

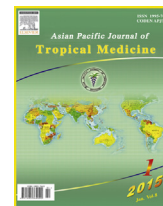
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journal homepage: <http://ees.elsevier.com/apjtm>Review <http://dx.doi.org/10.1016/j.apjtm.2017.03.021>**Acacia karroo** Hayne: Ethnomedicinal uses, phytochemistry and pharmacology of an important medicinal plant in southern AfricaAlfred Maroyi[✉]

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ABSTRACT

Acacia karroo (*A. karroo*) has been used as herbal medicine by the indigenous people of southern Africa for several centuries. The potential of *A. karroo* as herbal medicine, its associated phytochemistry and biological activities are reviewed. The extensive literature survey revealed that *A. karroo* is traditionally used to treat or manage 32 and five human and animal diseases and ailments, respectively. The species is used as herbal medicine for diseases and ailments such as colds, diarrhoea, dysentery, flu, malaria, sexually transmitted infections (STIs), wounds, and also as colic and ethnoveterinary medicine. Multiple classes of phytochemicals such as flavonoids, phenols, phytosterols, proanthocyanidin, tannin, terpenes as well as several minerals have been identified from leaves and roots of *A. karroo*. Scientific studies on *A. karroo* indicate that it has a wide range of pharmacological activities which include antibacterial, antifungal, anti-gonococcal, antihelmintic, antilisterial, antimalarial, antimycobacterial, antioxidant, HIV-1 reverse transcriptase, anti-inflammatory and analgesic. *A. karroo* has a lot of potential as a possible source of pharmaceutical products for the treatment of a wide range of both human and animal diseases and ailments. Future research should focus on the mechanisms of action of the different plant parts used as herbal medicines, isolated compounds, their efficacy, toxicity and clinical relevance.

1. Introduction

Acacia karroo (*A. karroo*) Hayne is a member of the genus *Acacia* Miller, family Fabaceae and subfamily Mimosoideae. The genus was first described by Philip Miller in 1754, the name was derived from the Greek word 'akis' which means point or barb, referring to the thorns found on African *Acacia* species [1]. The species name 'karroo' is the old spelling for the South African semi-desert natural biome 'karroo', where the species was first described by botanical explorers [2]. The genus contains a large number of species (approximately 1500), making it the largest genus within the Fabaceae family and is widespread, occurring in Australia, Asia, Africa and the Americas [3]. The genus *Acacia* was re-classified recently into five distinct genera, *Vachellia*, *Senegalia*, *Mariosousa*, *Acaciella* and *Acacia* which are clearly distinct based on a number of morphological, anatomical and biochemical attributes [4]. *A. karroo* was

therefore, renamed *Vachellia karroo* (*V. karroo*, Hayne) Banfi & Galasso when the genus *Acacia* was renamed *Vachellia*. Taxonomically, *Vachellia* is closer to *Senegalia*, the main difference is that *Vachellia* has capitate inflorescences (round, head-like flowers) and spinescent stipules (thorns) while *Senegalia* has spicate inflorescences (flowers in spikes) and the stipules are non-spinescent [3]. But taxonomists worldwide want the name *Acacia* to be conserved as renaming the genus as *Vachellia* will create numerous taxonomic and retypification problems [5]. In literature both names are used, for example *V. karroo* instead of *A. karroo* was used by Taylor and Barker [6] and Idamokoro *et al* [7]. But at the present moment *V. karroo* is regarded as an invalid name by the Royal Botanic Garden and Missouri Botanic Garden plant name database (www.theplantlist.org) and therefore, *A. karroo* has been adopted in this study.

A. karroo has been recorded throughout southern Africa, ranging from the south-western Cape in South Africa, northwards into Lesotho, Swaziland, Namibia, Angola, Botswana, Malawi, Mozambique, Zambia and Zimbabwe [6]. It has been introduced to North Africa, Australia, India, Myanmar and South America

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(Argentina, Bolivia, Chile and Paraguay), where it is often used as live fence around agricultural fields [8,9]. *A. karroo* grows from sea level to 1800 m on soils ranging from pure unconsolidated sand to heavy clays with an annual rainfall from 1500 mm down to less than 200 mm where ground water is available along drainage lines and around pans and dams [8]. The species can grow under different climatic conditions but its limiting factors are water availability and intense cold [8]. *A. karroo* is the most widespread *Acacia* in southern Africa, occupying a diverse range of habitats including dry thornveld, river valley scrub, bushveld, woodland, grassland, river banks and coastal dunes [6]. *A. karroo* shows a huge variety in terms of its growth form, with plants from different areas in the species' geographical range often having a different appearance. In the formal taxonomic revision of the species, Ross [10] detailed the vast range in morphology in this species, describing seven different informal taxonomic entities of the species which were generally correlated to its distribution. Recently, Taylor and Barker [6] evaluated the genetic variability of the species throughout South Africa using the Inter-Simple Sequence Repeat (ISSR) DNA 'fingerprinting' to determine whether there is any genetic structure that correlates to the morphological diversity of the species. The authors concluded that *A. karroo* should be considered as an ochlo species, as the evolution of the observed morphotypes has been recent and rapid, and therefore the genetic variation observed represents the ancestral gene pool that has not yet undergone lineage sorting as a consequence of isolation.

According to Barnes *et al* [8], *A. karroo* is a multipurpose tree with great potential for increasing productivity in agroforestry and silvopastoral systems over a wide range of sites in the dry zones of the tropics and subtropics. It is also categorized as a species with potential commercial value in Botswana, South Africa and Zimbabwe [8,11,12]. In Botswana, *A. karroo* exudate is used for pharmaceutical purposes and is considered to be of economic importance in this country [11] while the gum is collected and used as a substitute for gum arabic in Zimbabwe [8]. According to van Wyk [12], *A. karroo* bark and leaf have commercial potential as remedies for diarrhoea, its exudates are used as an emollient for conjunctivitis and haemorrhage and also as pharmaceutical aid in solid formulations. The seeds are traditionally roasted and used as a coffee substitute in southern Africa [13,14]. Gum collected from *A. karroo* can be used in the commercial production of sweets and other confectioneries [14]. Over the last three decades, various attempts have been made to investigate chemical constituents, biological activities of *A. karroo* and its ethnomedicinal uses in southern Africa. Unfortunately, no comprehensive review of this important plant species in southern Africa has been published, documenting the species' biology, traditional uses, phytochemistry and pharmacological properties. Therefore, in this study, the advances in traditional utilization, botany, phytochemistry, pharmacology and safety aspects of *A. karroo* are systematically reviewed.

2. Methodology of the review

The literature search was performed from June 2016 to January 2017 using electronic search engines such as Google, Google scholar, publishing sites such as Elsevier, scienceDirect, BioMed Central (BMC) and PubMed. The databases and literature sources were chosen based on the topic covered (*i.e.*,

ethnobotany, ethnomedicinal uses, ethnopharmacology, pharmacology, phytochemistry and therapeutic value) and geographical coverage (*i.e.*, southern Africa). The following keywords were used to search literature sources: *A. karroo* and *V. karroo*. Other literature sources included papers published in international journals, reports from international, regional and national organizations, conference papers, books, theses, web-sites and other grey literature. References were also identified by searching the library collections of the National Herbarium and Botanic Gardens (SRGH), Harare, Zimbabwe and the University of Fort Hare, South Africa.

3. Species description and ethnomedicinal uses

A. karroo varies from a multi-stemmed shrub to a tree of up to 15 m in height [15]. The stem of *A. karroo* is dark brown to almost black characterized by rough and somewhat flaky, revealing reddish underbark [8]. *A. karroo* has pairs of large white spines which occur on the twigs and branches. The leaves comprise about five pairs of leaflets, each divided into ten or more pairs of smaller leaflets of about 5 mm long [16]. The branches bear minute golden-yellow, ball-shaped flowers and the fruit is a long, narrow, spirally twisted pod [8].

A. karroo boasts a large number of recorded ethnomedicinal and traditional uses in southern Africa (Table 1). The roots of *A. karroo* are used as remedy for colic in infants in Lesotho [17,18] and South Africa [19,20] while bark, gum and leaf infusions are used as remedy for diarrhoea and dysentery in South Africa [19–23] and Zimbabwe [24]. *A. karroo* is also widely used as herbal medicine for sexually transmitted infections (STIs) such as gonorrhoea and syphilis in Zimbabwe [25,26], sexually transmitted diseases and venereal diseases in South Africa [20,27]. The bark, gum and leaves are used as emollient and astringent for colds, conjunctivitis and haemorrhage [28]. In Zimbabwe, roots of *A. karroo* are also used as aphrodisiac, for general body pains, convulsions and dizziness [25]. In Mozambique, root bark infusion of *A. karroo* is taken orally as remedy for malaria [29]. Gum of *A. karroo* is used with *Capsicum* spp. fruit and vinegar in a plaster dressing for acute osteomyelitis [28]. The gum from *A. karroo* has been used medicinally as emollient and as pharmaceutical aids such as emulsifiers, stabilisers of suspensions and additives for solid formulations. In South Africa, the gum of *A. karroo* has been applied to mouth ulcers and is diluted with water and used as a mouthwash against oral thrush and sprue [13,30]. Thorns are used to relieve heart pains and for magical purposes [31].

A. karroo is used in ethnoveterinary medicine for diarrhoea, coughs and ophthalmia in cattle and dogs [19,32]. Root infusions of *A. karroo* are used in ethnoveterinary medicine as an antidote to poisoning as a result of cattle and goats eating *Moraea* spp. [33]. *A. karroo* is used to treat cattle which have tulip poisoning, that is poisoning caused by consuming parts of *Homeria* spp., a bulbous plant species known to be poisonous to stock [1,13]. *A. karroo* provides shade for livestock such as cattle and goats in southern Africa [8]. The leaves, flowers, pods and its parasitic mistletoes are excellent fodder for livestock and game in southern Africa [8]. The wood is an excellent fuel, the bark can be used for tanning, the inner bark makes good cord and the sawn timber can be used for general purposes. *A. karroo* gum is collected and used as a substitute for gum arabic in Zimbabwe [8]. Seeds of *A. karroo* have been used as a substitute for coffee [19].

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