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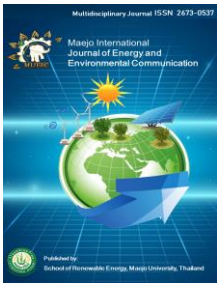

ARTICLE

Physiological and pharmacological properties of *Gentiana kurroo* Royle: Recent update and future perspective

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ABSTRACT

Gentiana kurroo Royle is an endangered bitter medicinal plant of the Indian subcontinent. This medicinal plant mainly grows in Kashmir, Himachal Pradesh, and North-west Himalayas. The medicinal plant's root and rhizome are frequently used by native people for various local remedies. This species has become critically endangered due to its endemic nature and high rate of extraction from its natural environment. In India rhizome and root of this medicinal plant are used as ant periodic, bitter tonics, anti-inflammatory, blood purifier, expectorant, antipsychotic, carminative, and stomachic. *Genitiana kurroo* can be propagated through micro-filtration of seeds, rhizome cutting, shoot-made segments, and somatic embryogenesis. The roots of *Genitiana kurroo* are rich in various ingredients such as flavonoids, alkaloids, and terpenoids which are responsible for analgesic, anticancer, and immune-modular effects. Considering these perspectives, the present review has intended to provide updated prospects of *Gentiana kurroo* and provides insights on the nutritional and various pharmacological properties based on updated research literature. This review explores the use of *Gentiana kurroo* across disciplines for its wide range of prominent-pharmacological properties.

1. Introduction

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Genitiana kurroo belongs to perennial herbs of plants. *Gentiana kurroo* Royle is a threatened bitter herb of Indian subcontinent region. It grows at an altitude of 1500-3000m in Kashmir, Himachal Pradesh, and the North-West Himalayas. It also occurs at village shaglahan of district Sirmour and karoltibba area of solan district of Himachal Pradesh provenance (Behera and Raina, 2011). It belongs to family Gentianaceae which is a flowering plant family with roughly 300 species worldwide. *Genitiana kurro* gets its common name from "Genitus," a king of Illyria (Europe) who is credited with discovering the medicinal benefits of gentian root. It is popularly known as “Karu” in hindi which means bitter, “Traayamaana” in Sanskrit, although it is known as “Neilkanth’’ in Kashmir Himalayan (Jain et al., 1968; Khare et al., 2007). It is located in dry and rocky grasslands and scrubs habitat in the south facing slopes between 1500–3000 m, also in the north-western Himalayas, where it is endemic and critically threatened (Raina et al., 2003; Khuroo et al., 2005). Over the last ten years, more than 80% of the population has decreased (Goraya et al., 2013). The plant's shoot system is made up of flowering branches with culine leaves; root structure is rhizome and adventitious root, while the stem is a modified rhizome. Flowering takes place from the last week of August to the first week of November, with the first two weeks of November being the optimal time for harvesting seeds (Raina et al., 2003). Iridoid glycosides such as gentiopicrine, gentiamarin, amaroswerin, and the alkaloid gentianine are abundant in the root and rhizome (Niiho et al., 2006). The roots contain 20% of a yellow, translucent, and brittle resin known as aucubin, aucubin, catalpol, 6-O-cinnamoyl catalpol (Sarg et al., 1991). The leaves, more than the roots, do, however, contain some of the important bitter compounds (Wani et al., 2011). Some morroniside and gentiopicroside were also discovered (Lin et al., 2008). This Species is used to treat ulcers, skin fungal infections, stomachaches, urinary infections, liver complaints, headaches, bronchial asthma, cough, leucoderma, leprosy, dyspepsia, colic flatulence, blood purifier, indigestion, gastric infections, anorexia, and high fevers in the folkloric system (Gilani et al., 2006; Sharma et al., 2006). Gentianine has anti-inflammatory, analgesic, anticonvulsant, hypotensive, antipsychotic, sedative, diuretic, antimalarial, anti-amoebic, and antibacterial effects, while amaroswerin has gastroprotective qualities (Sharma et al., 2006; Chang et al., 2002). The plant's medication is useful in eradicating all types of weakness and overtiredness in the body caused by long-term disease, as well as in the creation of stomachic tonics. This plant’s roots and rhizomes are used as antiperiodic, bitter tonics, anti-inflammatory, blood purifier, expectorant, antipsychotic, carminative. Phytochemical screening of this plant shows that the roots if *Gentiana kurroo* are rich in various ingredients such as flavonoids, alkanoids and terpenoids which are responsible for its analgesic, anticancer and immunomodulatory effects. The pharmaceutical industries are largely dependent on natural medicinal herbs, which leads to its extinction. Therefore, red data book of Indian plants has listed this species of medicinal plant as endangered species. This medicinal plant is also known as “Ram Vaan” because of its effective healing properties (Sharma et al., 2008). Figure 1 representing the G. *Kurroo Royle* collected from village Shaglahan District Sirmour, Himachal Pradesh.

Figure 1 *G. Kurroo* Royle collected from village Shaglahan District Sirmour, Himachal Pradesh.

1.1 Classification

Kingdom: Plantae
Phylum: Tracheophyta
Class: Magnoliopsida
Order: Gentianales
Family: Gentianaceae
Genus: Gentiana
Species: *Gentiana kurroo* Royle

1.2 Habitat and Distribution of G. kurroo Royle

The Gentianaceae family includes *G. kurroo* Royle (flowering plants family). This family includes about 1650 species and 90 genera of perennial and annual shrubs and herbs native to northern temprate climates worldwide (Judd et al., 1999; Struwe et al., 2002). There are over 360 different species of genus *Gentiana*. Out of the total number of *Gentiana* species, 62 species with 16 genera have been discovered in India's temperate zone (Sunita et al., 1982). The Himalayan region is home to this species, spanning the Indian subcontinent, Pakistan, and Nepal (Polunim et al., 1984). It is only found in the northwestern Himalayas, where it is endemic (Hooker et al., 1885). Himachal Pradesh, Kashmir and the northwestern Himalayan slopes between 1500 and 3000 meters above sea level and are among the most typical sites to discover this plant (Daniel et al., 2002; Raina et al., 2003; Sing et al., 200). Habitat Suitability and Distribution of *Genitiana kurroo* in Himachal Pradesh shown in Figure 2.

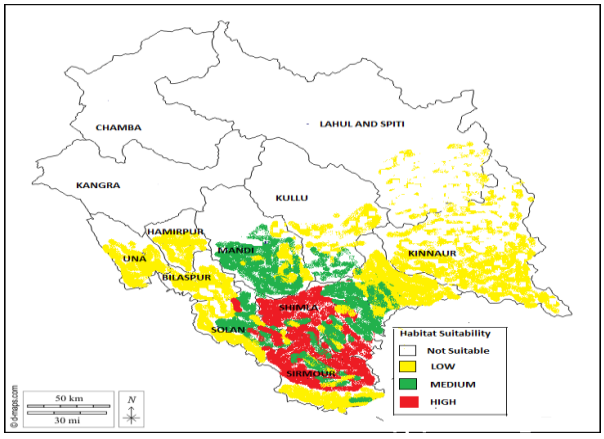

Figure 2 Habitat Suitability and Distribution of *Genitiana kurroo* in Himachal Pradesh.

In the Trans and Northwestern biogeographic provinces of the Indian Himalaya, potential habitats with high suitability thresholds were found in the lower elevations of the Shimla, Mandi, Solan, and Sirmaur districts of Himachal Pradesh. Primary field surveys, estimated potential habitats were usually found in dry grassland, pine, and oak forests of Himachal Pradesh (Goraya et al., 2013). This plant is most widespread on south facing upper slopes amid dry and stony sloppy grasslands and sparsely shrubby scrubs in Kashmir, but it has become sporadic in Himachal Pradesh's subalpine to alpine Meadows (1700–2000 m) (5,30). In a ten-year period, more than 80% of the species' population has been lost (Goraya et al., 2013; Singh and kumar, 2000). As a result, the species has been deemed severely endangered. India controls 80% of the geographical range, making the situation in India favorable. The *Gentiana* family has six genera and 55 species in the Kashmir Himalaya, a significant part of the Himalaya hotspot (Mittermeier et al., 2005). *Gentiana*, with 35 species, is a diverse genus in this province. Out of these species 31can be found at alpine or subalpine elevations (Dhar and Kachroo, 1983). *G. kurroo* Royle was classified as a new plant species based on specimens collected from the north-western Himalayas. This species of plant was initially discovered in the palgham area of Kashmir Himalaya at an elevation of 1850-2000m followed in the Kangan and Wangat areas. The plant species have been included in several floristic books dealing with Kashmir Himalaya, relying on 1943-pre collections rather than the author's own collections (Javeid et al., 1970; Sharma et al., 1998; Dar et al., 2002). Because of the massive scale, *G. kurroo* Royle, an extinct plant from Dachigam National Park, has been discovered. On a floristic mission to Dachigam National Park, it was rediscovered in November 2004. It has been documented in the Kashmir Himalaya for over sixty years. *G. kurroo* Royle has been substituted with *Gentiana decumbens, Gentiana tenella, Exacumbicolor, Picrorrhiza kurroa*, because of its high demand and restricted supply in the worldwide market (Datta et al., 1949; Nadkarni et al., 1976; Sreelatha et al., 2007). Purity and authenticity of crude pharmaceuticals can be determined by chemical and ash analysis, macroscopic, microscopic, and anatomical inspection (Trease et al., 1949; Mangal et al., 2017).

1.3 Morphology

The aerial parts of the plant consist of radical leaves which are present in the form of rosette. The leaves are basal, lanceolate and usually 10-12cm long. Flowering branches with cauline leaves depict the shoot. The funnel shaped flowers are blue and may have white spots. Usually, flowers are borne in pairs but may also be solitary. The colour of the root stock (adventitious root and rhizome) ranges from white to brown. It has arching stems that are 5-30cm long. Radical leaves are characterized by their thinness, length, and skendernes. When linked in pairs, they produce a shared sheath that is simple, sessile, simple, stipulated, whole lamina, lanceolate, sharp apex, leathery texture, and produce a shared sheath. Cauline leaves are tiny, straight, and pair together form a tube around the base of the flowering branch creating a tube around the flowering shoot at the base and have monochasial cymose kind of inflorescence. Flowers are big, bracteates, infundibuliform, pedicellate, hermaphrodite, complete, actinomorphic, pentamerous, hypogynous, and from the outside, it is deep violet blue with a corolla which is whitish under the plicae. The number of sepals is five, persistent, gamosepalous, tubular, with linier lobes of almost similar size. The odd sepal faces the mother axis. Petals have five lobed limbs, gamopetalous, and have obtuse tips. The odd petal is on the mother's side. Up until fruit maturity, sepals and petals remain persistent. The petals have five stamens that are free, epipetalous, and alternate with the petal lobes. With parietal placentation, the ovary is bicarpillary, syncarpous, unilocular, and superior. The ovules are large and anatropous. There is no difference in style. Fruit dehisces lengthwise and is a capsule. With n=13, the species is a genomic allotetraploid (Behera and Raina, 2011).

1.4 Phenology

Only flowering branches represent the shoot of this perennial herb. Stem is in the form of modified rhizome. Two types of leaves are present i.e, redical leaves at the plant’s base and cauline leaves on the flowering stalk. The colour of redical leaves is deep green and they are gradually replaced by newer leaves during the course of plant life cycle. The majority of fresh leaves emerge once the wet season has ended. The cauline leaves start off light green and fade as the inflorescence mature. In addition, with flowering plant they also shed. Flowering occurs during September- October. Large funnel shaped protandrous flowers are cross pollinated and entomophilous. Different insect vectors which are seen to visit flowers of *Gentiana kurroo* are honeybee (*Apismelifera*), bumble bee (*Bomus spp.*), lady bird beetle (*Coccinella septempunctata*). After fertilization, it takes 18-20 days for the capsule to mature (Behera and Raina, 2011).

2. Status of the plant

The roots and rhizomes of the medicinal plant are highly

extracted and are listed in the Indian pharmacy codex. This species faces a significant risk of extinction due to its limited distribution and widespread exploitation from natural habitats, as well as its lack of cultivation. This species is listed as endangered in the Indian Red Data Book, and its survival is critical (Tondon et al., 1997). This species is listed as endangered by the IUCN, and its cultivation is unknown (Mular and Walkar, 1998). As a result, the Indian government placed this species on the export blacklist with notice number. 2(RE98)1997-2002 dated April 13, 1998 (Tondon et al., 1997).

2.1 Macroscopical characters

This species is notable for dividing the older rhizome into four pieces. The rhizome breaks abnormally into four sections in the collar region after secondary growth at a distance of 2.02 + 0.435 cm. These four sections appear to combine into a single triangular or quadrangular structure. The vertically wrinkled rhizome surface and the tuft of leaf bases and flowering stems is scaly. Leaf is present on the bottom side and dorsiventral, stomata anamocytic in a transverse section of leaf and root. The stomatal index is between 24.26 and 25.78, and the palisade ratio is 5.68. The roots' xylem components are polyarch and radially oriented (Behera and Raina, 2011).

2.2 Physical constants

After cremation, the air-dried rhizome generates total ash (cream) 4.06%, acid-soluble ash 2.78%, and 8.03% sulphate ash. Calcium content is 0.28%. These macro and micro indicators can be utilized in conjunction with physical measures to determine the purity of *G.kurroo* raw materials (Behera and Raina, 2011).

3. Propagation

Genitianakurroo can be propagated through micro proliferation of seeds, rhizome cuttings, shoot node segments and somatic embryogenesis.

3.1 Propagation through seed

Flowering takes place in September and October, and capsule maturation takes 18-20 days following fertilization. The first two weeks of November are good for seed harvest. Seeds should be kept at a low temperature (below 5°C). Germination percentage decreases significantly after harvesting. More than One-year-old seeds are no longer viable and do not germinate. June is the best month for seeding and planting. 70% to 75% of seeds germinate (Raina et al., 2003). Germination begins on the sixth day after seeding and continues for up to 28 days (Tomor et al., 2011). Although the plants produce a lot of seed and the seed germinates well, seedling establishment is low (Raina et al., 2011). The reason behind this is premature anther development (Badola and Aitken, 2003). As soon as the first two leaves are formed, seedling should be potted and root system should not be disturbed (Bailey, 1929). *Genitiana kurro* needs well-drained, sandy soil rich in humus for the better growth (Tomar et al., 2011).

3.2 Propagation through rhizome cuttings

Macro breeding by rhizome cuttings is an effective method of breeding *Genitiana kurroo*. Rhizome with a diameter of 5-8cm are divided vertically into two such that each piece should be included on ground part of growing mother rhizome bud. Cuttings are processed by rooting hormones (IAA OR IBA) and it is planted in a raised bed. Among the rooting hormones, IBA is a long ago derived and provides better results (Tomar et al., 2011).

4.0 Micropropagation

4.1 Clonal propagation through shoot proliferation

Rapid clonal proliferation by auxiliary branch is a simple propagation procedure. Shoot spikes and knots mature plant segments are washed with deepol cleaning agent (about 15 minutes) and subsequent cleaning while running tap water (2 hours). Then they were surface disinfected with 0.1% $HgCl_2$ for 10 minutes and rinsed with sterile distilled water for minutes and in advance vertical transplantation into nutrient medium. MS (Murashige & Skoog) media supplemented with 6% sucrose (pH is about 5.8) is the most appropriate nutrient medium for shoot proliferation and approximately 90-100% rooting achieved (Sharma et al., 1993). The clonal plantlets for this reason produced are genetically solid and in vitro propagation of this species may be achieved on business basis indefinitely with none chance of genetic instability (Kaur et al., 2009).

4.2 Somatic embryogenesis

Seedlings, regenerating organs, callus tissue cell suspension and isolated protoplasts of *Genitiana kurroo* have high potential for shoot regeneration and somatic embryo formation (Fiuk et al., 2003). Protoplast is although is a type of plant cell, it is an embryogenesis suspension. It is best to have a high possibility of morphogenesis source (Fiuk and Rybczynski, 2007). The source of cell suspension culture, enzyme treatment, size of aggregate fraction and composition of culture medium affect the efficiency and success of regeneration of *Genitiana kurroo* by means of protoplast culture (Fiuk and Rybczynski, 2007).

5. Ethanopharmacy

Several researchers have discovered that *G. kurroo* Royle has great therapeutic qualities. The medicinal values of natural products date back to when humans first learned about natural cures for various disease. The rootstock of *G. kurroo* is highly regarded existence of the most well-known bitter substance like gentian and amaroswerin. This species of plant possesses antimalarial, anti-inflammatory, analgesic, anticonvulsant, diuretic, antiamoebic, antibacterial and amaroswerin gastroprotective (Singh et al., 2008). In the Indian system of medicine, rhizomes are rated as bitter tonics, anti-periodic, sputum,

anti-inflammatory, convergent, anti-helmintic, blood purifier, antipsychotics, anti-inflammatory drugs, soothing, antibacterial (Susawaengsup, et al., 2022). It's also medicated for healing skin diseases, vitiligo, leprosy, bronchial asthma, indigestion, anorexia, Helminthosis, inflammations, dysmenorrhea, painful dysuria, hemorrhoids, constipation and urinary tract infection (Chopra et al., 1956; Warrier et al., 1995). It is an important component of many stomachs' tonics preparation, because of its similar characteristics with *Genitiana lutea*, the root stock is many times substituted (Dutt, 1928; Dey et al., 1896). In folk lore medication, oil is mixed with Neilkanthi leaf powder and is used to apply on ulcer and fungal infection. Its roots used for stomach pain and urinary tract infectious diseases (Gilani et al., 2006). The decoction made from roots with ginger root powder used to treat high fever. Tea from the roots and bark of cinnamon are used as tonics. The whole plant is used against fever, cough, headache, liver disease, and as blood purifier by Amchi (traditional doctors) of Lahul & spiti (Sharma et al., 2006). The drug is very helpful in getting rid of every type of physical weakness and fatique from prolonged illness, improves the digestive system Anorexia. To prepare feed for fattening horses root is used as an ingredient (Quereshi et al., 2007). With Unani system of medicine, flower spikes (Gule-Ghafis) are traditionally used in the treatment of inflammation, pain, fever, hepatitis. From the ethnomedicinal properties, the analgesic activity of roots (methanolic extract) and anti-inflammatory activity of flower tips of *Gentiana kurroo* is scientifically validated (Latif et al., 2006).

5.1 Uses in Iranian traditional medicines

According to Iranian traditional medicine sources, distinct Gentian species have varied therapeutic characteristics that are linked to the plant's root. The main and common properties across the texts include the treatment of urine retention, menstruation, liver, and spleen dysfunctions, and the detoxification of animal poison (Momen et al., 2008). Drinking a Gentian extract made by macerating grinded root in water helped with inflammation and swelling of the liver, spleen, and stomach, as well as muscle weakness and sprains, and amenorrhea and urinary retention. The root plaster with vinegar was useful for harmful animal bites, such as scorpion and pit viper attacks, as well as for mending injuries and inflammations. It was also used to cure vitiligo and infected wounds. The 4.64 grams of Gentian root, pepper, and Ruta graveolens was used as a poisonous animal venom antidote. *Gentiana* is said to be one of the most effective scorpion antidotes for Snake and pit viper bites or drinking poisons unintentionally. The Tela of *Gentiana* root is used to stop menstruation rather than bleeding and the leaf of *Lawsonia inermis* on the palm was beneficial, but the Lotokh of the root was traditionally used to treat conjunctivitis. Using the Homul of the root and drinking the smashed root with honey and lukewarm water caused abortion.

Table 1 The main uses of *Gentiana* in Iranian Traditional Medicine

Organ system	Disease	Part	Dosage	Preparation
Stomach	Pain and swelling	Root	4.64g	Macerated *Gentiana* root in water
Liver and Spleen	Inflammation and swelling	Root	4.64g	Macerated *Gentiana* root in water
Nerve-Muscle	Muscle Weakness and Sprains	Root	6.68g	Macerated *Gentiana* root in water
Skin	Vitiligo, Injuries, Infected wounds	Root	6.68g	Plaster of root with vinegar
Reproductive	Abortion	Root	2.23g	Squashed root with honey and lukewarm water and the root's suppository
Reproductive	Menstruation over bleeding	Root	6.68g	Grinded root and *Lowsonia inermis* leaf macerated in water
Eye	conjunctivitis	Root	6.68g	Grinded root and *Lawsonia inermis* leaf macerated in water

In Iranian Traditional medicine *Gentiana was* used for various purposes as explained in above Table 1. The dosage of the *Genitiana* was used according to different organs and disease. Only root part was used to cure disease of all the organs. The dosage and preparation are varied according to different organ system and disease. For Stomach pain and swelling, amount of *Genitiana* root powder used was 4.64g and preparation is done by Macerated Gentiana root in water. For Liver and Spleen, amount of *Genitiana* root powder used was 4.64g and preparation is done by Macerated *Gentina* root in water against inflammation and Swelling. For Nerve-Muscle Weakness and Sprains, the amount of root powder used was 6.68g and preparation is done by macerated *Gentiana* root in water (Momen et al., 2008). For Skin vitiligo, injuries, infected wounds 6.68 *Genitiana* root powder was used, and preparation is done by plaster of root with vinegar. In Reproductive system for abortion 2.23g of root powder was used and preparation is done by Squashed root with honey and lukewarm water and the root's suppository and to stop menstruation over bleeding and preparation is done by grinded root and *Lowsonia inermis* leaf macerated in water. For Eye against Conjunctivitis 6.68g of *Genitiana* root powder was used and preparation is done by Grinded root and *Lawsonia inermis* leaf macerated in water.

5.2 Phytochemistry

The Gentianaceae family has taxonomically useful chemicals and pharmacological activities. Iridoids, xanthones, C-glucoxanthonemangiferin, and C-glucoflavones are among the chemicals identified. Iridoids (mainly secoiridoid glucosides) seems to be present in the whole species examined (Rodriguez et al., 1998), although 127 species have reported, 90 distinct iridoids compounds in 24 different genera. Although xanthones are not extensively distributed in Gentianaceae, but roughly 100 distinct components have been identified in 121 species across 21 genera. The C-glucoxanthonemangiferin has a smaller range than iridoids and typical xanthones, despite having been found in 42 species across seven genera. Similarly, C-glucoflavones are substantially less varied than iridoids and xanthones, with only nine distinct compounds described from 78 species in the bube genera (Jensen and Schripsema, 2002). The family contains the most bitter chemicals; one, Amarogentin (Chirantin), a glycoside, tastes bitter even at a dilution of 1:58,000,000 and is utilized as a scientific basis for determining bitterness (Ishimaru et al., 1990; Arino et al., 1997; Jiang et al., 2005; Vanhaelen et al., 1983). Bitter items have long been used as traditional treatments for fever and loss of appetite, and many "tonic" medications still contain them (Hostettmann et al., 1981; Inouye and Nakamura, 1971). Few of the best-known bitter glycosides like Amaroswerin, Gentiopicrine, Gentianine (alkaloid), Gentianamarin, are present in the roots an

Table 2 Phytoconstituents and Uses of different part of *Genitiana kurroo* Royle.

Plant Part	Uses	Phytoconstituents	References
Flower Tops	Flower tops (Gule-Ghafis) has been traditionally used for the treatment of inflammation, pain, fever, hepatitis in unani System of Medicine. Anti-inflammatory Property of *Gentiana Kurroo* Royle flower tops extracts is Scientifically Validated.	Alkaloids, Free phenols Sterols Glycosides Flavonoids	(Chang et al., 2002; Latif et al., 2006; Ibn-e-Sina et al.,1906)
Leaves	In folk lore medication Neilkanthi leaf powder mixed with oil is applied on ulcer and fungal infection.	Pentanol Hexanal 7-Oxabicylo (4,1,0)-Heptanes 2-Methyl Sulphide 3-Methyl Butanol Methanedriol 1,3-propanedriol A-Terpinyl Acetate Dimethyl sulfide Iridoid glycoside Volatile aroma compounds	(Wani et al., 2011; Inouye et al 1971; Kumar et al., 2003) .
Root and Rhizome	The root stock of *G. kurroo* is valued for the presence of the most known bitter compounds like gentianine &amaroswerin. Gentianine possesses anti-inflammatory, analgesic, anticonvulsant, hypotensive, antipsychotic, sedative, diuretic, antimalarial, antiamoebic and antibacterial properties and amaroswerin gastroprotective. Root stock is valued as bitter tonic, antiperiodic, expectorant, antibilious, astringent, stomachic, anthelmintic, blood purifier and carminative, antipsychotic, anti-inflammatory, sedative, anti-bacterial. It is also medicated for curing skin diseases, leucoderma, leprosy, bronchial asthma, dyspepsia, flatulence, colic, anorexia, helminthiosis, inflammations, amenorrhea, dysmenorrheal, strangury, hemorrhoids, constipation and urinary infections. It is an important ingredient of many tonics for stomachic preparation. Rhizome is mainly used for improving appetite, to dissolve stones in stomach, to treat diabetes, stomachache, renal troubles and as an ingredient in many tonic and stomachic preparation.	Carbohydrate Genianic acid Pectin Terpenes Flavonoids Phenolics Saponins Glycosides	(Wani et al., 2011; Baba and malik, 2014; Mubashir et al 2014; Sarg et al 1991; Tung et al., 2008; Yin et al., 2008; Rodriguez et al., 1998; Singh et al., 2008)

rhizome of this herb (Singh et al., 2008). Photochemical screening of *G. kurroo* Royle revealed some essential botanical components, such as a quantitative estimation (%) of the chemical composition of the flower tip of *G. kurroo* Royle and the proportion of flavonoids, the total content of phenol and flavonoid are shown in the Table 2. In addition to flavonoid and phenolic content, the root extract contains additional compounds. The iridoid glycosidesamaroswerin, gentiamarin, gentiopicrine, and the alkaloid gentianine come from the roots and rhizomes (Niiho et al., 2006; Singh et al., 2008; Sarg et al., 1991). Dried roots include 20% of yellow, transparent and brittle resin (Sarg et al., 1991), catalpas, 6-o-vanillol catalpol, 6-o-cinnamoyl catalpol and aucubin (Sarg et al., 1990, 1991). The leaves, on the other hand, contain a number of essential bitter compounds (Wani et al., 2011). Much more than roots the leaves also contain the iridoid glycoside2'-(2,3 dihydroxybenzoyloxy) 7 ketologanin (Inouye et al., 1971) and about 16 volatile aromatic compounds (Ghazanfar et al., 2017). Dimethyl sulphide (14.7%), 2-ethylfuran (17.5%), 1,8 cincor (7.8%), atrepinyl acetate (23.5%), and methanedriol (12.6%) are the major constituents leaf extracts of *Genitiana kurroo* Royle.1,3-Propanediol (2.1%), 2-methyl sulfide(2.1%), 3-methyl butanol (4.4%), Pentanal (3.2%), hexanal (2.7%), and 7-oxabicyclo(4,1,0)-heptane (2.0%)(Sajjad et al., 2019) are the components with lowest percentage. Morroniside and gentiopicroside are other isolated components (Lin et al., 2008).

5.3 Antibacterial Activity

The extracts of *Gentiana kurroo* were found to have antibacterial and antioxidant action, as they suppressed the growth of both Gram negative and Gram-positive bacteria. *G. kurroo* root and leaf extracts have stronger antibacterial activity for gram positive bacteria and lower antibacterial activity for gram negative bacteria. Because of the flavonoids high concentration, which have been linked to the suppresion of metabolic processes and nucleic acid formation, antibacterial activity could be attributable to a variety of factors (Cushnie and Lamb, 2005; Siler et al., 2010; Orak et al., 2011). However, it is not discovered yet by any study that which particular bioactive molecule exactly are responsible for regulating the bacterial growth ,but it did demonstrate that *G. kurroo* can be a good source for broad spectrum antimicrobial agents and could be used as food preservatives and also can be used as a preservative in non-food items; therefore, to isolate bioactive molecules out of the plant that might have wide range of pharmacological activities, more phytochemical analysis is needed.

5.4 Antioxidant Activity

G. Kurroo leaves and roots methanolic extracts have high flavonoid and phenolic content. Because of the ability of their hydroxyl groups to scavenge free radicals, phenolic compounds are important plant components, and the concentration of total phenolic can be used to quickly screen for antioxidant activity (Yi et al., 2007). and as well as linked to plant oxidative stress tolerance. The bulk of oxidising compounds are easily scavenged by flavonoids (Bravo, 1998; Wani et al., 2013). In contrast, flavonoids limit reactive oxygen production, chelate free-radical-producing trace elements, scavenge reactive species, and up-regulate and sustain antioxidant defences (Agati et al., 2012). Flavonoids, on the other hand, inhibit reactive oxygen generation, scavenge reactive species, chelate free-radical-producing trace elements, and up-regulate and sustain antioxidant defences. Antioxidant activity of root methanolic extract was higher than that of leaf methanolic extract, which could be attributable to the phenolic and flavonoid content of the two extracts (Mubashir et al., 2017; Cushnie et al., 2005).

5.5 Analgesic Activity

Baba and Malik, (2014) used two assays to determine *G. kurroo's* analgesic activity: to detect Peripheral analgesia and central analgesia, the test which was used is acetic acid induced writhing test and for detecting centrally acting analgesics hot plate test was used. The *Genitiana kurroo* root methanolic extract was found to be efficacious at doses of 500 and 250 mg/kg body weight. When utilizing acetic acid in a dose-dependent manner, the results showed a significant ($p< 0.05$) reduction in the writhing number (73.70% and 63.38% inhibition), which was comparable to the conventional drug diclofenac sodium (71.61% inhibition). The extracts analgesic effect was most likely caused by suppression of prostaglandin production or action (Deraedt et al.,1980). In the Eddy's hot plate test, however, the extract demonstrated dose dependent significant ($p<0.05$) increase in reaction time (higher threshold potential of pain) in response to the heat stimulus. In compared to the control, the stimulus was observed at various times (0–120 minutes). As a result, *Genitiana kurroo* Royle has a strong analgesic action against a variety of stimuli (Wani et al., 2011).

5.6 Anti-Diabetic Activity

Diabetes is also treated with the herb (A.B.D. Selvam et al, 2012). There is no scientific evidence to support *G. kurroo* Royle's anti-diabetic activity; however, a recent study conducted in 2017 proved *G. kurroo* Royle's anti-diabetic potential. Experiments on rats were conducted. The extracts of *G. kurroo* Royle was proven to enhance glycaemic management in the oral glucose tolerance tests. In tolerance tests, the plant extract quickly removes the glucose burden, as was discovered even in normal rats. Polyphagia, polydipsia, and polyuria were reported to be alleviated by hydroethanolic and methanolic extracts (all at a dose of 500 mg/kg of body weight). In diabetic rats, weight loss was also reduced. It can effectively combat other metabolic abnormalities caused by diabetes in rats. *G. kurroo* Royle's anti-diabetic activity may be attributed to bioactive components such as Swertiamarin, swertisin, and lupeol (Inouye et al., 1971). For a better knowledge of the hypoglycaemic potential of *G. kurroo* Royle plant extracts, a systematic investigation is necessary.

5.7 Anti-Arthritic and Anti-inflammatory Activity

The extracts of *G. kurroo* have showed positive results in acute and chronic anti-inflammatory tests in recent studies (Mubashir et al., 2014; 2017). The immediate inflammatory impact was studied using a rat carrageenin-induced paw edoema model. At a dose of 250 mg/kg body weight, various plant extracts were tested for anti-inflammatory effects. *G. kurroo* methanolic extracts reduced the inflammatory response to the greatest extent possible. The inhibitory effect measured in Wistar rats' paw edoema was 47.62 percent, which was significantly different ($p< 0.05$) from the control group which is 55.24%. A 750 mg/kg body weight dose, on the other hand, has showed highest action (67.27%), which is higher than that of normal drugs (56.36%). The findings were statistically significant in comparison to the control group. At $p<0.05$, the difference between the experimental and control groups is non-significant.

Anti-Inflammatory chronic study used Mycobacterium-induced adjuvant arthritis as an anti-inflammatory chronic test. A chronic inflammatory model was used. Each male Wistar rat was divided into seven groups. The equal number of animals in each group (= 5). The methanolic extract was found to be effective and has an inhibitory effect on edema production that is dosage and duration dependent. It's possible that the enhanced activity with higher doses is related to a large amount of extract's bioactive agent/s. When compared to other extracts, the *G. kurroo* methanolic extract exhibits a stronger impact. As a result, the reduction of inflammatory chemical mediators is recommended. The outcomes were at $p<0.05$, it was determined to be significantly important in relation to arthritic control. It could be because of the occurrence. The extract contains more bioactive agent(s) (Dymock et al, 1890; Mubashir et al., 2014). Secondary metabolites such as terpenoids and flavonoids in *G. kurroo* may have anti-inflammatory characteristics; monoterpenoids like borneol, β-pinene and camphene, have similar qualities (Tung, et al.,2008; Yin et al., 2008), while flavonoids like 6-methoxytricin have Analgesic and anti-inflammatory properties (Chopra et al.,1956). It's also possible that this is due to pro-inflammatory cells inhibition (Dymock et al, 1890; Mubashir et al., 2017). Although there has been extensive research on the anti-inflammatory drug obtained from *Genitiana kurroo* methanolic extract of against rheumatoid arthritis, it is limited in terms of the possible identification and mechanism of the bioactive compound from the *Gentiana kurroo* extracts; however, it has been verified that *G. kurroo* act as a drug source for rheumatoid arthritis and inflammation.

5.8 Pharmacological evaluation of Gentiana kurroo plant extracts against Alzheimer's Disease

Alzheimer's disease is serious public health problem with a growing worldwide impact. In the elderly, it is the most common kind of dementia. This disease has a complex aetiology. Many different hypotheses have been proposed at various times to explicate the causal components of this disease and to explain the disease's complex character, like the tau hypothesis, the cholinergic hypothesis, the oxidative stress hypothesis, the Aβ hypothesis, and Hypothesis of inflammation Oxidative damage has been linked to ageing and is prevalent in the AD brain. Many people have benefited from natural items and herbal cures. Plants have traditionally been a great source of novel anti-alzhemeric compounds because of their diversity due to their widespread usage in folk medicine. Plants have traditionally been a great source of novel anti-Alzhemeric medicine. As a result, several pre-clinical approaches must be used to validate its folkloric claims. The purpose of this research was to determine the possible neuroprotective properties of *Gentiana kurroo* the medicinal plant from Kashmir which is also found in some regions of Himachal Pradesh, which is historically utilised for the treatment of various illnesses. A qualitative phytochemical evaluation revealed secondary metabolites such as flavonoids found in ethanol and methanol extracts followed by ethyl acetate and aqueous extracts. The methanol extract contained the most phenols, followed by the ethanol and ethyl acetate extracts. The impact of *Gentiana kurroo* on scopolamine-induced memory impairment in mice was also examined. (EPM) elevated plus maze is a test that is used to determine whether or not a person is mentally *Gentiana kurroo* extract dissolved in methanol mice's learning and memory were improved when given orally (Sajjad et al., 2019).

6. Conclusion

The research on *Gentiana kurroo* is yet to gain its significance importance in India. Although, its nutritional and pharmacological properties of this wonder plant are on the verge of exploration of diverse range of medicinal application. *Gentiana kurroo* has great antibacterial, antioxidant, anti-arthritic, anti-inflammatory, analgesic activity, anti-diabetic activities. Besides, it is also used for improving appetite and used traditionally for the treatment of inflammation, pain, and fever so instead of taking medications we can use root, leaf and flower tops of this medicinal plant as natural home remedies to treat different disease and as many people are not aware of medicinal properties of this plant so worldwide research should be carried out on this plant. However, the less prevalent research to further substantiate of this plant need to overcome by focusing more fundamental research on its molecular dynamics and mechanism of *Gentiana kurroo'* extracts on antioxidant, anti-arthritic, anti-inflammatory, analgesic activity, anti-diabetic properties.

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