

Antimicrobial wound healing properties of indigenous medicinal plants of Lesotho and the pharmacist's role in minor wound care

OK Hlokoane , M Sello 

Department of Pharmacy, National University of Lesotho, Lesotho

Corresponding author, email: hlokoaneo@gmail.com

Abstract

Lesotho has a rich supply of indigenous medicinal plant resources. More than a dozen Lesotho medicinal plants have been used to treat minor wound infections among Basotho for over 100 years. The aim is to provide scientific validation of their antimicrobial activities against microorganisms relevant to the skin. The anti-infective activities of plants are thought to be due to the presence of active phytochemicals in parts of the plants, especially phenolic compounds, anthraquinones, glycosides, and alkaloids. Although there is limited research that establishes the structure-activity relationship of those phytochemicals, there are reports that attributed the phytochemical constituents with the antimicrobial effects through a variety of mechanisms ranging from inhibition of cytoplasmic membrane function, inhibition of energy metabolism to inhibition of bacterial nucleic acid synthesis. The role of the pharmacist is to provide medical information on these compounds to promote the safe use of herbal products and in combination with conventional medicines.

Keywords: antimicrobial wound healing properties, indigenous medical plants, Lesotho, minor wound care

© Medpharm

S Afr Pharm J 2021;88(1):33a-33e

Introduction

Lesotho is one of the Southern African countries that is rich with indigenous medicinal plant resources. In fact, the flora of Lesotho is said to encompass around 200 families, assigned to 800 genera and 3 000 species.¹ Historically, 303 of these have been used medicinally by Basotho.² The fact that medicinal plants are still viewed as the most cost-effective and accessible therapy by many rural dwellers in Lesotho cannot be denied. As a result, the demand and use of herbal medicines are high, especially in developing countries and globally. According to the 2019 World Health Organization (WHO) Global Report on Traditional and Complementary Medicine, 88% of WHO Member States use traditional and complementary medicines.³ In 2019, the global herbal medicine market size was US\$ 138 350 million and it is expected to reach US\$ 218 940 million by the end of 2026, with a compound annual growth rate (CAGR) of 6.7% during 2021–2026.⁴ Herbalists and traditional healers in Lesotho continue to dispense a wide range of topical herbal medicinal preparations for the treatment of minor wound infections,⁵⁻⁹ while severely infected wounds need appropriate medical attention.¹⁰

Skin is important as one of the largest organs in the body. It provides first-line protection against infections by acting as a physical barrier. A large number of microorganisms that colonise and infect wounds are the patient's own endogenous normal flora.¹¹ These pathogens are mainly gram-positive *Staphylococcus aureus*, coagulase-negative staphylococci, *Enterococci* and gram-negative bacteria such as *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella* species. Among fungal pathogens, *Candida albicans* is the most frequent cause of infections of the skin.¹¹

The antimicrobial activities of medicinal plants are thought to depend on the active phytochemicals present, their concentrations as well as their synergistic actions.¹² They act by various mechanisms, including inhibition of bacterial nucleic acid synthesis, inhibition of cytoplasmic membrane function, and inhibition of energy metabolism.¹³⁻¹⁶ Perhaps the plants produce these secondary metabolites because some of these chemicals are directly involved in plant defence mechanisms against pathogens.¹² Pharmacists, as health care providers, are the custodians of medicines and knowledge thereof. They play a vital role to educate and make recommendations on the use of medicines including herbal medicines, based on the existing evidence of their efficacy. This article aims to provide scientific validation to the antimicrobial wound healing properties of medicinal plants used to treat minor wound infections in Lesotho to inform pharmaceutical care. The basis for pharmacists' involvement with herbal products is an extension of their established role in pharmaceutical care, in which pharmacists are actively involved with the patients.¹⁷ There is a significant opportunity for pharmacists to have a greater role in caring for patients with minor wounds. In collaboration with prescribers, pharmacists can design and formulate topical treatments to meet the unique needs of the patient.¹⁸

Conventional medicines previously isolated from plants

Frequently encountered medicines in clinical settings that are originally from medicinal plants include:

- Digoxin is a cardiac glycoside native to European and Mediterranean regions, *Digitalis purpurea* commonly known as foxglove was used by traditional healers and physicians from time immemorial. It strengthens the force of contraction of weakened heart muscles in heart failure.^{19,20}
- Morphine is an alkaloid obtained from opium, air-dried milky latex obtained by incision from the unripe capsules of *Papaver somniferum* native to Asia, Europe, and northwestern Africa. It is a narcotic agonist-analgesic of opiate receptors that produces analgesia by inhibiting ascending pain pathways.²¹ These medicines were discovered through a systematic examination of traditional medicinal plants and associated traditional knowledge.¹⁹

African herbal medicines frequently sold in pharmacies include:

- Kaloba Pelargonium, often marketed for the treatment of cough and colds, is the root extract of *Pelargonium sidoides* a plant native to coastal South Africa.²² Its mechanism of action may include a cytoprotective effect against viral attack, an antimicrobial effect through the release of defensins from neutrophilic granulocytes, and an immune-boosting effect through the release of tumour necrosis factor, nitrous oxide, and an increase in natural killer cell activity.^{23,24}
- Heder, an expectorant, is a leaf extract of *Hedera helix* a plant with wide distribution including North Africa. Pharmacological studies showed that *H. helix* possessed respiratory, anti-inflammatory, analgesic, immunological, anticancer, antimutagenic, antimicrobial, anti-parasitic, gastrointestinal, and antithrombin activity.²⁵
- Devil's claw, often marketed for the treatment of painful chronic arthritic conditions, is an extract obtained from the root of the *Harpagophytum procumbens* a plant native to the Kalahari region in Southern Africa. It is effective for the treatment of chronic arthritic conditions because of its pain-relieving and anti-inflammatory actions²⁶ and
- Hoodia, an appetite-suppressant and dietary supplement, is extracted from a cactus-like succulent plant *Hoodia gordonii* native to the Kalahari desert in Southern Africa.²⁷ A steroidal glycoside isolated from this plant is believed to produce a loss of appetite through the central (CNS) mode of action.²⁸

These medicines have been used as commercial products due to their use in traditional medicine.

Plants used to treat minor wound infections in Lesotho

Although Basotho have been using medicinal plants to treat minor wound infections for over 100 years, their antimicrobial efficacies remained a mystery until recently. In 1999, Shale and his colleagues examined about ten (10) plant species from Lesotho used in wound care and found that six plant species had antibacterial activities against both gram-positive and gram-negative bacteria relevant to the skin; with a wider spectrum on gram-positive bacteria.⁸ Seleteng Kose and Mugomeri and

their colleagues documented related traditional knowledge through interviews of Lesotho traditional healers, herbalists, and pharmacists.^{5,6} Thereafter, the mysteries of the efficacies of herbal preparations used for wound care were further exposed by the studies conducted outside Lesotho which disclosed the actual active principles.²⁹⁻³⁹ Table I summarises names, method of preparation, and in vitro antimicrobial assays of medicinal plants commonly used by Lesotho herbalists and traditional healers. Medicinal plants whose in vitro antimicrobial activity had not yet been evaluated and those plants whose in vitro antimicrobial studies shown no activity were excluded.

Most plants are applied directly to the wounds, either as a dried and crushed powder or as an infusion to clean the wounds, thus minimising their systemic effects and possible interactions with the conventional medicines. The phenolic compounds which constitute the flavonoids and salicinoids were frequently isolated and were proven to be responsible for antimicrobial efficacies of most plants. These are followed by anthraquinones and alkaloids. *Aloe ferox* Mill., *Hypoxis hemerocallidea*, *Malva parviflora* L. var. *parviflora* and *Withania somnifera* (L.) were highly active species, with *Aloe ferox* Mill. showing activity to even methicillin-resistant *S. aureus* (MRSA). Due to increasing antimicrobial resistance, these plants can provide the leads to new antibiotic drug discovery.

The role of the pharmacist in Lesotho in the use of herbal medicines for minor wound care

The demand for use of herbal medicines is increasing as Basotho still views medicinal plants as the most cost-effective and accessible therapy. The majority of the patients that present in pharmacies with small wounds have used or are using the herbal medicinal products that are dispensed by traditional and herbal healers to treat minor wound infections. The pharmacist must keep abreast of the knowledge of the existing efficacies of traditional medicinal plants to be able to make recommendations to other healthcare providers and patients. In addition, pharmacists can also perform a specific patient pharmacological review to identify those oral conventional medications such as anticoagulants and immunosuppressants that are known to inhibit wound healing and could interact with the topical wound care herbal products.^{18,40}

Moreover, pharmacists can undertake small scale manufacture and packaging of herbs used in wound care as processed powders or plant extracts. Herbal medicines should be manufactured following good manufacturing practice (GMP) guidelines to ensure the uniform quality and safety of the products.^{41,42} To maintain a sustainable harvest of medicinal plant species, cultivation appears to be an important strategy for meeting the growing demand. Cultivation and domestication studies should be carried out through a dialogue between pharmacists on one hand, and agriculturists and botanists on the other.⁴³ Such collaboration, which would link the knowledge of safety and efficacy of medicines with the science of cultivating and knowledge of plants life, could result in a sustainable supply of inexpensive and high-quality medicinal herb raw materials for pharmaceutical, perfumery, and

Table 1: Name, method of preparation, and in vitro antimicrobial assays of medicinal plants commonly used by Lesotho herbalists and traditional healers^{29,39}

Scientific name/Family	Vernacular name (Lesotho)	Method of preparation	In vitro antimicrobial assay against common skin pathogens
<i>Aloe ferox</i> Mill. (Aloaceae)	Lekhala la quthing	Leaves juice extracts are mixed with water for wounds	<i>Staphylococcus aureus</i> , Methicillin-resistant <i>S. aureus</i> (MRSA), <i>S. epidermidis</i> , <i>Bacillus cereus</i> , <i>B. subtilis</i> , <i>Escherichia coli</i> , <i>Shigella sonnei</i> , <i>Candida albicans</i>
<i>Boophone disticha</i> (L.f.) Herb. (Amaryllidaceae)	Leshoma	Leaves placed on circumcision wounds and infusion of bulbs used to clean wounds	<i>S. aureus</i> , <i>E. coli</i> , <i>K. pneumoniae</i> , <i>Bacillus subtilis</i>
<i>Bulbine frutescens</i> (L.) Willd (Asphodelaceae)	Sereleli	Fresh leaf sap is applied to the wounds	<i>S. aureus</i> , <i>B. subtilis</i> , <i>E. coli</i> , <i>Micrococcus kristinae</i>
<i>Bulbine naricissifolia</i> Salm-Dyck (Asphodelaceae)	Khomo-ee-ballisa	Leave sap or roots extracts for wounds	<i>S. aureus</i> , <i>B. subtilis</i> , <i>Micrococcus kristinae</i>
<i>Chenopodium album</i> L. (Chenopodiaceae)	Seruoe	Decoction used to treat wounds	<i>S. aureus</i> , <i>S. epidermidis</i> , <i>B. subtilis</i> , <i>E. coli</i> , <i>K. pneumoniae</i> , <i>M. luteus</i> , <i>P. aeruginosa</i>
<i>Cheilanthes</i> sp.	'Mamaoaneng/ 'Mamarakoaneng	Slightly roasted whole plant material is applied to wounds	<i>S. aureus</i> , <i>S. typhi</i> , <i>E. coli</i> , <i>Enterobacter</i> sp, <i>S. paratyphi</i> , and <i>S. mutans</i>
<i>Rotheca hirsute</i> (<i>Clerodendrum glabrum</i>) E.Mey. (Verbenaceae)	Khopha	Decoction of leaf applied to wound	<i>S. aureus</i> , <i>K. pneumoniae</i> , <i>E. coli</i> , <i>C. Albicans</i> , <i>Cryptococcus neoformans</i>
<i>Cussonia paniculata</i> Eckl. Zeyh. ssp. <i>Sinuata</i> (Reyneke & Kok) De Winter (Araliaceae)	Motset'se	Leaf infusion is used to clean wounds	<i>S. aureus</i> , <i>P. aeruginosa</i> , and <i>N. gonorrhoeae</i>
<i>Cynoglossum lanceolatum</i> Forsk. (Boraginaceae)	Bohome	Crushed root used as a plaster for wounds	<i>C. Albicans</i> , <i>E. coli</i> , <i>S. aureus</i> , <i>Shigella sonnei</i> , <i>K. pneumoniae</i> , <i>S. epidermidis</i> , <i>Salmonella paratyphi</i> , <i>S. typhimurium</i>
<i>Euphorbia clavarioides</i> Boiss var. <i>clavarioides</i> (Euphorbiaceae)	Sehlehle/ Sehloko	Roots infusion used to treat wounds	<i>S. epidermis</i> , <i>B. subtilis</i> , <i>P. aeruginosa</i>
<i>Gunnera perpensa</i> L. (Gunneraceae)	Qobo	Leaves as a hot poultice for wounds and rhizome decoction is applied as wound dressing	<i>S. aureus</i> , <i>S. epidermidis</i> , <i>E. coli</i> , <i>P. aeruginosa</i> , <i>C. albicans</i> , <i>Cryptococcus neoformans</i> , <i>E. faecalis</i> , <i>A. fumigatus</i>
<i>Hypoxis hemerocallidea</i> (Hypoxidaceae)	Moli (African potato)	Crushed corms are boiled, and the decoction is administered three times a day	<i>S. aureus</i> , <i>E. faecalis</i> , <i>E. coli</i> , <i>P. aeruginosa</i> , <i>Bacillus cereus</i> , <i>Shigella flexneri</i> , <i>Trichophyton rubrum</i> , <i>Trichophyton tonsurans</i> , <i>Candida glabrata</i> , <i>Candida krusei</i>
<i>Malva parviflora</i> L. var. <i>parviflora</i> (Malvaceae)	Tika-motse	Tubular roots dried powder is applied into clean wounds	<i>S. aureus</i> , <i>S. epidermidis</i> , <i>B. subtilis</i> , <i>E. coli</i> , <i>K. pneumoniae</i> , <i>M. luteus</i> , <i>P. aeruginosa</i>
<i>Rumex acetosella</i> L. (Polygonaceae)	Bolilanyane	Crushed roots decoction used to bath wounds	<i>B. subtilis</i> , <i>E. coli</i> , <i>K. pneumoniae</i> , <i>M. luteus</i> , <i>P. aeruginosa</i> , <i>S. aureus</i> , <i>S. epidermidis</i> , <i>C. albicans</i>
<i>Salix mucronata</i> Thunb. (Salicaceae)	Moluoane	Preparation of plant to treat burn wounds	<i>K. pneumoniae</i> , <i>S. aureus</i> , <i>B. subtilis</i> , <i>E. coli</i>
<i>Solanum aculeatissimum</i> Jacq. (Solanaceae)	Thola	Powdered plant is rubbed into wounds	<i>B. subtilis</i> , <i>E. coli</i> , <i>K. pneumoniae</i> , <i>M. luteus</i> , <i>P. aeruginosa</i> , <i>S. aureus</i> , <i>S. epidermidis</i>
<i>Withania somnifera</i> (L.) Dunal (Solanaceae)	Mofera-ngope	Paste of leaves applied to wounds	<i>S. aureus</i> , <i>S. epidermidis</i> , <i>N. gonorrhoea</i> and <i>C. albicans</i> , <i>B. subtilis</i> , <i>E. coli</i> , <i>K. pneumoniae</i> , <i>Micrococcus pyogenes</i> , <i>Saccharomyces cerevisiae</i> , <i>S. typhi</i> , <i>Shigella dysenteriae</i> , <i>Vibrio cholerae</i>

cosmetic industries while conserving the environment.⁴³ Testing of herbal products for heavy metal and microbial contaminants before packaging them is highly recommended, and may become mandatory.⁴²

Furthermore, pharmacists can compound over-the-counter (OTC) topical herbal medicinal products. Using bases or carriers, easily compoundable herbal extracts can be compounded into wound care formulas as creams, ointments, or powders.¹⁸ For example; the gel of *Aloe vera* leaf can be easily compounded into creams or dried gel powder into powders for promotion of wound healing,⁴⁴ while green propolis extract can be easily compounded as a cream to aid the wound healing process by decreasing the inflammation at the site of injury through a combination of antimicrobial and anti-inflammatory activities.⁴⁵

Potential side-effects and toxicities of topical herbal medicines

It is popularly perceived by societies that herbal products, compared to products made from synthetic chemical ingredients. However, herbal ingredients in cosmetics products have been associated with hypersensitivity reactions resulting in inflammatory skin eruptions characterised by pruritis, erythematous vesicles, and papules.⁴⁶ For instance: eucalyptus oil, famous for its antibacterial, antiviral, antifungal, and anti-inflammatory properties, is regarded as safe and is included in topical antiseptics, soaps, mouthwashes as well as balms.⁴⁶ Nonetheless, some reports implicate its main constituent, 1,8-cineole, as the causative allergen in some side effects.⁴⁶ Indeed, the potential of encountering side-effects with herbal medicines could be greater when herbs are used in their crude forms, such as bulb, roots, bark, leaves, flowers, or seeds, compared to herbal formulas.⁴² Although the knowledge about which herbs are potentially toxic in Lesotho has passed from one generation to another through oral traditions, and most topical herbs are used without any problem, toxicities do occur possibly due to contamination with toxic medicinal plants and/or plant parts.⁴¹ Other toxic contaminants could include heavy metals from the soil where the plants are grown or traces of pesticides.⁴⁷

The contaminants that are most hazardous to health, especially in wound care products, are pathogenic bacteria which may include *Salmonella spp.*, *E. coli*, *S. aureus*, and *Shigella spp.*⁴⁸ They have the potential to wound infections and can complicate wound healing.

Advice to patients in Lesotho who treat minor wounds themselves

It is always important for patients to consult with community pharmacists or other health professionals before using any remedy, even for minor wounds caused by minor accidents, sports injuries, or sunburns, rather than to simply self-treat. Notwithstanding, many rural communities in Lesotho, especially those inhabiting the mountainous areas of the country, usually resort to consulting with the nearby traditional healers and/or to home treatment using medicinal plants probably due to their ease of access and cost-effectiveness as well as perceived safety.

Pharmacists should therefore advise patients who self-treat using herbs to avoid secondary infections and optimise wound healing by following the first aid wound care protocols:

- clean the affected area thoroughly with soap and running water to remove the foreign matter,
- apply a thin layer of gel from freshly cut antibiotic medicinal plant such as *A. ferox* to minimise infections, and
- cover the affected area with a clean ironed or sterile cotton cloth to create a moist healing environment.⁴⁹

Gels and extracts from the genus *Aloe*, including *A. vera* and *A. ferox*, have been successfully used for wound healing in communities and commercially and are thus recommended as the first-choice treatment for self-medication by patients. Patients should avoid plants that require storage and processing as this could introduce contaminants, including pathogenic microbes. The practice of planting medicinal plants is encouraged to avoid their uncontrolled harvesting from nature, and thus protect the environment.⁴³ Although the WHO has developed GMP guidelines to maintain the quality of herbal medicines, most distributors including traditional practitioners and handlers or processors, and consumers are not particularly aware of those guidelines.⁴⁷

Conclusion

The demand for and use of herbal medicines and herbal medicinal products are increasing. More than a dozen plants used in Lesotho for minor wound care contain active phytochemicals with proven antimicrobial efficacies. This information is important to pharmacists in order to be able to make recommendations to other healthcare providers and patients. By actively embracing this opportunity pharmacists will become recognised experts in this rapidly growing field of phytomedicine. While studies on the majority of medicinal plants have been limited to in vitro and/or animal models, large randomised human studies are needed. Finally, studies to isolate active phytochemicals and establish their mode of action, as well as toxicology studies of those compounds are recommended.

Acknowledgements

The authors would like to thank Dr Lerato Seleteng Kose for much useful advice.

Conflict of interest

The authors declare no conflict of interest.

Funding source

No funding source to be declared.

Ethical approval

The current study is a review of the secondary data from published sources and does not involve any human or animal studies. Thus, there is no ethical consideration to be disclosed.

ORCID

OK Hlokoane  <https://orcid.org/0000-0003-3165-7227>M Sello  <https://orcid.org/0000-0002-2025-6156>

References

- Mabaleha MB, Bonnet SL, Wilhelm A. Lesotho medicinal plants of the Acteraaceae family: a review of ethnobotany, chemistry and conservation status. *Nulistice*. 2018;51-56.
- Moteetea A, Van Wyk B-E. The medical ethnobotany of Lesotho: a review. *Bothalia*. 2011;41(1):209-28. <https://doi.org/10.4102/abc.v41i1.52>.
- World Health Organization. WHO Global Report on Traditional and Complementary Medicine 2019. Geneva: World Health Organization; 2019. Available from: <https://www.who.int/publications/i/item/978924151536>. Accessed 24 October 2020.
- Market Watch. Herbal Medicine Market 2020 Size, Share, Global, Trends, Comprehensive Research Study, Development Status, Opportunities, Future Plans, Competitive Landscape growth by Forecast 2026. Market Watch; 2020. Available from: <https://www.marketwatch.com/press-release/herbal-medicine-market-2020-size-share-global-trends-comprehensive-research-study-development-status-opportunities-future-plans-competitive-landscape-and-growth-by-forecast-2026-2020-08-10>. Accessed 24 October 2020.
- Seleteng Kose L, Moteetea A, Van Vuuren S. Ethnobotanical survey of medicinal plants used in the Maseru district of Lesotho. *Journal of Ethnopharmacology*. 2015;170:184-200. <https://doi.org/10.1016/j.jep.2015.04.047>.
- Mugomeri E, Chatanga P, Raditladi T, Makara M, Tarirai C. Ethnobotanical study and conservation status of local medicinal plants: towards a repository and monograph of herbal medicines in Lesotho. *Afr J Tradit Complement Altern Med*. 2016;13(1):143-56. <https://doi.org/10.4314/ajtcam.v13i1.20>.
- Moteetea A, Seleteng Kose L. A review of medicinal plants used by the Basotho for treatment of skin disorders: their phytochemical, antimicrobial, and anti-inflammatory potential. *Afr J Tradit Complement Altern Med*. 2017; 14(5):121-37. <https://doi.org/10.21010/ajtcam.v14i5.16>.
- Shale TL, Stirk WA, Van Staden J. Screening of medicinal plants used in Lesotho for antibacterial and anti-inflammatory activity. *J Ethnopharmacol*. 1999;67:347-54. [https://doi.org/10.1016/S0378-8741\(99\)00035-5](https://doi.org/10.1016/S0378-8741(99)00035-5).
- Mugomeri E, Chatanga P, Hlapisi S, Rahlao L. Phytochemical characterization of selected herbal products in Lesotho. *Lesotho Med Assoc J*. 2014;12(1):38-47.
- Brian JD, Bhat S. Wound care treatment and management: medical care, surgical care, future and controversies. *Medscape* [Internet]. c2020. Available from: <https://emedicine.medscape.com/article/194018-treatment>. Accessed 26 July 2020.
- Singhal H, Kaur K. Wound infection: background, pathophysiology, etiology. *Medscape* [Internet]. c2019. Available from: <https://emedicine.medscape.com/article/188988-overview#4>. Accessed 25 July 2020.
- Dhama K, Tiwari R, Chakraborty S, et al. Evidence based antibacterial potentials of medicinal plants and herbs countering bacterial pathogens especially in the era of emerging drug resistance: an integrated update. *International Journal of Pharmacology*. 2014;10(1): 1-43. <https://doi.org/10.3923/ijp.2014.1.43>.
- Lu C, Wang H, Lu W, et al. Antibacterial properties of anthraquinones extracted from rhubarb against *Aeromonas hydrophila*. *Fish Sci*. 2011;77:375. <https://doi.org/10.1007/s12562-011-0341-z>.
- Dhama K, Tiwari R, Chakraborty S, et al. Evidence based antibacterial potentials of medicinal plants and herbs countering bacterial pathogens especially in the era of emerging drug resistance: an integrated update. *International Journal of Pharmacology*. 2014;10(1): 1-43. <https://doi.org/10.3923/ijp.2014.1.43>.
- Tim Cushnie TP, Lamb AJ. Antimicrobial activity of flavonoids. *International Journal of Antimicrobial Agents*. 2005;26:343-56. <https://doi.org/10.1016/j.ijantimicag.2005.09.002>.
- Abozed MF, Hashish N, Gazer M. Efficacy of ethanol extract from leaves of *Malva parviflora* to inhibit bacterial biofilm formation. *Journal of Molecular Biology Research*. 2018;8(1):23-30. <https://doi.org/10.5539/jmbr.v8n1p23>.
- Nyamazana T, Manyama TL, Tshitake RM. A review on the prevention and management of diabetes mellitus complications and the role of the pharmacist. *S Afr Pharm J*. 2020;87(4):22-25.
- Rodd E, Oksanen G. Designer wound care: compounded topical formulations. *Wound Care Canada* 2020;18(1):41-45.
- Holland B. Prospecting for drugs in ancient texts. *Nature*. 1994;369:702. <https://doi.org/10.1038/369702a0>.
- Devkota BP. Digoxin level. *Medscape* [Internet]. c2019. Available from: <https://emedicine.medscape.com/article/2089975-overview>. Accessed 27 July 2020.
- Medscape reference [Internet]. c2020. Available from: <https://reference.medscape.com/drug/ms-contin-astramorph-morphine-343319>. Accessed 27 July 2020.
- Bladt S, Wagner H. From the Zulu medicine to the European phytochemistry Umckaloabo. *Phytomedicine*. 2007;14(1):2-4.
- Koch E, Wohn C. Pelargonium sidoides root extract EPs 7630 stimulates release antimicrobial peptides from neutrophil granulocytes in human whole blood. *Planta Medica*. 2007; 73:846.
- Kolodziej H, Kiderlen AF. In vitro evaluation of antibacterial and immunomodulatory activities of Pelargonium reniforme, Pelargonium sidoides and the related herbal drug preparation EPs 7630. *Phytomedicine*. 2007;14(1):18-26.
- Al-Snafi EA. Pharmacological and therapeutic activities of *Hedera helix* - a review. *Journal of Pharmacy*. 2018;8(5):41-53.
- Brien S, Lewith GT, McGregor G. Devil's Claw (*Harpagophytum procumbens*) as a treatment for osteoarthritis: a review of efficacy and safety. *The Journal of Alternative and Complementary Medicine*. 2006;12(10):981-93.
- Van Heerden FR. Hoodia gordonii: A natural appetite suppressant. *Journal of Ethnopharmacology*. 2008;119:434-7. <https://doi.org/10.1016/j.jep.2008.08.023>.
- MacLean DB, Luo L-G. Increased ATP content/production in the hypothalamus may be a signal for energy-sensing of satiety: studies of the anorectic mechanism of a plant steroidal glycoside. *Brain Research*. 2004;1020:1-11. <https://doi.org/10.1016/j.brainres.2004.04.041>.
- Kambizi L, Sultana N, Afolayan AJ. Bioactive compounds isolated from aloe feroc: a plant traditionally used for the treatment of sexually transmitted infections in the Eastern Cape, South Africa. *Pharmaceutical Biology*. 2004;42(8):636-9.
- Qhotsokoane-Lusunzi MA, Karuso P. Secondary metabolites from Basotho medicinal plants. I. Bulbine narcissifolia. *J Nat Prod*. 2001;64(10):1368-72. <https://doi.org/10.1021/np010279c>.
- Cooposamy RM. Traditional information and antibacterial activity of four Bulbine species (Wolf). *African Journal of Biotechnology*. 2011;10(2):220-4. <https://doi.org/10.5897/AJB10.1435>.
- Tetyana P, Prozesky EA, Jäger AK, Meyer JJM, Van Staden J. Some medicinal properties of *Cussonia* and *Schefflera* species used in traditional medicine. *South African Journal of Botany*. 2002;68:51-54. [https://doi.org/10.1016/S0254-6299\(16\)30454-9](https://doi.org/10.1016/S0254-6299(16)30454-9).
- Shinwari ZK, Malik S, Karim AM, Faisal R, Qaiser M. Biological activities of commonly used medicinal plants from Ghazi Brotha, Attock district. *Pak J Bot*. 2015;47(1):113-20.
- Maroyi A. From traditional usage to pharmacological evidence: systematic review of *Gunnera perpensa* L. Evidence-Based Complementary and Alternative Medicine. 2016;2:1-14. <https://doi.org/10.1155/2016/1720123>.
- James LM, John AA, Stephen OA, et al. In vitro antimicrobial effects of *Hypoxis hemerocallidea* against six pathogens with dermatological relevance and its phytochemical characterization and cytotoxicity evaluation. *Journal of Ethnopharmacology*. 2019;242:112048. <https://doi.org/10.1016/j.jep.2019.112048>.
- Katerere DR, Eloff JN. Anti-bacterial and anti-oxidant activity of *Hypoxis hemerocallidea* (Hypoxidaceae): Can leaves be substituted for corms as a conservation strategy? *South African Journal of Botany*. 2008;74:613-6. <https://doi.org/10.1016/j.sajb.2008.02.011>.
- Gautam SS, Navneet, Kumar S. Screening of antibacterial and phytochemical constituents of *Malva parviflora* Linn. fruit extracts against respiratory tract pathogens. *Research in Plant Biology*. 2018;8:13-16. <https://doi.org/10.25081/ripb.2018.v8.3567>.
- Wiegiera M, Kosikowska U, Malm A, Smolarx HD. Antimicrobial activity of the extracts from fruits of *Rumex L.* species. *Cent Eur J Boil*. 2011;6:1036-43. <https://doi.org/10.2478/s11535-011-0066-0>.
- Dovgii II, Grishkovets VI, Kachala VV, Shashkv AS. Triterpene glycosides of *Cussonia paniculata*. I. Isolation and structure determination of glycosides A, B₁, B₂, C, D, G₂, H₁, and H₂ from leaves of *Cussonia paniculata*. *Chem Nat Compd*. 2005;41:200-4. Available from: <https://link.springer.com/article/10.1007/s10600-005-0111-1>.
- Levine JM. The effect of oral medication on wound healing. *Adv Skin Wound Care*. 2017;30(3):137-42.
- Kamli Ankita S, Desai Shuchi M. A comparative study: good manufacturing practice (GMP) requirements for herbal products: INDIA & EUROPE. *Int J Pharm Sci Rev Res* 2018;52(1):75-81.
- De Wet B. Medicinal plants and human health. *S Afr Pharm J*. 2011;78(6):38-40.
- Sher H, Alyemini MN, Faridullah. Cultivation and domestication study of high-value medicinal plant species (its economic potential and linkages with commercialization). *African Journal of Agricultural Research*. 2010;5(18):2462-70.
- Hamman JH. Composition and applications of aloe vera leaf gel. *Molecules*. 2008;13:1599-1616. <https://doi.org/10.3390/molecules13081599>.
- Nogueira RJL, Danopoulos P, Swikidisa R, Pinheiro VA. Evaluation of the antibacterial activity of green propolis extract and meadowsweet extract against *Staphylococcus aureus* bacteria: Importance in wound care compounding preparations. *Int J Pharmaceutical Compounding*. 2016;20(4):333-7.
- Oliver B, Krishnan S, Pardo MR, Ehrlich A. Cosmeceutical contact dermatitis—cautions to herbals. *Curr Treat Options Allergy*. 2015;2:307-21. <https://doi.org/10.1007/s40521-015-0066-9>.
- Alwakeel SS. Microbial and heavy metals contamination of herbal medicines. *Res J Microbiol*. 2008;3(12):683-91.
- Turkson BK, Mensah MLK, Sam GH, et al. Evaluation of the microbial load and heavy metal content of two polyherbal antimalarial products on the Ghanaian market. Evidence-Based Complementary and Alternative Medicine. 2020;2020:1014273. <https://doi.org/10.1155/2020/1014273>.
- Terrie Y.C. Self-Treatment of minor wounds and burns. *Pharmacy Times*. c2017. Available from: <https://www.pharmacytimes.com/publications/issue/2017/May2017/self-treatment-of-minor-wounds-and-burns>. Accessed 24 October 2020.