Journal of Traditional and Complementary Medicine xxx (2016) 1–13

Contents lists available at ScienceDirect

Journal of Traditional and Complementary Medicine

journal homepage: http://www.elsevier.com/locate/jtcme

Review article

Biological activities and medicinal properties of Asafoetida: A review

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ARTICLE INFO

Article history:
Received 6 July 2016
Received in revised form
22 November 2016
Accepted 23 November 2016
Available online xxx

Keywords:
Ferula asafoetida Linn.
Oleo-gum-resin
Sulfur compounds
Sesquiterpenes
Biological activities

ABSTRACT

Ferula asafoetida Linn. is a main source of asafoetida, a strong, tenacious and sulfurous odor, and oleo-gum resin of medicinal and nutritional importance. Asafoetida has been consumed as a spice and a folk medicine for centuries. Recent studies have shown several promising activities particularly relaxant, neuroprotective, memory enhancing, digestive enzyme, antioxidant, antispasmodic, hypotensive, hepatoprotective, antimicrobial, anticarcinogenic, anticancer, anticytotoxicity, antiobesity, anthelmintic and antagonistic effect. This review effectively deals with phytochemistry and various pharmacological and clinical studies of asafoetida.

1. Introduction

Spices are used for thousands of years as food accessories to enhance the sensory quality of food. By imparting pleasant flavor, color and pungency, they can transform an otherwise dull food preparation into an attractive, appetizing meal. Spices are used not only alone, but also in the form of mixtures known as curry powders to math different tastes and preparations.[1] Spices are known to possess several medicinal properties. A number of health favorable physiological effects of dietary spices have been experimentally documented in recent decades.[2–4]

Asafoetida is used as a flavoring agent in food and as a traditional medicine for many diseases in many parts of the world. Asafoetida (*Ferula asafoetida*) is an oleo-gum-resin obtained from the stems of *Ferula* plants belonging to the family *Umbelliferae*. Out of more than 170 species, sixty spices of *Ferula* are widely distributed in Central Asia, particularly West Afghanistan, Iraq, Turkey and Eastern Iran, Europe and North Africa.[5] *F. asafoetida* is one of the important species of *Ferula* and is more native to Afghanistan and Iran than grows about 2 m in height and is in two types bitter and sweet.[6] Asafoetida is called Hing or Hingu in India.[3] Other names in different languages are given in Table 1.

Asafoetida is extracted from the *Ferula* plants which have massive taproots or carrot-shaped roots, around 15 cm in diameter at the crown when they are 4–5 years old. Before the plants flower, the upper part of the living rhizome root is laid bare and the stem cut off close to the crown. A dome-shaped structure made of twigs and earth covers the exposed surface. A milky juice exudes from the cut surface. The exudates are scraped off and a fresh slice of the root cut when more latex exudes, sometimes the resin is removed along with the slice. The collection of resin and slicing of the root are repeated until exudation ceases.[7]

Asafoetida has a strong, tenacious and sulfurous odor. Nowadays it is a popular ingredient in the Indian cuisine, most probably because its odor is reminiscent of the flavor of garlic and onion, two sprouting vegetables, as well as meat. Asafoetida is traditionally used for the treatment of different diseases, such as whooping cough, asthma, ulcer, epilepsy, stomachache, flatulence, bronchitis, intestinal parasites, antispasmodic, weak digestion and influenza.[8–11] Asafoetida is an effective remedy for several diseases of the stomach. The digestive stimulant actions of asafoetida are the most commonly experimented beneficial physiological effect via enhanced secretion of saliva and activity of salivary amylase. It plays an important role in the digestion of dietary lipids by stimulating bile flow and enhances the bile acid secretion and also enhances the activities of digestive enzymes of the pancreas and small intestine. Moreover, it is used for low acid levels in the stomach, stomach pressure, flatulence and loose stools. It is specially considered an ailment for women. It is used as a treatment of several problems such as unwanted abortion, unusual pain,

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Peer review under responsibility of The Center for Food and Biomolecules, National Taiwan University.

http://dx.doi.org/10.1016/j.jtcme.2016.11.004

Please cite this article in press as: Amalraj A, Gopi S, Biological activities and medicinal properties of Asafoetida: A review, Journal of Traditional and Complementary Medicine (2016), http://dx.doi.org/10.1016/j.jtcme.2016.11.004

Table 1
Various names of asafoetida in different countries.

Country	Name
Afghanistan	Kama, Anguza
Bangladesh	Hing
China	A-wei
Denmark	Dyvelsdrak
England	Asafetida
Finland	Asafetida, Hajupihka, Pirunpaska, Pirunpihka
France	Asafetide, Assa foetida, Ferule persique, Merde du diable
Germany	Asafetida, Asafotida, Asant, Stinkasant, Teufelsdreck
Greece	Aza
Hungary	Ordoggyoker
India	Hengu, Hing, Hingu, Ingu, Inguva, Kayam, Perungayam, Perunkaya, Raamathan
Iran	Rechina fena, Zaz
Italy	Assafetida
Myanmar	Sheingho
Netherlands	Asafetida, Duivelsdrek, Godenvoedsel, Sagapeen
Norway	Dyvelsdrekk
Pakistan	Anjadana, Kama, Anguza
Poland	Asafetida, Zapaliczka cuchnaca
Russia	Asafetida
Spain	Asafetida
Sri Lanka	Perunkayan
Sweden	Asafetida, Dyvelstrack
Tanzania	Mvuje
Tibet	Shing-kun
Turkey	Setan bokosu, Seytan tersi
United States	Asafetida, Devil's dung, Stinking gum

sterility, difficult and excessive menstruation and leucorrhoea. Recent pharmacological and biological studies have also shown several activities, such as antioxidant,[12,13] antimicrobial,[14–18] antiviral,[10] antifungal,[19–22] cancer chemopreventive,[23] anti-diabetic,[24] anticarcinogenesis,[23,25] antispasmodic and hypotensive,[26] relaxant effect,[27,28] neuroprotective[29,30] and molluscicidal[31] from this asafoetida. The present review deals with phytochemistry and various pharmacological and clinical studies of asafoetida.

2. Methods

Systematic literature searches were carried out in the terms: *F. asafoetida*, biological activities, umbelliprenin, bioavailability, antioxidant and relaxant effects. Information on *F. asafoetida* was collected via search and studies in electronic databases including Web of Science, Medline/Pubmed, Scifinder, Scopus, Embase and Google Scholar and also locally available books.

3. Chemical constituents

In general, Asafoetida consists around 68% of carbohydrates, 16% of moisture, 4% protein, 1% of fat, 7% of minerals and 4% of fiber.[10] It consists of three main fractions, including resin (40–64%), gum (25%) and essential oil (10–17%).[8] The resin fraction contains ferulic

Table 2
Phytochemical constituents of *Ferula asafoetida*.

Major chemical constituents	References
Coumarins and sesquiterpene coumarins	
Umbelliprenin	34,35
5-Hydroxyumbelliprenin	
8-Hydroxyumbelliprenin	
Tadshiferin	
Galbanic acid	34–36
8-Acetoxy-5-S-hydroxyumbelliprenin	34,35
Conferol	37
Gummosin	
Epi-samarcandin	
Epi-samarcandin acetate	
Franesiferol A	38,39
Franesiferol B	
Franesiferol C	
Asacoumarin A	36
Assafoetidin	40
Ferocaulicin	
Assafoetidinol A	41
Assafoetidinol B	
Polyanthinin	
Kamolonol	42
Foetidine	43
Saradaferin	32,41
10-R-Acetoxy-11-hydroxyumbelliprenin	
10-R-Karatavicinol	
Methyl galbanate	
Lehmferin	
Feselol	
Ligupersin A	
Epi-conferdione	
Microlobin	
Umbelliferone (7-hydroxycoumarin)	
Sulfur containing compounds	
2-Butyl 1-propenyl disulfide	8,32
1-(Methylthio) propenyl disulfide	
2-Butyl 3-(methylthio)-2-propenyl disulfide	
2-Methyl-2-propanethiol	
2,3-Dimethylthiirane	
1-Methylthio-(Z)-1-propene	
1-Methylthio-(E)-1-propene	
Dimethyl disulfide	
S-Methylpropanethioate	
2-(Methylthio) butane	
3,4-Dimethylthiophene	
Methyl (Z)-1-propenyl disulfide	
Methyl (E)1-propenyl disulfide	
Dimethyl trisulfide	
2-Butyl methyl disulfide	
Dipropyl disulfide	
2,3,4-Trimethylthiophene	
2-Butyl vinyl disulfide	
2-Butyl 1-propenyl disulfide	
Methyl 1-(methylthio)propyl disulfide	
Di-2-butyl disulfide	
Methyl 1-(methylthio)ethyl disulfide	
1-(Methylthio)propyl propyl disulfide	
1-(Methylthio)propyl 1-propenyl disulfide	
Asadisulfide	36
2-Butyl methyl trisulfide	44
Di-2-butyl trisulfide	
Di-2-butyl tetrasulfide	
Foetisulfide A	7,9
Foetisulfide C	
Diterpenes	
7-Oxocallitristic acid	9
Picealactone C	
15-Hydroxy-6-en-dehydroabietic acid	
Phenolics	
Vanillin	45
3,4-Dimethoxycinnamyl-3-(3,4-diacetoxyphenyl) acrylate	
Sesquiterpenes	
Taraxacin	35
Fetidone A	
Fetidone B	
Other compounds	
Falcarinolone	46
Oleic acid	47
β-Sitosterol	9,48
Galactose	
Arabinose	
Glucuronic acid	
Rhamnose	
Luteolin 7-β-D-glucopyranoside	
Ferulic acid	

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acid and its esters, coumarins, sesquiterpene coumarins and other terpenoids. The gum includes glucose, galactose, 1-arabinose, rhamnose, glucuronic acid, polysaccharides and glycoproteins, and the volatile fraction contains sulfur-containing compounds, monoterpenes and other volatile terpenoids.[32] Sulfur compounds in *F. asafoetida* resin show various biological activities and can be valuable in medicine.[33] Three major sulfur constituents that have been identified include 2-butyl 1-propenyl disulfide, 1-(methyl thio) propyl 1-propenyl disulfide and 2-butyl 3-(methyl thio)-2-propenyl disulfide.[8] The major constituents of *F. asafoetida* are well characterized and given in Table 2. Chemical structures of important sesquiterpene coumarins and sulfur-containing compounds present in *F. asafoetida* are given in Figs. 1 and 2 respectively.

4. Pharmacological and clinical studies of asafoetida

Various scientific investigations of asafoetida into physiological and pharmacological activities and critical evaluations of its various activity effects were discussed (Table 3). Schematic representation of various biological activities of asafoetida is shown in Fig. 3.

4.1. Relaxant effect

The relaxant effects of various preparations of *F. asafoetida* and its constituents on different types of smooth muscles were demonstrated. The relaxant effect of the asafoetida on tracheal smooth muscle of guinea pigs and its probable mechanisms were investigated by three cumulative concentrations of the aqueous extract (2, 5 and 10 mg/mL), theophylline (0.25, 0.50 and 0.75 mM) and saline were examined on non-incubated tracheal smooth muscle of guinea pig precontracted by 10 μM methacholine in group 1, pre-incubated tissues by propranolol and chlorpheniramine, contracted by methacholine in group 2 and pre-incubated tissues by propranolol contracted by methacholine in group 3. All concentrations of theophylline in group 1 and all concentrations of

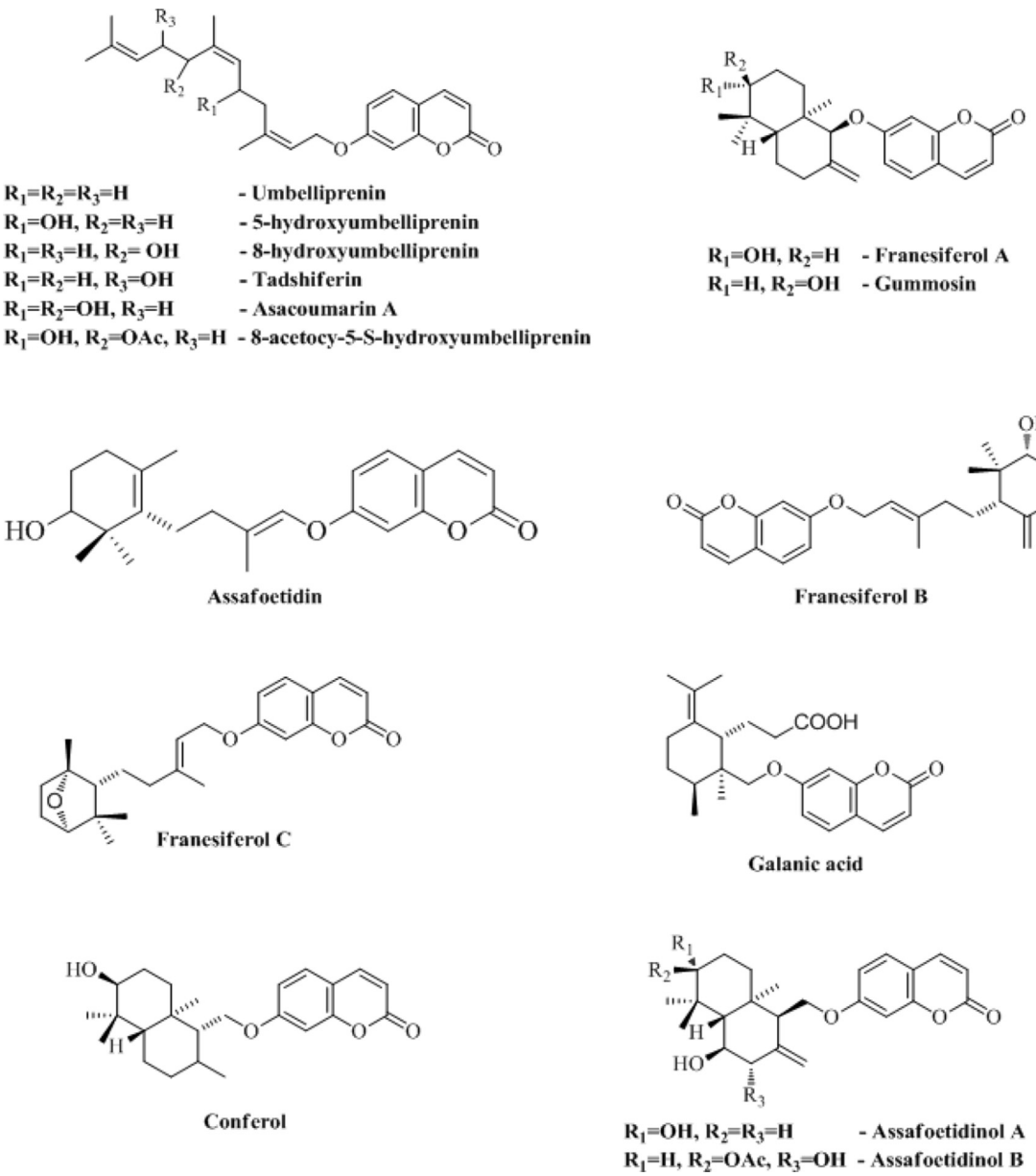

Fig. 1. Chemical structures of important sesquiterpene coumarins present in *Ferula asafoetida.*

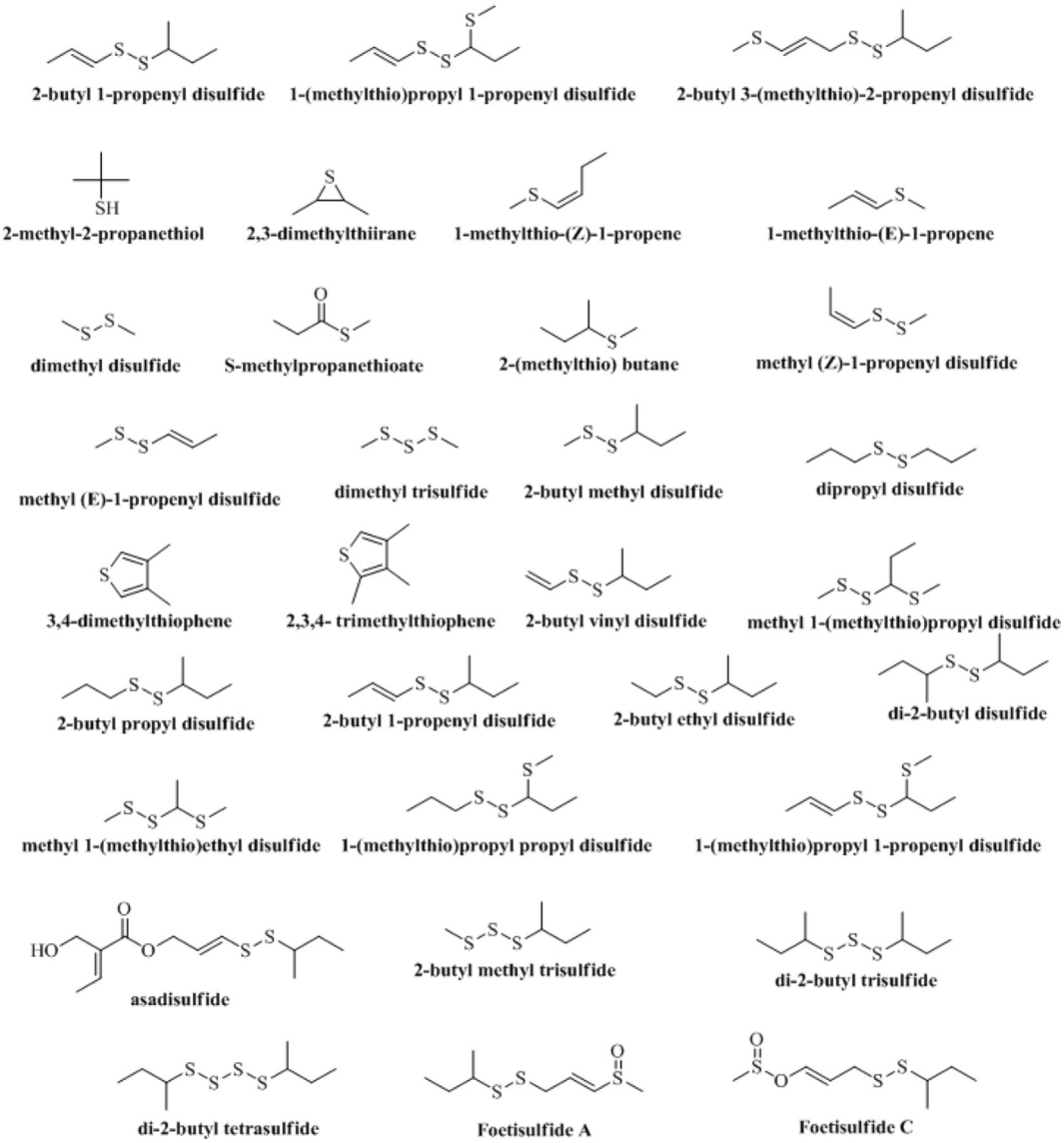

Fig. 2. Chemical structures of important sulfur compounds present in *Ferula asafoetida.*

the extract in the further three groups showed considerable relaxant effects compared to that of saline. Significant positive correlations have shown between the relaxant effects of the extract with their concentrations in all three groups. It is clearly indicated that a potent relaxant effect of the asafoetida extract on tracheal smooth muscle, which is perhaps due to muscarinic receptor blockade.[49] Bayrami et al[50] investigated the relaxant effects of oleo-gum-resin of asafoetida and its coumarin constituent umbelliprenin on tracheal chains of guinea pigs. The relaxant effects of three cumulative concentrations of the aqueous extract umbelliprenin, theophylline and saline were examined by their relaxant effects on pre-concentrated tracheal chains of guinea pig by 60 mM/L KCl in group 1 and 10 μM/L methacholine in group 2. In group 1 all concentrations of theophylline and the highest concentration of the extract showed significant relaxant effects compared with that of saline. In group 2, relaxant effects of all concentrations of theophylline, extract and two higher concentrations of umbelliprenin differed significantly compared with saline. The relaxant effect of the aqueous extract in group 2 was considerably greater than that of group 1. The relaxant effect of the extract was significantly more potent than umbelliprenin in both groups. It is indicated that a potent relaxant effect of the asafoetida extract on tracheal smooth muscle, which is due to its constituent umbelliprenin. The relaxant effect of asafoetida and essential oil from asafoetida seed was investigated by Bagheri et al[27] in isolated ileum of rat after three doses. Asafoetida produced an antispasmodic effect on acetylcholine (Ach) induced contraction in 0.2% and 0.3%. Spasmolytic evaluation showed that the essential oil derived from *F. asafoetida* seed in concentrations of 0.2 and 0.3%, significantly reduced Ach from 10 to 4 M induced concentrations. Exposure to the 0.2 and 0.3% asafoetida, reduced statistically significant, the percentage of maximum contraction induced by 10−4 M Ach to 43% and 12% respectively. Asafoetida can be used as an antispasmodic therapeutic agent. Khazdair et al[28] investigated the effect of asafoetida on muscarinic receptors of tracheal smooth muscle for relaxant effect. The effects of three cumulative concentrations of aqueous extract of *F. asafoetida* (2.2, 5 and 10 mg/mL), 10 nM atropine and saline on muscarinic receptors were tested in tracheal smooth muscle samples. The maximum responses to methacholine in the presence of higher concentration of the extract (10 mg/mL) were significantly lower than that of saline. Because of *F. asafoetida* or its constituents may bind to muscarinic receptor of tracheal smooth

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Table 3
Pharmacological studies on *Ferula asafoetida*.

Pharmacological and clinical activities	Model used and study design	Type of extract	Observations	References
Relaxant effects	Guinea pigs (400–700 g, both sexes) – tracheal smooth muscle	Aqueous extract *Ferula asafoetida* (2, 5 and 10 mg/ml) and theophylline anhydrous (0.25, 0.5 and 0.75 mM)	All concentrations of theophylline and the extract showed relaxant effect in comparison with saline which was not significantly different with that of theophylline. A potent relaxant effect for the asafoetida extract on tracheal smooth muscle which is perhaps due to muscarinic receptor blockade.	49
Relaxant effects	Precontracted tracheal chains of guinea pig by 60 mmol/L KCl and 10 μmol/L methacholine	Aqueous extract (2, 5 and 10 mg/mL), umbelliprenin (0.04, 0.2 and 0.4 mg/mL), theophylline (0.05, 0.1 and 0.15 mg/mL) and saline	The relaxant effect of the extract was significantly more potent than umbellipreni.	50
Relaxant effects	Male Wistar rats (250–350 g)	0.1, 0.2 and 0.3% of asafoetida aqueous extract	Essential oil derived from *F. asafoetida* seed in concentrations of 0.2% and 0.3% significantly reduced Ach (10–4 M) induced contractions. Exposure to the 0.2% and 0.3% asafoetida, reduced the percentage of maximum contraction induced by 10 −4 M Ach to 43% and 12% respectively.	27
Relaxant effects	Guinea-Pig Tracheal Smooth Muscle	Aqueous extract of *Ferula asafoetida* (2.5, 5 and 10 mg/mL), 10 nM atropine, and saline	The maximum responses to methacholine in the presence of 10 mg/mL concentration of the extract were significantly lower than that of saline. The values of CR-1, obtained in the presence of the extract, were significantly lower compared to atropine in the experimental group.	28
Neuroprotective effect	7-d rat brains and cerebellar granule neurons	80% methanol extract of *Ferula asafoetida* (100 μg/ml)	*F. asafoetida* extract displayed neuroprotective effects in glutamate-induced neurotoxicity. The extract exerted antiapoptotic activity in cerebellar granule neurons due to cell cycle arrest in G0G1 phase, which explain the beneficial effects of *F. asafoetida* extract as therapies for neurologic disorders.	29
Neuroprotective effect	Sciatic nerves of adult male Balb/c mice	Aqueous extract of oleo gum resin of *Ferula asafoetida* (0.1 mg/kg, 1 mg/kg and 10 mg/kg).	Aqueous extract of oleo gum rein of asafoetida increased the amplitude and decreased the latent period of nerve compound action potential (CAP). Nerve conduction velocity (NCV) and amplitude of CAP also improved in asafoetida treated animals. Histological and behavioral studies showed that asafoetida was able to facilitate the healing process in peripheral nerves.	51
Memory enhancing activity	Male inbred albino rats	Aqueous extract of *Ferula asafoetida* (200 and 400 mg/kg)	Significant improvement in memory score and dose-dependent improvement of transfer latency Memory enhancing potential of *F. asafoetida* can be attributed to acetylcholinesterase inhibiting and antioxidant properties.	52
Memory enhancing activity	Dementia induced by D-galactose and $NaNO_2$ in mice	100 mg/kg/d aqueous extract of asafoetida	Asafoetida could prevent and treat amnesia may be due to the presence of biologically active compounds such as sulfur containing and sesquiterpene coumarin.	53
Digestive enzyme activity	Adult female Wistar rats	14 spices with 50 mg of asafoetida	Fenugreek, mustard, and asafoetida affected chymotrypsin and trypsin activities.	54
Digestive enzyme activity	Adult female Wistar rats	14 spices with 50 mg of asafoetida	Positive influence of in vitro analysis on the activity of enzymes may have an additional role in the overall digestive stimulant action of spices to enhance the titers of digestive enzymes in pancreatic tissues.	55
Antispasmodic and hypotensive activity	Sprauge–Dawley rats and guinea-pigs	Aqueous extract of *Ferula asafoetida* (0.3–2.2 mg/100 g)	*Ferula asafoetida* gum extract is effective in reducing blood pressure in anaesthetized normotensive rats. The extract also decreased contractions induced by acetylcholine, histamine and KCl in the isolated guinea-pig ileum.	26

(*continued on next page*)

Table 3 (*continued*)

Pharmacological and clinical activities	Model used and study design	Type of extract	Observations	References
Hepatoprotective effect	Carbon tetrachloride-induced liver toxicity in Wistar rats	Petroleum either, chloroform, benzene, ethanol and aqueous extracts of *Ferula asafoetida*, *Momordica charantia* and *Nardostachys jatamansi* (Three different formulations were prepared)	Formulation 3 (containing chloroform, petroleum ether and aqueous extracts of *Ferula asafoetida*, petroleum ether and ethanol extracts of *Momordica charantia* Linn. and petroleum ether and ethanol extracts of *Nardostachys jatamansi*). It has shown significant hepatoprotective effect by reducing the elevated serum enzyme levels such as glutamate oxaloacetate transaminase, glutamate pyruvate transaminase and alkaline phosphatase.	56
Antimicrobial and antioxidant activity	Two food borne Gram-negative bacteria [*Salmonella typhi* PTCC 1609 and *Escherichia coli* PTCC 1330], two food borne Gram-positive bacteria [*Staphylococcus aureus* PTCC 1112 and *Bacillus subtilis* PTCC 1023], and two food borne fungi [*Aspergillus niger* PTCC 5010 and *Candida albicans* PTCC 5027]. ROS, NO, H_2O_2 and TBARS scavenging assay	Essential oils obtained from *Ferula asafoetida* oleo-gum resins in different collections times	Essential oil obtained from the earlier stages of *F. asafoetida* growth could be used as safe and effective natural antioxidants in food industry to improve the oxidative stability of fatty foods during storage. Essential oil obtained from the later stages of *F. asafoetida* growth could be used in health industry as a safe and effective source of antimicrobial agents.	13
Antimicrobial activity	*E. coli* MTCC-443, *Pseudomonas aeruginosa* MTCC-4673, *Staphylococcus aureus* MTCC-3160, *Bacillus subtilis* MTCC-441, *Aspergillus niger* MTCC-1344	Petroleum ether, acetone, carbon tetrachloride, methanol, ethanol and aqueous extracts of *Ferula asafoetida*	Alcoholic and aqueous extracts of *Asafoetida* showed significant effect against *B. subtilis*, *S. aureus*, *E. coli*, *P. aeruginosa* and *Aspergillus niger*.	14
Antimicrobial activity	Bacterial strains of *Staphylococcus aureus*, *Yersinia enterocolitica*, *Salmonella typhi*, *Bacillus cereus*, *Bacillus subtilis*, *Listeria monocytogenes*, *Escherichia coli* and *Salmonella paratyphi*	Volatile oils of two varieties of *Ferula asafoetida* (Pathani and Irani)	Pathani oil was found to be a good antibacterial agent. Irani oil was found to be a good fungicidal agent.	15
Antibacterial and antifungal activity	Antibacterial activity – *Bacillus subtilis*, *Staphylococcus aureus*, *Klebsiella pneumonia* and *Escherichia coli* Antifungal activity – *Aspergillus niger* and *Candida albicans*	Chloroform, ethyl acetate, ethanol, methanol and aqueous extracts of asafoetida	Ethyl acetate, ethanol, and methanol extract has significant antimicrobial and antifungal activity and highest activity was reported with methanolic extract.	17
Antibacterial activity	Gram negative – *E. coli* and *K. pneumonia*, *Sh. flexneri* Gram positive – *S. aureus* and *E. faecalis*	Red and white forms of *Ferula asafoetida* extracts in hot water, hexane, ethanol and petroleum ether	Highest antibacterial activity was shown by hexane extract against *Shigella flexineri* and *S. aureus*.	18
Antifungal activity	*Aspergillus niger, Candida albicans*, *Candida blanki*, *Candida cylindracea*, *Candida glabrata*, *Candida krusei*, *Candida tropicalis*, and *Saccharomyces cerevisiae*	Essential oils derived from 20 spices including asafoetida	Asafoetida oil showed inhibitory activity toward all fungal strains, but activity was strong toward *Candida tropicalis*, *Candida albicans*, *Saccharomyces cerevisiae*, and *Aspergillus niger*.	19
Antifungal activity	*Aspergillus niger, A. flavus, Fusarium oxysporum, F. moniliforme, F. nivale, F. semitectum, Drechslera hawiinesis* and *Alternaria alternata*	Essential oils extracted from the seeds of neem, mustard, black cumin and asafoetida	Asafoetida oil at 0.1% and 0.15% significantly inhibited the growth of all test fungi except *A. flavus* and *Nigella sativa*.	57
Antifungal activity	*Sclerotium rolfsii* ITCC 5226 and *Macrophomina phaseolina* ITCC 0482	Ninety formulations of neem oil, nicotinic acid and *Ferula asafoetida* at different concentrations with α, β-unsaturated carbonyl compounds	The formulations having *F. asafoetida* as the natural component showed significant antifungal activity.	20
Antifungal and allelopathic effects	*Trichoderma harzianum* and *Pleurotus* spp.	Methanol extract of Asafoetida oleo-gum-resin	Asafoetida showed fungicidal activity against *T. harzianum* strains and *Pleurotus* spp. at higher concentrations. Antagonistic activity of *T. harzianum* against the *Pleurotus* spp. was moderate.	21
Antifungal activity	*Bipolaris sorokiniana*, *Verticillium sp*, *Fusarium graminearum*, *Fusarium solani* and *Aspergillus niger*	Asafoetida seed essential oil	*Bipolaris sorokiniana* growth completely inhibited. Other species growth also increased with increase of essential oil concentration.	22
Antiprotozoa activity	*Blastocystis hominis*	Asafoetida (oleo-gum-resin) as powder and oil-form	Asafoetida decreased counts and viability of all tested isolates of *Blastocystis hominis*. The degree of the inhibitory effect was dependent on the concentration and time of incubation with asafoetida extracts.	58

Anticarcinogenic activity	Swiss albino mice	70% ethanol extract of *Ferula asafoetida*	Asafoetida extract inhibited two stage chemical carcinogenesis induced by 7,12 dimethyl benzanthracene and croton oil on mice skin with significant reduction in papiloma formation.	59
Anticarcinogenic activity	Swiss albino mice	Petroleum ether, benzene, ethyl acetate, acetone, methanol and aqueous extracts of *Ferula asafoetida*	The pretreatment of animals with asafoetida recovered the antioxidant level and reversed the induced ODC activity and DNA synthesis significantly.	23
Anticarcinogenic activity	Sprague–Dawley rats	Asafoetida (1.25 and 2.5%w/w in diet)	A significant decrease in tumor multiplicity after asafoetida treatment. A striking reduction in the number of terminal end buds during mammary gland differentiation.	25
Anticancer activity	Spargue–Dwaley rats (120–150 g)	Asafoetida orally daily (10 and 20 mg/100 g bw)	Asafoetida supplementation attenuates DMH induced deleterious effects in of rats. Medium dose of 10 mg/100 g bw exhibited more pronounced effect as it constantly influenced all the tested biochemical parameters.	60
Anti-quorum sensing activity	*Pseudomonas aeruginosa*	Essential oil extracted from *Ferula asafoetida* (25 μg/mL)	Fully abolished the violacein production by *C. violaceum*. Pyocyanin, pyoverdine, elastase and biofilm production were decreased in Ferula oil treatments.	61
Antihyperglycemic effect	Male Wistar rats (280–320 g)	Aqueous extract of oleo gum resin of *Ferula asafoetida* (50 mg/kg)	Blood glucose level in streptozotocin induced diabetic animals is reduced	62
Farnesyltransferase inhibition	Oncogenic ras-transformed NIH3T3/Hras-F cells	Coumarin-derived sesquiterpene galbanic acid, karatavicinol, umbelliprenin, farnesiferol B, and farnesiferol C	Galbanic acid demonstrated potent inhibition of the proliferation of oncogenic ras-transformed NIH3T3/Hras-F in a dose-dependent manner	63
Protein and metabolic activity	Male Wistar albino rats (230–250 g)	*Nigella sativa* (50–400 mg/kg), *Trigonella foenum-graecum* (25–600) and *Ferula asafoetida* (50–450)	Asafoetida significantly inhibited the mRNA and protein expression levels of CYP2C11 in a dose-dependent manner. The in vitro enzyme metabolic activity study showed a significant decrease in the formation of 4-hyroxy-tolbutamide, a tolbutamide metabolite, at the higher doses.	64
Anti-cytotoxicity activity	Male NMRI mice (18–28 g)	*Ferula asafoetida* oleo-gum resin at doses of 300 mg/kg	Oleo-gum-resin of *F. asafoetida* exhibited cytotoxic effect with LC_{50} values in the range of 6–321 μg/mL.	65
Anti-obesity and fat lowering effect	Male Wistar rats (285–300 g)	*Ferula asafoetida* oleo-gum resin at doses of 25 or 50 mg/kg	Administration of Ferula asafoetida significantly decreased body weights, abdominal fat and size of epididymal adipocyte compared to untreated rats. Levels of serum leptin were significantly decreased in treated rats.	66
Anxiolytic effect	Swiss albino mice (20–25 g) and Wistar albino rats (140–180 g)	Asafoetida orally daily (0.1, 0.3, 1, 1.5 and 2 g/kg)	A dose-dependent anxiolytic and analgesic activity of asafoetida, with a mild sedative effect in high doses. Compared to diazepam, the asafoetida seems to be a better alternative for the treatment of anxiety disorders.	67
Anthelmintic activity	Pheretima postuma-adult Indian earthworms	Aqueous extract from *Ferula asafoetida* (25, 50, 100 mg/mL)	The extract has exhibited significant anti-helmintic activity at the highest concentration of 100 mg/mL.	68
Anthelmintic activity	Liver fluke *Fasciola gigantic*	Acetone, ether, chloroform and ethanol extract from *Ferula asafoetida* (2–10 mg/mL)	The ethanol extract of *F. asafoetida* (2 h; LC_{50} 3.94 mg/mL) was high toxic against *Fasciola gigantic*.	69
Spermatic and testicular histopathology	Male Wistar rats (230–250 g)	Asafoetida orally daily (25, 50, 100 and 200 mg/kg)	Asafoetida significantly increased the number and viability of sperms Spermatogenesis process and numbers of Leydig cells were increased with increasing the dose.	70
Antagonistic Effect	Guinea pigs (600–800 g)	Aqueous extract from *Ferula asafoetida* (2.5, 5 and 10 mg/mL)	Competitive antagonistic effect of *F. asafoetida* at muscarinic receptors.	71

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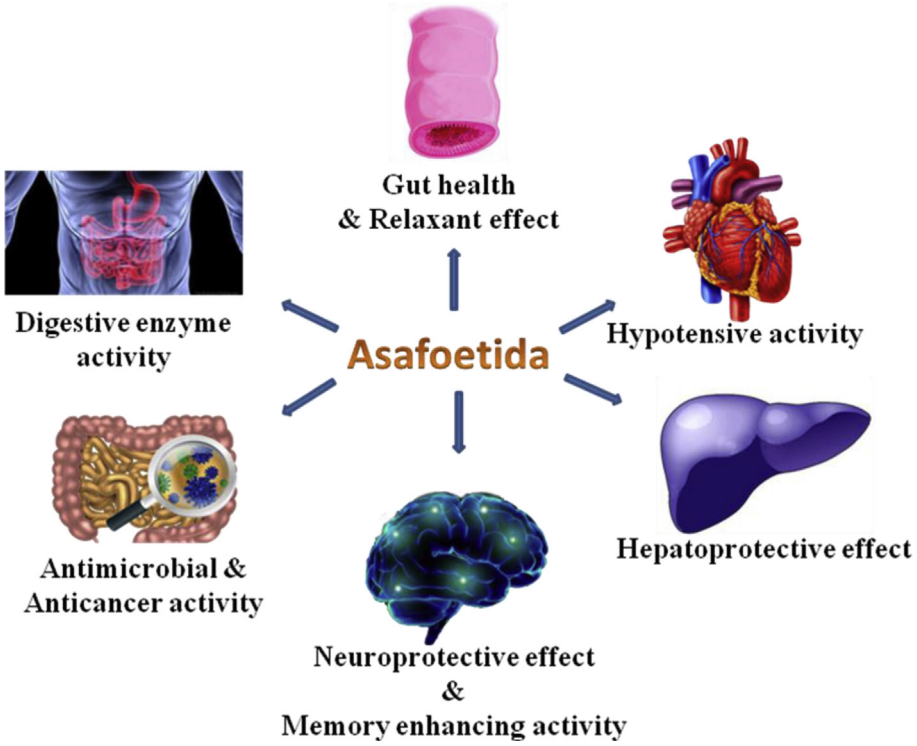

Fig. 3. Schematic representation of various biological activities of asafoetida.

muscle and put off the binding of methacholine to this receptor, it suggested the competitive antagonistic effect of *F. asafoetida* at muscarinic receptors.

4.2. Neuroprotective effect

Traditional usages and some recent findings suggested that *F. asafoetida* can exert some effects on the function of the nervous system particularly in neuroprotective and nerve stimulating effects. *F. asafoetida* extract treatment on glutamate-induced cell damaged in primary culture of rat cerebellar granule neurons was investigated by Tayeboon et al.[29] Cerebellums and cerebellar granule neurons were collected from seven days rat brains and eight days culture respectively. Cerebellar granule neuron cells were treated with *F. asafoetida* extract at 100 μg/mL concentration before, after and during exposure to 30 μM glutamate. Neuroprotective effects of extracts of *F. asafoetida* against glutamate-induced neurotoxicity confirmed by increased glutamate-induced reduction in cellular viability and attenuated glutamate-induced apoptotic/necrotic cell death. The extract exerted antiapoptotic activity in cerebellar granule neurons due to cell cycle arrest in G0G1 phase, which explain the beneficial effects of *F. asafoetida* extract as therapies for neurologic disorders.[29] *In vitro* studies were carried out by Moghadam et al[51] to identify the response of isolated sciatic nerves to various concentrations of oleo gum resin of asafoetida solved in Lock's solution. *In vivo* studies were also conducted to evaluate its effect on amelioration of peripheral neuropathy in mice. *In vitro* experiments authenticated that incubating the nerves in aqueous extract of the oleo-gum-resin of asafoetida increased the amplitude and decreased the latent period of nerve compound action potential. Nerve conduction velocity and amplitude of compound action potential improved in asafoetida treated animals. The ability of asafoetida to facilitate the healing process in peripheral nerves is also confirmed by the histological and behavioral studies. *In vitro* experiments showed that asafoetida is a nerve stimulant and its management in neuropathic mice exerted neuroprotecting effects through stimulating axonal regeneration and remyelination and decrement of lymphocyte infiltration.[51]

4.3. Memory enhancing activity

Loss of memory is the first symptom to manifest in majority of the people suffering from Alzheimer's disease around the world. Vijayalakshmi et al[52] investigated the effect of the *F. asafoetida* extract on learning and memory in rats. Learning and memorization were evaluated using elevated plus maze and passive avoidance paradigm after the oral administration of two doses (200 and 400 mg/kg) of *F. asafoetida* aqueous extract with rivastigmine as positive control. The extract produced significant improvement in memory score and dose-dependent improvement of transfer latency in elevated plus maze model. Dose-dependent inhibition of brain cholinesterase and significant improvement in antioxidant levels were also noted. Memory enhancing potential of *F. asafoetida* can be attributed to acetylcholinesterase inhibiting and antioxidant properties. Dietary usage of *F. asafoetida* is beneficial and can also be employed as an adjuvant to existing anti-dementia therapies. The effect of asafoetida on preventive treatment of Dementia induced by D-galactose and $NaNO_2$ in mice was investigated by Bagheri et al.[53] Animals were divided into four different groups such as normal control (NC), dementia control (DC), dementia prophylactic (DP) and dementia treated (DT). The groups DP, NC and DT were significantly shown greater memory retention ability than the DC group. Because of asafoetida could prevent and treat amnesia may be due to the presence of biologically active compounds such as sulfur containing and sesquiterpene coumarins. The anti-epileptic and anti-oxidant properties of the *F. asafoetida* gum extract, using the pentylenetetrazole (PTZ) kindling method. Considerable reduction of MDA and NO levels and increased the SOD level in the plant extract treatment groups compared to the PTZ group implies that probably *F. asafoetida* gum extract causes a

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decrease in oxidative damage and lipid peroxidation due to its antioxidant properties. The lowering effects of hydro-alcoholic *F. asafoetida* gum extracts on the PTZ-induced seizures are probably due to its antioxidant properties and decrease of oxidative stress.

4.4. Digestive enzyme activity

In general spices have been considered to strengthen salivary flow and gastric juice secretion and support in digestion. The digestive stimulating action of the spices is most likely through a stimulation of activities of enzymatic participate in digestion. A few common spices or their active principles were examined for their possible influence on digestive enzymes of the pancreas in experimental rat. Groups of animals were maintained for 8 weeks on the following spice diets are curcumin (0.5 mg), capsaicin (15 mg), piperine (20 mg), ginger (50 mg), cumin (1.25 mg) fenugreek (2 mg), mustard (250 mg) and asafoetida (250 mg). Among these spices, asafoetida prominently enhanced pancreatic lipase activity and also stimulated pancreatic amylase. The positive influence of the pancreatic digestive enzymes exerted by a good number of spices consumed in diet could be a factor contributing to the well recognized digestive stimulant action of spices.[54] Ramakrishna Rao et al[55] also examined the *in vitro* influence of fourteen spices with asafoetida on the activities of digestive enzymes of rat pancreas and small intestine by including them in the reaction blend at two dissimilar concentrations. A majority of spices enhanced the activity of pancreatic lipase and amylase when they are directly in contact with the enzyme. It is inferred that this positive influence on the activity of enzymes may have a supplementary role in the overall digestive stimulant action of spices, besides causing an enhancement of the titers of digestive enzymes in pancreatic tissue.

4.5. Antispasmodic and hypotensive activity

In 2004, Fatehi et al[26] demonstrated that *F. asafoetida* gum extract was effective in reducing blood pressure in anaesthetized normotensive rats. The effects of *F. asafoetida* gum extract on the contractile responses of the isolated guinea-pig ileum stimulated by histamine, acetylcholine, and KCl, and on the mean arterial blood pressure of rat were investigated. The average amplitude of spontaneous contractions of the isolated guinea-pig ileum was decreased when compared with control. Exposure of the precontracted ileum by acetylcholine to *F. asafoetida* gum extract caused relaxation in a dose-dependent manner. *F. asafoetida* gum extracts significantly reduced the mean arterial blood pressure in anaesthetized rats. It strength be concluded that the relaxant compounds in *F. asafoetida* gum extract interfere with a variety of histaminic receptor and muscarinic adrenergic activities or with the mobilization of calcium ions required for smooth muscle contraction nonspecifically.

4.6. Hepatoprotective effect

In 2008, Dandagi et al[56] explored the hepatoprotective activity of a variety of extracts of *Momordica charantia* Linn., *Nardostachys jatamansi* and *F. asafoetida* against experimental hepatotoxicity. These extracts were formulated as polyherbal suspensions and they were showing significant activity and evaluated for both hepatoprotective and physicochemical activity in evaluation with LIV-52 as standard. Three different formulations were prepared, among these Formulation 3 (containing chloroform, petroleum ether and aqueous extracts of *F. asafoetida*, petroleum ether and ethanol extracts of *M. charantia* Linn. and *N. jatamansi*) has shown a significant hepatoprotective effect by decreasing the elevated serum enzyme levels such as glutamate pyruvate transaminase, glutamate oxaloacetate transaminase and alkaline phosphatase. Experimental data also suggested that treatment with Formulation 3 enhances the recovery from hepatotoxicity induced by carbon tetra chloride.

4.7. Antimicrobial activity

Antimicrobial activity of spices depends upon the several factors such as class of species, composition and concentration of spices and its level of occurrence, composition of substrate, processing conditions and storage. Asafoetida is a spice and herbal medicine used to treat against various fungi and bacteria. Crude extracts of asafoetida were evaluated for their antimicrobial activity against various fungal and bacterial strains. It was observed that alcoholic and aqueous extracts of asafoetida showed significant effect against *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Aspergillus niger* by the agar disc diffusion method. The crude extract showed a broad spectrum of antimicrobial activities by inhibiting the respective fungi and bacteria. Agar disc diffusion assay for antimicrobial activity yielded the inhibitory zone of 4–16 mm diameter for asafoetida extracts. Asafoetida can be recommended for therapeutic and medicinal purposes.[14] Essential oils obtained from *F. asafoetida* oleo-gum resins (OGRs) in different collections times named as OGR1, OGR2 and OGR3 had different chemical compositions, antioxidant, ROS, RNS, H_2O_2 and TBARS scavenging. The essential oil from OGR1 was constituted high levels of bicyclic sesquiterpenes [10-epi-γ-eudesmol] and acyclic sulfur-containing compounds [(E)-1-propenyl sec-butyl disulfide and (Z)-1-propenyl sec-butyl disulfide] showed the highest radical scavenging and the lowest antifungal and antibacterial activities. Essential oil from OGR2 was constituted high levels of acyclic sulfur-containing compounds [(Z)-1-propenyl sec-butyl disulfide and (E)-1-propenyl sec-butyl disulfide] and bicyclic monoterpenes [β-pinene and α-pinene] and showed moderate radical scavenging, antifungal and antibacterial activities. Essential oil from OGR3 was constituted high levels of bicyclic monoterpenes [β-pinene and α-pinene] and heterocyclic disulfide [1,2-dithiolane] and showed the lowest radical scavenging and the highest antibacterial and antifungal activities. The essential oil obtained from the earlier stages of *F. asafoetida* growth could be used as safe and effective natural antioxidants in the food industries to get better oxidative stability of fatty foods during storage, while the essential oil obtained from the later stages of *F. asafoetida* growth could be used in the health industry as a safe and effective source of antibacterial agents.[13] Volatile oils of two varieties of *F. asafoetida*, namely Pathani and Irani, isolated by hydro-distillation were studied for their antimicrobial properties against various food-borne bacterial and fungal organisms. Pathani was more effective against bacteria such as *E. coli* and *B. subtilis*. The volatile oil of Irani showed 70 and 75% inhibition of growth of *Aspergillus ochraceus* and *Penicillium chrysogenum* respectively, whereas volatile oil of Pathani exhibited 49 and 45% inhibition. Pathani oil was found to be a good antibacterial agent while Irani oil a fungicidal agent.[15] Bhatnager et al[18] used two kind of *F. asafoetida* such as red and white gum to screen their antimicrobial activity against five dissimilar bacterial strains. Hexane extracts of both red and white asafoetida has shown the highest antibacterial activity against *Shigella flexneri* and *S. aureus* was found to be least affected by other extracts. Extracts of both red and white forms showed comparable antibacterial activities, so it may have the same chemical composition. *F. asafoetida* has broad-spectrum antibacterial activity because it showed the potential inhibitory effect against the tested strains of bacteria. Bioactive substances from this plant can therefore be worked in the

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formulation of antibacterial agents for the treatment of various bacterial infections mainly related to the digestive system. The antibacterial and antifungal activity of chloroform, ethyl acetate, ethanol, methanol and aqueous extracts of asafoetida were studied by Patil et al[17] Antibacterial activity was carried out against *B. subtilis, E. coli, Klebsiella pneumonia, S. aureus* and the antifungal activity was evaluated against *A. niger* and *Candida albicans*. Ethyl acetate, ethanol and methanol extract has significant antimicrobial activity due to the occurrence of a mixture of phytoconstituents and it could be a source of new antibiotic compounds.

Essential oils derived from 20 different spices were investigated for their antifungal activity against *A. niger, C. albicans, Candida cylindracea, Candida blanki, Candida krusei, Candida glabrata, Candida tropicalis* and *Saccharomyces cerevisiae* using the disc diffusion method. The sensitivity of fungi to various essential oils was compared with standard ketoconazole and an activity index was determined. Among the selected spices, asafoetida oil showed inhibitory activity toward all fungal strains, but activity was strong toward *C. tropicalis, C. albicans MTCC-227, S. cerevisiae* and *A. niger* while moderate toward *C. blanki, C. glabrata, C. krusei, C. cylindracea, C. albicans MTCC-3017* and *C. albicans NCIM-3100*. Essential oils extracted from the seeds of neem, mustard, black cumin and asafoetida were evaluated by Sitara et al[57] for their antifungal activity in 0.5, 0.1 and 0.15% against eight seed borne fungi viz., *Aspergillus flavus, A. niger, Fusarium moniliforme, Fusarium oxysporum, Fusarium nivlae, Fusarium semitectum, Drechslera hawaiiensis* and *Alternaria alternate*. Ridomyl gold (MZ 68% WP) was used for comparison. All the oils extracted except mustard, showed variation of degree of fungicidal activity against experimental species. Asafoetida oil significantly inhibited the growth of all test fungi except.[57] The antifungal and allelopathic effects of the methanol extract of asafoetida oleo-gum resin concentrations against *Pleurotus* spp. and *Trichoderma harzianumand* were investigated in dual culture experiments on an agar-based medium. It showed fungistatic and fungicidal properties against *T. harzianumand* and *Pleurotus* spp. at higher concentrations.[21] Ninety formulations of neem oil, nicotinic acid and *F. asafoetida* at different concentrations with α, β-unsaturated carbonyl compounds were screened for *in vitro* analysis against *Sclerotium rolfsii ITCC 5226* and *Macrophomina phaseolina ITCC 0482*. The formulations having *F. asafoetida* at a dose level of 66 mg/L as a natural product may be an effective novel alternative approach to control pathogenic fungi.[20] Mostafa et al[22] investigated the antifungal effect of asafoetida seed essential oil on some of plant pathogens fungi including: *Bipolaris sorokiniana, Fusarium graminearum, Verticillium sp, A. niger* and *Fusarium solani* based on completely randomized design and an *in vitro* method. Asafoetida seed essential oil compared with controls significantly inhibited the growth of all tested fungal species. *B. sorokiniana* growth completely inhibited by asafoetida seed essential oil, but inhibiting effect of other species was highly dose dependent. El Deeb et al[58] evaluated the activity of asafoetida against the *in vitro* growth of *Blastocystis* sp. Both powder and oil form of asafoetida extracts were incubated with isolates of *Blastocystis* sp. subtype 3 and compared to the reference antiprotozoan drug metronidazole. Both powder and oil form of asafoetida decreased counts and viability of all tested isolates of *Blastocystis* sp. subtype 3. The degree of the inhibitory effect was highly dependent on the concentration, form and time of incubation with asafoetida extracts. The lowest concentration of both powder and oil form of asafoetida that caused complete inhibition of *Blastocystis* growth and highest percentage inhibition of development was 16 and 40 mg/mL respectively. Asafoetida can potentially be used as a potent natural alternative Phytomedicine for treatment of *Blastocystis* sp. infection.[58]

4.8. Anticarcinogenic activity

Tumor reducing activity of extract of asafoetida was studied by Unnikrishnan and Kuttan[59] in mice transplanted intraperitoneally with Ehrlich ascites tumor. Asafoetida extract inhibited two stage chemical carcinogenesis induced by croton oil and 7,12-dimethyl benzanthracene on mice skin with considerable reduction in papiloma formation. It indicates the potential use of asafoetida as anticancer agents as well as antitumor promoters. Saleem et al[23] investigated the potential of antioxidant and anticarcinogenic activity of asafoetida in Swiss albino mice. The pretreatment of animals with asafoetida recovered the antioxidant level and reversed significantly the induced ornithine decarboxylase activity and DNA synthesis. Asafoetida can be an effective Chemopreventive agent and capable of alleviating cutaneous carcinogenesis. Mallikarjuna et al[25] were studied to ascertain the modulatory influences of *F. asafoetida* on the mammary epithelial tissue differentiation, hepatic drug metabolizing enzymes, antioxidant outlines and N-methyl-N-nitrosourea-induced mammary carcinogenesis in Sprague–Dawley rats. A significant decrease in tumor multiplicity after asafoetida treatment can be explained in light of the fact that the carcinogenic effect was suppressed to a considerable extent as evidenced by the strengthening of drug metabolizing and antioxidant enzymes, and also a striking reduction in the number of terminal end buds during mammary gland differentiation. The Chemopreventive potential of asafoetida was reflected in the reduced number of tumors per tumor bearing rat.

4.9. Anticancer activity

In 2015, Panwar et al[60] investigated the chemopreventive potential of different doses of *F. asafoetida* oleo-gum-resin on 1,2-dimethylhydrazine induced rat colon carcinogenesis by evaluating tumor size, tumor multiplicity and tumor incidence, serum total sialic acid levels as well as histoarchitecture of the colons of rats subjected to various treatment. The study revealed that asafoetida supplementation attenuates 1,2-dimethylhydrazine induced deleterious effects in of rats. The minimum dose of asafoetida (10 mg/100 g) exhibited more prominent effect as it continuously influenced all the tested biochemical parameters, which can be used as a promising chemopreventive agent against colon carcinogenesis.

4.10. Anti-quorum sensing activity

F. asafoetida was tested for its anti-quorum sensing activity against *P. aeruginosa*. Essential oil of *F. asafoetida* exhibited anti-quorum activity at 25 μg/mL of concentration and fully abolished the violacein production by *Chromobacterium violaceum*. Pyocyanin, pyoyerdine, elastase and biofilm production were decreased in *F. asafoetida* oil treatments. Expression analysis of quorum sensing dependent genes confirmed asafoetida as novel anti-quorum sensing and virulence inhibitors.[61]

4.11. Antihyperglycemic effect

Akhlaghi et al[62] evaluated the hypoglycemic activity of the asafoetida extract in streptozotocin induced diabetic rats. The asafoetida extract administration at dose of 50 mg/kg for 4 weeks has shown the hypoglycemic activity in streptozotocin-diabetic rats during 2nd week and 4th week of treatment period. Blood glucose level in streptozotocin induced diabetic animal is reduced may be at least in part by the presence of the phenolic acid and tannins in the extract.

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4.12. Farnesyltransferase inhibition, protein and metabolic activity

Farnesylation of the activated ras oncogene product by protein farnesyltransferase (FTase) is a critical step for its oncogenic function. The isolation of the coumarin-derived sesquiterpene galbanic acid from *F. asafoetida* extract as an active principal for FTase inhibitory action, collectively with the four structurally related sesquiterpenes such as karatayicinol, umbelliprenin, farnesiferol B and farnesiferol C. The 50% inhibitory concentration (IC_{50}) of galbanic acid against FTase in an enzyme-based assay was calculated as 2.5 μM. It also demonstrated potent inhibition of the proliferation of oncogenic ras-transformed NIH3T3/Hras-F in a dose-dependent manner. The IC_{50} value of galbanic acid on the proliferation of oncogenic ras-transformed NIH3T3/Hras-F cells was calculated as 16.2 μM, whereas its IC_{50} value on control vector-transfected normal ras-containing NIH3T3/ZIPneo cells was 58.5 μM.[63] Korashy et al[64] investigated the potential effects of 3 commonly used local herbal medicines such as *Nigella sativa, Trigonella foenum-graecum* and *F. asafoetida* on the expression of CYP2C11 gene at the mRNA, protein and metabolic activity levels in rat liver tissues. All the 3 herbs significantly inhibited the mRNA and protein expression levels of CYP2C11 in a dose-dependent manner. The *in vitro* enzymes metabolic activity study showed a significant decrease in the formation of 4-hydroxy-tolbutamide, a tolbutamide metabolite, at the higher doses. Asafoetida was a strong inhibitor of CYP2C11 expression that can lead to an objectionable pharmacological effect of clinically used CYP2C11 substrate drugs with a low therapeutic index.

4.13. Anti-cytotoxicity activity, anti-obesity and fat lowering effect

Cytotoxicity and anticonvulsant activity of the methanol extracts of some *Ferula* species particularly *F. asafoetida* were evaluated by Bagheri et al.[65] To evaluate general cytotoxicity, the brine shrimp (*Artemia salina*) was employed as a model assay system, it provided a suitable in-house pre-screening method. The methanol extracts of *Ferula* species and the oleo-gum resin of *F. asafoetida* exhibited cytotoxic effect with LC_{50} values in the range of 6–321 μg/mL and showed a dose-dependent cytotoxicity. Azizian et al[66] determined the effect of *F. asafoetida* on weight gain, fat accumulation, liver steatosis and leptin level in type 2 diabetic rats. Two treatment groups received *F. asafoetida* oleo-gum resin at doses of 25 or 50 mg/kg. Administration of *F. asafoetida* extensively decreased body weight, abnormal fat and size of epididymal adipocyte compared to untreated rats. Serum leptin levels were considerably decreased in treated rats. The results revealed that *F. asafoetida* gum has potent anti-obesity activities, fat lowering and can prevent liver steatosis. *F. asafoetida* gum can be a good candidate for the treatment of diabetes-induced obesity and hepatosteatosis.

4.14. Anxiolytic effect and anthelmintic activity

In 2012, Algasoumi[67] examined the anxiolytic, analgesic and sedative properties of asafoetida in rodents, using hole-board test, elevated plus maze, hot plate and motor activity meter. Diazepam was utilized as a reference anxiolytic agent. The results have shown a dose-dependent anxiolytic and analgesic activity of asafoetida, with a calm sedative outcome in high doses. Evaluated to diazepam, the asafoetida appears to be a better alternative for the treatment of anxiety disorders. The low doses of asafoetida can be a therapeutic alternative to the presently used anxiolytic drugs.

In 2013, Gundamaraju[68] evaluated the anthelmintic activity of three different concentrations of aqueous extract of *F. asafoetida* against *Pheretima posthuma* that involved the determination of time of paralysis and death of the worm. The extract has exhibited considerable anthelmintic activity at the highest concentration of 100 mg/mL. It has also shown better significant activity than the standard drug of piperazine citrate.[68] The effect of dried *Allium sativum* clove powder, *F. asafoetida* dried latex powder and flower but dried powder of *Syzygium aromaticum* in *in vitro* treatment against liver fluke *Fasciola gigantic* were studied by Kumar and Singh.[69] The anthelmintic activities of all the three plants were both concentration and time dependent. Ethanol extract was more toxic than other organic extract. The ethanol extract of *F. asafoetida* was highly toxic against *F. gigantic*. The dried root latex powder of *F. asafoetida* can be used as potent helminthicide.

4.15. Spermatic, testicular histopathology and antagonistic effect

In 2015, Bagheri et al[70] evaluated the effectiveness of asafoetida on spermatic parameters, blood testosterone levels and testis tissue. The asafoetida significantly increased the number and viability of sperms. Histological study showed that numbers of Leydig cells and spermatogenesis process were increased with increasing the dose. Johnsen score was found to be more when compared with experimental groups rather than the control group. Asafoetida has shown a positive effect on spermatic parameters even though the histopathological effects on the testis were observed, particularly at high doses.

Kiyanmehr et al[71] evaluated the effect of different concentrations of *F. asafoetida* extract, a muscarinic receptor antagonist, and saline on methacholine concentration-response curve in tracheal smooth muscles incubated with β-adrenergic and histamine (H1) [group 1], and alone β-adrenergic [group 2] receptors antagonists. The study showed a parallel right-ward shift in the concentration-response curve of methacholine and achievement of maximum response in the presence of *F. asafoetida,* which support the competitive antagonistic effect of *F. asafoetida* at muscarinic receptor. The absence of maximum response to methacholine in group 1, also suggest an inhibitory effect for the plant on histamine (H1) receptor of tracheal smooth muscles.

5. Toxic effect

A case of methemoglobinemia has been registered after intake of asafoetida in a 5 week old black male infant. He was recovered by the treatment of intravenous methylene blue from onset of tachypnea, grunting and cyanosis.[72] Large dose intake of asafoetida can lead to swelling of the mouth, digestive illness such as flatulence and diarrhea, anxiety and headache. The intake of asafoetida is prohibited during the pregnancy.[73]

6. Conclusion

On the basis of the available evidences in the literature, asafoetida can be used as different medicines by its phytochemical and biological activities. It is also widely used all over the world as an aroma spice in different foodstuff. Traditionally it is very much utilized for the treatment of a variety of diseases. In recent studies of pharmacological and biological activities have also shown that asafoetida acquire numerous activities such as a relaxant, neuroprotective, memory enhancing, digestive enzyme, antioxidant, antispasmodic, hypotensive, hepatoprotective, antimicrobial, anticarcinogenic, anticancer, anticytotoxicity, antiobesity, anthelmintic and antagonistic effect. Even though Asafoetida has very good medicinal significance, detailed studies are also very much needed.

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Conflict of interest

None declared.

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Please cite this article in press as: Amalraj A, Gopi S, Biological activities and medicinal properties of Asafoetida: A review, Journal of Traditional and Complementary Medicine (2016), http://dx.doi.org/10.1016/j.jtcme.2016.11.004

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