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The Ethnobotanical Significance of *Allium stracheyi* in Uttarakhand: From Tradition to Conservation

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Abstract: High-altitude ecosystems are considered to be hotspots of medicinal plant diversity. The government has declared Uttarakhand as herbal state due to the highest diversity of medicinal plant species. *Allium stracheyi* belonging to the family *Alliaceae* and locally known as Jamboo or Faran has been practiced by the Bhotiya communities of Niti and Milam valleys since the past several years. It was originally brought from Tibet decades ago. Traditionally, the plant has been known for its uses as spices, pickles and medicines for jaundice, cold, cough, wound healing and other stomach problems. Besides, it is used as a traditional vegetable. The plant is in endangered status and has been included in the Red Data Book of Indian plants due to its indiscriminate collection and resulting threat to its existence. The present study aimed to provide a general review of the *Allium stracheyi* on its ethnopharmacological uses, climatic distribution and Habitat, chemical constituents, pharmacological activities, threat and conservation status, cultivation practices, future perspectives and its commercialization.

Keywords: *Allium stracheyi* • Chemical constituents • Endangered • Medicinal plant.

Introduction

High altitude medicinal plants are used worldwide in both traditional and Western medicine systems (Gill *et al* 2015). The presence of ultraviolet (UV) filters, powerful antioxidants, free radical quenchers, and antifreeze carbohydrates contributes to the adverse conditions at higher altitude. Plants growing in such environments adapt to various ways of metabolite synthesis, which is the primary cause for the availability of diverse and distinct chemical entities in high-altitude plants (Singh 2020). The state of Uttarakhand covers nearly 15.5 percent of the total land area of the western Himalayas. The state contributes to 27% of all Indian Angio spermic flora and has the highest diversity of medicinal plant species among Himalayan states (Kala 2005) 1748 species of medicinal plant have been reported from the Indian Himalayan region (IHR), out of these,

701 species occur in Uttarakhand state. Due to the potential of this sector, the state government declared it as 'herbal state' (Kumar *et al* 2018).

The genus *Allium* is an endangered and ethnobotanically important herb with considerable therapeutic potential in the Himalayan states of India, primarily in Uttarakhand (Majumder *et al* 2020). Locally *A. stracheyi* is known as Jawaridhun Jamboo, Dhungar (Kumaun area), and Faran in Garhwal region (Fig. 1). It grows near running water or on dry open slopes and is used as a traditional vegetable. This plant grows extensively in Tibet and its neighboring borders in Uttarakhand and also grows in Jammu Kashmir, Himachal Pradesh, Nepal, and Pakistan (Tiwari *et al* 2014). Allium species are traditionally used to stimulate appetite, improve digestion, relieve stress, alleviates cold and cough and used to provide a distinct taste, flavor, and have also been known for preservative properties (Maikhuri *et al* 2017). It has been widely used by Himalayan tribal communities such as the Bhotia, Bhoxas, Tharus, Koltas, Kinnauries, and Jaunsaris for different health benefits. Both the bulb and the leaves can be consumed. Additionally, dried leaves are used to flavour food. Flowers are used as a salad garnish in their natural state. It is generally used in pickles and the arial part is used as spice (Nautiyal *et al* 2001; Maikhuri *et al* 2017). However, the plant has been listed in the Red Data Book of Indian plants due to indiscriminate collection and the subsequent threat to its existence (Bisht *et al* 2016).

Figure 1. *Allium stracheyi* in flowering stage and dried form

Climatic Distribution and Habitat

This Allium species (*A. stracheyi*) is a Himalayan herb that grows only at high altitudes. Allium species are found across the Northern Hemisphere, ranging from the dry subtropics to the boreal zones (Han *et al* 2020). This Allium species is distributed in the sub-alpine zone of Afghanistan, Pakistan, and the Western Himalayas to the Central Himalayas (at a height of 3,000–4,800 masl) (Majumder *et al* 2020). Originally, brought from Tibet decades ago, this species generally grows in higher temperate and alpine zones and in cold deserts, near sandy soils, moist rocks, steep and stony slopes, and arid regions, in the upper sub-alpine zone (bugyal) of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand states of India, Nepal and Pakistan at elevations of around 3,500 -

4,000 masl (Pandey *et al* 2021). Flowering season for *A. stracheyi* is from July to October (Büttner 2001). Due to its great cultural and traditional importance and strong market demand in Uttarakhand Himalayas, dried *A. stracheyi* is one of the most well-known edible species of Allium in the Indian area and is sold between INR 300 - 400/kg in local markets (Chhetri and Gupta, 2010).

Cultivation Practices

A. stracheyi is a perennial plant that is primarily found in the temperate biome and is a bulbous geophyte, naturally regenerating in the forests and grazing lands. It is the most dominant cultivated medicinal species, accounting for 70% of the total area of land (86% of the families) in which medicinal plants were cultivated on terraced slopes in the altitudinal range of 2500 to 3000 meters above sea level in Nanda Devi Biosphere Reserve in the Central Himalayas (Nautiyal *et al* 2001). Bhotiya populations in the Niti and Milam valleys have been using *A. stracheyi* for numerous years. Propagation of *A. stracheyi* via seed, collected by Bhotias from Uttarakhand nature and agricultural fields, is not a common practice due to ambiguous seed dormancy, low germination, and a low seedling survival rate.

It is generally harvested thrice in a year at lower altitude and twice in higher altitude. Planting material is derived partly through plot regeneration and in part from forests and pastures. The bulbs (single or two portions cut into vertical sections) are transplanted throughout the spring season (April-July). It prefers a damp, shady area and must be weeded every two weeks. It produces about 35.00 kg of dried leaves (foliage) from a 0.02-hectare plot annually when it is harvested twice a year (in June and September) (Kuniyal and Negi, 2018).

According to field data on its distribution and use, *A. stracheyi* is classified as an under cultivation and low-pressure medicinal and aromatic plant in Uttarakhand (Rawat, 2005). *A. stracheyi* is grown wildly in selected villages namely Lata, Garpak, Tolma, Reni, Pangrasu, Suki, Dronagiri, Laung, Malari, Jhealam of Nanda Devi Biosphere Reserve in Uttarakhand (Central Himalaya) and in hilly field of Malari village, Chamoli district (Negi, 2017; Gusain and Singh, 2023).

Ethnopharmacological Uses

The use of medicinal plants as a source of relief and therapy for a variety of diseases is as old as humanity itself. The indigenous tribes and cultivars of Uttarakhand uses *A. stracheyi* for a variety of aliment due to its medicinal and commercial value (Kuniyal and Negi, 2018). *A. stracheyi* has long been known for its uses as spices, pickle and medicines for jaundice, cold, cough, wound healing and other stomach problems and is also used to treat cholera and dysentery (Mukherjee and Chandrasekaran, 2010). The raw bulb is chewed to treat cough and cold, and for altitude sickness. It also possesses good antimicrobial activity against major pathogens. Its bulbs are boiled, then fried in ghee and consumed. Its juice is used as a moth repellent (Tiwari *et al* 2014). Leaf decoction serves as a digestive tonic and tonifies circulatory system.

Chemical Constituents

Herbal medicines consist of complex mixtures of numerous phytoconstituents. These phytoconstituents have a distinct physiological effect on the human body. Considering the phytoconstituents screening, various physiologically active compounds are present in *Allium* species including phenolic acids, flavonoids, anthocyanins, coumarins, thiosulfinates, alkaloids, fixed oils, phytosterols, sulfur-containing compounds, and many more (Joshi and Khan, 2016; Shiv Shanker *et al* 1970; Mukherjee *et al* 2013; Pandey *et al* 2021). The findings of a qualitative study showed that steroids are abundant in petroleum ether and

chloroform extracts, whereas alkaloid and saponins are abundant in methanolic and aqueous extracts (Ranjan *et al* 2010; Gusain and Singh, 2023). The presence of alkaloids, saponins, fixed oils, phytosterols, phenolics, and flavonoids were revealed in the qualitative phytochemical screening of the *A. Stracheyi* Baker extracts. It was found that sulphur-containing compounds are primarily responsible for the flavor and biological activity of Allium species (Mukherjee and Chandrasekaran, 2010).

Nutritional Value

The nutritional profile of *A. stracheyi* showed a larger number of fibres that are beneficial in regulating blood glucose levels. It also contains higher amounts of carbohydrate, protein, vitamin C, vitamin E, and phosphorus. Table 1 indicates the crude fiber and nutritional content of *A. stracheyi* which includes protein (4.26%), fat (0.1%), fibre (79.02%), carbohydrate (3.18%), calcium (0.8 mg), phosphorus (0.05 mg), iron (0.50 mg), magnesium (0.82 mg) and potassium (0.95 mg) per 100 mg respectively.

Table 1. Proximate analysis and nutritional content of *A. stracheyi* (Mohan *et al* 2019)

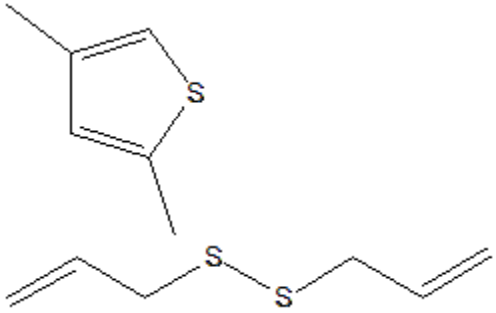
Crude fiber content (%)	
Total moisture (%)	11.13±0.08
Total ash (%)	11.79±0.14
Total fat (%)	4.64±0.30
Total crude fiber (%)	13.20±0.29
Total Protein (%)	6.29±0.18
Total carbohydrate (%)	64.92±7.07
Nutrients	**Amount in %/100 g**
Protein	4.26%
Fat	0.1%
Fibre	79.02%
Carbohydrate	3.18%
calcium	0.8 mg
Phosphorus	0.05mg
Iron	0.50 mg
Magnesium	0.82 mg
Potassium	0.95 mg

Volatile and Sulfur-Containing Compounds

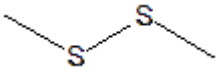
A. stracheyi contains a variety of compounds such as hydrocarbons, terpenes, terpenoid, and others, the majority of which have sulfur as a major content like 2,4-dimethylthiophene (Fig.2A), dimethyl disulfide (Fig. 2B), Diallyl disulfide (Fig. 2C) , dimethyl trisulfide (Fig 2D), 1,2-bis(methylthio) ethene (Fig. 2E)and 3-Phenylthiolane 1,1-dioxide (Fig 2F) as the volatile components (Saxena *et al* 2002; Samant *et al* 2007).

Solvent polarity significantly affects the solubility of phenolic compounds. In an Ultrasound Assisted extraction method using methanol and n-hexane at a concentration of 100, 75,50 and 25%, it was found that the total phenolic concentration (TPC) and total

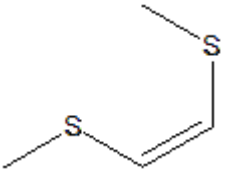
flavonoid content was highest in 25% methanol. The TPC values of *A. stracheyi* extracts of whole plant are in range from 21.366 ± 0.117 to 22.374 ± 0.117µg GAE/mg extract for hexane extract (100%) and 23.009 ± 0.093 to 24.653 ± 0.0968 µg GAE/mg (Joshi and Khan, 2016). Antinutrient such as phytic acid, tannic acid and oxalate are also found in the spices (Table 2).



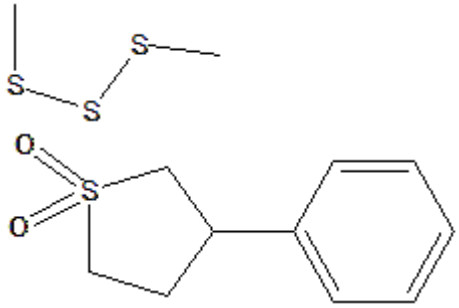
(A) 2,4-dimethylthiophene



(B) Dimethyl disulfide



(C) Diallyl disulfide



(D) Dimethyl trisulfide (E) 1,2-bis(methylthio) ethene (F) 3-Phenylthiolane 1,1-dioxide

Figure 2. Chemical structures of sulfur containing compounds of *A. stracheyi*.

Total Phenolic Contents

Table 2: Total phenolic, total flavonoid and antinutrient content in spices. (Joshi and Khan, 2016)

Total phenolic concentration of the extract at 100% solvent concentration		
Methanol (mg QE/g DW)	30°C	24.606±0.142
	60°C	24.653±0.0968
Total phenolic concentration of the extract at 100% solvent concentration		
Total Flavanoid Content (mg QE/g DW)	30°C	24.606±0.142
	60°C	24.606±0.142
Antinutrient content (%)		
Oxalate content (%)	0.5 %	
Tannic acid (%)	1 %	
Phytic acid (%)	3 %	

Pharmacological Activities

High altitude medicinal plants have tremendous healing powers and have been utilized for a very long time by civilizations around the world to cure various ailments and disorders. Due to the harsh environmental conditions, these plants produce a variety of distinctive bioactive chemicals as defense mechanisms. These compounds, such as antioxidants, flavonoids and alkaloids are often responsible for the medicinal properties of the plants (Fig 3). Table 3 indicates various pharmacological activities of *A. stracheyi***.**

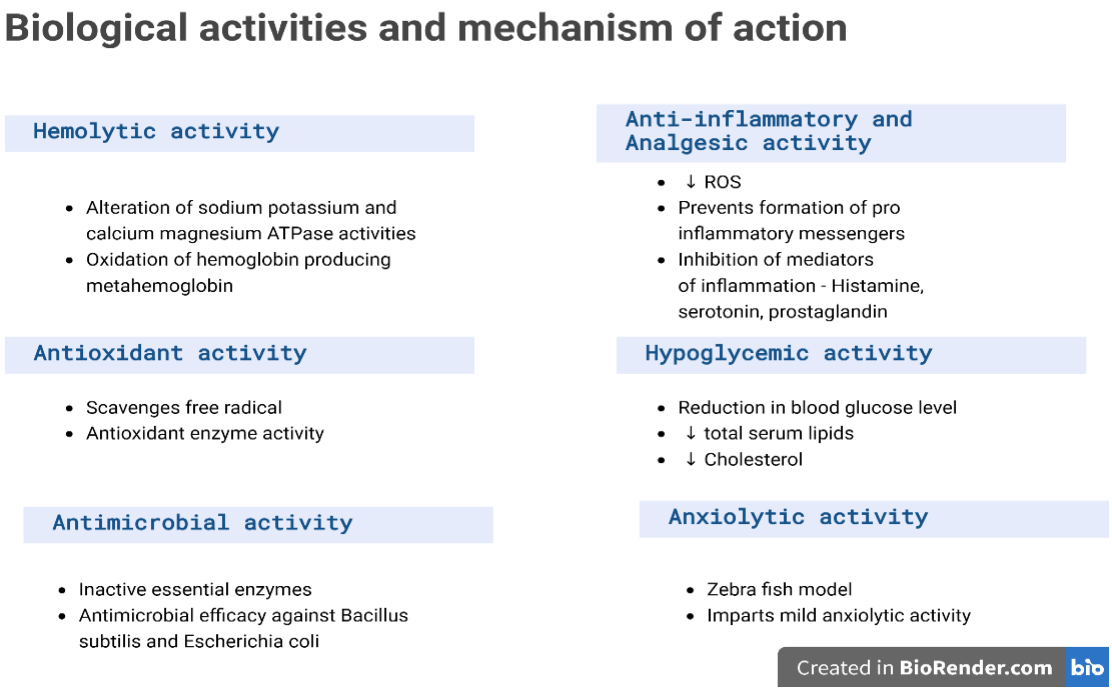


Figure 3. Biological activity and mechanism of action of *A. stracheyi*. (Mohan *et al* 2019)

Hemolytic activity

Several plants and their active components have been identified in recent years and have been shown to possess antiplatelet aggregating potential (Doug *et al* 1998). The activity of plant extracts or compounds serves as a general indication of cytotoxicity towards healthy, normal cells (Da Silva *et al* 2004). Measuring hemolytic activity is important as it is an indicator for cytotoxicity. To determine whether a drug with bioactivities such as antioxidants can be used in pharmacological applications, a hemolytic assay must be carried out (Kalaivani *et al* 2011). Pore formation in cell membranes which affects membrane permeability, or changes in the activities of sodium-potassium and calcium-magnesium ATPases can all contribute to hemolytic activity (Hu *et al* 1996). Study conducted by Mukherjee *et al*, indicates that *A. stracheyi is* a potent natural antiplatelet aggregating agent. In a hemolytic assay carried out using three different concentrations (50 µg, 250 µg and 500 µg) of leaf extracts of *A. stracheyi* in different solvents (pet. Ether, benzene, butanol, ethyl acetate, ethanol and water), it was found that the butanol extract showed maximum hemolytic activity followed by ethyl acetate extract. The extracts have demonstrated dose-dependent hemolytic

activity, and the hemolytic action has been found to increase with increasing extract concentrations (Mukherjee and Chandrasekaran, 2010). Since compounds like quercetin, myricetin, chrysin, naringenin, hesperidin, and apigenin are known to have hemolytic properties, it can be inferred that their presence in leaf extracts of *A. stracheyi* may contribute to their hemolytic activity. (Landolfi *et al* 1984; Homma *et al* 2000).

Anti-inflammatory activity

Even though it is a defensive reaction to injury or infection, inflammation can become pathological when it becomes exacerbated or severe, seeking early care for the best outcome. Anti-inflammatory herbs have proven to be effective in combating inflammatory reactions that cause severe abnormalities in the body. Medicinal plants or their constituents being readily available are less expensive, more effective and are highly potent than their synthetic alternatives (Yatoo *et al* 2018).

In a study carried out by Ranjan et al. 2010 on wistar rats to investigate the anti-inflammatory and analgesic potential of leaf extract of *A. stracheyi* using carrageenan induced paw edema method, it was found that the methanolic leaf extract caused significant reduction in inflammation in wistar rats. The anti-inflammatory effect was tested for petroleum ether, methanol and aqueous extract against the standard drug diclofenac sodium. Out of the three extracts methanolic extract showed significant reduction (61%) in paw volume followed by aqueous extract (46%) (Morris, 2003) In a previous study conducted on a different species of *Allium*, it was hypothesized that flavonoids and organosulphur compounds present in this species prevents formation of inflammatory mediators and are potent analgesic and anti- inflammatory agents (Ranjan *et al* 2010).

Antioxidant and antimicrobial activity

Plant extracts are known to possess a wide range of bioactive compounds, including antioxidants. These antioxidants help neutralize free radicals and protect cells from oxidative damage. The antioxidant activity of plant extracts can vary depending on the plant species, plant part used, extraction process, and the specific compounds present in it. Several studies have been reported that show a link between total flavonoid and phenol concentration and with antioxidant activity. Joshi *et al* studied the effect of various extracts of *A. stracheyi* extracted by ultrasound assisted extraction technique using various solvent concentrations (25, 50, 75 and 100% methanol and hexane). It was found that whole plant extract of *A. stracheyi* in 100% methanolexhibited significant free radical scavenging activity (74.654%) in the DPPH (1,1-diphenyl-2- picrylhydrazyl) assay. The results revealed that per cent radical scavenging of the extracts increased in the following order: 25 per cent methanol>25 per cent Hexane > 50 per cent methanol > 50 per cent Hexane > 75 per cent Methanol > 75 per cent Hexane. The antioxidant activity of the methanol extract is significantly higher than that of the hexane extract at all the concentrations (Joshi and Khan, 2016).

Joshi *et al* also reported the antimicrobial efficacy of methanolic and hexane extract of *A. stracheyi* against *Bacillus subtilis* and *E. coli*. Results of the study revealed that *A. stracheyi* extracts in 25, 50 and 75% hexane and methanol solvents did not show any antimicrobial activity against both of the bacterial strains. *A. stracheyi* extract in 100% methanol and hexane showed maximum inhibition *E. coli* with no effect on the growth of *Bacillus subtilis* (Joshi and Khan, 2016).

Hypoglycemic activity

Plants of Allium species like *Allium cepa*, Allium sativum L., Allium ascalonicum L. are known to be effective in the management of

diabetes (Mohamed *et al* 2016; Akash *et al* 2014). Allium species are thought to have hypoglycemic effects because of their high concentrations of the sulphur compound S-methylcystein and flavonoids like quercetin found in their leaves. However, study on hypoglycemic activity of *A. stracheyi* is still not done and needs to be explored.

Anxiolytic activity

The prevalence and comorbidity of psychiatric problems like anxiety, insomnia and depression are quite common. There is a significant medical and socioeconomic burden associated with anxiety, which is pervasive and associated with significant disability (Han *et al* 2020). The currently prescribed anxiolytics are associated with a wide range of clinical challenges, thus herbal drugs are being researched as an alternative to complementary therapy. Neurological and mental disorders are frequently treated using a range of herbal treatments. Anxiety issues are among the most prevalent reasons why individuals seek out herbal remedies (Beaubrun and Gray, 2000; Sarris, 2007).

Kumar *et al*. studied the effect of methanolic extract of A. stracheyi (Baker) for its anxiolytic activity in zebrafish behavioral models at different dose levels (50, 100, 200 and 400 mg/L and compared the results with standard drug diazepam (Kumar *et al* 2015). Results of the study revealed that *A. stracheyi* has mild anxiolytic action as compared to diazepam. The plant extract was thought to have anxiolytic effects through modulating the levels of brain monoamines, primarily serotonin.

Threat and Conservation Status

As the population grows and the demand for medicinal plants rises, constant pressure is put on available resources, leading to the extinction of some wild species and the alarming loss of natural wild flora (Mir *et al* 2021). The threat to the wild population is brought about by the indiscriminate destruction of aerial components, significant wild collection for therapeutic uses, and degradation of natural habitats. *A. stracheyi* Baker, an ethnobotanically important medicinal and aromatic plant is endemic to western Himalayas (Mukherjee and Chandrasekaran, 2010). It is categorized as vulnerable in the Red Data Book of Indian Plants and also categorized as vulnerable in the western Himalayan states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. Plant resource conservation is a global concern since we don't know what we're losing or what we'll need in the future.

Commercialization

This plant is considered to have the highest overall productivity and, hence, the greatest overall financial gain because of the wider area under cultivation, making it a crucial plant for the economy (Nautiyal *et al* 2001). It is a good source of income for Uttarakhand's tribal communities and cultivators. *A. stracheyi* costs Rupees 350/kg in Tolma, a village in Uttarakhand's Chamoli district, whereas it costs around 3000/kg in Dehradun of Uttarakhand (Kala, 2005). The flowers of this tiny herb are collected and dried to prepare a spice known as 'Pharan' in Uttarakhand. Pure material costs more than Rs 1000 per kg, but it is frequently adulterated with flowers of another *Allium* species known locally as 'Laddoo,' making it slightly cheaper (*Allium stracheyi – eFlora of India*).

Table 3. Pharmacological activities of *A.Stracheyi.*

S.No	Pharmacological activity /plant part	Plant Part	Findings	Reference
1.	Antioxidant activity	Leaves	The chloroform extract of *A. stracheyi* leaf, have strong antioxidant potential and is a potential source of natural antioxidants.	(Maikhuri *et al* 2017; Gusain and Singh, 2023)
2.	Hemolytic activity	Leaves	*A. stracheyi* leaf has potent antiplatelet aggregating activity.	Mukherjee and Chandrasekaran, 2010
3.	Anti-inflammatory and analgesic activity	Leaves	Methanol leaf extract has significant anti-inflammatory activity in carrageenan induced paw edema and analgesic activity in acetic acid induced writhing test.	Ranjan *et al* 2010)
4.	Antioxidant and antimicrobial activity	Whole plant	*A. stracheyi* methanolic extract showed significant antioxidant activity in DPPH and FRAP assay. Whole plant extract of *A. stracheyi* in 100% methanolexhibited significant free radical scavenging activity (74.654%) in the DPPH assay. *A. stracheyi* extract in 100% methanol and hexane showed maximum inhibition *E. coli* with no effect on the growth of *Bacillus subtilis.*	Joshi and Khan, 2016
5.	Anxiolytic activity	Whole plant	Methanolic extract of *A. stracheyi* (Baker) has mild anxiolytic activity in zebrafish model of anxiety.	Kumar *et al* 2015

Future perspectives

Keeping the value of Himalayan *Allium* spices- *A. stracheyi* and other species, urgent attention is drawn towards collection, conservation, evaluation and sustainable use of these precious resources of Uttarakhand Himalaya.

There is no information on the genetic regulation of flower color, blooming period length, or odor in any *Allium* species, nor do we know anything about the genetic control of floral developmental stages or the genetic and environmental interactions on these and other aspects. The availability of genetic variety determines progress in *Allium* improvement. As a result, the rapidly depleting genetic resources may affect future efforts to improve as well as the immediate endeavor of systematic collection and evaluation of genetic reserves.

The conservation of medicinal and aromatic plants is a high priority since wildcrafting will likely continue to play an important role in their future trade: the sustainable commercial use of their biological resources may provide a financial instrument for nature conservation.

Conclusion

The genus *Allium* has been valued as a food and a medicinal plant since ancient times. It is generally used in pickles and to ease gastrointestinal pain, and this species is also beneficial in aiding digestion and alleviating cold and cough. The phytochemicals present in *A. stracheyi* are biologically active and possess immense health benefits. Keeping the value of its medicinal properties and its economic importance, the plant *A. stracheyi* should be conserved. Plant resource conservation is a global concern since we don't know what we're losing or what we'll need in the future. Further research is also needed as the plant has not been fully explored.

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