Review Article

The Therapeutic Properties, Ethno pharmacology and Phyto-chemistry of Atriplex Species: A review

Basharat Ali [1], Sara Musaddiq [2]*, Sadia Iqbal [2], Tanzila Rehman[2], Nusrat Shafiq [3], Ajaz Hussain [4]

[1]Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, 64200, Pakistan

[2]Department of Chemistry, Kutchehry Campus, The Women University Multan, Multan 60000, Pakistan

[3]Department of Chemistry, Government College Women University, Faisalabad, 38000, Pakistan

[4] Institute of chemical Sciences, Bahauddin Zakariya University, Multan, 60000, Pakistan

*For Correspondence: drsara.chem@wum.edu.pk

Abstract: Atriplex species are prospective natural candidates for possible drug development because of their antioxidant, antibacterial, antiviral, anti-diabetic, anti-cancer, molluscicidal and anti-fungal properties. These pharmacological actions are associated to the presence of valuable bio-chemicals such as terpenoids, hydroxyecdysone, flavonoids and phenolics. These plants also have nutritional properties being rich source of proteins, vitamin A, vitamin C, flavonoids and amino acids. The proper utilization of the substances obtained from these plants can enhance the finesse of these abilities. Atriplex species are used as conventional cure of diseases due to their exceptional therapeutic uses. Plants of this genus have been employed by the common folk in several regions of the world to treat diabetes, jaundice, thyroid and liver disorder, snake bite and against infections in digestive, respiratory and urinary tract which indicate the worth of the herbs belonging to the genus Atriplex. These plants are not only medicinally important but are also important to boost economy specifically due to insecticidal properties of some species which make them suitable to be used for insecticidal applications in agriculture. In view of the medicinal and scientific uses along with the bioavailability of precious chemicals of Atriplex species, a comprehensive review is compiled which focuses on the detailed profile of chemicals present, medicinal uses of extracts, pharmacological functions and biological activities of Atriplex species so as to correlate the available data and explore their potential uses in all possible aspects.

Keywords: Antioxidant, Antibacterial, Antiviral, Anti-diabetic, Anti-cancer, Molluscicidal

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1. Introduction

The genus *Atriplex* of the plant family Chenopodiaceae, commonly known as salt bush and orach, consists of about 300 species. The genus is quite variable and widely distributed in Africa, Asia, Australia and North America. It includes many desert, seashore plants and halophytes, as well as plants of moist environments. Plants of this genus have medicinal as well as nutritional importance and act as a rich source of biologically active compounds. Previous chemical investigations of *Atriplex* species revealed the presence of phytoecdysteroids (Keckeis et al., 2000), flavonoids, triterpenoid saponins (Shaker et al., 2003), coumarins (Tawfik et al., 2011), saikosaponins (Jabrane et al., 2011) and alkaloids (Elvin-Lewis, 1987). Several species of this genus are used to treat fungal infections,

bronchitis and diabetes in some countries (Keckeis et al., 2000). Some medicinally important species explored so far are presented in Table 1.

Table 1: Reported specie of the Genus *Atriplex*.

Reported Species of the Genus Atriplex		
A. canescens	*A. inflate*	*A. parvifolia,*
A. confertifolia	*A. laciniata*	*A. patula*
A. crossifolia	*A. lasintha*	*A. portulacoides*
A. farinosa	*A. leucoclada*	*A. semibaccata*
A. glauca	*A. lindleyi*	*A. stylosa*
A. halimus	*A. littoralis*	*A. vesicaria*
A. hortensis	*A. nummularia*	

Purpose of this review is to gather available literature about phytochemistry and pharmacology of the genus that could provide a firm base for further research on this genus. Medicinal importance of some important species are given in the next session:

1.1 Atriplex canescens

This Species is commonly known as four-wing salt bush. Its medicinal importance is depicted by usage of its leaves to treat gastrointestinal infections in Mexico, the leaves paste is also used to treat snake bite topically in Gilgit Baltistan, Pakistan (Bano et al., 2014). The methanolic extract of *A. canescens* possess antibacterial effects against *E. coli* and *S. typhimurium* (Moreno Salazar et al., 2008). C. L. Cantrell *et al.* reported weak activity of extract against brine shrimp (*Artemiasalina*) (Cantrell et al., 2003). Insecticidal and ovicidal activity of the specie was investigated against the mosquito *Culex quinquefasciatus* where significant reduction in larval growth was observed at conc. of 1000 ppm (Ouda et al., 1998; Samidurai 2012). Not much work has been carried out on isolation of active candidates from this plant. In a single study published about chemical constituents of *A. canescens*, a phytoecdysone i.e., 20-hydroxyecdysone (1) has been isolated from the EtOH extract of its leaves along with other compounds identified as betaine (2), choline (3), isovanillic acid (4), *β*-sitosterol-D-glucoside (5) and oleanolic acid 3-O-*β*-D-glucopyranosyl-28-O-*β*-D-glucopyranoside (6) (Kumarihamy et al., 2015) (Figure 1).

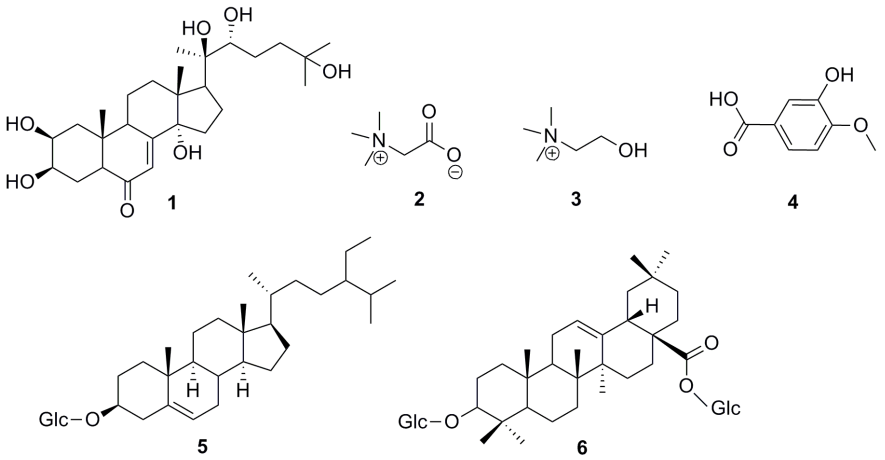


Figure 1: Chemical Constituents isolated from *Atriplex canescens*

1.2 Atriplex confertifolia

Anti-cancerous potential of *A. confertifolia* is depicted in a laboratory bioassay where a bioactive fraction of *species was* found to kill more than 94% of the HeLa cells. Anticancer potential of same specie has also been explored against human cervical cancer cells (HeLa) and three types of breast cancer cells, the bioactivity of this extract was comparable to an FDA-approved cancer drug Onxol® (Capua et al., 2010). Unfortunately, despite of its anti-cancerous potential, not much attention has been paid to this precious source and no reports are available about isolation of active secondary metabolites to find its uses in commercial applications.

1.3 Atriplex farinosa

M. Donia *et al.* studied anti ulcerative colitis (Abd El Raheim M. Donia et al., 2013) and anti fertility potential of *A. farinosa* extract and isolated scopoletin (7), scopolin (8), quercetin-4'-methoxy-7-glucorhamnoside (9), quercetin-6,4'-dimethoxy-3-glucorhamnoside (10) and kaempferol-4'-methoxy-3-glucorhamnoside (11) (Donia et al., 2012). From the same source some more flavoniods i.e., isorhamnetin-7-*O*-glucopyranoside (12), naringenin (13) and naringenin-7-*O*-glucoside (14) have also been isolated previously (Al-Jaber et al., 1991) (Figure 2).

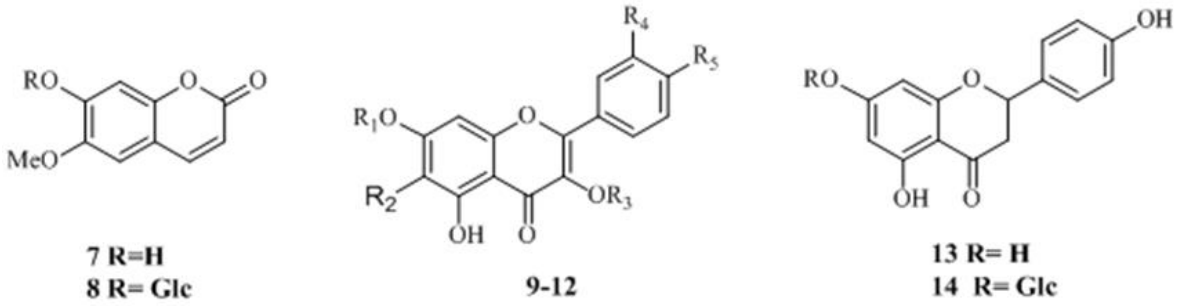
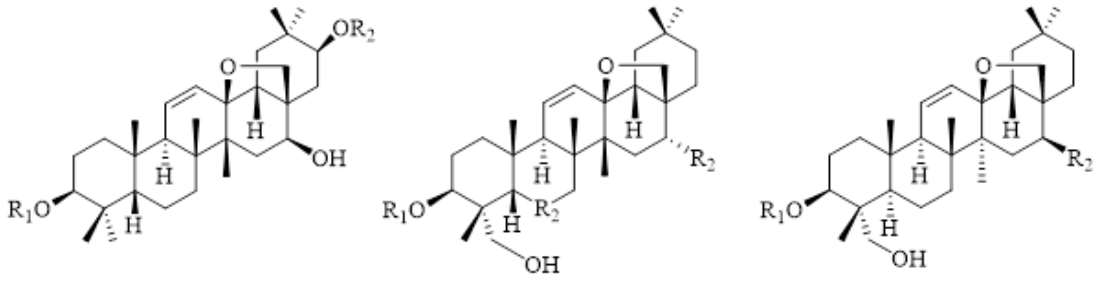


Figure 2: Chemical constituents of *A. farinose*

Compsound	R_1	R_2	R_3	R_4	R_5
9	Rha(1-6)-Glc	H	H	OH	OCH_3
10	H	OCH_3	Rha(1-6)-Glc	OH	OCH_3
11	H	H	Rha(1-6)-Glc	H	OCH_3
12	Glc	H	H	OCH_3	OH

1.4 Atriplex glauca

Anti cancer properties of *A. glauca* were unrevealed in a single study reported on this species in which A. Jabrane *et al.* characterized four saikosaponins; glaucaside A (15), glaucaside B (16), glaucaside C (17) and 3-*O*-*β*-D-glucopyranosyl- (1 → 2)-*β*-D-galactopyranosyl-saikogenin F (18) (Figure 3) and reported their moderate activity against HT-29 and HCT 116 human colon cancer cell lines (Jabrane et al., 2011). Fayez A. Bakry evaluated the molluscicidal activity of extract of *A. glauca* in different solvents like cold water, boiled water, methanol, ethanol, acetone and chloroform extracts against *Biomphalaria alexandrina* snails. Exposure of *B. alexandrina* snails to plant's methanolic extracts significantly reduced its survival and growth rates with LC_{50} and LC_{90} values of 94 and 180 ppm respectively (Bakry, 2009).



15-16 **17** **18**

Compound	R1	R2
15	*β*-D-[2-*O*-sulfate]-glc-(1 → 2)-*α*-L-ara-	H
16	*β*-D-[2-*O*-sulfate]-glc-(1 → 2)-*α*-L-ara-	4-(secbutylamido)-butanoyl ester
17	*β*-D-glc-(1 → 2)-*β*-D-gala	OH
18	*β*-D-glc-(1 → 2)-*β*-D-gala	OH

Figure 3: Chemical constituents isolated from Atriplex glauca.

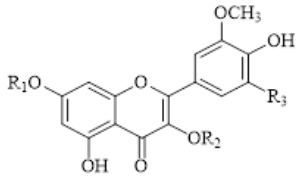
1.5 Atriplex halimus

A. halimus may be considered as most studied species among *Atriplex* plants. Various biological potentials like antifungal, antimicrobial, antidiabetic are associated with the its various species. Antifungal potential of methanolic extract of *A. halimus* was evaluated against *Alternaria alternate, Bipolarisoryzae, Chetomium, Rhizopus, Fusarium oxysporum, Fusarium solani, Mucor* and *Pythium ultimum,* where 91 % inhibition of *F. solani* was observed. Furthermore, hexane and methanolic extract of this plant against 15 gram positive and gram negative strains *in vitro* and proved methanolic extract superior in antibacterial activities than hexane extract (Abd-Ellatif et al., 2011). Decoction of leaves of *A. halimus* is used as blood purifier and also to treat fever, jaundice and liver diseases (Ahmad et al., 2016), Ouelbani R. *et al.* reported its medicinal uses for treatment of thyroid disorder (Ouelbani et al., 2016). Press juice and water extract from green leaves also expressed significant hypoglycemic activity in normal and alloxan-diabetic albino rats (Chikhi et al., 2014). I. Chikhi *et al.* also confirmed the antihypoglycemic effect of aqueous extract of *A. halimus* L in streptozotocin-induced diabetic rats and marked anti-hyperglycemic activity by improvement of the glucose tolerance test in normoglymemic rats and by lowering the blood glucose levels of 54% in STZ-induced-diabetic rats without any toxic effects (Aharonson et al., 1969). Anti-diabetic effects of dry extract of leaves of *A. halimus* in *in vivo* and *in vitro* test systems was also studied in combination with other herbs like *juglansregia* L, and *oleaeuropea, urticadioica*. No toxic effects were seen in cultured human fibroblasts and rats treated with increasing concentrations of Glucose level. Anti-diabetic effects were evidenced by inhibition of glucose intestinal absorption (~ 49%) in a rat gut-segment. Treatment with various glucose levels of Streptozotocin-induced diabetic rats for 2–3 weeks showed a significant reduction in glucose levels [above 400 ±50 mg/dl to 210 ±22 mg/dl ($P < 0.001$)] compared with positive control. Sixteen human volunteers with type 2 diabetes mellitus received Glucolevel tablets 1-3 daily for a period of 4 weeks. Clinically acceptable glucose levels were achieved during the 2–3 weeks of therapy. In addition, a significant reduction in hemoglobin A1C values (8.2±1.03 to 6.9±0.94) was found in six patients treated with Glucolevel. Results demonstrate safety, tolerability and efficacy of herbal combinations of four plants that act differently but synergistically regulate glucose-homeostasis (Said et al., 2008). Antioxidant properties of principal secondary metabolites from butanolic and ethyl acetate fractions of leaves and stems of *A. halimus*have also been

explored and it was observed that methanolic extract of leaves contained higher levels of total phenolics (10.12 ± 0.56 mg GAE/g DW) than stems methanolic extract (3.77 ± 0.19 mg GAE/g DW). The highest DPPH scavenging activity was found in butanolic and ethyl acetate fractions of the leaves, the EC_{50} values were 1.73 and 2.04 mg/mL respectively. Moreover, leaves saponins, leaves tannins and stems tannins are also able to donate hydrogen atoms to DPPH radicals. The lowest hydrogen atom donating ability was found in leaves and stems methanolic extract (31.83 and 20.58 mg/mL respectively) (Benhammou et al., 2009). Kabbash *et al.* studied bioactivities against multidrug resistant cancer, leishmanial disease. The antileishmanial activity was assessed against *Leishmania major* as a causative agent of cutaneous leishmaniasis. IC_{50} of the *n*-butanol soluble fraction was 92.09 ± 3.41 μg mL^{-1}, while the IC_{50} of amphotericin B (positive control) was 1.5 ± 0.95 μg mL^{-1}(Kabbash et al., 2012). Anticancer studies against human myelogenous leukemia (K562) cells and adriamycin resistant human myelogenous leukemia (K562/ADM) cells showed weak IC_{50}> 100 µg $mL^{-1}$of *n*-butanol soluble extract relative to verapamil (positive control) 17.0 ± 2.65 µg mL^{-1} (Kabbash et al., 2012).

In addition to vast canvass of biological potential, extensive studies have been carried out to explore chemical profile of this plant. As a result flavonoid glycosides i.e., 3′,5′-dimeth- oxymyricetin-3-*O*-*β*-D-xylopyranosyl-7-*O*-fucopyranosyl-(1→3)-*β*-D-glucopyranoside (19), 3′,5′-dimethoxymyricetin-7-*O*-fuco-pyranosyl-(1→3)-*β*-D-glucopyranoside (20), 3′-methoxy quercetin-7-*O*-*β*-L-rhamnopyranosyl-3-*O*-*β*-arabinofuranosyl-(1→ 6)-*β*-D-glucopyranoside (21) and 3′-methoxyquercetin-7-*O*-*β*-D-fucopyranosyl-(1→3)-*β*-D-glucopyranosyl-3-*O*-*β*–xylopyranosyl-(1→4)-*β*-xylopyranoside (22) have been isolated from aerial parts of *A. halimus* (Clauser et al., 2013) (Figure 4).

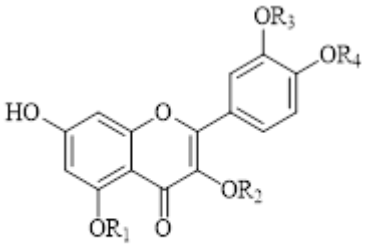
Further, some more flavonoids including atriplexoside A [(3'-*O*-methylquercetin-4'-*O*-*β*-apiofuranoside-3-*O*-(6''-*O*-*α*- rhamnopyranosyl-*β*-glucopyranoside)] (23), atriplexoside B, [3'-*O*-methylquercetin-4'-*O*-(5''''-*O*-*β*-xylo-pyranosyl-β-apiofuranoside)-3-*O*-(6''-*O*-*α*-rhamnopyranosyl-*β*-glu-copyranoside)] (24), 4'-*O*-methylquercetin-3-*O*-(6''-*O*-*α*-rhamnopyr- anosyl-*β*-glucopyranoside (25), 5-*O*-methylquercetin-3-*O*-(6''-*O*-*α*-rhamno pyranosyl-*β*-glucopyranoside (26) (Figure 5), along with 20-hydroxyecdysone (1), 3*α*-hydroxysulfonyloxy-5*α*, 6*α*-epoxy-7-megastigmen-9-one (27), 3,4- dimethoxyphenyl-1-*O*-*β*-D-glucopyranoside (28) and 3,4,5-trimethoxyphenyl- 1-*O*-*β*-D-glucopyranoside (29) were isolated from *A. halimus* (Kabbash et al., 2012) (Figure 6). Among isolated secondary metabolites, Compound 26 showed the highest DPPH radical scavenging activity activity (IC_{50} 13.62 ± 1.23 μM) as compared to the other tested compounds ($IC_{50} \geq 30$ μM), while the IC_{50} of trolox (positive control) was 4.90 ±1.05 μM.



19-21

Comp	R_1	R_2	R_3
19	*β*-D-fuc-(1→3)- *β* -D-glc-	*β* -D-xyl-	OCH_3
20	*β*-D-fuc-(1→3)- *β* -D-glc-	H	OCH_3
21	*β*-L-rha-	*β* –araf-(1 → 6)-*β*-D-glc-	H
22	*β*-D-fuc-(1→3)-*β*-D-glc-	*β*–xyl-(1→4)-*β*-xyl-	H

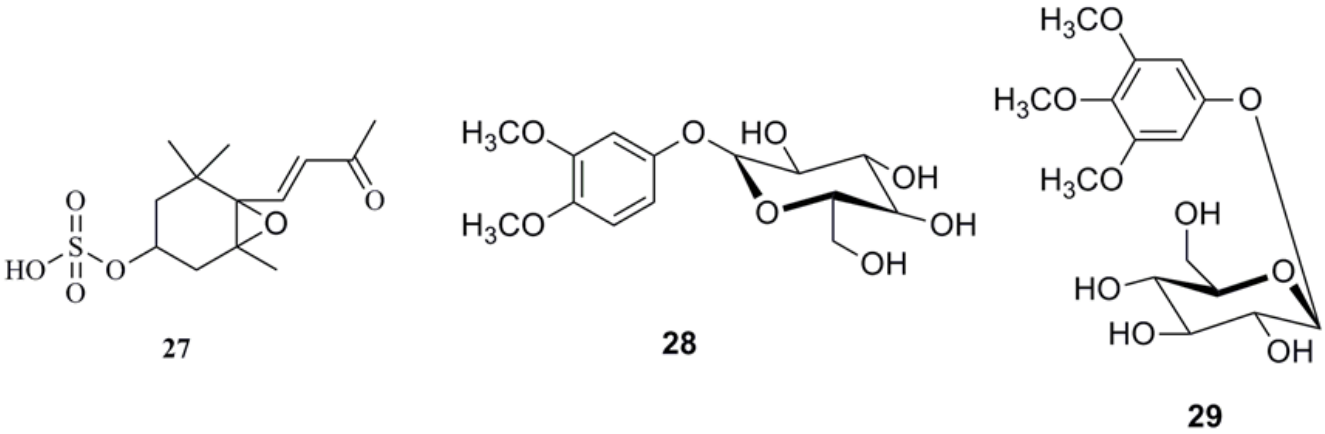
Figure 4: Chemical constituents isolated from Atriplex halimus



23-26

Compound	R_1	R_2	R_3	R_4
23	H	*α*- rha-*β*-glc	CH_3	*β*-apis
24	H	*α*-rhal-*β*- glc-	CH_3	*β*- xyl-*β*-apis
25	CH_3	*α*-rha-*β*-glc-	H	H
26	H	*α*-rha- *β*-glc-	CH_3	H

Figure 5: Other chemical constituents isolated from Atriplex halimus

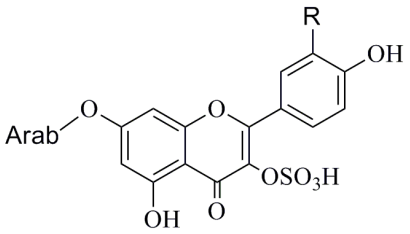


27 **28** **29**

Figure 6: Other chemical constituents isolated from *Atriplex halimus*

1.6 Atriplex hortensis

Atriplex hortensis L. is capable of growing in a wider range of ecological environments and is one of the oldest cultivated plants due to its dietary and conventional medicinal value (Wright et al., 2002). In folk medicine, *A. hortensis* is used to treat digestive, respiratory tract and urinary tract infections and its tonic is used to restore energy (Nicol, 1994). It stimulates digestion by absorption of food nutrients and is source of mineral components, vitamin A, vitamin C, flavonoids and amino acids (Siddiqui et al., 1994). Its leaves are rich source of proteins and can be used separately or mixed with other vegetables (Grzeszczuk et al., 2010). Bylka *et al.* isolated kaempferol-3-*O*-sulphate-7-*O*-*β*-arabinopyranoside (30) and quercetin-3-*O*-sulphate-7-*O*-*β*-arabinopyranoside (31) from *A. hortensis* (Bylka, 2004) (Figure 7).

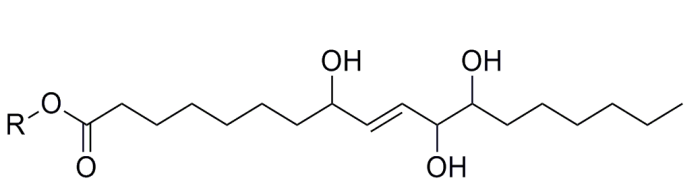


30 R = H
31 R = OH

Figure 7: Chemical constituents isolated from *Atriplex hortensis*

1.7 Atriplex inflata

Like many other *Atriplex* species, *A. inflata* also remained unexplored unless its leaves and fruits were screened for anti-herpetic activity against Herpes simplex virus type 1 (Ben et al., 2008). Later on, N. Hamed *et al.* reported its molluscicidal activities against *galba truncatula*. In this study, hexane extracts of leaves and fruits showed potent molluscicidal activity with LC_{50}values of 7.59 and 6.69 mg/L respectively, whereas, ethyl acetate extracts of leaves and fruits showed LC_{50} values of 5.90 and 7.32 mg/L respectively. These extracts were also checked for larvicidal potential and found to possess potent larvicidal activities with a delay rate exceeding 45.50%. Phytochemical tests showed that these activities may be attributed to the presence of triterpenoids and/or sterols (Hamed et al., 2015). Explored biological potential of *A. inflata* urged natural product researchers to carry out isolation of active metabolites from this source and in a recent attempt made about chemical study of *A. inflata,* isolation of fatty acids (9*E*)-methyl-8,11,12-trihydroxyoctadec-9-enoate (32) and (9*E*)-8,11,12-trihydroxyoctadecenoic acid (33) together with (*Z*)-litchiol B (34) and 20-hydroxyecdysone (1) has been carried out (Ben Nejma et al., 2017) (Figure 8).



32 R= CH_3
33 R = H

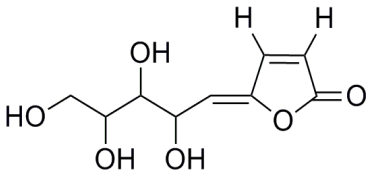


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Figure 8: Chemical Constituents isolated from *A. inflata*

1.8 Atriplex laciniata

Antioxidant potential of said species has been investigated for DPPH, ABTS and H_2O_2 free radical scavenging activities. In DPPH free radicals scavenging assay flavonoids, saponins and methanolic extract showed IC_{50} values of 33, 83 and 82 μg/mL respectively. Flavonoids, chloroform fractions and methanolic extract showed ABTS scavenging potential with IC_{50} values of 30, 190 and 70 μg/mL respectively. Further, H_2O_2 percent scavenging of flavonoids, saponins and ethyl acetate fractions showed IC_{50} value of 75, 70, 270 μg/mL respectively. In the same study, acetylcholinesterase (AChE) & butyrylcholinesterase (BChE) enzyme inhibitory activities of flavonoids, saponins, ethyl acetate, water fractions and methanolic extract was observed with IC_{50} values of 70, 90, 270, 263 and 280 μg/mL respectively for AChE and 100, 160, 120 and 220 μg/mL respectively for BChE (Kamal et al., 2015).

1.9 Atriplex lasiantha

A. lasiantha remained among unexplored species of *Atriplex* genus unless B. ali *et al.* reported 7*β*,15*α*,16-*β* trihydroxy olean- 12-ene-28,30-dioic acid-3-*O*-*β*-D-xylopyranoside (35), (3*β*,16*α*)-16-hydroxy-13,28-epoxy urs-11-en-3-yl *β*-D-xylopyranosyl-(1→2)-*β*-D-glucopyranosyl-(1→2)-6-deoxy-*β*-D-galactopyranoside (rotundifolioside I) (36) and saikogenin F-3-*O*-*β*-D-galactopyranosid (corchorusin B) (37) (Figure 9) from ethyl acetate fraction of *Atriplex lasiantha.* The isolated compounds (35-37) were evaluated for antibacterial, antioxidant and antiurease activities and found to exhibit the antibacterial activity against bacterial strains *E. coli* and *S. typhi* with IC_{50} value of 66.25-111.7 mg/mL, whereas, all the IC_{50}values of these compounds for antioxidant activities were observed in range of 68.7–75.4mg/mL while IC_{50} values of antiurease activity were in range of 25.5–49.3mg/mL (Ali et al., 2015).

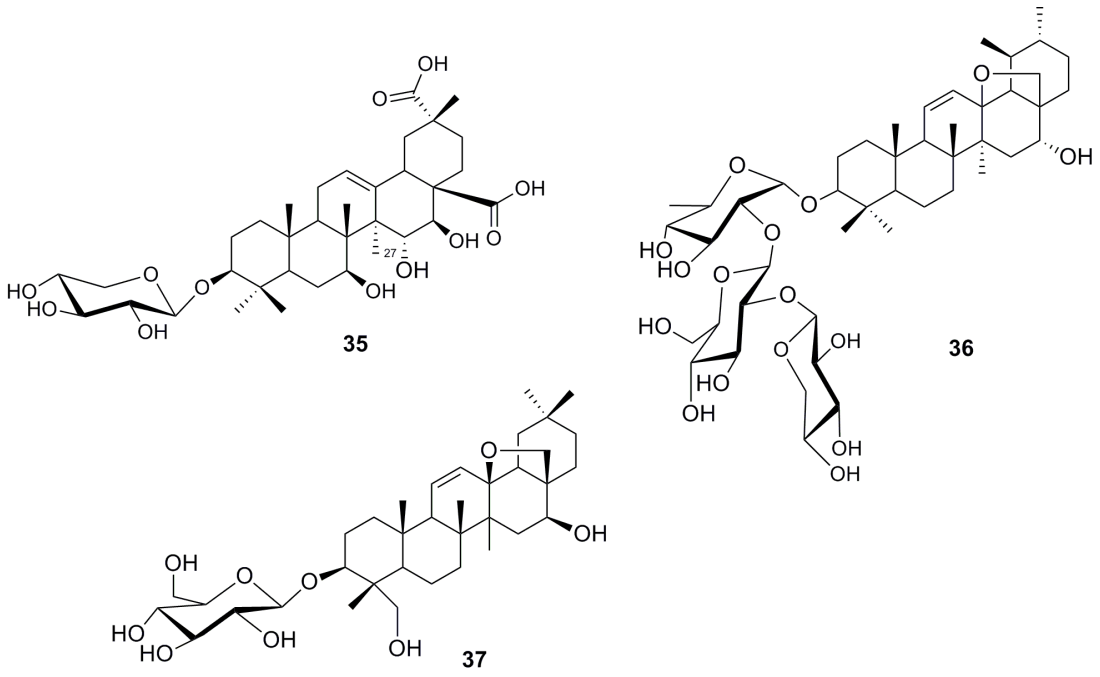
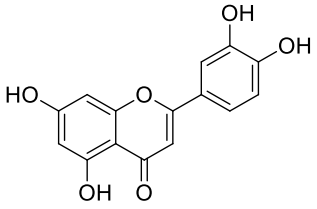


Figure 9: Chemical constituents isolated from *Atriplex lasiantha*

1.10 Atriplex Lindleyi

A. Lindleyi ethanolic extract and its phenolic constituents were investigated for antiplasmodial potential against the chloro quine-resistant strains of *Plasmodium falciparum* where moderate activity was observed for extract with IC_{50} ranging from 10–50 μg/mL. *In vitro* anti-infectious activity of extracts was also evaluated against representative strains of Gram-positive and Gram-negative bacteria and some fungal species.The radical scavenging activity was quantified by using IC_{50} values for DPPH activity of chloroform and ethyl alcohol extracts and was found to be 332.46 ± 16.21 and 345.70 ± 2.77 mg/L respectively. Among phytochemicals, quercetin (38), quercetin-7-*O*-arabinopyranoside-3-*O*-neo hesperidosides (39), quercetin-3-*O*-arabinopyranosyl(1→6)glucopyranoside (40), quercetin-3-*O*-glucopyranoside-7-*O*-rhamnopyranoside (41), quercetin-3-*O*-gluco- pyranoside-7-*O*-arabinoside (42), quercetin-7-*O*-glucopyranoside (43), isorhamnetin-3-*O*-*β*-glucopyranoside (44) and schaftoside (45) (Figure 10) have been isolated from the ethanol extract of *A. lindleyi*aerial parts (Souda et al., 2015).



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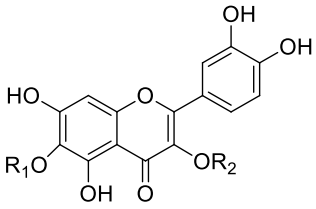

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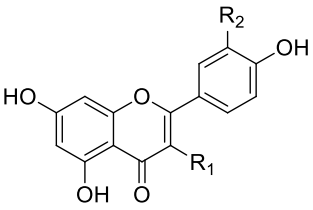

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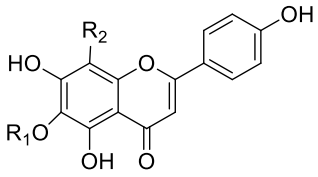

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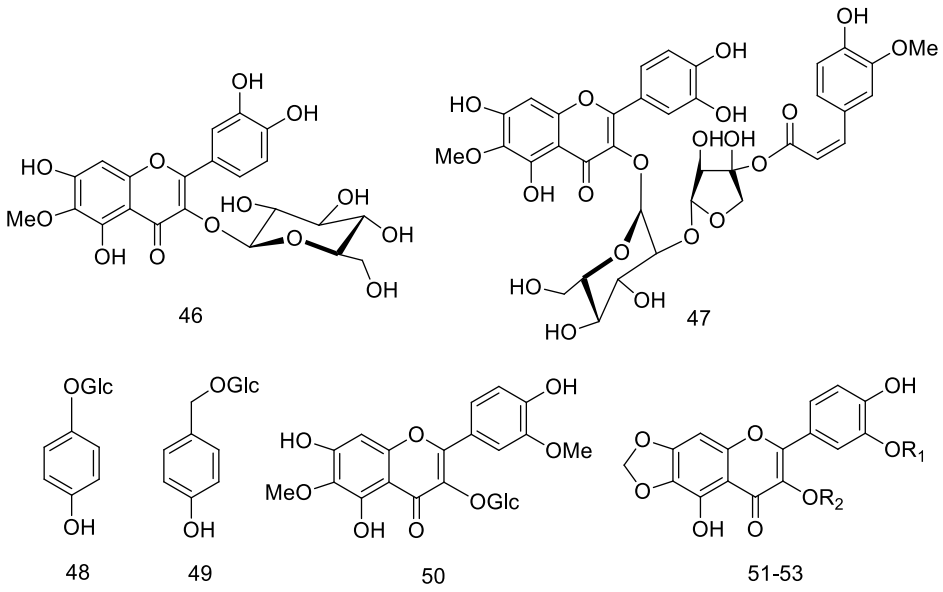
Compound	R_1	R_2
39	Ara-	α-L-Rha- (1→2) D-glc-
40	H	Ara-(1→6) –glc-
41	Rha-	Glc-
42	Ara-	Glc-
43	Glc-	H
44	Glc-	OCH_3
45	Glc-	Ara-

Figure 10: Chemical constituents isolated from *Atriplex lindleyi*

1.11 Atriplex littoralis

A. littoralis, also known as grass leaf orache, has been explored for its antioxidant potential as well as total phenolics content and flavonoids in terms of gallic acid equivalent (milligrams of gallic acid per gram) and rutin equivalent (milligrams of rutin per gram of extract). Total phenolic contents in *A. littoralis* were 109.51 mg of GA/g whereas concentration of flavonoids was found to be 127.58 of RU/g respectively. Antioxidant activity was determined by DPPH assay (mg/mL) whereplant extract exhibited low antioxidant activity having IC_{50} values as 456.31 ± 0.54 (mg/mL) (Stanković et al., 2015). Profile of secondary metabolites of the species showed the presence of variety of flavonoids in the aerial parts of the plant i.e., patuletin*3-O-β*-D-glucopyranoside(46), patuletin *3-O-*[5‴-*O*-feruloyl-*β-D-*apiofuranosyl(1‴→2″)-*β-D-*glucopyranoside] (47) (Bylka, 2004), arbutin (48), 4-hydroxybenzyl-*β*-D-glucopyranoside (49), spinacetin 3-*O-β*-D-glucopyranoside (50), 3-*O-α*-L-rhamnopyranosyl-(1→2)-*β*-D-glucopyranoside (atriplexin I) (51), 3′-*O*-methylquercetagetin 3-*O-α*-L-rhamnopyranosyl-(1→2)-*β*- D-glucopyranoside (atriplexin II) (52) and 3′-*O*-methylquercetagetin 3-*O-α*-L-rhamnopyranosyl-(1→6)-*β*-D-glucopyranoside (atriplexinIII) (53) (Figure 11). Among isolated compounds atriplexin I (51)was found to reduce the frequency of micronuclei in γ-radiation-induced cytogenetic damage of the human lymphocytes treated *in vitro* (Godevac et al., 2015).



Comp.	R_1	R_2
51	H	Rha-(1→2)]-glc -
52	CH_3	Rha-(1→2)]-glc -
53	CH_3	Rha-(1→6)]-glc -

Figure 11: Chemical isolated from *Atriplex littoralis*

1.12 Atriplex nummularia

A. nummularia is also known as old man saltbush by virtue of its high miner content (Moreno et al., 2017). The specie has potential to tolerate harsh environmental conditions of drought and flooding (Welch, 2004). In addition to traditional usage of *A. nummularia* seeds as food sources, protease-sensitive antifungal potential has also been explored against *Verticillium dahlia* (Last et al., 1997). Furthermore, anti-ulcerative colitis (Abd El Raheim M. Donia et al., 2013) and molluscicidal properties (Christensen et al., 1985) are also associated with said plant species.Molluscicidalproperties are attributed to the species due to presence of hederagenin-3-O-*β*-D-glucuronopyranoside (54) and oleanolic acid-3-O-*β*-D-glucuronopyranoside (calenduloside E) (55) each of these compounds is reported to present in a yield of 2% of dried plant material. In addition to these, *A. nummularia*has also been found to be a resource ofphytoecdysteroids i.e., 20-hydroxyecdysone (1) and polypodine (56) (Figure 12) that have been isolated from methanol extract of *A.nummularia* seeds (Keckeis et al., 2000).

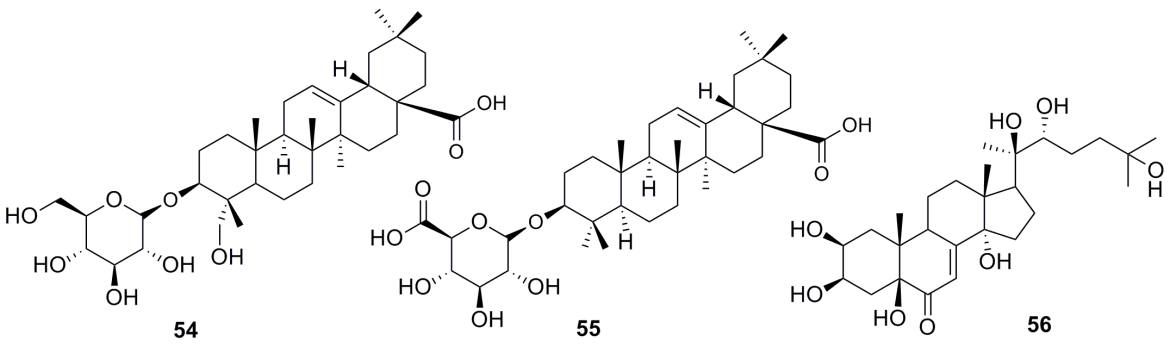


Figure 12: Chemicals isolated from *Atriplex nummularia*

1.13 Atriplex portulacoides

Ben Nejma isolated three compounds from *Atriplex portulacoides* roots and designated as 20-hydroxyecdysone (1), portulasoid (57) and septanoecdysone (58) (Figure 13) and evaluated them for their antioxidant, antibacterial and AChE activity. Compound 1 and 57showed weak IC_{50} value of 155.82 ± 9.82 and 180.26±12.36 μg/mL respectively against DPPH free radical scavenging activity (Ben Nejma et al., 2015). The antibacterial activity of these compounds was performed against *P. aeruginosa* ATCC 27853, *E. coli* ATCC 25922, *S. aureus* ATCC 25923 and *E. faecalis* ATCC 29212. The results showed that compounds 1 and 58 display the same activity (MIC 0.125 mg/mL) against *S. aureus* and *E. faecalis*. However, compound 58 (MIC 0.062 mg/mL) is more active than compound 57 (MIC 0.125 mg/mL) against *P. aeruginosa* (Gram positive), whereas the contrary is observed for *E. coli* (Gram negative).

The AChE activity of compounds 1, 57-58 was evaluated with different incubation times (10, 15, 20 and 30 min). Both compounds 1 and 57 were observed to exhibit a significant AChE activity at 30 min of incubation with 71.2% and 68.3% percentage of inhibition, respectively. These results were also expressed as IC_{50} values always showing the activity of compounds 1 IC_{50} 0.506 ± 0.018 mg/mL and 57 with IC_{50} = 0.550 ± 0.022 mg/mL Taking into account that compound 57 is not active, the slightly higher anti cholinesterase activity of compound 1 (IC_{50} 0.506 ±0.018 mg/mL vs 0.550 ± 0.022 mg/mL) can be probably attributed to skeleton of compound.

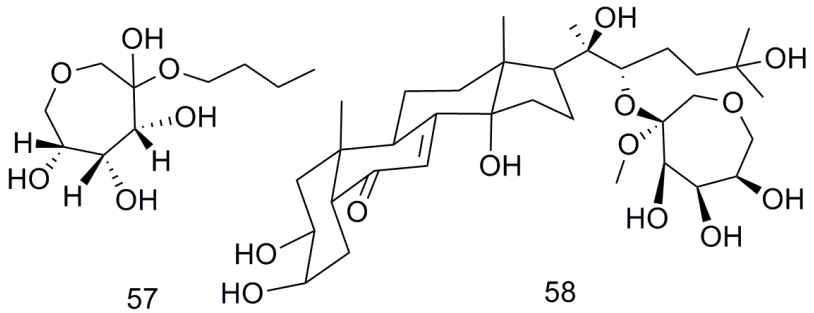
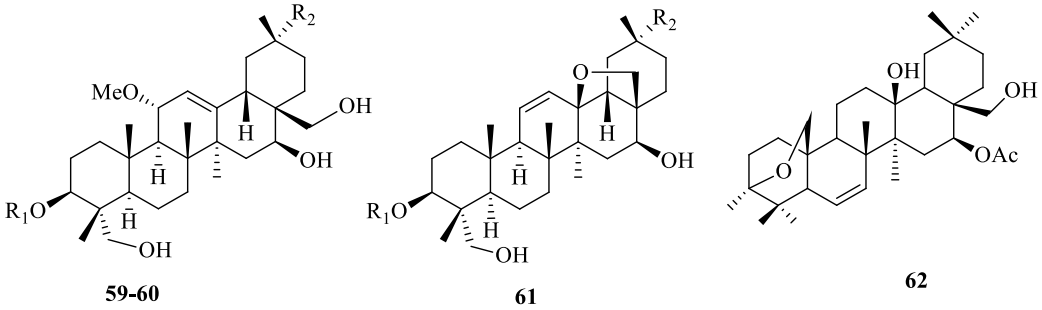


Figure 13: Chemical constituents isolated from *Atriplex portulacoides*

1.14 Atriplex Semibaccata

Atriplex semibaccata, berry saltbush, or creeping saltbush can also tolerate dry and saline conditions. In addition to common feed of animals, *A. semibaccata* extracts also have insecticidal effects against *Triboliums*p (Chaieb, 2011). Seed extract fruiting bracteole showed antifungal activity against *Rhizoetonia solani* and *Thielaviopsis basicloa* (Last et al., 1997). Among phytochemicals, *A. semibaccata* is known for the presence of saponins, some saponins isolated from *A. semibaccata* are characterized as 3-*O*-{[*β*-D-glucopyranosyl-(1→2)]-*β*-D-glactopyranosyl}-11*α*-methoxy-23-hydroxylongispinogenin (59), 3-*O*-{[*β*-D-glucopyranosyl-(1→2)]-*β*-D-glactopyrano- syl-11-*α*-methoxy-23,29-dihydroxy longi spinogenin (60), 3-*O*-{[*β*-D-glucopyranosyl-(1→2)]-*β*-D-galactopyranosyl}-29-hydroxy-saikogenin F (61) and 3-*O*-{[*β*-D-glucopyranosyl-(1→2)]-*β*-D-galactopyranosyl}-saikogenin F (62) (Shaker et al., 2003) (Figure 14).



Comp.	R_1	R_2
59	β-D-glu-(1→2)]-β-D-gla	CH_3
60	β-D-glu-(1→2)]-β-D-gla	CH_2OH
61	β-D-glu-(1→2)]-β-D-gla	CH_2OH

Figure 14: Chemical constituents isolated from *A. semibaccata*

1.15 Atriplex stocksii

A. stocksii leaves are used as thirst quencher and to treat skin diseases and joints pain in Pakistan (Bibi et al., 2015). The decoction or infusion of crushed leaves in water is said to relieve any kind of fever. Phytochemical screening of *A. stocksii* showed presence of alkaloids, carbohydrates, flavonoids, phenolics and glycosides compounds (Gahan, 1984). Triterpenoids i.e., ursolic acid (63), oleanolic acid (64), β-amyrin (65), and sterols i.e., β-sitosterol (66) and stigmasterol (67) (Figure 15) have also been isolated from *A. stocksii*. Qasim *et al.* reported total phenolic contents as 7.64 (0.32) mg GAE g^{-1}, antioxidant activity value against DPPH IC_{50} 701.26 (10.40) μg mL^{-1}) (Qasim et al., 2017).

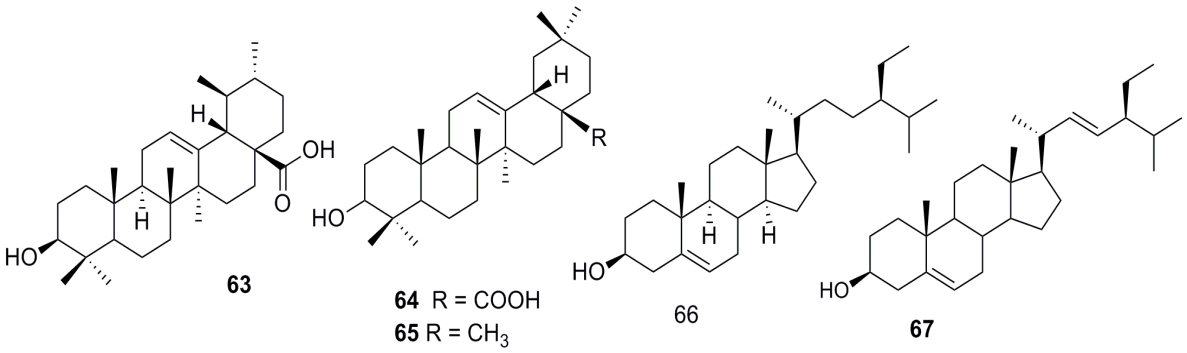


Figure 15: Chemical constituents isolated from *A. Stocksii*

2. Diverse Uses

Leaf infusion of *Atriplex patula* clears the brain (Calvo et al., 2015) while leaves of *A. crossifolia* are used to cure throat infection and jaundice in Pakistan (Wazir et al., 2004). Plant ash mixed with sesame oil is applied externally for rheumatic pain (Qureshi et al., 2009). Extract and secondary metabolites isolated from *A. leucoclada* possess antifungal activity against *alternaria solani* (Boughalleb et al., 2009). *A. vesicaria* possess anti-leukemic activity (Bandaranayake, 2002). Crude extract of different parts of some species like *Atriplex inflata, Atriplex parvifolia, Atriplex portulacoides, Atriplex semibaccata* showed insecticidal activity against *Tribolium* spp (Chaieb, 2011).

3. Conclusion

Cancer is one of most important cause of death all over the world. Many species of genus *Atriplex* are reported to possess anticancer properties against human cervical, breast cancer and adriamycine resistant human mylogenous leukemia cancer cells which suggest bioactivity-based fractionation and isolation of secondary metabolites that may lead to active compounds to provide an extra tool to combat this lethal disease. Traditional use of *A. halimus* to treat diabetes as well as experimental results supports its anti-diabetic activity. Phytochemical investigation shows presence of flavonoid glycosides *A. halimus* which are already reported to reduce blood glucose level. Similar type of flavonoid glycosides are reported in other species of this genus such as: *A. farinosa, A. hortensis, A. lindleyi and A. littoralis* which may also have antidiabetic activity. Antibacterial activity of extracts and secondary metabolites isolated from this genus against Gram positive and Gram negative bacterial strains can provide a new route for finding antibacterial drugs. Antifungal activity of extracts of *A. halimus, A. nummularia* and *A. semibaccata* against various fungal strains suggest a comparative evaluation of available plants from genus *Atriplex* may be useful for finding strongly active extract or secondary metabolite. Antioxidant activity of nearly all reported extracts may be attributed to flavonoids.

Different species of genus *Atriplex* are not only important medicinally but can also help in improvement of economy. In agrarian countries edible crops and livestock are major source of income. Loss of crops due to insects can be reduced due to insecticidal properties of *Atriplex canescens and A. semibaccata* extracts. Similarly extract of *Atriplex inflate* and *A. stylosa* will useful to save form animals from fasciolosis due to their molluscidal properties. Furthermore, phytochemical investigation and isolation of insecticidal secondary metabolites may lead to their synthesis on industrial scale. Out of nearly 300 species of genus *Atriplex* only few are investigated for their phytochemicals and medicinal uses. The rest of species need much attention for detailed screening for their potential medicinal and biological activities. Furthermore; comparative study of different plant extracts of this genus against a specific bioactivity such as antifungal or ant diabetic etc. has not been performed at all. Various classes of secondary metabolites have been identified and isolated majorly from *A. lindleyi, A. littoralis* and *A. lasiantha* but no detailed research reports are available on pharmacology of extracts and secondary metabolites from other species.

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