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Phytochemical and Pharmacological Review of Allium Species from Georgia

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ABSTRACT

This research aims to provide a comprehensive phytochemical and pharmacological review of Allium species growing in Georgia. Utilizing scientific sources and articles detailing these plants' phytochemical constituents and pharmacological activities. The study identifies 36 Allium species in Georgia, including five endemics to the country and 2 to the Caucasus region. Numerous biologically active compounds have been isolated from these species, such as over 20 saponins, 11 types of sapogenins, flavonoids, and sulfur compounds. Extensive research highlights pharmacological activities, including cytotoxic, antioxidant, antimicrobial, hepatoprotective, and fibrinolytic effects. Notably, cytotoxic studies on Allium species show significant activity against several cancer cell lines. Antioxidant assays highlight the potential of Allium extracts in scavenging free radicals and reducing oxidative stress. Despite these findings, 22 of the 36 Allium species in Georgia still need to be studied, with unknown chemical structures and biological activities of their compounds. This review underscores the need for further detailed and extensive studies to enhance understanding of these lesser-known species' pharmacological potential and chemical composition

Keywords: Allium; pharmacological activities; phytochemistry.

INTRODUCTION

The Allium genus, part of the Alliaceae family, comprises around 800 species, predominantly found in the northern hemisphere.[1]

These herbaceous plants have significant historical and traditional uses as food and medicine, with a cultivation history tracing over 4,000 years to ancient Egypt.[2]

In Georgian traditional medicine, Allium species are utilized for their antifungal, antiseptic, and antibacterial properties.[3,4] Georgia claims a rich and diverse vegetation due to its varied and contrasting physical and geographical conditions, complex geological history, and strategic location at the crossroads of different botanical and geographical provinces.

The flora of the Caucasus, particularly in Georgia, is highly endemic. Approximately 21% of its flora (around 900 species) is unique to the region, including about 600 species endemics to the Caucasus and 300 specifically endemic to Georgia. The region has a notable endemic genus, with 17 endemic and subendemic genera.[5]

This review aims to provide detailed information on the phytochemistry and pharmacological activities of Allium species growing in Georgia.

REVIEW

Allium species in Georgia

According to R. Gagnidze's book "Vascular Plants of Georgia," 36 species of the genus Allium are described in Georgia. Among these, five species are endemic to Georgia, and two species are endemic to the Caucasus region (Tab.1).[1]

TABLE 1. List of plants genus Allium described in Georgia

1	A. affine Ledeb.
2	A. albidum Fisch. Ex Bieb
3	A. albovianum Vved
4	A. atroviolaceum Boiss
5	A. aucheri Boiss
6	A. candolleanum Albov
7	A. cardiostemon Fisch. Et C.A. Mey
8	A. chevsuricum Tscholok
9	A. erubescens K. Koch
10	A. fuscoviolaceum Fomin
11	A. globosum Bieb. Ex DC
12	A. gracilescens Somm. Et Levier
13	A. gramineum K. Koch
14	A. karsianum Fomin
15	A. kunthianum Vved.
16	A. ledschanense Conrath et Freyn
17	A. leucanthum K. Koch
18	A. moschatum L.
19	A. oreophilum C.A. Mey
20	A. otschiauriae Tscholok.
21	A. paczoskianum Tuzs.
22	A. paradoxum (Bieb.) G. Don. F (Scillaparadoxa Bieb.)
23	A. ponticum Miscz. Ex Grossh.
24	A. pseudoflavum Vved
25	A. pseudostrictum Albov
26	A. rotundum L.
27	A. rubellum Bieb
28	A. rupestre Stev
29	A. ruprechtii Boiss
30	A. saxatile Bieb
31	A. scorodoprasum L. (A. waldsteinii G. Don f. A. jajlae Vved)
32	A. szovitsii Regel
33	A. tauricola Bieb(A. subquinqueflorum Boiss)
34	A. ursinum L.
35	A. victorialis L.
36	A. vineale L.

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A. albovianum, A. candolleanum, A. chevsuricum, A. gracilescens, and A. otschiauriae are endemic species of Georgia; A. ledschanense and A. leucanthum are endemic species of the Caucasus region.

Phytochemistry of plants genus Allium, growing in Georgia

From Allium species growing in Georgia, the following compounds have been isolated: Kaempferol-(acetylhexoside)-hexoside, Malondialdehyde (MDA), (E)-Propenyl propyl disulfide, 3,4-Dihydro-3-vinyl-1,2-dithiine, Methyl-2-propenyl trisulfide, (Z)-Di-2-propenyl trisulfide, Cyclopent-1-enecarboxylate, Allicin, Yayoisaponin C, β-Amyrin acetate, Inulin, Diallyl disulfide, 22-Cyclohexyl-1-docosanol, Dideglucoeruboside B, Astragalin, Allyl (methylthio)methyl disulfide, Nystose, 2-Vinyl-4H-1,3-dithiine, Atroviolaceoside, (E)-Di-2-propenyl trisulfide, Aginoside, Allivictoside A–H, Dimethyl disulfide, 2,4-Dimethylthiophene, Allyl propyl trisulfide, β-Sitosterol acetate, p-Vinylguaiacol, Alliumonoate, Allyl methyl disulfide, quercetin 3-O-β-glucopyranoside, Dimethyl tetrasulfide, Eruboside B, 2-Furaldehyde, Benzaldehyde, 2-Vinyl-1,3-dithiane, Allyl (Z)-1-propenyl disulfide, diosgenin-3-O-α-rhamnopyranosyl-(1→2)-β-D-glucopyranoside (Prosapogenin A of dioscin), (Z)-Methyl-2-propenyl disulfide, β-Sitosterol 3-O-β-glucopyranoside, 4-Methyl-1,2,3-trithiolane, Leucospiroside A, Kaempferol-3,7-di-O-β-D-glucopyranoside, isorhamnetin 3,7-di-O-β-glucopyranoside, Deltonine, Dimethyl thiophene-(E)-methyl-2-propyl disulfide, β-Sitosterol, Acetyl-kaempferol-deoxyhexose propylene sulfide, Aginoside, Allumine A and B, 1-Propenyl propyl disulfide, 5-Methyl-1,2,3,4-tetrathiane, 4-Methyl-1,2,3,5,6-pentathiepane, Methyl propyl trisulfide, Allyl (E)-1-propenyl disulfide, Methyl (methylthio)methyl disulfide, Allyl (methylthio)methyl trisulfide, isorhamnetin-3-O-β-D-glucopyranoside, 2-Methoxy tyrosol, (Z)-Propenyl propyl disulfide, Ophiopogonin C, Allyl methyl trisulfide, Diallyl trisulfide, Methyl (Z)-1-propenyl disulfide, Dimethyl trisulfide, Trillin, Kaempferol-3,7-di-O-β-D-glucopyranoside, Diallyl trisulfide, 2,4-Dimethylthiophene, Methyl (methylthio)methyl trisulfide, Methyl (E)-1-propenyl trisulfide, (Z)-Di-2-propenyl trisulfide, Methyl (Z)-1-propenyl disulfide, 4-Methyl-1,2,3-trithiolane, (E)-Propenyl propyl disulfide, quercetin 3-O-β-glucopyranoside, Cyclopent-1-enecarboxylate, Deltonine, Eruboside B, Ophiopogonin C, Allyl methyl disulfide, Acetyl-kaempferol-deoxyhexose propylene sulfide, Nystose, Allyl propyl trisulfide, Kaempferol-(acetylhexoside)-hexoside, β-Sitosterol acetate, (3Z)-Hexenol, Dideglucoeruboside B, β-Sitosterol 3-O-β-glucopyranoside, Trillin, 3,4-Dihydro-3-vinyl-1,2-dithiine, Alliumonoate, Atroviolaceoside, Allyl (Z)-1-propenyl disulfide, 2-Vinyl-1,3-dithiane, Dimethyl trisulfide, Carotenoids, 22-Cyclohexyl-1-docosanol, Diallyl disulfide, Allivictoside A–H, Aginoside, diosgenin-3-O-α-rhamnopyranosyl-(1→2)-β-D-glucopyranoside (Prosapogenin A of dioscin), Benzaldehyde, Methyl-2-propenyl trisulfide, Allumine A and B, Aginoside, Dimethyl disulfide, 2-Vinyl-4H-1,3-dithiine, (Z)-Methyl-2-propenyl disulfide, Allyl (methylthio)methyl disulfide, Allyl (E)-1-propenyl disulfide, β-Sitosterol, Astragalin, Methyl propyl trisulfide, 1-Propenyl propyl disulfide, 2-Furaldehyde, (2E)-Hexenal, (Z)-Propenyl propyl disulfide, 5-Methyl-1,2,3,4-tetrathiane, (E)-Di-2-propenyl trisulfide, Yayoisaponin C, β-Amyrin acetate, (Z)-Methyl-2-propenyl disulfide, β-Amyrin, Methyl (E)-1-propenyl trisulfide, Allyl methyl tetrasulfide, 2-Methoxy tyrosol, Diallyl trisulfide, (2E)-Hexenal, Allicin, 4-Methyl-1,2,3,5,6-pentathiepane, Malondialdehyde (MDA), 4-Methyl-1,2,3-trithiolane, Leucospiroside A, (Z)-Propenyl propyl disulfide, Allyl methyl trisulfide, Dimethyl tetrasulfide, isorhamnetin 3,4'-di-O-β-glucopyranoside, Inulin, Dimethyl thiophene-(E)-methyl-2-propyl disulfide.

Different types of sapogenins have also been isolated from these species: β-chlorogenin, Diosgenin, Yucagenin, Tigogenin, Nuatigenin, Hecogenine, Agigenin, Ruscogenin, Atroviolacegenin, Gitogenin, and Isonuatigenin.

Information about the biological activities and constituents of these plants is given in Table 2.

TABLE 2. Chemical compounds isolated from Allium species widespread in Georgia

Species	Compounds	Aglycone	Biological activity
Allium affine		Diosgenin, Tigogenin, Ruscogenin[6]	Antioxidant activity[7] Fibrinolytic activity[7]
Allium albidum		Diosgenin, Ruscogenin[8] Hecogenine[9]	
Allium atroviolaceum	Atroviolaceoside[10]	Atroviolacegenin[10]	Antiplatelet activity[11] Antibacterial activity[12] Cytotoxic and antiproliferative effect[13–15]
Allium erubescens	Eruboside B[16]	β-chlorogenin[16]	
Allium fuscoviolaceum		Diosgenin[17]	
Allium gramineum	isorhamnetin-3-O-β-D-glucopyranoside, diosgenin-3-O-α-rhamnopyranosyl-(1→2)-β-D-glucopyranoside (Prosapogenin A of dioscin), Deltonine[18] Isorhamnetin 3,7-di-O-β-glucopyranoside, Quercetin 3-O-β-glucopyranoside, β-sitosterol 3-O-β-glucopyranoside, Isorhamnetin 3,4'-di-O-β-glucopyranoside,[19] Eruboside B[9]		Cytotoxicity and Antioxidant activity[18]

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TABLE 2. Chemical compounds isolated from Allium species widespread in Georgia (continued)

Species	Compounds	Aglycone	Biological activity
Allium leucanthum	Yayoisaponin C, Eruboside B, Aginoside, Leucospiroside A, Three unknown saponins,[20] (25R)-5α-spirostane-3β,6β-diol-O-β-D-glucopyranosyl-(1--2)- O-β-D-glucopyranosyl-(1--4)-β-D-galactopyranoside, Leucofuranoside A[21–24]	Diosgenin β-chlorogenin Yucagenin, Agigenin[24]	Cytotoxic activity[20] Antifungal activity Antileishmanial activity[25] Antibacterial activity[26]
Allium paradoxum	Astragalin; 2-Methoxy tyrosol[27]	Dioscin related saponins[28]	Leishmanicidal activity,[28] Antioxidant activity,[29] Hepatoprotective effect,[30] Antiplasmodial activity,[31] Analgesic activity[32] Nephroprotective effect[33]
Allium rotundum	Trillin; Dideglucoeruboside B, Aginoside, Eruboside B, Yayoisaponin C,[34] Quercetin, Luteolin, Apigenin, Hyperin, Cinaroside, Apigenin-7-O-β-D-glucopyranoside, Scopoletin and Umbelliferone,[35] β-Carotene, Violaxanthin, Flavoxanthin, Lutein, Rubixanthin, and Zeaxanthin[36]	Tigogenin, Diosgenin, Gitogenin, β-Chlorogenin, Yucagenin, Agigenin[37]	Antioxidant and Antihemolytic effects[38]
Allium rubellum		Tigogenin[39]	Antioxidant activity[40]
Allium scorodoprasum			Antioxidant activity[41–43] Cytotoxicity, Antioxidant, Antimicrobial and anti-inflammatory activity[44]
Allium ursinum	Dimethyl disulfide, Di-2-propenyl disulfide, (Z)-Di-2-propenyl trisulfide, Di-2-propyl trisulfide, Di-2-propenyl tetrasulfide, (E)-Di-2-propenyl trisulfide, Methyl-2-propenyl trisulfide, Dimethyl trisulfide, 2-Vinyl-1,3-dithiane, (Z)-Methyl-2-propenyl disulfide, (E)-Propenyl propyl disulfide, (Z)-Propenyl propyl disulfide, 3,4-Dihydro-3-vinyl-1,2-dithiine, 2-Vinyl-4H-1,3-dithiine, Dimethyl tetrasulfide, Carotenoids, Allicin, Malondialdehyde (MDA), Kaempferol-3,7-di-O-β-D-glucopyranoside, Kaempferol-(acetylhexoside)-hexoside, Acetyl-kaempferol-deoxyhexose propylene sulfide, I-Ketose, Nystose and Inulin[45]		Antioxidant and Anti-tyrosinase activity[46,47] Cytotoxicity[48] Antifungal activity[49] Antiplatelet activity[50]
Allium victorialis	Allivictoside A–H[51] Allumine A and B, Cyclopent-1-enecarboxylate,[52] 22-Cyclohexyl-1-docosanol, Alliumonoate, β-Sitosterol acetate, β-Amyrin, β-Amyrin acetate, β-Sitosterol, β-Sitosterol 3-O-b-D-glucopyranoside[53]		Anti-neuroinflammatory effects[51] Chemopreventive and anticancer activities[54] Anti-diabetic activity[55]
Allium vineale	Deltonin, Ophiopogonin C and 7 other saponins[56] Allyl methyl disulfide, 1-Propenyl propyl disulfide, Dimethyl trisulfide, 2-Furaldehyde, 2,4-Dimethylthiophene, Benzaldehyde, (2E)-Hexenal, (3Z)-Hexenol, Methyl (Z)-1-propenyl disulfide, Methyl (E)-1-propenyl disulfide, Diallyl disulfide, Allyl (Z)-1-propenyl disulfide, Allyl (E)-1-propenyl disulfide, Methyl (methylthio)methyl disulfide, Allyl methyl trisulfide, 4-Methyl-1,2,3-trithiolane, Methyl propyl trisulfide, Methyl (Z)-1-propenyl trisulfide, Methyl (E)-1-propenyl trisulfide, Dimethyl tetrasulfide, Allyl (methylthio)methyl disulfide, Diallyl trisulfide, Allyl (Z)-1-propenyl trisulfide, p-Vinylguaiacol, Allyl propyl trisulfide, 5-Methyl-1,2,3,4-tetrathiane, Methyl (methylthio)methyl trisulfide, 4-Methyl-1,2,3,5,6-pentathiepane, Allyl methyl tetrasulfide[57]	Diosgenin, Nuatigenin and Isonuatigenin[56]	Antioxidant activity[57]

Biological activity

Numerous pharmacological studies have revealed that Allium species exhibit a variety of exciting activities, including cytotoxic, antioxidant, thrombolytic, antibacterial, and other beneficial effects.

Cytotoxic activity

Numerous experimental articles have discussed the cytotoxic activity of fractions and compounds isolated from Allium species. Khazaei et al. evaluated the cytotoxic activity of bulbs of Allium atroviolaceum on various cancer cell lines, including MCF7, MDA-MB-231, HeLa, and HepG2. Using the MTT cytotoxicity assay, they observed different growth responses across these cell lines. The IC50 values were as follows after 24, 48, and 72 hours of treatment:

- MCF-7 cells: 91.5, 88, and 75.7 µg/ml
- MDA-MB-231 cells: 149, 114, and 101 µg/ml
- HeLa cells: 154, 89.7, and 74.7 µg/ml
- HepG2 cells: 97, 70, and 58.7 µg/ml.[14]

Additionally, the anticancer effect of 4′,5,7-Trihydroxy-3′,5′-dimethoxyflavone (Tricin), initially isolated from Allium atroviolaceum, was investigated in combination with Docetaxel on the PC3 cell line. The IC50 values for Tricin and Docetaxel were 117.5 ± 4.4 µM and 0.1 ± 0.02 nM, respectively, as assessed by the MTT assay.[15]

The 80% ethanol extract of Allium gramineum flowers significantly inhibits the growth of breast adenocarcinoma cell lines, with IC50 values of 4.5 ± 0.7 µg/mL for MDAMB-231 and 4.8 ± 0.9 µg/mL for MCF-7 cells. This potent cytotoxicity is linked to saponins, which have an IC50 of about 3 µM.[18]

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Seven glycosides extracted from Allium leucanthum were tested for cytotoxicity against A549 and DLD-1 cell lines. Compounds 1-3 and 5 exhibited comparable cytotoxic effects on both cell lines, with IC50 values ranging from 5.6 to 8.2 µM for DLD-1 and 3.7 to 5.8 µM for A549.[20]

Demir et al. (2022) found that the extract of Allium scorodoprasum exhibits cytotoxic activity, with IC50 values of 82.78 µg/mL for MCF-7 cells and 76.53 µg/mL for MG-63 cells.[44]

Korga et al. (2019) evaluated the cytotoxicity of Allium ursinumextract on MKN28 and MKN74 cell lines, finding it toxic to both, with cell viability at 66.77 ± 3.00% and 31.55 ± 2.04%, respectively.[48]

The apoptosis-inducing potential of these extracts was evaluated using the MTT assay, DAPI staining, and DNA fragmentation assay in human colon cancer HT-29 cells.[54]

Antioxidant activity

Antioxidants play a crucial role in health by reducing disease risk and protecting the body against oxidative damage, which can lead to conditions such as diabetes, cancer, and neurodegenerative disorders. They help control oxidative processes that can deteriorate food quality due to reactive oxygen species (ROS) and free radical reactions.[45]

Antioxidants can naturally occur in plants, animals, and microorganisms, or they can be chemically synthesized. Higher plants are particularly rich in natural antioxidants like tocopherols and polyphenols, which are found in abundance in spices, herbs, fruits, vegetables, cereals, grains, seeds, teas, and oils.[58]

Numerous researches have been done on Allium species growing in Georgia to evaluate their antioxidant activity.

The DPPH scavenging test was used to evaluate the free radical scavenging activity of Allium affine hydroalcoholic extract, with an RC50 of 201 µg/mL, compared to 43 µg/mL for vitamin C.[7]

Isolated compounds from Allium gramineum, particularly isorhamnetin-3-O-β-D-glucopyranoside, showed strong scavenging effects with an IC50 of 20.1 ± 0.8 µM, while Prosapogenin A of dioscin and Deltonine had weak activity with IC50 values over 100 µM.[18]

Ebrahimzadeh et al. investigated the antioxidant activity of the aerial parts and bulbs of Allium paradoxum using eight in vitro assays. The total phenolic content was 62.7±3.5 mg/g in the aerial parts and 7.4±0.2 mg/g in the bulbs, while the total flavonoid content was 47.9±2.6 mg/g in the aerial parts and 23.61±1.1 mg/g in the bulbs. Both parts exhibited significant antioxidant activity and contained high levels of iron and manganese.[29]

Assadpour et al. investigated the antioxidant and antihemolytic effects of Allium rotundum's essential oil and methanolic extract. The methanolic extract displayed superior activity compared to the essential oil in reducing effects, nitric oxide-scavenging, DPPH scavenging (IC50 values: 284 ± 11.64 µg/mL for extract vs. 1264 ± 45.60 µg/mL for oil), nitric oxide-scavenging (IC50 values: 464 ± 19.68 µg/mL for extract vs. 1093 ± 38.25 µg/mL for oil), and Fe2+ chelating (IC50 values: 100 ± 3.75 µg/mL for extract vs. 1223 ± 36.25 µg/mL for oil). The extract and oil demonstrated significant dose-dependent H2O2 scavenging effects during H2O2-induced hemolysis (IC50: 786 ± 29.08 mg/mL for oil).[38]

Research by Motamed et al. revealed that Allium rubellum had the highest deoxyribose degradation inhibitory activity among the ten plants studied, with a 56.45 ± 1.56% inhibition.[40]

The analyses revealed that the bulb and leaf parts of A. scorodoprasum contained significant antioxidants. Total phenolic content ranged from 254.51 to 927.81 mg/kg in bulbs and 1929.05 to 19645.24 mg/kg in leaves. FRAP values ranged from 0.80 to 5.20 mM TE/g in bulbs and 14.31 to 47.83 mM TE/g in leaves. DPPH free radical scavenger effect varied from 0.99 to 9.02 µmol TE/g in bulbs and 36.61 to 241.06 µmol TE/g in leaves. Ascorbic acid content ranged from 29.14 to 314.01 mg/kg in bulbs and 200.64 to 1383.16 mg/kg in leaves. These findings highlight the abundant antioxidant richness of A. scorodoprasum subsp. rotundum leaves.[41] Antioxidant enzyme activity analysis of A. scorodoprasumrevealed notable results: compared to A. sativum. A. scorodorpasumexhibited an increase in catalase activity. Moreover, GPx and GSH-Px activities were detected in bulbs across all investigated Allium species. Among them, wild A. scorodoprasum displayed the highest GPx activity, showing a remarkable increase compared to A. sativum.[43]

The antioxidant and anti-tyrosinase activity of different A. ursinumextracts and their metal complexes were evaluated using DPPH radical scavenging and mushroom tyrosinase assay.[46] The outcomes indicated that the polarity of the extracting solvents and the solubility of the phenolic compounds in these solvents significantly impacted the yield and phenolic content as the antioxidant and anti-tyrosinase activities.[46]

Four flavonoids were isolated (1-4) From the water extract of A. vineale.[57] The assessment of total antioxidant activity was conducted using the ferric thiocyanate method in the linoleic acid system for both the crude extract and isolated compounds 1, 2, and 3, as well as Trolox and α-tocopherol. During the 20-hour incubation period at a concentration of 80 µg/ml, the activities were observed to be 64.8%, 79%, 75.6%, 82.2%, 75.7%, and 31.4%, respectively, for the crude extract, flavonoids 1, 2, and 3, Trolox, and α-tocopherol.[57]

Other biological activities

In addition to the activities previously mentioned, Allium species possess several other significant biological properties.

For instance, steroidal saponins and sapogenins with thrombolytic activity, such as diosgenin, tigogenin, and ruscogenin, have been isolated from A. affine.[7] Research indicates that A. atroviolaceum extract exhibits excellent antiplatelet activity, effectively inhibiting platelet aggregation

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in vitro induced by ARA and ADP, with IC50 values of 0.4881 (0.4826–0.4937) mg/mL and 0.4945 (0.4137–0.5911) mg/mL, respectively.[11] Similarly, the leaf extract of A. ursinum demonstrates antiplatelet activity. In vitro, testing of antiplatelet activity was conducted using light transmission aggregometry, with induction by ADP, collagen, A23187, epinephrine, and arachidonic acid (ARA).[50]

The antibacterial properties exhibited by aqueous and alcoholic extracts of A. atroviolaceum have also been investigated. Results show that after 48 hours of incubation, the minimum inhibitory concentration (MIC) of the aqueous extract against S. aureus was 3.125 mg/mL, while the alcoholic extract had an MIC of 6.25 mg/mL. For Escherichia coli, the MIC of the aqueous extract was 3.125 mg/mL, and the alcoholic extract's MIC was 12.50 mg/mL.[12] Additionally, the concentrated extract from A. scorodoprasum was tested against various microorganisms relevant to food technology, showing notable antimicrobial activity. The extract demonstrated the highest antibacterial activity against S. aureus (20.00 mm inhibition zone) and significant antifungal activity against A. niger (18.50 mm inhibition zone). However, E. coli exhibited a high resistance (MIC of 7.5 mg/mL) to the A. scorodoprasum extract. Among the tested bacteria and mold, A. scorodoprasum extract showed the most potent antibacterial effect against S. aureus and the most substantial antifungal effect against A. niger.[44]

Research by Mskhiladze et al. demonstrated that although the total steroid saponins from A. leucanthum show moderate antibacterial activity, the spirostanol fraction exhibits vigorous activity. At the same time, bacterial strains were resistant to the furostanol fraction. Glycosides of β-chlorogenine displayed more potent activity than agigenin glycosides.[26]

Phytochemical studies of A. paradoxum, particularly its saponin constituents, led to the isolation and identification of a dioscin-related steroidal saponin from the plant's bulbs by Rezaee et al. This compound exhibited significant leishmanicidal effects on promastigotes of L. majorat in both 10 and 50 µg/mL concentrations.[28]

Further investigation into A. leucanthum by Mskhiladze et al. found that the spirostanol fraction was ten times more active against Leishmania amastigotes than human cells.[25]

Extracts from the aerial parts and bulbs of A. paradoxum at doses of 500 and 750 mg/kg intraperitoneally demonstrated a significant hepatoprotective effect by reducing serum aspartate aminotransferase (AST) and alkaline phosphatase (ALP) levels.[30]

In vitro anti-plasmodial activity of A. paradoxum extract was most effective at an 80 µg/mL dosage, resulting in 60.43% parasite growth inhibition compared to control groups. At 40 µg/mL, growth inhibition was 52.48%, also statistically significant compared to controls.[31]

The analgesic activity of methanolic extracts of A. paradoxum was evaluated in male Balb/C mice using acetic acid-induced writhing and hot plate tests. The extracts demonstrated notable analgesic activity in both experimental models. In the writhing test, the extract exhibited significant analgesic effects across all tested doses compared to the control group, reducing writhing behaviors ($p<0.001$). In the hot plate test, the extract notably elevated pain thresholds by the 30th minute ($p<0.001$) compared to the control group.[32]

The nephroprotective effects of extracts derived from the aerial parts and bulbs of A. paradoxum were evident against gentamicin-induced nephrotoxicity in mice. Both extracts administered at 200 mg/kg/day exhibited protective effects by modulating blood urea nitrogen and creatinine levels.[33]

Woo et al. investigated the inhibitory activities of compounds isolated from A. victorialis(allivictoside A–H) on neuroinflammation by measuring NO levels in LPS-activated BV-2 cells. Compounds 2 and 6 significantly inhibited NO production, indicating that flavonoid derivatives from A. victorialispossess anti-neuroinflammatory properties.[51]

The anti-inflammatory activity of A. scorodoprasum extract was evaluated, showing that the extract concentrations required to inhibit 50% of LOX and XO activities were 9.75 and 9.71 mg extract/mL, respectively. The IC50 values of quercetin and allopurinol for LOX and XO were 1.22 and 2.69 mg/mL, respectively.[44]

CONCLUSIONS

In conclusion, this review compiles available literature on plants from the genus Allium growing in Georgia, focusing on the compounds isolated from these species and their biological activity. The gathered texts show that the major constituents of Allium plants in this region are saponins, phenolic, and sulfur compounds, which likely contribute significantly to their diverse pharmacological potentials.

No phytochemical studies have been conducted on several species of the genus Allium growing in Georgia, including A. ledchanense, A. otchiauriae, A. saxatile, A. moschatum, A. aucheri, A. gracilescens, A. rupetchii, A. tauricola, A. pseudoflavum, A. candolleanum, A. albovianum, A. ponticum, A. rupestre, A. karsianum, A. chevsuricum, A. globosum, A. oreophilum, A. pseudostrictum, A. kunthianum, A. paczoskianum, A. szovistii, A. cardiostemon. Therefore, future comprehensive studies are necessary to enhance understanding of these plants' pharmacological activities, chemical constituents, and effectiveness.

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