South African Journal of Botany 112 (2017) 54–69

Contents lists available at ScienceDirect

South African Journal of Botany

journal homepage: www.elsevier.com/locate/sajb

Review

Bioactive compounds from medicinal plants: Focus on *Piper* species

E.E. Mgbeahuruike *, T. Yrjönen, H. Vuorela, Y. Holm

University of Helsinki, Faculty of Pharmacy, Division of Pharmaceutical Biosciences, P.O. Box 56, FI-00014, University of Helsinki, Finland

ARTICLE INFO

Article history:
Received 19 October 2016
Received in revised form 5 April 2017
Accepted 11 May 2017
Available online xxxx

Edited by S Van Vuuren

Keywords:
Alkaloids
Amides
Anticancer activity
Antimicrobial activity
Piperaceae

ABSTRACT

This article reviews new discoveries related to the phytochemistry and biological activities of bioactive compounds from *Piper* species. It outlines the anticancer, anti-parasitic, and antimicrobial activities of *Piper* species in relation to drug discovery. The use of bioactive compounds from medicinal plants as therapeutic agents has been an important area in biomedical and natural product research. *Piper* species are effective medicinal plants used in folk medicine. They have traditionally been used to treat stomach ache, rheumatoid arthritis, diarrhoea and other general infections, and their efficacy has been attributed to their bioactive compounds. Bioactive compounds and extracts from *Piper* species have been examined and found to be of clinical importance for both malignant and non-malignant diseases. They have displayed pronounced efficacy as anticancer, antitumour and antimicrobial agents in various pharmacological studies. They have been reported to possess anti-inflammatory, antioxidant, antibacterial, antifungal, and antimalarial activities. The alkaloids piperine, piperlongumine, guineensine, chabamide and pellitorine, which have been isolated from most *Piper* species, are able to inhibit the growth of cancer cell lines inducing apoptosis and acting as nuclear export inhibitors. These bioactive compounds can improve the effectiveness of chemotherapeutic drugs with minimal systemic toxicity to normal cells in cancer therapy. Pinoresinol, guineensine and other bioactive compounds from this species exhibited strong antimicrobial efficacy against various microorganisms including pathogenic *Vibrio* strains, which are often involved in host cell invasion during *Vibrio cholera* infection. The anticancer, antimicrobial and antimalarial properties of *Piper* species are compiled to support further exploration of their bioactive compounds for drug discovery. Biomedical and pharmacological discoveries concerning their anticancer and antimicrobial properties are highlighted here for further clinical applications, which could pave the way for the proper therapeutic use of bioactive compounds and extracts from this plant species.

Contents

* Corresponding author.
E-mail addresses: eunice.mgbeahuruike@helsinki.fi (E.E. Mgbeahuruike), Teijo.yrjonen@helsinki.fi (T. Yrjönen), Heikki.vuorela@helsinki.fi (H. Vuorela), Yvonne.holm@helsinki.fi (Y. Holm).

http://dx.doi.org/10.1016/j.sajb.2017.05.007
0254-6299/

1. Introduction

Bioactive compounds from *Piper* species have played a substantial role as therapeutic agents in drug discovery (Barh et al., 2013). Piperaceae is a family of plants that contain valuable natural compounds. It comprises the genera *Macropiper*, *Zippelia*, *Piper*, *Peperomia* and *Manekia* (Nascimento et al., 2012). The genus *Piper* consists of 700 species growing in various parts of the world (Parmar et al., 1997). It is the largest genus in the family and has numerous medicinal and traditional uses (Table 1). These species are mostly shrubs, climbing herbs or trees and are widely distributed in tropical regions such as Asia, Central and Western Africa, South and Central America, and Pacific Ocean islands (Parmar et al., 1997; Trindade et al., 2012). Available images of *Piper* species most commonly utilized in traditional African medicine are presented in Fig. 1.

Piper species are often cultivated for their seeds and leaves, which have the pungent aroma that makes them important spices. *Piper* species are consumed for the treatment of various ailments such as fever, headache, diarrhoea, rheumatism, boils, scabies and stomach problems (Tsai et al., 2005; Chakraborty and Shah, 2011; Sharkar

Table 1
Piper species and medicinal uses.

Piper species	Medicinal/traditional uses	References
Piper aborescens Roxb.	Rheumatism, cytotoxic activity and antiplatelet aggregation.	Tsai et al. (2005)
Piper acutifolium Ruiz and Pav.	Antiseptic, wound healing, vaginal infections, gastritis, skin ulcerations and ailments.	De Feo (2003), Svetaz et al. (2010)
Piper aduncum L.	Stomach aches, vaginitis, influenza, rheumatism, cough, fever and general infections.	Martínez et al. (2003), Céline et al. (2009)
Piper alatabaccum Trel. and Yunck	Stomach aches and diarrhoea.	Facundo et al. (2005)
Piper angustifolium Lam.	Cutaneous leishmaniasis-associated lesions, stomatitis, vaginitis, liver disorders, and antiseptic.	Bosquiroli et al. (2015)
Piper auritum Kunth	Fever and sore throat.	Conde-Hernández and Guerrero-Beltrán (2014)
Piper barbatum Kunth	Headache, stomach pain, dermatitis, disinfectant, and wound treatment.	Tene et al. (2007), Calderón et al. (2010)
Piper betle L.	Cuts, boils, scabies, mouth odour, cough remedy, bronchitis, and nosebleed.	Ahmad and Ismail (2003), Chakraborty and Shah (2011)
Piper boehmeriifolium (Miq).C.D.C	Pain alleviation, rheumatism and arthritic conditions.	Tang et al. (2010)
Piper capense L.F.	Abdominal pain, diarrhoea, and cough.	Tekwu et al. (2012)
Piper chaba Hunter	Pain alleviation, asthma, bronchitis, fever, piles and stomach aches.	Parmar et al. (1997), Naz et al. (2012)
Piper clausenianum (Miq.) C. DC.	Candidiasis and virginal infections.	Curvelo et al. (2014)
Piper cubeba L.F	Renal disorder, gonorrhoea, syphilis, abdominal pain, enteritis and asthma.	Ahmad et al. (2012)
Piper cumanense Kunth	Malaria and fever	Garavito et al. (2006)
Piper dennisii Trel.	Rheumatic pain and arthritis.	Céline et al. (2009)
Piper fimbriulatum C. DC.	Pain and antiplasmodial activity.	Solís et al. (2005), Calderón et al. (2006a)
Piper glabratum Kunth	Skin ailments, skin ulcerations, wounds and antiseptic.	Calderón et al. (2010), Svetaz et al. (2010)
Piper grande Vahl	Antiplasmodial activity and leishmaniasis-associated lesions.	Calderón et al. (2006a)
Piper guineense Schum and Thonn	Cough remedy, bronchitis, venereal diseases, rheumatism, female infertility, and aphrodisiac.	Parmar et al. (1997), Tekwu et al. (2012), Umoh et al. (2013)
Piper hayneanum C.DC.	Wound and skin diseases.	Bastos et al. (2011)
Piper hispidum L.	Wounds and symptoms of cutaneous leishmaniasis, skin ailments, and stomach aches.	Parmar et al. (1997), Calderón et al. (2006b), Svetaz et al. (2010), Chahal et al. (2011)
Piper holtonii C.DC.	Treatment for leishmaniasis symptoms.	Calderón et al. (2006b, 2010)
Piper jacquemontianum Kunth	Skin ailments, infections, anaemia and body aches.	Svetaz et al. (2010), Cruz et al. (2011)
Piper jericoense Trel. & Yunck	Antiplasmodial and cytotoxic activity.	Mesa Vanegas et al. (2012)
Piper lanceaefolium HBK.	Skin infection.	López et al. (2002)
Piper longum L.	Antidote to snake bite, scorpion stings, chronic bronchitis, cough and cold.	Chahal et al. (2011)
Piper marginatum Jacq.	Anti-inflammatory, snake bites, diseases of the liver and bile duct.	Chahal et al. (2011)
Piper methysticum G.Forst	Narcotic beverage made from roots is drunk to cure diseases.	Parmar et al. (1997), Li et al. (2012)
Piper multiplinervium C.DC.	Stomach aches.	Calderón et al. (2006a), Rüegg et al. (2006)
Piper nigrum L.	Diarrhoea, fever, cold, colic disorder and gastric conditions.	Aziz et al. (2015)
Piper obrutum Trel. & Yunck.	Antiplasmodial and cytotoxic activity.	Mesa Vanegas et al. (2012)
Piper ovatum Vahl	Anti-inflammatory and analgesic.	Silva et al. (2009)
Piper pulchrum C.DC.	Treatment of haemorrhagic venom effect from snakebite and antidote for snakebite.	Otero et al. (2000)
Piper pyrifolium Vahl.	Diarrhoea and diuretic.	Fortin et al. (2002)
Piper regnellii (Miq.) C. DC.	Wounds, swellings and skin irritations.	Felipe et al. (2006)
Piper retrofractum Vahl	Digestive aid, stimulant, carminative, intestinal disorders, and postpartum treatment in women	Muharini et al. (2015)
Piper sanvicentense Trel. & Yunck.	Anti-tumour and anticancer properties.	Taylor et al. (2013)
Piper sarmentosum Roxb.	Toothache, headache, fungal dermatitis, cough, muscle weakness, and pain in the bones.	Rukachaisirikul et al. (2004), Mohamad et al. (2011), Chahal et al. (2011)
Piper sintenense Hatus.	Treatment of snake bites and wounds.	Chen et al. (2003)
Piper strigosum Trel. & Yunck.	Treatment of symptoms associated parasitosis and leishmaniasis, wounds.	Estevez et al. (2007)
Piper stylosum Miq.	Fever and Pain.	Salleh et al. (2014)
Piper tuberculatum Jacq.	Antidiuretic, analgesic, sedative, digestive disorders and antidote for snakebites.	Bezerra et al. (2015)
Piper umbellatum L.	Treatment of miscarriages, boils, dermatosis and leucorrhoea.	Céline et al. (2009), Calderón et al. (2010)
Piper xanthostachyum C. DC	Treatment of leishmaniasis symptoms.	Calderón et al. (2006a)