward to Somalia and southward to Botswana, Mozambique and Zimbabwe.[4-6,27-31] The species has been recorded in the drier types of woodland, deciduous *Brachystegia-Julbernardia* woodland, bushveld, bamboo thicket, grassland and often on termitaria in sandy, stony or rocky soils at an altitude up to 2100 m above sea level and in drier regions with rainfall ranging from 200 mm to 400 mm per annum.[4-6,27-31]

Medicinal uses of *Boscia salicifolia*

The bark, fruits, leaves, root bark, roots, stem bark and twigs of *B. salicifolia* are mainly used as an anthelmintic or dewormer and herbal medicine for parasitic diseases, eye problems, fertility, fever and malaria, gastro-intestinal problems, headache, skin diseases, sores and wounds, swellings, toothache and ethnoveterinary medicine (Table 1, Figure 1). In Tanzania, the leaves of *B. salicifolia* are mixed with those of *Maerua triphylla* A. Rich. as an antidote and as herbal medicine for tuberculosis.[32] In Ethiopia, the leaves of *B. salicifolia* are mixed with those of *Citrus limon* (L.) Osbeck as herbal medicine for ear problems.[33] In Kenya, the leaves of *B. salicifolia* are mixed with those of *Strychnos henningsii* Gilg and *Carissa spinarum* L. root bark as herbal medicine for joint pains.[34]

Phytochemical composition of *Boscia salicifolia*

Pauli et al.[75] identified boscialin and 4′-O-glucoside from the leaves of *B. salicifolia* while Walter and Séquin[76] isolated rhamnocitrin 3-O-β-neohesperidoside, rhamnetin 3-β-O-neohesperidoside, rhamnocitrin 3-O-β-glucopyranoside and rhamnetin 3-O-β-glucopyranoside from the leaves of *B. salicifolia* (Table 2). Pauli and Séquin[77] identified two flavonol glycosides, rhamnetin 3-O-β-neohesperidoside and rhamnocitrin 3-O-β-neohesperidoside from the leaves of *B. salicifolia*. Yakubu et al.[48] identified the compounds 1,2,3-propanetriol, 3,5-diterbutylphenol, 2-(2-hydroxy-2-phenylethoxy)phenol, methyl-12-methyltetradecanoate, n-hexadecanioc acid, 13-octadecanoate, 9-octadecanioc acid, n-octadecanoic acid and 9-octadecenal from the leaves of *B. salicifolia*. Hassan and Barde[24] identified alkaloids, anthraquinones, flavonoids, saponins and tannins from the leaves of *B. salicifolia*. Some of the pharmacological activities associated with the species could be attributed to the documented phytochemical compounds.

Biological activities of *Boscia salicifolia*

The following biological activities have been reported from the leaves, roots and stem bark extracts of *B. salicifolia*: anthelmintic,[39] antibacterial,[73,78] antiplasmodial,[37,38,53,65] antioxidant,[24] uterotonic[62] and cytotoxicity[37,40,79] activities.

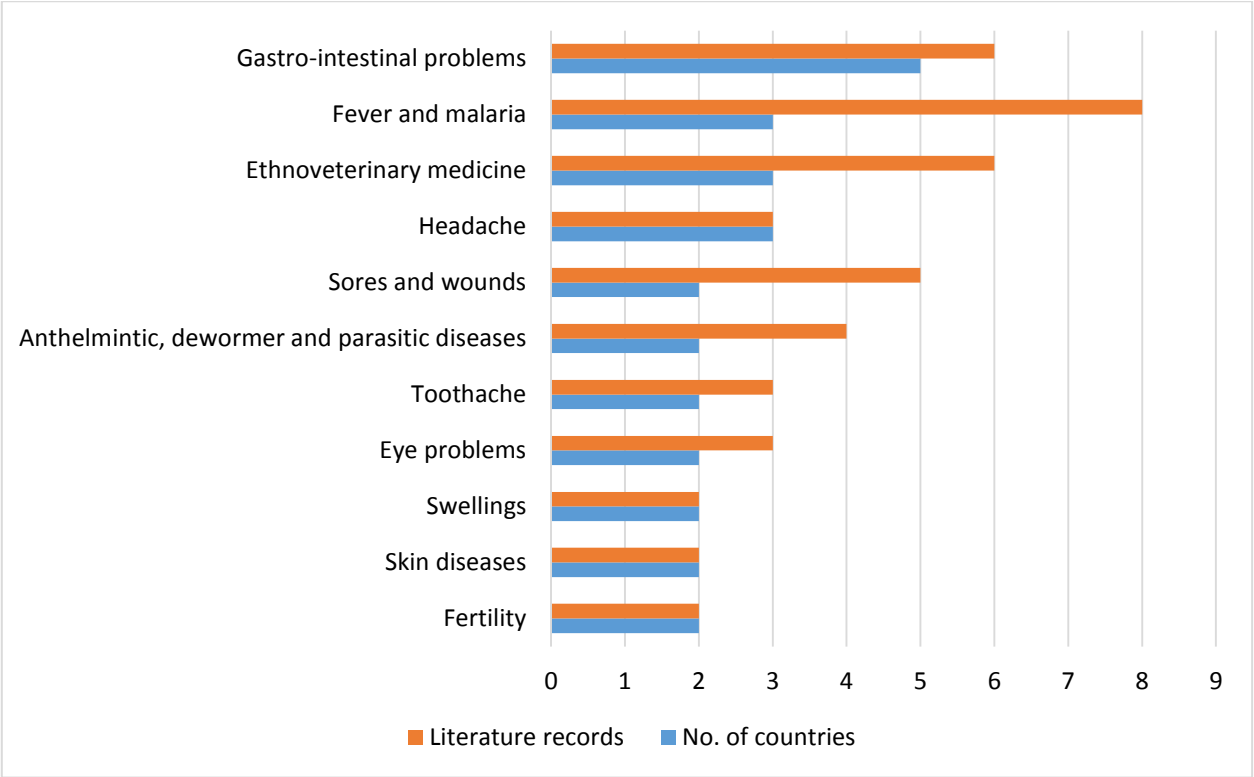

Figure 1. Medicinal applications of *Boscia salicifolia* derived from literature records

Table 1: Medicinal applications of *Boscia salicifolia*

Medicinal use	Parts used	Country/region	References
Anti-candida	Leaves	Namibia	Chinsembu et al.[35]
Anthelmintic, dewormer and parasitic diseases	Leaves and roots	Kenya and Sahel	Von Maydell[36]; Gathirwa et al.[37]; Gathirwa et al.[38]; Waterman et al.[39]
Antidote	Leaves mixed with *Maerua triphylla* A. Rich.	Tanzania	Hedberg et al.[32]
Aphrodisiac, impotence and scrotal masses	Bark, roots and stem bark	Tanzania	Hedberg et al.[32]; Moshi et al.[40]; Augustino et al.[41]
Backache	Bark and roots	Tanzania	Augustino et al.[41]; Stark et al.[42]
Cough	Bark	Sudan	Abd Alla[43]; Karar and Kuhnert[44]
Ear infection	Leaves	Ethiopia	Araya et al.[45]
Ear problems	Leaves mixed with *Citrus limon* (L.) Osbeck	Ethiopia	Chekole[33]
Eye problems	Leaves	Ethiopia and Tanzania	Hedberg et al.[32]; Chekole[33]; Nahashon[46]
Fatigue	Leaves	Nigeria	Idu and Onyibe[47]; Yakubu et al.[48]
Fertility	Roots	Kenya and Zambia	Fowler[49]; Cheruiyot et al.[50]
Fever and malaria	Bark, leaves, stem bark and twigs	Kenya, Nigeria and Sudan	Gathirwa et al.[37]; Abd Alla[43]; Karar and Kuhnert[44]; Kokwaro[51]; Muthaura et al.[52]; Muthaura et al.[53]; Danjuma and Darda'u[54]; Chinsembu[55]
Galactagogue	Leaves	Nigeria	Kankara et al.[56]
Gastro-intestinal problems (diarrhoea, digestive tract problems and stomach ache)	Fruits, leaves, root bark and roots	Eritrea, Ethiopia, Kenya, Sahel and Tanzania	Bein et al.[14]; Giday et al.[23]; Von Maydell[36]; Kokwaro[51]; Chhabra et al.[57]; Lulekal et al.[58]
Headache	Bark and roots	Kenya, Tanzania and Zimbabwe	Augustino et al.[41]; Kokwaro[51]; Gelfand et al.[59]
Human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS)	Roots	Zambia	Chinsembu[60]
Inflammed anus	Leaves	Tanzania	Hedberg et al.[32]; Watt and Breyer-Brandwijk[61]
Labour contractions	Roots	Malawi	Bullough and Leary[62]; Neuffer[63]
Liver problems	Leaves	Nigeria	Kankara et al.[64]
Joint pains	Leaves mixed with *Strychnos henningsii* Gilg leaves and *Carissa spinarum* L. root bark	Kenya	Wambungu et al.[34]
Mosquito repellent	Stem bark	Zimbabwe	Kazembe and Nkomo[65]
Mental illness	Roots	Tanzania	Chhabra et al.[57]
Muscular pain	Leaves	Nigeria	Idu and Onyibe[47]; Yakubu et al.[48]
Nose bleeding	Leaves	Nigeria	Idu and Onyibe[47]; Yakubu et al.[48]
Rectal infections	Stem bark	Tanzania	Khan and Nkunya[66]
Rheumatism	Bark and roots	Tanzania	Augustino et al.[41]; Stark et al.[42]
Scrofula	Leaves and roots	Tanzania	Hedberg et al.[32]
Skin diseases (abscess, furuncle and skin rash)	Leaves and roots	Malawi and Tanzania	Mwafongo et al.[17]; Hedberg et al.[32]
Sores and wounds	Bark and leaves	Tanzania and Zambia	Hedberg et al.[32]; Nahashon[46]; Fowler[49]; Harborne and Mabry[67]; Markam[68]
Stroke	Bark and roots	Tanzania	Augustino et al.[41]
Syphilis	Roots	Zambia	Chinsembu[60]
Swellings	Leaves and roots	Tanzania and Zimbabwe	Chhabra et al.[57]; Gelfand et al.[59]
Toothache	Leaves	Eritrea and Ethiopia	Bein et al.[14]; Teklay et al.[69]; Hishe and Asfaw[70]
Tuberculosis	Leaves mixed with *Maerua triphylla*	Tanzania	Hedberg et al.[32]
Typhoid	Roots	Kenya	Cheruiyot et al.[50]
Ethnoveterinary medicine (ectoparasites, febrifuge and fever)	Leaves and stem bark	Kenya, Tanzania and Zambia	Hedberg et al.[32]; Khan and Nkunya[66]; Bally[71]; Kaposhi et al.[72]; Khan[73]; Chinsembu[74]

Table 2: Phytochemical composition of *Boscia salicifolia*

Phytochemical compound	Value	Plant part	Reference
1, 2, 3-propantriol (%)	1.5	Leaves	Yakubu et al.[48]
2-(2-hydroxy-2-phenylethoxy) phenol (%)	0.6	Leaves	Yakubu et al.[48]
3,5-di-tert-butylphenol (%)	3.2	Leaves	Yakubu et al.[48]
9-octadecenal (%)	5.5	Leaves	Yakubu et al.[48]
9-octadecanioc acid (%)	55.4	Leaves	Yakubu et al.[48]
13-octadecanoate (%)	5.6	Leaves	Yakubu et al.[48]
Boscialin	-	Leaves	Pauli et al.[75]
Boscialin 4′-O-glucoside	-	Leaves	Pauli et al.[75]
Methy-12-methyltetradecanoate (%)	0.9	Leaves	Yakubu et al.[48]
n-Hexadecanioc acid (%)	12.6	Leaves	Yakubu et al.[48]
n-Octadecanioc acid (%)	14.7	Leaves	Yakubu et al.[48]
Rhamnocitrin 3-O-β-neohesperidoside	-	Leaves	Walter and Séquin[76]
Rhamnetin 3-β-O-neohesperidoside	-	Leaves	Walter and Séquin[76]
Rhamnocitrin 3-O-β-glucopyranoside	-	Leaves	Walter and Séquin[76]
Rhamnetin 3-O-β-glucopyranoside	-	Leaves	Walter and Séquin[76]
Rhamnetin 3-O-β-neohesperidoside	-	Leaves	Pauli and Séquin[77]
Rhamnocitrin 3-O-β-neohesperidoside	-	Leaves	Pauli and Séquin[77]

Anthelmintic activities

Waterman et al.[39] evaluated the anthelmintic activities of aqueous and organic leaf extract of *B. salicifolia* using a standard motility assay against a levamisole resistant strain of the nematode *Caenorhabditis elegans*. The degree of activity of extracts was presented as average percentage of worm death and statistically compared to a negative control. The aqueous extracts showed 12.7% dead worms higher than the negative control.[39]

Antibacterial activities

Khan et al.[78] evaluated the antibacterial activities of crude stem bark extract of *B. salicifolia* against *Escherachia coli* and *Staphylococcus aureus* using filter paper disc assay method. The extract exhibited activities against both *Escherachia coli* and *Staphylococcus aureus*.[78] Similarly, Khan[73] evaluated the antibacterial activities of acidic, basic and neutral fractions of petrol, ether and chloroform leaf and stem bark extracts of *B. salicifolia* against *Escherachia coli* and *Staphylococcus aureus* using the disc diffusion method. The neutral ether leaf extract and acidic ether stem bark extract exhibited activities against *Escherachia coli* and *Staphylococcus aureus*, respectively with zone of inhibition ranging from 10 mm to 15 mm.[73]

Antiplasmodial activities

Gathirwa et al.[37] evaluated antiplasmodial activities of aqueous and methanol stem bark extracts of *B. salicifolia* against the chloroquine sensitive (D6) and resistant (W2) *Plasmodium falciparum* using the semi-automated micro-dilution technique that measures the ability of the extracts to inhibit the incorporation of (G-^{3}H) hypoxanthine into the malaria parasite. The methanol and aqueous extracts exhibited activities with half maximal inhibitory concentration (IC_{50}) values of 1.0 µg/ml and 3.7 µg/ml, respectively against D6, and 8.9 µg/ml and 10.1 µg/ml, respectively against W2.[37] Gathirwa et al.[37] evaluated the *in vivo* antimalarial activities of aqueous and methanol stem bark extracts of *B. salicifolia* by using chloroquine sensitive *Plasmodium berghei* strain ANKA based on four-day suppressive test. The methanol and aqueous extracts were active in interperitonial injection treatment with chemo-suppression of 86.5% and 43.8% which were lower than 99.0% chemo-suppression of malaria parasites exhibited by the positive control, chloroquine.[37] Gathirwa et al.[38] evaluated the *in vitro* and *in vivo* drug interactions of aqueous and methanol stem bark extracts of *B. salicifolia* in combination with *Lannea schweinfurthii* (Engl.) Engl., *Searsia natalensis* (Bernh. ex C. Krauss) F. A. Barkley, *Turraea robusta* Gürke and *Sclerocarya birrea* (A. Rich.) Hochst. against chloroquine resistant (W2) *Plasmodium falciparum*. All combinations of *B. salicifolia* with *Lannea schweinfurthii*, *Searsia natalensis* and *Turraea robusta* extracts gave additive or synergistic interactions. But interaction of *B. salicifolia* with *Sclerocarya birrea* was additive at high concentration of *B. salicifolia* and antagonistic as its amount was reduced in the blend. The combination of aqueous extracts of *Turraea robusta* and *B. salicifolia* (20:80) resulted in no activity. The combination of *Searsia natalensis* and *B. salicifolia* (70:30), *Lannea schweinfurthii* and *B. salicifolia* (70:30) and *B. salicifolia* and *Sclerocarya birrea* (60:40) exhibited high chemosupression ranging from 90.6% to 95.8%. Testing these combinations in vivo demonstrated enhanced anti-malarial activities compared to the single B. salicifolia extracts with some giving chemosuppression close to that of chloroquine. The mean survival times of mice treated with blends of *B. salicifolia* and *Lannea schweinfurthii* were not significantly different from the control group treated with chloroquine.[38] Kazembe and Nkomo[65] evaluated the potential in vivo mosquitocide activities of powdered stem bark of *B. salicifolia* on *Aedes aegypti*. The authors showed that the minimum dose was 0.6 mg required to achieve 100% mortality of *Aedes aegypti* in 20 minutes. Muthaura et al.[53] evaluated antiplasmodial activities of aqueous and methanol stem bark extracts of *B. salicifolia* against the chloroquine sensitive (D6) and resistant (W2) *Plasmodium falciparum* using the semi-automated micro-dilution technique that measures the ability of the extracts to inhibit the incorporation of (G-^{3}H) hypoxanthine into the malaria parasite. The methanol and aqueous extracts

exhibited activities with IC_{50} values of 1.1 µg/ml and 3.6 µg/ml, respectively against D6, and 8.8 µg/ml and 10.1 µg/ml, respectively against W2.[53]

Antioxidant activities

Hassan and Barde[24] evaluated antioxidant activities of ethanol leaf extracts of *B. salicifolia* using the reducing power assay. The extract exhibited reasonable reducing capacities of Fe^{3+} to Fe^{2+} in ferric chloride in a concentration dependent manner.[24]

Uterotonic activities

Bullough and Leary[62] evaluated uterotonic activities of water extracts of roots of *B. salicifolia* using isolated guinea-pig uterus. The extract caused changes in amplitude and frequency of contractions, similar to those noted in response to oxytocin.[62]

Cytotoxicity activities

Moshi et al.[40] evaluated toxicity of ethanol root extract of *B. salicifolia* using the brine shrimp lethality test with cyclophosphamide as a positive control. The extract was toxic with median lethal concentration (LC_{50}) value of 22.8 µg/ml which was comparable to LC_{50} value of 16.3 µg/ml exhibited by the positive control.[40] Gathirwa et al.[37] evaluated the cytotoxicity activities of aqueous and methanol stem bark extracts of B. salicifolia on Vero cells using the plaque reduction assay. The methanol extract was the most active with CC_{50} value of 304.9 µg/ml and selectivity index values of 293.2 and 34.4 against chloroquine sensitive (D6) and resistant (W2) *Plasmodium falciparum*, respectively.[37] Similarly, Omosa et al.[79] evaluated the cytotoxicity of dichloromethane and methanol (1:1) extract of *B. salicifolia* aerial parts using the resazurin reduction assay against CCRF-CEM leukemia cell line with doxorubicin as a positive control. The extract exhibited weak activities with 74.9% cell viability at 10.0 µg/mL which was much higher than 6.5% exhibited by the positive control.[79]

CONCLUSION

The present review summarizes the ethnomedicinal uses, phytochemistry and biological activities of the bark, fruit, leaf, rootbark, root, stem bark and twig extracts of *B. salicifolia*. The historical traditional usage of *B. salicifolia* as herbal medicine in the Sahel and sub-Saharan Africa calls for detailed phytochemical and pharmacological studies aimed at correlating its documented ethnomedicinal uses with the phytochemical and pharmacological properties of the species. There is need for clinical and toxicological evaluations of both crude extracts and phytochemical compounds associated with *B. salicifolia*.

Conflict of interest

The author declares that he has no conflict of interest.

Acknowledgements

I would like to express my gratitude to the National Research Foundation (NRF), South Africa and Govan Mbeki Research and Development Centre (GMRDC), University of Fort Hare for financial support to conduct this study.

REFERENCES

[1] Hall, J.C., Sytsma, K.J., Iltis, H.H., *Am. J. Bot.* 2002, 89, 1826-1842.
[2] Kers, L.E., in: Kubitzki, K., Bayer, C. (Eds.), *The Families and Genera of Vascular Plants, Vol. 5*, Springer-Verlag, Berlin 2003, pp. 36-56.
[3] Hall, J.C., *Bot.* 2008, 86, 682-696.
[4] Wild, H., in Exell, A.W., Wild, H. (Eds.), *Flora Zambesiaca Vol 1, Part 1*, Flora Zambesiaca Managing Committee, London 1960, pp. 194–245.
[5] Elffers, J., Graham, R.A., DeWolf, G.P., in: Hubbard, C.E., Milne-Redhead, E. (Eds.), *Flora of Tropical East Africa*, Crown Agents for Oversea Governments and Administrations, London 1964, pp. 1-88.
[6] Kers, L.E., in: Edwards, S., Tadesse, M., Sebsebe, D., Hedberg, I. (Eds.), *Flora of Ethiopia and Eritrea, Vol 2, Part 1, Magnoliaceae to Flacourtiaceae*, The National Herbarium, Addis Ababa University, Addis Ababa 2000, pp. 74–120.
[7] Kamel, W.M., El-Ghani, M.M.A., El-Bous, M.M., *Afr. J. Pl. Sci. Biotechnol.* 2009, 3, 27-35.
[8] Iwu, M.M., *Handbook of African Medicinal Plants*, CRC Press, Boca Raton 1993.
[9] Lemmens, R.H.M.J., in: Schmelzer, G.H., Gurib-Fakim, A. (Eds.), Plant Resources of Tropical Africa 11: Medicinal Plants 2, Backhuys Publishers, Leiden 2013, pp. 21-22.
[10] Lemmens, R.H.M.J., in: Schmelzer, G.H., Gurib-Fakim, A. (Eds.), Plant Resources of Tropical Africa 11: Medicinal Plants 2, Backhuys Publishers, Leiden 2013, pp. 22-25.
[11] Burkill, H.M., *The Useful Plants of West Tropical Africa, Vol 1, Families A–D*, Royal Botanic Gardens, Kew, London 1985.
[12] Gomez, M.I., *Zambezia* 1988, 15, 53-73.
[13] Mbuya, L.P., Msanga, H.P., Ruffo, C.K., Birnie, A., Tengnäs, B., *Useful Trees and Shrubs for Tanzania: Identification, Propagation and Management for Agricultural and Pastoral Communities*, Technical Handbook 6, Regional Soil Conservation Unit, Nairobi 1994.
[14] Bein, E., Habte, B., Jaber, A., Birnie, A., Tengnas, B., *Useful Trees and Shrubs in Eritrea: Identification, Propagation and Management for Agricultural and Pastoral Communities*, Regional Soil Conservation Unit, Technical Handbook Series 12, Nairobi 1996.
[15] Arbonnier, M., *Trees, Shrubs and Lianas of West African Dry Zones*, CIRAD, Paris 2004.
[16] Ogbazghi, W., Bein, E., in: Ghebru, B., Mehari, T. (Eds.), *Innovative Agricultural Approaches of Promoting Food Security in Eritrea: Trends, Challenges and Opportunities for Growth*, Geographica Bernensia, Bern 2007, pp. 29-40.
[17] Mwafongo, E., Nordal, I., Magombo, Z., Stedje, B., *Ethnobot. Res. Appl.* 2010, 8, 75-93.
[18] Faye, M.D., Weber, J.C., Abasse, T.A., Boureima, M., Larwanou, M., Bationo, A.B., Diallo, B.O., Sigué, H., Dakouo, J.-M., Samaké, O., Diaité, D.S., *For. Trees Livelih.* 2011, 20, 113-136.
[19] Bahru, T., Asfaw, Z., Demissew, S., *J. Ecol. Nat. Environ.* 2012, 4, 141-149.
[20] Addis, G., Asfaw, Z., Woldu, Z., *Ethnobot. Res. Appl.* 2013, 11, 251-271.
[21] Hamidou, A., Boube, M., Mahamane, L., Ali, M., Mahamane, S., Bellefontaine, R., *J. Hortic. For.* 2015, 7, 149-159.
[22] Kidane, B., Van der Maesen, L.J.G., Asfaw, Z., Sosef, M.S.M., Van Andel, T., *Genet. Resour. Crop Evol.* 2015, 62, 221–234.
[23] Giday, K., Lenaerts, L., Gebrehiwot, K., Yirga, G., Verbist, B., Muys, B., *J. Herbal Med.* 2016, 6, 96–104.
[24] Hassan, Y., Barde, M.I., *Int. Ann. Sci.* 2019, 8, 12-16.
[25] Bello, A., Jamaladdeen, S., Elder, M.T., Yaradua, S.S., Kankara, S.S., Wagini, N.H., Stirton, C.H., Muasya, M., *Bothalia* 2019, 49, a2325.
[26] Quattrocchi, U., *CRC World Dictionary of Medicinal and Poisonous Plants: Common Names, Scientific Names, Eponyms, Synonyms and Etymology*, Taylor and Francis Group, Boca Raton 2012.

[27] Hyde, M.A., Wursten, B.T., Ballings, P., Palgrave, C.M., *Boscia salicifolia* Oliv.: Flora of Zimbabwe; 2019. Available from: https://www.zimbabweflora.co.zw/speciesdata/species.php?species_id=124530. [Accessed on 18 July 2019].
[28] Van Wyk, B., Van Wyk, P., *Field Guide to Trees of Southern Africa*, Struik Publications (Pty) Ltd, Cape Town 1997.
[29] Palgrave, M.C., *Keith Coates Palgrave Trees of Southern Africa*, Struik Publishers, Cape Town 2002.
[30] Germishuizen, G., Meyer, N.L., *Plants of Southern Africa: An Annotated Checklist*, Strelitzia 14, National Botanical Institute, Pretoria 2003.
[31] Drummond, R.B., *Kirkia* 1975, 10, 229-285.
[32] Hedberg, I., Hedberg, O., Madati, P.J., Mshigeni, K.E., Mshiu, E.N., Samuelsson, G., *J. Ethnopharmacol.* 1982, 6, 29–60.
[33] Chekole, G., *J. Ethnobiol. Ethnomed*. 2017, 13, 55.
[34] Wambugu, S.N., Mathiu, P.M., Gakuya, D.W., Kanui, T.I., Kabasa, J.D., Kiama, S.G., *J. Ethnopharmacol.* 2011, 137, 945–955.
[35] Chinsembu, K.C., Hedimbi, M., Mukaru, W.C., *J. Med. Pl. Res.* 2011, 5, 6787-6797.
[36] Von Maydell, H.-J., 1990. *Trees and Shrubs of the Sahel: Their Characteristics and Uses*, Verlag Josef Margraf, Weikersheim 1990.
[37] Gathirwa, J.W., Rukunga, G.M., Njagi, E.N.M., Omar, S.A., Guantai, A.N., Muthaura, C.N., Mwitaria, P.G., Kimani, C.W., Kirira, P.G., Tolo, F.M., Ndunda, T.N., Ndiege, I.O., *J. Nat. Med*. 2007, 61, 261–268.
[38] Gathirwa, J., Rukunga, G., Njagi, E., Omar, S., Mwitari, P., Guantai, A., Tolo, F., Kimani, C., Muthaura, C., Kirira, P., Ndunda, T., Amalemba, G., Mungai, G., Ndiege, I., *J. Ethnopharmacol.* 2008, 115, 223–231.
[39] Waterman, C., Smith, R.A., Pontiggia, L., DerMarderosian, A., *J. Ethnopharmacol.* 2010, 127, 755–579.
[40] Moshi, M.J., Mbwambo, Z.H., Nondo, R.S.O., Masimba, P.J., Kamuhabwa, A., Kapingu, M.C., Thomas, P., Richard, M., *Afr. J. Trad. Compl. Alt. Med.* 2006, 3, 48–58.
[41] Augustino, S., Hall, J.B., Makonda, F.B.S., Ishengoma, R.C., *J. Med. Pl. Res.* 2011, 5, 6352-6372.
[42] Stark, T.D., Mtui, D.J., Balemba, O.B., *Animals* 2013, 3, 158-227.
[43] Abd Alla, A.A., *J. For. Prod. Ind.* 2013, 2, 29–33.
[44] Karar, M.G.E., Kuhnert, N., *Pharmacogn. Rev.* 2017, 11, 83–103.
[45] Araya, S., Abera, B., Giday, M., *J. Ethnobiol. Ethnomed*. 2015, 11, 22.
[46] Nahashon, M., *Conservation of Wild-Harvested Medicinal Plant Species in Tanzania: Chain and Consequences of Commercial Trade on Medicinal Plant Species*. MSc Dissertation, Uppsala University, Uppsala 2013.
[47] Idu, M., Onyibe, H.I., *Nigeria Res. J. Med. Pl.* 2007, 1, 32-41
[48] Yakubu, M.B., Usman, I.A., Ado, M.T., *Nigerian J. Chem. Res.* 2019, 19, 31-36.
[49] Fowler D,G., *Kirkia* 2002, 18, 35-48.
[50] Cheruiyot, K.J., Elizabrth, N., Charles, M., Christine, B., Richard, K., Emily, T., J. Ethnobiol. Trad. Med. Photon 2013, 120, 633-649.
[51] Kokwaro, J.O., *Medicinal Plants of East Africa*, University of Nairobi Press, Nairobi 2009.
[52] Muthaura, C.N., Keriko, J.M., Derese, S., Yenesew, A., Rukunga, G.M., *Exp. Parasitol.* 2011, 127, 609-626.
[53] Muthaura, C.N.; Keriko, J.M.; Mutai, C.; Yenesew, A.; Gathirwa, J.W.; Irungu, B.N.; Nyangacha, R.; Mungai, G.M.; Derese, S., *J. Ethnopharmacol.* 2015, 175, 315–323.
[54] Danjuma, M.N., Darda'u, H., *Acad. Res. Int.* 2013, 4, 174-183.
[55] Chinsembu, K.C., *Acta Trop*. 2015, 152, 32–48.
[56] Kankara, S.S., Ibrahim, M.H., Mustafa, M., Go, R., *S. Afr. J. Bot.* 2015, 97, 165–175.
[57] Chhabra, S.C., Mahunnah, R.L.A., Mshiu, E.N., *J. Ethnopharmacol.* 1989, 25, 339-359.
[58] Lulekal, E., Kelbessa, E., Bekele, T., Yineger, H., *J. Ethnobiol. Ethnomed.* 2008, 4, 10.
[59] Gelfand, M., Drummond, R.B., Mavi, S., Ndemera, B., *The Traditional Medical Practitioner in Zimbabwe: His Principles of Practice and Pharmacopoeia*, Mambo Press, Gweru 1985.
[60] Chinsembu, K.C., *Evidence-Based Compl. Alt. Med.* 2016, vol. 2016, article ID 4238625.
[61] Watt, J.M., Breyer-Brandwijk, M.G., *Medicinal and Poisonous Plants of Southern and Eastern Africa*, E and S Livingstone, London 1962.
[62] Bullough, C.H.W., Leary, W.P., *Trop. Geogr. Med.* 1982, 34, 81-85.
[63] Neuffer, T., *J. Inquiry Stud. Cross Cult. Field Res.* 2018, 11, 3-13.
[64] Kankara, S.S., Isah, A.B., Bello, A., Ahmed, A., Lawal, U., *J. Med. Pl. Res.* 2018, 12, 375-386.
[65] Kazembe, T., Nkomo, S., Indian J. Trad. Knowl. 2010, 9, 394–397.
[66] Khan, M.R., Nkunya, M.H.H., *Antimicrobial Activity of Tanzanian Traditional Medicinal Plants. Part I: Use and Promotion of Traditional Medicinal Plants in the African Region*, Dar Es Salaam University Press, Dar Es Salaam 1991.
[67] Harborne, J.B., Mabry, T.J., *The Flavonoids, Advances in Research*, Chapman and Hall, London 1982.
[68] Markham, K.R., *Techniques of Flavonoid Identification, Vol. 31*, Academic press, London 1982.
[69] Teklay, A., Abera, B., Giday, M., *J. Ethnobiol. Ethnomed.* 2013, 9, 65.
[70] Hishe, M., Asfaw, Z., *Adv. J. Biol. Sci. Res.* 2015, 3, 8-36.
[71] Bally, P.R.O., *Bull. Miscell. Inf.* 1937, 1, 10-26.
[72] Kaposhi, C.K.M., Mundia, M.P., Mwangala, F.S., Banda, R., Mugoya, C., *Extraction and Evaluation of Active Ingredients from Selected Zambian Plants with Acaricidal and Insecticidal Properties*, Proceedings from the first National Symposium in Zambia, Lusaka, 2-5 August 1994.
[73] Khan, M.R., *Pharm. Biol.* 39, 3, 206-212.
[74] Chinsembu, K.C., in Chinsembu, K.C., Cheikhyoussef, A., Mumbengegwi, D., Kandawa-Schulz, M., Kasanda, C.D., Kazembe, L. (Eds.), I*ndigenous Knowledge of Namibia*, University of Namibia, Windhoek 2015, pp. 115-134.
[75] Pauli, N., Sequin, U., Walter, A., *Helv. Chim. Acta* 1990, 73, 578–582.
[76] Walter, A., Séquin, U., *Phytochem.* 1990, 29, 2561–2563.
[77] Pauli, N., Sequin, U., *Molecules* 1996, 1, 15–22.
[78] Khan, M.R., Ndaalio, G., Nkunya, M.H.H., Wevers, H., Sawhney, A.N., *Planta Med*. 1980, Suppl., 91-97.
[79] Omosa, L.K., Midiwo J.O., Masila V.M., Gisacho B.M., Munayi R., Francisca-Kamakama, Chemutai, K.P., Elhaboob, G., Saeed, M.E.M., Hamdoun, S., Kuete, V., Efferth, T., J. Ethnopharmacol. 2016, 179, 177–196.