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Review Article

Phytochemical and Pharmacological Review of *Allium* Species from Georgia

Giorgi jgerenaia[1,2], Michel Frederich[2], Lasha Mskhiladze[1*]

[1]Department of Pharmacognosy and Botany, Tbilisi State Medical University, Tbilisi, Georgia

[2]Department of Pharmacy, Centre Interdisciplinaire de Recherche du Médicament (CIRM), University of Liège, Liège, Belgium

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ABSTRACT

The aim of the research was phytochemical and pharmacological review of the species of genus *Allium*, growing in Georgia.

The material of the research was scientific sources and articles, where was described, phytochemical constituents and pharmacological activity of these plants.

36 species of genus *Allium* are described in Georgia. Among them 5 species are endemic for Georgia and 2 for Caucasus region. Many biologically active compounds are isolated from the studied species of this genus. Among them, more than 20 saponins, also 11 different types of sapogenins, flavonoids, sulphuric compounds, etc.

In the literature, there are many biological studies on these isolated compounds. According to the results of the research, extracts of the plants genus *Allium*, as well as, the individual compounds have important pharmacological activity, for example: Cytotoxic activity, antioxidant activity, antimicrobial activity, hepatoprotective activity, fibrinolytic activity, etc.

Among the 36 species of genus *Allium*, common in Georgia, 22 have not been studied. Chemical structure and biological activity of compounds in these species have not been determined.

In future, detailed and extensive studies are certainly required to improve the knowledge about the pharmacological activities, chemical constituents and efficacy of these plants.

Keywords: *Allium* species, Secondary metabolites, Biological activity

***Correspondence:** Lasha Mskhiladze, Department of Pharmacognosy and Botany, Tbilisi State Medical University, Tbilisi, Georgia, E-mail: l.mskhiladze@tsmu.edu

INTRODUCTION

The genus *Allium* belongs to family Alliaceae. The plants of the genus *Allium* are very important herbaceous plants. This genus involves up to 800 species, growing especially in the northern hemisphere (Gagnidze RI, *et al*., 2005).

Plants of the genus *Allium* have a long history of traditional uses worldwide dating back to the early ages as food and medicine. The story of *Allium* cultivation starts over 4000 years ago in ancient Egypt (Rahman K, 2001). *Allium* species are widely used in Georgian traditional medicine as an antifungal, antiseptic and antibacterial remedy.

Georgia has very rich and diverse vegetation. This is due to diverse and contrasting physical and geographical conditions of the country, its complex geological past, and its location on the crossroad of different botanical and geographical provinces.

The flora of the Caucasus, and especially that of Georgia, is highly endemic. In the region, about 21% of the flora (900 species) is endemic. Out of them, about 600 are Caucasian endemic species and about 300 species are endemic to Georgia. Also, there is a high level of endemic genera with 17 endemic and sub endemic genera.

The aim of this review is to provide comprehensive information about phytochemistry and pharmacological activity of the plants belonging to the genus of *Allium*, growing in Georgia.

LITERATURE REVIEW

Allium species in Georgia

According to the book of Gagnidze RJ, *et al*. "Vascular Plants of Georgia" 36 species of genus *Allium* are described in Georgia. Among them 5 species are endemic for Georgia and 2 for Caucasus region (Gagnidze RI, *et al*., 2005) *(Table 1)*.

Table 1: List of plants genus *Allium* described in Georgia

Scientific names of plants	
A. affine Ledeb.	*A. otschiauriae* Tscholok.
A. albidum Fisch. Ex Bieb	*A. paczoskianum* Tuzs.
A. albovianum Vved	*A. paradoxum* (Bieb.) G. Don. F
A. atroviolaceum Boiss	*Scilla paradoxa* M Bieb.
A. aucheri Boiss	*A. ponticum* Miscz. Ex Grossh.
A. candolleanum Albov	*A. pseudoflavum* Vved
A. cardiostemon Fisch. Et C.A. Mey	*A. pseudostrictum* Albov
A. chevsuricum Tscholok	*A. rotundum* L.
A. erubescens K. Koch	*A. rubellum* Bieb
A. fuscoviolaceum Fomin	*A. rupestre* Stev
A. globosum Bieb. Ex DC	*A. ruprechtii* Boiss
A. gracilescens Somm. Et Levier	*A. saxatile* Bieb
A. gramineum K. Koch	*A. scorodoprasum* L. (*A. waldsteinii* G. Don f.)
A. karsianum Fomin	*A. jajlae* Vved
A. kunthianum Vved.	*A. szovitsii* Regel
A. ledschanense Conrath et Freyn	*A. tauricola* Bieb (*A. subquinqueflorum* Boiss)
A. leucanthum K. Koch	*A. ursinum* L.
A. moschatum L.	*A. victorialis* L.
A. oreophilum C.A. Mey	*A. vineale* L.

A. albovianum; A. candolleanum; A. chevsuricum; A. gracilescens and *A. otschiauriae* are endemic species of Georgia, *A. ledschan-*

ense and *A. leucanthum* are endemic species of Caucasus region.

Phytochemistry of plants genus Allium, growing in Georgia

From plants genus *Allium* growing in Georgia, were isolated following compounds: Atroviolaceoside, Eruboside B, isorhamnetin-3-O-β-D-glucopyranoside; diosgenin-3-O-α-rhamnopyranosyl-(1→2)-β-D-glucopyranoside (Prosapogenin A of dioscin), Deltonine, Yayoisaponin C, Aginoside, Leucospiroside A, β-sitosterol 3-O-β-glucopyranoside, quercetin 3-O-β-glucopyranoside, isorhamnetin 3,4'-di-O-β-glucopyranoside, isorhamnetin 3,7-di-O-β-glucopyranoside, Astragalin (Ghavam-Haghi F and Dinani MS, 2017), 2-Methoxy tyrosol, Trillin, Dideglucoeruboside B, Aginoside, Allicin; Malondialdehyde (MDA); Carotenoids; Kaempferol-3,7-di-O-β-D-glucopyranoside; Kaempferol-(acetylhexoside)-hexoside; Acetyl-kaempferol-deoxyhexose propylene sulfide; Dimethyl disulfide; Dimethyl thiophene- (E)-methyl-2-propyl disulfide; (Z)-Methyl-2-propenyl disulfide; Dimethyl trisulfide; Di-2-propenyl disulfide; 2-Vinyl-1,3-dithiane; (E)-Propenyl propyl disulfide; (Z)-Propenyl propyl disulfide; Methyl-2-propenyl trisulfide; 3,4-Dihydro-3-vinyl-1,2-dithiine; 2-Vinyl-4H-1,3-dithiine; Dimethyl tetrasulfide; (E)-Di-2-propenyl trisulfide; (Z)-Di-2-propenyl trisulfide; Di-2-propyl trisulfide; Di-2-propenyl tetrasulfide; Inulin, Nystose; I-Ketose; Allivictoside A–H; Allumine A and B; Cyclopent-1-enecarboxylate; Alliumonoate (Khan S, *et al.*, 2011); β-Amyrin acetate; β-Sitosterol acetate; 22-Cyclohexyl-1-docosanol; β-Amyrin; β-Sitosterol; β-Sitosterol 3-O-b-D-glucopyranoside; Ophiopogonin C; 2-Furaldehyde; (2E)-Hexenal; (3Z)-Hexenol; 2,4-Dimethylthiophene; Allyl methyl disulfide; Methyl (Z)-1-propenyl disulfide; methyl (E)-1-propenyl disulfide; Benzaldehyde; Dimethyl trisulfide; Diallyl disulfide; Allyl (Z)-1-propenyl disulfide; Allyl (E)-1-propenyl disulfide; 1-Propenyl propyl 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; Allyl methyl tetrasulfide; Allyl (methylthio)methyl trisulfide; 4-Methyl-1,2,3,5,6-pentathiepane;

From these species were also isolated different types of sapogenins: Diosgenin, Tigogenin, Ruscogenin, Hecogenine, Atroviolacegenin, β-chlorogenin, Gitogenin, Yucagenin, Agigenin, Nuatigenin and Isonuatigenin (Zolfaghari B, *et al.*, 2006).

Detailed information about the plant species, their composition and biological activities are listed in *Table 2*.

Table 2: List of compounds, reported in *Allium* species, growing in Georgia

Species	Compounds	Sapogenin	Biological activity
Allium affine		Diosgenin, Tigogenin, Ruscogenin ((Sobolewska D, *et al.*, 2016)	Antioxidant activity; Fibrinolytic activity (Sadeghi M, *et al.*, 2017)
Allium albidum		Diosgenin, Ruscogenin (Pkheidze TA, *et al.*, 1971); Hecogenine (Kravets SD, *et al.*, 1990)	
Allium atroviolaceum	Atroviolaceoside (Zolfaghari B, *et al.*, 2006)	Atroviolacegenin (Zolfaghari B, *et al.*, 2006)	Antiplatelet activity (Lorigooini Z, *et al.*, 2015); Antibacterial activity (Hafeznia B, *et al.*, 2018); Cytotoxic and antiproliferative effect (Khazaei S, *et al.*, 2017; Khazaei S, *et al.*, 2013; Ghasemi S, *et al.*, 2019)
Allium erubescens	Eruboside B (Chincharadze DG, *et al.*, 1979)	β-chlorogenin (Chincharadze DG, *et al.*, 1979)	
Allium fuscoviolaceum		Diosgenin (Eristavi LI, 1972)	
Allium gramineum	isorhamnetin-3-O-β-D-glucopyranoside; diosgenin-3-O-α-rhamnopyranosyl-(1-2)-β-D-glucopyranoside (Prosapogenin A of dioscin); Deltonine (Mskhiladze L, *et al.*, 2021); β-sitosterol 3-O-β-glucopyranoside; quercetin 3-O-β-glucopyranoside; Isorhamnetin 3,4'-di-O-β-glucopyranoside; isorhamnetin 3,7-di-O-β-glucopyranoside (Mskhiladze L, *et al.*, 2016); Eruboside B (Kravets SD, *et al.*, 1990);		Cytotoxicity and Antioxidant activity (Mskhiladze L, *et al.*, 2021)
Allium leucanthum	Yayoisaponin C; Eruboside B; Aginoside; Leucospiroside A; Three unknown saponins (Mskhiladze L, *et al.*, 2008); (25R)-5α-spirostane-3β,6β-diol-O-β-D-glucopyranosyl-(1-2)-O-β-D-glucopyranosyl-(1-4)-β-D-galactopyranoside; Leucofuranoside A (Mskhiladze L, *et al.*, 2008; Mskhiladze L, *et al.*, 2015; Mskhiladze L, *et al.*, 2007; Mskhiladze L, *et al.*, 2007)	Diosgenin; β-chlorogenin; Yucagenin; Agigenin (Mskhiladze L, *et al.*, 2007)	Cytotoxic activity (Mskhiladze L, *et al.*, 2008); Antifungal activity; Antileishmanial activity (Mskhiladze L, *et al.*, 2008); Antibacterial activity (Mskhiladze L, *et al.*, 2008);

Allium paradoxum	Astragalin; 2-Methoxy tyrosol (Ghavam-Haghi F and Dinani MS, 2017)	Dioscin related saponins (Rezaee F, *et al*., 2018)	Leishmanicidal activity (Rezaee F, *et al*., 2018); Antioxidant activity (Ebrahimzadeh MA, *et al*., 2010); Hepatoprotective effect (Nabavi SM, *et al*., 2012); Antiplasmodial activity (Elmi T, *et al*., 2021); Analgesic activity (Maghsoodi R, *et al*., 2018); Nephroprotective effect (Nabavi SF, *et al*., 2012);
Allium rotundum	Trillin; Dideglucoeruboside B; Aginoside; Eruboside B; Yayoisaponin C (Maisashvili MR, *et al*., 2008); Quercetin, Luteolin, Apigenin, Hyperin, Cinaroside, Apigenin-7-O-β-D-glucopyranoside, Scopoletin and Umbelliferone (Maisashvili MR, *et al*., 2009); β-Carotene, Violaxanthin, Flavoxanthin, Lutein, Rubixanthin, and Zeaxanthin (Maisashvili MR, *et al*., 2009)	Tigogenin; Diosgenin; Gitogenin; β-Chlorogenin; Yucagenin; Agigenin (Maisashvili MR, *et al*., 2007)	Antioxidant and Antihemolytic effects (Assadpour S, *et al*., 2016)
Allium victorialis	Allivictoside A–H (Woo KW, *et al*., 2012); Allumine A and B; Cyclopent-1-enecarboxylate (Khan S, *et al*., 2013); Alliumonoate; β-Amyrin acetate; β-Sitosterol acetate, 22-Cyclohexyl-1-docosanol, β-Amyrin, β-Sitosterol, β-Sitosterol 3-O-b-D-glucopyranoside; (Khan S, *et al*., 2011)		Anti-neuroinflammatory effects (Woo KW, *et al*., 2012); Chemopreventive and anticancer activities (Kim YS, *et al*., 2017); Anti-diabetic activity (Kim YS, *et al*., 2013);
Allium vineale	Ophiopogonin C; Deltonin and 7 other saponins (Chen S and Snyder JK, 1989); 2-Furaldehyde; (2E)-Hexenal; (3Z)-Hexenol; 2,4-Dimethylthiophene; Allyl methyl disulfide; Methyl (Z)-1-propenyl disulfide; methyl (E)-1-propenyl disulfide; Benzaldehyde; Dimethyl trisulfide; Diallyl disulfide; Allyl (Z)-1-propenyl disulfide; Allyl (E)-1-propenyl disulfide; 1-Propenyl propyl 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; Allyl methyl tetrasulfide; Allyl (methylthio) methyl trisulfide; 4-Methyl-1,2,3,5,6-pentathiepane	Diosgenin, Nuatigenin and Isonuatigenin (Chen S and Snyder JK, 1989)	Antioxidant activity

Biological activity

The results from many pharmacological studies revealed several interesting activities of *Allium* species, for example cytotoxic, antioxidant, thrombolytic, antibacterial, and other.

Cytotoxic activity

Cytotoxic activity of fractions and compounds isolated from *Allium* species was discussed in many experimental articles. In research Khazaei S, *et al*. evaluated the cytotoxic activity of bulb of *Allium atroviolaceum* in MCF7 (Michigan Cancer Foundation-7) and MDA-MB-231 (Human Mammary Carcinoma), HeLa (Henrietta Lacks) and HepG2 (Liver Hepatocellular Carcinoma) cell lines (Khazaei S, *et al*., 2013). The MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-2H-tetrazolium bromide) cytotoxicity assay exhibited different growth responses in MCF7, MDA-MB-231, HeLa, and HepG2 cells. The IC50 (Half-maximal inhibitory concentration) values after 24, 48, and 72 h of treatment were 91.5, 88, and 75.7 µg/ml for MCF-7 cells, 149, 114, and 101 µg/ml for MDA-MB-231, 154, 89.7, and 74.7 µg/ml for HeLa cells and 97, 70, and 58.7 µg/ml for HepG2, respectively (Khazaei S, *et al*., 2017). In the study, the anticancer effect of 4′,5,7-Trihydroxy-3′,5′-dimethoxyflavone (Tricin) was investigated with Docetaxel on PC3 (prostate cancer) cell line. Tricin was initially isolated from the *Allium atroviolaceum*. IC50 of Tricin and Docetaxel were assessed 117.5 ± 4.4 µM and 0.1 ± 0.02 nM by MTT assay, respectively (Ghasemi S, *et al*., 2019).

The 80% EtOH extract of the flowers of *Allium gramineum* has been shown to strongly inhibit the growth of breast adenocarcinoma cell lines, with an IC50 of 4.5 ± 0.7 µg/mL for MDA-MB-231 and 4.8 ± 0.9 µg/mL for MCF-7 cells. The cytotoxic activity was related to the saponins which exhibited a potent cytotoxicity, with an IC50 around 3 µM (Mskhiladze L, *et al*., 2015).

The cytotoxic activities of 7 glycosides extracted from *Allium leucanthum* were evaluated against A549, DLD-1 (Colorectal adenocarcinoma). According to the results, compounds 1-3 and 5 possess a relatively similar cytotoxicity against both tumor cell lines, with IC50 values ranging from 3.7 to 5.8 µM for A549 and 5.6 to 8.2 µM for DLD-1 (Mskhiladze L, *et al*., 2008; Mskhiladze L, *et al*., 2016).

Demir T, *et al*. have also determined that the extract of *A. scorodoprasum* has cytotoxic activity (Demir T, *et al*., 2022). The amounts of the *A. scorodoprasum* L. extract inhibiting the 50% activity of MCF-7 and MG-63 cells were recorded as 82.78 and 76.53 µg/mL, respectively (Demir T, *et al*., 2022).

Cytotoxicity of the extract of *A. ursinum* was evaluated in the research by Korga A, *et al*. on MKN28 (Gastric Cancer) and MKN74 (Gastric adenocarcinoma) cell lines. The extract of *A. ursinum* was toxic for both cell lines

66.77 ± 3.00% viability and 31.55 ± 2.04% viability respectively (Korga A, *et al*., 2019).

The apoptosis-inducing capabilities of the extracts were evaluated by the 3-(4,5-dimethyl-2-thiazolyl)- 2,5-diphenyl-2H-tetrazolium bromide assay, 4',6-diamidino-2-phenylindole staining, and the DNA fragmentation assay in human colon cancer HT-29 cells (Chung HY and Park YK, 2017).

Antioxidant activity

Antioxidants play important roles in health. They are also used to reduce disease risk and can protect the body against oxidative damages, which cause several diseases (diabetes, cancer, and neurodegenerative disorders, etc.). Antioxidants can control oxidative processes, leading to food quality descent caused by Reactive Oxygen Species (ROS) and free radical reactions in the body (Kurnia D, *et al*., 2021).

Antioxidants may occur naturally in plants, animals and microorganisms or may be synthesized by chemical means. Higher plants and their constituents provide a rich source of natural antioxidants, such as tocopherols and polyphenols which are found abundantly in spices, herbs, fruits, vegetables, cereals, grains, seeds, teas and oils (Shahidi F and Zhong Y, 2015).

Many researches have been done on *Allium* species, which are growing in Georgia to evaluate their antioxidant activity.

DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging test was used for evaluation of free radical scavenging activity of *A. affine* hydroalcoholic extract. RC50 for Vit C as a standard antioxidant was 43 µg/mL. The scavenging effect of the plant extract RC50 was found to be 201 µg/mL (Sadeghi M, *et al*., 2017).

Anti-oxidant activity of isolated compounds from *Allium gramineum* were evaluated, a strong scavenging effect was obtained with isorhamnetin-3-O-β-D-glucopyranoside with the lowest IC50 values of 20.1 ± 0.8 µM while both Prosapogenin A of dioscin and Deltonine exhibited very weak radical scavenging activity as the IC50 values were higher (>100 µM) (Mskhiladze L, *et al*., 2015).

Antioxidant activity of the aerial part and bulbs of *Allium paradoxum* was investigated by eight *in vitro* assay systems by Ebrahimzadeh MA, *et al*. The total phenolic content of aerial parts and bulbs was 62.7 ± 3.5 and 7.4 ± 0.2 mg gallic acid equivalent/g of extract, respectively and the total flavonoid contents of aerial parts and bulbs was 47.9 ± 2.6 and 23.61 ± 1.1 mg quercetin equivalent/g of extract powder, respectively. The aerial and bulb extracts of *A. paradoxum* exhibited good but different levels of antioxidant activity in all the models studied, both cell-free and in cell systems. They both contained high iron and manganese content (Ebrahimzadeh MA, *et al*., 2010).

Assadpour S, *et al*. have investigated *in vitro* antioxidant and antihemolytic effects of the essential oil and methanolic extract of *Allium rotundum* (Maisashvili MR, *et al*., 2008; Maisashvili MR, *et al*., 2009; Maisashvili MR, *et al*., 2007; Maisashvili MR, *et al*., 2009). IC50 for DPPH radical-scavenging activity were 284 ± 11.64 for methanol extract and 1264 ± 45.60 µg ml^{-1} for essential oil, respectively. The extract has shown better reducing effects versus essential oil. The extract also demonstrated better activity in nitric oxide-scavenging activity. IC50 were 464 ± 19.68 for extract and 1093 ± 38.25 µg ml^{-1} for essential oil. The extract shows better activity than essential oil in Fe^{2+} chelating system. IC50 were 100 ± 3.75 for extract and 1223 ± 36.25 µg ml^{-1} for essential oil. The *A. rotundum* extract and essential oil showed significant H_2O_2 scavenging effects at dose-dependent manners in H_2O_2 induced hemolysis. IC50 was 786 ± 29.08 mg ml^{-1} for essential oil (Assadpour S, *et al*., 2016).

The research of Motamed SM and Naghibi F has showed that all the extracts had moderate inhibitory activity against deoxyribose (DR) damage. Among the 10 plants, *A. rubellum* showed the highest DR degradation inhibitory activity (56.45% ± 1.56%) (Motamed SM and Naghibi F, 2010).

As a result of the analyses conducted, in the bulb and leaf parts of the *A. scorodoprasum*, total phenolic matter values were 254.51-927.81 and 1929.05-19645.24 mg/kg, FRAP (Ferric Reducing Antioxidant Power) was 0.80-5.20 and 14.31-47.83 mM TE/g, DPPH free radical scavenger effect was 0.99-9.02 and 36.61-241.06 µmol TE/g and ascorbic acid content was 29.14-314.01 mg/kg and 200.64-1383.16 mg/kg, respectively (Mollica A, *et al*., 2018). These data reveal that the leafs of *A. scorodoprasum subsp. rotundum* plants are rich in antioxidants (Taşcı B, *et al*., 2019). Antioxidant enzyme activity of *A. scorodoprasum* has showed following results: An increase in Catalase activity, compared with *A. sativum*, was observed in *A. scorodorpasum* (36.8%). The GPx (Glutathione peroxidase) and GSH-Px (Plasma glutathione peroxidase) activities were also detected in bulbs of all *Allium* species investigated. The highest GPx activity was detected in wild *A. scorodoprasum* (641.7% increase compared with *A. sativum*) (Štajner D, *et al*., 2008).

The antioxidant and anti-tyrosinase activity of different *A. ursinum* extracts and their metal complexes were evaluated using DPPH radical scavenging assay and mushroom tyrosinase assay, respectively (Nikkhahi M, *et al*., 2018). The results showed that the polarity of extracting solvents and the solubility of the phenolic compounds in the solvents had a noticeable influence on the yield, phenolic content, antioxidant and anti-tyrosinase activity (Bârlă GF, *et al*., 2016; Nikkhahi M, *et al*., 2018).

From water extract of *A. vineale* 4 flavonoids were isolated (1-4) (Chen S and Snyder JK, 1989; Rissato SR, *et al*., 2007). Total antioxidant activities of crude extract, isolated compounds 1, 2, 3, Trolox and α-tocopherol were determined by the ferric thiocyanate method in the linoleic acid system. The activities of 80 µg/ml concentration over the incubation period (20 h) of crude extract, flavonoids 1, 2, 3, Trolox and α-tocopherol were found to be 64.8%, 79%, 75.6%, 82.2%, 75.7% and 31.4%, respectively (Rissato SR, *et al*., 2007).

Other biological activities

Except above-described activities, *Allium* species possess other biological properties which are equally important.

Some steroidal saponins and sapogenins with thrombolytic activity including diosgenin, tigogenin and ruscogenin have been isolated from *A. affine* (Sobolewska D, *et al*., 2016; Sadeghi M, *et al*., 2017; Pkheidze TA, *et al*., 1971; Chincharadze DG, *et al*., 1979; Eristavi LI, 1972; Mskhiladze L, *et al*., 2007; Mskhiladze L, *et al*., 2007). Study has found that *A. atroviolaceum* extract has excellent antiplatelet activity and is able to inhibit platelet aggregation *in vitro* induced by ARA and ADP with each IC50 value of 0.4881 (0.4826-0.4937) and 0.4945 (0.4137-0.5911) mg/mL (Lorigooini Z, *et al*., 2015). Antiplatelet activity is also described in the leaf extract of *A. ursinum*. Testing of antiplatelet activity *in vitro* was conducted using light transmission aggregometry which has been induced with Adenosine Diphosphate (ADP), collagen, A23187, epinephrine and Arachidonic Acid (ARA) (Hiyasat B, *et al*., 2009).

Antibacterial effect of aqueous and alcoholic extracts of *A. atroviolaceum* was investigated, results has shown that After 48 hours' incubation, the minimum inhibitory concentration of aqueous and alcoholic extractions against *S. aureus* was 3.125 mg ml^{-1} and 6.25 mg ml^{-1} receptively. Also, the minimum inhibitory concentration result of aqueous and alcoholic extractions against *Escherichia coli* was 3.125 mg ml^{-1} and 12.50 mg ml^{-1} receptively (Hafeznia B, *et al*., 2018). The antimicrobial activities of the concentrated extract, obtained from *A. scorodoprasum* under optimal conditions, were tested against different microorganisms that are important in terms of food technology (*S. aureus*; 20.00 mm, *E. faecalis*; 17.50 mm, *E. coli*; 14.00 mm, *A. niger*; 18.50 mm, *A. flavus*; 14.5 mm). MIC (Minimum Inhibitory Concentration) results showed that only *E. coli* presented a high resistance (7.5 mg/mL) against *A. scorodoprasum* L. extract. Among the selected bacteria and mold, *A. scorodoprasum* L. extract indicated the highest antibacterial activity against *S. aureus* and the highest antifungal activity against *A. niger* (Demir T, *et al*., 2022; Pacirc M, *et al*., 2011).

Results of the research of Mskhiladze L, *et al*. has demonstrated that the sum of steroid saponins from *A. leucanthum* have medium activity towards bacteria, spirostanol fraction has strong activity (Ismailov AI, *et al*., 1976). Bacterial strains were resistant towards furostanol fraction (Kravets SD, *et al*., 1990). Glycosids of β-chlorogenine are characterized by stronger activity, than agigenin glycosids (Mskhiladze L, *et al*., 2008).

Phytochemical study of *A. paradoxum*, specially the saponin constituents of the plant, resulted in isolation and identification of a Dioscin related steroidal saponin from bulbs of the plant by Rezaee F, *et al*. The leishmanicidal effects of the isolated compound was evaluated, which interestingly exhibited its significant activity on promastigotes of *L. major* with both 10 and 50 μg/mL concentrations (Rezaee F, *et al*., 2018).

Antileishmanial activity was also studied in *A. leucanthum* by Mskhiladze L, *et al*. obtained results suggested that the spirostanol fraction, extracted from the plant, was ten-fold more active on *Leishmania* amastigotes than on human cells (Mskhiladze L, *et al*., 2008).

Aerial parts and bulbs extracts of *A. paradoxum* at the doses 500 and 750 mg/kg, i.p. offered significant hepatoprotective effect by reducing the serum marker enzymes, serum Aspartate aminotransferase (AST) and alkaline Phosphatase (ALP) (Nabavi SM, *et al*., 2012).

The results of *in vitro* anti-plasmodial activity demonstrated that the highest significant efficacy of *A. paradoxum* extract was related to 80 μg/mL dosage which led to a 60.43%-growth inhibition of parasites in cultures compared to the control groups. The growth inhibition was also statistically significant with 52.48% when 40 μg/mL was administrated in comparison with the control groups (Elmi T, *et al*., 2021).

Analgesic activity of methanolic extract of *A. paradoxum* was evaluated by Hot plate and acetic acid induced Writhing test on male Balb/C mice. Extracts showed significant Analgesic activity in both models. In writhing test extract showed significant analgesic activity in all doses tested compered to control group and reduced writhing behaviors ($p<0.001$). In Hot plate test Extract caused increase in pain threshold compared to control specifically in 30^{th} minute of the test ($p<0.001$) (Maghsoodi R, *et al*., 2018).

The curative effect of extracts from the aerial parts and bulbs of *A. paradoxum* against gentamicin-induced renotoxicity in mice was determined. Both extracts at the dose 200 mg kg (-1) day (-1) offered nephroprotective effect by change in the blood urea nitrogen and creatinine (Nabavi SF, *et al*., 2012).

During the research Woo *et al*. have investigated the inhibitory activities of isolated compounds (allivictoside A-H (1-8)) from *A. victorialis* on neuroinflammation by measurement of produced NO levels in LPS (Lipopolysaccharide)-activated BV-2 cells, Compounds 2 and 6, from the leaves of *A. victorialis* significantly inhibited NO production in LPS-activated BV-2 cells. These results indicate that flavonoid derivatives from *A. victorialis* have anti-neuroinflammatory effects (Woo KW, *et al*., 2012; Khan S, *et al*., 2013; Kim YS, *et al*., 2013).

Anti-inflammatory activity of *A. scorodoprasum* extract was evaluated. The extract concentration inhibiting the 50% activity LOX (Lipoxygenase) and XO (Xanthine oxidase) were found as 9.75 and 9.71 mg extract/mL, respectively while the quercetin and allopurinol IC50 values for LOX and XO were 1.22 and 2.69 mg/mL, respectively (Demir T, *et al*., 2022).

CONCLUSION

In this review, we have complied available literature on plants genus *Allium* growing in Georgia, considering the compounds, isolated from these species and their biological activity.

From the available literature, it is evident that the major constituent of plants genus *Allium* are saponins, phenolic and Sulphur compounds which probably play main role in pharmacological activities.

In the literature, no phytochemical studies were provided on these following species of genus *Allium*, growing in Georgia: *A. albovianum, A. aucheri, A. candolleanum, A. cardiostemon, A. chevsuricum, A. globosum, A. gracilescens, A. karsianum, A. kunthianum, A. ledchanense, A. moschatum, A. oreophilum, A. otchiauriae, A. paczoskianum, A. ponticum, A. pseudoflavum, A. pseudostrictum, A. rupestre, A. rupetchii, A. saxatile, A. szovistii, A. tauricola*. Therefore, in future, detailed and extensive studies are certainly required to improve the knowledge about the pharmacological activities, chemical constituents and efficacy of these plants.

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