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## Phytochemicals of *Acorus calamus* (Sweet flag)

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### Abstract

Sweet flag (*Acorus calamus*) is mentioned in Ayurveda and belongs to the genus *Acorus* L. of the family Araceae and is widely distributed temperate to sub temperate regions. It is commonly used in traditional medicinal systems of Asian and European countries to treat appetite loss, diarrhoea, digestive disorders, bronchitis indigestion, chest pain, nervous disorders. This review focuses on the therapeutic potential of essential oils, phenyl propanoids, sesquiterpenes and monoterpenes as well as xanthone, glycosides, flavones, lignans, steroids and inorganic constituents.

**Keywords:** Sweet flag, Ayurveda, and traditional medicine

### Introduction

Nearly 80% of the world's population in developing countries mainly depends on natural products for their health needs (Ramakrishna *et al.*, 1984) [20]. Mother earth has bestowed to the mankind and various plants with healing ability for curing the ailments of human being. This unique feature has been identified since pre historic times. The WHO has also estimated that 80% of the world population meets their primary health care needs through traditional medicine only. Medicinal plants are those plants possessing secondary metabolites and are potential sources of curative drugs with the very long list of chemicals and its curative nature. India is the eighth largest country having rich plant diversity with a total of around 47,000 species, of which more than 7500 species are being used as medicinal plants. Plant products are used as main source of medicine throughout the world for treating various human ailments (Balakumbahan R *et al.*, 2010) [1]. About 50% of the present day medicines in the United States of America are derived from natural sources especially from various plants (Copping, 1996) [2]. The use of traditional medicine in both developing and developed countries is significantly increasing in recent times. *Acorus calamus* Linn. Commonly known as Sweet Flag, belongs to the family Araceae (Araceae). It is also called as *Acorus odoratus*. The genus *Acorus* derived from *Acoron* (coreon = the pupil of the eye) and the species *calamus* is derived from the Greek word Calamos (a reed). The family *Araceae* comprises about 110 genera and more than 1,800 species. The members of the family are rhizomatous or tuberous herbs. *Acorus calamus* Linn. Commercially occurs in both peeled and unpeeled forms. This perennial herb is common on the banks of streams and in damp marshy places. In Ayurvedic medicine *Calamus* is an important herb, and is valued as a "rejuvenator" for the brain and nervous system and as a remedy for digestive disorders. The rhizome of calamus is used for various medicinal purpose mainly appetite, fever, stomach cramps, tooth ache and cholera (Divya *et al.*, 2011) [3]. It is used in the conditions of hoarseness, flatulence dyspepsia, helminthiasis and nephropathy (Palani *et al.*, 2010) [18]. The plant is known by different names in India and abroad (Divya *et al.*, 2011) [3] viz; Vernacular names are listed in Table -1. And the Taxonomical classification is given by Singh *et al.*, 2011 [21] which is listed in Table.

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**Table 1:** Vernacular names of *Acorus calamus*

Bengali	Bach
Gujarat	Vekhand
Ayurvedic	Vacha
Unani	Bacch
Hindi	Bajai
Gora	bach, Vasa bach
Marathi	Vekhand
Tamil	Vasambu
Telugu	Vadaja, Vasa
Kannada	Baje
Malayalam	Vayambu
Sanskrit	Bhutanashini, Uragandh, Jatila
Italy	Plant of Venus

**Table 2:** Taxonomical classification of *Acorus calamus*

Kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Liliopsida
Subclass	Arecida
Order	Arales
Family	Acoraceae
Genus	<i>Acorus</i>
Species	<i>Calamus</i>

### 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 (Fig 1, Fig 2, and Fig 3). It is now found widely wild on the margin of pounds and rivers in most English countries.

**Fig 1:** Aerial part of *Acorus calamus***Fig 2:** Distribution Area**Fig 3:** Rhizomes of *Acorus calamus*

The purpose of this review is to collect all the possible information regarding the chemical constituents and ethnomedicinal uses of *Acorus calamus*, thus will help to the researchers and scientists to take action for future study in this discipline.

*A. calamus* is a perennial plant with creeping and extensively branched, aromatic rhizome, cylindrical, up to 2.5 cm thick, purplish-brown to light brown externally and white internally. At the rhizome forming, perennial that can grow to 2 meters resembling an iris.

It consists of long creeping roots which spread out just below the surface of the soil.

The leaves are thick, erect and are very similar in appearance to the iris but edges are crimped the leaves of *A. calamus* has a single prominent mid vein and then on both sides slightly raised secondary veins and many, fine tertiary veins. This makes it clearly distinct from *Acorus americanus*. The leaves are between 0.7 and 1.7 cm wide, with average of 1 cm. The sympodial leaf of *A. calamus* is somewhat shorter than the vegetative leaves. The leaves are free, alternate, green and wavy. 1-3 in seeded having thin testa which is cylindrical in shape and green in colour.

The flower is very rarely grown in this plant if grown than it is 3- 8cm long, cylindrical in shape, greenish brown in color and covered with the multitude of rounded spikes. The flowers are small, sessile and densely packed and 5-10 cm of spadix. The spadix, at the time of expansion, can reach a length between 4.9 and 8.9 cm. Flowers from early to late summer depending on the latitude, grows wild in marshy places up

The fruits are small and berry- like c-diglucoiside; chemical constituents vary in ecotypes and containing few seeds. Flowering and Fruiting occurs in July. The other species in this genus is *Acorus gramineus* native to eastern Asia commonly called as Japanese sweet flag, Japanese rush, grassy-leaved sweet flag, dwarf sweet flag is an aquatic or wetland perennial with semi evergreen grass like foliage. It has narrow, 6 to 14in (15 - 35.6 cm) glossy leaves and looks like thick, lush grass. The leaves are carried in two ranks, like opposing fans. They are flat, about a 0.5 in (1.3 cm) wide and tend to flop over. The insignificant flowers, shaped like little horns, are produced in mid-summer on erect hollow stems. Usually, only plants grown in water produce flowers.<sup>5,6</sup>

### USES

Parts used: The parts used are leaves, root (rhizome) and stem. In Asia, Sweet flag has been used for at least the last 2000years. The ancient peoples of China used it to lessen swelling and for constipation. In Ayurvedic medicinal practice India, the rhizomes have been used to cure several

diseases like fever, asthma and bronchitis, and as a sedative. Native tribes used it to treat a cough, made a decoction as a carminative and as an infusion for cholera. In Western herbal medicine the herb is chiefly employed for digestive problems such as gas, bloating, colic, and poor digestive function. Calamus helps distended and uncomfortable stomachs and headaches associated with weak digestion. Small amounts are thought to reduce stomach acidity, while larger doses increase deficient acid production, it is a good sedative so that the extract is used for epilepsy, insanity and as a tranquillizer along with valeriana jatamansi and nardostacys grandiflora. It is an ingredient of any Ayurvedic preparation "Brahmi Bati" (Budhivardhar) which is indicated in epilepsy, coma, and hysteria and in cases of mental retardation; the same uses are prescribed for an *Acorus* containing Unani drug Ma' jun Baladur".

### Cultural Aspects

**Soil and climate:** It is a hardy plant found growing from tropical to subtropical climates. Plenty of sunshine should be available to the plant during its growth and after harvesting for drying the rhizomes. Temperature ranging from 10 to 38°C and annual rainfall between 70 and 250 cm are best suited. Cultivation should be avoided in places where there is no irrigation facility. This species comes up well in clayey loams, sandy loams and light alluvial soils of river banks.

**Land Preparation:** The land should be ploughed twice or thrice prior to the onset of rains. The land should be prepared like paddy fields.

**Propagation:** *Acorus* is propagated through rhizomes. Rhizomes obtained from earlier planting are kept preserved in the soil and constantly kept moist. After emergence, the rhizomes are cut into small pieces and planted. Sprouted rhizome pieces are planted at a spacing of 30 x 30 cm and depth of 4 cm in the month of July-August. The best time for planting is the second fortnight of June. Around 1, 11,000 plants can be planted per hectare. As the growth rate is very fast, sprouts are visible on the second day of planting (Balakumbahan R *et al.*, 2010) [1].

### Chemistry of *Acorus Calamus*

According to Imam *et al.*, 2013 [9], 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, calamenol, 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  $\beta$ -asarone,  $\alpha$ -asarone, elemicine, cisisoelemicine, cis and trans isoeugenol and their methyl ethers, camphene,  $P$ -cymene,  $\alpha$ -selinene,  $\beta$ -gurjunene,  $\beta$ -cadinene, camphor, terpinen-4-ol,  $\alpha$ -terpineol and a calacorene, acorone, acronone, acoragermacrone, 2-deca-4,7-dienol, shyobunones, linalool and preiscalamendiol are also present. Acoradin, galangin, 2,4,5-trimethoxy benzaldehyde, 2,5-dimethoxy benzoquinone, calamendiol, spathulenol and sitosterol have been isolated from *Acorus calamus*.

Dong *et al.*, (2010) [4, 25] isolated three new sesquiterpenes, 1 $\beta$ , 7 $\alpha$ (H)-cadinane-4 $\alpha$ , 6 $\alpha$ , 10 $\alpha$ -triol (1), 1 $\alpha$ , 5 $\beta$ -guaiane-10 $\alpha$ -O-ethyl 4 $\beta$ , 6 $\beta$ -diol (2), and 6 $\beta$ , 7 $\beta$ (H)-

cadinane-1 $\alpha$ , 4 $\alpha$ , 10 $\alpha$ -triol (3), together with 25 known ones, from the rhizome of *Acorus calamus*.

*A. calamus* were characterized by a higher percentage of  $\beta$ -asarone (11%), which was the main compound, followed by higher percentages of camphene (2.27%), enriched (E)- $\beta$ -ocimene (3.28%), camphor (1.54%), calarene (1.42%),  $\alpha$ -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%), preiscalamendiol (22.81%) and acorone (26.33%). (Paithankar *et al.*, 2011, Singh *et al.*, 2011, Kirtikar *et al.*, 2007, Divya *et al.*, 2011 and Raja *et al.*, 2009) [16, 21, 12, 3, 19].

Other compounds that are identified in *A. calamus* were 4-Terpeneol, 2-Allyl-5-ethoxy-4-methoxyphenol, Epiudesmin, Lysidine, Spathulenol, Borneol, Furethyl ketone, Nonanoic Acid, 2,2,5,5-Tetramethyl-3-hexanol, Bornyl acetate, Galgravin, Retusin, (9E,12E,15E)-9,12,15-Octadecatrien-1-ol, Butyl Butanoate, Geranylacetate, Sakuranin, Acetic acid, Camphor, Isoelemicin,  $\alpha$ -Ursolic acid, Acetophenone, Dehydroabietic acid, Isoeugenol methylether, Apigenin 4',7'-dimethyl ether, dehydrodiisoeugenol, Linalool, Elemicin, Linolenic acid (Balakumbahan *et al.*, 2010) [1].

The percentage of chemical components varies depending on the part of the plant from which the oil is extracted. (Motley 1994) [15].  $\beta$ -Asarone [(Z)-asarone] is the major constituent in the leaves (27.4 to 45.5%), whereas acorone is dominant in the rhizomes (20.86%) followed by isocalamendiol (12.75%). Monoterpene hydrocarbons, sequestrine ketones, (trans- or Alpha) Asarone (2,4,5-trimethoxy-1-propenylbenzene), and  $\beta$ -asarone (cis-isomer) and eugenol were also identified (Balakumbahan *et al.*, 2010) [1].

The constituents of the essential oils in *Acorus calamus* are phenylpropanes, mono-terpenes, and thermolabile sesquiterpenoids (Motley, 1994) [15]. Calamenone (a tricyclic sesquiterpene) as well as calamendiol and isocalamendiol (both sesquiterpenes) are found in the roots. The volatile oil also has terpenoids calamine, calamenol, calamenone, eugenol, camphene, pinene and asaronaldehyde. Acorafuran is a new sesquiterpenoid found in Calamus oil (Pandy *et al.*, 2013) [17].

Methyleugenol, cis-methylisoeugenol,  $\beta$ -asarone, geranylacetate,  $\beta$ -farnesene, shyobunone, epihyobunone and isoshyobunone are the most abundant chemical compounds which are present in 20% of the essential oil. The other chemical components include  $\alpha$  and  $\gamma$ -asarone, calamenene, asaronaldehyde, acorone, calamenone, n-heptanoic acid, calamendiol, numerous sesquiterpenes, and other compounds in the plant. (Motley, 1994) [15].

The aromatic constituents namely asarylaldehyde in roots and asarone in leaves are responsible for the smell of volatile oil. (Venakutonis and Dagilyte 2003) [23]. An oily substance named calamol was extracted which was found to be an allyl trimethoxy benzene derivative. It is isomeric with asarone many phenylpropanoids were extracted and isolated from chloroform extract (Raja *et al.*, 2009) [19] viz.

1. isoeugenol methyl ether
2.  $\gamma$ -asarone(1,2,4-trimethoxy-5(2-propenyl) benzene)
3. cis-asarone(cis-1,2,4-trimethoxy-5(2-propenyl) benzene)
4. Trans-asarone(trans-1,2,4-trimethoxy-5(2-propenyl) benzene)
5. Acoramone(1,2,4-trimethoxy-5(2-propenyl) benzene)
6. asarylaldehyde (2,4,5-trimethoxy benzaldehyde)
7. Z-3-(2,4,5-trimethoxy phenyl)-2-propenal
8. 2,3-dihydro-4,5,7-trimethoxy-1-ethyl-2-methyl-3-(2,4,5-trimethoxy phenyl) indene.

### Monoterpenes

A number of monoterpenes have been reported in the plant. Some of the monoterpenes reported are as  $\alpha$  and  $\beta$ -pinenes, myrcene, Para-cymene,  $\alpha$ -terpinen,  $\beta$ -phellandrene, gamma-terpinene, Terpinolene, Thujane (Fig 4) and Limonene (Fig 5). They were isolated by steam distillation from volatile oil. (Raja *et al.*, 2009) <sup>[19]</sup>

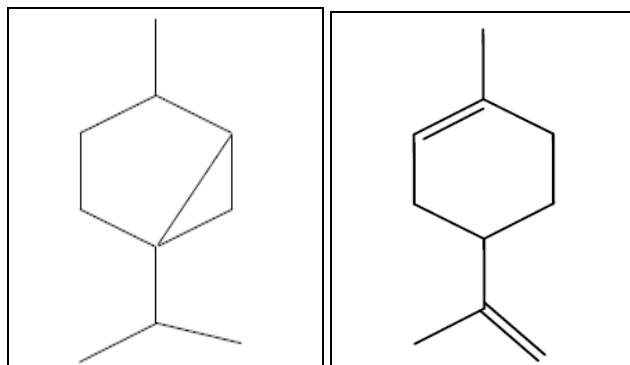
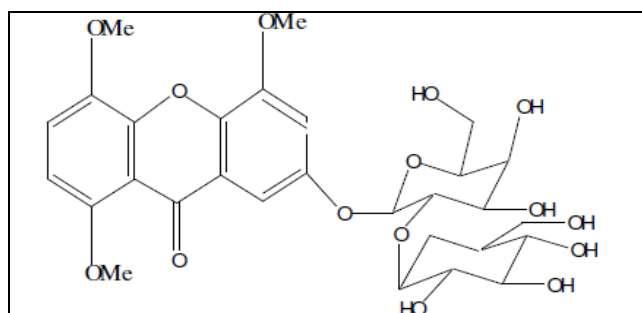


Fig 4: Thujane

Fig 5: Limonene

### Xanthone glycosides

A new xanthone glycoside was isolated from rhizome part. It was designated as 4, 5, 8-trimethoxyxanthone-2-O- $\beta$ -D-glucopyranosyl (1-2)-O- $\beta$ -D-galactopyranoside (Fig 6). (Raja *et al.*, 2009) <sup>[19]</sup>.

Fig 6: 4, 5, 8-trimethoxyxanthone-2-O- $\beta$ -D-glucopyranosyl (1-2)-O- $\beta$ -D-galactopyranoside

### Lignans

A lignan was isolated from the rhizome part of the plant and it was designated as acoradin (Fig 7). It was eluted using benzene from chloroform extract of the *Acorus calamus*. (Raja *et al.*, 2009) <sup>[19]</sup>

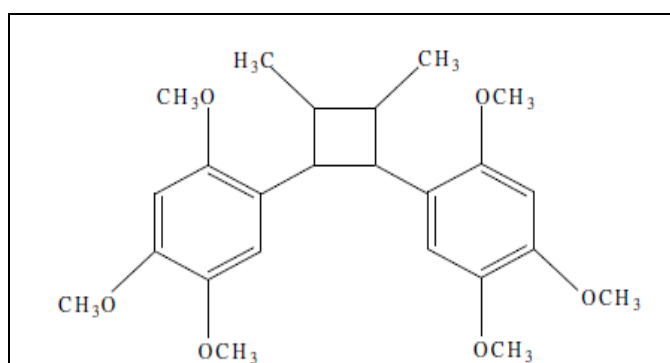
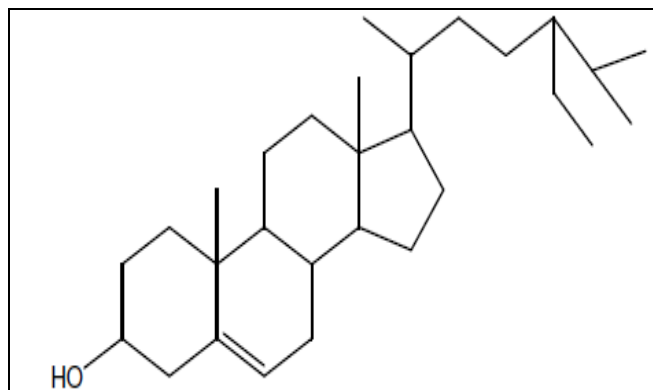


Fig 7: Acoradin

### Steroids

A  $\beta$ -Sitosterol (Fig 8) is isolated from the plant *Acorus calamus* by Hui-Lan Yeh and Wm. H. Adolph (1938) <sup>[11]</sup>.

Fig 8:  $\beta$ -Sitosterol

### Flavones

5, 7-dihydroxyflavonol (Galangin) (Fig 9) isolated from the plant *Acorus calamus* (Stahl and Keller 1981) <sup>[22]</sup>.

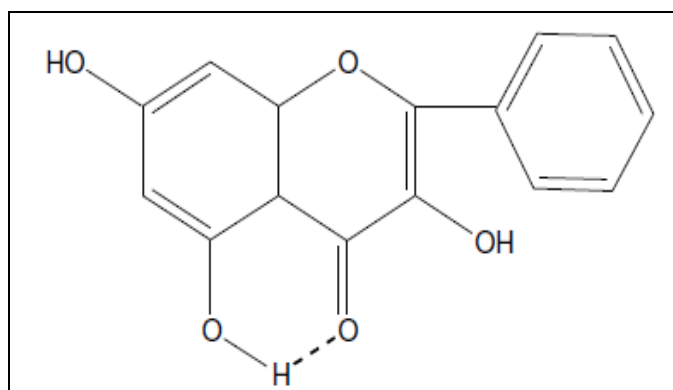


Fig 9: 5, 7-dihydroxyflavonol

### Triterpenoid saponins

Two new triterpenoid saponins have been isolated and they are characterized as follows (Rai Renu *et al.*, 1998). 1, 2, 3, 19-tetrahydroxyurs-12-en-28-oic acid-28-O{-D-glucopyranosyl (1,2)} - D-galactopyranoside 3, 22, 24, 29-tetrahydroxyolean-12-en-3-O{-D-arabinosyl (1,3)}--Darabinopyranoside.

### Essential oil

The essential oil of calamus was first isolated practically in Frankfurt in 1592 and in the dispensatorium Noricum in 1589 (Gildemeister and Hoffmann 1900) <sup>[7]</sup>. GC-MS analysis of the essential oil of *A. calamus* rhizomes led to the identification and quantification of a total of 32 major components, accounting for 97.52% of the total components present. The principal compounds in the essential oil of *A. calamus* rhizomes were  $\alpha$ -asarone (50.09%), (*E*)-methylisoeugenol (14.01%), and methyleugenol (8.59%) (Figure 1), followed by  $\beta$ -asarone (3.51%),  $\alpha$ -cedrene (3.09%) and camphor (2.42%). (Xin Chao Liu *et al.*, 2013) <sup>[24]</sup>.

The results are quite different from the previous reports. For example, preisocalamenediol (18.0%), acorenone (14.2%), shyobunone (13.3%) and cryptoacorene (7.5%) were major compounds of the essential oil of *A. calamus* collected from Quebec, Canada (Garneau, *et al.*, 2008) <sup>[6]</sup>. Preisocalamenediol (17.3%), isoshyobunone (13.0%), 1,4-(*trans*)-1,7-(*trans*)-acorenone (10.5%), camphor (5.9%) 2,6-diepishyobunone (2.6%) and  $\beta$ -gurjunene (2.5%) were the main components of the essential oil of *A. calamus* roots obtained from Turkey.

However, the essential oil of *A. calamus* rhizomes collected from Italy contained acorenone (21.6%), (*Z*)-sesquilandulol (13.0%), shyobunone (7.0%),  $\alpha$ -asarone (5.1%), and dehydroxyisocalamenediol (3.5%) (Marongiu *et al.*, 2005) <sup>[14]</sup>.

while the essential oil of *A. calamus* rhizomes collected from Lithuania contained acorenone (20.9%), isocalcamendiol (12.8%), shyobunone (7.8%), camphor (5.1%) and  $\alpha$ -selinene (4.9%) (Venskutonis and Dagilyte 2003) [23]. Linalool (0.3%–12.0%), isoshyobunone (0.6%–9.4%), (*Z*)-methyl isoeugenol (2.4%–48.9%), (*E*)-methyl isoeugenol (1.1%–7.9%),  $\beta$ -asarone (20.5%–75.6%) and  $\alpha$ -asarone (1.0%–16.0%) were reported to be the main components of *A. calamus* oil from Japan (Fujita *et al.*, 1971) [5].

As for samples collected from China,  $\beta$ -asarone (85.68%) was demonstrated to be major constituent compound in one essential oil of *A. calamus* (Huang *et al.*, 2013) and  $\beta$ -asarone (47.43%), calamenene (9.75%) and isocalamendiol (5.41%) were major compounds in the essential oil of *A. calamus* rhizomes collected from Hubei Province (Gong *et al.*, 2007) [8]. Li and Jiang identified constituents of calamus oil isolated from different plant parts of *A. calamus* and found (*Z*)-methylisoeugenol (36.4% and 17.7%), acoragermacrone (4.1% and 7.4%) and  $\delta$ -cadinene (4.1%–3.7%) as major components in leaf and rhizome oil, respectively. However, the essential oil of *A. calamus* rhizomes collected from Yunnan Province contained  $\beta$ -asarone (13.46%),  $\alpha$ -asarone (7.22%), cedrol (6.19%),  $\alpha$ -cedrene (5.61%), and berganotene (5.48%) while the sample from Sichuan Province had  $\alpha$ -asarone (10.01%),  $\beta$ -asarone (9.16%), cedrol (7.94%),  $\alpha$ -palchoulene (7.05%), and  $\alpha$ -guaidiene (6.68%) (Zhang *et al.*, 2010) [25]. In a recent report,  $\beta$ -asarone (59.60%), 4-(5-hydroxy-2,6,6-trimethyl-1-cyclohexen-1-yl)-3-buten-2-one (19.49%), shyobunone (5.78%), dehydrofukinone (4.21%), and elemicin (3.26%) were the main constituent compounds in the oil harvested from Zhejiang Province (Lin *et al.*, 2012) [13].

## Conclusion

This systematic review contains specific time bound data completion of isolated constituents and other class of natural compounds from *Acorus calamus* and fairly useful for research aspirates working on this plant.

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