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Review

Warburgia: A comprehensive review of the botany, traditional uses and phytochemistry

Carmen M. Leonard, Alvaro M. Viljoen *

Department of Pharmaceutical Sciences, Faculty of Science, Tshwane University of Technology, Private Bag X680, Pretoria 0001, South Africa

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ABSTRACT

Ethnopharmacological relevance: The genus *Warburgia* (Canellaceae) is represented by several medicinal trees found exclusively on the African continent. Traditionally, extracts and products produced from *Warburgia* species are regarded as important natural African antibiotics and have been used extensively as part of traditional healing practices for the treatment of fungal, bacterial and protozoal infections in both humans and animals. We here aim to collate and review the fragmented information on the ethnobotany, phytochemistry and biological activities of ethnomedicinally important *Warburgia* species and present recommendations for future research.

Materials and methods: Peer-reviewed articles using "*Warburgia*" as search term ("all fields") were retrieved from Scopus, ScienceDirect, SciFinder and Google Scholar with no specific time frame set for the search. In addition, various books were consulted that contained botanical and ethnopharmacological information.

Results: The ethnopharmacology, phytochemistry and biological activity of *Warburgia* are reviewed. Most of the biological activities are attributed to the drimane sesquiterpenoids, including polygodial, warburganal, muzigadial, mukaadial and ugandensial, flavonoids and miscellaneous compounds present in the various species. In addition to anti-infective properties, *Warburgia* extracts are also used to treat a wide range of ailments, including stomach aches, fever and headaches, which may also be a manifestation of infections. The need to record anecdotal evidence is emphasised and conservation efforts are highlighted to contribute to the protection and preservation of one of Africa's most coveted botanical resources.

Contents

* Corresponding author. Tel.: +27 12 382 6360; fax: +27 12 382 6243.
E-mail address: viljoenam@tut.ac.za (A.M. Viljoen).

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1. Introduction

The genus *Warburgia*, a member of the cinnamon family (Canellaceae), has been described as the panacea of Africa (Mavi, 1994; van Wyk and Gericke, 2000). These evergreen trees grow to approximately 10–27 m high and are predominantly found in east and southern Africa. Controversy still exists regarding its infra-generic classification. Currently, the genus consists of five taxa: *Warburgia elongata* Verdc., *Warburgia salutaris* (G.Bertol.) Chiov., *Warburgia stuhlmannii* Engl., *Warburgia ugandensis* Sprague subsp. *ugandensis* and *W. ugandensis* subsp. *longifolia* Verdc. (Lovett, 2006; van Wyk, 2008). Several of the above-mentioned taxa boast an illustrious history of traditional use such as an expectorant for dry coughs, as well as a natural antibiotic for treating upper respiratory tract infections, candidiasis, sinusitis, gastro-intestinal ailments, rheumatism, malaria, dermatological disorders, venereal diseases and toothaches (Table 2). Although the powdered bark is most often used for the various herbal formulations, the leaves, roots and stalks are also sometimes used (Maroyi, 2013). The bark of *Warburgia* is most often prepared as a decoction or infusion (54.5%) which is taken orally but alternative modes of administration such as smoke inhalation, snuff or it may be consumed as a tea have been reported. Usually monotherapy treatments (91.3%) are administered but polyherbal treatments have also been described in the literature (Maroyi, 2014). For example, *W. salutaris* mixed with fat, and sometimes in conjunction with the leaves and stalks of *Hibiscus surattensis* L., is applied topically to treat genital sores and inflammation (van Wyk et al., 2009; Hutchings et al., 1996). The bark is also used in combination with *Artemisia afra* Jacq. ex Willd. (leaves) and the roots of *Acorus calamus* L. as an anti-infective agent (Felhaber and Mayeng, 1997). The bark powder of both *W. salutaris* and *Erythrophleum lasianthum* Corbishley is combined as a snuff to treat headaches (Hutchings et al., 1996). These polyherbal combinations of *Warburgia* need to be further explored to document potential additive or synergistic interactions.

Although the toxicity remains poorly investigated, *Warburgia* has been contra-indicated in pregnancy (van Wyk et al., 2000). Several drimane sesquiterpenes, such as polygodial, muzigadial and warburganal, have been isolated from *Warburgia* and have been suggested to contribute to the broad spectrum of biological properties reported for *Warburgia* species. *In vitro* efficacy against various micro-organisms, alone or as part of polyherbal mixtures, has also been reported for *Warburgia*.

Self-medication by various animals has also been recorded. African elephants in the Kibale forest in Uganda consume the bark of *W. ugandensis* for this purpose (Wing and Buss, 1970). *W. ugandensis* was found to form part of the diet of *Cercopithecus mitis* (blue monkeys) although this plant rarely occurred in the region where these primates live (Butynski, 1990). This suggests that animals use the plant for self-medication and travel outside their normal habitat to find *Warburgia.*

Although *Warburgia* species are considered an integral part of African traditional medicine, these trees are also widely utilised for non-medicinal properties such as inciting aggression in bees and dogs, for crafting wooden ornaments, for firewood and timber, as a mulch for soil conservation, for shade and resin, to season food and as antifeedants (Lovett, 2006; van Wyk et al., 2009; van Wyk, 2011).

As in the case of many medicinal trees, it is often the bark or the roots that are used for their curative properties. Due to over-exploitation and unsustainable harvesting practices, many species are considered endangered. *W. elongata*, *W. stuhlmannii* and *W. salutaris* are currently on the Red List of threatened and endangered plants listed by the International Union for Conservation of Nature (2014) due to excessive harvesting of bark (Sarasan et al., 2011; Williams et al., 2013). Plant-part substitution (using the leaf material rather than the bark), growth in protected commercial sites, propagation from soft-wood stem cuttings and *in vitro* micropropagation have all been explored to address and ensure long term sustainability (Botha et al., 2004; Kowalski and van Staden, 2001; Zschocke et al., 2000).

This review, focusing on the ethnopharmacology, phytochemistry and biological activities, as well as on the conservation and commercialisation of these medicinally important trees, aims to coherently unite these aspects and to further encourage research on one of Africa's most treasured botanical assets.

2. Methods

The relevant literature was collected by searching the major databases including Scopus, ScienceDirect, SciFinder and Google Scholar. Peer-reviewed articles using "*Warburgia*" as search term ("all fields") were retrieved from the databases with no specific time frame set to limit the search. In addition, regional literature and various books were consulted that contained botanical and ethnopharmacological information on *Warburgia*.

3. Botanical aspects

3.1. History

The genus was named after the traveller, German botanist and renowned author, Otto Warburg (1859–1938) who lectured at the University of Berlin. He wrote three volumes of *Die Pflanzenwelt* (*Ost-Afrikas und der Nachbargebiete*) based on his travels in East Africa and neighbouring regions (Engler, 1895). The books were edited by Adolf Engler and thus the genus, *Warburgia*, was described under the family Winteraceae (Canellaceae) as *Warburgia* Engl. (Engler, 1895). In the early 1900s, Mr N.T. Dawe, Officer in Charge of the Forestry and Scientific Department of the Uganda Protectorate, was tasked with exploring selected forests and conducting a botanical survey. A plant in the Kibale district with the vernacular name of "*masuko*" was provisionally described as a new species, *Dawea ugandensis* Sprague. However, after it was examined more carefully it was renamed *W. ugandensis* Sprague (Stapf, 1904). Later, *Warburgia* was collected by Bryce and Eggeling on the Rondo Plateau in Tanzania. These collections were found to be a subspecies of *W. ugandensis* and the differences