



Historical origin, chemical constituents and therapeutic potentials of sanatha (*Dodonaea viscosa*) – A brief review

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Abstract

Dodonaea viscosa is an evergreen shrub belonging to the family Sapindaceae that is a known indigenous medicinal plant having hypoglycaemic effect thus extensively used in ethnomedicinal practices. It has a cosmopolitan distribution in tropical, subtropical and warm temperate regions of Africa, America, southern Asia and Australia. *Dodonaea viscosa* is an extremely variable species throughout its natural range. Some essential phytochemicals of this plant include rutin, iso-rhamnetin, 5,7,4'-tri-hydroxy-3-methoxy-flavone, 5,7,4'-tri-hydroxy-3'-(3-hydroxy-methyl-butanol)-3,6-di-methoxy-flavone, 6-hydroxy-3,6,7-trimethoxy-flavone, 5,7-dihydroxy-flavanone, 5,4'-dihydroxy-3,6,7-trimethoxy-flavone, 5-hydroxy-7,4'-dimethoxy-flavone, 3'-(γ,γ -dimethyl-allyl)-5,7-dihydroxy-3,6,4'-trimethoxy-flavone, (S)-5,4'-dihydroxy-7-methoxy-flavone, 5,7-di-hydroxy-3,6,4'3'-tetra-methoxy-flavone, 3,5,7,4'-tetra-hydroxyl-3'-methoxy-flavone, 3,5,7,4'-tetra-hydroxyl-3'-methoxy-flavone-3,5,7,4'-tetra-hydroxyl-3,4'-di-methoxy-flavone, 5-hydroxy-3,7,4'-trimethoxy-flavone, dihydroxy-7,4'-dimethoxy-flavone, 5,4'-dihydroxy-6,7-di-methoxy-flavone and 5,7-dihydroxy-6, 4'-dimethoxy-flavone. Due to these essential chemical constituents, this plant is known to possess strong anti-microbial, anti-bacterial, anti-ulcer, wound healing, anti-oxidant, anti-inflammatory, analgesic, anti-pyretic, anti-fungal and anti-malarial potentials.

Key words: *Dodonaea viscosa*, hypoglycaemic effects, rutin, isorhamnetin, sukuranetin, trimethyl ether, anti-microbial, anti-ulcer, anti-oxidant, anti-inflammatory, anti-fungal, anti-malarial

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1. Botany

Sanatha (*Dodonaea viscosa*) is an evergreen shrub belonging to the soapberry family Sapindaceae that is an indigenous medicinal plant having been used empirically since centuries as a hypoglycaemic agent in the ethnomedicinal practices. It has a cosmopolitan distribution in tropical, subtropical and warm temperate regions of Africa, America, Australia and Southern Asia. Hop bush is native to subtropical and tropical areas worldwide, where it typically grows in dry regions. The flowers are relatively unspectacular but its winged fruits can become red or purple as they mature making it an attractive garden plant in the tropics and subtropics. One cultivated variety also develops purple leaves when grown in direct light. The generic name *Dodonaea* is named after the Flemish physician and botanist Rembert Dodoens (1517-1585). The specific epithet *viscosa* is derived from viscous or sticky nature. The common name of hop bush is used for *Dodonaea viscosa* specifically but also for the genus as a whole. In the south Indian state of Tamil Nadu, this plant is called *viraali*.

Australian common names include broad leaf hop-bush, candle wood, giant hop bush, narrow leaf hop bush, sticky hop bush, native hop bush, soap wood, switch sorrel, wedge leaf hop bush and native hop. Additional common names include 'a'ali'i, as well as 'a'ali'i-ku ma kua and 'a'ali'i ku makani in Hawaii, akeake in New Zealand, lampuaye in Guam, mesechelangel in Palau, chirca in Uruguay and Argentina, romerillo in Sonora and Mexico, jarilla in Southern Mexico, hayuelo in Colombia, ch'akatea in Bolivia, casol caacol in Seri, ghoraskai in Afghanistan and sanatha in Pakistan. Different parts of the *Dodonaea viscosa* were extracted with different organic solvents and phytochemical analysis showed the presence of glycosides, terpenes, flavones and steroids. Dodonic acid was isolated and confirmed from the ether extract of the aerial parts of this plant. Sitosterol was also present in the hexane extract of the plant material. Alcoholic extract of leaves showed the presence of quinonoid compounds whereas 5,7,3,4-tetrahydroxy flavone was isolated and characterized from the alcoholic extract of root bark and kaempferol was

isolated and identified from flowers of *Dodonaea viscosa* [1].

The total lipid composition was found to be very similar to the seed oil composition. The unsaponifiable matter showed the presence of β -sitosterol while seed cake protein on anal showed the presence of arginine, lysine, tryptophan, leucine, isoleucine, valine, serine and glutamic acid in its composition. *Dodonaea viscosa* readily colonizes open areas and secondary forest and is tolerant to salinity, drought and pollution. It is therefore useful for dune stabilization, restoring degraded lands and for reforestation. Its fast growth and tolerance of strong winds make it an excellent hedge and windbreak and it is planted as a decorative shrub in South Africa, Australia and southern USA. A traditional use of this plant in traditional medicine is owing to its anti-spasmodic, anti-inflammatory, anti-pyretic and anti-microbial potentials. *Dodonaea viscosa* is a flowering evergreen shrub that consists of about 150 genera and approximately 2000 species. The plant is known to have flavonoids, aromatic acids, diterpenes, saponins and inositols. Traditionally, *Dodonaea viscosa* is used for the treatment of skin diseases. Various biological activities such as anti-malarial, anti-diabetic and anti-bacterial potentials have been associated with this plant. Methylene bisantoin is a rare methylene-bridged bisflavonoid from *Dodonaea viscosa* which inhibits *Plasmodium falciparum* enoyl-ACP reductase.

2. Historical Milestones

Dodonaea viscosa is indigenous and widespread throughout the tropics. In Hawai'i, *Dodonaea viscosa* is found on all the main islands except Kaho'olawe in almost every habitat ranging from almost sea level to 7,500 feet. It is often found in open locations such as ridges and is an early colonizer of lava fields and pastures [2]. *Dodonaea viscosa* is widely distributed in southern hemisphere including Australia, New Zealand, South and Southeast Asia, Africa and Latin America and also found to occur in southern United States. It is tolerant of drought and can grow in coastal environments. It is intolerant of frost and does not grow well in shade. The sanatha is present in Kala chitta. Pabbi hills salt range, Malakand, Chakdara Hunu Parachinar, Fort Sundryman, Nizampur, Khyber pass and also in sub mountain areas of Haripur. *Dodonaea viscosa* is a stiff bushy plant. Muthuvan tribes and Tamilian native who reside in the Shola forest regions of Kerala use leaves of this plant for headaches and backaches. It is commonly known as "virali". Water boiled with leaves is used to foment swellings, backaches and used for steam inhalation in cough and colds. *Dodonaea viscosa* is used for stomach pain and piles. It is also used to heal simple ulcer. This plant has reported anti-inflammatory and anti-microbial activities.

The smoke from sticky hop-bush was thought to be used by aboriginal people for pain relief. In the dreaming story of Tjilbruke, Tjilbruke's nephew Kulultuwi had been

killed near the Sturt River at Marion. His body was taken to a place near Brighton where he was smoked and dried in accordance with ancient tradition. It is thought that the smoke was produced using the leaves from sticky hop-bush. *Dodonaea viscosa* is used for the treatment of rheumatism, skin infections, diarrhea, stomachaches, pains of hepatic or splenic origin, uterine colic and other disorders involving smooth muscles. It is also used as an anti-pruritic in skin rashes and for the treatment of sore throat, dermatitis and hemorrhoids. Literature survey reveals that this plant collected in different countries demonstrates variable biological activity. The methanol extract of the entire plant collected in Saudi Arabia possesses no activity against *Escherichia coli*, *Proteus vulgaris*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Candida albicans*.

On the other hand, a similar extract of leaves of Mexican species showed weak activity against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis* and *Candida albicans*. Approximately 50% methanol of flowers and leaves of the Nigerian species demonstrated anti-bacterial activity against *Bacillus subtilis*, *Escherichia coli*, *Proteus species*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. *Rumex nervosus* is used as a cure for acne, a hypoglycemic agent and an ophthalmic anti-septic. It also shares uses of *Rumex abyssinicus* for treatment of wounds, eczema, typhus and rabies. The methanol, water and chloroform extracts of leaf, bark, stem and root parts of *Rumex nervosus* and root of *Rumex abyssinicus* were reported to possess anti-bacterial activity against several bacteria including *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Evaluation of the anti-microbial and anti-inflammatory activities of the medicinal plants such as *Dodonaea viscosa*, *Rumex nervosus* and *Rumex abyssinicus* is a recent trend in medicinal chemistry and pharmacology.

3. Morphological Features and Ecological Perspective

Dodonaea viscosa is an extremely variable species throughout its natural range. There are many distinctive populations and these have been described as separate species by some authorities. Wagner considers Hawaiian *Dodonaea viscosa* populations as one distinctive species [1]. *Dodonaea viscosa* can be a medium-sized shrub or small tree upto 25 feet tall but most often it is 6 to 12 feet in height. The plant may have one or several main trunks which have reddish-brown to blackish gray bark. The leaves are variable in shape, from elongated to spoon-shaped or wedge-shaped, are sometimes reddish or purplish and are usually shiny and sticky to the touch. They generally have conspicuous veins and their edges may be weakly toothed or undulating. Most often, leaves are 1 to 4 inches long. They are usually glossy green and often have reddish midribs or stems. The new leaves and sometimes older ones as well, are covered with a sticky substance. Generally, older leaves have a rough, sandpapery texture [3]. The individual flowers

are small, 1/4 inch in diameter and occur in branched clusters.

They are either male or female and only the female flowers develop into the decorative capsules. Some plants will have both male and female flowers in which case only a single plant is required to produce capsules. Other plants will have either male or female flowers so that at least one male plant is required for the female plants to produce capsules [4]. The fruit of *Dodonaea viscosa* is a winged capsule containing several small, round, black seeds. This species is particularly variable in capsule size, number of wings (generally 2 to 4) and degree of inflation (roundness). Capsule color ranges from straw colored to brown, pink to mahogany red to reddish purple. Each capsule contains a few round dark seeds; each seed is about 1/8 inch in diameter [5]. To remove the seeds from the dry papery capsules, air dry them at room temperature in a bowl or paper bag. Carefully rub the fruits through a strainer with the appropriate size mesh or rub them between your hands. If using a strainer, the seeds should fall through leaving the debris in the strainer [2]. Hot water treatment will usually improve germination rate and speed, but treatment may not be necessary for fresh seed.

NTBG and Rauch suggest using water that has been brought to a boil, but temperatures ranging from 120-135°F may be adequate. Cover the seeds with about three times as much water and soak them for 24 hours. Stratton *et al* recommends soaking for 4 to 24 hours in hot or room temperature water [1]. The pollen is transported by the wind and the lack of petals maximizes exposure to the breeze. The female flowers, after pollination, develop into 3 or 4 winged papery capsules, each with 2-3 black seeds. These capsules turn red or purple as the fruit matures. The requirements for growing *Dodonaea viscosa* is well drained soil and the best time to plant a *Dodonaea viscosa* plant is spring/summer and best time to prune this plant is autumn/winter and full sun/half shade are optimal condition for growing *Dodonaea viscosa* as it cannot grow indoor it is grown in desert climate, mediterranean climate, subtropics climate, temperate climate and tropics climate etc.

4. Botanical Specifications

Dodonaea viscosa is an evergreen shrub upto 5m tall; young parts covered with a yellow and viscid resin. Leaves are sub-sessile, oblanceolate to spathulate, 3-9cm long, 0.5-2cm broad, glabrous, entire and sub-acute to apiculate. However, panicles are terminal, 3cm long; flowers are greenish yellow; pedicel 4-8mm long. Sepals are 3-5cm long, connate at the base, ovate, 3mm long, puberulous and persistent. Stamens 6-8 in number and are free, rudimentary in female flower; anthers subsessile, oblong, 2-5mm long, sparsely hairy at tip. Disc is annular, cushion-shaped. Ovary triquetrous, 2.2 mm long, 3-locular, sparsely hairy, rudimentary in male flower; style 3mm long, minutely papillose; stigma 3-fid. Capsule 12-14mm long,

15-19mm broad, 2-4 valved; valves membranous, light brown, green or maroon, winged at the back. Seed are sub-globose, 4mm long and black.

5. Chemical Composition and Phytochemicals

A comprehensive review of chemistry of *Dodonaea viscosa* was carried out by some recent researchers [6]. This plant was known to have twenty three different flavones from seeds, bark, flower and leaves [7]. A review of the chemistry and pharmacology of the species was also done by some other scientists [8] and it was observed that many uses of the herb by indigenous people from various countries show remarkable similarities, which in turn appear to correlates with the known active constituents [7]. The major investigation of flavonoids was conducted by Sachdev who isolated eight compounds, providing UV, MS and HNMR data for these flavonoids [9]. A research review makes reference to eighteen flavonoids including glycosides of quercetin (e.g. rutin) and isorhamnetin, these were isolated previously by some other scientists also [8]. Sukuranetin and 6-hydroxykaempferyl-3,7-diamethyl ether were isolated from Mexican specie of *Dodonaea viscosa* [40] that had not previously been found in this plant.

Leucocyanidins were reported by [10] and [6]. Methanolic extract of *Dodonaea viscosa* contains bioactive compounds like flavonoids, terpenoids, tannins and volatile oil [11] while ethanolic extract of *Dodonaea viscosa* leaf contains photochemical like alkaloids, flavonoids, saponins, steroids, triterpenoids and phytosterols [12]. Tannins, saponins, flavanoids and terpenoids were detected from aqueous extract of all the plant parts [13] and some investigators [14] also reported the presence of flavonoids, terpenoids, tannins and steroids. Four flavonoids were isolated from dichloromethane fraction of crude *Dodonaea viscosa* leaf extracts like 5-hydroxyl-3,7,4-trimethoxyflavone, 5,7-dihydroxy-3,6,4-trimethoxyflavone, 3,6-dimethoxy-5,7,4-trihydroxyflavone and 4-O-methylkaempferol [15].

The knowledge of individual chemical constituents of a medical plant is essential for optimizing extraction procedures, understanding pharmacological activity as well as potential toxicity. In general, the species contains diterpenes and triterpenes, saponins, flavonoids and a complex mixture of other phenolic compounds. It is that any therapeutic activity in the herb is associated with polyvalent pharmacological effects brought on by synergistic combination of several constituents rather than any single isolated one [16]. Siddiqui's 1988 review makes reference to eighteen flavonoids including glycosides of quercetin (e.g. rutin) and isorhamnetin-these were isolated previously by Nair and Subramanian in 1975. Mata and coworkers isolated sakuranetin from Mexican *Dodonaea viscosa* in 1991. Leucocyanidns were reported by Sastry and Nayudamma in 1966. More recently Getie *et al* isolated relatively large

concentrations of quercetin, kaempferol and isorhamnetin in *Dodonaea viscosa* crude leaf extract [17]. Previous chemical studies on this species resulted in isolation and characterization of several flavonoids [18], diterpenoid acids [19], some biologically active saponins [20] and plant acids a novel p-coumarin acid ester [10], essential oils, sterols [21] and tannins from aerial parts of *Dodonaea viscosa* and saponin esters from the seeds of *Dodonaea viscosa* [22].

Table.1 Flavonoids of *Dodonaea viscosa* [23-25]

Common Name	Chemical Name	References
Aliarin	5,7,4'-trihydroxy-3'-(3hydroxymethylbutanol) 3,6-dimethoxyflavone	[26]
Pinocembrin	5,7-dihydroxyflavanone	[26]
Penduletin	5,4'-Dihydroxy-3,6,7-Trimethoxy flavone	[26]
Viscosol	3'-(γ,γ -dimethylallyl)-5,7-dihydroxy-3,6,4'-trimethoxy Flavone	[26]
Sakuranetin	(S)-5,4'-dihydroxy-7-methoxyflavone	[10]
Iso kaempferide	3,5,7,4'-Tetrahydroxyl-3'-methoxyflavone	[26]
Iso kaempferide Ermanin (Kaempferol 3,4'dimethylether)	3,5,7,4'-Tetrahydroxyl-3'-methoxyflavone 3,5,7,4'-Tetrahydroxyl-3,4'-dimethoxyflavone	[26]
Cirsimaritin (Scutellarein 6,7-Dimethoxy flavone)	5, 4'-Dihydroxy-6,7-dimethoxyflavone	[26]
Pectolinarigenin (Scutellarein 6,4'-Dimethoxy flavone)	5, 7-Dihydroxy-6, 4'-dimethoxyflavone	[26]
Kaempferol7,4'-dimethylether 3,5-Dihydroxy-7,4'-dimethoxyflavone	Dihydroxy-7,4'-dimethoxyflavone	[27]
Kaempferol3,7,4'-trimethylether	5-Hydroxy-3,7,4'-trimethoxyflavone	[27]
Santin	5,7-dihydroxy-3,6,4'3'tetramethoxy flavone(trimethoxy flavone)	[27-28]
Acacetin7-methyl ether	5 hydroxy-7,4'-dimethoxyflavone	[27]
6 Hydroxy kaempferol-trimethyl ether	6 Hydroxy-3,6,7 trimethoxy flavone	[29]
Kaempferol3-methyl ether	5,7,4'Trihydroxy-3-methoxyflavone	[29]

6. Pharmacological Applications and Bioactivities

The leaves of *Dodonaea viscosa* are used in treatment of fever, malaria, ulcers, diarrhea, dysmenorrhea, rheumatism, sprains, bruises, burns and wounds [30-31]. It

is proved to have anti-bacterial, anti-viral, analgesic, anti-inflammatory, anti-ulcer and anti-oxidant activity. Literature showed the presence of flavonoids, diterpenoid acids, saponins, p-coumarin acid ester, sterols, essential oils and tannins [32-33]. Wound healing is a complex process encompasses migration to the wounded area, proliferation, deposition and remodeling of extracellular matrix [34]. A variety of materials for wound dressing, skin substitutes and recombinant growth factors which are shown to enhance healing process entered into the market with therapeutic efficacy. Many natural products and extracts are also known to possess wound healing properties. Hence, there is a great interest to find new wound healing products. Based on the folklore claim of *Dodonaea viscosa*, this study was designed to explore the wound healing potential of this plant by using cell proliferation assay with human keratinocytes which is established wound healing model [35-36]. The shrub has medicinal properties. The leaves are chewed for toothache, but the liquid is spit out because leaves have an extremely high content in tannin.

Because of tannin astringent nature, leaves are used externally to heal wounds and insect bites. Some cultures ingest herb internally as a remedy for fever. *Dodonaea viscosa* is also used for house construction elsewhere in Southeast Asia, West Africa and Brazil. Hopwood is also used in New Guinea for making tools and fish traps, for stimulating lactation in mothers, as incense for funerals and as a remedy for dysentery. Various parts of plant are used traditionally in Africa and Asia for digestive system disorders, infections, rheumatism, respiratory complaints and skin problems. Early settlers in Australia used *Dodonaea viscosa* as a substitute for hops for brewing beer. Hopwood leaves have been reported to be chewed as a stimulant in some parts of the world. *Dodonaea viscosa* readily colonizes open areas and secondary forest and is tolerant of salinity, drought and pollution. It is therefore useful for dune stabilization, restoring degraded lands and for reforestation. Its fast growth and tolerance of strong winds make it an excellent hedge and windbreak and it is planted as a decorative shrub. The bitter fruits are a substitute for hops and yeast in making beer. The chewed leaves are said to be stimulating but they contain saponins and are also said to be slightly cyanogenic so their use is not very advisable.

Dodonaea viscosa is also an important medicinal plant that is used for anti-inflammatory, anti-viral, spasmolytic, laxative, anti-microbial and hypotensive potentials [19]. The leaves were reported to possess local anesthetic, smooth muscle relaxant [9], anti-bacterial, anti-fungal, anti-inflammatory [10] and anti-ulcerogenic activities. *Teucrium* species have been used as medicinal herbs for over 2000 years as diuretic, diaphoretic, tonic, anti-pyretic, anti-spasmodic, cholagogic and many of them are used in folk medicines [20]. Anti-inflammatory, anti-

hypertensive and anorexic effects are other reported activities of *Teucrium polium* L. [21]. In the local areas, it is used frequently for treatment of gastro-intestinal or abdominal ailments and for its hypoglycemic properties. Local uses of *Euryops pinifolius* and *Helianthemum lippii* are not known but in other parts of the Arabian Peninsula, these are used as analgesic and anti-inflammatory agents [37].

6.1 Anti-Microbial Potentials

Anti-microbial effects of aqueous, methanolic, ethanolic and ethyl acetate leaf extracts of *Dodonaea viscosa* and *angustifolia* were tested against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Candida albicans* and *Mycobacterium smegmalis*. Better activity was observed in liquid dilution assay with all extracts, the ethanolic and methanolic extracts of *Dodonaea viscosa* showed good inhibition against *Staphylococcus aureus* and *Mycobacterium smegmatis* with minimum inhibitory concentration (MIC) value of 2.5mg/ml and 1.25mg/ml respectively in the bioassay. In disc diffusion study, ethanolic extract of *Dodonaea viscosa* showed inhibition against *Candida albicans*. The essential oil of *Dodonaea viscosa* seeds was tested for anti-microbial activity against seven gram positive and three gram negative bacteria by the zone inhibition and by minimal inhibitory concentration (MIC) methods. The oil showed effective anti-bacterial activity against *Staphylococcus aureus* and was not inhibitory to *Micrococcus flavus* and *Sarcina lutea*.

6.2 Anti-Bacterial Activity

The crude ethanolic extract and n-hexane, dichloromethane, ethyl acetate, n-butanol and aqueous fractions of *Dodonaea viscosa* were analyzed for anti-bacterial potential against four gram positive bacteria: *Bacillus subtilis*, *Bacillus aereus*, *Micrococcus lutes* and *Staphylococcus aureus* and three gram negative bacteria: *Escherichia coli*, *Salmonella typhi* and *Pseudomonas aeruginosa*. Preliminary screening and initial tests showed inhibition against *Staphylococcus aureus*, *Micrococcus luteus*, *Escherichia coli* and *Pseudomonas aeruginosa*. The thin layer chromatograms of fractions showed inhibition zone at different Rf values against *Bacillus subtilis*, *Micrococcus luteus*, *Escherichia coli*, *Salmonella typhi* and *Pseudomonas aeruginosa* indicating the presence of anti-bacterial components. *Dodonaea viscosa* fractions showed good activity against *Bacillus subtilis* with prominent inhibition zones for the n-hexane (two zones of inhibition), ethyl acetate (one zone of inhibition) and n-butanol (one zone inhibition) extracts. Minimum inhibition concentrations (MICs) of the crude fractions were found to be within the range of 5-20.0mg/mL. The high levels of MICs of the fractions are attributable to the facts that active components present that serve as growth promoters for the bacteria, thereby, necessitating the presence of high amount of the fraction to inhibit the growth. The n-hexane fraction found

to show higher bactericidal potential as compared to the ethyl acetate and n-butanol fractions.

6.3 Anti-Ulcer Preliminary Potentials

Phyto-pharmacological investigations of *Dodonaea viscosa* leaves revealed the presence of flavonoids, tannins, sterols, bitter principles, phenols and saponins and showed promising anti-ulcer activity. Among the conducted bioactivity-guided fraction studies of *Dodonaea viscosa* using various experimental gastric ulcer models, ethyl acetate extract exhibited higher ulcerative lesion index, increased serum calcium level and decreased alkaline phosphatase activity in all experimental models. Hexane extract at a dose 500mg/kg exhibited 90% and 92% protection against ethanol induced and indomethacin induced gastric lesions respectively and also inhibited acid secretion to prevent ulcer aggravation.

6.4 Wound Healing Effects

Ethanolic extract of dried leaves showed potent wound healing activity in excised and incised wound model in rats. In excision model, 10% extract treated wounds were found to have faster rate of wound contraction and epithelization. Suspension and ointment of ethanol extract produced a significant response in wound models like breaking strength of skin, granuloma and wound contraction and also found to overcome the anti-healing properties of dexamethasone [38].

6.5 Anti-Oxidant Activity

All the extracts are able to reduce peroxidation however hot water extracts have the most potent anti-oxidant capacity in both the spectrophotometer and micro plate methods, despite containing low flavonoid levels. In the assay of spectrophotometer, anti-oxidant activities are expressed as percentage inhibition of control rate of oxidation i.e. percentage oxidation. The hot water extracts showed 95% inhibition at 4%, 92% inhibition at 2% and the result came from the 4% ethanol extract, which produced a mean inhibition rate of 96%. In micro plate assay hot water extracts showed highest inhibition rate (82%) at 5mg/ml. The methanolic extract of *Dodonaea viscosa* showed high effective free radical scavenging activity in the DPPH assay and exhibited remarkable anti-oxidant (50%) effect at low concentration of 50µg/ml. This extract exhibited 94.29% and 92.45% radical scavenging activity at a dose of 500µg and 1000µg/ml respectively; hence provide prophylaxis against various diseases including, arteriosclerosis, heart diseases and cancers [11].

6.6 Anti-Inflammatory Effects

The extracts of *Dodonaea viscosa* were found to be very effective against inflammation, inhibiting 30% to 60% of edema. Almost 50% of ethanolic extract in the dose of 1000mg/kg exhibited maximum 56.67% anti-inflammatory effects with carragenan induced edema in the hind paw of rats equivalent to inhibition by 100mg/ml of phenyl butazone (66%) given intra-peritoneally. Even aqueous

extracts in dose of 100mg/kg exhibited significant anti-inflammatory activity within carragenan induced rat paw edema method [39].

6.7 Analgesic and Antipyretic Activity

Ethanollic seed extract of *Dodonaea viscosa* upon preliminary photochemical screening, showed the presence of alkaloids, saponins and carbohydrates. The extract showed significant CNS depressant activity at the dose level of 30 mg/kg, when compared with morphine sulphate, diazepam and phenytoin as standard drugs. Significant analgesic and anti-convulsant activities were also observed at the same dose. In-vivo analgesic activity was demonstrated in the mouse acetic acid-induced writhing test and hot plate method. Water extract of *Dodonaea angustifolia* (50-200 mg/kg) dose dependently and significantly inhibited the writhes induced by 2% acetic acid. It shows anti-pyretic activity in the rat (LP-induced rectal temperature increase) at a concentration of about 100.0 mg/kg.

6.8 Other Activities

Application of leaf decoction of *Dodonaea viscosa* for tooth ache has been tested on patients by a herbal physician and hence used as a mouth wash and was found to show anti-fungal activity on *Candida albicans* from HIV infected patients. *Dodonaea viscosa* yet to be reported for its anti-malarial use as traditionally the fresh leaf infusion was used for malaria.

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