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THE THERAPEUTIC PROPERTIES AND APPLICATIONS OF *ACORUS CALAMUS* (SWEET FLAG): A REVIEW

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Key words : *Medicinal Plants*, Acorus calamus, *Acoraceae, Vacha, Rhizomes, Phytoconstituents*

Abstract – Medicinal plants have been used in the preparation of medicine since ancient times and may even be considered the origin of modern medicine. *Acorus calamus* (Linn.) is one such a medicinal herb that found as a member of family Acoraceae and most commonly known as 'sweet flag'. Herb is commonly distributed in the moderate and the sub moderate rainfall regions of the Asia, Europe and North America. It is a tall, semi-aquatic in habitat, monocotyledonous, perennial, aromatic herb with branched cylindrical spreading rhizomes. The well growth habitats for sweet flag include edges of small lakes, rivers, marshes, ponds in temperature ranging from 10 to 38 °C. The major phyto constituents of herb include alpha-Asarone, beta-Asarone, elemicine, alpha-terpineol and acorone, acorenone, acoragermacrone cis-isoelemicine, isoeugenol and their methyl ethers, camphene, P-cymene, beta-cadinene, camphor, beta-gurjunene, 7-dienol, shyobunones, isohyobunones, calamusenone alpha-selinene, terpinen-4-ol, alpha-calacorene 2-deca-4, linalool and pre-isocalamendiol etc. *Acorus calamus* (Vacha) constituents important for treatment of the various types of the ailments like epilepsy, diarrhea, dysentery, mental ailments, chronic bronchial catarrh, intermittent and tumors. It also has the insecticidal, antifungal, anticancerous, neuroprotective, antioxidant, antibacterial, antidiabetic, antidiarrhoeal, analgesic and anticonvulsant, spasmolytic, vascular modulator activities. The present review focuses on the detailed composition of *Acorus calamus* its different phytoconstituents having various pharmacological activities that helps to improve the health and prevent from various kinds of ailments.

INTRODUCTION

Pharmaceutical companies invest a lots of money to develop a drug but due its higher prices and safety related issues majority of population is not able to afford this. But keeping cost factor aside safety is the main issue so main focus is upon to provide a safe and effective drug, which is very challenging in new development of new medicine now a days (Yadav *et al.,* 2019). From the last few decades most of the population again shown a notable interest in the medicinal plants. Now a day's herbal medicines and natural products are in significant demand today in the entire world. Medicinal plants serves as the powerful source of antioxidant compounds (Chandel *et al.,* 2019). The reason behind is the increasing awareness about the limitations of the synthetic chemotherapeutic agents (Gagan *et al*., 2015). As per a survey by WHO around80% of the world population use traditional medicines to fulfill their primary health care needs. Medicinal plants constitute wide rangeof the secondary metabolites

which serve as the major sources for development of curative drugs and are used to treat the various ailments (Chandera *et al.,* 2017).Various secondary metabolites present in plants includes phenolic compounds which protect the cells from free radicals and shows the significant antioxidant properties (Chandel *et al.,* 2020).

Vacha is another important medicinal herbs used in Ayurveda traditional medicine to treat different ailments and maintain health condition. *Acorus calamus* (Linn.) is one such a medicinal herb that found as a member of family Acoraceae and most commonly named as 'sweet flag'. The term 'acorus' was came from the Greek word 'acoron', which was used by Pedanius Dioscorides and taken from the word 'coreon' meaning 'pupil' (of an eye), as it was used to remedy the diseases of eye (Khwairakpam *et al.,* 2018). The genus *Acorus* belongs to family Acoraceae and generally comprises of about 110 genera and 1800 species. The genus *Acorus* contains about 40 species and some of which are *Acorus calamus* (Linn.), *Acorus christophii*, *Acorus tatarinowii* (Schott.) and *Acorus gramineus* (Sol.) (Rajput *et al*., 2014). Traditional medicinal including medicinal herbs from the ancient time to treat the wide range of immune disorders, including respiratory, metabolic, kidney neurological, gastrointestinal and liver disorders and other health disorders (Sharma *et al.,* 2020). *Acorus calamus* is found in higher rainfall regions i.e. in tropical regions like in India and Sri Lanka. It is found abundantly in Nagaland, Kashmir Sikkim, Manipur, and in Himachal Pradesh. In Karnataka the plant is regularly cultivated in Koratagere taluk. The best soil for the cultivation of *Acorus calamus* is Light alluvial soil and clayey loams (Chandera *et al.,* 2017).

Traditionally *Acoruscalamus* regarded as a "rejuvenator" as it renovate the brain and nervous system and also serve as best treatment of digestive problems. The rhizome part of *Acorus calamus* is used in the treatment ofstomach cramps, tooth ache, appetite, fever, and cholic(Chandera *et al.,* 2017). *Acorus calamus* (Vacha) is very important treatment of the various types of the diseases like epilepsy, bronchial catarrh, intermittent and tumors mental ailments, chronic diarrhea, dysentery. It also has the antifungal, antibacterial, antioxidant, anticholinesterase, insecticidal, tranquilizing, antidiarrhoeal, antidyslipidemic, neuroprotective, spasmolytic, vascular modulator activities. Sweet flag also valuable in preparation of some beneficial herbal formulations like *Vachadichurna, Vachadighrita, Vachavaleha* etc. (Gagan *et al*., 2015). The therapeutic applications of the Acoraceae is increasing day by day due to presence of various bioactive compounds having beneficial pharmacological applications such as, anti-adipogenic, antimicrobial, fungicidal,

Fig. 1. Figure showing the *Acorus calamus.*

Table 1. Table showing the Taxonomic Classification of *Acorus calamus* (Imami *et al.,* 2013)

Kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta.
Class	Liliopsida
Subclass	Arecida
Order	Arales
Family	Acoraceae
Genus	Acorus
Species	Species: *calamus* Linn., *griffithii* Schott., *belangeii* Schott., *cassia* Bertol

Table 2. Table showing vernacular names of *Acorus calamus* (Umamaheshwari *et al.,* 2018)

Languages	Local Name
Arabic	Vaj, Vash, OudulVaj
Sanskrit	Bhadra, BhutanashiniVacha
Arabic Hindi	Bach, Ghorbach, Safedbach
Gujarati	Gandhilovaj, Godavaj
Kashmir	Vachi, Vaigandar
Persian	Agar, Agarturki
Kannada	Baje, Vasa
English	Sweetflag, Acoruscalamus, Myrtle grass
Urdu	Bach, Vaj
Tamil	Vashambu, pullaivalathi
Nepali	Bojho
Ayurvedic	Vacha
Unani	Vajturki, Bacch

anti-inflammatory/ immunosuppressive, insulin sensitizing/antidiabetic, neuroprotective activities. Antimicrobial agents are in great demand as the reducing the global burden of various diseases (Chandel *et al.,* 2019). *Acoruscalamus* has tremendous potency in treatment of wide variety of ailments and also indicated as brain tonic as helpful in improvement of memory and intellect. Asarone, beta-asarone, eugenol, methyl eugenol, and tannins are the major constituents present which has the wide range of pharmacological applications. Traditionally used in curing various diseases like diarrhea, slurred speech, piles, indigestion, acid gastritis, headache, edema, skin diseases, eye diseases, colic, heart disease and ear diseases (Rashmi *et al*., 2017).

Fig. 2. Figure showing the distribution area of *Acorus calamus*

Vernacular name

Distribution

Sweet flag commonly found in moderate and sub-moderate rainfall regions of the world and is indegenous to China, Japan, South East India, Asia, Mongolia, Kazakhstan, and Sulawesi (Khwairakpam *et al.,* 2017). This herb naturally recorded all over India like in swamp areas and also cultivated up to an altitude of 2200 m in the Himalayas especially Karnataka, Assam, Tamil Nadu, Kerala and Andhra Pradesh (Kareem *et al*., 2012). In India *Acorus calamus* is cultivated in the swampy areas of Kashmir, Shirmaur, Manipur, Nagahills, Koratagere taluka and Karnataka (Gagan *et al*., 2015).

Botanical Description

'Sweet flag'is a perennial herb and usually grow in marshy areas, monocotyledon, 1-4 feet tall in height and belongs to the family Acoraceae. The morphological structure of this herb generally consists of tufts of the basal roots that directly come out from the spreading rootstock. This herb consists of a branched rhizome part which is a root like subterranean stem, always growth in horizontal direction from which at the specific interval tuft of basal leaves grows above ground in a population and fine coarse fibrous roots develops below (Gagan *et al.,* 2015).

Fig. 3. Figure showing the rhizome part of *Acorus calamus*

Morphological character

The morphological characters are green and sword leaves, creeping roots, cylindrical, long and branched rhizome.

Fig. 4. Figure showing the Roots of *Acoruscalamus*

Rhizome

The branching rhizomes parts of the plant are root like stems that grows in horizontal direction under the ground. Rhizome of this plant is long, indefinite branched, smooth, cylindrical, pale green in color and thick up to 2.5 cm. Tufts of basal leaves grows above ground and present at intervals along these rhizomes while coarse fibrous roots grow below. The plant propagates by its rhizomes. The internal portion of rhizome is white pink in color and when squash it provide a very pleasant aroma and having a bitter taste.

Roots

The underground part of plant consists of long

Fig. 5. Figure showing the leaves of *Acorus calamus*

creeping roots along with the root fibers which grows out just below the surface of the soil. The thickness of roots is about 1 cm and helps the plant in absorption of water and dissolved minerals for growth (Kumar *et al.,* 2013).

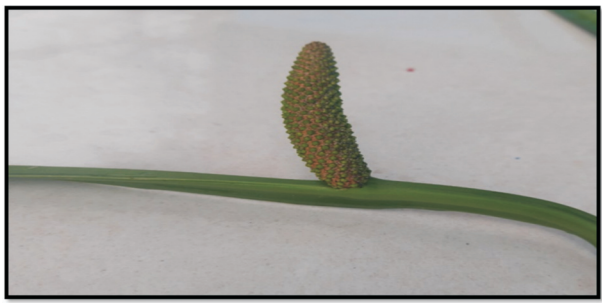


Fig. 6. Figure showing the flower of *Acorus calamus*

Leaves

The leaves of the plant arise from the spreading rhizome are erect, green and sword in shaped, resembling in appearance to Iris leaves. Leaves are flattened, taping in to a long, acute point and with smooth edges which are crimped and pink sheathing at bases of tufts of leaves. The leaves size is ranges from 7 and 17 mm in width with average of 12 mm. Sympoidal leaves of plant are short heightedas compare to that of the vegetative leaves. In the middle of leaf structure single prominent mid veins and then on both sides raised secondary veins and fine tertiary veins are present. The margin is curly edged or undulate (Chandera *et al.,* 2014).

Flowers

This plant produces flowers very rarely in the months of march-May. Flowers are cylindrical in shape, ranges from 30-80mm in length and nightingale brown in color and is covered with the multiple of rounded spikes. The inflorescence of this plant consists of the two parts spa the which is leaf-like and spadix spike-like in appearance. The spadix arises from the middle of the spa the and densely covered with numerous green and yellow colored flowers which are present in diamond shaped pattern. Each flower has 6 tepals and 6 stamens. The flowers of this plant are small in size, sessile or permanently attached and densely packed in 50-100 mm of spadix. When spadix expand it can grow up to a length of 49 and 89 mm. Depending upon the latitude the blooming period of plant start in between the end of spring and the starting of summer. Plant grows wildely in wetlands up to altitude of 2000 m (Gagan *et al.,* 2015).

Fruits

The fruits are small in size and contain very less seeds. The Flowers blossoms in the month of July and after that fruiting starts. Fruit has narrow, 6 to 14 in (15 - 35.6 cm) shiny leaves, thick and lush grass like in appearance. The leaves grow in two ranks, like opposing fans. Fruits of herb are generally flat, ranges from 0.5 in (1.3 cm) in width (Umamaheshwari *et al*., 2018).

Cultural Aspects

Soil and climate

This herb can be grows in tropical and sub-tropical climate condition. During growing stage of *Acorus calamus* and after harvesting rhizomes the sufficient amount of sun light is required. A temperature in between 10-38 ^{0}C with a rainfall of 10-250 cm annually is best suited environment. As the water is necessary for the cultivation, so cultivation of this herb must be avoided where irrigation system is not proper. The herb is best grown in sandy loams, clay loams and alluvial soil. The pH of the soil must be in the range of 5 to 7 (Chandera *et al*., 2017).

Land Preparation

The field preparation to cultivate the *Acorus calamus* is similar to as of paddy fields. The field should be filled with water. The water must be mixed with the farm yard manure and green manure and then ploughed finely. The plantation must be done in the beginning of monsoon.

Propagation

Propagation of *Acorus* is usually done through rhizomes. The rhizomes obtained from earlier planting. These rhizomes are preserved under the soil and the soil must be moist. The rhizomes are planted by cutting them into small pieces. A spacing

of 30X30 cm is used for the plantation of sprouted rhizomes. The depth of plantation is about 4cm. The best time to cultivate *Acorus* is early monsoon (Rajan *et al.,* 2016).

Harvesting

The crop can be harvested after 6to 8 months after cultivation. When the leaf tips turned yellow and get dry, it indicates that the crop is mature and ready for harvesting. Before harvesting the soil must be dried so that digging will be easy (Umamaheshwari *et al*., 2018).

Crop Yield

The average per hectare yield of the rhizome is around 40 quintal (Umamaheshwari *et al.,* 2018).

Chemical Constituents

A wide range of phytoconstituents have been reported from Photochemical studies of *Acoruscalamus* include glycosides, alkaloids, polyphenolic compounds, mucilage, flavonoids, saponins, tannins, volatile oil and bitter principle. The essential oil contains the major constituent like calamen, calameon, clamenolasarone and sesquiterpenes. Plant also contains a bitter glycoside named as acorine along with eugenol, pinene and camphene. The Phytoconstituentsfrom the various parts like rhizomes, leave and roots of the plant includes β–asarone, α–asarone, camphene, P–cymene, selinene, betagurjunene, aterpineol, terpinen and a calacorene, acorone, isoeugenol, cisisoelemicine elemicine and their methyl ethers, acrenone, β cadinene, camphor, acoragermacrone, 2deca -4,7dienol, linalool, shyobunones and preisocalamendiol are also present. Acoradin, 2, 5 dimethoxy benzoquinone, calamendiol, spathulenol galangin, 2, 4, 5 trimethoxybenzaldehyde and sitosterol have been isolated from *Acoruscalamus* (Chandera *et al.,* 2017).

The content and composition of the wide variety of chemical constituents in plant parts (Rhizomes, leaves, stem, roots) vary with different factors like geographic habitat, age, climate and ploidy etc. In *Acorus calamus var*, *angustata* ENGER (tetraploid), about 80% β-asarone is reported. But the triploid plants (e.g. *A. calamus var. calamus* L.), 5% quantity of â asarone was present in essential oil, whereas in diploid plants such as *A. calamus var. americanus* WULFF β-asarone is absent, but contain increased concentration of geranyl acetate. The rhizomes extract of few Chinese *Acorus tatarinowii* samples, previously called as *Acorus gramineus*, contain about 80% high amount of β asarone were detected. β-asarone is the major constituent present in the leaves (27.4–45.5%) while acorenoneis in the rhizomes (20.86%) followed by isocalamen-diol (12.75%) (Rajput *et al*., 2013). Plant also contain the other constituents such as lectins, mucilage, phenols, quinine, saponins, sugars, alkaloids, flavanoids, gums, lectins, tannins and triterpenes and various sugars such as maltose (0.2%), glucose (20.7%) and fructose (79.1%) are detected (Balakumbahan *et al.,* 2010). Isocalamendiol, Calamenone (a tricyclic sesquiterpene) as well as calamen-diol mostly present in the roots extracts(Umamaheshwari *et al.,* 2018).

According to (Ranjan *et al.,* 2016)photochemical studies have reported the presence phenylpropanoids (isoeugenol methyl ether, γ-asarone, Cis and Trans-asarone, Acoramone, asarylaldehyde), Sesquiterpenes (Shyobunone, Epishyobunone, 2, 6-diepishyobunone, Isocalamendiol, Acoragermacroneand Preisocalamendiol) Monoterpenes (α and β-pinenes, myrcene, Cymene-Para, Terpinen-alpha, Phellandrene-beta, Terpinene-gamma, Terpinolene, Thujane) Xanthone glycosides (4, 5, 8-trimethoxyxanthone-2-O-β-D-glucopyranosyl (1 2)-O-β-D-galactopyranoside) Flavones (Galangin), Steroids (β-Sitosterol) Volatile Organic Compounds (alcohols, aldehyde, esters, furan, hydrocarbos, ketones) Inorganic constituents (Oxalate and calcium) Triterpenoid saponin (1β, 2α, 3β, 19α-tetrahydroxyurs-12en-28-oicacid-28-O {-β-D-glucopyranosyl (1 2)} β-Dgalactopyranoside).

β-Asarone (isoasarone) is the major chemical constituent present in the plant. alpha-Asarone, elemicine, cis-isoelemicine, isoeugenol, alpha-calacorene 2-deca-4,7-dienol,shyobunones, isohyobunones, calamusenone, camphene, P-cymene, beta-cadinene, camphor, beta-gurjunene, alpha-selinene, terpinen-4-ol, alpha-terpineol and acorone, acorenone, acoragermacrone, linalool and pre-isocalamendiol are also present. And the other chemical constituents are 2,5-dimethoxy benzoquinone, calamendiol, spathulenol, Acoradin, galagin, 2,4,5-trimethoxy benzaldehyde, and sitosterol have been isolated from *Acorus calamus* (Kumar *et al*., 2013). The root oil composition of *A. calamus* was quite different from the rhizome and leaves oil composition of the same population. The rhizome and leaf oils of the investigated population were characterized by higher amount of (Z)-asarone

Table 3. Molecular structure, formula, molecular weight, IUPAC name and CID no. of selected phyto compounds

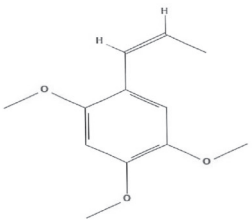
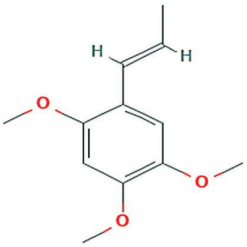
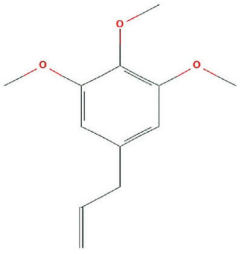
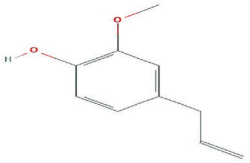
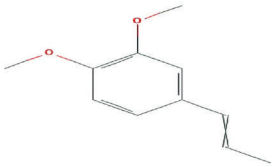
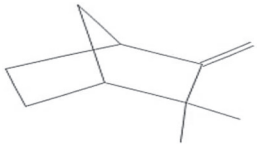
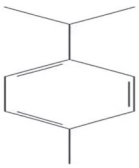
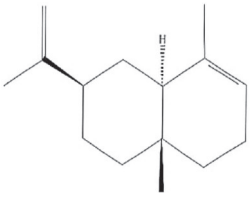
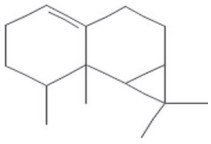
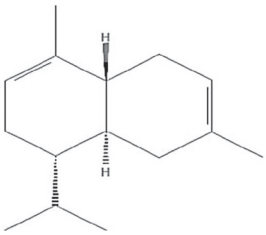
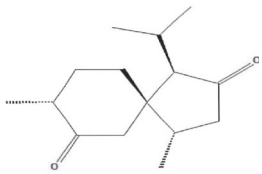
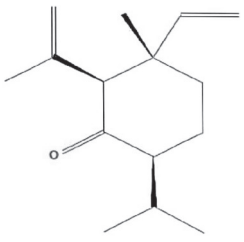
Sr. No.	Compounds (Molecular formula)	IUPAC Name (Compound CID)	Molecular structures	Molecular weight (g mol^{-1})	Pharmacological Properties
1	β–asarone ($C_{12}H_{16}O_3$)	1,2,4-trimethoxy-5-[(*Z*)-prop-1-enyl] benzene(5281758)		208.25	Antibacterial and Anthelmintic (McGaw *et al.*, 2002), Antifungal activity (Lee *et al.*, 2004), Anticancer activity (Shenvi *et al.*, 2014)
2	á- asarone ($C_{12}H_{16}O_3$)	1,2,4-trimethoxy-5-[(*E*)-prop-1-enyl] benzene(636822)		208.25	Antiplatelet activities (Poplawski *et al.*, 2000), Neuroprotective effect (Limón *et al.*, 2009), Cognitive enhancing effects (Kumar *et al.*, 2012), Induced anxiety (Lee *et al.*, 2014),
3	Elemicine ($C_{12}H_{16}O_3$)	1,2,3-trimethoxy-5-prop-2-enylbenzene (10248)		208.25	Analgesic and anticonvulsant effects (Jayaraman *et al.*, 2010), Antimicrobial activity (Radulovic *et al.*, 2013)
4	Eugenol ($C_{10}H_{12}O_2$)	2-methoxy-4-prop-2-enylphenol(3314)		162.4	Antioxidant activity (Fujisawa *et al.*, 2002), Antifungal activity (Chami *et al.*, 2004), Anticanceractivity (Fujisawa *et al.*, 2004), Antiinflammatory activity (Lee *et al.*, 2007).
5	Methyl isoeugenol ($C_{11}H_{14}O_2$)	1,2-dimethoxy-4-prop-1-enylbenzene(7127)		178.23	Insecticidal activity (Silva *et al.*, 2008), Anxiolytic and antidepressant effects (Fajemiroye *et al.*, 2014), Antimicrobial Activity (Gangan *et al.*, 2018).
6	Camphene ($C_{10}H_{16}$)	2,2-dimethyl-3-methylidenebicyclo [2.2.1]heptane (6616)		136.23	Antitumor activity (Girola *et al.*, 2015), Insecticidal activity (Benelli *et al.*, 2018), anti-Mycobacterium tuberculosis activity (Souza *et al.*, 2019)

Table 3. *Continued ...*

Sr. No.	Compounds (Molecular formula)	IUPAC Name (Compound CID)	Molecular structures	Molecular weight (g mol^{-1})	Pharmacological Properties
7	Pcymene ($C_{10}H_{14}$)	1-methyl-4-propan-2-ylbenzene(7463)		134.22	Antioxidant activity (Grigore *et al.,* 2010), Antinociceptive and Anti-inflammatory (Quintans *et al.,* 2013)
8	α-selinene ($C_{15}H_{24}$)	(3*R*,4*aR*,8*aR*)-5,8*a*-dimethyl-3-prop-1-en-2-yl-2,3,4,4*a*,7,8-hexahydro-1*H*-naphthalene (10856614)		204.35	Antioxidantl activity (Chandra *et al.,* 2017)
9	β-gurjunene ($C_{15}H_{24}$)	(1*aR*,4*R*,4*aR*,7*aR*,7*bR*)-1,1,4-trimethyl-7-methylidene-2,3,4,4*a*,5,6,7*a*,7*b*-octahydro-1*aH*-cyclopropa[e]azulene(6450812)		204.35	Hypoglycaemic effect (Math *et al.,* 2005)
10	β–cadinene ($C_{15}H_{24}$)	(1*S*,4*aR*,8*aS*)-4,7-dimethyl-1-propan-2-yl-1,2,4*a*,5,8,8*a*-hexahydronaphthalene (10657)		204.35	Flavor compounds (Kim *et al.,* 2000), Antibacterial effects (Kim *et al.,* 2005), Antifungal activities (Giordani *et al.,* 2008)
11	Acorone ($C_{15}H_{24}O_2$)	(1*S*,4*R*,5*S*,8*R*)-1,8-dimethyl-4-propan-2-ylspiro[4.5]decane-3,9-dione (5316254)		236.35	Antimicrobial and antioxidant (Souza *et al.,* 2016)
12	Shyobunones ($C_{15}H_{24}O$)	(2*S*,3*S*,6*S*)-3-ethenyl-3-methyl-6-propan-2-yl-2-prop-1-en-2-ylcyclohexan-1-one(5321293)		220.35	Insecticidal activity (Liu *et al.,* 2013), Antimicrobial activity (Prabha *et al.,* 2021)

(83.6 and 78.6 %, respectively) as compared to root oil and generally indicate triploid nature of the population. The root oil of *A. calamus*, growing in northern India can serve as a potential source of chemical constituents like β-gurjunene and aristolene (Verma *et al.,* 2014).

Pharmacological Applications of *Acorus calamus*

Antibacterial Activity

It was observed that rhizomes extract of Vachha showed antibacterial activity against various bacterial strains such as *Staphylococcus aureus, Staphylococcus epidermidis* and *Escherichia coli* by

Table 4. List of various medicinal properties of *Acorus calamus* (Sweet flag).

Researcher's Name	Journal	Title	Medicinal uses	Findings
Ghosh *et al.*, 2006	Annals of botany	Antifungal properties of haem peroxidase from *Acorus calamus*	Antifungal effects	*Acorus calamus* leaves extract contain a class III haem peroxidase which plays important role in host's defense by inhibiting fungal growth of pathogenic fungi such as *Macrophomina phaseolina*, *Fusarium moniliforme* and *Trichosporium vesiculosum*.
Palani *et al.*, 2010	Acta Pharmaceutica Sciencia	Therapeutic efficacy of *Acorus calamus* on acetaminophen induced nephrotoxicity and oxidative stress in male albino rats	Nephrology	Ethanolic extracts of leaves part of *Acorus calamus* showed protective effect in acetaminophen induced necrotic tissue and renal damage in experimental rats
Patel *et al.*, 2012	Asian pacific Journal of Tropical Diseases	Antihypertensive effect of rhizome part of *Acorus calamus* on renal artery occlusion induced hypertension in rats	Cardiovascular Health(Blood pressure)	In hypertensive experimental rats, 250mg/kg of ethyl acetate extract of rhizome part of *Acorus calamus* causes attenuation in increased systolic and diastolic blood pressure.
MD Kapadia *et al.*, 2012	International Journal of Pharmaceutical Sciences and Research	Antidiarrhoeal activity of leaves of *Acorus calamus*	Anti-diarrhoeal	Effect of the methanol extract of leaves of *Acorus calamus* on Inhibition of castor oil induced Diarrhoea (400mg/kg) showed control wet feaces (0.98±0.35).
Liu *et al.*, 2016	Drug Design, Development and Therapy	Neuroprotective effect of β-asarone against Alzheimer's disease: regulation of synaptic plasticity by increased expression of SYP and GluR1	Memory and Learning	β-asarone's oral ingestion at a dose of 12.5-50mg/kg for 28 days is able to preserve cognition in rats
Rawat *et al.*, 2016	Biotech	Anti-oxidant and anti-microbial properties of some ethno-therapeutically important medicinal plants of Indian Himalayan Region.	Antioxidant effects and antibacterial activity	Study showed that rhizome and leaves extracts of plant contain sufficient amounts of vitamin C and total polyphenolic compounds and also showed antimicrobial activity against *Bacillus subtilis*, *Escherichia coli*, *Aspergillus flavus*, *Candida albicans*.
Chellian *et al.*, 2018	European Journal of pharmacology	Alpha-asarone attenuates depression-like behavior in nicotine-withdrawn mice: Evidence for the modulation of hippocampal pCREB levels during nicotine-withdrawal	Depression	This study showed the effect of α-asarone on treatment of depression. α-asarone one of the major constituent of plant was used to attenuate the depression like behavior upon oral administration of nicotine solution to mice by modulating hippocampal CREB signaling pathways.

Table 4. *Continued ..*

Researcher's Name	Journal	Title	Medicinal uses	Findings
Muchtaromah *et al.,* 2019	Jurnal Biodjati	Phytochemical Screening and Antibacterial Activity of *Acorus calamus* L. Extracts	Antibacterial activity	The chloroform extract of rhizome part of *Acorus calamus* showed inhibitory effect against pathogenic bacterial strains *Staphylococcus aureus* and *Escherichia coli.*
Pawar *et al.,* 2020	Vegetos	*In vitro* antibacterial activity of *Acorus calamus* extract on methicillin-resistant *Staphylococcus aureus* wound isolates and reduced invasion into mucosal fibroblasts	Antibacterial activity	Methanolic extract of the rhizome part of *Acorus calamus* showed antibacterial activity against methicillin-resistant *Staphylococcus aureus*isolated from wound and serve as potential drug for various skin diseases.

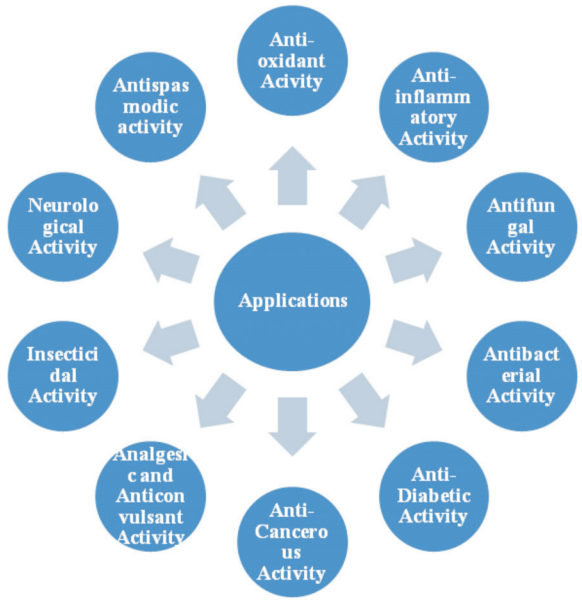


Fig. 7. Figure showing the flower of *Acorus calamus*

using disc diffusion method to determine the susceptibility of bacteria at various concentrations ranges from (100-400 mg/ml). The Minimal Inhibitory Concentration (MIC) of rhizome extracts generally varied from 25-100 mg/ml against these susceptible bacteria. The ethanolic extracts plant showed maximum inhibitory activity having (16mm) diameter zone of inhibition against *Staphylococcus epidermidis.* The presence of major phytocompounds of plants from the essential oil of rhizome part analyzed by Gas Chromatography and Mass Spectrometry (GC-MS) techniques which showed the antibacterial properties. The various solvent extracts of rhizome part could be useful for effective formulation which helps in curing various kinds of infectious ailments (Haghighi *et al.,* 2014).

Antifungal Activity

It wasexamined that presence of active compounds in the essential oil of rhizome part by using Gas Chromatography-Mass Spectroscopy (GCMS) and identify the antifungal effect of against *Candida albicans.* Agar well diffusion method was used to check the antifungal activity. Antifungal effect of rhizome oil showed best inhibition against *Candida albicans* fungal strain which increased with the increase of the oil concentration for test. Results revealed that the MIC value of essential oil toward at 1% concentration of oil give the 7.83 mm inhibition zone against test organism (Rita *et al.,* 2017).

The present studyevaluated the antifungal activity of *Acorus calamus* (rhizome) extracts of the plant. The extracts prepared in different solvents like petroleum ether, methanol, ethanol, and aqueous evaluated for antifungal activity against *Fusarium oxysporum f. sp. lycopersici* by using paper disc diffusion method. Results showed that the acetone solvent extract of rhizome was most effective and at its 1000 mg/ml concentration showed the best antifungal activity with inhibition zone of 29.5 mm against *Fusariumo xysporum f. sp. lycopersici* (Rawal *et al.,* 2015).

Anti-inflammatory Activity

The author's of studyinvestigated that the anti-inflammatory activity of leaf part of *calamus* (ACL) extract on human keratinocyte HaCaT cells. HaCaT cells firstly treated with polyinosinic: polycytidylic

acid (polyI:C) and peptidoglycan (PGN). The treatment leads to the production of the incendiary responses detected by methods like immunoblotting, RT-PCR, staining ELISA assay, immunofluorescence. HaCaT cells induced for the production ofpro-inflammatory cytokines, interleukin-8 (IL-8) and/or interleukin-6(IL-6) expressions after treatment with immunostimulant. Plant leaves extract inhibited the expression these major cytokines responsible for inflammation. These results showed that plant extract inhibit the release of cytokines which are responsible for inflammation and therefore plant may be serves as efficacious anti-inflammatory agent for curing various types of skin ailments (Kim *et al.,* 2008).

Anti-oxidant Acivity

Investigators of the study successfully reported the antioxidant activities of methanolic extracts of rhizome part of *Acorus calamus*. The antioxidant activity determined by detecting three major activities like DPPH radical scavenging effect, reductive ability and metal chelating action. The maximum reducing power observed in sample 15R which was collected from the site Gumti of district Almora, Uttarakhand (IC50 = 104.62 ± 0.922 µg/mL) while 20R which was collected from the site Khedagao of district Almora, Uttarakhand (IC50 = 241.81 ± 0.762 µg/ml) exhibit lowest reducing power activity. Maximum antioxidant activity (DPPH assay) was observed in 7R sample collected from site Chaukhutiya of district Almora (IC50 = 143.35 ± 0.741 µg/ml) while 17R from site Donprewa of district Nainital exhibited lowest radical scavenging activity (IC50 = 919.55 ± 0.588 µg/ml) and maximum metal chelating action was detected in 20R (IC50= 308.57 ± 0.855 µg/ml) whereas 6R sample collected from site Paithani (IC50 = 1439.35 ± 2.896 µg/ml) showed minimum Chelating activity. Finally, it has been concluded that methanolic extracts of *Acorus calamus* serves as a best source of natural antioxidant for medicinal uses (Chaubey *et al.,* 2017).

Anti-Diabetic Activity

It wasreported the male albino rats were rendered diabetic by oral administration of STZ (40 mg/kg, intraperitoneally). In this experimental study *Acorus calamus* rhizome extract (200 mg/kg) was administered orally to diabetic rats upto 21 days to know the antihyperglycemic activity. Results showed that oral administration of methanol extract of rhizome part of *Acorus calamus* in streptozotocin (STZ) induced diabetic rats showed significant restoration of the levels of blood and glucose level. Male albino rats observed after treatment extract results shows that blood glucose, lipid profile (total cholesterol, LDL and HDL- Cholestrol), glucose 6-phosphatase, fructose 1,6 bis phosphatase levels and hepatic marker enzymes (alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase) quantity were decreases when compared with control. Glucose- 6-phosphate dehydrogenase, Plasma insulin, tissue glycogen, levels were increased significantly as compared to control. Results from the study revealed that the methanolic extracts of rhizome part possess the effective antihyperglycemic activities and considered as most powerful drug for treatment of diabetes (Prisilla *et al.,* 2012).

Anti-Cancerous Activity

According to author's ethanolic and methanolic extracts of rhizome and essential oil showed anticancerous effect on human gastric cancer cell line (AGS). The study showed that anticancerous activity of extract and essential oil inhibited the growth of AGS cells and also inhibited the angiogenesis in HUVEC cells. Results of the study showed that the extracts and the essential oil of Vachha caused G1 arrest in cells lines and down regulation of Oct 4 and NS. The GC-MS analysis results also exhibited the presence of new compounds such as epiprezizaene, valencene and isocyclocitral in essential oil of Vachha (Haghighi *et al.,* 2017).

Insecticidal Activity

The present analysis showed thelethal concentration 50 (LC50) values of ethanolic extract of *Acoruscalamus* (rhizome) against larvae, adult males and females of *Drosophila melanogaster* were recorded as 109.54, 52.51 and 41.11 mg/l respectively. Genotoxicity of adult's flies were determined at 30 and 55 mg/l ethanolic extract of *Acoruscalamus* (rhizome). The mean comet tail length was 4.24±0.653 µm and 6.13±0.721 µm and the respective DNA damage was 5.1% and 7.3% with reference to controls. Results showed that ethanolic extract of *Acoruscalamus* rhizome showed higher effect as insecticidal activity in adults than larvae of *Drosophila melanogaster*. But the results from genotoxicity studies further support the insecticidal activity against adult stages of *Drosophila*

melanogaster. The study reflects ethanolic extract of *Acoruscalamus* could be used as an alternative pest control negotiator for minimizing the noxious effects of pesticides in the environment (Kumar *et al.,* 2015).

Antispasmodic Activity

Gilani *et al.,* 2006 reported the antispasmodic and anti-diarrhoeal effect of *Acoruscalamus* (rhizome). In this experiment the crude extract of rhizome part firstly tested positive for the presence of phytochemicals alkaloid, saponins and tannins. The crude extract of *Acoruscalamus* (rhizome) was tested inthe isolated rabbit jejunum which caused inhibition of spontaneous and high K^+(80 mM)-which is responsible to produce contractions, with EC_{50} values of 0.42 ± 0.06 and 0.13 ± 0.04 mg/mL (mean ± SEM; *n* = 6–8), thus showing antispasmodic activity, mediated possibly through calcium channel blockade (CCB) system. The crude extract (0.0003 – 0.001 mg/mL) caused a rightward shift in the Ca^{++} dose-response curves regarding this similar effects to that also caused by verapamil, a standard calcium channel blocker. These results suggest that this plant serves as potential agent as an intestinal relaxant showing spasmolytic effect. The experimental study gives effective evidence for the traditional use of plant in treatment of various gastrointestinal disorders such as colic pain and diarrhea[29].

Analgesic and Anticonvulsant Activity

The analgesic activity of methanolic roots extracts of plant detected by using two main methods acetic acid induced Writhing response and Rat caudal immersion method as compared to anticonvulsant activity which was measured by utilizing pentylenetetrazol induced convulsion methods. Oral administration at 0.1 and 0.2 g/kg concentration, showed the protective action against the pain models in mice. Methanolic root extract significantly increased the latency duration in seizures induced by drug pentylenetetrazole (PTZ) in mice (Jayaraman *et al.,* 2010).

The anticonvulsant effect of ethanolic extract of roots by using maximal electroshock seizure (MES) and pentylenetetrazol (PTZ)-induced seizure models on albino (Wistar strain) rats. Result of study showed that extract treatment reduced the time period of tonic hind limb extension in MES model, and with PTZ model increase in latency and occurrence of convulsions was observed (Kaushik *et al.,* 2018).

Effect on Neurological Activity

In this study,evaluate the anxiolytic or anti-anxiety activity of major phytocompound á -asarone isolated from *Acorusgramineus*in rat model used in experimental study in which the anxiety behavior induced due to repeated oral administration stress hormone corticosterone (CORT). The anti-anxiety activity of compound in ratswas evaluated by the elevated plus maze (EPM) test and the hole-board test (HBT) tests of anxiety. The results of the study give the detailed information of the neurobiological mechanisms in rat models responsible for changes in emotions induced by repeated administration of high doses of corticosterone hormone or by elevated levels of hormones associated with chronic stress. The α-asarone (AAS) compound from *Acorusgramineus* did exhibit anxiolytic-like effects in animal models of anxiety (Lee *et al*., 2014).

CONCLUSION

This review supports that the *Acorus calamus* is the unique source of various types of phytocompounds having wide range of biological activities. α-asarone and β-asarone are the major bioactive constituents presents in this versatile medicinal plant. Herb used as the therapeutic agent for the treatment of various types of ailments and possess the property of improving the memory power and enhancing the intellect power. Herb possesses various pharmacological activities such as antimicrobial, anti-inflammatory, antioxidant, antidiarrheal, antiulcer, antispasmodic, anticancerous, analgesic and anticonvulsant, immunosuppressant have been reported by different workers. Therefore it has been proved from the above literature reviewed that *Acorus calamus* can be explored successfully for various marketed formulation.

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