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ALLIUM PORRUM: A REVIEW

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ABSTRACT

Plants with medicinal capacity have always been an important target for drug development. Plants of the genus *Allium* have recognised as rich sources of secondary metabolites endowed with interesting biological activities. *Allium porrum* L. (Synonym: leek) is a bulbous perennial plant belongs to the *Alliaceae* family. Leeks have a delicate, sweet oniony flavour. The phytochemical screening of the plant showed the presence of tannin, saponins, flavonoids, quinine, glycoside, cardiac glycoside, terpenoids, phenol, coumarins, steroids, alkaloids, anthocyanin and betacyanin. *Allium porrum* used in many pathological conditions such as stomach ulcer, sores, wounds, tuberculosis, reduced blood pressure and anti-helmenthic. It is used treatment of blood clotting disease. Recent studies showed that consumption of leeks Cause reduction in the serum triglycerides in hypercholesterolemia, reduces the risk of prostate cancer, colorectal cancer, stomach cancer, breast cancer and prevention of neural tube defects and other disorders. *Allium* species are toxic to dogs and cats. Clinical signs of *Allium* species toxicosis may appear within one day of consumption if large amounts of material have ingested. Clinical signs often include depression, haemoglobinuria, Hemosiderin urinary casts, icterus, tachypnea, tachycardia, weakness, exercise intolerance, inappetence, abdominal pain, diarrhoea and cold sensitivity.

KEYWORDS: *Allium porrum*, leek, *Allium* species, Kaempferol, phytochemicals, pharmacological review.

INTRODUCTION

Allium is a genus belongs to the family Liliaceae. *Allium* vegetables have used as folk medicine since ancient times. The *Allium* genus includes approximately 500 species, the most widely used of which are onions (*Allium cepa*), garlic (A*llium sativum*), leeks (*Allium porrum*), chives (*Allium schoenoprasum*) and shallots (*Allium ascalonicum*). Such plants have been employed for centuries for the pungency and flavouring value and for their medicinal properties.[1] Plants of the genus *Allium* have recognised as rich sources of secondary metabolites endowed with interesting biological activities.

Figure 1: *Allium porrum* L.

Allium porrum is a hardy biennial plant of the amaryllis family (Amaryllidaceae/ Liliaceae). The leek is an ancient crop and is native to eastern Mediterranean lands and the Middle East. Leeks have a delicate, sweet oniony flavour. Leek stalks are widely used in European soups and stews, especially as a complement to potatoes and

can be cooked whole as a vegetable.[2] It is one of the daily edible green vegetables for Brazilian people. It is widely cultivated and used as food in Brazil. It is also grown and eaten in the western world and are essential to many European cuisines.

All parts of *Allium porrum* have an offensive, pungent odour and an acrid taste, dependent on an essential oil, of which allyl sulphide is the main ingredient.[3] *Allium porrum* as other members of *allium* species, produce non protein sulphur amino acids derived from cysteine, i.e., alk(en)yl cysteine sulfoxides. These amino acids are precursors of sulphur volatiles because their contact with the enzyme allinase produced, after the rupture of plant tissue cells leads to the formation of sulphur volatiles mainly in the form of thiosulfinates that subsequently breakdown and rearrange into disulphides and trisulphides.[4-6] *Allium porrum* contains high levels of sulphur compounds that work on the inhibition of microbial growth by inhibiting para-amino benzoic acid formation, which is the major component for synthesizing folic acid that is essential for continuous growth and multiplication of microbial cell. Allicin has antibacterial properties against a wide range of bacteria. Allicin showed effectiveness against multidrug resistant strains of E.coli.[7] Recent studies showed that consumption of leeks cause reduction in the serum triglycerides in hypercholesterolemia, reduces the risk of prostate cancer, colorectal, stomach breast cancer and prevention of neural tube defects and other disorders.[8-11]

Taxonomical Classification

Kingdom : Plantae
Sub kingdom : Tracheobionta
Super division : Spermatophyta
Division : Magnoliophyta
Class : Lilopsida
Subclass : Lilidae
Order : Liliales
Family : Liliaeceae/Amarydillaceae
Genus : *Allium* L.
Species : *Allium Porrum* L.
Synonym : *Allium ampeloprasum L. var. porrum*(L.)

General Description[12,13]

- **Bulbs:** Solitary, cylindrical, some with poorly developed bulbs, others ovoid with 1-2 large bulbs and yellowish to light brown.
- **Bulbels:** tunic white to membranous.
- **Outer coat:** enclosing one or more bulbs, yellowish, membranous.
- **Inner coat:** white to light brown.
- **Fibres:** parallel & few.
- **Leaves:** linear to linear-lanceolate, shorter than scape, blade solid, flat, channelled, 1-5cm or more, slightly conduplicate and abaxially keeled.
- **Umbel:** persistent, erect, compact to 500 flowered in variants with bulbils, globose.
- **Spathe:** 1-valved, deciduous, beak long; bracts - persistent, 3-5, 2-3-veined, lanceolate, equal apex abruptly narrowed to beak (10cm).
- **Flowers:** urceolate, 4-5.5mm.
- **Tepals:** erect, white, pink or dark red, unequal, becoming papery and investing capsule in fruit.

a) **Outer tepal:** oblong lanceolate, margins - entire, apex -obtuse, sometimes mucronate.
b) **Inner tepal:** narrowly ovate to spatulate, margins - entire, apex- obtuse, stamens equalling perianth or exserted.

- **Perianth:** white to pale purple; segments with green midvein, suboblong, apex acute, outer ones denticulate along midvein abaxially.
- **Filaments**: slightly longer than perianth segments, connate at base and adnate to perianth segments.

a) **Outer**: narrowly triangular to linear-triangular, margin- denticulate toward base, simple.
b) **Inner:** oblong, as wide as perianth segments 2/3 their length, 1-toothed on each side, teeth with apex elongated into a twisted, filiform cusp much longer than anther bearing cusp.

- **Anthers:** yellow or purple, pollen yellow.
- **Ovary:** ovoid - globose with transversely convex nectaries near middle of septa.
- **Style:** exaserted; linear equalling stamens.
- **Stigma:** capitate, scarcely thickened, unlobed.
- **Pedicel:** 15-50mm, sub equal, bracteolate, as long as perianth.

Growth, Cultivation and Distribution

Leeks are upright and have broad, flattened blue-green to grey-green leaves that arch and it pointed at the tip. The leaves overlap to create the long stem base. The base of the leek is white and slightly bulbous (kind of like an elongated onion). Leeks produce surprisingly pretty flowers in the spring of their second year. The perfectly round flower clusters rise from tall, leafless stems. A single plant will typically produce one flower head comprised of lots of white, starry flowers. Occasionally, the heads will have small bulbs instead of flowers. These can be planted in the ground To produce leeks on the following year.[14]

In the plant's first season of growth, long linear leaves arise from a compressed stem or stem plate; the thick leaf bases overlap and are arranged concentrically in a nearly cylindrical bulb. A tuft of fibrous shallow roots grows from the base of the stem plate. Many growers pile soil or mulch around the lower portion of the stalk several times throughout the growing season to limit chlorophyll production, resulting in a long white section of the stalk below the leaves. If left unharvested, second-season leeks produce a large umbel with many flowers; the seeds are small, black, irregular and angular. If grown in full sun and organic rich, well-drained soil, leeks will thrive. Sandy loam is ideal. They grow well in light supplemental nitrogen and grown in areas with cool, pleasant summers. Regular water supply is needed if conditions become too dry. Many problematic pests

and pathogens damage leeks. Onion flies and leek moths can infest the bulbs and white rot can be a problem—especially in poorly drained soils.[2,14] Leeks planted in spring season as either bulbs or seedlings in mounds. Seedlings planted at a depth that is two or three times their width. As the plants grow, the soil mounded around their stems up to the lowest leaf joint is called blanching and produces a longer, tenderer white stem for cooking and eating. Leeks can be harvested when they are at half an inch to two inches thick (one to six centimetres) or after 120 to 210 days of growth. It is preferable to harvest them before the soil freezes. Any small, uprooted leeks that are not ready can be replanted.[15]

Distribution: *Allium porrum* was native in temperate regions, cultivated in Africa, Asia-temperate, Asia-tropical, Australia, Europe and Southern America. The largest areas of leek cultivation can be found in western European countries where it is cultivated on about 30,000 ha.[16]

Leek is a major source of inulinase production. Inulinase is 2,1-β-D-fructan fructanohydrolase which yields 95% of fructose by removal of the terminal fructose residues from the non-reducing end of the inulin molecule. Its beneficial role includes enhancing iron absorption in children, ethanol removal from blood of highly intoxicated persons, higher sweetening capacity with low calories, prevention of colon cancer, and coronary heart disease, obesity, hypercholesterolemia, type 2 diabetes, hypertension, cataract, osteoporosis and disturbances in the GIT(colic pain, dyspepsia).[17,18]

Traditional Uses: Plinius the Elder in his *Historiae naturalis* report the first citation about its use in folk medicine as a remedy "to make good the voice", in the first century A.D. The bulb has used reputedly in the traditional Brazilian medicine for treating inflammatory symptoms. The crushed bulb used to treat initial stages of cough, mucous secretion and sore throat. The fresh juice is taken orally as a stomachic and antispasmodic and is also reputed to possess digestive properties.[19] Fresh juice of the plant also claimed to be bactericide, diuretic, hypotensive and digestive properties are attributed to this plant.[20] *Allium porrum* used in many diseases such as stomach ulcer, sores, wounds, tuberculosis reduced blood pressure and anti-helmenthic. It is used in the treatment of blood clotting disease.[21]

Contradiction and adverse effects: Hypersensitivity to leek as a cause of asthma and dermatitis, and occupational rhinitis may occur due to inhalation of leek juice.[22,23] In dogs and cats, clinical signs of *Allium* species toxicosis may appear within one day on consumption of large amount of material. Clinical signs often include depression, haemoglobinuria, haemoglobin and possibly hemosiderin urinary casts, icterus, tachypnea, tachycardia, weakness, exercise intolerance, inappetance, abdominal pain, diarrhoea and cold sensitivity.[24]

Nutritional Composition[25]

Table 1: In Raw leeks, bulbs and lower leaves.

Nutritional value per100g(3.5oz)	
Energy	255kJ (61kcal)
Carbohydrates	14.15g
Sugars	3.9g
Dietary fibre	1.8g
Fat	0.3 g
Protein	1.5g

Minerals	
Calcium	59mg (6%)
Iron	2.1mg (16%)
Magnesium	28mg (8%)
Manganese	0.481mg(23%)
Phosphorus	35mg (5%)
Potassium	180mg (4%)
Other constituents	
Water	83g

Vitamins

Vitamin A equiv. beta-Carotene lutein zeaxanthin	(10%)83 µg (9%) 1000 µg 1900 µg	Vitamin B6	(18%) 0.233 mg
Thiamine (B1)	(5%) 0.06 mg	Folate (B9)	(16%) 64 µg
Riboflavin (B2)	(3%)0.03 mg	Vitamin C	12mg (6%)
Niacin (B3)	(3%) 0.4 mg	Vitamin E	(6%) 0.92 mg
Pantothenic acid (B5)	(3%) 0.14 mg	Vitamin K	(45%) 47 µg

Phytochemicals

The phytochemical screening of the plant showed the presence of tannin, saponins, flavonoids, quinine, glycoside, cardiac glycoside, terpenoids, phenols, coumarins, steroids, alkaloids, anthocyanin and betacyanin. Ethanol and acetone leaf extract exhibits highest positive response followed by other solvent such as chloroform, petroleum ether and aqueous extract. (Table 2).

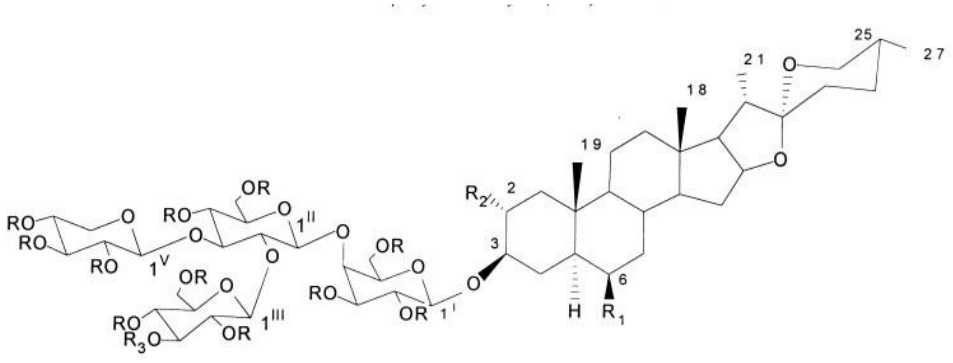
Table No. 2: Qualitative phytochemical analysis.[26]

S.no	Phytochemicals	Ethanol	Acetone	Petroleum ether	Chloroform	Aqueous extract
1	Tannin	+	+	-	-	+
2	Saponins	-	-	-	-	-
3	Flavonoids	+	+	+	+	+
4	Quinones	+	+	+	+	+
5	Glycosides	-	-	-	-	-
6	Cardiac glycosides	+	+	+	-	-
7	Terpenoids	+	+	+	+	-
8	Phenols	+	+	+	+	+
9	Coumarins	+	+	+	+	+
10	Steroids	+	+	-	+	+
11	Alkaloids	+	+	+	-	+
12	Anthocyanin	-	_	-	-	-
13	Betacyanin	+	+	-	-	+

(+) : present ; (-): not detectable

Total phenol content and Flavonoid content was estimated whose concentration were 14 mg Quercetrin per gram of dry sample and 108 mg of Gallic acid per gram of dry sample.[26]

Saponins: The methanolic bulb extracts of *Allium porrum* revealed the presence of four saponins (1-4), in that two of which (3, 4) are new compounds. They are (25R)-5α-spitostan-3 β,6 β -diol 3-O-{O-β-D-glucopyranosyl-(1→2)-O[β-D-xylopyranosyl-(1→3)[-O-β-D-glucopyranosyl]-(1→4)- β-D-galactopyranoside} and (25R)-5α-spitostan-3,6-diol 3-O-{O- β -D-glucopyranosyl-(1→3)-O- β -D-Glucopyranosyl-(1→2)-O-[β -D-xylopyranosyl]-(1→3)-O- β -D-glucopypranosyl-(1→4)-β-D-galactopyranoside}.[20]



	R	R_1	R_2	R_3
1	H	H	OH	H
2	H	H	OH	β-Glc ^{IV}
3	H	OH	H	H
3a	Ac	OAc	H	Ac
4	H	OH	H	β-Glc^{IV}
4a	Ac	OAc	H	β-Glc^{IV}-2,3,4,6-OAc

Figure 2: Novel saponins isolated from Methanolic extract of *Allium porrum* L.[20]

Steroidal Saponins: A new steroidal saponins was isolated from the bulbs of *Allium ampeloprasum var. porrum* L. whose structure was established as (3 β,5α,6 β,25R)-6-[(β -D-glucopyranosyl) oxyl]-spirostan-3-yl O-β-D-glucopyranosyl-(1→2)-O-[β-D-glucopyranosyl-(1→3)] -β —D-galactopyranoside.[27]

Sapogenins: i.) Two new sapogenins, 12-keto-porrigenin(1a) and 2,3 – seco-porrigenin (2a) was isolated from the organic extract of *Allium porrum*.(Figure 3).[28]

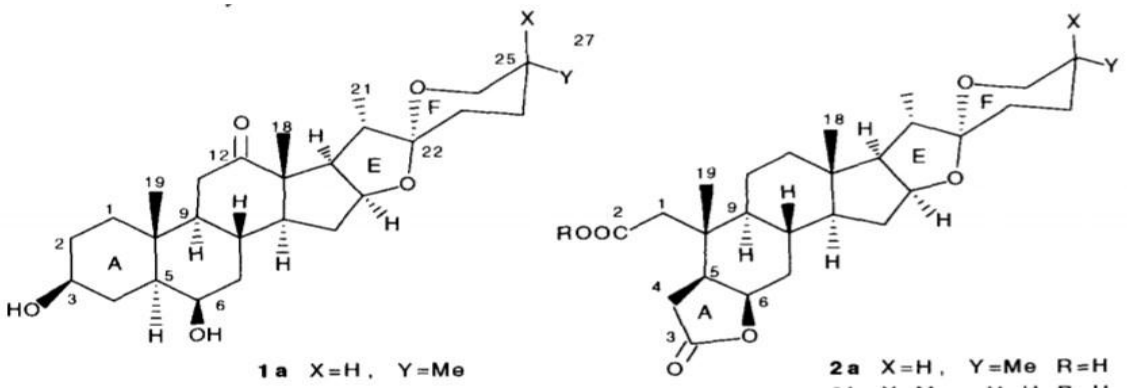


Figure 3: Novel sapogenins: 1a- 12-keto-porrigenin;2a-2,3-seco-porrigenin.

ii.) Spirostanol sapogenins such as porrigenin C (1a) and of small quantities of its 25S' isomer neoporrigenin (1b) were isolated from bulb extract of *Allium porrum*.[29]

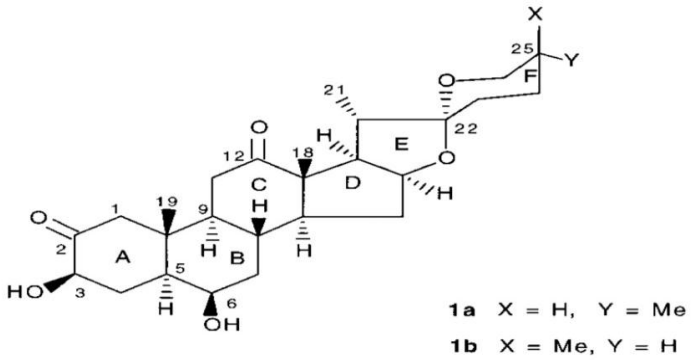


Figure 4: Spirostanol Sapogenins: 1a-porrigenin;1b- Neoporrigenin.

iii.) Four new sapogenins, porrigenins A (2a) and B (3a), identified as (25R)-5R-spirostan-2β,3β,6 β -triol and (25R)-2-oxo-5R-spirostan-3 β,6 β -diol, respectively, and neoporrigenins A (2b) and B (3b) were also isolated from Allium porrum. In addition, the known agigenin (1a) and its 25S epimer, neoagigenin (1b) were also identified(Figure.5).[30]

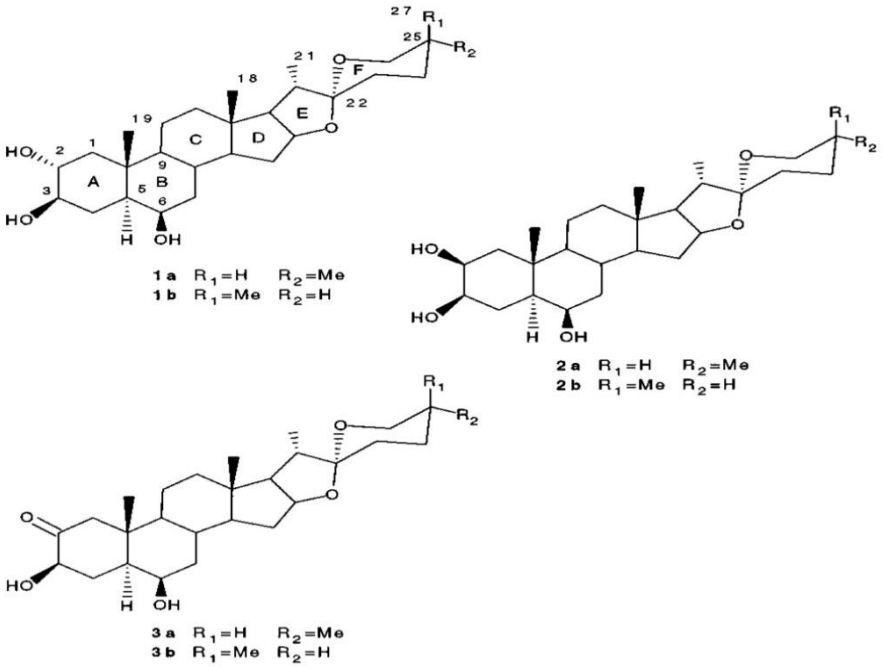


Figure 5: Novel Sapogenins.

iii) A new steroidal saponins was isolated from the bulbs of *Allium ampeloprasum L. var. porrum*. On the basis of chemical evidence, comprehensive spectroscopic analyses, and comparison with known compounds, its structure was established as (3β,5α,6*β*,25R)-3-{(O- *β*-D-glucopyranosyl-(1→3)- *β*-D-glucopyranosyl-(1→2)-O-[O- *β*-D-glucopyranosyl-(1→3)]-O- *β*-D-glucopyranosyl-(1→4)- *β*-D-galactopyranosyl) oxy}-6-hydroxyspirostan-2-one (Figure 6).[31]

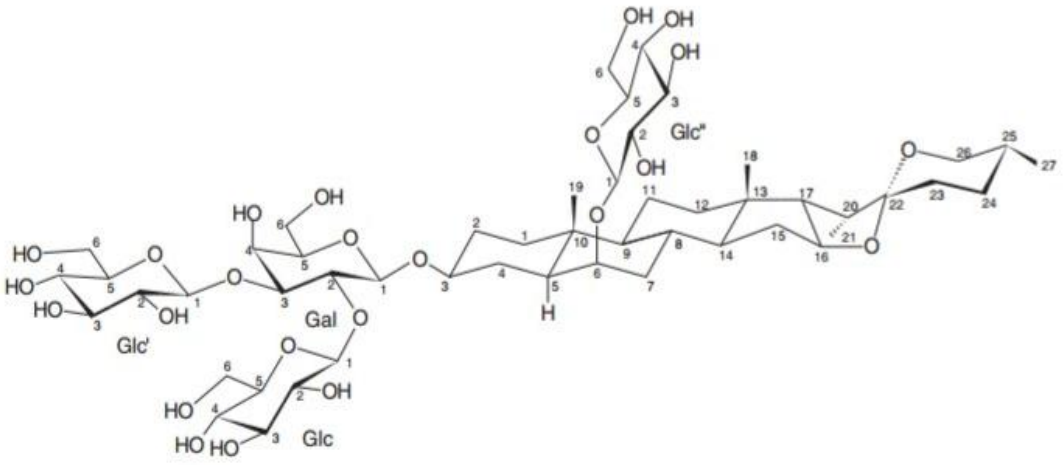


Figure 6: Structure of Steroidal Saponin.

Flavonoids: The isolated compounds from bulbs of *Allium porrum* are flavonol glycosides, two of which based on a Kaempferol aglycone and acylated with a 3-methoxy-4-hydroxycinnamoyl moiety are new products. They are Astragalline (**1**), Kaempferol -3-o-neohesperidoside(**2**) , compound **3**(constituent of Quercus suber and Eryngium campstre), Kaempferol 3-O[2-O-(trans-3-methoxy-4-hydroxy cinnamoyl)-β-D-galactopyranosyl]-(1→4)-O-β-D-glucopyranoside (**4**) and Kaempferol 3-O-[2-O-(trans 3-methoxy-4-hydroxycinnamoyl)- β -D-glucopyranosyl]-(1→6)-O- β -D-glucopyranoside (**5**) and other derivatives.[32]

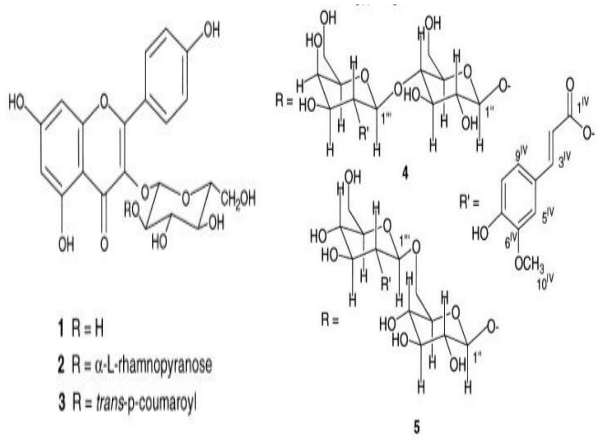


Figure 7: The Flavonoids of Leek.

Other phenolic compounds present are: Rosamarinic acid, quercetin, rutin from stem extracts and quercetin, apigenin from leaf extracts were isolated.[33]

The methanolic extract of the leaves of *Allium porrum L.* was fractioned and the structures of the isolated components characterized and identified using high performance liquid chromatography and mass spectrometry. The isolated compounds (malonyl flavonols) are derivatives of Kaempferol namely mono-hexose, dihexose , coumaroyl, feruloyl and caffeoyl acylated di-hexose derivatives whose common characteristic of these structures relies on the presence of malonyl moiety on the primary alcoholic function of the sugar linked to the aglycone.[34]

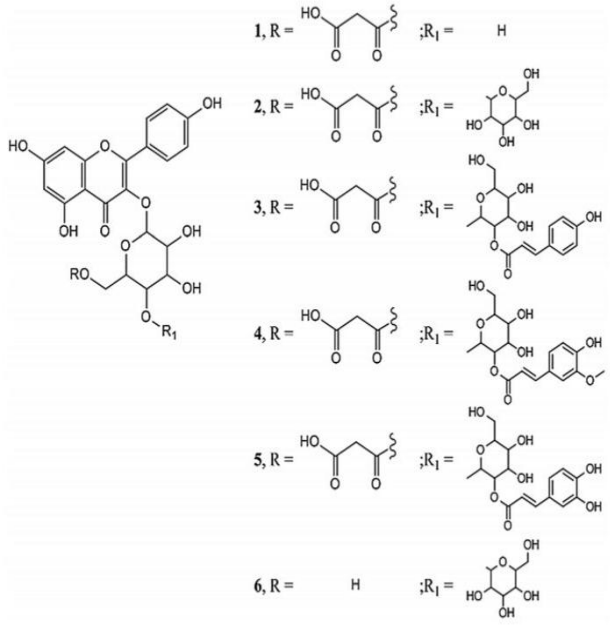


Figure 8: Structure Of Malonyl Glycosylated Kaempferol Compounds.[34]

Organosulfur compounds: *Allium porrum* contains numerous organosulfur compounds, including trans -S-(1-propenyl) cysteine sulfoxide, S- methylcysteine sulfoxide, S-propenylcysteine sulfoxide, cycloallin.[8,35]

Volatile oils: 67 major volatile constituents of leek oil obtained by steam distillation and the components were analysed using gas liquid chromatography and mass spectrometry. The structure of these components was identified by comparison of their mass spectra and retention times with those of reference compounds.[36]

Peak no.	Component	Supplier[a]	Ip[b]	Identification
1	Methanal[c]			MS[d]
2	Ethanal	M		MS, RT, A
3	Methanethiol[c]	S, F		MS, RT, A
4	Propanal[c]	U		MS, RT, A
5	Ethanol	U, A		MS, RT, A
6	Diethyl ether[e]	U		MS, RT, A
7	Dichloromethane[e]	U		MS, RT, A
9	Allyl alcohol	A		MS, RT, A
10	*n*-Propanol	U, A		MS, RT, A
11	2-Butanone[f]	U		MS, RT, A
12	1-Propanethiol[c]			MS, RT
13	Ethyl acetate	U	603	MS, RT, A
14	2-Methylpropanol	A	627	MS, RT, A
15	3-Methylbutanal	A	633	MS, RT, A
16	2-Methylbutanal		643	MS, RT
17	*n*-Butanol	U	664	MS, RT, A
18	*n*-Pentanal	A	675	MS, RT, A
19	Allyl methyl sulfide		678	MS, RT
20	2-Hydroxy-3-butanone[f]	A	689	MS, RT, A
21	Pyridine	A	719	MS, RT, A
22	Dimethyl disulfide		723	MS, RT
23	3-Methylbutanol[f]		722	MS, RT
24	2-Methylpentanal		740	MS, RT
25	Methylthiophene (2 isomers)		753-755	MS, RT
26	*n*-Pentanol	U	762	MS, RT, A
28	*n*-Hexanal	A	779	MS, RT, A
29	Methylpyrazine		798	MS, T
30	2-Furaldehyde	F, A	804	MS, RT, A
31	2-Methylpent-2-enal		811	MS, RT
32	2-Methylpentanol	F	827	MS, RT, A
33	*trans*-Hex-3-en-1-ol		843	MS, RT
34	2-Furyl alcohol	F	846	MS, RT, A
35	Dimethylthiophene (isomer)		855	MS, RT
36	Allyl propyl sulfide		858	MS, RT
37	*n*-Hexanol	U	859	MS, RT, A
38	Dimethylthiophene (isomer)		861	MS, RT
39	2-Heptanone		871	MS, RT
40	*n*-Heptanal	A	881	MS, RT, A
41	3,4-Dimethylthiophene		887	MS, RT
42	2,6-Dimethylpyrazine		891	MS, T
43	Allyl methyl disulfide[c]		895	MS, RT
45	Methyl propyl disulfide[c]		914	MS, RT
46	Methyl propyl disulfide[c]		922	MS, RT
47	Benzaldehyde	A, U	932	MS, RT, A
48	Dimethyl trisulfide		948	MS, RT
52	2-Octanone		972	MS, RT
53	2-Ethyl furyl ketone		983	MS, RT
55	Benzyl alcohol	U	1013	MS, RT, A
56	2-Pyrrolcarboxaldehyde		1023	MS, T
60	*n*-Octanol	A	1060	MS, RT, A
61	2-Nonanone		1073	MS, RT
64	Dipropyl disulfide[c]	F	1092	MS, RT, A
65	2-Phenylethanol	M	1096	MS, RT, A
66	1,2-Dimethoxybenzene	R	1114	MS, RT, A
67	Methyl propyl trisulfide		1132	MS, RT
69	*n*-Nonanol		1160	MS, RT
71	2-Decanone		1174	MS, RT
72	2,5-Dihydro-3,4-dimethylthiophen-2-one		1193	MS, RT
73	Benzothiazole	A	1196	MS, RT, A
78	Decomposed		1291	
79	Propenyl propyl trisulfide (isomer)		1310	MS, RT
80	Propenyl propyl trisulfide (isomer)		1317	MS, RT
81	2,3-Dihydro-2-*n*-hexyl-5-methylfuran-3-one		1413	MS, RT
82	2-Tridecanone		1477	MS, RT
83	2,3-Dihydro-2-*n*-octyl-5-methylfuran-3-one		1619	MS, T
84	2-Pentadecanone		1681	MS, RT
85	Diphenylacetylene		>1700	MS, T

[a] Supplier: F = Fluka, M = Merck, U = Union Chimique Belge; A = Aldrich; R = Riedel-de Haen; S = Schuchardt. [b] Retention index on OV 1 between C_6 and C_{17} with linear temperature programming (Rasquinho, 1965). [c] Previously identified by other workers. [d] MS, mass spectrometry; RT, retention index; A, comparison with authentic compound. [e] Solvent peaks. [f] The steam distillation was carried out twice. This component was only present in one steam distillate.

Figure 9: Volatile Oils.

Glucofructan: A novel compound isolated from the hot water bulb extracts of *Allium porrum* was α-D-Glcp-(1→1)-β-D-Fruf-(2→1)-{[α-D-Glcp-(1→6)-β-D-Fruf-(2→6)]-α-D-Fruf-(2→1)}4-α-D-Fruf-(2M1)-β-D-Glcp.[37]

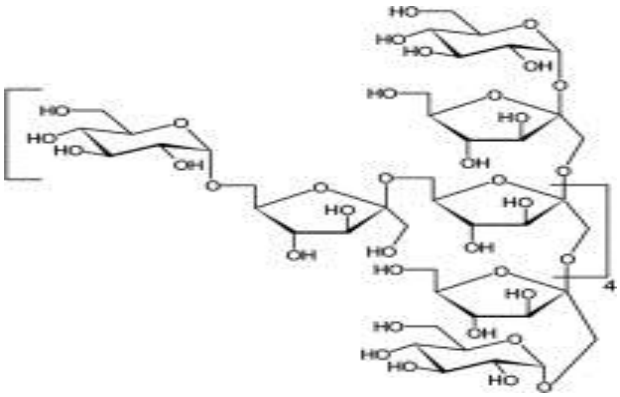
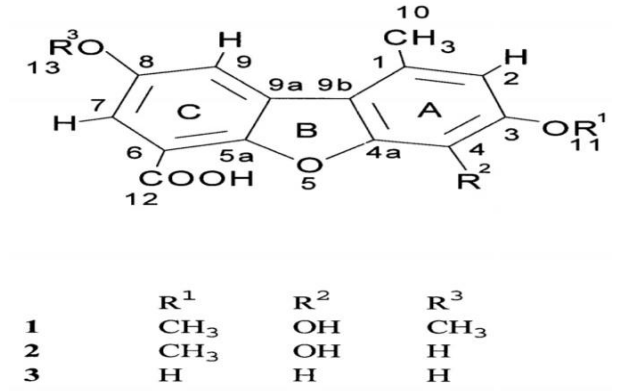


Figure 10: Schematic Representation Of The Glucofructan Isolated From *AlliumAmpeloprasum Var. Porrum:* α-D-Glcp-(1→1)-β-D-Fruf-(2→1)-{[α -D-Glcp-(1→6)-β-D-Fruf-(2→6)]-α -D-Fruf-(2→1)}4-α -D-Fruf-(2M1)-β-D-Glcp.

Dibenzofurans: Three new benzofurans such as Porric acids A, B, C have been isolated from the bulbs of *Allium porrum L.* their structures have been elucidated by spectroscopic analyses including 2D HMBC and ROESY.[38]



	R^1	R^2	R^3
1	CH_3	OH	CH_3
2	CH_3	OH	H
3	H	H	H

Figure 11: Porric acid A (1), B (2), C (3)

Pharmacological Actions

Anti-inflammatory activity: The anti-inflammatory activity of novel steroidal saponins investigated using an acute inflammation model and the results measured by inhibition of carrageenan induced mouse paw oedema. The carrageenan-induced inflammation is a biphasic phenomenon. The early phase of oedema attributes to the release of histamine, serotonin and similar substances. The later phase results mainly from the potentiating effects of prostaglandins on mediator release. The steroidal saponins showed significant anti-inflammatory potential, promptly controlling both phase of inflammation and provoking an inhibition of oedema formation similar to the reference compound dexamethasone. It shows anti-oedematous properties with potency similar to that of bioactive compounds isolated from other medicinal plants used against inflammatory disorders.[27]

Antioxidant: Ethanol extracts of edible leek parts were prepared by ultrasound-assisted extraction, which followed by evaluation of total phenols, flavonoids and antioxidant activity. Antioxidant activity assessed by scavenging the stable free radical 2, 2- diphenyl 1-picrylhydrazyl (DPPH), ORAC and FRAP assay. The results of antioxidant activity compared with control antioxidants: vitamin C and BHT. The leek's ethanol extract of stem had higher phenolic and flavonoid content, which showed higher antioxidant activity. Green leaks leaves shows significant higher antioxidant capacity than the white part. Correlation analysis between the total phenolics and the ascorbic content and the antioxidant activity showed that phenolics and ascorbic acid contribute significantly to the antioxidant activity of leek. Phenolic compounds will be partly responsible for their activity, because their biosynthesis requires the presence of light.[33,39–41]

Anti-hypertensive: Oral administration of alcoholic extract *Allium porrum* (250 and 500mg/kg) exhibits significant reduction of the elevated systolic blood pressure induced by L-NAME (50mg/kg) compared with hypertensive control group.[42] L-NAME is a nitric oxide synthase inhibitor thus it inhibit nitric oxide synthesis from its precursor L-arginine which has been shown to be the active principle of the endothelium derived relaxing factor, it leads to vasoconstriction and hypertension.[43]

Anti-diabetic: The effect of *Allium sativum* and *Allium porrum* on D-glucose, fluid absorption (mucosal disappearance) and transport (serosal appearance) across everted intestinal sacs of rat was studied. Different concentrations of *Allium sativum* and *Allium porrum* (2.5 and 5.0mg/ml) were incubated in the intestinal segments in the mucosal solution. Data obtained from the investigation explain that *Allium sativum* and *Allium porrum* inhibit the active transport of D-glucose across rat enterocytes and found that increased concentrations of *Allium sativum* and *Allium porrum* at 2.5 and 5.0mg/ml in the mucosal solution significantly decreased the absorption as the transport across the rat intestine. The D-glucose absorption along with transport significantly inhibited at 2.5 and 5.0mg/ml of *Allium sativum* and *Allium porrum*, which compared to the control experiment group (Table no. 3). *Allium porrum* was found to be more potent than *Allium sativum* on glucose uptake in diabetic rats.[44]

Table No-3.

S.no	Group	Dose	D-glucose transport (µM/g tissue wet. wt)		
			Mucosal appearance	Gut wall content	Serosal appearance
1.	Control		71.21 ± 2.6	25.55 ± 2.2	45.66 ± 2.3
2.	*Allium sativum*	2.5 mg/ml	67.74 ± 2.0 [-4.86]	25.68 ± 1.5 [+0.50]	42.05 ± 1.5 [7.90]
		5.0 mg/ml	65.97 ± 2.3 [7.35]	22.86 ± 1.4 [+10.52]	43.11 ± 1.8 [5.68]
3.	*Allium porrum*	2.5 mg/ml	65.12 ± 2.1 [8.55]	22.34 ± 2.9 [+12.56]	40.81 ± 2.8 [10.62]
		5.0 mg/ml	64.56 ± 2.6 [9.33]	21.0 ± 2.4 [+17.80]	43.56 ± 2.4 [4.56]
4.	Standard Insulin	40 µM/ml	60.36 ± 2.9 [15.23]	22.52 ± 2.4 [+11.85]	37.84 ± 3.5 [17.12]

Hypolipidemic And Anti Atherosclerotic Effect: The anti-hypercholesteraemic effect of a hydroalcoholic extract of *Allium porrum* L. bulbs evaluated in rabbits on hypercholesteraemic diet. The extract at three doses was given as 250, 500 and 1000 mg/kg of body weight. Plasma total cholesterol decreased in all groups treated with *Allium porrum* extract in a dose-dependent fashion. The increase of the hypocholesterolaemia effect of the extract in the period of treatment (12 weeks) indicates that the anti-hypercholesteraemic effect of *Allium porrum* is dose dependent. Leek-treated animals also showed a decrease in the atherogenic index (Table No.4), which is generally believed to be beneficial since the HDL level inversely correlated with coronary heart disease and reduction in this ratio is considered as an anti-atherosclerotic factor.[45,46]

Table 4: Atherogenic index.

Group	Atherogenic index
Control	2.3 ± 1.1
Hypercholestremic diet	20.8 ± 2.3
Leek extract	
250mg/kg	9.8± 1.6
500mg/kg	4.9 ± 1.3
1000mg/kg	3.47± 1.1

Anti-bacterial: The aqueous extracts of leaves *Allium porrum* showed higher activity against Gram-positive bacteria rather than Gram-negative bacteria. The below table showed the inhibition zone reached 31mm in diameter against *Bacillus subtilis, Staphylococcus aureus and Streptococcus pneumonia*. On the other hand, the zone of inhibition reached to 26, 56, 25, 24 mm in diameter against *Pseudomonas aeruginosa*, *Proteus vulgaris and Escherichia coli* respectively. The presence of organosulphur compounds is responsible for antimicrobial activity.[37,47]

Table 5: Antibacterial activity of crude aqueous extract of *Allium porrum(A. porrum)* against some pathogenic bacterial species as compared with Gentamicin and Tetracycline.[47]

Bacterial strain	Mean diameter of growth inhibition zone in (mm)		
	Crude aqueous extract of *A. porrum*	Gentamicin	Tetracycline
B. subtilis	31	30	27
S. aureus	30	20	31
S. pneumonia	30	24	28
E.coli	24	25	24
P.aeruginosa	26	25	-
P.vulgaris	25	22	-

The leaf and stem extracts of *Allium porrum* L. was also effective against *Klebsiella pneumoniae, Escherichia coli, Proteus mirabilis.*[33]

Antifungal: Two new spirostanol saponins from *Allium porrum* was isolated which was effective against *Fusarium culmorum.*[20] Three new dibenzofurans namely Porric acid A, B ,C have been isolated from the bulbs of *Allium porrum L.* were found to exhibit antifungal activity against *Fusarium culmorum*[38] The leaf and stem extracts of *Allium porrum* L. was also effective against *Candida albicans, Asperigillus niger*.[33]

Anti-platelet: *Allium porrum* extract inhibits platelet aggregation, which is due to presence of flavonoids. Kaempferol inhibited platelet aggregation and ATP release of platelets induced by arachidonic acid or collagen. Kaempferol also acts as a thromboxane receptor antagonist and it has been claimed as an active agent in the prevention of atherosclerosis and acute platelet thrombus formation.[32]

Chelating agent: The Hydroalcoholic extract of *Allium porrum* at a dose of 400mg shows significant iron chelating property when compared to control. The plant extracts with dose 200mg /kg also reduced the iron and ferritin content but the effect was lower level compare to higher doses. The plant extract effects were similar to that of standard drug Deferoxamine. Significant decrease in serum ferritin and iron concentration was reported in iron overload rats which induced by iron dextran. The iron chelating action produced by forming soluble and

stable forms by interactions with flavonoids.[21] Plant with higher concentration of phenolic substances have a good iron chelating potential, hence this extract can be used as an alternate chelator to treat thalassemia.[48]

Gastroprotective activity/anti-ulcerogenic activity: The glucofructan were isolated from the hot water extract of *Allium ampeloprasum var. porrum* and steroidal saponins isolated from *Allium porrum* exhibits significant gastro protective activity evaluated by measuring acute lesions induced by acidified ethanol. The result suggested that compounds interfere with the ulcerogenic mechanism and showed cytoprotective property.[31,37,49]

Anti-trypanosomal activity: Clinical manifestations of trypanosomes such as increased rectal temperature, weakness and dullness occurs in experimental rats. Intra-peritoneal injection of Ethyl acetate extracts and Ethanol extracts of *A. porrum* causes feeble changes in the pre-treatment and post treatment parasitemia level in the groups treated with ethylacetate extract of *A. porrum* while there was significant clearance in parasitemia in the control group. It concludes that it has trypanosomal reduction activity when compared to control group.[50,51]

Anti-osteoporotic: Oral administration of alcoholic extract of *Allium porrum* (250 and 500mg/kg)had significant antioxidant activity which results in a significant elevation in the decreased bone mineral density in osteoporotic rats as compared with control group.(18) Flavonol derivatives such as quercetin and Kaempferol stimulates osteoblastic activity and such compounds may represent new pharmacological tools for the treatment of osteoporosis.[52,53]

Haemolytic activity: Normal human red blood cell suspension (0.5 ml of 0.5%) was mixed with 0.5 ml of diluent containing 5, 10, 20, 30, 40, 50, 100, 250, and 500 mg/ml of compound 1, Al(OH)3, purified Quillaja saponin (QS-21), and 5–500 mg/ml of Freunds Complete Adjuvant (FCA) and Freunds Incomplete Adjuvant (FIA) in saline solution. The mixtures were incubated for 30 minutes at 37^0C and centrifuged at 70g for 10 min. Saline and distilled H2O were included as minimal and maximal haemolytic controls, respectively. The haemolytic percent developed by the saline control subtracted from those of all groups. The adjuvant concentration inducing 50% of the maximal haemolysis considered as the median haemolytic dose (HD50; graphical interpolation). Every experiment has done in triplicates at each concentration. Steroidal saponins exhibits haemolytic activity in in-vitro assay.[31,54]

Immunological adjuvant activity: Mice immunized with oval albumin conjugated with steroidal saponins showed response greater than those combined with commercial adjuvants. This response developed rapidly after immunization and persisted at high levels for at least 3 days.[31,54]

Anti-proliferative activity: Two new sapogenins, 12-keto-porrigenin and 2, 3 – seco-porrigenin was isolated from the organic extract of *Allium porrum*. These two compounds exhibit significant anti-proliferative activity against murine Leukemia (P388) cell line.[28]

Cytotoxicity: The ethanol extract of *Allium porrum* L. inhibit Hep 2c human laryngeal carcinoma cell line), L20B (murine Fibroblastic tumour cell line) and RD (Human myosarcoma cell line) in a dose dependent manner.[33] The eight saponins isolated from leek were tested for their cytotoxic activity against two different cell lines (Invitro) in which three of them showed cytotoxicity activity.[55] Organosulphur compounds such as Allicin, diallyl sulphide acts by blocking NF-κB activation process.[56] Kaempferol inhibits cancer cell growth, simultaneously preserves normal cell viability.[57]

CONCLUSION

Allium porrum L possess several pharmacological activities as discussed above which is due to the presence of phytoconstituents such as saponins, flavonoids, glucofructans etc. It may still contain several phytoconstituents which should be explored in future for clinical use.

CONFLICT OF INTEREST

All authors have no conflict of interest.

REFERENCES

1. Sengupta A, Ghosh S, Bhattacharjee S. Allium vegetables in cancer prevention: an overview. Asian Pac J Cancer Prev APJCP. 2004 Sep; 5(3): 237–45.
2. Leek | plant [Internet]. Encyclopaedia Britannica. [Cited 2017 Nov 30]. Available from: https://www.britannica.com/plant/leek.
3. Wood HC, Remington JP. The Dispensatory of the United States of America.[Internet]. Philadelphia: Lippincott; 1918 [cited 2017 Nov 28]. cxxii, 2010 p. (United States dispensatory). Available from: https://catalog.hathitrust.org/Record/100163146.
4. Block E. The Organosulfur Chemistry of the Genus Allium – Implications for the Organic Chemistry of Sulfur. Angew Chem Int Ed Engl [Internet] 1992 Sep 1 [cited 2017 Nov 28]; 31(9): 1135–78. Available from: http://onlinelibrary.wiley.com/doi/10.1002/anie.199211351/abstract.
5. Virtanen AI. Studies on organic sulphur compounds and other labile substances in plants. Phytochemistry [Internet]. 1965 Mar 1 [cited 2017 Nov 28]; 4(2): 207–28. Available from: http://www.sciencedirect.com/science/article/pii/S0031942200861683.
6. Auger J, Lecomte C, Thibout E. Leek odor analysis by gas chromatography and identification of the most active substance for the leek moth,

Acrolepiopsis assectella. J Chem Ecol, 1989 Jun; 15(6): 1847–54.
7. Ankri S, Mirelman D. Antimicrobial properties of allicin from garlic. Microbes Infect, 1999 Feb; 1(2): 125–9.
8. Bianchini F, Vainio H. Allium vegetables and organosulfur compounds: do they help prevent cancer? Environ Health Perspect, 2001 Sep; 109(9): 893–902.
9. Lucock M. Folic acid: nutritional biochemistry, molecular biology, and role in disease processes. Mol Genet Metab, 2000 Oct; 71(1–2): 121–38.
10. Hsing AW, Chokkalingam AP, Gao Y-T, Madigan MP, Deng J, Gridley G, et al. Allium vegetables and risk of prostate cancer: a population-based study. J Natl Cancer Inst, 2002 Nov 6; 94(21): 1648–51.
11. Stover PJ. Physiology of folate and vitamin B12 in health and disease. Nutr Rev, 2004 Jun; 62(6 Pt 2): S3–12; discussion S13.
12. Allium porrum : Leek | NBN Atlas | NBN Atlas [Internet]. [cited 2017 Nov 28]. Available from: https://species.nbnatlas.org/species/NBNSYS0000002250.
13. Garden Leek - Allium porrum - Details [Internet]. Encyclopedia of Life. [cited 2017 Nov 28]. Available from: http://eol.org/pages/1084841/details.
14. Learn2Grow [Internet]. [cited 2017 Dec 11]. Available from: http://www.learn2grow.com/plants/allium-porrum/.
15. Currah L. Leek breeding: a review. J Hortic Sci [Internet]. 1986 Jan 1 [cited 2017 Nov 25]; 61(4): 407–15. Available from: https://doi.org/10.1080/14620316.1986.11515720.
16. Taxonomy - GRIN-Global Web v 1.9.9.2 [Internet]. [cited 2017 Nov 30]. Available from: https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?2351.
17. Tasar OC, Erdal S, Algur OF. Utilization of Leek (Allium ampeloprasum var. porrum) for inulinase production. Prep Biochem Biotechnol, 2015 Aug 18; 45(6): 596–604.
18. Siham M. A. E-S, Nemat A. Z. Y, Osama A B, Mostafa AE-M, Hanan M. A-S. Study of the effect of Allium porrum on osteoporosis induced in rats. Sch Res Libr, 2013; 5(1): 188–98.
19. Corrêa P. Diccionario das plantas uteis do Brasil. Rio de Janeiro: Ministerio da agricultura, 1926.
20. Carotenuto A, Fattorusso E, Lanzotti V, Magno S. Spirostanol saponins of Allium porrum L. Phytochemistry, 1999 Aug; 51(8): 1077–82.
21. Mirzaei A, Delaviz H, Mirzaei M, Tolooei M. The Effects of Medicago Sativa and Allium Porrum on Iron Overload in Rats. Glob J Health Sci, 2015 Apr 23; 7(7 Spec No): 137–42.
22. Cadot P, Tits G, Bussels L, Ceuppens JL. Asthma and hand dermatitis to leek. Allergy [Internet]. 2001 Feb 1 [cited 2017 Nov 26]; 56(2): 192–3. Available from: http://onlinelibrary.wiley.com/doi/10.1034/j.1398-9995.2001.056002192.x/abstract.
23. Armentia A, Lombardero M, Fernàndez S, Asensio T, Martín G, Callejo A, et al. Occupational rhinitis to leek (Allium porrum). Allergy [Internet]. 2005 Jan 1 [cited 2017 Nov 26]; 60(1): 132–3. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1398-9995.2004.00605.x/abstract.
24. Salgado BS, Monteiro LN, Rocha NS. Allium species poisoning in dogs and cats. J Venom Anim Toxins Trop Dis [Internet]. 2011 [cited 2017 Nov 28]; 17(1): 4–11. Available from: http://www.scielo.br/scielo.php?script=sci_abstract&pid=S1678-91992011000100002&lng=en&nrm=iso&tlng=en.
25. Food Composition Databases Show Foods -- Leeks, (bulb and lower leaf-portion), raw [Internet]. [cited 2017 Nov 27]. Available from: https://ndb.nal.usda.gov/ndb/foods/show/2996?manu=&fgcd=&ds=.
26. Comparative study of Qualitative Phytochemical screening and antioxidant activity of Mentha arvensis, Elettaria cardamomum and Allium porrum [Internet]. [cited 2017 Nov 28]. Available from: http://www.iajpr.com/archive/volume-4/may-2014/14may34.html.
27. A new steroidal saponin with antiinflammatory and antiulcerogenic properties from the bulbs of Allium ampeloprasum var. porrum - ScienceDirect [Internet]. [cited 2017 Nov 25]. Available from: http://www.sciencedirect.com/science/article/pii/S0367326X11001882.
28. 12-Keto-porrigenin and the unique 2,3-seco-porrigenin, new antiproliferative sapogenins from Allium porrum - ScienceDirect [Internet]. [cited 2017 Nov 25]. Available from: http://www.sciencedirect.com/science/article/pii/S0040402097000628.
29. Fattorusso E, Lanzotti V, Magno S, Taglialatela-Scafati O. Sapogenins of Allium porrum L. J Agric Food Chem [Internet], 1998 Dec 1 [cited 2017 Nov 25]; 46(12): 4904–8. Available from: http://dx.doi.org/10.1021/jf980849n
30. Carotenuto A, Fattorusso E, Lanzotti V, Magno S, De Feo V, Carnuccio R, et al. Porrigenins A and B, Novel Cytotoxic and Antiproliferative Sapogenins Isolated from Allium porrum. J Nat Prod [Internet]. 1997 Oct 1 [cited 2017 Nov 25]; 60(10): 1003–7. Available from: http://dx.doi.org/10.1021/np960657r.
31. Adão CR, da Silva BP, Parente JP. A new steroidal saponin with antiinflammatory and antiulcerogenic properties from the bulbs of Allium ampeloprasum var. porrum. Fitoterapia [Internet]. 2011 Dec 1 [cited 2017 Nov 25]; 82(8): 1175–80. Available from: http://www.sciencedirect.com/science/article/pii/S0367326X11001882.

32. Fattorusso E, Lanzotti V, Taglialatela-Scafati O, Cicala C. The flavonoids of leek, Allium porrum. Phytochemistry, 2001 Jun; 57(4): 565–9.
33. Radovanović B, Mladenović J, Radovanović A, Pavlović R, Nikolić V. Phenolic Composition, Antioxidant, Antimicrobial and Cytotoxic Activites of *Allium porrum* L. (Serbia) Extracts. J Food Nutr Res J Food Nutr Res [Internet]. 2015 Nov 9 [cited 2017 Nov 25]; 3(9): 564–9. Available from: http://pubs.sciepub.com/jfnr/3/9/1/index.html.
34. Di Donna L, Fabio M, Domenico T, Anna N, Giovanni S. Structural characterisation of Malonyl flavonols in Leek (Allium porrum L.) using High-performance Liquid Chromatography and Mass spectrometry. Publ Online Wiley Online Libr, 28 Dec. 2014; 207–12.
35. Casella S, Leonardi M, Melai B, Fratini F, Pistelli L. The role of diallyl sulfides and dipropyl sulfides in the in vitro antimicrobial activity of the essential oil of garlic, Allium sativum L., and leek, Allium porrum L. Phytother Res PTR, 2013 Mar; 27(3): 380–3.
36. Volatile flavor components of leek - Journal of Agricultural and Food Chemistry (ACS Publications) [Internet]. [cited 2017 Nov 25]. Available from: http://pubs.acs.org/doi/abs/10.1021/jf60204a056?journalCode=jafcau.
37. Malafaia CRA, da Silva BP, Tinoco LW, Parente JP. Structural characterization and gastroprotective property of a novel glucofructan from Allium ampeloprasum var. porrum. Carbohydr Res [Internet]. 2015 Jan 30 [cited 2017 Nov 25]; 402(Supplement C): 44–9. Available from: http://www.sciencedirect.com/science/article/pii/S0008621514003954.
38. Carotenuto A, Fattorusso E, Lanzotti V, MAGNO S. Porric Acids A-C - New Antifungal Dibenzofurans from the Bulbs of Allium Porrum L. Cheminform, 2010 Jul 21; 29.
39. Mladenović JD, Mašković PZ, Pavlović RM, Radovanović BC, Aćamović-Đoković G, Cvijović MS. Antioxidant activity of ultrasonic extracts of leek Allium porrum L. Hem Ind [Internet], 2011 [cited 2017 Nov 25]; 65(4): 473–7. Available from: http://www.doiserbia.nb.rs/Article.aspx?ID=0367-598X1100033M&AspxAutoDetectCookieSupport=1
40. Bernaert N, De Paepe D, Bouten C, De Clercq H, Stewart D, Van Bockstaele E, et al. Antioxidant capacity, total phenolic and ascorbate content as a function of the genetic diversity of leek (Allium ampeloprasum var. porrum). Food Chem [Internet]. 2012 Sep 15 [cited 2017 Nov 25]; 134(2): 669–77. Available from: http://www.sciencedirect.com/science/article/pii/S0308814612003743.
41. Bernaert N, Droogenbroeck B, Bouten C, De Paepe D, Bockstaele E, De Clercq H, et al. The antioxidant capacity of leek (Allium ampeloprasum var. porrum), 2011; 76: 173.
42. Osama a B, Nemat a. Z. yassin, siham m. a. el-sheNawy, Mostafa AE-M, Hanan M. A-S. STUDY OF THE EFFECT OF Allium porrum ON Hypertension Induced IN RATS. Rev Latinoamer Quím, 2013 Jul; 41.
43. Nakamura T, Ohyama Y, Masuda H, Kurashina T, Saito Y, Kato T, et al. Chronic blockade of nitric oxide synthesis increases urinary endothelin-1 excretion. J Hypertens, 1997 Apr; 15(4): 373–81.
44. Comparative study of garlic species (Allium sativum and Allium porrum) on glucose uptake in diabetic rats - ScienceDirect [Internet]. [cited 2017 Nov 27]. Available from: http://www.sciencedirect.com/science/article/pii/S1658361213000334.
45. Movahedian A, Sadeghi H, Ghannadi A, Gharavi M, Azarpajooh S. Hypolipidemic Activity of Allium porrum L. in Cholesterol-Fed Rabbits. J Med Food [Internet], 2006 Mar 1 [cited 2017 Nov 25]; 9(1): 98–101. Available from: http://online.liebertpub.com/doi/abs/10.1089/jmf.2006.9.98.
46. Eidi M, Soleimani F, Ebrahimi S. Hypolipidemic Effects of Allium porrum L. Leaves in Healthy and Streptozotocin-Induced Diabetic Mice. J Med Plants [Internet], 2007 Dec 15 [cited 2017 Nov 25]; 4(24): 85–91. Available from: http://jmp.ir/article-1-571-en.html.
47. RanaK. N, Noora A. H. The Antimicrobial activity of Allium porrum Water Extract against some pathogenic bacteria. Journal of Kerbala University, 2012; 10(2): 45–9.
48. Mirzaei A, Abbasi M, Sepehri S, Mirzaei M. The effects of Allium porrum and Medicago sativa on iron concentration in thalassemia serums. Life Sci J., 2013 Jan 1; 10: 27–31.
49. Adão CR, da Silva BP, Parente JP. A new steroidal saponin from Allium ampeloprasum var. porrum with antiinflammatory and gastroprotective effects. Phytochem Lett [Internet]. 2011 Sep 1 [cited 2017 Nov 25]; 4(3): 306–10. Available from: http://www.sciencedirect.com/science/article/pii/S1874390011000838.
50. Odeyemi OS, Yahaya U, Abdulsalami MS. Anti-trypanosomal activity of ethanolic bulb extract of Allium porrum in albino rats experimentally infected with Trypanosoma brucei brucei. Niger J Parasitol, 2017 Sep 29; 38: 261.
51. Omonike S, Yahaya A, Abdulsalami M. Antitrypanosomal Activity of Allium porrum Ethyl Acetate Bulb Extract in Trypanosoma brucei brucei Experimentally Infected Wister Albino Rats. Eur J Med Plants, 2017 Jan 10; 19: 1–8.
52. Prouillet C, Mazière JC, Mazière C, Wattel A, Brazier M, Kamel S. Stimulatory effect of naturally occurring flavonols quercetin and kaempferol on alkaline phosphatase activity in MG-63 human osteoblasts through ERK and estrogen receptor pathway. Biochem Pharmacol [Internet], 2004 Apr

[cited 2017 Nov 26]; 67(7): 1307–13. Available from: http://europepmc.org/abstract/med/15013846.

53. Chen C-H, Chou T-W, Cheng L-H, Ho C-W. In vitro anti-adenoviral activity of five Allium plants. J Taiwan Inst Chem Eng [Internet]. 2011 Mar 1 [cited 2017 Nov 25]; 42(2): 228–32. Available from: http://www.sciencedirect.com/science/article/pii/S1876107010001331.
54. Adão CR, Pereira da Silva B, Tinoco LW, Parente JP. Haemolytic Activity and Immunological Adjuvant Effect of a New Steroidal Saponin from Allium ampeloprasum var. porrum. Chem Biodivers [Internet], 2012 Jan 1 [cited 2017 Nov 25]; 9(1): 58–67. Available from: http://onlinelibrary.wiley.com/doi/10.1002/cbdv.201100005/abstract
55. Fattorusso E, Lanzotti V, Taglialatela-Scafati O, Di Rosa M, Ianaro A. Cytotoxic Saponins from Bulbs of Allium porrum L. J Agric Food Chem [Internet], 2000 Aug 1 [cited 2017 Nov 25]; 48(8): 3455–62. Available from: http://dx.doi.org/10.1021/jf000331v0.
56. Angel Nivya M, Raja K, Kumaravel M, Salini Sasidharan, and Seethapathy G S, Role of nutraceuticals in cancer; International Journal of Pharmacy and Pharmaceutical Sciences, 2012; 4(4): 415–420.
57. Chepuri Kalyani, Mangamoori Lakshmi Narasu, Yumnum Priyadarshini Devi, Synergistic Growth inhibitory effect of flavonol - kaempferol and conventional chemotherapeutic drugs on cancer cells,; Int J Pharm Pharm Sci, 9(2): 123-127.