



## Ethnobotanical, Phytochemical and Pharmacological Aspects of Genus *Alysicarpus*

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### ABSTRACT

Plant species and their active constituents play an important role in the prevention of a variety of ailments. The genus *Alysicarpus* comprises of about 30 species, out of which, eight species are found in Pakistan. Only a few species of the genus *Alysicarpus* have been investigated for phytochemical and biological activities. A variety of potentially bioactive molecules such as alkaloids, flavonoids, phenolics, terpenoids and steroids have been isolated from various species of genus *Alysicarpus*. It has been reported that these species possess analgesic, anti-inflammatory, antimicrobial, antiplasmodial, larvicidal, mosquitocidal, antioxidant, hepatoprotective, antiproliferative and antifertility activity. This article aims to highlight the ethnomedicinal uses, phytochemical and pharmacological aspects of *Alysicarpus* species and illustrates the potential of the genus as a source of therapeutic agents.

**Keywords:** *Alysicarpus*, Phytochemical, Pharmacological aspects.

### INTRODUCTION

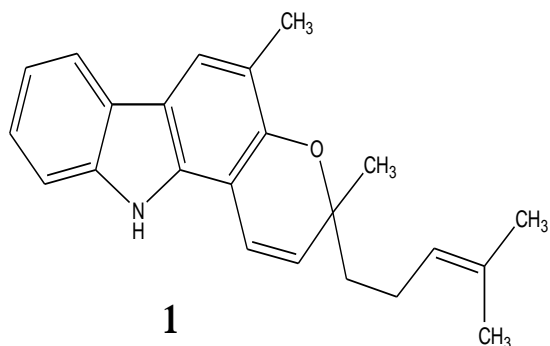
Natural products coming from various sources, such as terrestrial plants, microorganisms, marine organisms, vertebrates and invertebrates, have importance as they provide an amazing source of new drugs as well as new drug leads and chemical entities for further drug development [1,2].

In recent times, interest in plant research has increased all over the world owing to its potential use in traditional systems of medicine for treating a wide variety of diseases. Therefore, ethnobotanical and ethno pharmacological studies are essential to discover new substances for the treatment of diseases. Various medicinal plants have been identified and modern scientific approaches have been used to study their authenticity, safety and efficacy of their therapeutic use that highlight the great potential of medicinal plants in the field of pharmacology [3,4].

This review aims to summarize the ethnobotanical uses, phytochemical work and the biological potential of genus *Alysicarpus*.

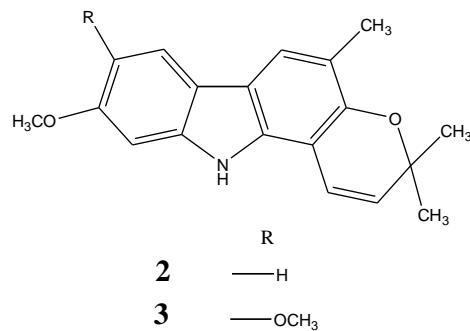
#### The genus *Alysicarpus* Desv

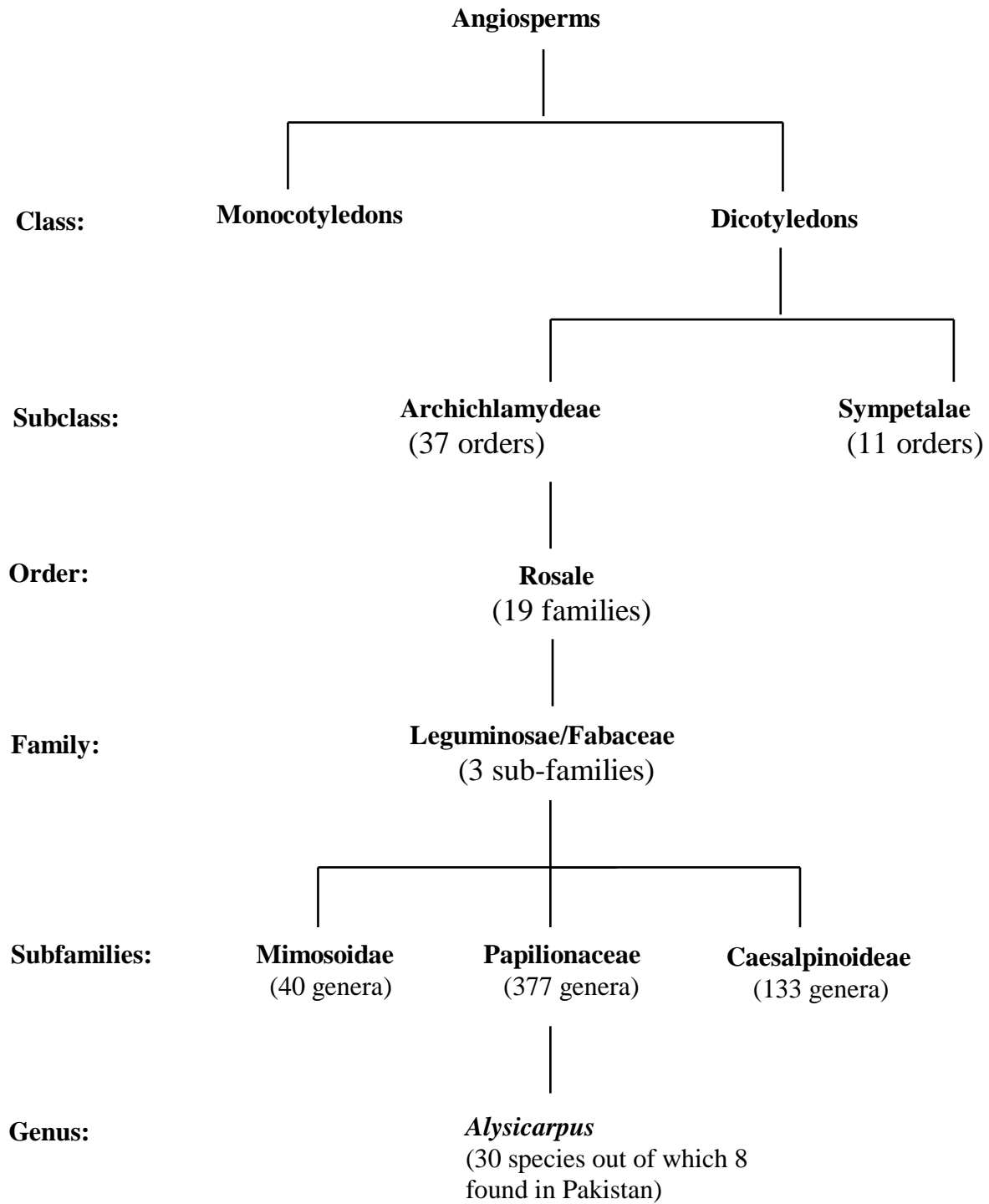
The genus *Alysicarpus* belongs to the second largest family, Leguminosae/Fabaceae. It includes 30 species distributed in Africa, Asia, Australia, Polynesia and Tropical America. Among them, eight species are found in Pakistan namely *Alysicarpus bupleurifolius*, *Alysicarpus heterophyllus*, *Alysicarpus longifolius*, *Alysicarpus monilifer*, *Alysicarpus ovalifolius*, *Alysicarpus rugosus*, *Alysicarpus scariosus* and *Alysicarpus tetragonolobus* [5,6]. The taxonomic classification of the genus *Alysicarpus* is given in Figure 1.



This genus includes herbs that erect or diffuse. Leaves unifoliate, very rarely trifoliate, leaflets 2-stipellate; stipules scarious, acuminate, free or connate. Inflorescence terminal and axillary a raceme or panicle, flowers often in pairs, bracts scarious and deciduous. Calyx is deeply divided, two upper lobes often connate to the apex. Corolla

generally not exerted; vexillum is obovate/orbicular, narrowed into a claw. The wings are obliquely oblong, adhering to the keel. Keel is slightly incurved and often appendaged. The stamens are diadelphous and anthers are uniform. The ovary is sessile / stipitate, ovules many. The style is filiform which is curved at the apex. The stigma is terminal capitate. Fruit is constricted between seeds [6]. The various species of genus investigated so far are shown in Figure 2.





**Figure 1:** The taxonomic classification of genus *Alysicarpus*.



*Alysicarpus bupleurifolius*



*Alysicarpus longifolius*



*Alysicarpus ovalifolius*



*Alysicarpus glumaceus*



*Alysicarpus rugosus*



*Alysicarpus vaginalis*

**Figure 2:** Various phytochemically investigated species of *Alysicarpus*.

**Ethno-medicinal uses of *Alysicarpus* species**

*Alysicarpus* species have been used traditionally to treat various ailments such as asthma, bronchitis, cough, rheumatism, fever, skin diseases, stomach-ache, diarrhea,

dysentery, jaundice, urinary troubles and leprosy. The details of ethno-medicinal uses of *Alysicarpus* species are given in Table 1.

**Table 1:** The ethno-medicinal uses of *Alysicarpus* species.

Plant name	Uses
<i>Alysicarpus bupleurifolius</i>	Whole plant (5-10 g) is used for the treatment of asthma, bronchitis, pneumonia, rheumatism and fever. It is administered 2-3 times per day for a period of one week. It also possesses stomachic, antifungal and glactogenic actions. Leaves are used for the healing of wounds and root extracts are given in asthma [7-10].
<i>Alysicarpus heyneanus</i>	The juice of fresh leaves is given for the protection of liver and to treat the sores of calves. Roots for biliousness and fever; used in veterinary medicines [7].
<i>Alysicarpus glumaceus</i>	The juice of leaves is employed for bruises and skin diseases, stomach-ache. The Roots are used to relieve edema. It also possesses aphrodisiac activity. Roots and leaves are used as abortifacient and to treat pulmonary troubles, diarrhea and dysentery [7].
<i>Alysicarpus pubescens</i>	Whole plant tonic, astringent [7].
<i>Alysicarpus quadrangularis</i>	Whole plant powder (4-5 g) is orally administered for curing diarrhoea, fever, cough and vomiting. The whole plant is expectorant, carminative and antifungal [8].
<i>Alysicarpus hamosus</i>	Leaves decoction is given orally to cure cough, as antipyretic. Roots as antidote [8].
<i>Alysicarpus longifolius</i>	The decoction of whole plant is poured into the nose. Leaves decoction is given to treat constipation. One teaspoon of powdered leaves and root bark is administered orally to cure joint pain twice a day for 8-10 days. Seed oil is antibacterial and antifungal [7-8,11].
<i>Alysicarpus rugosus</i>	Leaves decoction in cough, bronchitis, leprosy and urinary complaints, edema, dropsy, swelling, fever, indigestion, headache, as laxative and carminative. Leaves and roots are taken as febrifuge. It is given for pulmonary troubles. It possesses astringent properties. The infusion of roots is drunk to induce emesis. It is also used in veterinary medicines [7-8]. Whole plant decoction for cough, bronchitis, guinea worm, dracunculiasis, as health drink [7,12-13].
<i>Alysicarpus monilifer</i>	1-2 g of root powder is administered orally for one week to alleviate cough and asthma, for treating leprosy and to relieve urinary complaints [8]. Whole plant decoction is given twice daily for 5-6 days to treat rheumatism, used for cough and bronchitis, skin problems, dysentery, antidote to snakebite, as laxative and antipyretic [8,12,13]. Leaves are used in fever and Jaundice, taken as febrifuge [14]. Shoots are ground into a paste and given orally twice a day for the treatment of jaundice [15].
<i>Alysicarpus ovalifolius</i>	Leaf sap, juice and root decoction are given in jaundice and to relieve cough. The decoction of root is given to treat colic, as tonic, for the healing of wounds. Whole plant is used for the treatment of fever and ringworm infections, healing of wounds, acute and chronic bleeding piles. It acts as a stimulant in birth control [16,17].
<i>Alysicarpus quartinianus</i>	Leaves and roots were crushed and applied as lotion on the lesions of patients of abiato (Shererit) [18].
<i>Alysicarpus tetragonolobus</i>	Whole plant tonic, astringent [7]. Stem juice is used in rheumatism [19].

<i>Alysicarpus vaginalis</i>	Leaves taken in bronchitis, pneumonia, typhoid, cancer and as purgative. Seeds infusion used against dysentery and colics [7,8]. Shoots are ground into a paste and given orally twice a day for the treatment of jaundice [15]. Whole plant used to treat weak eyesight, ear ache, sword wounds, pain in joints, bone fractures, renal stones, renal oedema, dysuria, urolithiasis, as antipyretic [20-22]. Roots as antifertility, antidote to snakebite, expectorant, leprosy, urinary complaints, antifertility, pulmonary troubles, a decoction taken for coughs, headache and fever; used in veterinary medicines [23-26].
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### Phytochemical studies on genus *Alysicarpus*

The seven species of genus *Alysicarpus* namely *A. bupleurifolius*, *A. monilifer*, *A. longifolius*, *A. ovalifolius*, *A. procumbens*, *A. rugosus* and *A. vaginalis* have been phytochemically investigated.

### Phytochemical screening

The previous phytochemical studies, reported so far, from above mentioned species of *Alysicarpus* showed the presence of different classes of secondary metabolites such as alkaloids, cardiac glycosides, flavonoids, tannins, saponins, terpenoids and steroids. The details of phytochemical screening of *Alysicarpus* species are given in Table 2.

### Isolation of phytochemicals

The phytochemicals isolated from various species of *Alysicarpus* belong to different classes of secondary

metabolites such as alkaloids, flavonoids, phenolics, terpenoids and steroids as described below.

### Alkaloids

The evaluation of stem bark of *A. ovalifolius* has led to the isolation of three carbazole alkaloids namely, mohanimbine (1), koenimbine (2) and koenidine (3). Mohanimbine displayed larvicidal activity and significant antimicrobial activities against gram positive *Staphylococcus aureus* and *Candida albicans* with zone of inhibition ranging from 10.4 to 13.8 mm in diameter at a concentration of 100 µg/ml. Koenidine showed promising activity against *Plasmodium falciparum* with IC<sub>50</sub> 54.19 ng/ml [27].

**Table 2:** Phytochemical screening of *Alysicarpus* species.

Plant name	Extract	Class of secondary metabolites						
		Alkaloids	Cardiac glycosides	Saponins	Tanins	Flavonoids	Phyto-sterols	Terpenoids
<i>A. bupleurifolius</i> (Whole plant) [28]	Ethanol	+	-	-	+	-	+	+
<i>A. longifolius</i> (Whole plant) [29]	Methanol	+	nd	+	+	+	+	+
<i>A. longifolius</i> (roots) [30,31]	Powder	+	-	-	+	+	-	+
<i>A. monilifer</i> (Aerial parts) [32]	Chloroform	-	-	+	nd	-	+	+
<i>A. monilifer</i> (Whole plant) [33]	Methanol	+	+	+	-	+	+	nd

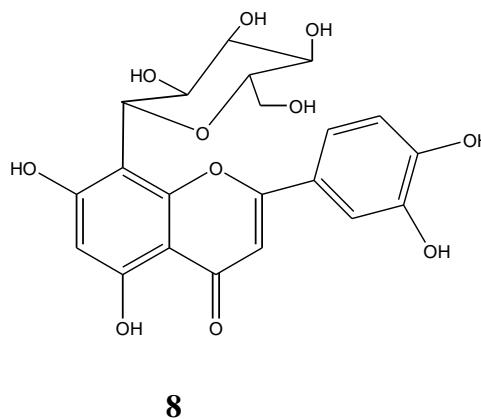
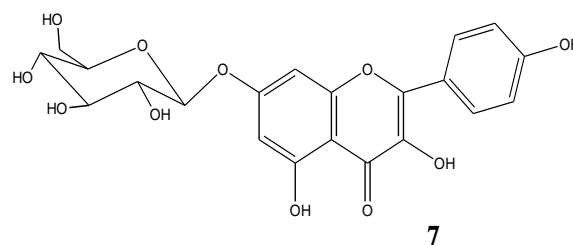
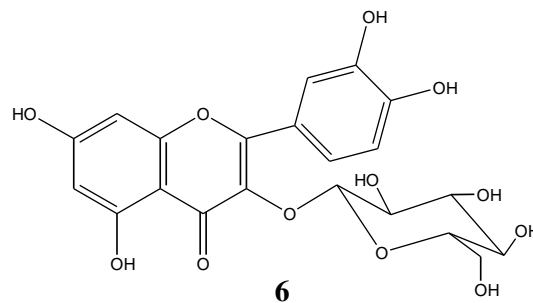
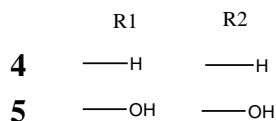
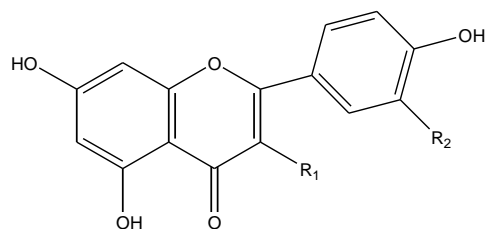
<i>A. ovalifolius</i> (Aerial parts) [34]	Methanol	-	+	+	-	+	+	+
<i>A. procumbens</i> (Aerial parts) [35]	Powder	-	+	+	+	-	+	nd
<i>A. vaginalis</i> (Whole plant) [36]	Ethanol	+	nd	+	+	+	nd	+
<i>A. vaginalis</i> var. <i>nummularifolius</i> (Whole plant) [37]	<i>n</i> -Hexane	+	++	-	+	+	nd	++
	Methano	++	++	-	+	++	nd	+
	Ethanol	+	++	++	++	+	nd	++

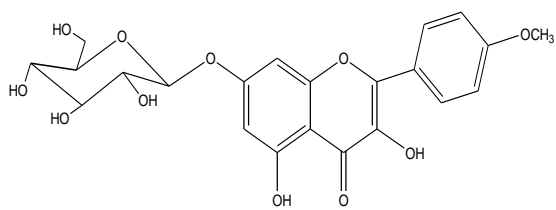
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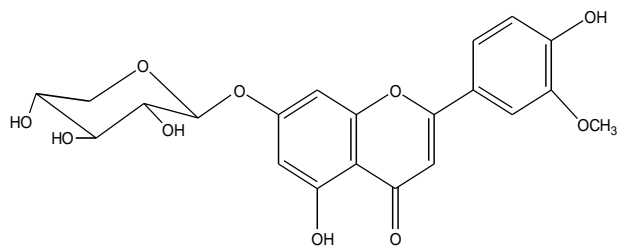
### Flavonoids

The phytochemical investigation of stem bark of *A. ovalifolius* resulted in the isolation of six flavonoids namely apigenin (4) quercetin (5) quercetin 3-O-glucoside (6), kaempferol 7-O-glucoside (7) and orientin (8) [27]. The *n*-butanol fraction of *A. ovalifolius* was subjected to column chromatography using Sephadex LH-20 resulted into the purification of a flavonol glycoside namely kampferide 7-O-glucopyranoside (9) [34]. Vitexin (10) and isovitexin (11) were isolated from the methanol extract of *A. monilifer* and their structures were elucidated with the help of spectral techniques such as  $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR and 2D NMR [38]. The flavonoids reported from the leaves of *A. longifolius* were rutin (12), chrysoeriol-7-O-xyloside (13), lepidoside (14), vincetoxicoside B (15) and phegopolin (16) [39-41].

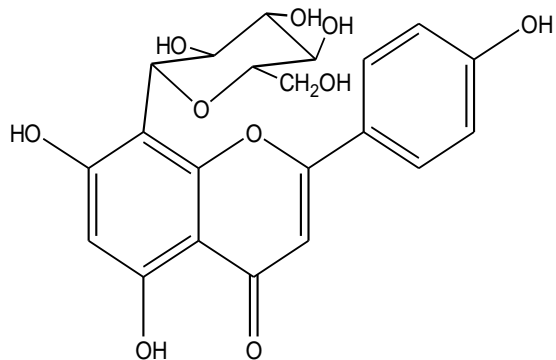




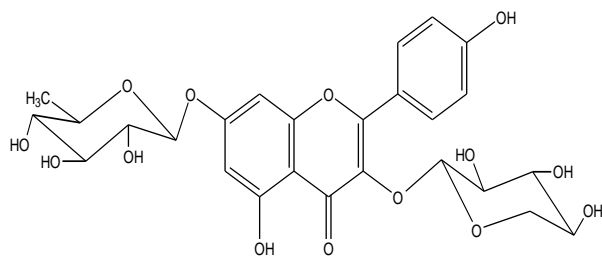
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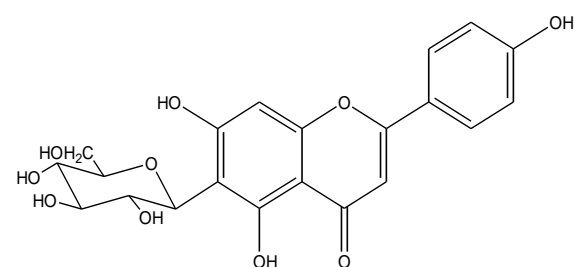
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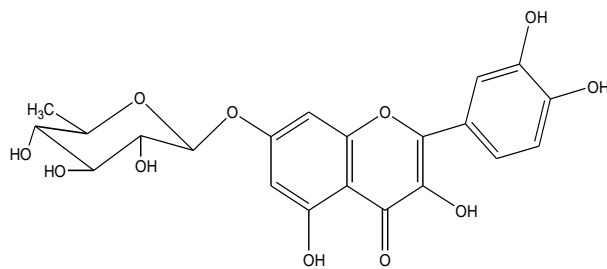
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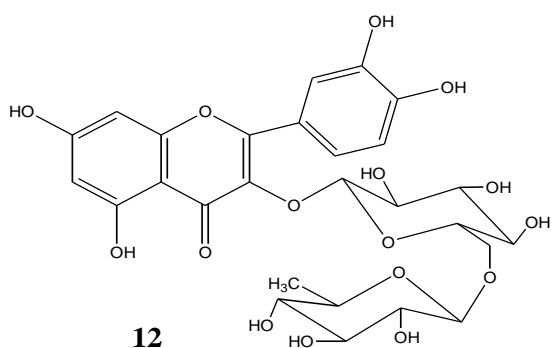
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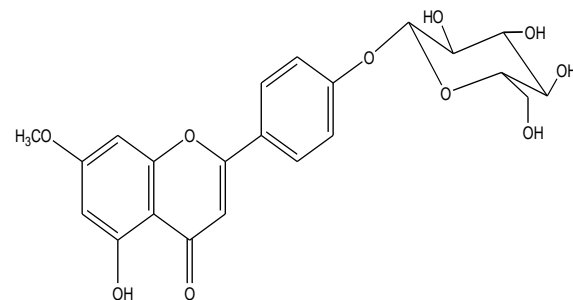
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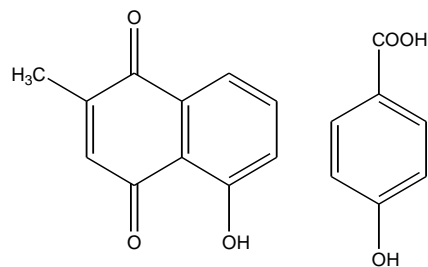
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### Phenolics

The phenolic compounds have been reported from *A. monilifer* includes usnic acid (17), methyl  $\beta$ -orsellinate (18) and 3-hydroxy benzoic acid (19) [42]. Plumbagin (20) has been reported from the stem bark of *A. ovalifolius* [27].

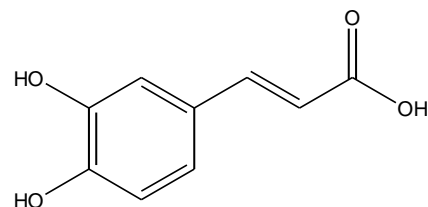


The phytochemical studies have been carried out for the evaluation of the leaves of *A. bupleurifolius*, *A. monilifer*, *A. vaginalis* and *A. rugosus*. *p*-hydroxybenzoic (21) acid was found in all the above mentioned species of *Alysicarpus*. Caffeic acid (22) and vanillic acid (23) were reported from *A. monilifer* whereas catechol (24) was observed in *A. monilifer* and *A. vaginalis*. Gentisic acid (25) was identified in *A. bupleurifolius*, *A. rugosus* and *A. vaginalis*. Gallic acid (26) was found in three species namely *A. bupleurifolius*, *A. monilifer* and *A. vaginalis*. Syringic acid (27) was identified in *A. monilifer* and *A. rugosus*. Salicylic acid (28) was observed in *A. bupleurifolius* and *A. rugosus* whereas coumaric acid (29) was identified only in *A. vaginalis* [43].

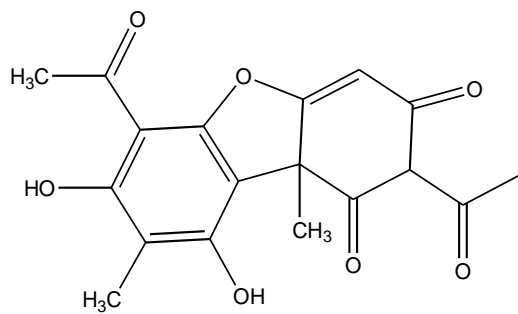


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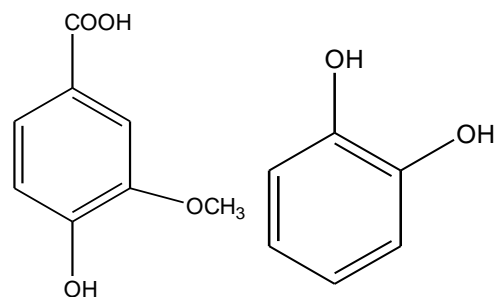
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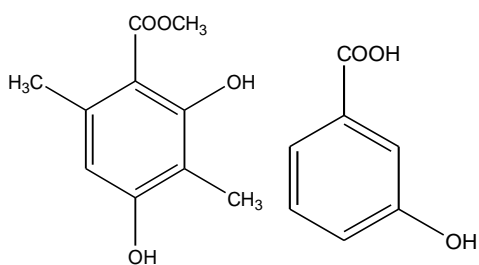


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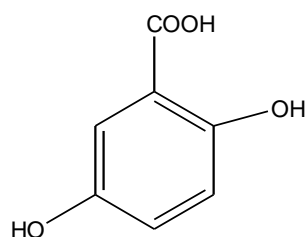
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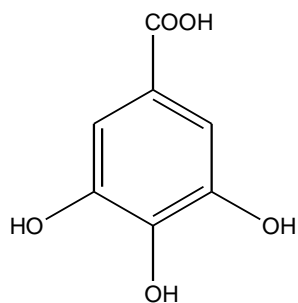
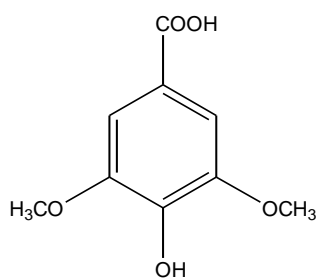
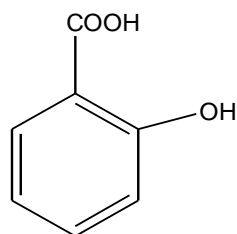
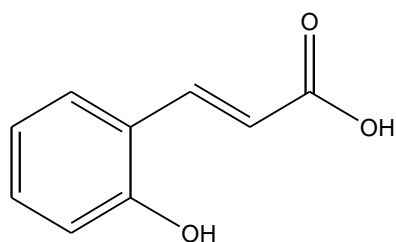


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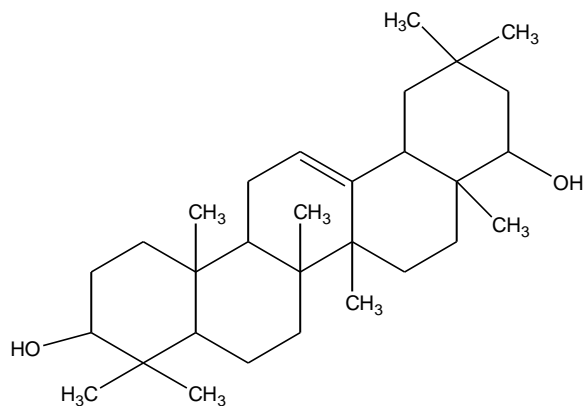
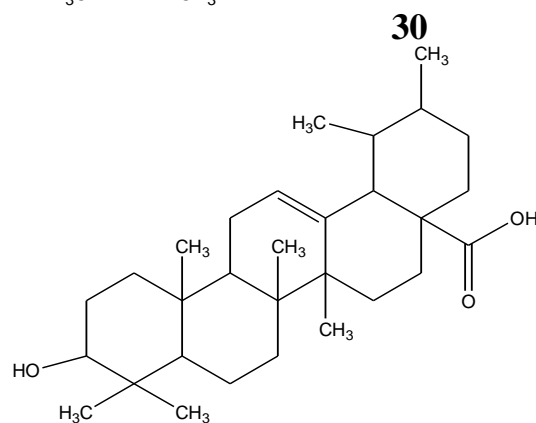
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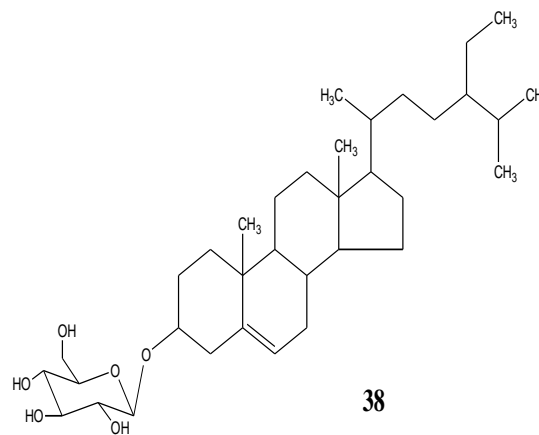
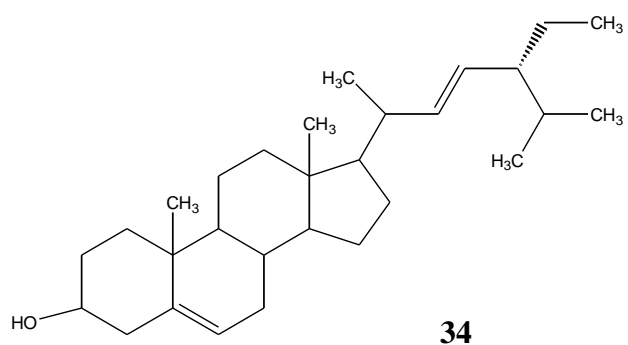
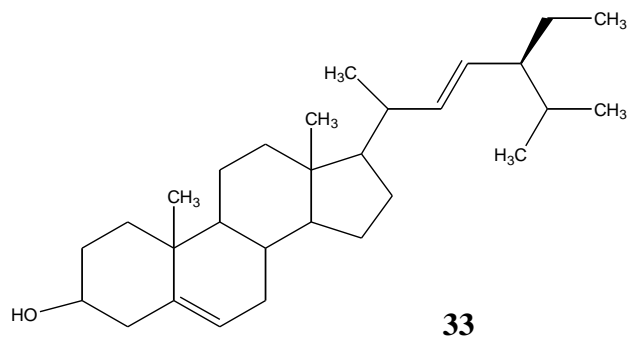
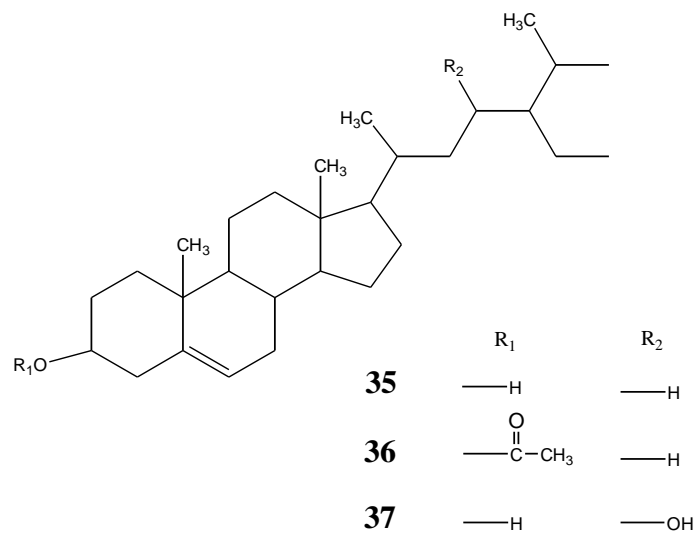
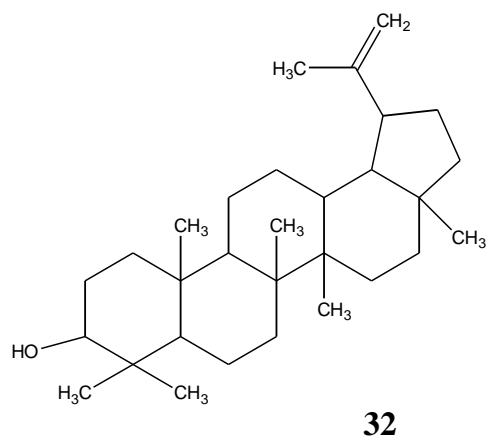
**26****27****28****29**

*vaginalis* [44]. Various sterols have been isolated from different species of *Alysicarpus*. These include stigmasterol (**33**) from *A. monilifer*, *A. vaginalis*, *A. longifolius* and *A. ovalifolius*, poriferasterol (**34**) from *A. monilifer*,  $\beta$ -sitosterol (**35**) from *A. vaginalis*,  $\beta$ -sitosterol acetate (**36**) from *A. longifolius*, 3- $\beta$  cholest-5 ene-3, 21-diol (**37**) from *A. ovalifolius* and daucosterol (**38**) from *A. bupleurifolius* [27,34,39,44-46].

**30****31**

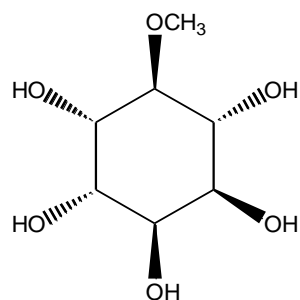
### Terpenoids and Sterols

Alysinol (**30**) along with ursolic acid (**31**) have been isolated from the methanol extract of whole plant of *A. monilifer* [42]. Lupeol (**32**) has been reported from *A.*

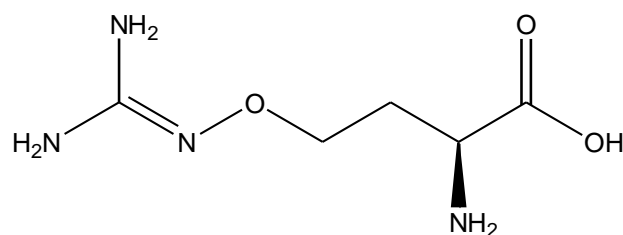


### Miscellaneous compounds

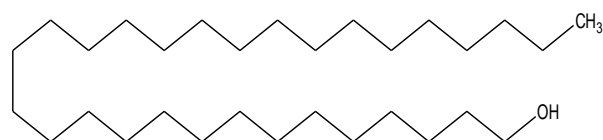
An insulinomimetic, D-Pinitol (**39**) first reported from pine tree [47], has also been isolated from *A. bupleurifolius* and *A. longifolius* [39,46]. (*S*)-Canavanine (**40**) has been isolated from seeds of *A. ovalifolius* [48]. Tricontanol (**41**) has been reported from leaves of *A. longifolius* [39].



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### Biological activities of genus *Alysicarpus*

The *Alysicarpus* species have been investigated for their pharmacological activities. The various extracts of *A. bupleurifolius*, *A. longifolius*, *A. ovalifolius*, *A. monilifer* and *A. vaginalis* were reported to have antimicrobial, anti-plasmodial, larvicidal, mosquitocidal, antiproliferative, analgesic, cytotoxic, anti-inflammatory, hepatoprotective, antifertility and antioxidant activities.

The previous studies on antimicrobial activities revealed the susceptibility of some pathogenic bacteria (*Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Salmonella typhimurium*, *Bacillus subtilis*) and fungi (*Candida albicans*, *Aspergillus fumigates*, *Aspergillus niger*) to *Alysicarpus* species (Table 3).

**Table 3:** Antibacterial and antifungal activities of *Alysicarpus* species.

Plant name	Extract	Zones of inhibition (mm in diameter) at a concentration of 1000 µg/ml							
		Antibacterial activity					Antifungal activity		
		<i>S. aureus</i>	<i>P. aeruginosa</i>	<i>E. coli</i>	<i>S. typhimurium</i>	<i>B. subtilis</i>	<i>C. albicans</i>	<i>A. fumigates</i>	<i>A. niger</i>
<i>A. ovalifolius</i> (root bark) [27]	Dichloro-methane	15.3	–	10.8	5.0	–	13.2	7.4	–
	Methanol	12.3	–	8.1	13.3	–	9.1	7.2	–
<i>A. bupleurifolius</i> [28]	EtOAc	6.1	6.3	6.2	–	–	–	–	–
	Ethanol	6.8	6.6	6.5	–	–	–	–	–
	Aqueous	6.1	6.3	6.7	–	–	–	–	–
<i>A. vaginalis</i> var. <i>nummularifolius</i> (whole plant) [37]	<i>n</i> -Hexane	21.23	20.3	14.16	–	–	10.7	–	13.3
	EtOAc	16.23	20.2	14.1	–	–	19.0	–	26.0
	Methanol	22.26	16.3	12.16	–	–	21.0	–	12.2

A. <i>longifolius</i> [49,50]	Chloroform	-	-	15.0	-	13.0	-	-	-
	Aqueous	-	-	14.0	-	14.0	-	-	-

EtOAc: Ethylacetate

Ochung et al. investigated the mosquitocidal, larvicidal and anti-plasmodial activities of various extracts (*n*-hexane, dichloromethane and methanol) of *A. ovalifolius*. The methanol extract possessed larvicidal activity against *Anopheles gambiae* larvae (LC<sub>50</sub> 85.64 µg/ml) and dichloromethane extract exhibited significant larvicidal and mosquitocidal activities with LC<sub>50</sub> values 9.86 µg/ml and 17.83 µg/ml respectively. The extracts were found to be low-moderately active against multi-drug resistant and

chloroquine sensitive strains of *Plasmodium falciparum* [27].

The cytotoxic activity has been reported from the *n*-hexane and ethanol extracts, of *A. vaginalis* var. *nummularifolius*, with LC<sub>50</sub> values 900.05 µg/ml and 754.35 µg/ml respectively [37]. Further, the reports on analgesic, anti-inflammatory, hepatoprotective, antifertility, tiproliferative and antioxidant activities of *A. monilifer* and *A. vaginalis* are shown in Table 4.

**Table 4:** Antifertility, analgesic, antioxidant, anti-proliferative and hepatoprotective activities of *A. monilifer* and *A. vaginalis*.

Plant name	Part used/ dose	Anti-inflammatory activity change in edema thickness (mm)	Hepatoprotective activity (IU/L)			Antifertility activity (% inhibition of implantation site)	Analgesic activity (Response time in sec)		Anti-oxidant activity		Anti-proliferative activity against PA-1 cell line (% cell viability)
			AST	ALT	ALP		Hot plate method	Tail flick method	LPIA (% inhibition)	DPPH (mg of GAE/g wet weight)	
A. <i>vaginalis</i>	Whole plant (200 µg/ml) [36,51]	-	-	-	-	-	-	-	65.0	345.70	35
	Aerial parts (200 mg <sup>*</sup> ) [52]	-	48.42	58.56	133.5	-	-	-	-	-	-
	Roots (300 mg <sup>*</sup> ) [53]	-	-	-	-	49.98	-	-	-	-	-
A. <i>monilifer</i>	Whole plant (800 mg <sup>*</sup> ) [54]	-	158.0	150.2	225.1	-	-	-	-	-	-
	Aerial parts (200 mg <sup>*</sup> ) [55,56]	6.05	-	-	-	-	8.0	6.5	-	-	-

\* per kg body weight of tested animal, **ALT:** Alanine transaminase; **AST:** Aspartate transaminase; **ALP:** Alkaline phosphatase; **LPIA:** Lipid peroxidation inhibition assay; **DPPH:** 1, 1-diphenyl-2-picrylhydrazyl assay; **PA-1:** Ovarian cancer cell line.

**CONCLUSION**

In conclusion, this review reveals that the genus *Alysicarpus* is endowed with many medicinal plants some of which have potential for the discovery of new drugs. On the basis of results regarding *in vitro* and *in vivo* efficacy and toxicity studies, *A. vaginalis* holds the most promising compounds with antiproliferative, hepatoprotective and antioxidant activity that may be due

to the presence of phenolics such as tannins and flavonoids. The alkaloids of *A. ovalifolius* were reported to possess antimicrobial potential. Flavonoids, vitexin and iso-vitexin, from *A. monilifer* are so far the most promising compounds that could be developed as hepatoprotective agents. The other *Alysicarpus* species and isolated compounds require further studies to validate or ascertain their medicinal potentials.

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