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Antitussive Medicinal Herbs - An Update Review

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ABSTRACT
The cough is a protective reflex mechanism that removes foreign material and secretions from the bronchi and bronchioles of the airways; it is inappropriately stimulated in various situations like inflammation of the respiratory tract or neoplasia. In these cases, cough has a pathological character and it is necessary sometimes to use cough-suppressant drugs. The most frequently used antitussive drugs in clinical conditions produce adverse effects like depression of the respiratory centre, decreased secretion in the bronchioles and inhibition of ciliary activity, increased sputum viscosity, decreased expectoration, hypotension and constipation acts as limitation to the therapy. Use of herbal drugs is increasing all over the world for various ailments including antitussive activity as they are safe and devoid of adverse effects. Medicinal plants are an important source for the discovery of novel bioactive compounds, which have served and continue to serve as lead molecules for the development of new drugs. Thus this review may provide an insight into herbs possessing antitussive activity.

Keywords: Cough, antitussive herbs, expectorants, cough suppressants.

INTRODUCTION

The cough is a protective reflex mechanism that removes foreign material and secretions from the bronchi and bronchioles of the airways (foreign objects, catarrhs of the respiratory system, etc.); it is inappropriately stimulated in various situations like inflammation of the respiratory tract or neoplasia. In these cases, the cough has a pathological character and it is necessary sometimes to use cough-suppressant drugs. The antitussive agents are used mainly to suppress dry, painful and patient-disturbing coughs; the use of this group of drugs suppresses only one symptom without influencing the underlying condition. Administration of such drugs in cough associated with bronchiectasis or chronic bronchitis should be prevented because of possible harmful sputum thickening and retention, however agents with expectorant activity are preferable (secretolytics, secretomotorics and mucolytics), and can suppress cough by other mechanisms. [1] The most frequently used antitussive drugs in clinical conditions belong to the group of narcotic analgesics, the antitussive dose is lesser than analgesic dose. Adverse effects like depression of the respiratory center, decreased secretion in the bronchioles and inhibition of ciliary activity, increased sputum viscosity, decreased expectoration, hypotension and constipation acts as limitation to the therapy. [1] Use of herbal drugs is increasing all over the world for various ailments including antitussive activity as they are safe and devoid of adverse effects. Medicinal plants are an important source for the discovery of novel bioactive compounds, which have served and continue to serve as lead molecules for the development of new drugs. [2] Thus this review may provide an insight into herbs possessing antitussive activity.

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Medicinal Plants as antitussives

The medicinal herbs proved to possess antitussive property are *Abies webbiana* Lindl, *Adhatoda vasica*, *Althaea officinalis* Linn., *Arctium lappa* L, *Asparagus racemosus, Bergenia ciliata* Sternb., *Carum copticum*, *Cassia fistula*, *Crocus sativus*, *Cuminum cyminum* Linn *, Drymaria cordata* Willd, *Emblica officinalis* Gaertn, *Glycyrrhiza glabra* Linn, *Glycyrrhizae radix, Guiera senegalensis*, *Ionidium suffruticosam* Ging**,** *Jussiaea suffruticosa* Linn., *Leucas lavandulaefolia*, *Lagerstroemia parviflora*, *Mahonia aquifolium* (pursh) Nutt., *Malva mauritiana* L., *Nigella sativa, Paederia foetida, Passiflora incarnata*, *Prunus persica* L *Batsc, Rudbeckia fulgida*, *Salvia officinalis, Stemona tuberose, Terminalia belerica, Trichodesma indicum, Vigna trilobata* and *Xanthium strumarium.*

***Abies webbiana* Lindl** (Family: Pinaceae)

The plant *A. webbiana* is well known under the vernaculars 'Himalayan silver fir' in English, 'Talispatra' in Hindi, 'Talispatri' in Tamil. [3] In Indian traditional medicine it is used against cough, asthma and chronic bronchitis and

various other diseases. [4-6] The leaf juice of this plant is used in folklore to treat cough and asthma in the rural areas of the Sikkim and Kashmir (India).

In a study the methanolic extract of *A. webbiana* Lindl leaves at doses 400 and 600 mg/kg (orally) exhibited significant antitussive activity against sulphur dioxide-induced cough reflex in mice compared with codeine phosphate in a dose dependent manner 71.69% and 78.67%, respectively and the activity was comparable with codeine phosphate. [7]

Adhatoda vasica (Family: Acanthaceae)

Adhatoda vasica (AV) is commonly called as malabar nut. AV is well known under the vernaculars Vasa in Sanskrit, Arusha and Adulasa in Hindi, Adathodai in Tamil. [8] The leaves, flowers, fruits and roots possess a number of pharmacological actions and are extensively used for treating cold, cough, whooping-cough, chronic bronchitis, asthma and rheumatism. It is a bronchial antiseptic, bronchodilator, sedative, expectorant and antispasmodic. [9]

It is also mentioned in Vedas as an herbal remedy for treating cold, cough, whooping cough, chronic bronchitis and asthma.

A study with AV extract produced marked antitussive activity, comparable to codeine against peripherally induced cough. The extract was 1/20 as active as the opiate in centrally induced cough (by vagus nerve stimulation) in the anaesthetized guinea pigs. Neverthless in peripherally induced cough model i.e mechanical stimulation of rabbit tracheal mucosa and electrical stimulation of guinea pig tracheal mucosa, the extracts was 1:10 and 1:4 as active as codeine respectively. These results indicate that oral administration of the extract has a better antitussive activity in peripheral cough model as compared to the central cough model. [10-11]

Althaea officinalis **Linn.** (Family: Malvaceae)

Althaea officinalis Linn**.,** is also called as Mallards, Mauls, Schloss Tea. The plant decoction made in wine or milk relieves diseases of the chest, constituting a popular remedy for cough, bronchitis, whooping-cough, etc., is frequently given in the form of syrup, which suits to infants and children as well. [12]

A study was evaluated with rhamnogalacturonan, one of the constituents of the mucilage isolated from the roots of marsh mallow for antitussive activity on mechanically induced cough in nonanesthetized cats and found that rhamnogalacturonan reduced significantly the number of cough efforts and the intensity of attacks from the irritated laryngopharyngeal and tracheobronchial mucous membranes of the airways and promoted expectoration. But the activity exhibited activity was found to be lower than that of the narcotic codeine, but higher than those of the comparative nonnarcotic drugs. [13]

A study was conducted with polysaccharides isolated from roots of marsh mallow on laryngopharyngeal and tracheobronchial stimulated cough in unanaesthetized cat and correlated the cough suppressant activity with changes in the lateral pressure of trachea. The results of the experiments showed that administration of the polysaccharide at a dose of 80 and 100mg/kg significantly decreased the number of cough efforts both from laryngopharyngeal and tracheobronchial areas of the respiratory system. [14]

Arctium lappa **L var.** ***Herkules*** (Family: Compositae)

Arctium lappa L. (AL) is a very popular edible vegetable in Japan called "Gobo". In a study AL-R, a dominant polysaccharide component of AL, administered perorally caused a noticeable decrease in parameters characterizing cough-suppressing activity against mechanically induced cough in adult non-anaesthetised cats. The ability of AL-R to suppress the cough parameters was compared to antitussive efficiency of the drugs commonly used in clinical practice for the anti-tussive activity. AL-R showed 30.1% inhibition of cough, whereas the most frequently used opioid codeine inhibited it 61.8%, the inhibitory effect of AL-R was higher than that of non-narcotic antitussives dropropizine with 28.3% and prenoxdiazine with 24.7% inhibition of cough reflex. [15]

Asparagus racemosus **Willd** (Family: Asparagaceae)

Asparagus racemosus Willd. is commonly known as Shatawari (Hindi And Sanskrit) Shatamuli (Bengali). [16] Asparagus racemosus has significant antitussive effects and the key active constituents present in this herb are steroidal saponins, known as shatavarins I-IV.

In a study the methanolic extract of root at doses of 200 and 400 mg/ kg p.o. in mice exhibited 40-58.5 % inhibition of SO_2 induced cough and proved effective when compared to the standard anti-tussive drug codeine phosphate. [17]

Bergenia ciliata **Sternb** (Family: Saxifragaceae)

Bergenia ciliata known commonly as "Pakhanbhed" (Hindi) [18] It is used against fever, cough and pulmonary infections. [19] The juice of the rhizome of *B. ciliata* is used as an anti-tussive for cold and cough by the local people of the Sikkim and Darjeeling districts of West Bengal, India. The chemical constituents of the extract were confirmed by high performance thin layer chromatographic study for the presence of steroids, flavonoids, tannins and reducing sugars.

In a study A dose-dependent inhibition of SO_2 induced cough was observed in the groups of mice treated with extract of *B. ciliata* and the results were also comparable with that of the effect produced by codeine phosphate, a prototype anti-tussive agent, maximum inhibition of cough reflex occurred 90 min after drug administraion. The highest cough inhibition (44.2%) was produced by the extract at a dose of 300 mg/kg (p.o.), whereas codeine phosphate (10 mg/kg) showed 48.9% inhibition. The results obtained with 100 and 200 mg/kg doses of extract were also statistically significant. [20]

Carum copticum (Family: Apiaceae)

Carum copticum is known as ajowan in Hindi and omam in Tamil. The seeds of this plant have an odour similar to thymol; and its essential oil contains terpinene, cymene, α-pinene, ß- pinene and other substances such as thymol and carvacrol. [21-22]

Boskabady et al., (2005) studied the antitussive effect of aqueous (2.5 and 5% w/v) and macerate extracts (2.5 and 5% w/v) of this plant using citric acid (0.1 g/ml) induced cough model in guinea pig. [23-24] The results of the study demonstrated a potent antitussive effect of extracts similar to that of codeine. [2]

Cassia fistula (Family: Leguminosae)

The common names of *Cassia fistula* or *Cana fistula* are golden shower, Indian laburnum, purging fistula, purging cassia etc. *C. fistula* seeds contain approximately 2% anthraquinones, 24% crude protein, 4.5% crude fat, 6.5% crude fiber, and 50% carbohydrates. [26]

In a study the methanolic extract of C. *fistula* was proved to possess a significant anti-tussive activity on cough model induced by SO_2 gas in mice in a dose dependent manner. The C. *fistula* extract at a dose of 400 mg/kg and 600 mg/kg

showed maximum inhibition of cough by 44.44% and 51.85% respectively and was comparable with codeine phosphate. [27]

Crocus sativus (Family: Iridaceae)

Crocus sativus is commonly known as saffron. The herb is found to possess chemical constituents such as safranol, picrocrocin and crocin and the styles are extremely rich in riboflavin. [28] In traditional medicine, the stigmas are used as anti-tussive and expectorant.

In a study the ethanolic extract of *C. sativus* (100-800mg/kg) and safranol (0.25-0.75 ml/kg) significantly reduced the cough induced by citric acid in guinea pigs, which is comparable with the codeine treatment. [29]

Cuminum cyminum **Linn** (Family: Umbelliferae)

Synonym: *Cumino aigro* (Malta). *Cuminum cyminum*, besides being used medicinally, in the middle ages, it was one of the commonest spices of European growth. Several therapeutic effects including the effect on asthma and dyspnoea have been described for the seeds of cumin, *Cuminum cyminum* Linn. [30]

Mohammad *et al*., (2006) studied the anti-tussive effect of this plant. The anti-tussive effects of aerosols of two different concentrations of aqueous and macerated extracts, were studied on guinea pigs by counting the number of coughs produced due to aerosol of citric acid and showed significant reduction of cough number in the presence of both concentrations of aqueous and macerated extracts and Codeine (P<0.01 to P<0.001). The cough number observed in the presence of higher concentrations of aqueous and macerated extracts were not significantly different than those of lower concentrations. Thus antitussive effect of cumin was comparable to that of codeine. [31]

Drymaria cordata **Willd** (Family: Caryophyllaceae)

Drymaria cordata Willd. is a herbaceous plant found abundantly in Sikkim and the sub-Himalayan region of India. [32-33] vapours of the herb are inhaled for the relief of cough, sinusitis or in acute cold attack. This herb is also used for snake bite, burns and skin diseases in the form of topical application. [34-35] The plant has alkaloid, steroid and saponin.

Mukherjee *et al*., studied the effect of methanolic extract of *Drymaria cordata* on sulfur dioxide-induced cough reflex in mice. [36] At a dose of 400mg/kg D. *cordata* exhibited 51.5% inhibition of cough which was comparable with codeine phosphate. The herb was proved to be safe as it didnot cause mortality in mice at a dose as high as 3 g/kg (i.p.) or 4 g/kg (p.o.) indicating high therapeutic index. [37]

Emblica officinalis **Gaertn** (Family: Euphorbiaceae)

Emblica officinalis Gaertn., syn. *Phyllanthus emblica* L. is commonly called as Indian Goosebery, Emblica Myrobalan in English, Amla, Aovla in Hindi and is used traditionally in Ayurvedic medicine. The chemical constituents proved to be present in *E. officinalis* are emblicanin A (37%), emblicanin B (33%), punigluconin (12%) and pedunculagin (14%). [38]

The drug inhibits prostanoid synthesis which inturn inhibits airway smooth muscle contractility, and this may also be one of the factor to account for its anti-tussive action. [39] The antioxidant, spasmolytic and antibacterial activities have a part in the antitussive efficacy of the dry extract of fresh fruits of *Emblica officinalis*. The extract of *Emblica officinalis* has an irritant effect on the neural vagal endings of the gastrointestinal mucous membranes, which also stimulates the secretion of mucus from the respiratory tract and also saliva. Therefore the airways are covered with mucus and so the cough receptors ("irritant receptors") are hardly accessible for irritation, leading to a decrease of the cough reflex. [40]

In a study the extract of *Emblica officinalis* showed significant antitussive activity perorally at a dose of 50 mg/kg, 200 mg/kg. The effect was proved in conscious cats where cough was mechanically induced and the results were compared with codeine at a dose of 10 mg/kg and dropropizine at a dose of 100 mg/kg intraperitoneally. [41-42]

Glycyrrhizae radix (Family: Leguminosae)

Glycyrrhizae radix has been used since ancient Egyptian times as a drug for the respiratory organs. It is a used in treatment of severe dry cough in patients with bronchitis, pharyngitis, bronchial problems, coughs, mucous congestion, stomach problems, such as peptic ulcers, and for bladder and kidney ailments. [43-44] *G. radix* contains a potent antitussive compound: liquiritin apioside, the antitussive potency of liquiritin apioside was as high as that of dihydrocodeine.

In a study the 50% methanolic eluted fraction (100 mg/kg, p.o.) caused a more than 60% reduction in the number of capsaicin-induced coughs. 50% methanol-eluted fraction contained mainly liquiritin and liquiritin apioside, Liquiritin apioside (3–30 mg/kg, p.o.) dose-dependently inhibited the number of coughs. The study concluded that the antitussive effect of liquiritin apioside depends on both peripheral and central mechanisms of cough. [45]

Guiera senegalensis **(**Family**:** Combretaceae**)**

Guiera senegalensis is used in traditional medicine for the treatment of cough, bronchitis, fever, gastrointestinal disorders, venereal diseases, skin ulcers, wounds, malaria, dysentery, syphilis and gingivitis.

The antitussive activity of *Guiera* was evaluated using the classical citric acid-evoked cough model in guinea pigs. *Guiera* decoction, at increasing doses of 250, 500, 1000 mg/kg decoction significantly and progressively inhibited 12.1%, 38.3% and 58.62%, the number of coughs and increased the latency of the first cough after oral administration. The results were comparable with codeine phosphate at a dose of 10 mg/kg which showed an inhibition of 76.32%. They have concluded that the decoction of the leaves of *Guiera* has a beneficial effect when used in the traditional treatment of cough and can be used as an 'improved traditional prescription' against cough associated with respiratory infections. [46]

Ionidium suffruticosam **Ging. (**Family: Violaceae)

Ionidium suffruticosam Ging., is a tiny herb, with pretty flowers, found in most parts of India, Africa, and Australia. The plant is familiar as Ratanpuras (Hindi), orilaitamarai (Tamil) in Indian traditional medicine. In the Ayurvedic system of medicine this plant is used as a diuretic, demulcent, and tonic. It is also used in the treatment of asthma, epileptic fits, cough, pain and dysentery. The plant contains some uncharacterised alkaloids. [47-48]

In a study, antitussive potential of methanolic extract of *Ionidium suffruticosam* Ging. (Violaceae) was investigated by sulfur dioxide gas induced cough model in albino mice. It exhibited significant dose-dependent antitussive activity when compared with the control, 250 and 500 mg/kg (p.o.) of the extract showed 28.37% and 54.16% inhibition of the cough with respect to control group. The antitussive activity of the extract was comparable to that of codeine phosphate with 64.27% inhibition of cough. [49]

Jussiaea suffruticosa **Linn** (Family: Onagraceae)

The plant *Jussiaea suffruticosa* Linn. is well known as Banlunga (Hindi), Nirrkrambu and Kattukrambu (Tamil) in Indian traditional medicine. [50] The plant is a semi-shrubby, erect, perennial, 60–90 cm high, distributed as a weed in cultivated paddy fields and wet fields throughout India and Ceylon. [51] The rural people of Tamilnadu, India, use the juice of the leaves for the relief of cough and cold.

In a study the *Jussiaea suffruticosa* leaf extract showed a dose dependent inhibition of cough on sulphur dioxide induced experimental cough model and the results were comparable to the effect produced by codeine phosphate. The results obtained with 200 and 400 mg/kg doses of extract were statistically significant. The highest inhibition of cough (59.81%) was produced by the extract at a 400 mg/kg dose level, whereas codeine phosphate (10 mg/kg) showed 63.37% inhibition [52], indicating the equipotent effect at this dose.

Leucas lavandulaefolia (Family: Labiatae)

Leucas lavandulaefolia is commonly known as Guma (Hindi). [53-54] The plant is reported to be used in jaundice, fever, cold – cough old sores, dermatosis, conjunctivitis and migraine. [55] The tribal people of Tripura, India use the juice of the aerial parts of this plant as an antitussive in cold cough,

In a study 400 mg/kg of the extract exhibited 56.5% inhibition of cough, whereas codeine phosphate 10mg/kg showed maximum inhibition of 59.2%. The extract inhibited cough similar to that of standard drug and the authors concluded that the extract might be acting via the central nervous system. [56]

Lagerstroemia parviflora (Family: Labiatae)

Lagerstroemia parviflora is a medium sized decidous tree found abundantly in different parts of sub-Himalayan region of India. It has been found that the local tribes of chotanagpur region of India use this plant as an antitussive and astringent. [57]

The anti-tussive effect of *Lagerstroemia parviflora* extract was studied on sulfur dioxide induced cough in mice model and was compared with the standard drug codeine phosphate. The percentage inhibition of cough produced by *L. parviflora* was 53.48% at the dose of 300 mg/kg. 10mg/kg codeine phosphate showed maximum inhibition of 60.46%. The results of the above study provided a support of the use of leaves of *Lagerstroemia parviflora* in the treatment of cough by traditional medicine practitioners. [58]

Malva mauritiana **L (**Family**: Malvaceae)**

Malva sylvestris L. the synonym for *Malva mauritiana,* is an annual (in Eygpt and the Levant), biennial (in much of the Mediterranean region) or perennial herb widely distributed from Western Europe to the Himalayas and Central Asia, perhaps to China, and naturalised in many temperate regions. [59]

Rhamnogalacturonan isolated from *Malva mauritiana* has been tested for antitussive activity on mechanically induced cough on nonanaesthetized cats of both sexes. It was found that rhamnogalacturonan reduced significantly the number of cough efforts and the intensity of attacks from the irritated laryngopharyngeal and tracheobronchial mucosa membranes of the airways and promoted expectoration. The exhibited activity was found to be lower than that of the narcotic codeine, but higher than nonnarcotic drugs. [60]

Mahonia aquifolium (Family: Berberidaceae)

Mahonia aquifolium is an evergreen shrub related to the barberry. The plant is in no way related to grapes, but gets the name from the purple clusters of berries. Berberine and other alkaloids present in Oregon grape root destroy a wide range of microbes. [61] Recent studies indicated that M. aquifolium contains a specific multidrug resistant pump inhibitor (MDR Inhibitor) named 5'methoxyhydnocarpin (5'MHC) which decreases bacterial resistance to antibiotics and antibacterial agents.

From the stems of *Mahonia aquifolium* (Pursh) Nutt. a water-soluble (4-O-methyl-α- glucurono)- xylan was isolated by alkaline extraction and fractionation of the crude hemicellulose, employing ion-exchange chromatography and gel filtration. When tested for antitussive activity on mechanically induced cough in cats, the glucuronoxylan exhibited a much greater effect in comparison to the codeine. [62]

Nigella sativa (Family: Ranunculaceae)

Nigella sativa L. is a grassy plant with green to blue flowers and small black seeds, which grows in temperate and cold climate areas. The seeds of *Nigella sativa* contain thymoquinone, monoterpenes such as *p*-cymene and pinene [63], nigellidine [64], nigellimine [65] and a saponin. [66] The plant has been proved to be effective against asthma and dyspnea. [67] The relaxant effect of the volatile oil from this plant was tested on different smooth muscle preparations including rabbit aorta [68], rabbit jejunum [69] and guinea pig isolated tracheal muscle. [70] It also possesses functional antagonistic effect on muscarinic receptors [71], an inhibitory effect on histamine (H1) receptors [72] and calcium channel blocking effect. [73]

Mahfouz and Dakhakhnsy (19960) reported that the volatile oil from *Nigella sativa* protected guinea pigs against histamine induced bronchospasm. [74] However, in an *in vivo* study, i.v. administration of volatile oil increased respiratory rate and intratracheal pressure of guinea pigs. [75]

In a study, aerosols of plant extracts showed significant reduction in number of coughs induced by citric acid aerosol and results were comparable with codeine. [76]

Pederia foetida (Family: Rubiaceae)

Paederia foetida, is locally known as skunkvine in english. The decoction of the whole plant is traditionally used in Ayurvedic medicine for the treatment of various diseases. [77]

The anti-tussive activity of *P. foetida* was demonstrated in conscious cats by mechanical stimulation of laryngopharyngeal (LP) and tracheobronchial (TB) mucous areas of airways. The results showed that the ethanolic extract of *P. foetida* at the oral dose of 200 mg/kg had a cough-suppressive effect. It caused a significant decrease of the number of cough efforts and frequency of cough from both LP and TB areas. The antitussive activity of the ethanolic extract of *P. foetida* was lower than that of the classical narcotic antitussive drug - codeine, but similar to that of the non-narcotic antitussive agent dropropizine. [78]

Passiflora incarnate (Family: Passifloraceae)

Passiflora incarnate is commonly called as Maypop. Passion flower has calming and sleep inducing effect, relieves pain and muscular spasms. It is useful for the treatment of general insomnia, insomnia in asthmatics, hysteria, cramps, and nerve pain. Its constituents include harmine. Harmine was originally known as telepathine because of its peculiar ability to induce a contemplative state and mild euphoria.

The methanolic extract of the leaves of *Passiflora incarnata* (100 and 200 mg/kg, p.o.) exhibited significant antitussive activity on sulfur dioxide-induced cough in mice, the cough inhibition (39.4 and 65.0%, respectively) being comparable to that of codeine phosphate (10 and 20 mg/kg, p.o., respectively). [79]

The methanolic extract of the leaves of *P. incarnata* was evaluated for its antiasthmatic effects against acetylcholine chloride induced bronchospasm in guinea pigs at doses of 50, 100 and 200 mg/kg. Using a 7-day treatment regimen, significant prevention of dyspnoea-related-convulsions was noted in the animals treated with a 100 mg/kg dose of this extract. No preventive effect was exhibited at 50 mg/kg dose and at a higher dose, i.e. 200 mg/kg; Acetylcholine chloride induced dyspnoea was decreased. [80]

Prunus persica L Batsch **(**Family:Rosaceae)

The Peach (*Prunus persica*) is a species of Prunus native to China that bears an edible juicy fruit also called a peach. The leaves have astringent, demulcent, diuretic, expectorant, febrifuge, laxative, parasiticide and mildly sedative effects. They are used internally in the treatment of gastritis, whooping cough, coughs and bronchitis.

A polysaccharide obtained from peach was tested on conscious cats by mechanical stimulation of the laryngopharyngeal and tracheobronchial mucous areas of the airways through a surgically implanted endotracheal cannula. Parameters of the cough reflex (number of cough efforts, cough frequency, intensity of the maximal cough effort and intensity of the coughing attack during inspiration and during expiration) were assesed and statistically evaluated. The results were compared with commonly used antitussive drugs from groups, narcotic (codeine) and non-narcotic (dropropizine) and the cough suppressive ability of polysaccharide was significantly similar to dropropizine and lower than codeine. [81]

Rudbeckia fulgida (Family: Asteraceae)

Rudbeckia fulgida is a perennial herbaceous plant growing up to 120 cm tall, form rosettes that develop at the end of stolons. Stems are glabrous or moderately covered in hirsute hairs with spreading branches.

An alkali-extracted low-molecular glucuronoxylan and two water-extractable polysaccharide complexes isolated from various parts of *Rudbeckia fulgida* were tested for antitussive activity on mechanically induced cough in nonanaesthetized cats. The polysaccharide complexes differed from each other regarding the qualitative and quantitative composition of the sugar components. It was found that oral administration of all the compounds led to a significant suppression of the cough reflex without negative influence on expectoration. Glucuronoxylan and the complex from the aerial parts of the herb exhibited 48.2% and 46.5% and the complex from the roots showed 23.5% activity. This decrease in activity may be because the roots lack uronic acid component. The standard drug used in the study was dropropizine and prenoxdiazine which exhibited 28.3% and 24.7% activity respectively, whereas the complex from the root exhibited only 23.5% activity as the root lacks uronic acid component. [82]

Salvia officinalis (Family: Lamiaceae)

Common sage (*Salvia officinalis*) is a small evergreen subshrub, with woody stems, greyish leaves and blue to purplish flowers native to southern Europe and the Mediterranean region.

Antitussive activity of carbohydrate substances from *Salvia officinalis* were tested on conscious cats by mechanical stimulation of the laryngopharyngeal and tracheobronchial mucous areas of the airways through a surgically implanted endotracheal cannula. Parameters of the cough reflex (number of cough efforts, cough frequency, intensity of the maximal cough effort and intensity of the coughing attack during inspiration and during expiration) were measured and statistically evaluated. Comparative tests with commonly used antitussive drugs from both groups, narcotic (codeine) and non-narcotic (dropropizine) were carried out under the same conditions. The cough suppressive ability of polysaccharide compounds from *Salvia officinalis* was significant and antitussive effect was lower than codeine but significantly similar to dropropizine. [83]

Stemona tuberose (Family: Stemonaceae)

Stemona tuberosa is an herbaceous plant found in Central China, Indochina, Taiwan and India. [84] Chung *et al*. (2003) isolated and characterized of four new stenine-type *Stemona* alkaloids, namely tuberostemonine J, tuberostemonine H, *epi*-bisdehydrotuberostemonine J and neostenine, together with the known neotuberostemonine from crude extract. These five isolated alkaloids were examined for antitussive activity in citric acid aerosol induced cough in guinea pigs. They reported that the compounds neotuberostemonine and neostenine showed significant antitussive activities. [85]

Terminalia belerica (Family: Combretaceae)

The common names of *Terminalia belerica are* beleric, belleric myrobalan, baehra fruit. They are grown throughout India. *Terminalia belerica* a rich source of tannins is an astringent, tonic, expectorant and laxative. It is used in coughs and sore throat, leprosy, fever and hair care, the pulp is used in dropsy, piles and diarrhoea. [86]

Bahera fruit has shown remarkable results in treating symptoms of asthma and chronic sinusitis. Clinical trials have also shown anti-histaminic, antitussive, anti-bacterial and anti-fungal properties. A recent study conducted in Kerala, India has shown an anti-HIV and anti-malarial action. [87]

Trichodesma indicum **(Linn.) R. Br.** (Family: Boraginaceae)

Synonym: *Borago indica* Linn. It is commonly known as surasa (Sanskrit), chhota kulpha (Hindi) and Kazhutha thumba (Tamil). The leaves and flowers are used as emollient and diuretic. Their roots were used successfully in the treatment of dysentery, cough, cold, fever and joint pains. [88] The leaves and the roots are esteemed as a remedy for snake bites; and also considered diuretic. A cold infusion of the leaves is considered depurative. [89-90]

The effect of methanolic extract of whole plants of *Trichodesma indicum* was proved to inhibit sulphur dioxide SO_2 induced cough reflux in swiss albino mice and the results were comparable with that of inhibition exerted by codeine phosphate. The dose of 200 mg/kg *Trichodesma indicum* produced 59.1% inhibition of the cough reflux. [91]

Verbascum thapsiforme (Family: Scrophulariaceae)

Verbascum thapsiforme is commonly called as woolly mullein. [92] From the flowers of mullein a crude mixture of polysaccharides was isolated by water extraction and ethanol precipitation. Purification of the crude product by chromatographic methods gave a polysaccharide component built up of galactose, glucose, xylose, arabinose, mannose, and uronic acids. Crude polysaccharide, isolated from

mullein, at a dose of 50 mg/kg resulted in a statistically significant decrease in the mechanically induced cough reflex parameters from both the Tracheo bronchial and Laryngopharyngeal mucous areas of airways in conscious cats and was comparable to opiate agonist codeine at a dose of 10 mg/kg and peripherally acting dropropizine at a dose of 100 mg/kg. [93]

***Vigna trilobata* (L.) Verdc.** (Family: Fabaceae)

Synonyms are *Dolichos trilobatus* L. *Phaseolus trilobatus* (L.) Schreb. and common names are african gram, three-lobe-leaf cowpea, jungle mat bean (English). [94]

Plant extracts of *Vigna trilobata* has been reported to be useful in cough and cold and whole plant and seeds are used as anti-tussive agents. [95] *Vigna trilobata* on oral administration decreased the cough frequency similar to that of codeine phosphate. The anti-tussive activity of the extract was highly significant at 500-1000 mg/kg. [96]

Xanthium strumarium (Family: Asteraceae)

The plant is commonly called as rough cockleburr, common cocklebur. [97] According to Ayurveda, *X. strumarium has* cooling, laxative, fattening, anthelmintic, alexiteric, tonic, digestive, antipyretic, and improves appetite, voice, complexion, and memory activities. It cures leucoderma, biliousness and poisonous bites of insects, epilepsy, salivation and fever. Seed yields semi-drying edible oil (30-35%) which resembles sunflower oil and used in bladder infection, herpes, and erysipelas. Cake can be used as manure whereas shell can be used as activated carbon. [98-99]

The water extract of the entire plant *Xanthium strumarium* has been evaluated for its effect on cough induced by sulphur dioxide gas in mice. The extract shows significant anti-tussive activity in a dose dependent manner. The extract at a dose level of 100, 200 mg/kg (p.o) showed significant inhibition of cough reflex by 39.75% and 65.58% respectively. [100] The anti-tussive potential of extract was comparable to that of codeine phosphate (10 mg/kg) a standard drug.

At this time, the only known effective herbal agents for the treatment of cough are the pungent spices (hot remedies) and menthol (a cold remedy). Other herbs may be regarded as `luke-warm' remedies and they induce a corresponding degree of enthusiasm among tussologists and mucologists. Whether or not they are simply effective in clinical studies may not be resolved by science, since the challenges and expenses of studies may prove prohibitive. Concerns about their potential therapeutic qualities may encourage hot debates, although, in modern parlance, herbal antitussives appeal to the consumer because they are cool, particularly since they may be regarded as food supplements that can be used as part of a sophisticated diet.

As mentioned there are number of medicinal plants and formulations that posses antitussive activity comparable to clinical effective synthetic antitussive agents. Thus plant based formulations can be effectively used for the treatment of mild to moderate cases of cough with fewer side effects than the conventional drugs.

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