REVIEW ARTICLE

Sweet flag (*Acorus calamus* Linn.): An incredible medicinal herb

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The aim of the present paper is to provide information regarding the ethnopharmocology, ethnobotany, therapeutic uses and scientific studies carried out on sweet flag (*Acorus calamus* Linn). The search was carried out by examining the classical texts of Unani, Ayurveda and other traditional medical systems, as well as the ethnobotanical literature and Google scholar. The drug is popularly known as "Sweet flag" in traditional medicine and used to treat a number of diseases. The plant has a rich ethnobotanical history dating possibly back to the time of Moses in the Old Testament of the Bible and in early Greek and Roman medicine. Sweet flag has been valued for its rhizome and fragrant oils which have been used medicinally, in alcoholic beverages, as a fragrant essence in perfumes and oils, and for insecticidal properties. Chemical analysis of sweet flag shows that it contains sesquiterpenes, flavonoids, α- and β-asarone and various other constituents. Research studies have shown that it possesses various pharmacological activities. An extensive review of the ancient traditional literature and modern research revealed that the drug has numerous therapeutic actions, several of which have been established scientifically which may help the researchers to set their minds for approaching the utility, efficacy and potency of sweet flag.

Key words: Ethnobotany, sweet flag, traditional medicine, Unani medicine, β-asarone

INTRODUCTION

Sweet flag (*Acorus calamus*) is commonly known drug in traditional system of medicine. It is a tall perennial wetland monocot plant from the *Acoraceae* family. The scented leaves and rhizomes of sweet flag have been traditionally used as a medicine and the dried and powdered rhizome has a spicy flavour and is used as a substitute for ginger, cinnamon and nutmeg for its odour.[1] Due to varied uses, there has been demand for the plant. The herb rarely produces seeds and is mainly propagated by vegetative means. *In vitro* method of vegetative multiplication of *Acorus calamus* would have considerable benefits for the medicinal trade and germplasm conservation. It has been long known for its medicinal value, it is wild or cultivated throughout Himalayas at an altitude ascending up to 6000 feet. The rhizomes of *Acorus calamus* contain aromatic oil that has been used medicinally since ancient times and has been harvested commercially. The rhizomes are considered to possess anti-spasmodic, carminative, anthelmintic, aromatic, expectorant, nauseate, nervine, sedative, stimulant properties and also used for the treatment of epilepsy, mental ailments, chronic diarrhoea, dysentery, bronchial catarrh, intermittent fevers, glandular and abdominal tumors.[2]

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TAXONOMICAL CLASSIFICATION

Kingdom: Plantae
Subkingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyta
Class: Liliopsida
Subclass: Arecida
Order: Arales
Family: Acoraceae
Genus: *Acorus*
Species: *Calamus*[3]

Vernacular Name

Arabic: Vaj, Vash, Oudul Vaj; Sanskrit: Bhadra, Bhutanashini, Vacha; Hindi: Bach, Ghorbach, Safed bach; Gujarati: Gandhilovaj, Godavaj; Kashmir: Vachi, Vaigandar; Persian: Agar, Agarturki, Kannada: Baje, Vasa; English: Sweet flag, Calamus, Myrtle grass; Urdu: Bach, Vaj; Tamil: Vashambu, pullai-valathi; Nepali: Bojho; Ayurvedic: Vacha; Unani: Vaj turki, Bacch; Italy: Plant of Venus.[4]

BOTANICAL DESCRIPTION

Phytomorphology

Acorus calamus Linn. is an herbaceous perennial with a rhizome that is long indefinite branched, smooth,

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pinkish or pale green. Its leaf scars are brown white and spongy and it possess slight slender roots. The leaves are few and distichously alternate whose size was found to be between 0.7 and 1.7 cm wide with average of 1 cm. The sympoidal leaf of *Acorus calamus* is shorter than that of the vegetative leaves. The flowers are 3 to 8 cm long, cylindrical, greenish brown and contains multitude of rounded spikes covering it. The fruits are found to be small and berry like with few seeds.[5]

Distribution

It is distributed throughout the tropics and subtropics, especially in India and Sri Lanka. It is found in marshes, wild or cultivated, ascending the Himalayas up to 1800 m in Sikkim. It is plentiful in marshy tracts of Kashmir and Sirmoor, in Manipur and Naga Hills. It is regularly cultivated in Koratagere taluk in Karnataka. The plant is grown in clayey loams and light alluvial soil of river bank. It is now found widely wild on the margin of pounds and rivers in most English countries.[6]

Parts Used

The parts used in most of the experimental studies are the leaves, roots (rhizomes) and stem of the plant. In Traditional systems of medicine mostly the rhizomes are used.[1]

Trade Name

Sweet Flag, Calamus, Calamus root, Myrtle grass, Myrtle root, Bacch, Vaj.

PHYTOCHEMICAL CONSTITUENTS

Photochemical studies have reported the presence of glycosides, flavonoids, saponins, tannins, polyphenolic compounds, mucilage, volatile oil and bitter principle. The plant has been reported for the presence of glucoside, alkaloid and essential oil containing calamen, clamenol, calameon, asarone and sesquiterpenes. It also contains a bitter glycoside named acorine along with eugenol, pinene and camphene. The plant has been extensively investigated and a number of chemical constituents from the rhizomes, leave and roots of the plant have previously reported which includes β- asarone, α- asarone, elemicine, cisisoelemicine, cis and trans isoeugenol and their methyl ethers, camphene, P-cymene, α-selinene, bgurjunene, β-cadinene, camphor, terpinen-4-ol, aterpineol and a calacorene, acorone, acrenone, acoragermacrone, 2-deca -4,7 dienol, shyobunones, linalool and preisocalamendiol are also present. Acoradin, galangin, 2, 4, 5- trimethoxy benzaldehyde, 2, 5 dimethoxy benzoquinone, calamendiol, spathulenol and sitosterol have been isolated from *Acorus calamus.* Alcoholic extracts of the triploid *A. calamus* were characterized by a higher percentage of β-asarone (11%), which was the main compound, followed by higher percentages of camphene (2.27%), enriched (E)-β-ocimene (3.28%), camphor (1.54%), calarene (1.42%), α-selinene (5.02%) and s-cadinol (2.00%), when compared to the diploid A. calamus. The latter had higher percentages of isoshyobunone (8.62%), bsesquiphellandrene (3.28%), preiso calamendiol (22.81%) and acorone (26.33%).[2,7]

Dong W *et al.*, isolated three new sesquiterpenes, 1β,7α(H)-cadinane- 4α,6α,10α-triol (1), 1α,5 β-guaiane-10α-O-ethyl 4β,6 β-diol (2), and 6β,7β(H)-cadinane-1α,4α, 10α-triol (3), together with 25 known ones, from the rhizome of *Acorus calamus* L. Their chemical structures were established on the basis of interpretation of spectroscopic data and comparison with those of the related known compounds.[8]

HISTORY AND TRADITIONAL LORE

One of the earliest records of sweet flag is the calamus of the Bible. It was first mentioned when God told Moses to make a holy oil to anoint the tabernacle, the ark of testimony, and other ritual paraphernalia (Exodus 30:23, 24, 34). Calamus was also one of the plants said to grow in the gardens of Solomon (Solomon 4:14). Sweet flag was also used by the early Greeks and Romans. Hippocrates (460- 377 B.C.) used the plant medicinally and in early herbals of the first century Dioscorides and Pliny referred to a plant called acoron, which appears to be sweet flag. Theophrastus (371-287 B.C.) mentioned calamus in his works, and Celsus reported its presence in Indian markets nearly two thousand years ago. Aphrodisiac properties were attributed to the rhizome by the Roman and Arabic cultures for centuries.

In the eleventh century sweet flag, a native of China and India was transported into Russia and Poland by the Tatars during their conquests. The first record of sweet flag cultivation was in 1574 by the Austrian botanist Clusius, who obtained a rhizome from Asia Minor and propagated it in Vienna. The fragrant leaves of sweet flag were used in medieval times on the floors of castles, churches and cottages to help cover odours and repel insects resulting from poor sanitation. The unpeeled, dried rhizome was listed in the U.S. Pharmacopoeia until 1916 and in the National Formulary until 1950, for medicinal use on humans.[9]

CULTURAL ASPECTS

Cultivation

Sweet flag comes up in almost all types of soil with sufficient moisture or irrigation. This can also be grown in waterlogged or marshy soils. Tropical to sub tropical climate is suitable for this crop. Such field is irrigated and tilled with green manure before planting. The rhizome (previous year's) along with bud

is cut into pieces (Cut without affecting bud). The cut pieces of rhizome with bud is planted in the fine sand mixed soil at 0.3 m apart, leaving the leafy portion little bit above the soil so that the bud can be seen from outside. Weeding: The crop is weeded once every month from the first four to five months.

Fertilizers

Chemical fertilizers of 45:12.5:12.5 kg NPK (Nitrogen, Phosphorous and Potash) per hectare.

Harvesting

The crop is ready for harvesting in about a year after cultivation. The leaf tip begin to turn yellow this is the indication of crop maturity. The rhizomes are usually collected during autumn (September-October) till early spring (March-April) seasons.

Yield of the Crop

The average yield of rhizome is 40 quintal per hectare.

Market

This crop has regional and international market. The market price in India is Rs. 28.00 to Rs 40.00 per kilogram. While in America the price of herb powder of this plant is $ 17.50 per 1lb or $ 17.50 per 0.45 kilogram.[10,11]

TRADITIONAL MEDICINAL USES

The rhizomes of sweet flag (*Acorus calamus*) are used for numerous medicinal purposes. The herb is used both internally as well as externally. In rheumatism, rheumatic fever and inflamed joints, the paste applied externally alleviates the pain and swelling. Internally sweet flag is valuable in a vast range of diseases. It is effective for digestive ailments such as flatulence, loss of appetite, abdominal dull pain and worms. The powder of sweet flag given with lukewarm salt-water, induces vomiting and relieves phlegm, while easing coughs and asthma.

In epilepsy, the powders of sweet flag, Brahmi and jatamamsi work well, when given with honey. The popular Ayurvedic formulation Sarasvata Choorna, which contains sweet flag, is commonly used to treat epilepsy, hysteria and as a brain tonic. Granule Asabi (Unani preparation) is an excellent nervine tonic which improves memory, reception as well as the speech. As it stimulates the uterine contractions, so it is used to augment the labour pains. It is also salutary in dysmenorrhoeal.[12,13] Some popular market formulations of Sweet flag are mentioned in Table 1.

Table 1: Marketed formulations of sweet flag (*Acorus calamus*) plant[3]

Formulations	Company
Scavon Vet cream	The Himalaya Drug Company, Makali, Bangalore, India
Acorus calamus Herbal extract	Vidya Herbs Private Limited, Bangalore, Karnataka, India
Ayurvedic and Herbal Chemicals of *Acorus calamus*	Jenson Enterprises Private Limited, Chengalpattu, India
Varch oil	Herbotech Pharmaceuticals, Amritsar, India
Anxi-6	Kalhan Pharmaceuticals Private Limited, Jalandhar, India
Herbal preparations of *Acorus calamus*	Sydler Remedies Private Limited, Mumbai, India
Ayurvedic Preparations of *Acorus calamus*	Kebee Pharmachemie Private Limited, Andheri, Mumbai, India
Perfumes, Vach oil, Alcoholic Drinks, toothpastes	Ram Prakash Company, Khari Baoli, New Delhi, India
Botanical Insecticide (Vasambu)	Coimbatore, Tamil Nadu Agricultural University and Bhuvicare Private Limited Tirunelveli, India
Nervine tonic, Antispasmodic	Salem Impex, Salem, Tamil Nadu, India
Stresnil	Universal Pharmaceuticals Limited, Chennai, Tamil Nadu, India
Calamus Oil	Modern Natural Products, Mumbai, India
Natural oil of Vacha	Bhagat Aromatics Limited, New Delhi, India
Calamus Essential Oil	Katyani Exports, Pitam Pura, New Delhi, India
Insecticides	Ajinkya Chemtech Private Limited, Pune, India
Krush capsules	Prakruti Remedies Pvt. Ltd Karnataka (India)
Brainokan	Kangra Herb Private Limited, Kangra, HP, India

PHARMACOLOGICAL ACTIONS

Nootropic Activity

The neuropsycho-pharmacological effect of a polyherbal formulation Bramhi Ghrita (BG) on learning and memory processes in rats by elevated plus maze, and in mice by Morris water maze model. BG contains *Acorus calamus*. Its effect (30, 50 and 100 mg/kg, p.o.) was tested on learning and memory processes. BG may act as a memory enhancer formulation and may also be useful as a supportive adjuvant in the treatment of impaired memory functions.[14]

Anti-diabetic Activity

Oral glucose tolerance test (OGTT) was performed in normal rats. Male albino rats were rendered diabetic by STZ (40 mg/kg, intra-peritoneally). 200 mg/kg of AC extract was administered orally to diabetic rats for 21 days to determine the anti-hyperglycaemic activity by estimating various biochemical parameters. Results showed significant restoration of the levels of blood glucose level. After 21 days of treatment, blood glucose, lipid profile, glucose 6-phosphatase, fructose 1, 6 bis phosphatase levels and hepatic markers enzymes were decreased when compared with diabetic control. Plasma insulin, tissue glycogen, glucose-6-phosphate dehydrogenase levels were increased significantly compared to diabetic control. Concurrent histopathological studies of the pancreas showed comparable regeneration by extract which were earlier necrosed by STZ.[15]

Anti-seizures Activity

To evaluate the efficacy of aqueous extract of *Acorus calamus* (AEAC) on electrical and chemical induced seizures in albino mice. Either normal saline or sodium valproate or AEAC was given sixty minutes prior to the experiment in acute study, whereas in chronic study, they were given twice daily for ten days and the last dose was given one hour prior to the exposure of the animal either to maximal electrical shock (MES) or pentylenetetrazole (PTZ) administration. On acute administration, AEAC dose dependently reduced the duration of tonic hind limb extension in MES induced seizure which was comparable to that produced by sodium valproate. Whereas, in PTZ induced seizures, the test drug decreased the latency and increased the duration of seizures as well as mortality. On repeated administration (chronic study) the test drug significantly reduced the duration of tonic hind limb extension and also the clonus phase of MES induced seizures.[16]

Antidepressant Activity

In a clinical study in fifty cases of depression at OPD of S.S. Hospital BHU, Varanasi, *Acorus calamus* (500 mg in a dose of 2 tablets three times a day after meal with water) given for six weeks showed reduction in the degree of severity of depression and better rehabilitation. There was also a significant improvement in assessment based on rating of symptoms on Hamilton depression rating scale. The rate of improvement before and after treatment was significant ($P < 0.001$).[17]

Neuromodulatory Effect

The effect of *Acorus calamus* methanolic extract (ACME) and acetone extract (ACAE) pre-treatment at various doses against apomorphine (APM) induced stereotyped behavior and haloperidol induced catalepsy in mice was studied. ACME (20, 50 mg/kg BW p.o) significantly reversed stereotypy induced by APM, when administered 6 h prior to APM. It is also found that ACME (50 mg/kg body weight, per oral) and ACAE (20, 50 mg/kg body weight, per oral) administration significantly potentiated the haloperidol induced catalepsy in mice.[18]

Anticancer Activity

Gaidhani *et al.*, Evaluated anticancer activity of *Acorus calamus* rhizomes. They prepared hydro alcoholic extract of *Terminalia chebula*, rhizome of *Acorus calamus* and root of *Glycyrrhiza glabra* and further studied their anti-proliferative activity on anti cancer cell. Results predict the fact that all of these plant materials have significant anti-proliferative activity.[19]

Antioxidant Activity

The antioxidant activity of aqueous extract of *Acorus calamus* was determined by the following radical scavenging assays namely DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging assay, nitric oxide scavenging assay, superoxide radical scavenging assay, ferrous chelating assay, reducing power assay and phosphomolybdenum assay. The aqueous extract showed strong dose dependent reducing activity. The results showed that *Acorus calamus* exhibits free radical scavenging, reducing power and metal chelating property.[20]

Antihypertensive Effect

Hypertension in rats was induced by clamping the left renal artery for 4h by arterial clamp (2K1C). At the end of experiment animal were anesthetized with ketamine (50 mg/kg). Carotid artery was cannulated which was connected to pressure transducer for estimation of blood pressure. Results shows Ethyl acetate extract of *Acorus calamus* rhizomes (EAAC) treated rats that underwent hypertension, demonstrated significant ($P < 0.01$) lower systolic blood pressure and diastolic blood pressure when compared with 2K1C rats indicated blood pressure lowering activity. In conclusions, EAAC treatment attenuated renal artery occlusion induced hypertension via nitric oxide generation and decreases the plasma rennin activity.[21]

Anti HIV Activity

40 traditional Asian medicinal plants were screened against HIV-1 reverse transcriptase. The results showed that the crude extracts from plants *Cinnamomum loureiroi* (stem bark), *Quercus infectoria* (fruit), *Plumbago indica* L. (root), and *Acorus calamus* L. (rhizomes) showed strong HIV-1 reverse transcriptase inhibition effects. The efficiency of anti-HIV-1RT activity was reported as 50% inhibitory concentrations (IC50). This showed that the hexane crude extracts from *Acorus calamus* L. and *A. heterophyllus* Lam. contained potent activity against HIV-1 RT.[22]

Cytotoxic Effect

Rajkumar *et al.*, used methanolic and aqueous extract of *Acorus calamus* plant and further studied cytotoxic effect. From whole study they concluded that it might be act against the cytotoxicity in time and concentration dependent manner.[23]

Immunosuppressive Activity

Mehrotra *et al.*, evaluated anti cellular and immunosuppressive potential of ethanolic extract of *Acorus calamus*. The ethanolic extract of *Acorus calamus* rhizome showed anti proliferative and immunosuppressive properties. This extract causes the tumor necrosis through which inhibits the proliferation of mitogen, antigen stimulated peripheral blood mononuclear cells in humans, nitric oxide and interleukins-2.[24]

Radioprotection and DNA Repair Activity

Whole-body exposure of mice to 4 Gy γ-irradiation resulted in considerable damage in the genomic DNA of peripheral

blood leucocytes, bone marrow cells and splenocytes. An alkaline comet assay revealed that the nuclear DNA comet parameters of these cells, such as % DNA in tail, tail length, tail moment and olive tail moment, had increased following whole-body γ-irradiation. Administration of *Acorus calamus* extract (250 mg/kg body weight) orally to mice 1 h prior to whole-body γ-irradiation exposure prevented the increase in the comet parameters of cellular DNA. The comet parameters were found to decrease with post irradiation time, indicative of a decrease in radiation-induced DNA lesions due to DNA repair.[25]

Coronary Vasodilator Effect

Coronary vasodilator effect was studied in isolated bovine coronary arterial rings, suspended in tissue baths filled with Krebs solution, maintained at 37°C, aerated with carbogen and responses were measured on Power Lab data acquisition system. In bovine coronary arterial preparations, crude extract of *Acorus calamus* (Ac.Cr) caused inhibition of U46619 (20 nM) pre contractions, Activity-directed fractionation revealed that endothelial-derived hyperpolarizing factor (EDHF) -mediated activity is concentrated in the n-Hexane fraction. These data indicate that Ac. Cr mediates coronary vasodilator effect primarily through EDHF, responsible for the increase in coronary flow.[26]

Antispasmodic and Anti-diarrhoeal Effect

In the isolated rabbit jejunum preparation the crude extract (Ac. Cr), which tested positive for the presence of alkaloid, saponins and tannins, caused inhibition of spontaneous and high K^+ (80 mm) induced contractions, with respective EC_{50} values of 0.42 ± 0.06 and 0.13 ± 0.04 mg/mL, thus showing spasmolytic activity, mediated possibly through calcium channel blockade (CCB). These results suggest that the spasmolytic effect of the plant extract is mediated through the presence of CCB-like constituent(s) which is concentrated in the n-hexane fraction and this study provides a strong mechanistic base for its traditional use in gastrointestinal disorders such as colic pain and diarrhoea.[27]

Insulin Sensitizing Activity

To investigate the insulin sensitizing activity and anti-diabetic effects of the ethyl acetate fraction of *Acorus calamus* L. (ACE). Glucose consumption mediated by insulin was detected in L6 rat skeletal muscle cells. Diabetes and its complications related indexes were monitored after orally administrating to genetically obese diabetic C57BL/Ks db/db mice daily for 3 weeks. Results show ACE increased glucose consumption mediated by insulin in L6 cells ($P < 0.05$ and $P < 0.01$). In db/db mice, ACE (100 mg/kg) significantly reduced serum glucose, triglyceride, reinforce the decrease of total cholesterol. Owing to the ability of insulin sensitizing, ACE has the potential to be useful for the treatment of diabetes and cardiovascular complications without body weight gain.[28]

Wound-healing Activity

A wound was induced by an excision- and incision-based wound model in rats of either sex. The extracts were applied topically once daily in conc. of 40% w/w and 20% w/w in the form of ointment and compared with a standard drug (povidion-iodine). The healing of the wound was assessed by the rate of wound closure, period of epithelialisation, tensile strength and weight of the granulation tissue, hydroxyproline content and histopathology of the granulation tissue. The ethanolic extract of *Acorus calamus* promoted wound-healing activity significantly in both the wound models studied. Enhanced wound contraction, decreased epithelialisation time, increased hydroxyproline content and histological characteristics suggest that *Acorus calamus* extract may have therapeutic benefits in wound healing.[29]

Anti-inflammatory Activity

Human Keratinocyte (HaCaT) cells treated with polyinosinic: Polycytidylic acid (polyI: C) and peptidoglycan (PGN) induced the inflammatory reactions. The anti-inflammatory activities of ACL were investigated using RT-PCR, ELISA assay, immunoblotting, and immunofluorescence staining. Result shows that the HaCaT cells induced the pro-inflammatory cytokines, interleukin-8 (IL-8) and/or interleukin-6 (IL-6) expressions after treatment with polyI: C or PGN. ACL inhibited the expression of IL-8 and IL-6 RNA and protein levels, and attenuated the activation of NF-κB (nuclear factor kappa-light-chain-enhancer of activated B cells) and IRF3 (Interferon regulatory factor 3) after poly I: C treatment. ACL also inhibited expression of IL-8 and activation of NF-κB following PGN induction.[30]

Synergistic Anthelmintic Activity

Merekar *et al.*, reports the synergistic anthelmintic activity of rhizomes of *Acorus calamus* and root part of *Vitex negundo*. The study shows that the ethanolic extract of *A. calamus* and *V. negundo* shows dose dependant anthelmintic activity against earthworms. Also the synergistic anthelmintic activity of *A. calamus* and *V. negundo* is significant than the individual activity of both the plants. For this study marketed drug was used as a standard reference drug.[31]

Antihepatotoxic Activities

Palani S *et al.*, evaluate the antihepatotoxic and antioxidant activities of ethanolic extract of *Acorus calamus* (AC) at two dose levels of 250 mg/kg and 500 mg/kg B/W on acetaminophen induced hepatotoxicity in rats. It observed that the ethanol extract of AC confers hepatoprotective and antioxidant activities by histopathological and observations against acetaminophen induced liver

injury in rats. It observed that the ethanol extract AC confers hepatoprotective and antioxidant activities by histopathological and biochemical observations against acetaminophen induced liver injury in rats. The activity of ethanol extract of AC (500 mg/kg B/W) is comparable to the standard drug silymarin (25 mg/kg B/W).[32]

Anti-ischemic Heart Disease Activity

In the clinical trial on 45 patients of ischemic heart disease at the OPD of S.S Hospital BHU, the efficacy of the drug *Acorus calamus* was tested. The patient was divided randomly in the three groups. To the first group the trial drug in a dose of 1.5 3 g/day in divided dose for three month was given. The second d group was given purified 'guggulu' while the third group which was the control group was given a capsule containing lactose powder. There was an encouraging improvement in the first and second groups. The drug was found to be effective in the improvement of chest pain, dyspnoea on effort, reduction of body weight index, improving in ECG decreasing serum cholesterol, decreasing SLDL (serum low density lipoproteins) and increasing SHDL (serum high density lipoproteins).[33]

Antifungal Activity

Ethanolic extract of 40 higher plants representing 23 families were tested for antifungal activity against some phytopathogenic fungi. The two most active plants showing potent antifungal activity were *Acorus calamus* and *Piper betel*. The rhizome extract of *A. calamus* exhibited highest antifungal activity inhibiting the mycelial growth completely (100%) against all the 6 test pathogens. *P. betel* exhibited more than 50% inhibition against most of the test fungi. The ethanolic extract of several higher plants could be used as alternative source of antifungal agents for protection of plants or crops against fungal infection.[34]

Antibacterial Activity

The aqueous and ethanolic extracts of *Acorus calamus* was evaluated for antibacterial activity against clinically important bacteria viz. *Bacillus subtilis* (MTCC 441), *Staphylococcus aureus* (MTCC 96), *Escherichia coli* (MTCC 443), *Proteus mirabilis* (MTCC 1429), *Pseudomonas aeruginosa* (MTCC 424). The in-vitro antibacterial activity was performed by agar well diffusion method. The ethanolic extracts of *A. calamus* was active against all the investigated bacterial strains while aqueous extract was totally inactive against the studied gram negative bacterial strains (*E. coli*, *P. mirabilis* and *P. aeruginosa*) and showed moderate antibacterial activity against gram positive bacteria *B. subtilis* and *Stap. aureus* at high concentration (200ml).[35]

Analgesic Effect

The analgesic activity of the methanolic extract of the *Acorus calamus* and Oroxylum indicum at the dose of 250 and 500 mg/kg body weight was evaluated against the standard drug - Diclofenac sodium, at a dose of 25 mg/kg body weight. Adult Swiss albino mice of either sex of five numbers in each group, was undertaken for study and evaluated by acetic acid induced writhing method. The methanol extract of *Acorus calamus* inhibited writhing reflex by 30.77% and 39.86% at the dose of 250 and 500 mg/kg body weight. The methanolic extract of *Acorus calamus* was found to be more active than Oroxylum indicum as a pain killer.[36]

Antipyretic Activity

Aqueous, dichloromethane and methanol extracts of *Acorus calamus* along with eight other plants were screened for larvicidal, antioxidant, *in vivo* antipyretic and *in vitro* antiplasmodial activities. The dichloromethane and methanol extracts significantly ($P \leq 0.05$) reduced pyrexia with activity increasing in a concentration dependent manner. The results support the use of these plants in folk medicine and suggest that these plants contained constituents that could be developed as potent anti-malarial drugs.[37]

Bronchodilatory Activity

A study was undertaken to provide a pharmacological basis for traditional use of *Acorus calamus* in airways disorders. For this purpose isolated guinea-pig trachea and atria were suspended in organ baths bubbled with carbogen and mechanisms were found using different parameters. Result shows crude extract of *Acorus calamus* was more effective than carbachol in causing relaxation of high K^+ (80 mM) preconstruction's, similar to verapamil, suggesting blockade of calcium channels.[38]

Licicidal Activity

Dried rhizomes of *A. Calamus* were subjected to exhaustive sequential extraction with four solvents n-hexane, chloroform, methanol and distilled water respectively. All four fractions were studied for *in vitro* licicidal activity using Goat-lice *Damalinia caprae* (Trichodectidae) as experimental organism. Only n-hexane and chloroform fractions showed licicidal activity. Significant decrease in mean time required to kill the lice was observed at concentration 1% w/w and 10% w/w when compared to 1% w/w lindane solution.[39]

Mosquito Larvicidal Activity

Dried rhizomes of *A. Calamus* were subjected to soxhlet extraction with two solvents petroleum ether and ethyl alcohol. All two fractions were studied for *Aedes aegypti* larvicidal activity and determined lethal concentration which kills 50% and 90% population (LC_{50} and LC_{90} value). Petroleum ether extract exhibited LC_{50} at 57.32 ppm (parts per million), LC_{90} at 120.13 ppm, while ethyl alcohol extract exhibited LC_{50} at 64.22 ppm, LC_{90} at 130.37 ppm. This study

indicated that *Acorus calamus* carry huge potential as a mosquito larvicide.[40]

Repellent and Oviposition Deterrent Activity

Repellent and oviposition deterrent effects of sweet flag (Acorus *calamus* L.) along with five other plant extracts each in petroleum ether, acetone and ethanol were evaluated at 2% concentration against peach fruit fly *Bactrocera zonata* in a free choice bioassay. Petroleum ether extract of *Curcuma longa,* ethanol and acetone extracts of *Peganum harmala* were the most promising repellents against Peach fruit fly. Acetone extract and ethanol extract of *Acorus calamus* L. have shown effective repellence and oviposition deterrent.[41]

DISCUSSION

Sweet flag is the common name of *Acorus calamus* L. belongs to the family *Araceae*. This perennial herb, which is indigenous to central Asia, India, and the Himalayan region, is found commonly on the banks of streams and in damp marshy places. It is commonly known as Bach in India. It has been used in Indian medicine for ages. In addition, it has been used in traditional medicine of other countries such as China, Nepal and Pakistan.[3]

New pharmacological studies have almost confirmed the traditional uses of sweet flag as an antispasmodic, antihelminthic, anti-epileptic, antidepressant, anti-inflammatory, and antibacterial agent. In addition, there is a correlation between some traditional uses of sweet flag and those of new studies. For example, modern phytochemical and pharmacological studies have been revealed that α- and β-asarone is one of the major components of sweet flag possessing strong anti bacterial, antifungal, antihelminthic, neuroprotective, antiepileptic activity.[5] Currently, mosquito larvicidal activity of sweet flag is investigated by the author and his colleagues.[40]

Major chemical constituents identified in sweet flag are α- and β-asarones along with other constituents, other constituents such as caryophyllene, isoasarone, methyl isoeugenol, and safrol are also responsible for medicinal activity but most of the biological actions of sweet flag have been attributed to presence of α- and β-asarones. In a recent finding beta-asarone was shown to possess ameliorative potential in cognitive impairment thereby suppressing the neuronal apoptosis. Moreover, alpha-asarone is also noted reduce the excitatory action by stimulation of glutamate uptake and inhibition of excitatory neurotransmitter transporter mediated current. Some chemical constituents of sweet flag β-asarone in particular, have been demonstrated to possess toxic effects like prolonged vomiting, hallucinogen, carcinogenic, and genotoxic action in dose dependent manner. Thus, low level of β-asarone could only be acceptable for therapeutic use, and the level of β-asarone can be minimized by decoction process. Although, a significant data advocate therapeutic potential of sweet flag in various ailments but there is only little conclusive evidence regarding its acute and sub-acute toxicity.[42]

In 2012 Muthuraman *et al*., evaluate the acute and sub-acute oral toxicity profile of the hydroalcoholic extract of *Acorus calamus* (HAE-AC) Single oral administrations of the HAE-AC 2500-10000 mg/kg induced increase in general behavioural abnormalities in mice. The mortality rate also increased with increasing dosage (median lethal dose; LD_{50} = 5070.59 mg/kg). Overall, the findings of this study indicate that, HAE-AC is non-toxic and has at high dose, a mild but acceptable toxicity potential.[42]

Regarding calcium channel blocker as one of approaches to treat hypertension and epilepsy, this offers a rationalization for the traditional use of sweet flag, in the treatment of hypertension and epilepsy.[16,21] Another biological activity of sweet flag, which has been confirmed by a number of new studies, is anti-proliferative activity. Different mechanisms seem to impact on this activity such as free radical scavenging reducing power and metal chelating activity, increase in the activity of endogenous antioxidants and decrease in oxidative parameters.[19,20]

Recent *in vivo* study has shown an antiepileptic and nootropic activity that provides convincing support for the traditional use of sweet flag as an antiepileptic and memory enhancing agent.[14,16] Antispasmodic and anti-diarrhoeal effects are another reported in traditional use of sweet flag in different countries. In India, Nepal, China and Iran, it is traditionally used for diarrhoea, abdominal cramps and distension. There is a study regarding this important activity of sweet flag done by Gilani *et al*.,[27] In 2009, Silprasit *et al*., evaluated antiviral activity of sweet flag, hexane crude extracts showed strong HIV-1 reverse transcriptase inhibitory effects.[22]

CONCLUSION

The above collected information regarding the use of Sweet flag (*Acorus calamus*) in world is matched with available literature. Sweet flag was included in many of the early herbals and has a rich history in the Chinese and Indian cultures. Very few plants have gained such widespread use in diverse cultures. Recent years, ethno-botanical and traditional uses of natural compounds, especially of plant origin received much attention as they are well tested for their efficacy and are generally believed to be safe for human use. It is an effective approach in the search of new molecules for management of various diseases. Thorough screening of literature available on sweet flag has been

found to be a popular remedy among many cultures including Unani, Ayurvedic and Chinese practitioners for treatment of various ailments.

It is strongly believed that detailed information as presented in this review on the phytochemical and biological activities of sweet flag provides detailed evidence for the use of this plant in different medicines. Regarding the rich background of biological activities of sweet flag, it seems there are still a large number of unaccomplished investigations, particularly clinical trials of sweet flag and its bioactive compounds.

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REFERENCES

1. Balakumbahan R, Rajamani K, Kumanan K. *Acorus calamus*: An overview. J Med Plant Res 2010;4:2740-45.
2. Paithankar VV, Belsare SL, Charde RM, Vyas JV. *Acorus calamus*: An overview. Int J Biomed Sc. 2011;2:518-29.
3. Singh R, Sharma PK, Malviya R. Pharmacological Properties and Ayurvedic value of *Indian Buch Plant*. (*Acorus calamus*): A short review. Advan Biol Res 2011;5:145-54.
4. Kirtikar KR, Basu BD. Indian medicinal plants., Vol. 4, 2nd ed. Dehradun: International Book Distributors; 2007. p. 2628-9.
5. Divya G, Gajalakshmi S, Mythili S, Sathiavelu A. Pharmacological Activities of *Acorus calamus*: A review. Asian J Biochem Pharm Res 2011;1:57-64.
6. Anonymous. The wealth of India, Vol. 1. New Delhi: Council of Scientific and Industrial Research; 2004. p. 19-65.
7. Raja AE, Vijayalakshmi M, Devalarao G. *Acorus calamus linn*: Chemistry and Biology. Res J Pharm Tech 2009;2:256-61.
8. Dong W, Yang D, Runhua Lu. Chemical Constituents from the Rhizome of *Acorus calamus L*. Planta Med 2010;76:454-7.
9. Motley TJ. The ethnobotany of sweet flag, *Acorus calamus* (Araceae). Economic Botany 1994;48:397-412.
10. Mukhia PK. Management guide for *Acorus calamus* and Neopicrorhiza. Thimphu: Royal Government of Bhutan Ministry of Agriculture Dept. of Forest Resources Development Division. Thimphu: FRDD; 2004. p. 1-23.
11. Lokesh GB. Sweet flag (*Acorus calamus*): Cultivation and economics aspects. Nat Prod Rad 2004;3:19-21.
12. Available from: http://www.herbalcureindia.com/herbs/acorus-calamus.htm [Last accessed on 2012 Nov 29].
13. Nadkarni KM. Indian Plants and Drugs with their medicinal properties and Uses. New Delhi: Srishti Book Distributors; 2005. p. 16-7.
14. Dwivedi P, Singh R, Malik MT, Jawaid T. A traditional approach to herbal Nootropic agents: An overview. Int J Pharm Sci Res 2012;3:630-6.
15. Prisilla DH, Balamurugan R, Shah HR. Antidiabetic activity of methanol extract of *Acorus calamus* in STZ induced diabetic rats. Asian Pac J Trop Biomed 2012;2 Suppl 2:941-6.
16. Gopalakrishna HN, Sudhakar P, Shilin G, Shenoy AK, Holla, GK, Nair V, *et al*. Effect of *Acorus calamus* on electrical and chemical induced seizures in mice. Int J Appl Biolo Pharma Technol 2010;1:465-72.
17. Tripathi AK, Singh RH. Clinical study on an indigenous drug vaca (*Acorus calamus*) in the treatment of depressive illness. J Res Ayur Siddha 1995;16:24-34.
18. Vengadesh PK, George T, Vinoth KR, Nancy J, Kalaivani M, Vijayapandi P. Neuromodulatory effect of Acrous calamus leaves extract on dopaminergic system in mice. Int J Pharm Tech Res 2009;1:1255-9.
19. Gaidhani SN, Lavekar GS, Juvekar AS, Sen S, Singh A, Kumari S. *In-vitro* anticancer activity of standard extracts used in ayurveda. Phcog Mag 2009;5:425-9.
20. Subathraa K, Poonguzhali TV. *In vitro* studies on antioxidant and free radical scavenging activities of aqueous extract of *Acorus calamus* L. Int J Curr Sci 2012;1:69-73.
21. Patel P, Vaghasiya J, Thakor A, Jariwala J. Antihypertensive effect of rhizome part of *Acorus calamus* on renal artery occlusion induced hypertension in rats. Asian Pac J Trop Dis 2012;2 Suppl 1:6-10.
22. Silprasit K, Seetaha S, Pongsanarakul P, Hannongbua S, Choowongkomon K. Anti-HIV-1 reverse transcriptase activities of hexane extracts from some Asian medicinal plants. J Med Plant Res 2011;5:4194-201.
23. Rajkumar V, Guha G, Kumar RA, Mathew L. Evaluation of cytotoxic potential of *Acorus calamus* rhizome. Ethnobotanical Leaflets 2009;7:832-9.
24. Mehrotra S, Mishra KP, Maurya R, Srimal RC, Yadav VS, Pandey R, *et al.* Anticellular immunosuppressive properties of ethanolic extract of *Acorus calamus* rhizome. Int Immunopharmacol 2003;3:53-61.
25. Sandeep D, Nair CK. Radioprotection by *Acorus calamus*: Studies on *in vivo* DNA damage and repair. Int J Low Radiat 2010;7:121-32.
26. Shah AJ, Gilani AH. Aqueous-methanolic extract of sweet flag (*Acorus calamus*) possesses cardiac depressant and endothelial-derived hyperpolarizing factor-mediated coronary vasodilator effects. J Nat Med 2012;66:119-26.
27. Gilani AH, Shah AJ, Ahmad M, Shaheen, F. Antispasmodic effect of *acorus calamus* Linn. Is mediated through calcium channel blockade. Phytother Res 2006;20:1080-4.
28. Wu HS, Zhu DF, Zhou CX, Feng CR, Lou YJ, Yang B, *et al.* Insulin sensitizing activity of ethyl acetate fraction of *Acorus calamus* L. *in vitro* and *in vivo*. J Ethnopharmacol 2009;123:288-92.
29. Jain N, Jain R, Jain A, Jain DK, Chandel HS. Evaluation of wound-healing activity of *acorus calamus* Linn. Nat Prod Res 2010;24:534-41.
30. Kim H, Han TH, Lee SG. Anti-inflammatory activity of a water extract of *Acorus calamus* L. leaves on keratinocyte HaCaT cells. J Ethnopharmacol 2009;122:149-56.
31. Merekar AN, Pattan SR, Parjane SK, Nirmal SA, Patel DS, Shitre MR, *et al.* Synergistic Anthelmintic activity of rhizomes of *Acorus calamus* and roots of Vitex negundo. Pharmacologyonline 2011;3:209-12.
32. Palani S, Raja S, Kumar RP, Venkadesan D, Devi K, Sivaraj A, *et al.* Therapeutic efficacy of antihepatotoxic and antioxidant activities of *Acorus calamus* on acetaminophen- induced toxicity in Rat. Int J Integ Biol 2009;7:39-44.
33. Mamgain P, Singh RH. Control clinical trial of the lekhaniya drug vaca (*Acorus calamus*) in case of ischemic heart diseases. J Res Ayur Siddha 1994;15:35-51.
34. Begum J, Yusuf M, Chowdhury JU, Khan S, Anwar MN. Antifungal activity of forty higher plants against phytopathogenic Fungi. Bangladesh J Microbiol 2007;24:76-8.
35. Manikandan S, Devi RS, Srikumar R, Thangaraj R, Ayyappan R, Jegadeesh R, *et al. In-vitro* antibacterial activity of aqueous and ethanolic extracts of *Acorus calamus*. Int J Appl Biol Pharm Technol 2010;1:1072-5.

36. Hosen SM, Das R, Rahim ZB, Chowdhury N, Paul L, Saha D, *et al.* Study of analgesic activity of the methanolic extract of *Acorus calamus* L. and Oroxylum indicum vent by Acetic acid induced writhing method. Bull Pharm Res 2011;1:63-7.
37. Nethengwe MF, Opoku AR, Dludla PV, Madida KT, Shonhai A, Smith P, *et al.* Larvicidal, antipyretic and antiplasmodial activity of some Zulu medicinal plants. J Med Plant Res 2012;6: 1255-62.
38. Shah AJ, Gilani AH. Bronchodilatory effect of *Acorus calamus* (Linn.) is mediated through multiple pathways. J Ethnopharmacol 2010;131:471-7.
39. Nalamwar VP, Khadabadi SS, Aswar PB, Kosalge SB, Rajurkar RM, *et al*. *In vitro* Licicidal Activity of Different Extracts of *Acorus calamus* Linn. (Araceae) Rhizome. Int J Pharm Tech Res 2009;1:96-100.
40. Imam H, Zarnigar, Sofi G. Mosquito Larvicidal efficacy of *Acorus calamus* extracts against Aedes aegypti L. larvae. Asian Pac J Trop Biomed 2012;2:1-4.
41. Rehman J, Jilani G, Khan MA, Masih R, Kanvil S. Repellent and Oviposition Deterrent Effects of Indigenous Plant Extracts to Peach Fruit Fly, Bactrocera zonata Saunders (Diptera: Tephritidae). Pakistan J Zool 2009;41:101-8.
42. Muthuraman A, Singh N. Acute and sub-acute oral toxicity profile of *Acorus calamus* (Sweet flag) in rodents. Asian Pac J Trop Biomed 2012;2 Suppl 2:1017-23.

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