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Phytochemistry and therapeutic effects of *Alhagi* spp. and Tarangabin in traditional and modern medicine: a review

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ABSTRACT

Alhagi maurorum is one of the species of *Alhagi* genus producing manna of Tarangabin. Tarangabin is mainly prepared in Iran and Afghanistan. The medicinal properties of Tarangabin and *A. maurorum* have been mentioned in some major Materia Medica manuscripts in the Islamic era. Tarangabin has various pharmacological properties including antioxidant, anti-inflammatory, antipyretic, diaphoretic, diuretic, expectorant, analgesic and gastrointestinal effects. The purpose of this review is to introduce *Alhagi* plant and its different species, to present its geographical distribution, and to review its phytochemical and pharmacological properties as well as traditional and folklore applications. Phytochemistry of different parts of *Alhagi*, such as root, leaf and manna is also explained in details. In addition, temperament and medicinal uses of Tarangabin mentioned in the Islamic traditional medicine (ITM) books are presented. Indeed, sparse clinical research has been done on the medicinal properties of Tarangabin, which calls for future well-designed trials.

Implication for health policy/practice/research/medical education:
This review highlights the health benefits of *Alhagi* spp. and Tarangabin in the treatment of human diseases.
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Introduction

Alhagi maurorum Medik. (from Fabaceae family) is a perennial plant with a wide geographical distribution. Animal and human studies have been conducted on its effects, some of which include antioxidant, anti-inflammatory, antipyretic, diaphoretic, diuretic, expectorant and analgesic properties (1,2). Its morphology, nature, and clinical uses have been explained in the Materia Medica manuscripts in Islamic era by the sage physicians (3-5).

Tarangabin, a kind of manna which is produced on some *Alhagi* species, is collected mostly in Iran and Afghanistan and exported from these areas to other countries. Special attention has been paid to Tarangabin in some major Materia Medica manuscripts of Islamic era as one of the most commonly used medicinal matters in Islamic traditional medicine (ITM) (3,4,6,7). However, few studies have been performed on its pharmacological effects.

The aim of this study is to review its uses in ethnobotanical, traditional medical schools, and ITM, and to present its phytochemical plus pharmacological

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priorities found in recent studies.

Botany of *Alhagi maurorum*

Alhagi maurorum commonly called camelthorn belongs to Fabaceae (Papilionaceae) family. Fabaceae is the third largest flowering plant family, following Orchidaceae (Orchid family) and Asteraceae (Aster family), which consists of more than 700 genera and about 20 000 species of trees, shrubs, vines, and herbs worldwide (8). According to The Plant List, there are 38 scientific plant names of species ranking for the genus *Alhagi*, of these 9 are accepted species names. Table 1 summarizes all synonyms of *Alhagi* species based on the website 'TPL' (http://www.theplantlist.org.). This is a perennial shrub with a height of 40 to 80 cm, without fluff and green, with numerous thorns. It grows in tropical and subtropical regions which can be found in dry, rocky, and salty soils (9) and grows in disturbed urban areas along waterway, rivers, irrigation paths of farms, and farmlands (10). Its roots are stout, cylindrical, tortuous, externally dark brown and internally pale brown. The stem arising from the stout basal cylindrical underground crown has aerial branches. The leaves are simple, elliptical, alternate, oblong, mucronate, subsessile, hairy, young drooping, stipulate, with silvery hue, 0.5 to 1.0 cm long and 0.2 to 0.5 cm wide (2).

Small pink flowers lie on a spiky axis and on the upper parts of the plant. The fruits are brown to red (11,12). In different countries, the root, stem, leaf, flower, and manna of this plant are used in the treatment of different diseases.

Geographical distribution

This plant is found in wet and tropical regions as well as in Eurasia and Northern India, the Middle East, Afghanistan, Azerbaijan, Armenia, Iran, Iraq, Cyprus, Jordan, Kazakhstan, Kuwait, United Arab Emirates, Bahrain, Saudi Arabia, Palestine, Lebanon, Mongolia, Pakistan, Syria, Tajikistan, Turkmenistan, Turkey, Uzbekistan, Russia, Northwest China, China in the Uyghur region Xin Jiang, India more in dry areas of Gujarat, Punjab, Uttar Pradesh Rajasthan, Southeast Europe, Australia, America, and North Africa (2).

Alhagi species have different common names in each region, as listed in Table 2.

Tarangabin (Manna of *Alhagi*)

Tarangabin is a kind of manna with various names such as Merniabin manna, *Alhagi* manna, and Caspian manna (Table 3).

It is sweet, yellowish-white in color and semi-liquid exudate, created on the aerial parts of some *Alhagi* genera such as *A. maurorum*. Tarangabin is produced by an insect called *Poophilus nebulosus* Leth which lives on the aerial parts of the plant. The insect belongs to the genus *Larinus*, Cercopidae family, *Homoptera phylum*. Indeed, Tarangabin is the exudation of this insect produced after nourishment on *A. maurorum*, which crystallizes and dries on the plant. It is not producible from all genera of *Alhagi*. In addition, the climate condition can play a significant role in the formation of Tarangabin. As a result, in a particular species of *Alhagi*, presence of *P. nebulosus* and appropriate climate are necessary for the formation of Tarangabin (16).

Ibn Sina (Avicenna, 980–1037 C.E) mentioned Tarangabin as a crop of Khorasan and Transoxiana (Māwarā' an-Nahr). At time, it can be obtained from other provinces of Iran including Yazd, Qom, Bushehr, eastern

Table 1. Scientific names and synonym(s) of reported *Alhagi species* [according to The Plant List (2013)]

***Alhagi* species (Accepted names)**	**Synonym(s)**
Alhagi canescens (Regel) B.Keller & Shap.	*Alhagi camelorum* var. *canescens* Regel *Alhagi maurorum subsp. canescens* (Regel) Yakovlev
Alhagi graecorum Boiss.	*Alhagi mannifera* Jaub. &Spach *Alhagi tournefortii* Heldr.
Alhagi kirghisorum Schrenk	*Alhagi maurorum* subsp. *kirghisorum* (Schrenk) Yakovlev
Alhagi maurorum Medik.	*Alhagi camelorum* DC. *Alhagi camelorum* Fisch. *Alhagi camelorum* var. *spinis-elongatis* Boiss. *Alhagi maurorum* subsp. *maurorum*, *Alhagi persarum* Boiss. & Buhse, *Alhagi pseudalhagi* (M.Bieb.) Fisch., *Hedysarum alhagi* L., *Alhagi pseudalhagi* subsp. *persarum* (Boiss. & Buhse) Takht., *Hedysarum pseudalhagi* M.Bieb
Alhagi maurorum var. *turcorum* (Boiss) Meikle	*Alhagi camelorum* var. *turcorum* (Boiss.) Boiss. *Alhagi turcorum* Boiss.
Alhagi nepalensis (D. Don) Shap.	*Alhagi napaulensium* DC. *Manna nepalensis* D.Don
Alhagi pseudalhagi (M. Bieb.) Desv. ex B. Keller & Shap.	
Alhagi sparsifolia Shap.	*Alhagi kirghizorum* var. *sparsifolia* Shap. *Alhagi maurorum* subsp. *sparsifolium* (Shap.) Yakovlev
Alhagi sparsifolium (Shap.) Shap.	*Alhagi kirghisorum* var. *sparsifolium* Shap.

Table 2. Common names of *Alhagi* species

Region/country/language	Common names	Ref.
Iran	khareshotor, oshtorkhar, khardaro, alafe taranjabin, kharangabin, haj	(3, 4, 6)
Turkish	Doe Ticani	(3, 4)
India	Bharbhara, Jawasa	(1, 2, 4)
Arabic	Shook, Aqool, Shook El Jamal, Shprim, Lehlah, shokai	(1, 4, 5)
English	Camel thorn bush, Caspian manna, Persian manna	(1, 13)
French	Alhagi des Maures	(1)
Germany	Kameldorn Manna, Mannastrauch	(1)
Italian	Lupinella alhagi, Manna di Persia	(1)
South Africa	Kameeldoringbos, Volstruisdorin	(1, 13)

Table 3. Common names of Tarangabin

Language	Common names	Ref.
Persian	Tar-angabin, Terenjebin, Oshtorangebin, Asal al nada (Dew honey),	(5, 14, 15)
English	Merniabin manna, Alhagi manna, Hedysarum manna and Caspian manna	(14, 15)
French	Manne de perse, Manne d' hedysarum and Manna d' alhagi	(14, 15)

Azerbaijan and Hamedan, as well as from Afghanistan (Herat and Kandahar) and Uzbekistan (Bukhara).

Tarangabin is usually collected during the night and early in the morning depending on the weather conditions of the area, from the end of spring to fall. This manna appears on the shoots and leaves of the herb and dries in air (15,17).

Alhagi maurorum and Tarangabin in ITM

Nature of *Alhagi* and Tarangabin described in ITM

Abū Rayḥān Bērōnī (973–1050 C.E) wrote about *Alhagi maurorum*: The plant has a very long root reaching water or moisture, has a small red fruit that is also covered with red pods. Its leaves are tube-shaped and among them, there are green insects with a broad head. He considered Tarangabin as a product of *Alhagi* (5). Its temperament is considered hot and dry in Medica manuscripts (3,4).

Ibn Sina knew Tarangabin as a kind of dew coagulated (produced) on *Alhagi* of the Khorasan and Transoxiana regions. He declared that the best crop for medicinal use should be fresh and white, and recognized its temperament to be moderate and mildly hot.

Other authors in Persia and Islamic lands also followed Avicenna opinion about the temperament of Tarangabin (3,18,19), but Aqili Shirazi (1670-1747 C.E), the writer of Makhzan al-adviyah, considered its temperament hot and wet (4).

The therapeutic doses of Tarangabin can range from 35 to 140 g depending on the patient's condition (7).

Pharmacological actions and therapeutic usages of *Alhagi* and Tarangabin according to ITM literature

Aqili described the pharmacological properties of *Alhagi* as follows: restrainer (radi), opener (mofatih), detergent (jali), and antidote (Padzahr). He recommended it for the treatment of joint pain and headache, and especially advised its blossom for improving hemorrhoid as a well-experienced treatment (4). It is recommended as a topical treatment for progressive ulcers (3).

Tarangabin is highly used in ITM, which is recommended in the treatment of various diseases (7,20). Tarangabin properties as listed in the majority of ITM literature include laxative, detergent, purgative for yellow bile, cough reliever, thirst quencher, antipyretic, antiemetic, and warming agent of the body. It has been suggested in compound forms to treat some ailments for example with butter for dysuria, with fresh milk to increase libido, and with cumin to resolve flatulence (6,7,13,21).

A combined form of Tarangabin and milk called Dava-al-tarangabin has been described in ITM literature and recommended as one of the most effective medications for renal ailments which can be known as chronic kidney disease today (7).

Contraindications for *Alhagi* and Tarangabin in ITM

Based on the Medica manuscripts of ITM, *Alhagi* is harmful for kidney and it should be consumed with Tragacanth as modifier. Tarangabin is prohibited in acute fever, smallpox, typhoid, bloody diarrhea and hemorrhage. It is also harmful for spleen and for those with hot temperament, but if consumed with tamarind, jujube or decoction of barley, the side effects will be prevented (3,4).

Folklore claims

Due to the geographic distribution of *Alhagi*, people from different countries use the components of this plant in folk medicine to treat various diseases, which are presented in Table 4.

Table 4. Folklore claims of *Alhagi* species in various countries

Country or Area	Medicinal properties	Ref.
Egypt	Used to treat various types of gastrointestinal discomfort, liver and urinary tract disorders.	(2)
India	Laxative, diuretic, used for the treatment of asthma, rheumatism, fever, hemorrhoid, chest pain and headache	(2)
Iran	Icterus, laxative, febrifuge, thirst quencher, aphtos ulcers, antidiarrheal, diuretic and kidney stone, appetite suppressant, diuretic, febrifuge, hemorrhoids, cardiac pains and dysuria	(22-24)
China	Rheumatism, cancer	(2)
Palestine	Urinary system and kidney stones	(25)
Turkey	Tonic	(26)
Jordan	Kidney stones	(2)
Afghanistan	Treatment of gastrointestinal diseases (dysentery, diarrhea), kidney stones, jaundice, skin wounds, and as appetizer, cholagogue	(27)
Pakistan (Baluchistan)	Improvement of eyesight, powder of dry flowers in stomachache Anti-rheumatic, anti-piles	(2,28)
Qatar	Used for treating cataracts, jaundice, migraine, painful joints and as an aphrodisiac.	(29)
South Asian countries	Gastrointestinal tracts and hemorrhoids	(30)
Saudi Arabia	Anti-tussive, anti-hemorrhoids, analgesic, aphrodisiac, diuretic and laxative, antioxidant, anti-nociceptive	(31)
Uzbekistan	Cough, bleeding, dysenteries, diuretic, gastritis, hemorrhoids, dysentery, nasopharynx, angina, antipyretic, eczema	(32)

Phytochemical study

Phytochemical studies have revealed the presence of many compounds in the *Alhagi* species. The majority of these compounds are sugars, polyphenols, flavonoids, essential oil, alkaloids, and other compounds. Table S1 presents the most important compounds isolated from *Alhagi* species along with their structures (Table 5).

Polyphenols are compounds that are abundant in nature, many of which have been identified. Polyphenols are classified according to the number of phenolic rings and structural elements that connect these rings to each other. Flavonoids, lignans, and phenolic acids are among them.

Flavonoids, a large and important group of natural substances with a polyphenolic structure, are found in fruits, vegetables, and certain drinks. These natural compounds are known and have health-promoting effects (33-35). Flavonoids can be divided into different subgroups depending on their structures. These subgroups include anthoxanthins, flavanones, flavanonols, flavans, and anthocyanidins. Flavanones are an important class of flavonoids, with rutin being an example that is isolated from the aerial parts of *A. sparsifolia* (36). Anthocyanins are flavonoids responsible for color production in plants, flowers, and fruits. Among these, cyanidin and delphinidin derivatives are of the most important compounds, which are extracted from the aerial parts of *A. pseudalhagi* (37).

Essential oils are a large group of volatile compounds, which are found in *Alhagi* species. Essential oils, like other organic compounds, are composed of hydrocarbon molecules and are divided into terpenes, alcohols, esters, aldehydes, ketones, and phenols.

We found few phytochemical studies on Tarangabin. Paucity of phytochemical studies on Tarangabin may be due to the simplicity of its chemical ingredients. These ingredients in Tarangabin are sugars whose content is as follows: melissitoz sugar (47.7%), sucrose (26.44%), and fructose reductant (11.5%) (15).

Attributing all the pharmacological effects of Tarangabin to the sugars seems doubtful, thus requiting interdisciplinary studies in this regard.

Pharmacological properties of *Alhagi*

Gastrointestinal effects

An animal study on rats evaluated the anti-ulcerogenic effects of *A. maurorum* extract (AME) in two types of gastric ulcers induced by alcohol and water immersion restraint-stress. The AME reduced gastric acid content and elevated gastric pH in water immersion restraint-stress ulcer (38). In an experimental study on rats, administration of *A. maurorum* ethanol extract protected against inflammation caused by aspirin. The acid output diminished for *Alhagi* extract more than for ranitidine (39). Another study on rabbit showed the antidiarrheal activity of AME. This study investigated the effect of *A. maurorum* on the castor oil-induced diarrhea. The anti-diarrheal effect of *Alhagi* might be due to its calcium channel-blocking properties (40).

Hepatoprotective effects

In a study, the crude extracts of aerial parts of *A. maurorum* at the doses of 250 and 500 mg/kg were devoid of any hepatoprotective effects in Wistar albino rats with liver injury induced by carbon tetrachloride (41). However, in another study administration of 660 mg/kg of the ethanol extract of *A. maurorum* to mice yielded a significant hepatoprotective effect against carbon tetrachloride and acetaminophen; it revealed a significant decrease in the

Table 5. Chemical structures of the major compounds isolated from different parts of *Alhagi* species

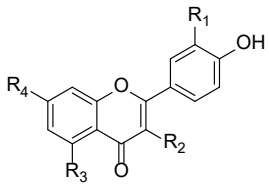
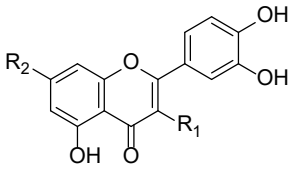
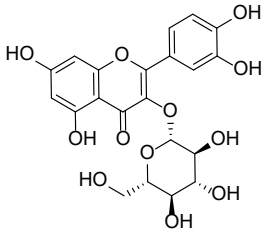
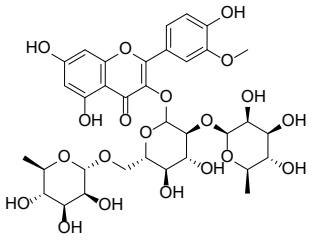
No.	Name of compounds	Structures	Species	Plant parts	Ref
		polyphenols			
					
1	kaempferol: R_1= H, R_2= OH, R_3= OH, R_4= OH		*A. maurorum*	Aerial parts	(58)
			A. pseudalhagi	Aerial parts	(59)
2	kaempferol-3-galactorhamnoside: R_1= H, R_2= galactose-rhamnos, R_3= OH, R_4= OH		*A. maurorum*	Aerial parts	(58)
3	kaempferol 3-*O*-β-$_D$-rutinoside: R_1= H, R_2= *O*-β-$_D$-rutinoside, R_3= OH, R_4= OH		*A. sparsifolia*	Aerial parts	(36)
4	kaempferol-3-*O*-β-$_D$-(6-*O*-*p*-coumaroyl)-glucoside: R_1= H, R_2= *O*-β-$_D$-(6-*O*-*p*-coumaroyl)-glucoside, R_3= OH, R_4= OH		*A. pseudalhagi*	Aerial parts	(60)
5	chrysoeriol: R_1= OMe, R_2= H, R_3= OH, R_4= OH		*A. maurorum*	Aerial parts	(58)
6	chrysoeriol-7-*O*-xylosoid: R_1= OMe, R_2= H, R_3= OH, R_4= xylose		*A. maurorum*	Aerial parts	(58)
					
7	quercetin: R_1= OH, R_2= OH		*A. sparsifolia*	Aerial parts	(36)
			A. pseudalhagi	Aerial parts	(59)
			A. persarum	Aerial parts	(61)
8	quercetin-3-*O*-α-$_L$-rhamnopyranoside: R_1= *O*-α-$_L$-rhamnopyranoside, R_2= OH		*A. persarum*	Aerial parts	(61)
9	quercetin-3-*O*-(2-β-$_D$-xylopyranosylrutinoside: R_1= *O*-(2-β-$_D$-xylopyranosylrutinoside, R_2= OH		*A. sparsifolia*	Aerial parts	(36)
10	quercetin-3-O-(2'', 6''-di-*O*-α-$_L$-rhamnopyranosyl)-β-$_D$-glucopyranoside: R_1= *O*-(2'', 6''-di-*O*-α-$_L$-rhamnopyranosyl)-β-D-glucopyranoside, R_2= OH		*A. sparsifolia*	Aerial parts	(36)
11	quercetin-3-*O*-β-$_D$-glucopyranoside: R_1= *O*-β-$_D$-glucopyranoside, R_2= OH		*A. sparsifolia*	Aerial parts	(36)
12	quercetin-3-*O*-α-$_L$-arabofuranoside: R_1= *O*-α-$_L$-arabofuranoside, R_2= OH		*A. persarum*	Aerial parts	(61)
13	quercetin 3, 7-diglycoside: R_1= glycoside, R_2= glycoside		*A. maurorum*	Aerial parts	(1)
14	quercetin 3-*O*-β-$_D$-glucopyranoside R_1= *O*-β-$_D$-glucopyranoside, R_2= OH		*A. maurorum*	Whole plant material	(62)
15	Isoquercitrin		*A. pseudalhagi*		(63)
			A. pseudalhagi	Aerial parts	(60)
16	Typhaneoside		*A. sparsifolia*	Aerial parts	(36)

Table 5. Continued

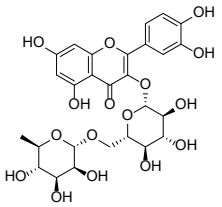
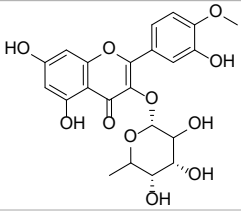
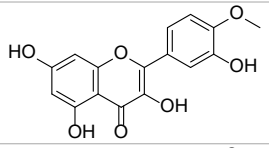
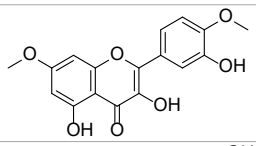
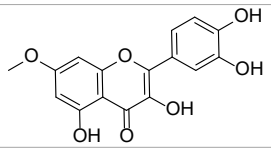
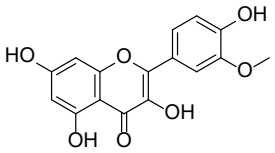
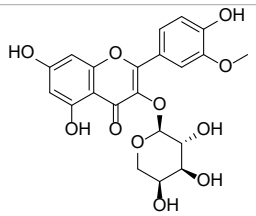
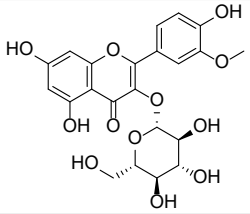
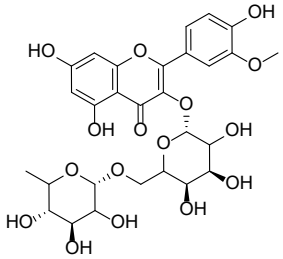
No.	Name of compounds	Structures	Species	Plant parts	Ref
17	Rutin		*A. sparsifolia*	Aerial parts	(36)
			A. pseudalhagi	Aerial parts	(59)
18	Tamarixetin 3-*O*-rhamnoside		*A. maurorum*	Aerial parts	(1)
19	Tamarixetin		*A. pseudalhagi*	Aerial parts	(60)
20	Ombuine		*A. pseudalhagi*	Aerial parts	(60)
21	Rhamnetin		*A. pseudalhagi*	Aerial parts	(60)
22	Isorhamnetin		*A. maurorum*	Aerial parts	(58)
			A. sparsifolia	Aerial parts	(36)
			A. pseudalhagi	Aerial parts	(59,60)
			A. persarum	Aerial parts	(61)
23	isorhamnetin-3-*O*-α-$_{L}$-arabopyranoside		*A. persarum*	Aerial parts	(61)
24	isorhamnetin 3-*O*-β-$_{D}$-glucopyranoside		*A. pseudalhagi*	Aerial parts	(59)
			A. persarum	Aerial parts	(61)
25	isorhamnetin 3-*O*-β-$_{D}$-rutinoside		*A. pseudalhagi*	Aerial parts	(59,60)
			A. sparsifolia	Aerial parts	(36)

Table 5. Continued

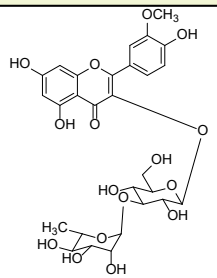
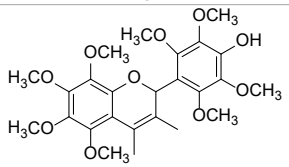
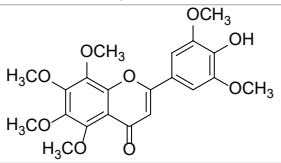
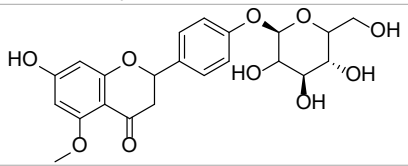
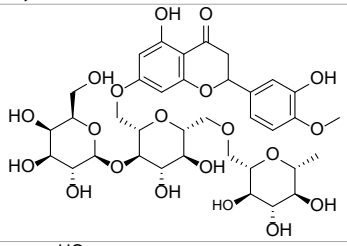
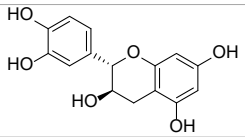
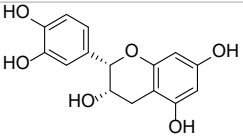
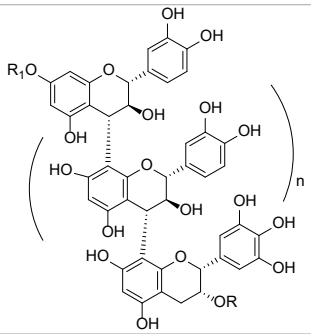
No.	Name of compounds	Structures	Species	Plant parts	Ref
26	isorhamnetin-3-*O*-[-a-$_L$-rhamnopyranosyl-(1→3)]-β-$_D$-glucopyranoside		*A. maurorum*	Whole plant material	(62)
27	5,6,7,8,2′,3′,5′,6′-octamethoxyflavan-3-en-4′-ol		*A. maurorum*	Roots	(64)
28	5,6,7,8,3′,4′,5′-heptamethoxyflavone		*A. maurorum*	Roots	(64)
29	Alhagitin		*A. pseudalhagi*	whole plant	(65)
30	Alhagidin		*A. pseudalhagi*	whole plant	(65)
31	Catechin		*A. camelorum*	Aerial parts root	(66)
32	Epicatechin		*A. camelorum*	Aerial parts root	(66)
					
33	Alhacin: R= H, R_1= Glcp $\xrightarrow{6}$ Galloyl, n=1		*A. pseudalhagi*	Aerial parts	(30)
34	Alhacidin: R= Galloyl, R_1= Glcp $\xrightarrow{6}$ Galloyl, n= 3		*A. pseudalhagi*	Aerial parts	(30)

Table 5. Continued

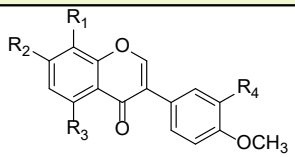
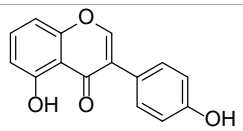
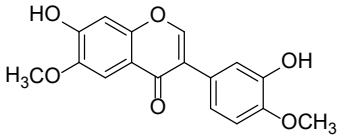
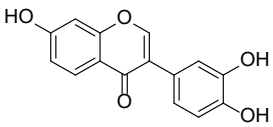
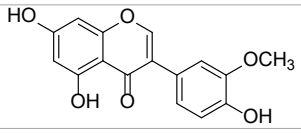
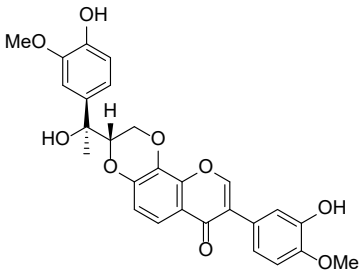
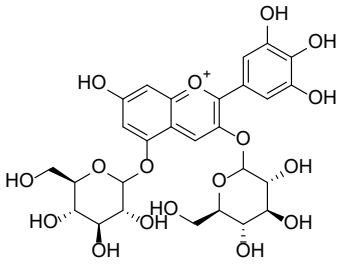
No.	Name of compounds	Structures	Species	Plant parts	Ref
					
35	pratensein: R_1= H, R_2= OH, R_3= OH, R_4= OH		*A. pseudalhagi*	Aerial parts	(67)
36	calycosin: R_1= H, R_2= OH, R_3= H, R_4= OH		*A. pseudalhagi*	Aerial parts	(67)
37	3′,7-dihydroxyl-4′,8-dimethoxylisoflavone: R_1= OMe, R_2= OH, R_3= H, R_4= OH		*A. pseudalhagi*	Aerial parts	(67)
			A. pseudalhagi		(63)
			A. sparsifolia	Aerial parts	(36)
38	3′,7-dihydroxyl-4′-methoxylisoflavone: R_1= H, R_2= OH, R_3= H, R_4= OH		*A. sparsifolia*	Aerial parts	(36)
			A. pseudalhagi		(63)
39	formonoetin: R_1= H, R_2= OH, R_3= H, R_4= H		*A. pseudalhagi*	Aerial parts	(67)
			A. sparsifolia	Aerial parts	(36)
			A. pseudalhagi		(63)
40	ononin: R_1= H, R_2= OGlc, R_3= H, R_4= H		*A. pseudalhagi*	Aerial parts	(67)
			A. pseudalhagi	Aerial parts	(59)
41	daidzein 4',7-dihydroxy isoflavone		*A. maurorum*	Aerial parts	(1)
42	3′,7-dihydroxyl-4′,6-dimethoxylisoflavone		*A. sparsifolia*	Aerial parts	(36)
43	3′,4′,7-trihydroxylisoflavone		*A. sparsifolia*	Aerial parts	(36)
44	3′-*O*-methylorobol		*A. maurorum*	whole plant material	(62)
			A. maurorum	Aerial parts	(1)
45	isoflavonolignan		*A. pseudalhagi*	Aerial parts	(67)
46	delphinidin-3,5-diglucoside		*A. pseudalhagi*	Aerial parts	(37)

Table 5. Continued

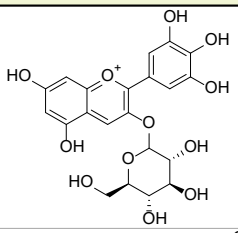
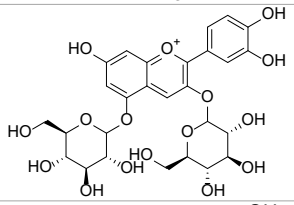
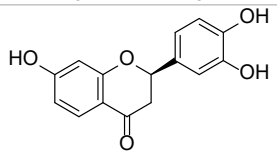
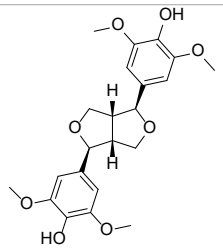
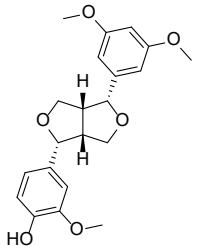
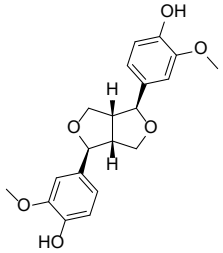
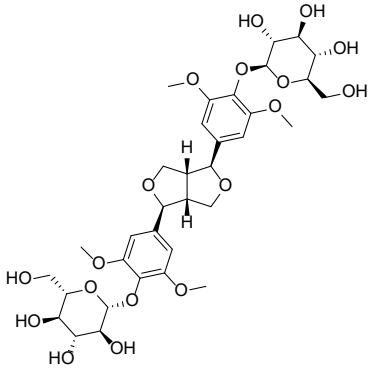
No.	Name of compounds	Structures	Species	Plant parts	Ref
47	delphinidin-3-monoglucoside		*A. pseudalhagi*	Aerial parts	(37)
48	cyanidin3,5-diglucoside		*A. pseudalhagi*	Aerial parts	(37)
49	Butin		*A. sparsifolia*	Aerial parts	(36)
50	Syringaresinol		*A. sparsifolia*	Aerial parts	(36)
51	bombasinol A		*A. sparsifolia*	Aerial parts	(36)
52	Pinoresinol		*A. sparsifolia*	Aerial parts	(36)
53	Liriodendrin		*A. sparsifolia*	Aerial parts	(36)

Table 5. Continued

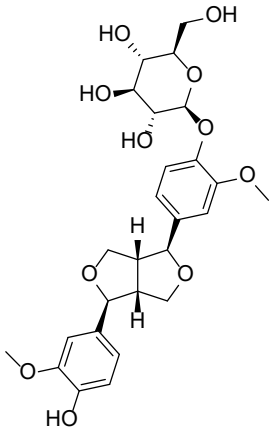
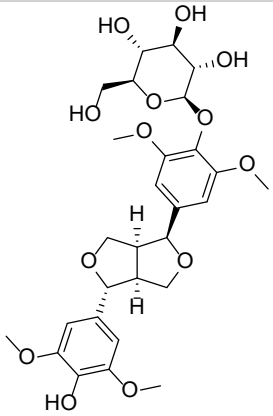
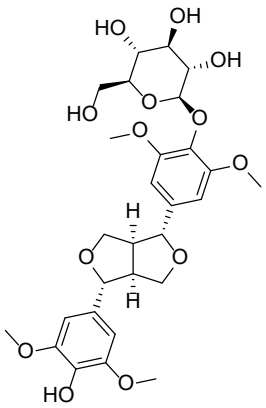
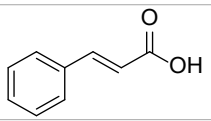
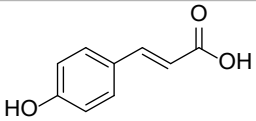
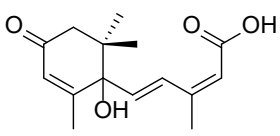
No.	Name of compounds	Structures	Species	Plant parts	Ref
54	Pinoresinol-4-*O*-β-$_D$-glucopyranoside		*A. sparsifolia*	Aerial parts	(36)
55	(+) Tortoside A		*A. sparsifolia*	Aerial parts	(36)
56	(-) tortoside A		*A. sparsifolia*	Aerial parts	(36)
57	*trans*-cinnamic acid		*A. maurorum*	Aerial parts	(68)
58	*p*-coumaric acid		*A. maurorum*	Aerial parts	(68)
59	abscisic acid		*A. sparsifolia*	Aerial parts	(36)

Table 5. Continued

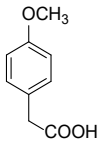
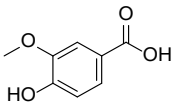
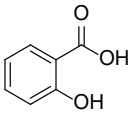
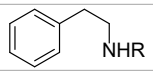
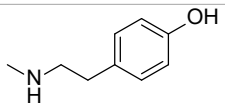
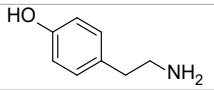
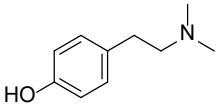
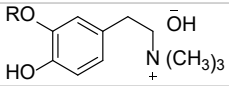
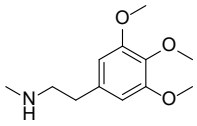
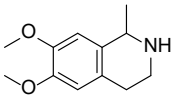
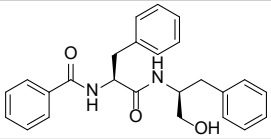
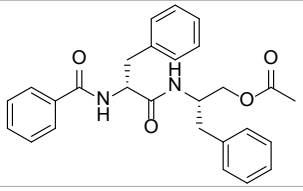
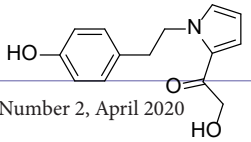
No.	Name of compounds	Structures	Species	Plant parts	Ref
60	Methoxyphenyl acetic acid		*A. sparsifolia*	Aerial parts	(36)
61	Vanillic acid		*A. pseudalhagi*		(63)
62	Saliylic acid		*A. pseudalhagi*		(63)
	Alkaloids				
					
63	β-phenethylamine: R= H		*A. pseudalhagi*	Stems roots	(69)
			A. pseudalhagi	Roots	(70)
64	*N*-methyl-β-phenethylamine: R= CH_3		*A. pseudalhagi*	Stems roots	(69)
			A. pseudalhagi	Roots	(70)
65	*N*-methyl-tyramine		*A. pseudalhagi*	Stems roots	(69)
66	Tyramine		*A. pseudalhagi*	Aerial parts	(60)
67	Hordenine		*A. pseudalhagi*	Stems roots	(69)
			A. pseudalhagi	Roots	(70)
					
68	4-dihydroxy-β-phenethyltrirnethylammonicrm hydroxide: R=H		*A. pseudalhagi*	Stems roots	(69)
			A. pseudalhagi	Roots	(70)
69	3-methoxy-4-hydroxy-β-phenethyltrimethylammonium hydroxide: R= CH_3		*A. pseudalhagi*	Stems roots	(69)
70	*N*-methylmescaline		*A. pseudalhagi*	Stems roots	(69)
			A. pseudalhagi	Roots	(70)
71	Salsolidine		*A. pseudalhagi*	Stems roots	(69)
			A. pseudalhagi	Roots	(70)
72	Aurantiamide		*A. sparsifolia*	Aerial parts	(36)
73	aurantiamide acetate		*A. sparsifolia*	Aerial parts	(36)
74	Alhagifoline A		*A. pseudalhagi*	Aerial parts	(55)

Table 5. Continued

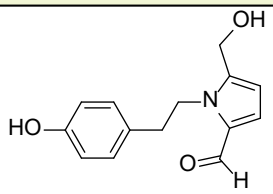
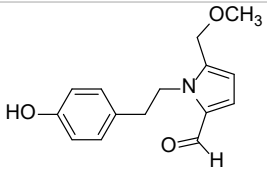
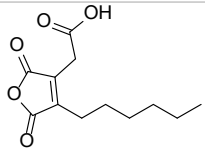
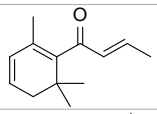
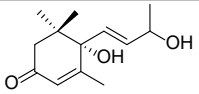
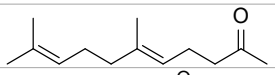
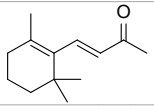
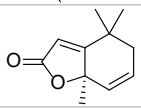
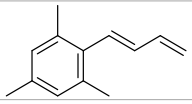
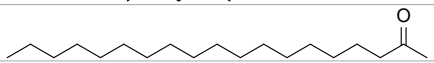
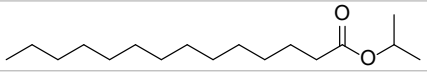
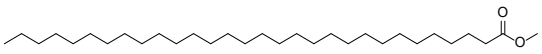
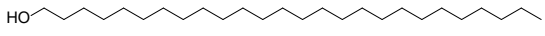
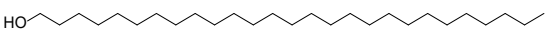
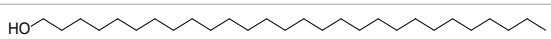
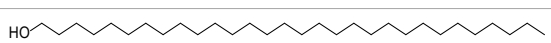
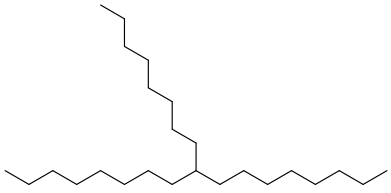
No.	Name of compounds	Structures	Species	Plant parts	Ref
75	Pyrrolezanthine		*A. pseudalhagi*	Aerial parts	(55)
76	Pyrrolezanthine-6-methyl ether		*A. pseudalhagi*	Aerial parts	(55)
		Essential oils			
77	4-hexyl-2,5-dihydro-2,5-dioxo-3-furanacetic acid		*A. maurorum*	Leaves	(71)
78	β-Damascenone		*A. maurorum*	Stems	(71)
79	Blumenol A		*A. sparsifolia*	Aerial parts	(36)
80	*E*-geranyl acetone		*A. maurorum*	Stems	(71)
81	*trans*-β-ionone		*A. maurorum*	Stems	(71)
82	Actinidiolide		*A. maurorum*	Stems	(71)
83	2-(1,3-butadienyl)-1,3,5-trimethylbenzene		*A. maurorum*	Stems	(71)
84	2-nonadecanone		*A. maurorum*	Leaves	(71)
85	Isopropyl myristate		*A. maurorum*	Stems	(71)
86	Triacontanoic acid methyl ester		*A. pseudalhagi*	Aerial parts	(59)
87	1- hexacosanol		*A. pseudalhagi*	Aerial parts	(59)
88	1-heptacosanol		*A. pseudalhagi*	Aerial parts	(59)
89	Octacosanol		*A. pseudalhagi*	Aerial parts	(59)
90	1-triacontanol		*A. pseudalhagi*	Aerial parts	(59)
91	9-octylheptadecane		*A. maurorum*	leaves	(71)

Table 5. Continued

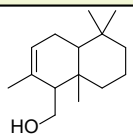
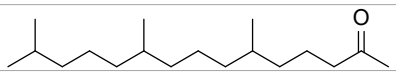
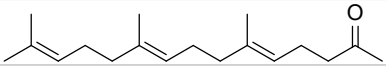
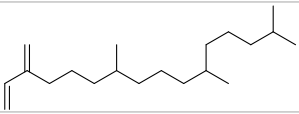
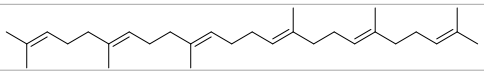
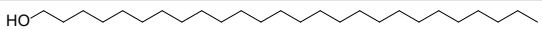
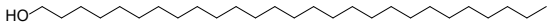
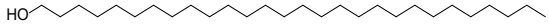
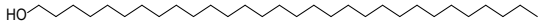
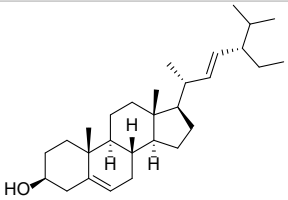
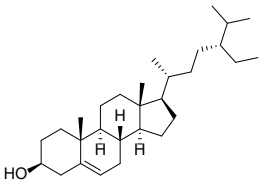
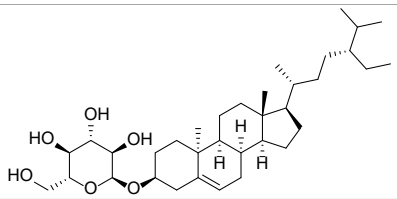
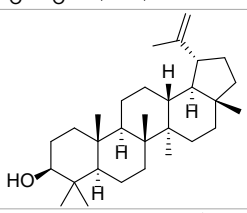
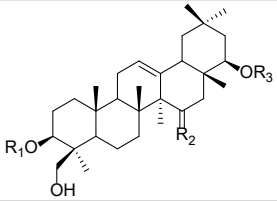
No.	Name of compounds	Structures	Species	Plant parts	Ref
92	Drimenol		*A. maurorum*	Leaves	(71)
93	6,10,14-Trimethyl-2-pentadecanone		*A. maurorum*	Stems	(71)
94	farnesyl acetone		*A. maurorum*	Stems	(71)
95	Neophytadiene		*A. maurorum*	Stems	(71)
96	Pentacosane		*A. maurorum*	Leaves	(71)
97	Squalene		*A. maurorum*	Leaves stems	(71)
98	Nonacosane		*A. maurorum*	Stems	(71)
99	Hentriacontane		*A. maurorum*	Stems	(71)
100	1-hexacosanol		*A. pseudalhagi*	Aerial parts	(59)
101	1-heptacosanol		*A. pseudalhagi*	Aerial parts	(59)
102	Octacosanol		*A. pseudalhagi*	Aerial parts	(59)
103	1-triacontanol		*A. pseudalhagi*	Aerial parts	(59)
104	Stigmasterol		*A. pseudalhagi*	Aerial parts	(60)
105	β-sitoserol		*A. pseudalhagi*		(63)
			A. maurorum	Aerial parts	(68)
106	β-sitosterol-3-*O*-β-$_D$-glucopyranoside		*A. maurorum*	Aerial parts	(68)
107	Lupeol		*A. maurorum*	root barks	(72)
					

Table 5. Continued

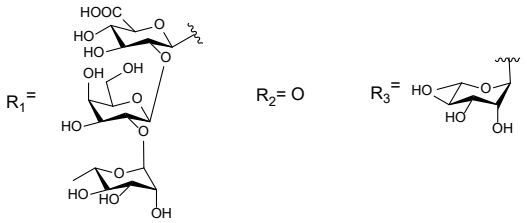
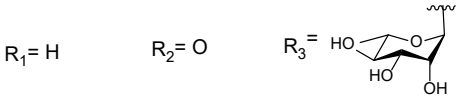
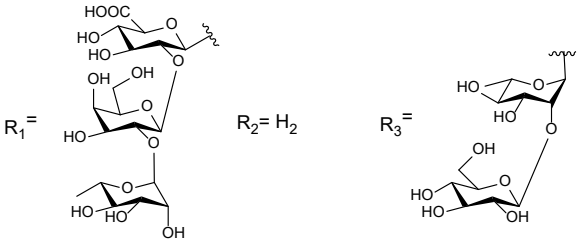
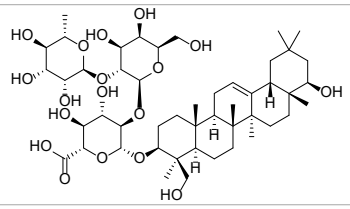
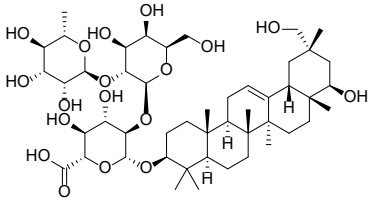
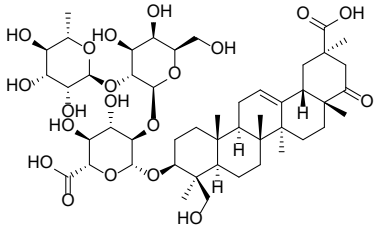
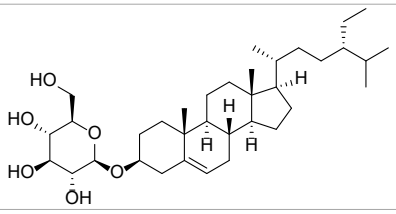
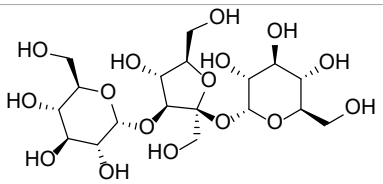
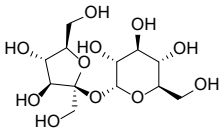
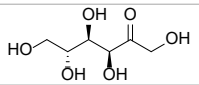
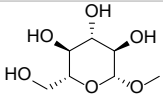
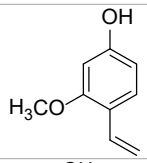
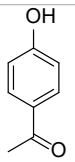
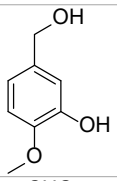
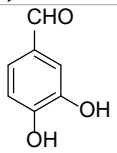
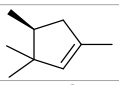
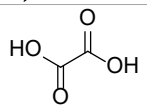
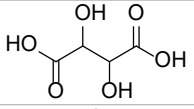
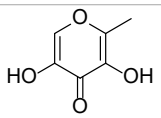
No.	Name of compounds	Structures	Species	Plant parts	Ref
108	3β,22β,24-trihydroxy-olean-12-ene-15-oxo 3-*O*-α-$_L$-rhamnopyr anosyl-(1→2)-β-$_D$-galactopyranosyl-(1→2) -β-$_D$-glucuronopyranosyl 22-*O*-α-$_L$-rhamnopyranoside		*A. maurorum*	Root	(73)
109	3β,22β,24-trihydroxy-olean-12-ene-15-oxo 22-*O*-α-$_L$-rhamnopyranoside		*A. maurorum*	Root	(73)
110	3β,22β,24-trihydroxy-olean-12-en 3-*O*-α-$_L$-rhamnopyranosyl(1→2)-β-$_D$-galactopyranosyl-(1→2)-β-$_D$-glucuronopyranosyl 22-*O*-β-$_D$-glucopyranosyl-(1→2)-α-$_L$-rhamnopyranoside		*A. maurorum*	Root	(73)
111	Soyasaponin I		*A. maurorum*	Root	(73)
112	Abrisaponin A		*A. maurorum*	Root	(73)
113	Abrisaponin I		*A. maurorum*	Root	(73)
114	Daucosterol		*A. pseudalhagi*		(63)

Table 5. Continued

No.	Name of compounds	Structures	Species	Plant parts	Ref
		Sugars			
115	Melezitose		*A. persarum*	Stems leaves	(15)
116	Saccharose		*A. persarum*	Stems leaves	(15)
			A. pseudalhagi	Aerial parts	(74)
117	Fructose		*A. persarum*	Stems leaves	(15)
118	1-*O*-β-methyl-glucoside		*A. pseudalhagi*	Aerial parts	(60)
		Other compounds			
119	4-ethenyl-3-Methoxyphenol		*A. sparsifolia*	Aerial parts	(36)
120	4′-hydroxylacetophenone		*A. sparsifolia*	Aerial parts	(36)
121	3-hydroxyl-4-methoxybenzyl alcohol		*A. sparsifolia*	Aerial parts	(36)
122	Protocatechualdehyde		*A. sparsifolia*	Aerial parts	(36)
123	1,3,3,4-tetramethyl-cyclopentene		*A. sparsifolia*	Aerial parts	(36)
124	Oxalic acid		*A. persarum*	Stems leaves	(15)
125	Tartaric acid		*A. persarum*	Stems leaves	(15)
126	5-hydroxymaltol		*A. pseudalhagi*	Aerial parts	(74)

level of serum glutamate oxaloacetate transaminase and serum glutamate pyruvate transaminase (42,43).

Urinary tract effects

In a study oral administration of the methanol extracts of *A. maurorum* in a single or repeated (1 × 5 days) oral dose of 500 or 1000 mg/kg orally compared to furosemide 20 mg/kg, increased urine volume, sodium and potassium excretion rate, and had significant diuretic, kaluretic, and saluretic effects (44). The diuretic effect of *A. maurorum* was also evaluated in an *in vivo* study. The results indicated that oral administration of 8-16 ml/kg of the distilled product of *A. maurorum* had diuretic effects (1).

A new aliphatic ester isolated from the root of *A. maurorum,* glyceryl-*n* tetracosan-17-ol-1-oate demonstrated a relaxant effect in guinea-pig ureter due to suppression of histamine-induced spasms. It can help relieve the pain of kidney stones resulting from contraction of the ureter (45). Addition of the ethanol extract of *A. maurorum* powdered roots completely suppressed contractions at doses of 5 mg/mL bathing to the isolated guinea-pig ureter with continuous contractions induced by histamine at doses of 3 µg/mL bathing fluid (46).

Anti-inflammatory, anti-nociceptive, and antipyretic effects

In a study, the aerial parts of *A. graecorum* were extracted and aqueous ethanol extract was evaluated *in vivo*, using two animal models: the carrageenan induced rat paw edema and the granuloma formation in albino Wistar rats induced by cotton pellets. The isolation of bioactive components including one hydrolysable tannin and four flavonol glycosides kaempferol compared with diclofenac sodium as a positive control, demonstrated anti-inflammatory effect of extract of *A. graecorum* (47). The effects of the ethanolic extract of *A. maurorum* on intraperitoneal administration into mice reduced the rectal temperature by 0.2-3.3°C in a dose-dependent manner (46). An aqueous extract of *A. maurorum* had anti-inflammatory activities among mice in the model of formalin-induced paw edema assay. The aqueous extract of *Alhagi* expressed protective effects against free radicals mediated inflammatory diseases (48). The anti-nociceptive effect of methanol extracts (200 and 400 mg/kg) of *A. maurorum* in oral administration has been shown in a study using acetic acid-induced writhing and tail-flick tests in mice (49). Intraperitoneal administration of a new phytocompound, glyceryl-*n*-tetracosan-17-ol-1-oate, isolated from the root of the *A. maurorum*, also lowered the body temperature in mice (45).

Musculoskeletal effects

The ethanol extract of *A. maurorum* at a concentration of 4 µg/mL bathing fluid for 5 minutes antagonized acetylcholine-induced contraction in the exposure of the frog's rectus abdominis muscle and blocked the action of the neurotransmitter non-competitively and acted as a skeletal muscle relaxant.

Intraperitoneal administration of the ethanolic extract of *A. maurorum* at a dose of 1.6 g/kg in conscious mice also generated mild sedation, decreased the locomotion activity, and induced skeletal muscle relaxation indicating a skeletal muscle neuromuscular junction effect (46).

Cardiac effects

The ethanolic extract of *A. maurorum* powdered roots at a dose of 1 g/kg in anaesthetized rats induced bradycardia without myocardial depression (46).

Antimicrobial effects

The antimicrobial and antifungal activities of the extracts of leaves and flowers have been shown against *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, and *Candida albicans* using disc diffusion method (50). Nevertheless, in another study different concentrations of aqueous extract of *A. maurorum* had no antibacterial activity against both Gram-negative (*Escherichia coli* and *Pseudomonas aeruginosa*) and Gram-positive (*S. aureus* and *Streptococcus pyogenes*) bacteria (48). A study revealed the antibacterial activity of methanol extract of *A. maurorum* at a concentration of 20 mg/mL against two strains of *E. coli* (51). However, in Neamah's study conducted using cup-plate agar diffusion method, no doses of aqueous extract had any antibacterial activity against *P. aeruginosa*, *E. coli*, *S. aureus*, and *S. pyogenes* (48). The methanol extract of the leaves of *A. maurorum* demonstrated growth inhibitory effects against Gram-negative bacteria except of *Acinetobacter baumannii* (52). Also, the methanol extract of *A. maurorum* indicated antifungal activities against *Aspergillus flavus*, *Fusarium oxysporum*, *Alternaria alternate*, *Fusarium solani*, *Chaetomium*, *Bipolaris oryzae*, and *Mucor* (53). The anti-*Helicobacter* activity of *A. maurorum* extracts was assessed using agar diffusion method and represented an effective activity (54).

Antioxidant effects

To assay the antioxidant effect of the aqueous extract of *A. maurorum*, the levels of malondialdehyde and total antioxidant capacity were measured compared to acetylsalicylic acid antioxidant activity. The results showed significantly reduced malondialdehyde levels and potent antioxidant activity (48). In another study, the antioxidant activity of the methanolic extract of *A. maurorum* was evaluated using free radical scavenging activity method and ferric reducing activity power method. *A. maurorum* revealed a significant antioxidant activity and was introduced as a natural antioxidant source (55). *A. maurorum* is a rich source of lupeol and has chemical constituents like flavonoids, coumarins, fatty acids, alkaloids, and sterols with antioxidant activities (56).

Cytotoxic effects

The effects of diethyl ether and petroleum ether extracts of *A. maurorum* have been investigated on human cancer cell lines by sulforhodamine B assay for their potential cytotoxicity. *A. maurorum* inhibited the viability of tumor cell lines in a concentration-dependent manner (56). The *in vitro* cytotoxicity assessment of *A. maurorum* was performed using methyl thiazolyl tetrazolium on the human acute myeloid leukemia cell line (HL-60). The cytotoxic effects of leaves and flowers extracts were dose and time-dependent where the inhibitory effect against the proliferation of HL-60 cells and the IC50 was 16.0 and 22.0 µg/mL, respectively (50).

Pharmacological properties of Tarangabin

Immunomodulatory

Immunostimulatory effects of the total aqueous fraction of Tarangabin manna were proven in a laboratory study. The cell line applied in this study was Jurkat cells. Several carbohydrate macromolecules with different biological activities and structures were isolated from the water-soluble fraction of Tarangabin manna. While three of these macromolecules exhibited some degrees of cytotoxicity in a dose-dependent manner, the crude water-soluble fraction of Tarangabin manna had proliferative effects. This effect was due to smaller molecules in the manna antagonizing the cytotoxic effects of the macromolecules (14).

Hyperbilirubinemia in neonate

The effect of Tarangabin extract on hyperbilirubinemia in neonate was evaluated in a clinical study. Administration of the extract significantly reduced bilirubin levels after 48 hours (57).

Conclusion

The pharmacological properties of *Alhagi* have been confirmed by *in vivo* and *in vitro* studies. These include anti-inflammatory, anti-nociceptive, antipyretic, diuretic, muscle relaxant, hepatroprotective, gastrointestinal, anti-ulcerogenic, antidiarrheal, antimicrobial, antioxidant and cytotoxic effects. However, some properties of this plant have only been described in traditional medicine and thus need confirmation in modern experimental and clinical studies.

Tarangabin is a kind of manna obtained from *A. maurorum*. Some of its properties, as listed in the ITM literature, include laxative, detergent, purgative for yellow bile, cough reliever, thirst quencher, antipyretic, antiemetic and warming agent of the body. Due to their vast geographical distribution and therapeutic effects described in the ITM, well-designed pharmacological and clinical studies are warranted to harness the medicinal properties of *Alhagi* spp.

Authors' contributions

All the authors contributed to data collection and preparation of the manuscript. The first draft was prepared by APT. All authors read the final version and confirmed for the publication.

Conflict of interests

The authors declared that there was no conflict of interest in the study.

Ethical considerations

Ethical issues including text plagiarism, misconduct, manipulation or appropriation, data fabrication, falsification, redundant publication as well as duplicate submissions have been carefully observed by authors.

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