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Review

Ethnobotany, phytochemistry and pharmacology of *Arctotis arctotoides* (L.f.) O. Hoffm.: A review☆

Md. Moshfekus Saleh-e-In, Johannes Van Staden*

Research Centre for Plant Growth and Development, School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, Private Bag X01, Scottsville 3209, South Africa

ARTICLE INFO

Chemical compounds studied in this article:
3-O-[β-D-(6´-nonadeanoate) glucopyranosyl]-β-sitosterol (PubChem CID: not found)
Daucosterol (PubChem CID: 296119)
Stigmasterol (PubChem CID: 5280794)
Serratagenic acid (PubChem CID: 21594175)
β-sitosterol (PubChem CID: 222284)
Lupeol acetate (PubChem CID: 92157)
Lupeol (PubChem CID: 259846)
Abietic acid (PubChem CID: 10569)
Perydiscolic acid (PubChem CID: not found)
Nepetin (PubChem CID: 5317284)
Pedalitin (PubChem CID: 31161)
Glycerol-1-docosanoate (PubChem CID: 53480989)
Zaluzanin D (PubChem CID: 12445012)
Dehydrocostus lactone (PubChem CID: 73174)
Zaluzanin C (PubChem CID: 72646)
3-Desacetyl-10,14-desoxoarctolide (PubChem CID: not found)
11β, 13-Dihydro-10, 14-desoxoarctiolide (PubChem CID: not found)
10,14-Deoxyarctolide (PubChem CID: not found)
3-Deacetyl-3-propionyl-11, 14-deoxoarctolide (PubChem CID: not found)
Arctolide (PubChem CID: 442144)
Arctiolide (PubChem CID: not found)
11β, 13-Dihydroarctiolide (PubChem CID: not found)
Arctodecurrolide (PubChem CID: not found)
3-Deacetyl-3-propionylarctolide (PubChem CID: not found)
3-Deacetyl-3-isobutyryl arctolide (PubChem CID: not found)
Grosshemin (PubChem CID: 442256)

ABSTRACT

Ethnopharmacological relevance: Arctotis arctotoides (Asteraceae) is part of the genus Arctotis. Arctotis is an African genus of approximately 70 species that occur widely in the African continent with diverse medicinal values. This plant is used for the treatment of indigestion and catarrh of the stomach, epilepsy, topical wounds and skin disorders among the ethnic groups in South Africa and reported to have a wide spectrum of pharmacological properties.

Aim of the review: The aim of the present review is to appraise the botany, traditional uses, phytochemistry, pharmacological potential, analytical methods and safety issues of *A. arctotoides*. Additionally, this review will help to fill the existing gaps in knowledge and highlight further research prospects in the field of phytochemistry and pharmacology.

Materials and methods: Information on *A. arctotoides* was collected from various resources, including books on African medicinal herbs and Zulu medicinal plants, theses, reports and the internet databases such as SciFinder, Google Scholar, Pubmed, Scopus, Web of Science, and Mendeley by using a combination of various meaningful keywords. This review surveys the available literature of the species from 1962 to April 2017.

Results: In vitro and *in vivo* studies of the medicinal properties of *A. arctotoides* were reviewed. The main isolated and identified compounds were reported as sesquiterpenes, farnesol derivatives, germacranolide, guaianolides and some steroids, of which, nine were reported as antimicrobial. Monoterpenoids and sesquiterpenoids were the predominant essential oil compound classes of the leaves, flowers, stems and roots. The present review revealed potential pharmacological properties such as anti-oxidant, antibacterial, antifungal and anticancer activities of plant extracts as well as isolated compounds. Moreover, the review reports the safety profile (toxicity) of the crude extracts that had been screened on brine shrimps, rats and human cell lines.

Conclusions: The present review has focused on the phytochemistry, botany, ethnopharmacology, biological activities and toxicological information of *A. arctotoides*. On the basis of reported data, *A. arctotoides* has emerged as a good source of natural medicine for the treatment of microbial infections, skin diseases, anti-inflammatory and anticancer agents and also provides new insights for further isolation of new bioactive compounds, especially the discovery of antimicrobial, anti-inflammatory and anticancer novel therapeutic lead drug molecules. Additionally, intensive investigations regarding pharmacological properties, safety assessment and efficacy with their mechanism of action could be future research interests before starting clinical trials for medicinal practices.

Abbreviations: ABTS, 2, 2'-azino-bis 3-ethylbenzothiazoline-6-sulphonic acid; BHT, butylated hydroxytoluene; Ca, Calcium; CC, column chromatography; COX-2, cyclooxygenase-2; DPPH, 2,2-diphenyl-1-picrylhydrazyl; EDXS, energy-dispersive X-ray spectroscopy; EtOH, ethanol; Et_2O, diethyl ether; EtOAc, ethyl acetate; FRAP, ferric reducing ability of plasma; GFC, gel filtration chromatography; GC-MS, gas chromatography-mass spectroscopy; HPTLC, high pressure thin layer chromatography; IL-1β, interleukin 1 beta; IR, infrared spectroscopy; iNOS, inducible nitric oxide synthase; K, Potassium; LOX, lipoxygenase; MeOH, methanol; MIC, minimum inhibitory concentration; MS, mass spectroscopy; MTT, 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide; Na, Sodium; NF-kB, nuclear factor-kappa B; NMR, nuclear magnetic resonance spectroscopy; NO, nitric oxide; P, Phosphorus; PTLC, preparative thin layer chromatography; PGE_2, prostaglandin E_2; ROS, reactive oxygen species; S, Sulphur; SEM, scanning electron microscopy; SiO_2, silica gel; TNF-α, tumor necrosis factor alpha; VLC, vacuum liquid chromatography

☆ Research Centre for Plant Growth and Development, School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, Private Bag X01, Scottsville 3209, South Africa.
* Corresponding author.
E-mail address: Rcpgd@ukzn.ac.za (J. Van Staden).

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4β, 15-dihydro-3-dehydro-zaluzanin C (PubChem CID: not found)
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Dehydrobrachylaenolide (PubChem CID: 44566739)
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Linalool (PubChem CID: 6549)
Myrtenol (PubChem CID: 10582)
Piperitone (PubChem CID: 6987)
cis-α-Farnesene (PubChem CID: 5317320)
cis-α-Bergamotol acetate (PubChem CID: 102208434)
trans-α-Bergamotol (PubChem CID: 6429302)
β-Caryophyllene (PubChem CID: 5281515)
γ-Curcumene (PubChem CID: 12304273)
cis-α-Bergamotene (PubChem CID: 91753502)
Spathulenol (PubChem CID: 92231)
Bicyclogermacrene (PubChem CID: 5315347)
cis-Nerolidol (PubChem CID: 5320128)
β-Bisabolol (PubChem CID: 27208)
Caryophyllene oxide (PubChem CID: 1742210)
α-Cadinol (PubChem CID: 6431302)

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1. Introduction

Plants produce basic and sophisticated medicinal ingredients that have been applied by humans as natural medications for thousands of years. South Africa is unique in that it has an extremely rich floral biodiversity, with over 30,000 species of higher plants that includes the most diverse temperate flora in the world (Van Wyk et al., 1997; Mita et al., 2009). About 25% of the total number of higher plants in the world are found in Africa south of the Sahara (Klopper et al., 2006). Particularly noticeable is the extraordinary degree of endemism of this flora and the cultural diversity of its population. It is estimated that around 27 million South Africans depend on traditional medicine for their primary health care (Mander, 1998). Although many of these remedies are expected to contain active constituents, most of them have not yet been identified, characterized or properly formulated (Newton et al., 2010). *Arctotis arctotoides* (L.f.) O. Hoffm. has an impressive history of ethnopharmacological uses by the indigenous people of South Africa, particularly Zulu, Sotho, Venda and Xhosa communities. They take this plant in different forms for the treatment of epilepsy, indigestion and catarrh of the stomach. They apply the leaf juice and paste for topical wounds (Van der Walt, 2002). The plant contains diverse bioactive secondary metabolites including terpenes, steroids, guaianolides and farnesol derivatives, some of which are very effective as antimicrobial agents (Tsichritzis et al., 1990; Oyedeji et al., 2005; Sultana and Afolayan, 2007) and as a traditional remedy against opportunistic fungal infection (Otang et al., 2012). Limited reports have been found on antibacterial, antifungal, anticancer and anti-oxidant activities (Afolayan, 2003; Afolayan et al., 2007; Fouche et al., 2008).

The knowledge of traditional medicinal plants and their beneficial effects in health care has always guided the discovery of new drugs. Thereby, the traditional importance of this species encourages scientist to search its phytoconstituents and evaluate pharmacological activities. In this review, our aim was to consistently organize the unsorted information on phytochemistry, pharmacology, biological properties and the botanical features of *Arctotis arctotoides*. This review could be encourage future research on this medicinal plant as well as help botanists, ethnopharmacologists and chemists to develop new bioactive materials for several remedies.

2. Methods

The extensive literature review of *Arctotis arctotoides* documents on phytochemistry and pharmacological activity was undertaken through several popular electronic search engines and databases such as Scopus®, Web of Science®, SciFinder®, PubMed®, GoogleScholar®, ScienceDirect®, Springer Online, Wiley Online Library®, Informa®, ResearchGate®, Taylor & Francis Online® and Mendeley®. The literature was searched from the databases using the keywords 'Arctotis' and 'Arctotis arctotoides' with no exact time limit (all fields) as well as various books that were accessed for information that relates to the