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Review

Tithonia diversifolia (Hemsl) A. Gray. (Asteraceae: Heliantheae), an invasive plant of significant ethnopharmacological importance: A review

A.A. Ajao, A.N. Moteetee *

University of Johannesburg, Department of Botany and Plant Biotechnology, P.O. Box 524, Auckland Park, 2006 Johannesburg, South Africa

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ABSTRACT

Tithonia diversifolia is a shrub-like perennial or annual invasive plant, native to north and Central America. The plant is widely used in several countries such as Costa Rica, Democratic Republic of Congo, Kenya, Nigeria, Mexico, the Philippines, São Tomé and Príncipe, Taiwan, Uganda, and Venezuela to traditionally treat numerous diseases including diabetes, malaria, snake bite, measles, gastric ulcer, menstrual pains, and wounds. This paper reviews the ethnomedicinal importance of *T. diversifolia*, as well as its proximate analysis, phytochemistry, biological activities, and potential toxicity. Published literature on *T. diversifolia* were sourced from data bases such as Google Scholar, Medicine, PubMed, Science Direct, Scopus, and SciFinder. Literature indicates that *T. diversifolia* is used to cure an array of ailments owing to its biochemical constituents which are mainly sesquiterpenes. Regardless of the invasive nature of *T. diverisifolia*, it has also been found useful in folkloric medicinal practices as well as in remediation of heavy metals from the soil. This review provides a basis for future investigation such as isolation of bioactive components and mechanism of action of the bioactivities elicited by this plant.

Contents

* Corresponding author.
E-mail address: amoteetee@uj.ac.za (A.N. Moteetee).

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1. Introduction

Tithonia diversifolia (Hemsl) A. Grey. also known as Mexican sunflower (Asteraceae: Heliantheae) is a shrub-like perennial or annual, native to north and central America, but is naturalised in Africa, Australia, and Asia, where it is an aggressive invader (Varnham, 2006; Xu et al., 2007). Due to the invasiveness of this plant in Nigeria, farmers have abandoned their lands owing to the difficulty of curbing the Mexican sunflower from taking over their farms (Chukwuka et al., 2007). This plant usually flowers in October and produces about 80,000 to 160,000 seeds m^{-2} annually, with germination rates ranging from 18 to 56% at 25 °C, seed dispersal is by vectors such as humans, livestock, and water currents (Wang et al., 2004).

Tithonia diversifolia is usually 1.2–3 m tall. The leaves are alternately arranged, lobed (occasionally the upper leaves are not lobed), with attenuate or decurrent bases, acute or acuminate apexes, and crenate margins, 5–17 × 3.5–12 cm in size, densely pubescent beneath; with palmate venation. Flower heads are solitary on a peduncle 6–13 cm in length; florets yellow, rays 3–6 cm × 5–18 mm (Orwa et al., 2009). Anatomical analysis of the leaf and the stem by Márcia and Cláudia (2012), revealed that the leaf has anomocytic stomata on both sides, dorsiventral mesophyll and several collateral vascular bundles arranged as a ring at the midrib. The stem is characterised by angular-tangential collenchyma, a conspicuous endodermis with sclerenchymatic caps adjoining the phloem. The spot characters for structural identification of *T. diversifolia* are the non-glandular and glandular (capitate and non-capitate) trichomes on the leaves, as well as the midrib, and secretory ducts that are very close to the vascular system.

Despite its invasive nature, the plant has been used as an organic fertiliser to increase the yield of vegetable crops and maize in Nigeria and Kenya (Jama et al., 2000; Nziguheba et al., 2002; Sangakkara et al., 2002). Since time immemorial, this plant has been traditionally sought after to provide succour for numerous ailments, coupled with several phytomedicinal and ethnopharmacological activities credited to it (Goffin et al., 2002; Madureira et al., 2002; Elufioye and Agbedahunsi, 2004; Njoroge and Bussmann, 2006a, 2006b; Maregesi et al., 2007; Hui et al., 2009; Maregesi et al., 2009; Muganga et al., 2010). Chagas-Paula et al. (2012) presented a comprehensive review of the ethnobotany, chemistry, and biological activities of the genus *Tithonia*. However, since the main focus of the review is at generic level, the information at species level is not exhaustive, for example, the information on the distribution of essential oils in *T. diversifolia* is based only on one reference. In this regard, new information has become available since the review was published. Furthermore, other uses of this species such as phytoremediation and soil improvement not included in Chagas-Paula et al. (2012) are highlighted in the current review. Since *T. diversifolia* is also used for animal feed, we also provide available information on its nutrient composition (proximate analysis), which is not discussed by Chagas-Paula et al. (2012).

2. Methods

Published literature on *T. diversifolia*, were sourced from databases such as Google Scholar, Medicine, PubMed, Science Direct, Scopus, and SciFinder using keywords such as anti-microbial, antioxidant, chemical constituents, ethnobotany, ethnomedicine, morphology, phytochemistry, proximate composition, and toxicity of *T. diversifolia*.

3. Results and discussion

3.1. Ethnomedicinal usage of T. diversifolia

Globally, *T. diversifolia* is used in folklore medicine by many ethnic groups. In America and Venezuela, the stem and leaf extracts are taken orally to treat abscesses, hematomas, and muscular cramps (Frei et al., 1998; Játem-Lásser et al., 1998), in Mexico and Nigeria, it is used orally for the treatment of malaria (Heinrich et al., 1998; Ajaiyeoba et al., 2006). Apart from the dried leaves that are used externally for wounds in Costa Rica, *T. diversifolia* is also popularly sought after by several ethnic groups in India, where the powder from toasted leaves is used for the treatment of dermatological conditions including bruises, wounds, and skin infections (Kuo and Chen, 1997; Frei et al., 1998; Heinrich, 2000). In Uganda, *T. diversifolia* is used orally or to wash the affected area for the treatment of microbial infections in sexual organs (Kamatenesi-Mugisha et al., 2008). The leaf is administered in Kenya as an antidote for snakebite (Owuor et al., 2005; Njoroge and Bussmann, 2006a) and in traditional veterinary medicine against ecto-parasites (Njoroge and Bussmann, 2006a). The Taiwanese use the infusion of the leaves to treat diabetes (Miura et al., 2005), while the Indonesians use the plant for the treatment of diabetes, diarrhoea, liver diseases, stomach-ache, and wounds (Wahyuningsih et al., 2015). The folkloric usage of the *T. diversifolia* are presented in Table 1.

3.2. Chemical composition of T. diversifolia

Generally, plant organs such as leaves, stems, inflorescences, and roots contain substances (nutritive or non-nutritive) that can be used for pharmacological purposes. Such plants are employed in the management of many ailments because of the medically active components they contain (Doughari, 2012). Umar et al. (2015) reported the phytochemical and mineral analyses of leaves, stems, and roots of *T. diversifolia*. The authors observed that phytochemicals such as alkaloids, flavonoids, phenols, saponins, tannins, and terpenoids, are present in aqueous and ethanol extracts of the three parts of the plant. However, the phytochemicals are found to be more prominent in the leaves, followed by the root and the stem, except for phenol which is predominantly distributed in the roots. Spectrophotometric analysis for trace metals in the leaves of *T. diversifolia* by John-dewole and Oni (2013) also revealed the presence of manganese zinc, copper, nickel, magnesium, iron, phosphorous and sulphur.

3.2.1. Terpenoids

Terpenoids are the most common metabolites in this species, of which the majority are sesquiterpenes. Sesquiterpenes are a large group of secondary metabolites with a C_{15} skeleton, formed from three isoprene units, with oxidation of one of the methanol groups to lactones (Marin, 2003). Naturally, this metabolite plays an important role in plant defence and allelopathy. In addition, several pharmacological activities such as antimalarial, antibacterial, antiviral, antifungal, and antidiabetic have been attributed to these metabolites (Matejic et al., 2014). Recently, there has been increasing interest in sesquiterpene lactones isolated from *T. diversifolia* called Tagitinins. This sesquiterpene has a wide range of pharmacological activities including anti-inflammatory and anticancer. Tagitinins C (1), F (2), and A (3) have been reported to reduce lipopolysaccharide-induced interleukin-6, interleukin-8 and tumour necrosis factor alpha production by human neutrophils (Abe et al., 2015). Therefore, there is possibility that *T. diversifolia* could be effective against cancer cells if there is further probe into this line of research. The isolated compounds from *T. diversifolia* are presented in Table 2.

3.2.2. Essential oils

Essential oils are naturally occurring volatile substances obtained from a variety of plants including *T. diversifolia*. Commercially, essential oils have many uses such as pharmaceuticals, flavour in many food stuffs and condiments, odorants in fragrances, and as insecticides (Pushpanathan et al., 2006). The stems, leaves, and flowers of *T. diversifolia* are known to be very rich in essential oils and an array of compounds has been reported. In a study by Moronkola et al. (2007) on the identification of the essential oil composition of