Asian J Agri & Biol. 2018;6(2):287-294.

AJAB

Review Article

Dicoma capensis less: a review of its botany, ethno medicine, phytochemistry and pharmacology

Alfred Maroyi*

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

Received:
February 05, 2018

Accepted:
May 01, 2018

Published:
June 30, 2018

**Corresponding author email:*
amaroyi@ufh.ac.za

Abstract

Dicoma capensis is widely used as traditional medicine in southern Africa. The potential of *D. capensis* as herbal medicine, its botany, phytochemistry and biological activities are reviewed. The literature relevant to the botany, phytochemistry and biological activities of *D. capensis* was obtained from the main online scientific sites including ScienceDirect, SciFinder, Pubmed, Google Scholar, Medline and SCOPUS. Searches were also undertaken in the University of Fort Hare library, dissertation and thesis search engines like ProQuest, Open-thesis, OATD, and EthOs. *Dicoma capensis* is used as herbal medicine against colds, fever, influenza, cancer, stomach problems, high blood pressure, back pain and diarrhoea in southern Africa. The chemical composition of *D. capensis* is made up of melampolides, germacranolides, eudesmanolides, steroids, terpenoids, saponins, flavonoids, alcohol precipitable solids (APS), amino acids and phenolic acids. The biological activities demonstrated by the species include antibacterial, antifungal, anticancer and bitterness properties. The traditional ethnomedicinal usage of *D. capensis* highlights the importance of detailed information on botanical, ethnopharmacology, phytochemistry and toxicological reports on the species.

Keywords: Antibacterial, Anticancer, Antifungal, Asteraceae, *Dicoma capensis*, Southern Africa

Introduction

Dicoma capensis Less. (Family Asteraceae) has played a major role as herbal medicine in southern Africa over the past centuries. The species is included in the monographic guide of the most valuable herbal medicines in South Africa (Van Wyk et al., 2013). Therefore, *D. capensis* is an integral part of the indigenous pharmacopoeia of South Africa, used regularly and regarded as an important component of the cultural heritage of the South African people. In South Africa, herbal medicines like *D. capensis* are considered not to be inferior alternatives to western or orthodox medicine, but such traditional medicines are regarded as necessary and desirable to the primary healthcare needs of local communities (Mander et al., 2007). Mander et al. (2007) argued that the use of traditional medicines by communities in both rural and urban areas of South Africa is based on therapeutic results and the need to maintain traditional beliefs. Research has also shown that herbal medicines are widely used because they are culturally and spiritually more acceptable by local communities and therefore, this is an important alternative form of primary

healthcare to manage several diseases and ailments. Research by Van Wyk et al. (2008) and Nortje (2011) showed that *D. capensis* is regarded as a panacea, that is, remedy for all diseases in South Africa. Research by Van Wyk (2011) revealed that the leaves and roots of *D. capensis* are known to have commercial therapeutic potential as herbal medicines for colds, fever and as general herbal medicine. *Dicoma capensis* is widely known for its high medicinal value and therefore, traded in informal herbal medicine markets in the Cape Peninsula in Cape Town, South Africa (Loundon, 2008) and other major cities in South Africa (Van Wyk, 2017). *Dicoma capensis* has been introduced in medicinal home gardens in several provinces in South Africa including the Western Cape (Philander, 2010) so that the species is readily available and accessible to the users. Therefore, the present study provides the summary of up-to date details on the botanical, ethnopharmacology and toxicological properties of *D. capensis*.

Literature Review

The literature relevant to the botany, phytochemical properties and biological activities of *D. capensis* was performed from November 2016 to December 2017. The information was obtained from the main online scientific sites including ScienceDirect, SciFinder, Pubmed, Google Scholar, Medline and SCOPUS. Searches were also undertaken in the University of Fort Hare library, dissertation and thesis search engines like ProQuest, Open-thesis, OATD, and EthOs. The keywords used in the search included "*Dicoma capensis*", the synonym of the species "Tibestina lanuginosa Maire", English name "fever bush" and Afrikaans vernacular names "koorsbossie, wilde karmedik, karmedik, vyfpondbos". The literature sources included 12 papers published in international journals, nine books, four dissertations, and book chapters, theses and websites (two each).

Botanical description, occurrence and distribution

The genus *Dicoma* Cass. (family Asteraceae) was first described by Cassini in 1817, comprise 50 species and 16 of these occur in southern Africa (Germishuizen et al., 2006). The four most important medicinal *Dicoma* species in southern Africa are *D. capensis, D. schinzii* O. Hoffm. and *D. anomala* Sond. (Loundon, 2008). The name of the genus "*Dicoma*" was derived from two Greek words "di" and "kome" meaning "two" and "tuft of hair", respectively, in reference to the double row of pappus bristles which are characteristic of the species of the genus (Mnegwane et al., 2007). The specific name "*capensis*" means "from the Cape" in reference to the Cape province in South Africa where the type specimen was collected from (Pope, 1992). The synonym of *D. capensis* is *Tibestina lanuginosa* Maire (Pope, 1992). *D. capensis* has been recorded in Botswana, Namibia, South Africa and Swaziland (Germishuizen et al., 2006). The species is common in dry to very dry areas, grassland, scrubland in sandy soils and sometimes on the edges of pans (Germishuizen et al., 2006).

Dicoma capensis is a very small plant with creeping branches spreading from a woody and perennial root system. The stems are annual, branched, many from the root crown, sometimes woody at the base, decumbent, approximately 30 cm long (Pope, 1992). The leaves are variable in shape, often oblong but sometimes very narrow, leaf margins finely undulate, greyish-green in colour and leaves covered with short, dense, white hairs. The flower heads are few to many, solitary and terminal on branches or short shoots, subsessile axillary and subtended by several leaves. The inner floret corollas are pale-mauve in colour, about 7 mm long with linear lobes which are erect but recurved at the apex. The achenes are about 3 mm long, narrowly turbinate, 10-ribbed with basal hairs (Pope, 1992).

Ethnomedicinal uses of *D. capensis*

The different plant parts including twigs, whole plant, fruits, flowers, roots and leaves of *D. capensis* are widely used to cure at least 27 diseases in southern Africa (Table 1). Information on medicinal uses of the species has been found in Botswana, Namibia and South Africa, representing 75% of the countries where *D. capensis* is indigenous. The country with the highest number of medicinal uses is South Africa with 25 records (92.6%) of human ailments or diseases treated or managed by concoctions prepared from *D. capensis* (Table 1). Colds, fever, influenza, cancer, stomach problems, high blood pressure, back pain and diarrhoea (Figure 1) are the most commonly treated ailments and diseases using concoctions prepared from *D. capensis*. The medicinal properties of *D. capensis* were recognized a long time ago when local people in South Africa, particularly in the Northern Cape province started using the species as herbal medicine against fever. Hence the Afrikaans local name "koorsbos" which is made up of two terms

"koors" and "bos" which means "fever" and "bush" in English, and hence, the common name "fever bush". Today, *D. capensis* is a popular herbal medicine for fever in South Africa (Van Wyk et al., 2013). In South Africa, leaf infusion of *D. capensis* is taken orally mixed with *Sutherlandia frutescens* (L.) R. Br. as remedy for colds, diabetes, fever, flatulence, influenza and stomach problems (Nortje, 2011). In Botswana, flower and fruit decoctions of *D. capensis* are applied topically on sores and wounds (Mukanganyama et al., 2011). In Namibia, whole plant decoction of *D. capensis* is widely used orally against cough and stomach problems, and root decoction taken orally or as vapour bath for fever (Von Koenen, 2001).

Phytochemistry and biological activities

Zdero and Bohlmann (1990) isolated several sesquiterpene lactones which included melampolides, germacranolides and eudesmanolides from the aerial parts of *D. capensis* collected in Namibia. Detailed research is required as the documented sesquiterpene lactones are still to be linked to some biological activities (Van Wyk et al., 2013). Qualitative colour tests and TLC analysis revealed the presence of steroids, terpenoids, bitter principles, saponins and flavonoids in leaf, root and stem of *D. capensis* (Olivier, 2012). Olivier (2012) isolated alcohol precipitable solids (APS), amino acids (Table 2) and phenolic acids from leaf, root and stem extracts of *D. capensis*. Asparagine, glutamine and proline are the most abundant amino acids in leaf, root and stem extracts of *D. capensis* (Table 2).

Antibacterial activities

Mukanganyama et al. (2011) evaluated the antibacterial activities of *D. capensis* ethanol fibre, fruit, leaf and root extracts against *Bacillus subtilis, Bacillus cereus, Escherichia coli, Mycobacterium aurum, Staphylococcus aureus* and *Pseudomonas aeruginosa* using disc agar diffusion method using ethanol and ampicillin as negative and positive controls, respectively. Only leaf extracts of *D. capensis* showed inhibitory properties against *Bacillus subtilis* with zone of inhibition value of 1.0 ± 0.0 mm. The fibre, flowers and fruit extracts of *D. capensis* demonstrated clinical importance by showing antibacterial activities against *Mycobacterium aurum* with minimal inhibitory concentrations (MIC) value of 5 mg/ml (Mukanganyama et al., 2011). The *Mycobacterium aurum* is regarded as a fast-growing, non-pathogenic mycobacterium which is characterized by similar drug susceptibility properties similar to those of Mycobacterium tuberculosis (Mukanganyama et al., 2011). Further antibacterial evaluations are recommended as the roots and leaves of *D. capensis* are widely used as traditional medicines for bacterial infections such as dairrhoea (Philander, 2010; Van Wyk, 2017), stomach problems in Namibia (Von Koenen, 2001) and South Africa (Archer, 1994; Philander, 2010; De Beer and Van Wyk, 2011; Nortje, 2011), tuberculosis (Nortje, 2011) and other microbial infections such as sores and wounds in Botswana (Mukanganyama et al., 2011). Therefore, there is need to evaluate antibacterial activities of *D. capensis* against bacteria that cause gastro-intestinal infections, namely *Shigella sonnei, Shigella boydii, Salmonella typhi, Shigella dysenterae, Shigella flexneri, Vibrio cholerae* and *Staphylococcus aureus* (Mathabe et al., 2006). Such evaluation is important to corroborate the species' antibacterial properties and potential including the utilization of the species in managing gastro-intestinal infections throughout its distributional range.

Antifungal activities

Mukanganyama et al. (2011) evaluated antifungal properties of ethanol extracts of *D. capensis* fibre, fruit, leaf and root extracts against *Candida mycoderma* and *Candida albicans* using disc agar diffusion method with fungazole and ethanol as positive and negative controls, respectively. Fibre, fruit and leaf extracts showed inhibitory properties against *Candida albicans* and *Candida mycoderma* with zone of inhibition ranging from 1.0 ± 0.0 mm to 3.0 ± 0.0 mm. Fruit extracts of *D. capensis* showed activities against the *Candida albicans* with minimal inhibitory concentrations (MIC) values of 1.25 mg/ml (Mukanganyama et al., 2011). The antifungal properties exhibited by *D. capensis* extracts confirm the use of *D. capensis* as herbal medicine against microbial infections and other opportunistic diseases associated with the acquired immunodeficiency syndrome (AIDs) and human immunodeficiency virus (HIV) as *Candida albicans* and *Candida mycoderma* are opportunistic pathogens in HIV/AIDs patients (Mukanganyama et al., 2011).

Anti-cancer activities

Steenkamp and Gouws (2006) evaluated cytotoxic activities of aqueous extracts of *D. capensis* against the three human cancer cell lines, the DU-145 prostate cancer cells, the MDA-MB-231 and the MCF-7 breast

cancer cells and a non-malignant breast cell line, MCF-12A with cisplatin, a well-known anti-tumour agent as a positive control. The *D. capensis* extract inhibited the proliferation of the DU-145, MCF-7 and the MCF-12A cells. The half (50%) maximal inhibitory concentration (IC_{50}) values of *D. capensis* were 30 µg/ml and 31 µg/ml in the MCF-7 and the MCF-12A cells, respectively (Steenkamp and Gouws, 2006). The positive control, the cisplatin, had the IC_{50} values of 0.27 µg/ml and 0.14 µg/ml in the MCF-7 and the MCF-12A cells, respectively (Steenkamp and Gouws, 2006). The in vitro anti-cancer activities exhibited by extracts of *D. capensis* corroborate the traditional uses of the species as remedy for cancer in South Africa (Steenkamp and Gouws, 2006; Philander, 2010; Nortje, 2011; Van Wyk and Gorelik, 2017).

Bitterness activities

Olivier and Van Wyk (2013) evaluated the bitterness values of leaves and twigs of *D. capensis* using procedures prescribed by the World Health Organisation (2002) and the European Pharmacopoeia (2005) and compared to the bitterness value of quinine hydrochloride set at 200 000. The bitterness value of 14531 ± 2135 was obtained for *D. capensis* leaves and twigs. The physiological effects associated with bitter taste of herbal medicines are ascribed to the bitter tonic (amarum) effect, that is, result in the stimulation, secretion of saliva, secretion of gastric juices and secretion of bile through taste stimuli via the nervus vagus (Olivier and Van Wyk, 2013). The amarum effect is illustrated by an extremely bitter plant species, *Gentiana lutea* L. with bitterness value of 10 000 – 30 000 (Wagner et al., 1995). Research by Olivier and Van Wyk (2013), and Van Wyk and Gorelik (2017) showed that *D. capensis* is widely used as a tonic, adaptogenic, alterative, adjuvant or stimulant in South Africa. Olivier (2012) defined tonic as a substance or mixture of substances that are able to impart healing and health by aiding in the re-establishment of homeostasis and improving strength in a gentle, non-toxic way. Van Wyk and Wink (2004) argued that tonics are usually used as multi-purpose herbal medicines and such substances help to maintain and restore health and vigour of patients. Since *D. capensis* is regarded as a tonic herb in most provinces in South Africa, it is expected to support and tone either specific organs of the body or the entire body by strengthening and stimulating the entire immune system, the nerve functions or the entire hormone system of the body. Medicinal plants used as tonics are believed to exert balancing actions in organ systems and biochemical processes of the body (Mowrey, 1998) and protect the body against environmental factors that cause stress (Tharakan and Manyan, 2006). Tonics assist the body by reducing reactions to stress related activities, prevent exhaustion, burnout of the body, chronic fatigue of the body, loss of concentration, depression and associated degenerative diseases (Mowrey, 1998; Tharakan and Manyan, 2006). Tonics are also believed to help and tone specific body organs, or the entire body by strengthening and stimulating the entire immune system or specific nerve or hormonal functions (Mowrey, 1998) and also seem to protect the body against environmental or external factors that cause stress (Panossian and Wagner, 2005).

Table 1: Ethnomedicinal uses of *D. capensis* in southern Africa

Use	Plant parts used	Country	References
Asthma	Leaf infusion taken orally	South Africa	(Nortje, 2011)
Back pain	Whole plant decoction taken orally as herbal tea	South Africa	(Nortje, 2011; Van Wyk and Gorelik, 2017)
Bladder problems	Whole plant decoction taken orally	South Africa	(Nortje, 2011; Van Wyk and Gorelik, 2017)
Cancer	Decoctions of leaves and twigs taken orally	South Africa	(Steenkamp and Gouws, 2006; Philander, 2010; Nortje, 2011; Van Wyk and Gorelik, 2017)
Colds	Whole plant decoction taken orally as herbal tea	South Africa	(Mannetti, 2010; Philander, 2010; Nortje, 2011; Van Wyk and Gorelik, 2017)
Colds	Leaf infusion taken orally mixed with *Sutherlandia frutescens* (L.) R. Br.	South Africa	(Nortje, 2011)
Constipation	Leaf infusion taken orally	South Africa	(Nortje, 2011)
Cough	Leaf or whole plant infusion taken orally	Namibia, South Africa	(Archer, 1994; Von Koenen, 2001)

Diabetes	Leaf infusion taken orally	South Africa	(Nortje, 2011)
Diabetes	Leaf infusion taken orally mixed with *Sutherlandia frutescens*	South Africa	(Nortje, 2011)
Diaphoretic	Leaf infusions taken orally	South Africa	(Watt and Breyer-Brandwijk, 1962)
Diarrhoea	Whole plant decoction taken orally	South Africa	(Philander, 2010; Wyk and Gorelik, 2017)
Diuretic	Decoctions of leaves taken orally	South Africa	(Nortje, 2011; Van Wyk, 2017)
Expel retained placenta	Leaf infusion taken orally	South Africa	(Nortje, 2011)
Febrile conditions	Leaf infusions taken orally	South Africa	(Watt and Breyer-Brandwijk, 1962)
Fever	Leaf, root or twig decoctions taken orally or as vapour bath	Namibia, South Africa	(Von Koenen, 2001; Steenkamp and Gouws, 2006; Philander, 2010; Nortje, 2011; Van Wyk, 2017)
Fever	Leaf infusion taken orally mixed with *Sutherlandia frutescens*	South Africa	(Nortje, 2011)
Flatulence	Leaf infusion taken orally	South Africa	(Nortje, 2011)
Flatulence	Leaf infusion taken orally mixed with *Sutherlandia frutescens*	South Africa	(Nortje, 2011)
Haemorrhoids	Whole plant decoction taken orally	South Africa	(Philander, 2010)
High blood pressure	Whole plant decoction taken orally as herbal tea	South Africa	(Steenkamp and Gouws, 2006; Philander, 2010; Van Wyk et al., 2013)
Influenza	Whole plant decoction taken orally as herbal tea	South Africa	(Mannetti, 2010; Philander, 2010; Nortje, 2011; Van Wyk and Gorelik, 2017)
Influenza	Leaf infusion taken orally mixed with *Sutherlandia frutescens*	South Africa	(Nortje, 2011)
Kidney problems	Whole plant decoction taken orally	South Africa	(Nortje, 2011; Van Wyk and Gorelik, 2017)
Liver problems	Whole plant decoction taken orally as herbal tea	South Africa	(De Beer and Wan Wyk, 2011)
Nausea	Whole plant decoction taken orally	South Africa	(Van Wyk and Gorelik, 2017)
Rheumatism	Whole plant decoction taken orally	South Africa	(Van Wyk et al., 2008; Nortje, 2011)
Sores	Flower and fruit decoctions applied topically	Botswana	(Mukanganyama et al., 2011)
Stomach problems	Whole plant decoction taken orally as herbal tea	Namibia, South Africa	(Archer, 1994; Von Koenen, 2001; Philander, 2010; Nortje, 2011; Van Wyk et al., 2013)
Stomarch problems	Leaf infusion taken orally mixed with *Sutherlandia frutescens*	South Africa	(Nortje, 2011)
Tonic	Whole plant decoction taken orally as herbal tea	South Africa	(Van Wyk and Gorelik, 2017)
Tuberculosis	Leaf infusion taken orally	South Africa	(Nortje, 2011)
Wounds	Flowers and fruits decoction applied topically	Botswana	(Mukanganyama et al., 2011)

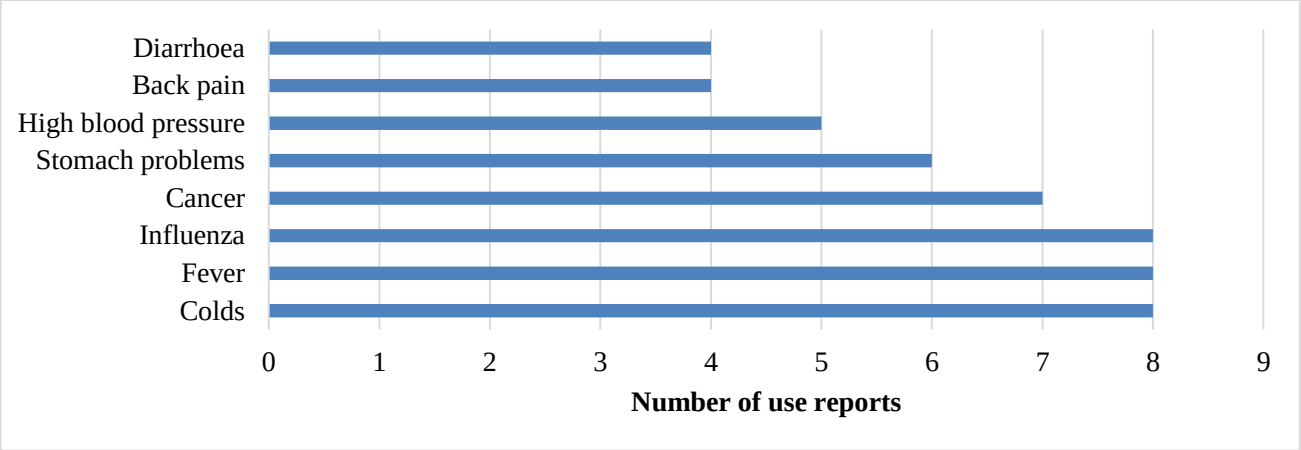

Figure 1: Main ethnomedicinal uses of *D. capensis* in southern Africa. An ethnomedicinal use is only counted once per publication

Table 2: Amino acid content of *D. capensis* leaf, root and stem extract after Olivier (2012)

Amino acids	Values
Alanine	11.2 mg/g
Allo-isoleucine	9.8 mg/g
α-aminoadipic acid	3.0 mg/g
α-aminobutyric acid	0.43 mg/g
γ-aminobutyric acid	1.9 mg/g
β-aminoisobutyric acid	3.6 mg/g
Asparagine	192.0 mg/g
Aspartic acid	20.0 mg/g
Glutamic acid	7,9 mg/g
Glutamine	318.4 mg/g
Glycine	3.2 mg/g
Histidine	9.4 mg/g
Isoleucine	4.9 mg/g
Leusine	4.3 mg/g
Lysine	10.5 mg/g
Ornithine	7.1 mg/g
Phenylalanine	9.9 mg/g
Proline	274.2 mg/g
Serine	2.2 mg/g
Threonine	1.8 mg/g
Tryptophan	12.9 mg/g
Tyrosine	8.7 mg/g
Valine	9.2 mg/g

Conclusion

The traditional usage of *D. capensis* as herbal medicine for human diseases calls for detailed ethnopharmacological and toxicological analyses of the species aimed at identifying its biological activities and phytochemicals that can be linked to the wide usage of the species as herbal medicine. Currently, there is not much phytochemical and pharmacological profiling of the species has been carried out. No clinical research trials and toxicological evaluations involving the species have been undertaken. There is also need to validate traditional medicinal uses of *D. capensis* via in vitro and in vivo experiments. Such

research will provide some insight into the therapeutic potential of *D. capensis*.

Acknowledgment

The author would like to express his gratitude to the National Research Foundation, South Africa and Govan Mbeki Research and Development Centre, University of Fort Hare for financial support to conduct this study.

Conflict of Interest

The author declares that he has no conflict of interest.

References

Archer FM, 1994. Ethnobotany of Namaqualand: the Richtersveld. M.A. thesis, University of Cape Town, Cape Town, South Africa.

De Beer JJJ and Van Wyk B-E, 2011. An ethnobotanical survey of the Agter-Hantam, Northern Cape Province, South Africa. S. Afr. J. Bot. 77(3): 741-754.

European Pharmacopoeia, 2005. Bitterness value. Council of Europe; 2005, Strasbourg, France.

Germishuizen G, Meyer NL, Steenkamp Y and Keith MA, 2006. Checklist of South African plants. Southern African Botanical Diversity Network Report No. 41, SABONET, Pretoria, South Africa.

Loundon PM, 2008. Medicinal plant trade and opportunities for sustainable management in the Cape Peninsula, South Africa. M.S. thesis, Stellenbosch University, Cape Town, South Africa.

Mander M, Ntuli L, Diederichs N and Mavundla K, 2007. Economics of the traditional medicine trade in South Africa, pp. 189-199. In S. Harrison, R. Bhana and A. Ntuli (eds), South African health review. Health Systems Trust, Durban, South Africa.

Mannetti L, 2010. Understanding plant use by the Khomani Bushmen of the southern Kalahari. M.S. thesis, University of Stellenbosch, Cape Town, South Africa.

Mathabe MC, Nikolova RV, Lall N and Nyazema NZ, 2006. Antibacterial activities of medicinal plants used for the treatment of diarrhoea in Limpopo province, South Africa. J. Ethnopharmacol. 105(1-2): 286-293.

Mnegwane J and Koekemoer M, 2007. Dicoma anomala Sond. South African National Biodiversity Institute, Pretoria. Http://www.plantzafrica.com/plantcd/dicomanom.htm.

Mowrey DB, 1998. Herbal tonic therapies. Keats Publishing, New York, USA.

Nortje JM, 2011. Medicinal ethnobotany of the Kamiesberg, Namaqualand, Northern Cape province, South Africa. M.S. thesis, University of Johannesburg, Johannesburg, South Africa.

Mukanganyama S, Ntumy AN, Maher F, Muzila M and Andrae-Marobela K, 2011. Screening for anti-infective properties of selected medicinal plants from Botswana. Afr. J. Pl. Sci. Biotech. 5(1): 1-7.

Olivier DK, 2012. The ethnobotany and chemistry of South African tonic plants. Ph.D dissertation, University of Johannesburg, Johannesburg, South Africa.

Olivier DK and Van Wyk BE, 2013. Bitterness values for traditional tonic plants of southern Africa. J. Ethnopharmacol. 147(3): 676-679.

Panossian A and Wagner H, 2005. Stimulating effect of adaptogens: an overview with particular reference to their efficacy following their single dose administration. Phytoth. Res. 19(10): 818-838.

Philander EL, 2010. An emergent ethnomedicine: Rastafari bush doctors in the Western Cape, South Africa. Ph.D dissertation, The University of Arizona, Tucson, USA.

Pope GV, 1992. Compositae. Flora of Zambia. 6(1): 37-38.

Steenkamp V and Gouws M, 2006. Cytotoxicity of six South African medicinal plant extracts used in the treatment of cancer. S. Afr. J. Bot. 72(4): 630-633.

Tharakan B and Manyam BV, 2006. Botanical therapies in chronic fatigue. Phytother. Res. 20(2): 91-95.

Van Wyk BE, 2017. A review of African medicinal and aromatic plants, pp. 19-60. In M. Neffati, H. Najjaa and Á. Máthé (eds), Medicinal and aromatic plants of the world: Africa. Volume 3. Springer, Dordrecht, The Netherlands.

Van Wyk BE, 2011. The potential of South African plants in the development of new medicinal products. S. Afr. J. Bot. 77(4): 812-829.

Van Wyk B-E and Gorelik B, 2017. The history and ethnobotany of Cape herbal teas. S. Afr. J. Bot. 110: 18-38.

Van Wyk BE and Gericke N, 2007. People's plants: a guide to useful plants of southern Africa. Briza Publications, Pretoria, South Africa.

Van Wyk BE and Wink M, 2004. Medicinal plants of the world. Timber Press, Portland, USA.

Van Wyk BE, Van Oudtshoorn B and Gericke N, 2013. Medicinal plants of South Africa. Briza Publications, Pretoria, South Africa.

Van Wyk BE, de Wet H and Van Heerden FR, 2008. An ethnobotanical survey of medicinal plants in the south eastern Karoo, South Africa. S. Afr. J. Bot. 74(4): 696-704.

Von Koenen E, 2001. Medicinal, poisonous and edible plants in Namibia. Klaus Hess Publishers, Windhoek, Namibia

Wagner H and Wiesenauer M, 1995. Phytotherapie: phytopharmaka und pflanzliche homöopathika. Gustav Fischer Verlag, Stuttgart, Germany.

Watt JM and Breyer-Brandwijk MG, 1962. The medicinal and poisonous plants of southern and eastern Africa. 2nd Edition. E and S Livingstone Ltd, Edinburgh, UK.

World Health Organisation (WHO), 2002. Quality control methods for medicinal plant materials. Geneva: World Health Organisation. Http://apps.who.int/iris/bitstream/10665/41986/1/9241545100.pdf.

Zdero C and Bohlmann F, 1990. Sesquiterpene lactones from *Dicoma* species. Phytochem. 29(1): 183-187.