Ethnomedicinal and traditional application of *Allium wallichii* Kunth (Himalayan Onion): An unexplored and underutilized nutraceutical plant foods from Himalayan regions.

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Reviews

Abstract

Background: Allium wallichii Kunth (Family: Amaryllidaceae), commonly known as "Himalayan onion" is well recorded as popular ethnomedicine for medicinal and nutritional uses by different people and communities native to Bhutan, India, Myanmar, Nepal and Southwestern China.

Methods: Despite the wide ethnomedicinal and pharmacological studies on *A. wallichii*, there are no concise elaborated article comprising reviews of published literature. So, herein we designed this review article to discuss the potential health benefit in both traditional ethnopharmacology and modern pharmacology. To achieve this exhaustive literature searches using *A. wallichii* as keywords for screening of relevant information online databases such as Google Scholar, PubMed, Science Direct, SciELO, Scopus and SpringerLink were performed.

Results: Only few published studies relevant to our objective was found and presented under different section of the current work. It was observed that different parts of *A. wallichii* was recorded in different regions of the Asia for health, economical and nutraceutical benefits such as dysentery, cholera, cold, cough, blood cholesterol levels, itching, to remove maggots from wounds, leech remover, antidote, cut, wounds (finger and toe infections), gastric problems, bile complaints, moth repellent, body ache, sinusitis, carminative, dizziness, mumps, hypertension, intestinal pain, liver diseases, indigestion for children, high altitude sickness, condiment for curries, pickles, soup and vegetable source for cash income. Major bioactive phytochemicals such as 1,2 bis (methylthio) ethene, diosgenin, 2,4 dimethyl thiophene, tigogenin, dimethyl disulfide and trisulfide were reported. However, in modern pharmacology anti-microbial, antioxidant, and anti-cancer activities was established.

Conclusion: It was concluded that *A. wallichii* need special attention for protected cultivation and conservation in near future for maximum output and utilization are required. Moreover, *A. wallichii* could be considered as an excellent source of safe and effective medicinal and nutritional herbal remedies for human and animal consumption after only careful investigation.

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Background

Allium is regarded as one of the most popular and largest genera of monocots (mostly petaloid) accounted for more than 750-850 approximate species and primarily distributed throughout the temperate, semi-arid and arid regions of northern hemisphere (Friesen *et al.* 2006, Miryeganeh & Movafeghi 2009). Out of which approximately 200 species are growing in Asia. Interestingly, several species of Allium genus including onion and garlic are mostly utilized for the source of vegetable and medicine throughout world. Among these *Allium wallichii* Kunth (Family: Amaryllidaceae; Locally known as Jimbu or Himalayan onion) are one such fewer known species (with rare and endangered status in some places) having high medicinal and culinary value and are commonly used by Himalayan tribal communities (Tiwari *et al.* 2014; Mohan *et al.* 2019). As per records, *Allium polyastrum*, *Allium bulleyanum* and *Allium praelatitium* are some of the common synonyms known for the plant (Quattrocchi 2016). In brief, *A. wallichii* is a perennial herb of higher altitude (between 2700 to 3600 m elevations) having single, conical, and short bulb (flowering during August and September and having garlic like odor), majorly habitat in Bhutan, India, Myanmar, Nepal and Southwestern China, respectively (Chhetri & Gupta 2007, Rana & Samant 2010, Huang *et al.* 2014; Chen *et al.* 2021). The detailed pharmacognostical and phylogenetic studies revealing various identification characters has been carried out in the recent past (Tiwari *et al.* 2014, Huang *et al.* 2014, Paul *et al.* 2019, Tang *et al.* 2021). A study conducted on 110 informants suggested strong aroma for *A. wallichii* by 100%. However, during this study *A. stracheyi* was evaluated as sweet onion by 50% of participants and rest 50% of them categorized it as mild garlic (Pandey *et al.* 2021). Figure 1 showing several morphological features for easy and quick identification of the plant.

Additionally, the plant has mixed aroma of both onion and garlic, attains 40-65 cm of height, having undeveloped insignificant cylindrical bulb, linear to lanceolate (or oblong) leaves, with old fibrous leaf covered stem base, roots are thick, rhizomatous and elongated and densely flowered (Tiwari *et al.* 2014, Pandey *et al.* 2022). Particularly, the occurrence of thickened fleshy roots as storage organs and the lack of true bulbs or rhizomes are the major identification features (Huang *et al.* 2014, Hanelt & Fritsch 1994). Despite the wide ethnomedicinal and pharmacological studies on *A. wallichii*, there are no concise elaborated article comprising reviews of published literature. So, herein we designed this review article to discuss the current ethnopharmacology, pharmacognosy, phytochemistry, pharmacology and intellectual property status of *A. wallichii.*

Materials and Methods

The electronic databases such as Google Scholar, PubMed, Science Direct, SciELO, Scopus and SpringerLink thoroughly scrutinized on *A. wallichii* for inclusion of botany, traditional uses, medicinal uses, herbal preparations, phytochemistry and biological activities. No time limit was set for the search and all literature sources published in English and aligned with the scope of the research were included. The key word *Allium wallichii* and synonyms Himalayan onion were paired with relevant terms such as "ethnomedicinal uses", "biological activities", "phytochemicals", "ethnomedicinal", "pharmacological properties" and "traditional uses" to get the outcome-based result.

Taxonomic classification

Taxonomically Allium genus (monocotyledonous) was considered controversial on classification. During earlier classification *Allium* genus was placed in Liliaceae, which was later included in Amaryllidaceae on the basis of inflorescence structure (Melchior 1964). The plant is differentiated from one geographic location to another by reproductive trait (Tang 2021). In a very recent study by our group, stomata type, number and index were studied. Study depicted that presence of paracytic stomata, stomata number was found to be (4 for upper surface and 6 for lower surface) and stomatal indexes was found to be 25 for upper surface and 28.57 for lower surface, respectively (Rana *et al.* 2022).

Biodiversity and conservation status

Presently, the species is less known, underutilized, rare, threatened, over-exploited and needs conservation concern, the concerned reports have been published earlier by many groups (Tiwari *et al.* 2014, Dahal *et al.* 2017, Thakuri *et al.* 2020, Dash *et al.* 2021). A report further published the endangered status of the plant in Sikkim, India (Ved *et al.* 2017, Rai & Rai 2020). However, International Union for Conservation of Nature (IUCN) still omitted the name of plant from red data list. Further, *A. wallichii* has enormous olericulture importance and consider as high cash value nutraceutical and medicinal plant (Paudyal *et al.* 2021). Moreover, *A. wallichii* was considered as threatened plant of Nepal and a micropropagation method by shoot culture for production of plantlets suitable

for field culture was established earlier (Wawrosch *et al.* 2001, Shahzad & Shaheen 2013). Additionally, protected cultivation, information and training to farmers about *A. wallichii* may be useful for maximum utilization and exploration the economic potential in terms of health benefits in near future.

Figure 1. Morphological features of *Allium walichii* Kunth (Where, A: whole plant; B: scape; C: Leaves apex; D: Whole leaf; E, F and G: Bulbs with roots).

Ethnomedicinal and traditional culinary and health benefit application

A. wallichii have been found place in Ayurvedic medicine and listed in database of Ayurveda plants prepared by Foundation for Revitalization of Local Health Tradition (FRLHT), Bangalore (Mohan *et al.* 2019). In an earlier report, the plant has been indicated for tuberculosis, nerve defects, blood circulatory defects, and long life and rejuvenation in Ayurvedic medicinal system (Singh & Rawat 2011). Table 1 mentioned various culinary, nutraceutical and health benefit of *A. wallichii* by different communities across different country. Moreover, summary of both culinary and health benefit is described herewith:

Ethnomedicinal Traditional culinary uses

A. wallichii is majorly consumed for culinary, nutraceutical and medicinal purpose by some local communities (Sundriyal *et al.* 2004, Acharya *et al.* 2011, Borborah *et al.* 2014). In brief, apart from source of perineal vegetable (condiments for pickles and curries), shade dried herbs are powdered and used for year as food flavoring agent (due to presence of sulphur compounds) and for medicine purpose (Facciola 1990, Manning & Snijman 2002, Joshi

& Joshi 2005, Pandey *et al.* 2005, Singh & Sundriyal 2005, Misra *et al.* 2008, Shrestha 2013, Devi *et al.* 2014, Toensmeier *et al.* 2020, Baluni *et al.* 2021, Neupane & Poudel 2021, Shyaula *et al.* 2021). Similarly, upper part of the plant is utilized for aromatic source at South Central Tibet (Malaisse *et al.* 2012). In Nepal, bulbs are meant for medicinal treatment of cough, cold and high-altitude sickness. However, green leaves are generally cooked to get vegetable and dried ones are utilized as source of spices (Manandhar 1980, Dobremez 1982. In another study, bulb was reported to be utilized by boiling and fraying with ghee at western Guring, Nepal for treatment of cholera and diarrhea (Coburn 1984). Beside this leaves are added during cooking on food material to get fragrance (Saini 2008).

Ethnomedicinal Traditional health benefit

The bulbs are boiled, then fried in ghee, and eaten for treatment of higher blood cholesterol level, cholera and dysentery (Rai & Rai 2020, Singh & Rawat 2011, Sharifi-Rad *et al.* 2016, Penjor *et al.* 2020). The raw bulb is chewed to treat cough, cold, infections, and altitude sickness, while fresh juice is applied to treat snake bite and wound (Kunwar *et al.* 2006, Joshi & Joshi 2007, Limbu & Rai 2013, Dhital *et al.* 2021, Khakurel *et al.* 2021, Kumari *et al.* 2009, Kumar & Pandey 2015, Bhattarai *et al.* 2009, Topwal & Uniyal 2018). The juice is used as a moth repellent and dried leaves (or flower) decoction is used in intestinal pain and liver diseases (Tiwari *et al.* 2014, Semwal *et al.* 2013, Semwal *et al.* 2010). Further, the different parts and whole plant is also documented for the treatment of body pain, cut, hypertension, headache, gastritis, bile problem, carminative, indigestion, sinusistis, skin diseases, mumps, leech removal, and as source of cash income (Singh & Rawat 2011, Khajuria *et al.* 2021, Sharma 2012, Adhikari *et al.* 2021, Khakurel *et al.* 2021, Tiwari *et al.* 2010, Ong *et al.* 2018, Singh *et al.* 2019, Miya *et al.* 2020, Singh & Attri 2014, Handa *et al.* 2006, Pande *et al.* 2007, Bhattarai *et al.* 2010, Joshi & Siwakoti 2012, Kapale 2012, Paudyal & Singh 2014, Sah *et al.* 2020, Sørnes *et al.* 2021, Bhandari *et al.* 2021. Moreover, *A. wallichii* was in practice by Vaidyas, Palsi and others for prevention and treatment of several ailments including indigestion and dysentery as reported in Kedarnath Valley of Uttarakhand, India (Semwal *et al.* 2010).

Phytochemistry

Only very few studies reported in this section and require through investigation in future. A study demonstrated identification of 96 volatile compound from cryogenic traps including 27 sulphur compounds. Among them major phytochemicals reported are 1,2 bis (methylthio) ethene, 2,4 dimethyl thiophene, dimethyl disulfide and trisulfide (Kattel & Maga 1995). In another earlier study two steroidal sapogenins (diosgenin and tigogenin) was isolated and estimated for contents (by GLC method) was found to be 0.21% of diosgenin and 0.13% of tigogenin, respectively (Kamal & Sharma 1984). Moreover, flavonoids, reducing sugars, glycosides, steroids and terpenoids are some important class of secondary metabolites are found to be present (Bhandari *et al.* 2017). Further, reported compound was found to be bioactive for prevention and treatment of several disease as depicted in Table 2 and their chemical structures was depicted in Figure 2.

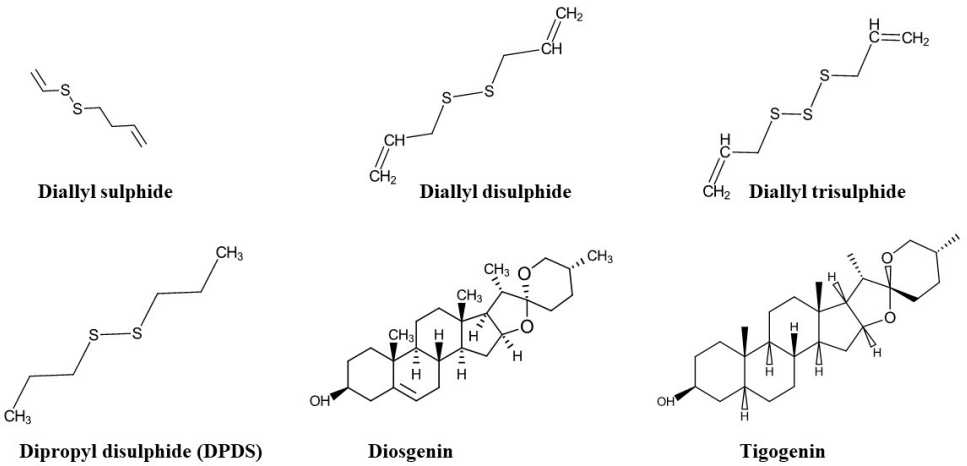

Figure 2. Chemical structures of bioactive compounds present in *Allium wallichii* Kunth

Table 1. Ethnobotanical and traditional applications of *A. wallichii* Kunth

Mode of preparation and treatment methods	Local Name	Health Benefits	Communities/localities
Bulbs			
Boiled and fried with ghee	Lainka	Dysentery	Kedarnath Wildlife Sanctuary, Uttarakhand, India (Singh & Rawat 2011).
Boiled and fried with ghee	Lainka	Dysentery	Mandal area of Western Himalaya, India (Singh *et al.* 2011).
Boiled and fried	Ban Lasun	Cholera and dysentery	Northwest Himalayas, India (Sharifi-Rad *et al.* 2016)
Raw	Ban Lasun	Cold, cough and altitude disease	Northwest Himalayas, India (Sharifi-Rad *et al.* 2016)
Raw	Lagop	Dysentery, cough and cold	Taktse Chiwog, Central Bhutan (Penjor *et al.* 2020)
Boiled and fried with ghee	Ban Lasun	Cholera, dysentery and cholesterol levels	Darjeeling, Himalaya, India (Rai & Rai 2020)
Raw	Vanlasun	Cough and cold	Dolpa, Humla, Jumla and Mustang, Nepal (Kunwar *et al.* 2006)
Fresh juice	Jimbu Jhar or Vanlasun	Itching and to remove maggots from wounds	Kali Gandaki, Bagmati and Tadi Likhu Watersheds of Nepal (Joshi & Joshi, 2007)
Raw bite and topical application	Albeit (Ban lasun)	Sucking poison out of blood from the wound is a very effective first aid, common cold, cut and wound	Limbu community, Limbuwan, Eastern Nepal (Limbu & Rai 2013)
Raw	Doona	Gastric problems and bile complaints	Pauri, Uttarakhand, India (Khajuria *et al.* 2021)
Juice	Jambu	Moth repellent	Uttarakhand, India (Tiwari *et al.* 2014)
Juice	Van Lahsun	Bodyache	Darjeeling Hills, India (Sharma 2012)
Raw	Ban Lasun	Hypertension	Sankhuwasabha, Nepal (Dahal *et al.* 2017)
Decoction	Ban lasun or Chilime	Cough and Cold (Sorang- Syapchim)	Tamang community, Dolakha, Nepal (Dhital *et al.* 2021)
Powder	Banlasun	Cut and wounds (finger & toe infections)	Kanda, Bajhang, Kailash Sacred Landscape, Nepal (Adhikari *et al.* 2021)
Leaves			
Raw and cooked to get soup	Lagop	High altitude sickness	Taktse Chiwog, Central Bhutan (Penjor *et al.* 2020)
Fried in mustard oil and mixed with spices	Chiskan/onion	Vegetable source	Kinnaura tribals, Himachal Pradesh, India (Geeta et al. 2015)
Raw	Vanlasun	Cough and cold	Dolpa, Humla, Jumla and Mustang, Nepal (Kunwar *et al.* 2006)
Raw	Ban Lahsun	Condiment for curries and pickles. Tonic and used to treat coughs and colds	Western Nepal, India (Khakurel *et al.* 2021)
Decoction	Jambu	Intestinal pain and liver diseases.	Kalimath valley, Rudraprayag, Uttarakhand, India (Semwal *et al.* 2013)
Paste	Pharan	Indigestion for children	Garhwal Himalaya, Uttarakhand, India (Tiwari *et al.* 2010)
Raw	Van Lahsun	Curry & soup	Darjeeling Hills, India (Sharma 2012)
Decoction and raw		Carminative and dizziness	Three chin communities, Natma Taung National Park, Myanmar (Ong *et al.* 2018)
Powder 1/2 -1 teaspoon with water	Lainka	Gastric 12 Anti-microbial, antioxidant, and anti-cancer	Urgam Valley, Chamoli Garhwal, Uttarakhand, India (Singh *et al.* 2019)

Raw	Ban lasun	Sinusitis	Tangbeton, Hilly Districts in Nepal (Miya *et al.* 2020)
Raw	Ban Lehasun	Indigestion	Bageshwar valley, Kumaun Himalaya, Uttarakhand, India (Singh & Attri 2014)
Infusion	Himalaya Onion / Banlasun	Vomiting	Tamze Medicinal Plants Conservation Area (MPCA) of Sikkim Himalaya, India (Dahal *et al.* 2017)
Decoction	Laynka	Jaundice, cold and cough	Dhauli Ganga, Central Himalaya (Kandari *et al.* 2012)
Root			
Two node given daily	Jangali Lasun	Infection	Uttarakhand, Himalayan Region, India (Kumari *et al.* 2009)
Paste	Jangali Lasun	Infection	Tons river area, Dehradun, Uttarakhand, India (Kumar & Pandey 2015)
Paste	Ban Lahsun	Mumps	Nepal (Handa *et al.* 2006)
Paste	Ban Lahsun	Leech remover for cattle	Uttaranchal, India (Pande *et al.* 2007)
Flower			
Decoction	Jambu	Intestinal pain and liver diseases.	Kalimath valley, Rudraprayag, Uttarakhand, India (Semwal *et al.* 2013)
Shoot			
Cooked to get soup	Lagop	High altitude sickness	Taktse Chiwog, Central Bhutan (Penjor *et al.* 2020)
Whole plant			
Ocimum basilicum seeds (half spoon) soaked for 24 h with 3 cups of water for 24 hours + 50 g sugar cube + 10 g powder of *A. wallichii* to get 2 cups of juice after filtration taken once a day till recovery	Vanlasun	Cough, cold and feeling of higher level of heat inside the body until recovery.	Nawalparasi, Central Nepal (Bhattarai *et al.* 2010)
Herb	Ban Lahsun	Vegetable source for cash income	Trans-himalayan arid zone, Mustang, Nepal (Bhattarai *et al.* 2010)
Herb powder	Ban Lahsun	Indigestion	Kedarnath Wildlife Sanctuary, Western Himalaya, India (Singh & Rawat 2011)
Herb	Ban lasun	Vegetable source for cash income	Tamang, Bankaria and Newar communities, Makawanpur, Nepal (Joshi & Siwakoti 2012)
Herb	Van Lahsun	Skin Diseases and Indigestion	Baiga tribals, Meikal, Amarkantak, Madhya Pradesh, India (Kapale 2012)
Herb	Jimbu	Sinusistis	Migratory Tangbetons, Pokhara, Nepal (Paudyal & Singh 2014)
Herb	Garlic	Medication-overuse headache and antioxidative	Nepal (Sørnes *et al.* 2021)
Boiled or pickled stir-fried with eggs	Shanjiucai or Caiguageizai	Lactation stimulant	Yi people in Mile City, Yunnan Province, China (Sun *et al.* 2020)
Whole plant is boiled with water and soup is taken orally	Chyapi, Ban lasun, Jimbu, Jimbu jhar	Antihelmentic and altitude sickness (headache).	Humla, Western Nepal (Rokaya *et al.* 2010)

Table 2. List of bioactive compounds present in *A. wallichii*

Name of compounds	Pharmacological and biological functions	References
Diallyl sulphide (DAS)	Prevent cellular toxicities from alcohol, analgesic drugs, xenobiotics, HIV, diabetes, anticancer activity (role as CYP2E1 inhibitor) against melanoma (A375), carcinoma (BCC), prostate carcinoma (LNCaP) and lung carcinoma (H460 and NSCLC)	Lanzotti *et al.* 2014, Rao *et al.* 2015, Casella *et al.* 2013
Diallyl disulphide (DADS)	Anti-inflammatory, antioxidant, antibacterial, antifungal, antiviral, detoxification, cardiovascular, neuroprotection, regulation of glycose and lipid metabolism, neuroprotective, hepatoprotective, kidney function. Anticancer activity against melanoma (A375 and SK MEL-2), carcinoma (BCC), colorectal adenocarcinoma (HCT-15), leukemia (HL60), lung carcinoma (H460, NSCLC and A549), neuroblastoma (SH-SY5Y) and prostate carcinoma (LNCaP)	Lanzotti *et al.* 2014, He *et al.* 2021, Song *et al.* 2021
Diallyl trisulphide (DATS)	Antifungal Anticancer activity against melanoma (A375) and breast cancer	Lanzotti *et al.* 2014, Gong *et al.* 2021, Malla *et al.* 2022, Seki *et al.* 2008
Dipropyl disulphide (DPDS)	Anticancer activity against colorectal adenocarcinoma (HCT-15), lung carcinoma (A549) and melanoma (SK MEL-2) antimicrobial activity	Lanzotti *et al.* 2014, Casella *et al.* 2013
Diosgenin	Cancer, diabetes, neuroprotection, atherosclerosis, bone health, arthritis, asthma, menopause, cardiovascular disease hypercholesterolemia, anti-thrombic, immune modulation. inflammation, and several types of infections.	Jesus *et al.* 2016, Semwal *et al.* 2022, Huang *et al.* 2022
Tigogenin	Cancer cultures (A549 lung cancer, DLD-1 colorectal cancer, and WS1 normal skin fibroblasts), immuno-modulation, hyperlipidemia, antimycobacterial, molluscicidal, antifungal, cholinesterase inhibition and antituberculosis	Nadaraia *et al.* 2018, Michalak *et al.* 2020, Murad *et al.* 2019, Merlani *et al.* 2004, Abdel-Gawad *et al.* 2015, Merlani *et al.* 2009, Yang *et al.* 2006, Deniz *et al.* 2021

Nutritional analysis

Nutraceutical content of various parts of plant has been studied and reported in Table 3. Study includes majority proteins (5.15%), fibre (0.69%), fat (0.1%), carbohydrate (32.63%), Ca (56.49%), K (40.21%), S (0.93%), Si (0.93%), Mn (0.67%), Fe (0.43%), Cu (0.13%), Zn (0.13%), Rb (0.1%) and vitamin C (27.46 mg) (Yee 2019, Wang *et al.* 2018, Midday *et al.* 2020). There are several possibilities of nutraceutical studies that are still warranted.

Table 3. Nutritional contents on various parts *A. wallichii* (Geeta *et al.* 2015, Yee 2019, Xu *et al.* 2014, Wang *et al.* 2018, Midday *et al.* 2020)

Nutritional Parameters	**Nutritional content**			
	Root	**Bulb**	**Leaves**	**Scapes**
Energy/100 g sample	NFL	NFL	239.3 kcal/ 100 g sample	NFL
Moisture (%)	8.53	60.22	18.44/100 g sample	NFL
Crude Protein (%)	10.54	5.15	20.47/ 100 g sample	NFL
Crude Ash (%)	15.29	1.25	11.46/100 g sample	NFL
Crude Fat (%)	0.84	0.1	0.22/100 g sample	NFL
Fiber (%)	NFL	0.69	2.06	NFL
Carbohydrate (Total sugar) in %	NFL	32.63	11.25 (Average of 3), 16.67 and 38.86/100g	29.07

Elemental contents				
Calcium (Ca)	0.09%	56.489%	19583 (Average of 3) and 20458 mg/kg	8083.6 mg/kg
Phosphorus (P)	0.33%	NFL	6492 (Average of 3) and 7104 mg/kg	6412 mg/kg
Copper (Cu)	NFL	0.131%	10.49 (Average of 3) and 13.98 mg/kg	12.87 mg/kg
Selenium (Se)	NFL	NFL	0.108 (Average of 3) and 0.17 mg/kg	0.15 mg/kg
Potassium (K)	NFL	40.207%	54958 (Average of 3), 48750 mg/kg and 3160 mg/100 g	28375 mg/kg
Sulphur (S)	NFL	0.927%	NFL	NFL
Silicon (Si)	NFL	0.926%	NFL	NFL
Manganese (Mn)	NFL	0.656%	204.7 Average of 3) and 217.70 mg/kg	151.67 mg/kg
Magnesium (Mg)	NFL	NA	4709 (Average of 3) and 5358.3 mg/kg	2433.6 mg/kg
Iron (Fe)	NFL	0.434%	526.3 (Average of 3), 551.33 mg/kg and 41.8 mg/100 g	104.60 mg/kg
Zinc (Zn)	NFL	0.130%	307.3 (Average of 3) and 201.83 mg/kg and 1.7 mg/100 g	147.33 mg/kg
Lead (Pb)	NFL	0.1%	0.25 (Average of 3) and 0.35 mg/kg	0.32 mg/kg
Arsenic (As)	NFL	NFL	0.228 (Average of 3) and 0.38 mg/kg	0.09 mg/kg
Cadmium (Cd)	NFL	NFL	0.819 (Average of 3) and 7.27 mg/kg	2.54 mg/kg
Mercury (Hg)	NFL	NFL	0.013 (Average of 3) and 0.02 mg/kg	Not Detected
Amino Acids				
Amino acids (Average of 3) in %	NFL	NFL	20.84	NFL
Aspartic acid (Asp) in %	NFL	NFL	2.06	NFL
Threonine (Thr) in %	NFL	NFL	1.00	NFL
Serine (Ser) in %	NFL	NFL	1.05	NFL
Glutamic acid (Glu) in %	NFL	NFL	3.30	NFL
Glycine (Gly) in %	NFL	NFL	1.24	NFL
Alanine (Ala) in %	NFL	NFL	1.40	NFL
Cysteine (Cys) in %	NFL	NFL	1.56	NFL
Valine (Val) in %	NFL	NFL	1.21	NFL
Methionine (Met) in %	NFL	NFL	0.43	NFL
Isoleucine (Ile) in %	NFL	NFL	1.02	NFL
Leucine (Leu) in %	NFL	NFL	1.85	NFL
Tyrosine (Tyr) in %	NFL	NFL	0.74	NFL
Phenylalanine (Phe) in %	NFL	NFL	1.16	NFL
Histidine (His) in %	NFL	NFL	0.65	NFL
Lysine (Lys) in %	NFL	NFL	1.47	NFL
Arginine (Arg) in %	NFL	NFL	1.28	NFL
Proline (Pro) in %	NFL	NFL	0.39	NFL
Vitamins				
Vitamins C	NFL	NFL	41.84 mg/100 g sample	NFL
Vitamin K	NFL	NFL	4.29 mg/100 g sample	NFL
Folic acid	NFL	NFL	0.103 mg/100 g sample	NFL

NFL* (Not found in literature)

Pharmacology

The plant has been studied for wide variety of health promotion and management of several diseases pharmacologically. Progress of research pertaining biological and pharmacological updates on *A. wallichii* have been depicted below:

Antimicrobial activity

Methanol extract (2 to 6%) exhibited antimicrobial activity against *Escherichia coli*, *Enterococcus faecalis*, Pseudomonas species, *Klebsiella pneumoniae*, *Klebshiella oxytoca*, *Salmonella typhi*, *Salmonella paratyphi* and *Staphylococcus aureus*. Additionally, LC50 values was found to be 64.71 ppm using brine shrimp lethality test (Acharya *et al.* 2011). Subsequently, antimicrobial activity on *B. cereus*, *E. coli*, *B. thuringiensis*, *P. mirabilis*, Rhizopus, *A. flavus*, *P. aerugenosa* and *B. subtilis* was established (Bhandari *et al.* 2017). Progressively, 7 mg/ ml concentration of aqueous, ethanol and methanol extract of bulb was found to inhibit *Bacillus pumilus*, *Candida albicans*,

Escherichia coli, *Staphylococcus aureus* and *Pseudomonas aeruginosa* significantly in another study. Further higher antioxidant activity was shown by water extract (IC50 = 1.21 μgmL^{-1}) when compare with ethanol extract (IC50 = 2.10 μgmL^{-1}) via DPPH method (Yee 2019, Arifa *et al.* 2020). In another study presence of spatially structured unique useful microbiome to differentiate from other plant sources has been investigated. Additionally, it was demonstrated that plant associated microorganism was contributing many health beneficial functions. Further, presence of bacterial genus *Pseudomonas* was found to be a universal component (Chen *et al.* 2021).

Antitumor activity

A study demonstrated that high consumption of certain Allium vegetables, in particular garlic and leek, may reduce the risk of breast cancer, while high consumption of cooked onion may be associated with an increased risk of breast cancer (Pourzand *et al.* 2016). Subsequently, alcohol and water extract (roots and rhizome, 20 g/kg/bw) possess antitumor effect during *in vivo* experiments on transplanted S180 sarcoma and H22 hepatoma of KM mice, lung cancer of C57BL mice and EMT-6 breast cancer of BALB/C mice (Wang *et al.* 2016). Further, a study demonstrated presence of flavonoids, glycosides, reducing sugars, steroids and terpenoids with anticancer activity (prostate cancer cell line: 69.69 µg/ml, breast cancer cell line: 55.29 µg/ml and cervical cancer cell line: 46.51 µg/ml). Additionally study demonstrated moderate antioxidant (via DPPH: 17.87 µg/ml) activity and cell viability assay (B-Lymphoma cell Line: 3.817 ± 1.99 mg/ml) for further support (Bhandari *et al.* 2017, Iqbal *et al.* 2018).

Immunomodulatory

A. wallichii was reviewed to have immune-enhancer candidate via antioxidant and anti-inflammatory mechanism (Prakash *et al.* 2018).

Clinical trial

A population based clinical study for treatment of Headache and medication overuse for cause of headache was demonstrated (Sørnes *et al.* 2021)

Patents

In an invention antitumor activity was disclosed, which was comparable to cis-platinum or cyclophosphamide [Chinese patent application (CN104524139A)., 2015. *Allium wallichii* extract and application thereof]. In another invention anti-fatigue activity was demonstrated [Chinese patent application (CN107625875A)., 2017. A kind of preparation method and purposes of *Allium wallichii* extract]. Recently two Indian Patent Application published viz an invention entitled as Nutraceutical polyherbal composition for *Diabetes mellitus* [Application Number: 202211035406; Year: 2022] and Nutraceutical herbal composition for *Diabetes mellitus* [Application Number: 202211036868; Year: 2022] proves its potential.

Conclusion and future direction

The rich biodiversity of plants present in several parts of world has several medicinal and nutraceuticals possibilities, which need to explore further. There are many plants which was underutilized and ignored continuously in modern research. These plants require serious attention in order to established scientific validation in terms of medicinal and nutraceutical usage on the basis of traditional ethnomedicinal applications. Herewith author presented one of such plant (*A. wallichii*), which was less studied and requires serious attention. This plant has been well established in traditional and folklore system for variety of use and can be utilized as source of income generation by many communities. However, very few scientific investigations have been taken place in modern science to establish it as choice of food and medicine. Certainly, rich bioactive and nutraceutical component make this plant as choice of future alternative for garlic and onion. It was concluded that method enlisting protective cultivation, conservation and scientific validation will make to convert several value-added products of choice using Himalayan onion.

Declarations

List of Abbreviations: *A. bulleyanum* (*Allium bulleyanum*); *A. flavus* (*Aspergillus flavus*); *A. polyastrum* (*Allium polyastrum*) *A. praelatitium* (*Allium praelatitium*) *A. wallichii* (*Allium wallichii*); AG (Avinash Gangal); *B. cereus* (*Bacillus cereus*); *B. subtilis* (*Bacillus subtilis*); *B. thuringiensis* (*Bacillus thuringiensis*); Ca (Calcium); Cu (Copper); DB (Dheeraj Bisht); DPPH (2,2-diphenylpicrylhydrazyl); *E. coli* (*Escherichia coli*); EMT-6 (Experimental Mammary Tumour-6); Fe (Iron); FRLHT (Foundation for Revitalization of Local Health Tradition); IUCN (International Union for Conservation of Nature); K (Potassium); KM (Kun Ming); MD (Manisha Duseja); Mn (Manganese); NKS (Neeraj Kumar Sethiya); *P. aerugenosa* (*Pseudomonas aeruginosa*); *P. mirabilis* (*Proteus mirabilis*); Rb (Rubidium); RG (Rupa Gupta); S (Sulphur); Si (Silicon); VSR (Vijay Singh Rana) and Zn (Zinc)

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