Reviewarticle

Roscoeapurpurea(Kakoli):Exploringtheimperativeforconservationof an endangered Ashtawarga plant through comprehensive review

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ABSTRACT

InCOVIDEra,achievingholistichealththroughAyurvedaisgainingpopularitydaybyday.However,marketfails to satisfy this ever-increasing demand due to unavailability and extinction of some of the major medicinal flora. Being an Ashtawarga plant, Roscoea purpurea, known for its multiple Ayurvedic formulations, medicinal and rejuvenatingproperties,isalsoavailableinverylimitedquantityandconsideredendangered.Traditionally,various partsoftheplantlikeleaves,rootsandflowersareusedfortreatingdiseaseslikediarrhoea,diabetes,inflammatory disorders,rheumaticpainandfever.Onaccountofitsrichchemicalbaseconsistingpolyphenolsandflavonoids,it isreportedtohaveanti-cancerousandanti-oxidantactivities.Howbeit,duetoitsendangeredstatus,Department ofAYUSH,Govt.ofIndiahaspermittedtoswapthesekindofrareherbswithaccessiblesubstitutes.Adulteration with other plants opens the ground for exploitation in drug industry and degrades the quality and credibility of Ayurvedicmedicine.So,thestudyaimstoprovidetheimportanceofthisendangeredplantinlieuofitstraditional uses,Ayurvedicpropertiesandbioactivities.Italsotriestoemphasizethat,owingtoitsrichmedicinalrecord,not onlytheplantneedstobeexploredfurtherbutconservationisimportantaswell.Hence,astrategicconservation plan has also been presented.

Keywords*:Ashtawarga*,Ayurveda,conservation,herbaldrugs,*Roscoeapupurea*,

INTRODUCTION

*Roscoea*isanimportantgenerabelongingtothe familyZingiberaceaewhichconstitutesnearly24 herbaceous tuberous geophytes, according to Royal Botanic Gardens, Kew having various medicinal uses (Dhyani *et al*., 2020; Zhao *et al*., 2017). *Roscoea purpurea,* known by the common name of *Kakoli*,is a large lushgreenperennial rhizomatousherbbetween15-30cminheightwith light brown, thick, fleshy, and bundled roots (rhizomes).The leaves are fleshy and flowers are hooded expressing a purple tone shade (Sahu *et al*., 2010; Gopal *et al*., 2014). It is an important species of the "*Ashtawarga*" group with *Jivaka-Rishibhak*,*Mahameda-Meda*,*Riddhi-Vriddhi*and *Kakoli-Kshirakakoli*asclanmembers.Theseplants are claimed to be useful in healing and treating fracturedbones,weakness, pyrexia,body overweight, and regulating diabetes; also renowned for their effect in balancing *vata*, *pitta*, and *raktadoshas*(Dhyani*etal*.,2010;Chinmay*etal*., 2011; Virk *et al*., 2015; Rajashekhar *et al*., 2015; Misra *et al*., 2015). Due to lack of clarity, several different authors used the substituted species of *Roscoeaprocera*Wall.,*Roscoeaalpina*Royleand others but it is evident that the genuine species of *Kakoli* is *Roscoea purpurea* Smith, which can be characterized by purple colour stout stem and flowers as described in ancient literatures of *Shaligram* and *Bhav Prakash Nighantus* and also indicated by Balkrishna *et al*. (2012). Although, due to its rare nature, the Ministry of Ayush has now permitted to replace it with other available sourceslike*Aswagandhâ*(*Withaniasomnifera*(L.) Dunal) and *Krsna-mûsalî* (*Curculigo orchioides* Gaertn) but the real nature of the plant should be conserved,for whichits conservationand cultivation is mandatary (Virk *et al*., 2017).

Further, in order to correctly characterize the trueidentityofspecies,somecompoundshavebeen isolated and purified from different plant parts to be usedas chemicalmarkers. Kaur *etal*., (2020a) has reported the presence of a compound, named Sitostanol caffeate in the roots of plant, which can be used as chemo-marker. Several other studies reported the presence of flavonoids, steroids, terpenoids, alkaloids and phenolic acids. Rhizomes of *R. purpurea* are reported to possess significant antidiabetic and hypolipidemic activity. In other studies, immunomodulatory, spermopiotic, and anti-tubercular potency have been revealed (Bairwa *et al*., 2012; Subramoniam *et al*., 2013; Kumar, 2014). Traditionally, roots (rhizomes), leaves, and flowers are used in the treatment of diabetes, diarrhoea, high blood pressure, hyperthermia, haematemesis, polydipsia, rheumatic pain and inflammation etc. Immuno-stimulating properties of rhizomes, extracted in ethanolic extract have also been demonstrated (Handa, 1980; Singh and Rawat, 2011; Gopal *et al*., 2014). The rhizomes and tubers are essential ingredients of number of herbal formulations prepared like tonic and Chyawanprash (Handa, 1980; Singh and Rawat, 2011; Kaur *et al*., 2020a). In Nepal, boiled tubers of the plant are eaten and traditionally used in veterinary medicines (Handa, 1980; Singh and Rawat, 2011). So, with an objective to present a comprehensive and upgraded review of this highly valuable Ayurvedic species, this study has been drafted to include traditional uses, major phytochemicals and biological studies conducted till now. The present review summarizes the updated information regarding the chemical constituents, pharmacological study, medicinal uses and ayurvedic significance along with its various formulations as well as also mentioned the different ways to conserve and cultivate it which is a pressing need.

Botanical description

Kakoli is a stout perennial herb, 25-38 cm tall. Leaves are 4-8, elliptic, lance-shaped to oblong-ovate, 14-20 cm long, sometimes sickle-shaped, tip tapering and slightly eared at a base on lower leaves, side veins parallel; leaf eared fringed with hairs. Flowers are borne in a cluster at the top, the cluster stalks are enclosed by upper leaf sheaths, only the upper part of bracts and flowers visible. Typical structured flowers are slightly purple, mauve, lilac, pink or white with purple markings where only one or two flowers open at a time. Outer calyx is tubular-shaped, three petals arising from the calyx form a slightly longer tube than the calyx and terminates with trilobular structure raised vertically having one hooded central lobe surrounded by two slightly smaller side lobes. Staminodes, constituting four sterile stamens, are formed inside the petals where the two lateral staminodes appeared as small straight petals and the other two central ones got partially fused at the base and forms a lip. Lip is non-deflexed, 4.5-6.5×2-5 cm (Flowers of India).

Geographical distribution

As a native species of Nepal, *R. purpurea* is distributed and scattered in India and Bhutan also, where it prefers to grow along green hillsides, alpine grassland, stony ridges and slopes of Central to Eastern Himalaya extending from Uttarakhand to Assam and Sikkim, upto an elevation of 3300 m (Dhyani *et al*., 2010; Gopal *et al*., 2014).

Ayurvedic properties and formulations of *Kâkoli*

Kâkolî is one of the most profligate plants of the nature. It is grouped among *Ashtawarga* plants, *Jîvanîya*, *Sukrajanana* and *Bramhaniyagana* in different ayurvedic scriptures (Mishra, 2020). The plant is sweet in taste, heavy and mucilaginous in attribute and cold in potency. In Ayurveda, it is considered *Vatapitta samaka*, *slesmataka*; *roghanatâ* and is a part of different Ayurvedic preparations namely, *Chyavanprashrasayan* (a class of rejuvenating tonics), *Mahakalyan* and *Jivaniyaghrita* (Herbal medicines with *ghee* as a base), *Vachadi* and *Chitrakadi* taila (herbal oil, having properties to treat enlarged lymph nodes, fistula and sinus), *Vrahinigutika* (useful against erectile dysfunction) and *Astawarga* and *Jivaniya* gunachurna (Marde and Mishra, 2019).

Phytoconstituents of *Roscoea purpurea*

Several bioactive compounds from different chemical categories such as diterpenoids, flavonoids, and phenolic acids have been reported from *R. purpurea* till now (Table 1). Sitostanol caffeate, a compound claimed to lower the risk of coronary heart diseases has been isolated from the roots by Kaur *et al*., (2020a), which can be further utilized as a marker to identify and differentiate the species from its homotypes. In Nepal, the boiled tubers are eaten and used in veterinary medicine. A research conducted by Misra *et al*., (2015) have provedthenutraceuticalvalueofthesetubersand showed that they are highly rich in fibre (28%), proteins(3.5%)andoil(3.5%).Totalphenolicand flavonoidcontentwerefoundtoberangedbetween 7.10 to6.10 %,respectively.Phytochemicalscreeningofthepowderedtubersshowedthe presence of alkaloids, carbohydrates, flavonoids, glycosides,phenolics,proteins,saponins,and tannins(Misra*etal*.,2015,DevkotaandTimalsina, 2021).Thenutritionalcomponentsoftherhizomes constitutefiber,oil,protein,sugar,andstarch (Owolabi *et al*., 2012; Misra *et al*., 2015). Rawat *et al*. (2014) reported the presence of riboflavin, thiamine,minerals,fatandfibersinrhizomes.The methanolextracthavingblackish-brown compositiondisplayedthepresenceoftwo compoundsbelongingtocatechin-typeofclasssuch asepigallocatechinandepicatechinalongwith othercompoundsintheroots(Kaur*etal*.,2020a). Singamaneni*etal*.(2021)reportedtwonew compoundscoronarinKandLfromtheclass labdanediterpenesalongwithotherknown compoundsascoronarinA,kaempferol3-O-methyl ether, kaempferol, fenozan acid, 3-(3-methoxy,4-hydroxyphenyl)-2-propenoicacidferulicacid, caffeicacid,bisdemethoxycurcuminandgallicacid from its rhizomes. Coronarin Kdemonstrated to haveanti-cancerpotencywhenevaluatedagainst lungcancercellline(A-549).

Miyazaki *et al*., (2014) isolated flavonoids as kaempferide, kaempferide3-O-β-D-glucuronopyranoside,kaempferol3-O-β-D-glucuronopyranoside and (Z)-3-hexen-l-ol-β-D-glucopyranoside from aerial parts and kaempferide, kaempferol 3-O-methyl ether from the rhizomes of *R. purpurea*. Kaur *et al.* (2020b) reported the triterpenoid, lupenone for the first time from*Kakoli* roots. Similarly, stigmasterol was also obtained frompowderedleavesof*R.purpurea*byBaraiand Bag (2019) which is known to possess various pharmacologicalactivities includinganti-osteoarthritic,antioxidant,anti-inflammatory,anti-mutagenic, hypoglycemic, anti-genotoxicity and anticancerous(Kaur*etal*.,2011;Ali*etal*.,2015). They have alsoreportedthe presenceof monoterpenoids in ethanolic extract of leaves by GC-MS study.

Medicinaluses

Roscoea pupurea is an important species contributingto the Ayurvedicmembersof *Ashtawarga*plants,consideredasprime*rasayana* group possessing health rejuvenating properties. Due to its anti-oxidant, anti-anging and cell regenerativeproperties,itisanessentialingredient of several poly herbal formulations, specially '*Chayawanprash*', which is widely used in India as an energy and immunity booster supplement (Misra*etal*.,2015;Raval*etal*.,2015).Itsregular use also enhances the intellect, long life and memory (Tripathi, 2013).Traditionally, its roots and otherpartsintheformofvariouspreparationsare usedmedicinally(Table2).Rootsandrhizomesare consideredasgoodappetizer,aphrodisiac,andtonic (Miyazaki *et al*., 2014).Therapeutically, they are reportedtobeanti-rheumatic,diuretic,expectorant, febrifuge,galactagogue,haemostaticand *Sukrajanana* (semen count enhancer) in nature (Balkrishna*etal.*,2012;SharmaandSharma2008). InAyurveda, it roots are considered beneficial in *Vishamajvara* (high fever), *Pittaroga*, *Raktapitta* (Bleeding disorders), *Netraroga* (Eye disorders), *Hridayaroga* (Heart disorders), *Daha* (Burning sensation)and*Swasaroga*(Respiratorydisorders) (AyurvedicPharmacoepiaof India,2001). AccordingtoSaheli*etal*.(2019),theplantisknown topossessanti-diabeticandhypoglycemiceffects. Thevariousmedicinalpropertiesoftheplantalong with its parts have been summarized (Fig. 2).

Anti-oxidantactivity

Tubers and rhizomes of *R. purpurea* are commonlyusedfor variousAyurvedic formulations,sosomeoftheresearchershavetried to summarize pharmacological aspects of these parts. The methanolic extract derived from the tubers of *R. purpurea* was tested for anti-oxidant activitybyusingferricreducingpower,DPPHand αcarotenelinoleateassays.Theextracthasshown toupregulatethereducingpowerwithanincrease in concentration, similar to positive control (ascorbicacid,quercetin,rutinandBHT).InDPPH and carotene bleaching assay, the extract showed IC_{50}810.66±1.154&600.66±1.154μg/ml,which canbejustifiedbythepresenceofpolyphenolic content of the tubers which are well validated for theirpotentbioactivities(Misra,*etal*.,2015).Ina similar study, the ethanolic extract and its petroleum ether,chloroform,acetone,ethanolicandaqueous fractionspreparedfromtubersof*R.purpurea*were evaluatedforanti-oxidantactivitybyusingDPPH assay.Theextractandpetroleumether,chloroform, acetone,ethanolicandaqueousfractionsexhibited anti-oxidant effects with IC_{50} of 0.925±0.005, 1.25±0.005,0.25±0.005,0.48±0.005,0.77±0.011 & 1.04±0.005 mg/ml, respectively (Srivastava *et al*., 2015).

Anti-canceractivity

AccordingtoWHO,canceristheleadingsource of death globally with a record 10 million deaths in2020.Lungcancerandbreastcancerareamong themostcommoncancersandthesearchforplant bioactives as anticancerous aid is progressing. In hisresearchstudy,Singamaneni,*etal*.(2021)has evaluated the potential of methanolic extract, its chloroformfractionandcompounds,coronarinK and L, firstly isolated from rhizomes of*R. purpurea*, alongwithotherknowncompounds;coronarinA, bisdemethoxycurcumin and kaempferol 3-O-methylforanti-canceractivityagainsthumanlung (A549), colon (HCT-116), breast (MCF-7) and pancreas(Bxpc-3)cancercelllinesbyusingMTT assay. Paclitaxel was used as standard (IC_{50}6.2±0.20,8.6±0.045.46±0.74&3.81±0.32μM, respectivelyforA549,HCT-116,Bxpc-3&MCF- 7 cells). It was found that extracts and fraction exhibitedanti-cancereffectsagainstalltestedcell lineswithIC_{50}21.35±0.83to>100μMwhen comparedwithpaclitaxel.Moreover,coronarinK showed potent anti-cancer effect against A549, HCT-116, Bxpc-3 &MCF-7 cells with IC_{50}13.49±0.62,26.03±1.46,56.70±2.17&56.24±0.83 μM,respectivelywhencomparedwithpaclitaxel. Furthermore,coronarin LandcoronarinAdisplayed anti-cancereffectsagainstA549cellswithIC_{50} 33.78±1.37&61.80±2.82μM,respectivelywhile coronarinLagainstMCF-7cellswithIC_{50} 49.84±2.61μMwhencomparedwithpaclitaxel. Additionally, coronarinL, coronarinA and bisdemethoxycurcumin showed effects against Bxpc-3cellswith IC_{50}56.83±1.92, 22.83±1.47& 68.15±2.41μM,respectivelywhencomparedwith paclitaxel.Theseresultsrevealedthat*R.purpurea* possessed prominentanti-cancereffects. (Singamaneni*etal*.,2021).Inapreviousstudy,the ethanolicextractanditspetroleumether, chloroform,acetone, ethanolic and aqueous fractionsfromrhizomesof*R.purpurea*werealso evaluatedforanti-cancerpotentialagainsthuman lung carcinoma (A549), cervical cancer (SiHa), chinese hamster ovary cells (CHOK1) and rat glioma (C6) cell lines using SRB assay where vinblastinewasestablishedascontrol.Itisnoticed that the extract and fractions exhibited cytotoxic effectagainstallcelllineswithIC_{50}<10to>150 μg/ml(Srivastava*etal*., 2015).

Immunomodulatoryactivity

The ethanolic extract (300 & 600 mg/kg, p.o.) from the rhizomes was investigated for immunomodulatoryactivitybyanalyzingdelayed typehypersensitivity(DTH)responseand macrophagephagocytosisusingcarbonclearance assayinSwissAlbinomice.Cyclophosphamide(30 mg/kg) utilized as standard. It was observed that, the extract at both doses significantly ($p<0.05$) increased the foot pad thickness, WBC and total plateletcountofanti-genically(SRBCssuspension) challenged mice when compared with control group.Moreover,extractatbothdosessignificantly ($p<0.05$) increased the phagocytic index using carbon clearance method when compared with controlgroup.Therefore,theseresultsjustifiedthat theextractpossessedimmunostimulantproperties (Sahu *et al*., 2010).

Whydoweneedtoconserve*Roscoeapurpurea* (Kakoli)?

India has ample resource of medicinal plants comprises of 8,000 diverse species. In the 21st century, there is a remarkably focus among individualson healthand environmental preservation, resulting in a significant increase in theutilizationofmedicinalplants.Thesubstantial amountofrawmaterialisderivedfromforestarea. Therefore,theforestareahasbeenexacerbatedby the pharmaceutical and associated industries. Consequently,myriadnumberofplantshavebeen threatenedandsomeofthemhavebeenentailedin RedDataBook.*Roscoeapurpurea*(Kakoli)isalso among one of them, which is needed to be conserved and cultivated due to its excessive utilization(KumarandJnanesha,2016;Virk*etal*., 2017).

Thereare two mainstrategiesfor the conservation:*insitu*and*exsitu*conservation.*In-*

Table1: Chemicalconstituents of *Roscoeapurpurea* indifferent plant parts

ChemicalConstituents	Plant Parts	Extract	References
1. Phenoliccompounds			
Protocatechuicacid	Tubers	Methanol/Ethanol	(Mishra *etal*., 2015; Srivastava*etal*.,2015)
Ferulic acid	Tubers	Methanol/ Ethanol	(Mishra *et al*., 2015; Srivastava*etal*.,2015)
Syringic acid	Tubers	Methanol/Ethanol	(Mishra *et al*., 2015; Srivastava*etal*.,2015)
Apigenin	Tubers	Ethanol	(Srivastava*etal*.,2015)
Vanillicacid	Tubers	Methanol	(Mishra*etal*., 2015)
Gallicacid	Rhizomes	Methanol-Chloroformfraction	(Singamaneni *etal*.,2021)
Caffeic acid	Rhizomes	Methanol-Chloroformfraction	(Singamaneni*etal*.,2021)
Ellagicacid	Rhizomes	Methanol-Chloroformfraction	(Giri*etal*., 2017)
Ferulic acid	Rhizomes	Methanol-Chloroform fraction	(Singamaneni*et al*., 2021)
Fenozan acid	Rhizomes	Methanol-Chloroform fraction	(Singamaneni*et al*., 2021)
3-(3-methoxy,4-hydroxyphenyl)-2-propenoicacidferulicacid	Rhizomes	Methanol-Chloroformfraction	(Singamaneni*etal*.,2021)
2. Flavonoids	Aerial parts/	Methanol	(Miyazaki*etal*.,2014)
Kaempferide	Rhizomes		
Kaempferol	Rhizomes/ Tubers	Methanol	(Singamaneni*etal*.,2021; Mishra *et al*., 2015)
Kaempferide 3-O-â-D-glucuronopyranoside	Aerial parts	Methanol	(Miyazaki*etal*.,2014)
Kaempferol 3-O-â-D-glucuronopyranoside	Aerial parts	Methanol	(Miyazaki*etal*.,2014)
Kaempferol 3-O-methyl ether	Rhizomes	Methanol	(Miyazaki *et al*., 2014; Singamaneni *etal*.,2021)
Quercetin	Rhizomes	Methanol	(Misra*etal*.,2015,Devkota and Timalsina, 2021)
Epicatechin	Roots	Methanol	(Kaur*etal*.,2020a)
Epigallocatechin	Roots	Methanol	(Kaur*etal*.,2020a)
Rutin	Rhizomes/ Tubers	Ethanol	(Giri *et al*., 2017; Srivastava*etal*.,2015)
6-methylpinocembrin	Tubers	Ethanol	(Chaudhari,1988)
3. Curcuminoid			
Bisdemethoxycurcumin	Rhizomes	Methanol-Chloroformfraction	(Singamaneni*etal*.,2021)
4. Terpenoids			
CoronarinA(Labdanediterpenes)	Rhizomes	Methanol-Chloroform fraction	(Singamaneni*etal*.,2021)
Coronarin K	Rhizomes	Methanol-Chloroform fraction	(Singamaneni *et al*., 2021)
Coronarin L	Rhizomes	Methanol-Chloroform fraction	(Singamaneni *et al*., 2021)
Sterols			
Stigmasterol	Leaves	Ethyl acetate	(BaraiandBag,2019)
Beta-sitosterol	Tubers	Ethanol	(Chaudhari,1988)
Beta-sitosterol-beta-D-glucoside	Tubers	Ethanol	(Chaudhari,,1988)
Triterpenoids			
Lupenone	Roots	Methanol	(Kaur*etal*.,2020b)
Ursolic acid	Tubers	Ethanol	(Chaudhari,1988)
5. Miscellaneous			
Adenosine	Rhizomes	Methanol	(Miyazaki *etal*.,2014)
(Z)-3-hexen-l-ol-â-D-glucopyranoside	Aerial parts	Methanol	(Miyazaki *etal*.,2014)
n-hentriacontane	Tubers	Ethanol	(Chaudhari,1988)

Table2: Medicinaluses and formulationsof*Roscoeapurpurea*

TraditionalUses	**Preparation/Ayurvedicformulations**	**References**
Abdominaldisorders	Wholeplant*:*Processedwith*Vacâdi*oiland otherherbsisusedasan*anuvâsanavasti*to treat distension, dyspepsia and *gulma*.	(Rao,2011)
Cardio-vascular disorders Cardiacdiseases Chest injury	Roots: Powder with other herbs as *Crepidium acuminatum*, *Malaxis muscifera*, *Pueraria tuberosa*, *Crepidium acuminatum*, *Malaxismuscifera*,*Polygonatumverticillatum*, *Pueraria tuberosa*, *Medâ*, *Mahâmedâ* mixed with honey. *Nâgabalâsarpi* processed with *Roscoea purpurea* and other herbs are usefulin chest injury	(Balkrishna,2014)
Cutsand wounds	Leavesand roots: Dried powder	(Pande,Tiwari,and Pande, 2006;Bisht,2017).
Diabetes	Leaves, roots, rhizomes and flowers: Infusion/ Singamaneni,2021;Seth	(Misra *et al*., 2015;paste. and Kondal, 2020).
Diarrheaanddysentry	Leaves,roots,rhizomesandflowers:Infusion/ Decoction.	(Seth and Kondal, 2020; Misra*et al*.,2015; Singamaneni,*etal*.,2021)
Gout	Wholeplant:Decoctionwith*Prunuscerasoides*, *Glycyrrhizaglabra*,*Curcumalonga*, *Vetiveria zizanioides*, *Rubia cordifolia*, *Liliumpolyphyllum*,ispreparedasapaste, processedwithoilandmadeintoa*taila*known as *Khuâkapadmataila*, useful in treating gout and burning sensation.	(Tripathiand Pandey, 2012)
Hemorrhage	Roots: Powder helps to treat bleeding disorders. Whole plant: Powder processed with *Nâgabalâsarpi*andotherherbsareusefulin intrinsic haemorrhage.	(Balkrishna,2014)
Paediatric diseases	Wholeplant:powder,processedwith*Ghrta* (clarified butter) and *Cedrus deodara*,*Liliumpolyphyllum*,*Crepidiumacum inatum*, *Malaxis muscifera*, *Vigna trilobata*and *Teramnus labialis* is useful in appropriate doses in case of emaciation in children.	(Balkrishna,2014)
Respiratory disorders	Tubers:Paste.	(Swar,2014)
Cold and cough	Whole Plant: Powder with other herbs andhoney**.**	(Balkrishna,2014)
Bronchitis and asthma	Rhizome: Powder mixed with orange rind powder	(Balkrishna, 2014)
Reproductive disorders Impotency	Roots and Rhizomes: Decoction	(Kaur *et al*., 2017; SethandKondal,2020)
Sinusitis	Wholeplant:Powderprocessedwith *Ghrta*andherbsas*Glycyrrhiza-glabra*,*Curcumalonga*,*Polygonatumverticillatum*, *Nelumbo nucifera*, used as *parishechana* (irrigativetherapy)in*pittaja*associatederysipelas and sinus.	(Rao,2011).
Skin disorders	Roots: powder, mixed with black pepper and rat dropping, applied to boils.	(Singh,2009;Quattrocchi, 2012).
Tuberculosis	Wholeplant:Powderprocessedwith *Nâgabalâsarpi* and other herbs.Bulbs are used to treat phthisis.	(Balkrishna,2014;Saroya, 2013).
Urinarydisorders	Roots:Extractasatonic;ingestedtotreat urinaryinfectionandpolyuria	(Misra*et al*., 2015; Miyazaki*et al*.,2014)

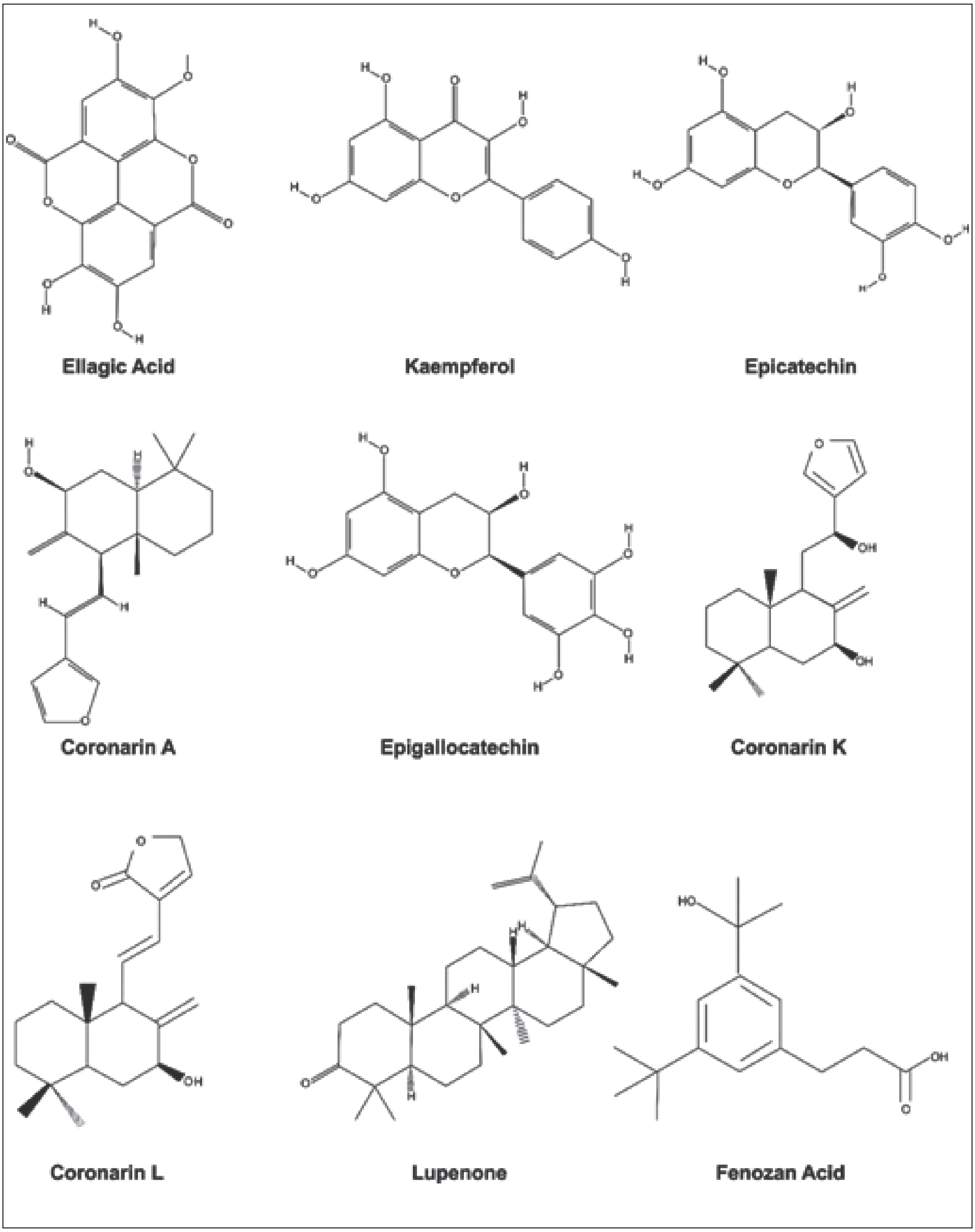

Fig.1:Chemicalstructuresof *R.purpurea*compounds

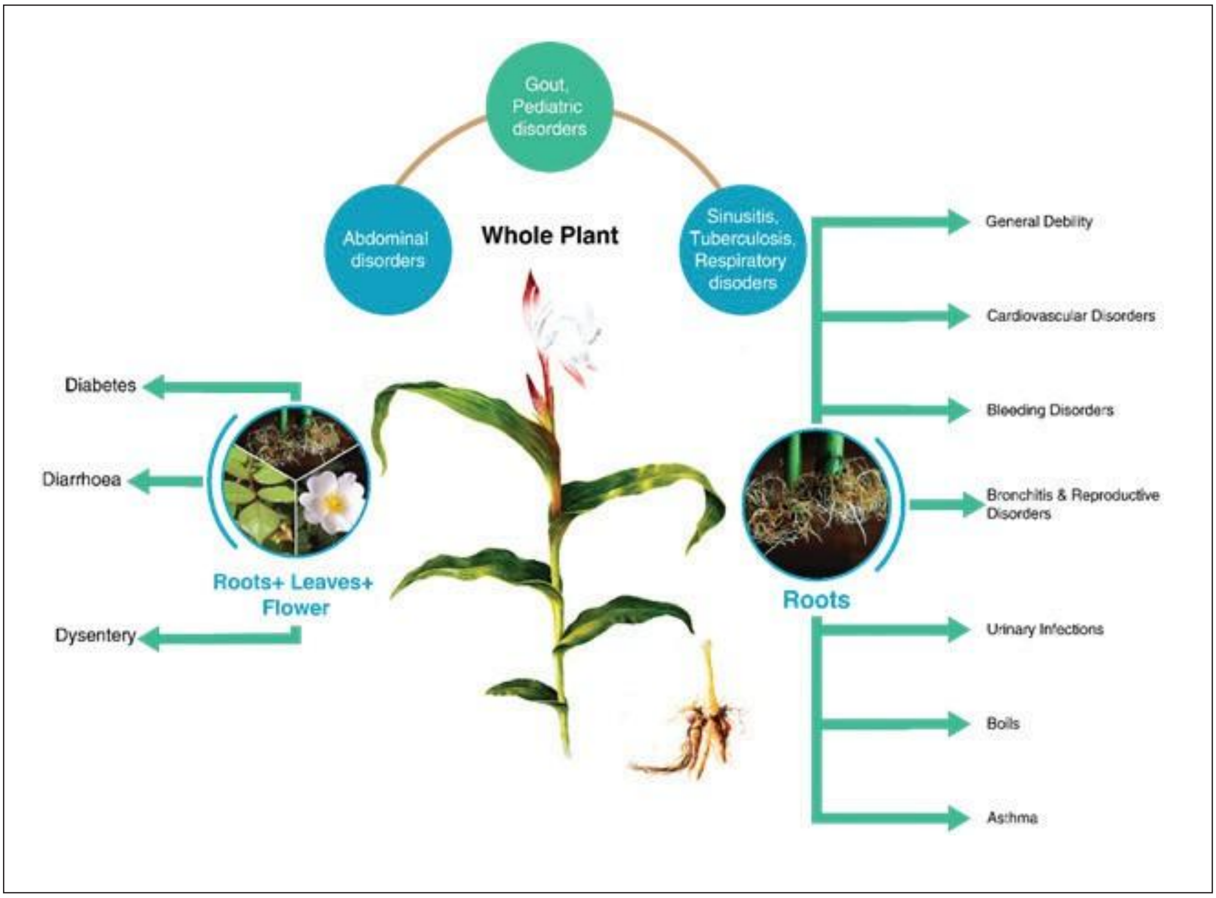

Fig.2 :Medicinal Properties ofKakoli (*R.purpurea*).

situ strategy of conservation focuses on the "on-site conservation" of the wild genetic diversity in natural environment**.** It is a methodological techniquethatentailstoconservesuchendangered plantspecieswithindispensabletherapeuticvalue (Chandra, 2016).The involvement of community istopreserveboththreatenedplantspeciesaswell astheirnaturalcommunities.Thisprocedureadopts an eco-centric strategy for conservation, where preservingendangeredplantspeciesisprioritized whileminimizinghumanintervention(Akshay*et al*.,2014).Therearetwoessentialsegmentofthis technique,firstly,istoexploreforthegeographical location of these plant species based on their therapeuticpropertiesand industrialvalue. Secondly, to monitor, manage, and preserve such plant species by forming a network and zone of forest habitat of a specified size that must be established(Dhama*etal*.,2018).Inadditiontothis, thesignificantaspectofthismethodistoinvestigate andsurveyofsuchplantafteraregularinterval of timethatmayleadstocontributebetterperception of natural biodiversity and various methods of preservation of such plants. This type of well-organisedconservationstrategycanevokerecovery of endangered plant species.

Thereareseveral*in-situ*conservationmethods for medicinal plants such as biosphere reserve, national park, sacred groves and others**.** The MinistryofEnvironmentandForest,Government ofIndiahadidentified13biospherereserveforthe conservationofmedicinalplantsindifferentstates ofIndia(KadamandPawar,2020).InWestBengal andTamilNaduhaveestablishedbiospheresnamed SunderbanandGulfofMannarrespectivelyforthe protection medicinal plant species (Chandra, 2016). InIndia,thereare91nationalparks,2outofthem namely,Pin Valley NationalPark and Great HimalayanNationalParkinHimachalPradeshhave beenestablished.Unluckily,a substantial population live in proximity to these forests (Chandra,2016).Theestablishmentofnationalpark create the involvement of local people which generate responsibility towards them to protect medicinal plant species (Huang *et al*., 2002). People who live near to forests area can help in ensuring the survival of endangered medicinal plant species only if they are made aware of conservation methods.

Sacred groves are said to be small or substantial areas of vegetation that are protected on the basis of tradition and religious beliefs. In India there are 13,720 small scale sacred groves through which medicinal plant species is protected (Murtem and Chaudhry, 2014). Manipur is the state reported over 365 sacred groves. These groves persists significant ecologically value because they link ritual behavior to ecology, especially in order to protect threatened plant species. Traditional agricultural methods are eco-friendly and long-lasting approach which supports to conserve the diversity of medicinal plant species (Ahmad *et al*., 2021). The native farmers who live near the forest region have gathered more knowledge about medicinal plant (Benniamin, 2011) and their expertise should be organized through appropriate documentation. We can disseminate the garden conservation for the protection of medicinal plants in small apartments, ûats, house and bungalows. For the conservation of medicinal plant species proper monitoring is needed in above mentioned protected areas. People may be driven to support conservation efforts *via* financial incentives.

Ex-situ strategy of conservation focuses on the "off-site conservation" of the wild genetic diversity in natural environment. It is a pivotal procedure for the protection of medicinal plant species that are high risk of extinction (Werden *et al*., 2020). *Ex situ* conservation objective to reintroduce the endangered species into their native habitat in order to secure their survival and periodically to produce substantial amount of planting resources used in the formation of therapeutic drugs. In recent years, the government promotes long-term plant species conservation through parks and botanical gardens. When the medicinal plant species were grown away from their natural habitat, not only they retain their high efficacy but their reproductive parts are extracted and maintained in the repository in seed banks for future regeneration (Kumar and Jnanesha, 2016). There are several *ex-situ* conservation methods for medicinal plants such as seed bank, botanical garden etc.

In India, one of the Institute named Tropical Botanical Garden and Research Institute (TBGRI) located in Kerala has taken step towards the conservation and sustainable use of medicinal plant wealth of peninsular India. The TBGRI performs major activities such as seed gene bank, *in-vitro* gene bank and field gene bank to protect medicinal plant species (Bhattacharyya *et al*., 2006). Botanical garden also plays a vital role sustaining the ecosystem to escalate the survival of rare and endangered plant species. They include a large diverse variety of plant species that share common condition. Botanical garden act as center for release, revive and rehabilitation of rare, endangered and extinct prone species of medicinal plants and other significant plant genetic resources. Apart from this, it plays significant function in education and training center sector such as horticulture, gardening, landscaping, *ex-situ* conservation and environmental awareness. A case study was done to elucidate the medicinal plant conservation through botanical garden wherein Malabar Botanic Garden of India is used to train local farmers for the cultivation and repository methods of medicinal plants moreover giving market guidance. In 2 years, they have trained more than 200 farmers, who later established a farmers' association to exchange knowledge (Hawkins, 2007). Botanical gardens have been built in several regional communities. Example: Government Botanical Gardens in Tamil Nadu, Garden of Medicinal Plants in West Bengal and many more across the country (Kadam and Pawar, 2020).

CONCLUSION

The rhizomes, tubers and other parts of *R. purpurea* are well described in various Ayurvedic texts and literatures as an analeptic, widely used for treating various health ailments in Nepal and India. Despite the wealth of historical data supporting its traditional applications, there exists a shortage of comprehensive studies validating these assertions. While existing publications have demonstrated the plant's potential as a natural antioxidant and cytostatic agent, there remains a dearth of empirically grounded literature designating it as a promising candidate for future drug discovery initiatives. The phytochemical profilingoftheplanthasrevealedthepresenceof flavonoids and phenolic acids, known for their robustbioactiveattributes.Assuch,itisadvisable toinvestigatetheindividualcompoundsandtheir synergisticeffectsto determineoptimal formulationsanddosages.Notably,compoundslike stigmasterol, due to their nanoscale dimensions, holdpromisefor advancementin nanobiotechnologyresearch.To lay the groundwork for forthcoming research endeavors, an increased number of both *in-vivo* and *in-vitro* studiesareimperative.Rigorousclinicaltrialsare essentialtosubstantiatethetherapeuticefficacyof this traditional medicine within the conventional medicalframework.Addressingtheseresearchgaps should be a focal point for future investigations, guidedbytheimperativetoconservethesevaluable botanicalresources.

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