Traditional uses, phytochemistry and biological activities of *Roscoea purpurea* Sm.

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Reviews

Abstract

Background: *Roscoea purpurea* Sm. (Zingiberaceae) is an important Himalayan plant used as tonic and for the treatment of various diseases.

Methods: The scientific information about the traditional uses, bioactive compounds, and biological activities were collected from the published research articles, books, and online scholarly databases such as Scopus, SciFinder and PubMed.

Results: *R. purpurea* is a valuable medicinal plant in the traditional medicinal system *Ayurveda* and is also locally used for the treatment of diabetes, urinary troubles, etc. Various bioactive compounds including phenolic acids, flavonoids and diterpenoids are reported mainly from the rhizomes. The extracts and compounds obtained from the rhizomes showed antioxidant, antimicrobial, cytotoxic and oxidative DNA damage protecting activities.

Conclusion: The study highlighted the traditional uses, bioactive compounds, and biological activities of *R. purpurea*. Published scientific articles suggest that the rhizomes are rich in bioactive compounds with pharmacological importance. Rhizomes can be a potential source for the development of functional foods and nutritional products. As most of the bioactivity analyses were based on *in-vitro* assays, future studies should focus more on *in vivo* and clinical studies.

Keywords: *Roscoea*, kakoli, rasgari, antioxidant, phenolic acids, flavonoids

Background

Zingiberaceae family consists of about 50 genera and about 1600 aromatic perennial herbs distributed over tropical Africa, America, and Asia (Christenhusz & Byng 2016). Many species are widely used as food and nutritional products and for the treatment of cold, digestive problems, inflammation, pain, respiratory diseases, etc. (Devkota *et al.* 2021, Tushar *et al.* 2010, Lakhan *et al.* 2015, Timalsina *et al.* 2021).

Roscoea is one of the important genera of Zingiberaceae consisting of about 22 herbaceous plant species having diverse medicinal uses (Dhyani *et al.* 2020, Zhao *et al.* 2017). *Roscoea purpurea* Sm. (Syn. *Roscoea procera* Wall.) is

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a Himalayan perennial rhizomatous herb about 20-40 cm tall (Fig. 1), commonly known as **rasgari, katare,** in Nepal and **kakoli**, **ksheera**, **karnika**, **vaysasha,** and **vayasoli** in India (Ghimire *et al.* 2021, Watanabe *et al.* 2013, Misra *et al.* 2015). It is widely distributed in the mountainous region of Nepal, India and Bhutan at about 1520-3100 m (Zhao *et al.* 2017, Paudel *et al.* 2015, Watanabe *et al.* 2013). It is one of the *Astavarga* plants used as tonic in many Ayurvedic formulations such as *Chyawanprash* (Kaur *et al.* 2020, Miyazaki *et al.* 2014, Acharya *et al.* 2012). Traditionally, rhizomes are used in the treatment of various diseases and symptoms such as fever, wound, urinary troubles, diarrhea and dysentery (Rawat *et al.* 2014, Kumari *et al.* 2011). Few scientific studies about bioactive compounds and evaluation of bioactivities have been reported in recent years. However, there is no detailed review published on *R. purpurea* regarding its traditional uses, bioactive compounds and biological activities as per our knowledge. Thus, the main aim of this article was to collect and analyze the published information about traditional use, phytochemistry and biological activities of *R. purpurea*.

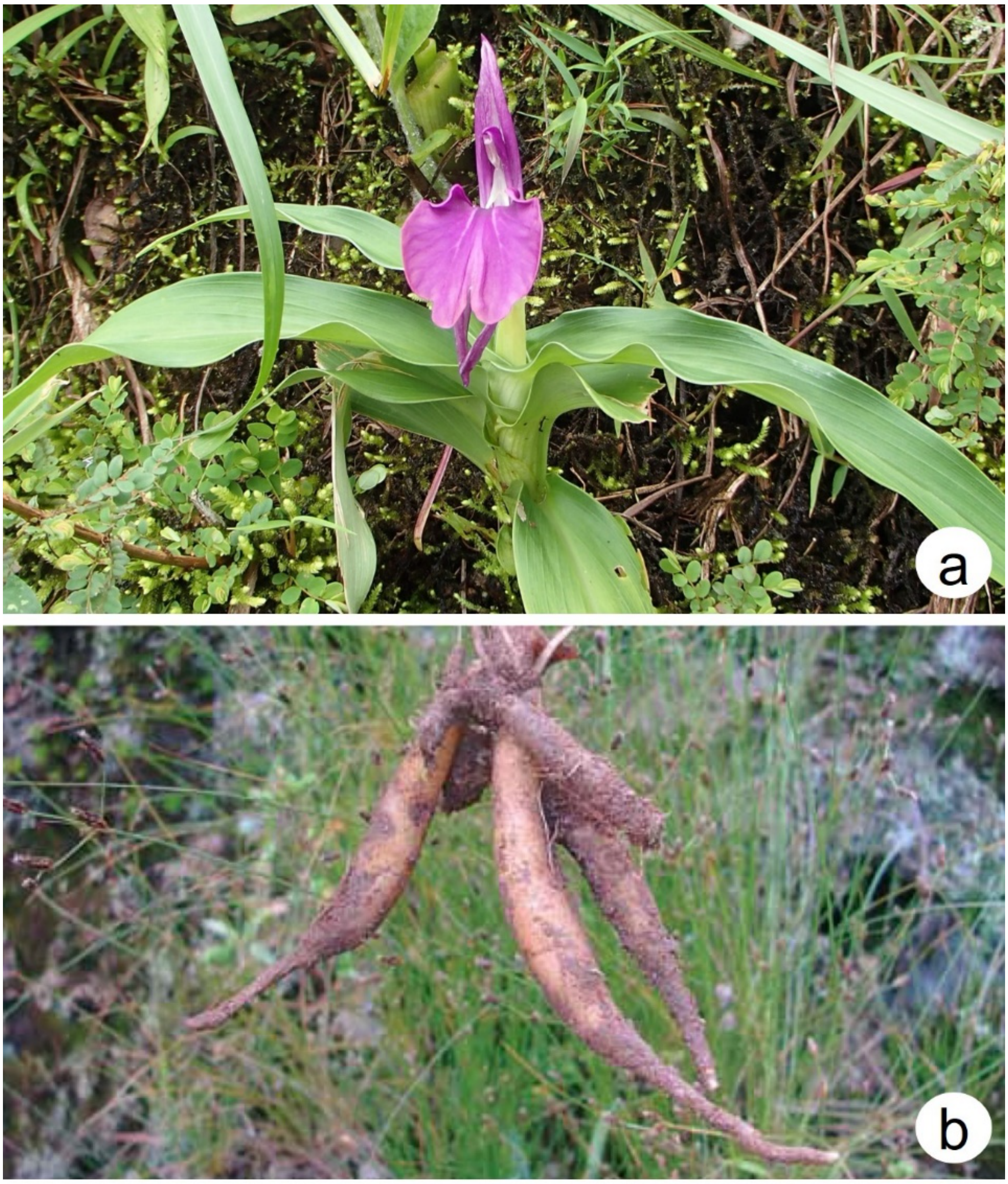

Figure 1. Photographs of aerial parts (a) and rhizomes (b) of *R. purpurea.* [Figure (b) was reproduced from Watanabe *et al.* 2013].

Materials and Methods

The relevant scientific information of *R. purpurea* was collected from published articles, books and various scholarly databases including SciFinder, PubMed, Scopus and Google Scholar by using the keywords such as *Roscoea pupurea*, *Roscoea procera,* kakoli, chemical constituents and biological activities.

Traditional uses

The rhizome known as **kakoli** is one of the important *Astavarga* plants and it is used as tonic in many Ayurvedic formulations such as *Chyawanprash* (Kaur *et al.* 2020, Miyazaki *et al.* 2014, Singh 2006). It is reported to have antirheumatic, febrifuge, galactagogic, hemostatic, expectorant, stimulant, diuretic, sweet and cooling properties (Acharya *et al.* 2012). Rhizomes are widely used as a tonic, aphrodisiac, and remedy for wounds and urinary troubles in traditional medicine in Nepal (Watanabe *et al.* 2013, Kunwar & Adhikari 2005). The powder of rhizome mixed with orange rind powder is reported to be used to treat bronchitis and asthma. Similarly, clarified butter processed with this powder is taken to treat cephalic diseases, stomatitis, gouts, emaciation, etc. (Acharya *et al.* 2012). The decoction prepared from the rhizomes is used to treat diarrhea, dysentery, and impotency (Rawat *et al.* 2014). Rhizomes are also used to treat diabetes, diarrhea, hypertension, inflammation, jaundice, and other ailments (Shah 2019, Rawat *et al.* 2016a, 2016b, 2016c, Misra *et al.* 2015, Kumari *et al.* 2011).

Phytochemistry

Various bioactive chemical constituents of different chemical classes such as phenolic acids, flavonoids and diterpenoids have been reported from *R. purpurea* (Table 1, Fig. 2). The nutritional components and phytochemicals of the rhizomes were analyzed and the results showed the presence of nutritional components such as fiber (28.1%), oil (3.5%), protein (3.46%) and starch (0.84%). Phytochemical screening of powder of the tuber showed the presence of carbohydrate, phenolics, flavonoids, saponins, tannins, glycosides, proteins, and alkaloids. Total phenolics and flavonoids contents in the methanol extract of rhizomes were found to be about 14 mg gallic acid equivalent/g and 12 mg quercetin equivalent/g, respectively (Misra *et al.* 2015). Rawat *et al.* (2014) reported the contents of various nutritional components such as thiamine, tannins, alkaloids, phenols, flavonoids, riboflavin, fat, minerals, and fibers in rhizomes. Rawat *et al.* (2016a) also reported the analysis of geographical and environmental variation in phenolic compounds and antioxidant activity. Among the various solvent extracts of the rhizomes i.e. water, methanol, ethanol, acetone and hexane extracts, methanol, ethanol and acetone extracts had higher contents of total phenolic and flavonoid compounds (Rawat *et al.* 2016c)

Table 1. Bioactive compounds reported from *R. purpurea*

Chemical class and compounds	**Plant parts**	**References**
Phenolic acids		
Gallic acid	Rhizomes	Singamaneni *et al.* 2021, Giri *et al.* 2017, Rawat *et al.* 2016c
Vanillic acid	Tubers	Misra *et al.* 2015
Protocatechuic acid	Tubers	Misra *et al.* 2015, Srivastava *et al.* 2015
3-Hydroxybenzoic acid	Rhizomes	Giri *et al.* 2017
Syringic acid	Tubers	Misra *et al.* 2015, Srivastava *et al.* 2015
Ellagic acid	Rhizomes	Giri *et al.* 2017
p-Coumaric acid	Rhizomes	Giri *et al.* 2017, Rawat *et al.* 2016c
Caffeic acid	Rhizomes	Singamaneni *et al.* 2021
Ferulic acid	Rhizomes	Singamaneni *et al.* 2021, Misra *et al.* 2015, Srivastava *et al.* 2015
3-Hydroxycinnamic acid	Rhizomes	Giri *et al.* 2017
Fenozan acid	Rhizomes	Singamaneni *et al.* 2021
Flavonoids		
Kaempferol	Rhizomes/Tubers	Singamaneni *et al.* 2021, Misra *et al.* 2015, Srivastava *et al.* 2015
Kaempferol 3-*O*-methyl ether	Aerial parts/ Rhizomes	Singamaneni *et al.* 2021, Miyazaki *et al.* 2014
Kaempferol 3-*O*-glucuronide	Aerial parts	Miyazaki *et al.* 2014
Kaempferide	Aerial parts/Rhizomes	Miyazaki *et al.* 2014
Kaempferide 3- *O*-glucuronide	Aerial parts	Miyazaki *et al.* 2014
Rutin	Rhizomes	Giri *et al.* 2017, Misra *et al.* 2015, Srivastava *et al.* 2015
Catechin	Rhizomes	Rawat *et al.* 2016a, , Rawat *et al.* 2016c
Epicatechin	Roots	Kaur *et al.* 2020a
Epigallocatechin	Roots	Kaur *et al.* 2020a

Apigenin	Rhizomes	Srivastava *et al.* 2015
Curcuminoid		
Bisdemethoxycurcumin	Rhizomes	Singamaneni *et al.* 2021.
Diterpenoids		
Coronarin A	Rhizomes	Singamaneni *et al.* 2021
Coronarin K	Rhizomes	Singamaneni *et al.* 2021
Coronarin L	Rhizomes	Singamaneni *et al.* 2021
Other compounds		
Lupenone	Roots	Kaur *et al.* 2020b
(*Z*)-3-Hexen-1-ol-*β*-D-glucopyranoside	Aerial parts	Miyazaki *et al.* 2014
Adenosine	Rhizomes	Miyazaki *et al.* 2014

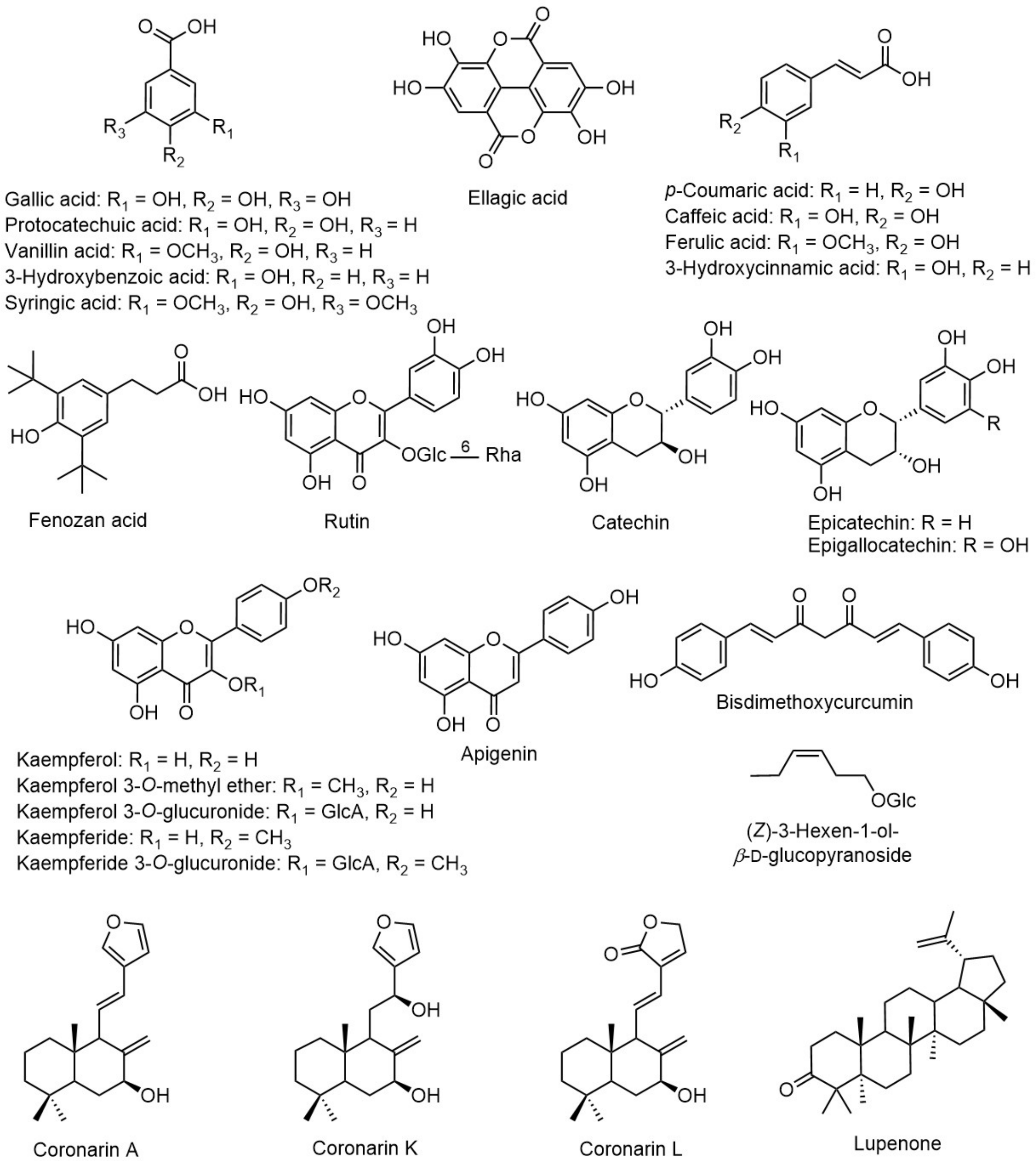

Figure 2. Structures of compounds reported from *Roscoea purpurea*

Biological activities

The extracts obtained from *R. purpurea*, mainly rhizomes, are subjected to the evaluation of some biological activities such as antioxidant, antimicrobial, cytotoxic and oxidative DNS damage protecting activities.

The antioxidant properties of the tubers were studied using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay and β–carotene bleaching assay and the IC_{50} values for the methanolic extract were found to be of 810.66 ± 1.154 and 600.66 ± 1.154 µg/ml, respectively (Misra *et al.* 2015). Rawat *et al.* (2016a) reported the variation in antioxidant activity of the rhizomes due to geographical and environmental factors based on 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), DPPH and ferric reducing antioxidant power (FRAP) assays and suggested that the rhizomes from the plants collected from open grassy lands had higher antioxidant activity. Rawat *et al.* (2017) also reported the variation in the content of major phenolic contents and antioxidant activity of different phases of life cycle of the plant and suggested that the senescence phase (around November) would be the best phase to collect rhizomes as they had higher content of phenolic compounds and antioxidant activity. Among the different solvent extracts of rhizomes, methanol extract showed highest antioxidant activity (Rawat *et al.* 2016c). All these studies evaluating the antioxidant activity were based on *in-vitro* assays and there is necessity of confirming the activity using animal models.

Rawat *et al.* (2016c) evaluated the antibacterial and antifungal activity of the water, methanol, ethanol, acetone and hexane extracts of rhizomes. These extracts showed variable antibacterial activity against *Bacillus subtilis, Staphylococcus aureus, Micrococcus luteus* and *Escherichia coli*. However, these extracts were active only against *Candida albicans* among the tested fungal species. These activities were limited only to the evaluation zone of inhibition. The determination of minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) is still lacking and future studies should focus on more detailed studies evaluating these parameters.

Few studies have also reported the cytotoxic activities of extracts and compounds against cancer cell lines based on *in vitro* assays. Cytotoxic activity of methanolic and chloroform extracts of the rhizomes was tested in different human cancer cell lines i.e. lung cancer (A549), breast cancer (MCF-7), colon cancer (HCT-116) and pancreas cancer (Bxpc-3) cells using MTT assay. Both methanolic extract and chloroform extract showed the cytotoxic activities against these cell lines. Compounds isolated from the methanol extract were also tested and coronarin K showed promising activities (Singamaneni *et al.* 2021). Srivastava *et al.* (2015) also reported the cytotoxic activity of ethanol extract and its fractions against A549, human cervical cancer (SiHa), rat glioma (C-6) and Chinese hamster ovary cells (CHOK1) cells. The extract and the petroleum ether fraction showed relatively strong cytotoxic activities.

Giri *et al.* (2017) reported the potent oxidative DNA damage protecting activity of the 80% methanol extract of the rhizomes.

There are several other traditional uses such as tonic, would healing, anti-diabetic properties, which are not studies yet for *R. purpurea*. The detailed mechanisms of action of the extracts and bioactive compounds are yet to be elucidated using *in vivo* and clinical studies.

Conclusion and future perspectives

The rhizomes of *R. purpurea* are traditionally used as tonic and for the treatment of various diseases/symptoms. However, there no sufficient information about the collection season of the plant, processing methods, preparation of formulations, methods of administration and dosage. Future studies on ethnopharmacological surveys should highlight these aspects. Nutritional and chemical constituent analysis of the rhizomes has revealed the presence many bioactive compounds that are previously reported to have various health beneficial effects such as flavonoids and phenolic acids. It can be a potential source for the development of nutritional products and functional foods. Only a very few biological activity evaluations have been performed and most of them are based on in vitro assays. Regarding antibacterial activities, determination of MIC and MBC is necessary. Similarly, other activities should be evaluated using properly designed *in vivo* studies. To provide evidence for the therapeutic efficacy as traditional medicine, appropriate clinical studies are necessary. Future studies should focus to fulfil these gaps in research.

Declarations

Ethics approval and consent to participate: Not applicable.
Consent for publication: This paper does not include any person´s data and further permission for publication is not required.

Availability of data and materials: The data was not deposited in public repositories.
Conflict of interests: The authors declare that they have no competing interests.
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Authors' contribution: H.P.D. conceived the idea and both contributed to the preparation of first drat and revision. Both authors read, reviewed, and approved the final version of the manuscript.

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