

Ethnomedicinal Uses, Phytochemistry and Pharmacology of *Dorema* Species (Apiaceae): A Review

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The application of antique medical instructions, practices, skills and knowledge has been considered as the most affordable treatment in many developing countries. The use of these preparations and prescriptions over generations has made a useful and valuable guide for drug discovery in modern medicine. Medical herbs have been of a high importance for this purpose. The genus *Dorema*, of Apiaceae family (Umbelliferae) has a wide use in ethnobotany and traditional medicine around the world. It has been used as a treatment for CNS disease, convulsion, upper respiratory tract problems, gastrointestinal disorder and high blood sugar. Furthermore, phytochemical investigations have reported *Dorema* species to contain a wide range of constituents including terpenes, coumarins and phenolic compounds. The current review summarizes comprehensive information regarding botany, phytochemistry and pharmacological aspects of *Dorema* spp.

Keywords: *Dorema*, phytochemistry, pharmacology

INTRODUCTION

The genus *Dorema* D. Don, belongs to the Apiaceae family (Umbelliferae) with important medicinal and aromatic species. It contains a total of 12 accepted species worldwide (<http://www.theplantlist.org>). Among them 7 are represented in Iran [1]. The genus has been used as a food additive as well as for various medicinal purposes in traditional and folklore medicine around the world [2].

Dorema ammoniacum, commonly known as “Ushaq” or “Vasha”, is considered as one of the most studied species [3]. Being rich in *ammoniacum*, a medicinal gum-resin, it has been mentioned in Islamic Traditional Medicine (ITM) as a treatment for various disorders, such as gastrointestinal, upper respi-

ratory tract and central nervous systems problems [3-5]. Furthermore, numerous chemical compounds including terpenes, coumarins and phenolic compounds have been isolated from *Dorema* species and a wide range of pharmacological activities including anti-microbial, anti-inflammatory, antioxidant, cytotoxicity, anticonvulsant, anti-diabetic and hypolipidemic activities have been reported from this genus in modern medicine [6].

In the current review we present a comprehensive report on ethnobotanical and traditional uses, phytochemical compounds and pharmacological activities of the genus *Dorema*.

BOTANY

1. Botanical description of *Dorema* spp.

Dorema species are large monocarpic perennial plant, with thickened storage roots, and have large simple umbels with regular flowers, bisexual and staminate, the bisexual on upper branches and the staminate on lower, rarely flowers mixed; Involucre of few caducous leaflets, or lacking; calyx 5-toothed, indistinct; petals are yellow, cream-colored or greenish yellow, nerve darker, ovate-elongate, with inward curved tip; The stigmas are truncate or thickened; stylopodium is flat, fleshy with lobed broadened margin, becoming cup-shaped; ovary is cylindrical, faintly ribbed. Fruit with free carpophore, dorsally piano-compressed, elliptic, with filiform protruding ribs, 2 lateral ribs fusing with unthicken, whitish margin. Geographically, *Dorema* is distributed in the Caucasus and the southern parts of Central Asia. It also grows in Iran, Afghanistan and Baluchistan. Its northernmost representative (*Dorema microcarpum* Korovin.) appears in Central Asia, its southern limit lies in Tien Shan. *Dorema* is typical in arid conditions and most species occur in dry foothills and hills, some grow in deserts.

They are confined to calcareous soils, often mixed with rock debris. One species, *Dorema sabulosum* Litv. is a typical psammophyte [7, 8]. According to The Plant List, there are 25 scientific plant names of species rank for the genus *Dorema*, of these 12 are accepted species names (<http://www.theplantlist.org>). In Iran, the genus *Dorema* is represented by seven species, namely, *D. aitchisonii* Korovin ex Pimenov, *D. ammoniacum* D. Don, *D. aucheri* Boiss., *D. aureum* Stocks, *D. glabrum* Fisch. & C.A. Mey., *D. hyrcanum* Koso-Pol. and *D. kopetdaghense* Pimenov which among them *D. aucheri* Boiss. is endemic to Iran. *Dorema kopetdaghense* Pimenov in *Flora Iranica*, treated as a synonym of *D. hyrcanum* Koso-Pol. However, phylogenetic analysis of nrDNA internal transcribed spacer (ITS) sequences showed that these two species should be retained as separate species [1, 9, 10]. Table 1 summarizes all synonyms of *Dorema* species based on the website “TPL” (<http://www.theplantlist.org>).

2. Threats and conservation priorities

The genus *Dorema*, contains monocarpic perennial species, so that only once produces flowers during the life cycle and only reproduces through seeds. These plants are potentially endangered and vulnerable taxa [11]. Some of these taxa such

Table 1. Scientific names and synonyms of reported *Dorema* species worldwide [according to The Plant List (2013)]

No	<i>Dorema</i> species (Accepted names)	Synonyms
1	<i>D. aitchisonii</i> Korovin ex Pimenov	
2	<i>D. ammoniacum</i> D. Don	<i>D. gummiferum</i> (Jaub. & Spach) K.M. Korol. <i>D. hirsutum</i> Lofius ex I.G. Borshch.
3	<i>D. aucheri</i> Boiss.	<i>D. robustum</i> Lofius ex I.G. Borshch.
4	<i>D. aureum</i> Stocks	
5	<i>D. badhysi</i> Pimenov	
6	<i>D. balchanorum</i> Pimenov	
7	<i>D. glabrum</i> Fisch. & C.A. Mey.	
8	<i>D. hyrcanum</i> Koso-Pol.	<i>D. gummiferum</i> auct.
9	<i>D. karataviense</i> Korovin	
10	<i>D. kopetdaghense</i> Pimenov	
11	<i>D. microcarpum</i> Korovin	<i>D. namanganicum</i> K.M. Korol.
12	<i>D. sabulosum</i> Litv.	<i>D. sabulosum</i> var. <i>borszczowii</i> Litv.

as *D. aucheri* are narrow-range endemics which occur only in a few specialized niches. *D. aucheri* is considered as a unique endemic species which is intensively collected. Overexploitation of this plant has caused a significant decrease in its population in the area [12]. Furthermore, some others are sub-endemics with threatened species including *D. ammoniacum*, and *D. kopetdaghense*. Today, *D. kopetdaghense* is also considered as endangered in the IUCN Red List of threatened Species [13]. It has been used in traditional medicine from ancient times [2].

Dorema ammoniacum commonly known as “Ushaq” or “Vasha” is one of the most important industrial and medicinal plants of Iran which has been used in ethnobotanical since ancient times. It is endangered due to superfluous and unsustainable harvesting methods [3, 4]. *Dorema glabrum* is another endangered species that grows in loamy or rocky slopes of Nakhichevan, Autonomous Republic- Azerbaijan, Armenia and Iran [1, 10]. The plant has immense applications as an herbal remedy or food additive in these regions. Over harvesting from wild populations and destructive collecting methods, are considered as serious threats that often lead to disappearance of these taxa, and must be avoided. There is an urgent need for conservation priorities and management strategies for all taxa assigned to a threat category through seed and gene banking, and planting in botanical gardens. Otherwise, we will lose these

Table 2. Chemical composition from different parts of *Dorema* species

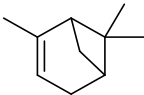

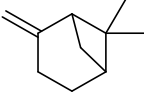
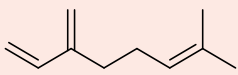
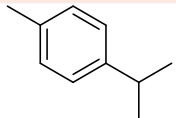
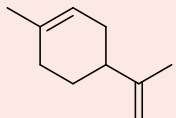
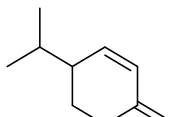
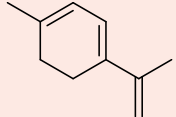
Name of compound	Structure	Species	Plant part	Ref		
	Essential oil components					
1 α -pinene		<i>D. ammoniacum</i>	Aerial parts Flower Stem Seed Leaf Root Leaves	[14-18]		
		<i>D. aucheri</i>	Aerial parts	[19, 20]		
		<i>D. glabrum</i>	Aerial parts	[21]		
		2 camphene		<i>D. ammoniacum</i>	Flower Stem Root	[14]
				<i>D. aucheri</i>	Seed Stem	[19, 20]
				3 β -pinene		<i>D. ammoniacum</i>
<i>D. aucheri</i>	Seed Stem	[19, 20]				
4 β -myrcene		<i>D. aucheri</i>	Seed Stem			[19, 20]
		<i>D. glabrum</i>	Aerial part	[21]		
		<i>D. ammoniacum</i>	Flower Stem Root Leaves	[14, 17, 18]		
		5 <i>p</i> -cymene		<i>D. ammoniacum</i>	Aerial parts Flower stem Root	[14, 15, 18]
6 limonene				<i>D. ammoniacum</i>	Flower stem Seed Root Leaf Leaves	[14, 16, 18]
				<i>D. aucheri</i>	Aerial parts	[19, 20]
7 β -phellandrene		<i>D. glabrum</i>	Seed Stem	[21]		
		<i>D. ammoniacum</i>	Aerial parts Root	[15]		
8 1,3,8- <i>p</i> -menthatriene		<i>D. ammoniacum</i>	Aerial part	[22]		

Table 2. Continued 1

Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
9 <i>p</i> -mentha-1,8-diene		<i>D. ammoniacum</i>	Fruit	[22]
10 (<i>E</i>)- β -ocimene		<i>D. ammoniacum</i>	Flower Stem Root Leaves	[14, 18]
		<i>D. aucheri</i>	Aerial parts	[19]
		<i>D. glabrum</i>	Aerial parts	[21]
11 (<i>Z</i>)- β -ocimene		<i>D. glabrum</i>	Aerial parts	[21]
		<i>D. ammoniacum</i>	Stem Leaves	[18]
12 terpinolene (δ -terpinene)		<i>D. ammoniacum</i>	Aerial parts Flower Root Stem Leaf Leaves	[14, 15, 17-19]
		<i>D. aucheri</i>	Aerial parts Seed Stem	[19, 20]
13 terpinene-4-ol		<i>D. aucheri</i>	Aerial part	[20]
14 thymol methyl ether		<i>D. ammoniacum</i>	Flower stem Root Seed	[14, 16]
		<i>D. aucheri</i>	Aerial parts	[19]
15 thymol		<i>D. ammoniacum</i>	Seed Stem	[16]
		<i>D. aucheri</i>	Aerial part Seed Stem	[20]
16 methyl geranate		<i>D. aucheri</i>	Aerial part	[19]
17 carvacrol methyl ether		<i>D. ammoniacum</i>	Flower Stem Root	[14]
		<i>D. glabrum</i>	Root	[23]
18 carvacrol		<i>D. aucheri</i>	Stem Seed	[20]
		<i>D. ammoniacum</i>	Stem Seed	[16]
19 methyleugenol		<i>D. ammoniacum</i>	Seed	[16]

Table 2. Continued 2

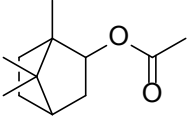
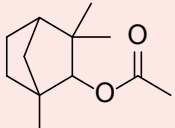
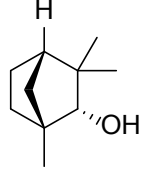
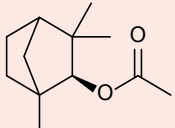
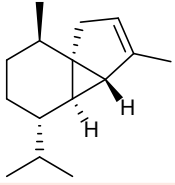
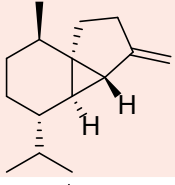
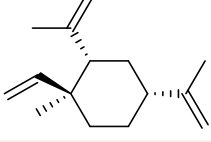
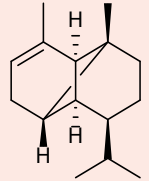
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
20 bornyl acetate		<i>D. ammoniacum</i>	Flower Stem Root Leaves	[14, 18]
		<i>D. aucheri</i>	Aerial parts Seed Stem	[19, 20]
21 fenchyl acetate		<i>D. glabrum</i>	Aerial parts	[21]
22 endo-fenchol		<i>D. ammoniacum</i>	Leaf	[18]
23 α -fenchyl Acetate		<i>D. glabrum</i>	Root	[23]
24 α -cubebene		<i>D. ammoniacum</i>	Flower Fruit Stem Root	[14, 22]
		<i>D. aucheri</i>	Aerial parts	[19]
25 β -cubebene		<i>D. aucheri</i>	Aerial parts	[20]
26 β -elemene		<i>D. aucheri</i>	Aerial parts	[20]
27 α -copaene		<i>D. ammoniacum</i>	Flower Fruit Stem Seed Leaves Root	[14, 16, 22]
		<i>D. aucheri</i>	Aerial parts Seed Stem	[19, 20]
		<i>D. glabrum</i>	Root	[23]

Table 2. Continued 3

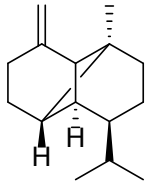
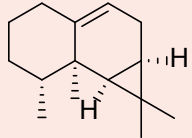
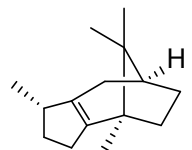
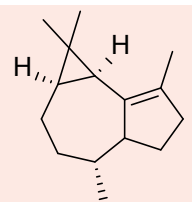
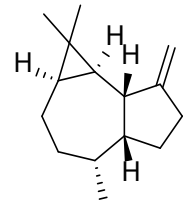
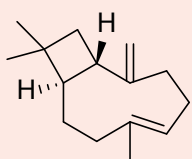
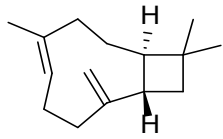
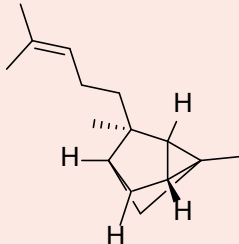
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
28 β -copaene		<i>D. aucheri</i>	Aerial parts	[22]
29 aristolene		<i>D. ammoniacum</i>	Flower stem	[14]
30 β -patchoulene		<i>D. aucheri</i>	Aerial parts	[19]
31 α -gurjunene		<i>D. ammoniacum</i>	Flower stem	[14, 16]
32 β -gurjunene		<i>D. ammoniacum</i>	Flower Stem Root	[14]
		<i>D. aucheri</i>	Aerial parts Seed Stem	[19, 20]
33 β -caryophyllene		<i>D. ammoniacum</i>	Flower stem Seed Root Leaf	[14, 16, 17]
		<i>D. aucheri</i>	Aerial parts Seed Stem	[19, 20, 24]
34 caryophyllene		<i>D. ammoniacum</i>	Aerial parts	[15]
35 α -santalene		<i>D. aucheri</i>	Aerial parts	[19]

Table 2. Continued 4

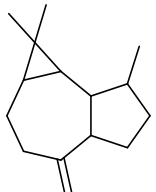
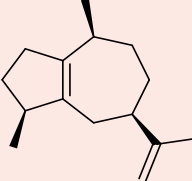
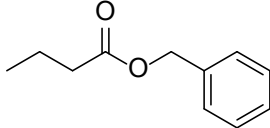
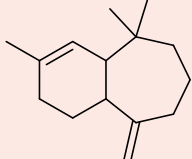
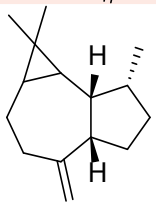
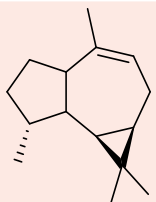
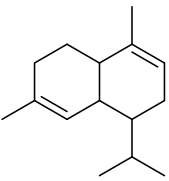
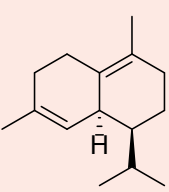
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
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		<i>D. aucheri</i>	Aerial parts	[19]
37 α -guaiene		<i>D. ammoniacum</i>	Flower stem Root	[14]
38 benzyl butanoate		<i>D. ammoniacum</i>	Root	[14]
39 α -himachalene		<i>D. ammoniacum</i>	Flower stem Root	[14]
40 allo-aromadendrene		<i>D. ammoniacum</i>	Flower stem Root	[14]
41 dehydroaromadendrane		<i>D. ammoniacum</i>	Flower stem Root	[14, 16]
42 α -amorphene		<i>D. ammoniacum</i>	Flower stem Root	[14]
		<i>D. aucheri</i>	Seed Stem	[20]
43 δ -amorphene		<i>D. ammoniacum</i>	Flower stem Root	[14]

Table 2. Continued 5

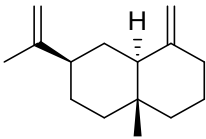
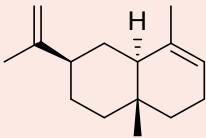
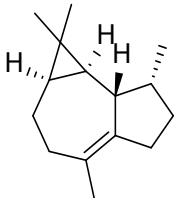
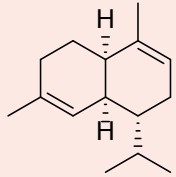
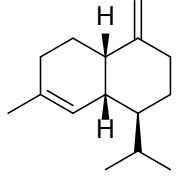
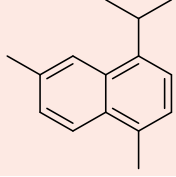
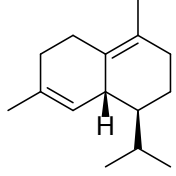
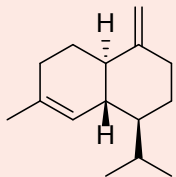
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
44 β -selinene		<i>D. ammoniacum</i>	Flower stem	[14, 16]
		<i>D. aucheri</i>	Seed Root Stem	[20]
45 α -selinene		<i>D. ammoniacum</i>	Aerial part	[14, 15]
		<i>D. aucheri</i>	Flower Root Stem Seed Stem	[20]
46 viridiflorene		<i>D. aucheri</i>	Aerial part	[19]
47 α -muurolene		<i>D. ammoniacum</i>	Flower, stem	[14]
		<i>D. glabrum</i>	Root Root	[23]
48 γ -muurolene		<i>D. ammoniacum</i>	Stem	[16]
49 cadalene		<i>D. glabrum</i>	Root	[23]
50 δ -cadinene		<i>D. ammoniacum</i>	Flower seed	[14, 16, 17]
		<i>D. aucheri</i>	Stem Aerial parts Seed Stem	[18, 20, 24]
		<i>D. glabrum</i>	Root	[23]
51 γ -cadinene		<i>D. aucheri</i>	Aerial parts	[19]
		<i>D. ammoniacum</i>	Seed Stem	[16]

Table 2. Continued 6

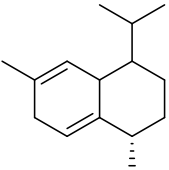
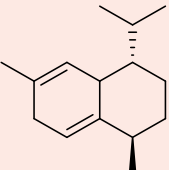
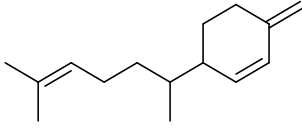
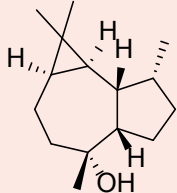
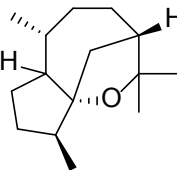
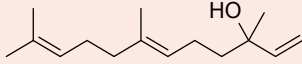
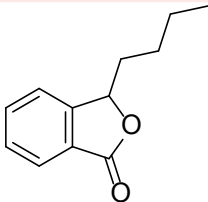
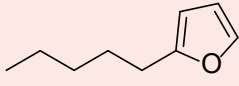
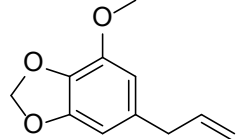
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
52 cadina-1,4-diene		<i>D. aucheri</i>	Aerial part	[19]
53 <i>trans</i> -cadina-1(2),4-diene		<i>D. ammoniacum</i>	Stem	[16]
54 β -sesquiphellandrene		<i>D. ammoniacum</i>	Seed	[16]
55 ledol		<i>D. ammoniacum</i>	Stem	[16]
56 liguloxide		<i>D. ammoniacum</i>	Flower Root Stem	[14]
57 (<i>E</i>)-nerolidol		<i>D. ammoniacum</i>	Flower Root Leaf Stem Seed	[14, 16, 17]
		<i>D. glabrum</i>	Root	[23]
58 3- <i>n</i> -butyl phthalide		<i>D. ammoniacum</i>	Root	[14]
59 2-pentylfuran		<i>D. glabrum</i>	Aerial parts	[21]
60 myristicin		<i>D. glabrum</i>	Aerial parts	[21]

Table 2. Continued 7

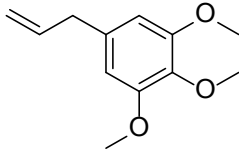
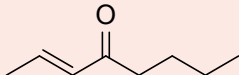
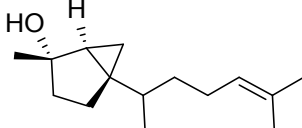
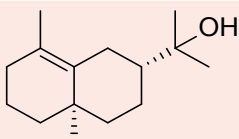
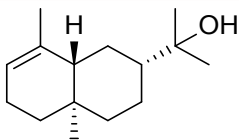
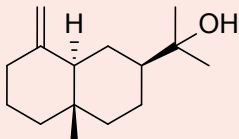
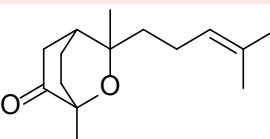
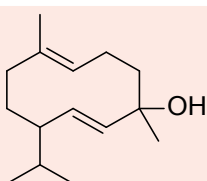
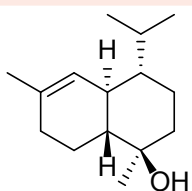
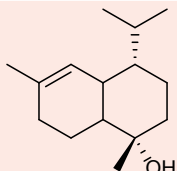
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
61 elemicin		<i>D. glabrum</i>	Aerial parts	[21]
62 methyl heptenone		<i>D. ammoniacum</i>	Aerial parts	[15]
63 <i>trans</i> -sesquisabinene hydrate		<i>D. aucheri</i>	Aerial parts	[19]
64 γ -eudesmol		<i>D. ammoniacum</i>	Seed Stem	[16]
		<i>D. aucheri</i>	Aerial parts	[19]
65 α -eudesmol		<i>D. ammoniacum</i>	Seed Stem	[16]
		<i>D. aucheri</i>	Aerial parts	[19, 24]
66 β -eudesmol		<i>D. ammoniacum</i>	Seed Stem	[16]
67 sesquicineol-2-one		<i>D. ammoniacum</i>	Seed Stem	[16]
68 germacrene D-4-ol		<i>D. aucheri</i>	Aerial part	[19]
69 α -cadinol		<i>D. ammoniacum</i>	Stem Seed	[16]
		<i>D. aucheri</i>	Aerial parts	[19]
		<i>D. glabrum</i>	Root	[23]
70 δ -cadinol		<i>D. glabrum</i>	Root	[23]

Table 2. Continued 8

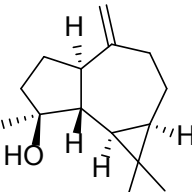
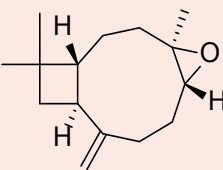
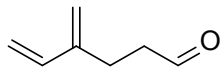
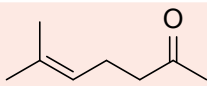
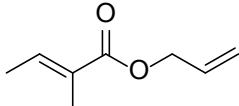
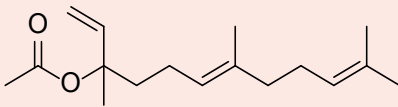
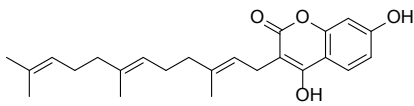

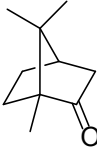
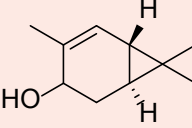
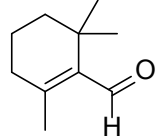
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
71 spathulenol		<i>D. ammoniacum</i>	Fruit	[16, 22]
		<i>D. aucheri</i>	Seed Stem	[20]
72 caryophyllene oxide		<i>D. ammoniacum</i>	Fruit Seed Stem	[16, 17, 22]
		<i>D. aucheri</i>	Leaf Seed Stem	[20]
73 4-methylene-5-hexenal		<i>D. ammoniacum</i>	Stem	[18]
74 6-methyl-5-hepten-2-one		<i>D. ammoniacum</i>	Stem	[18]
75 allyl tiglate		<i>D. ammoniacum</i>	Stem	[18]
76 nerolidyl acetate		<i>D. ammoniacum</i>	Stem	[16]
77 ammosesinol		<i>D. ammoniacum</i>	Aerial parts	[25]
78 nonanol		<i>D. ammoniacum</i>	Aerial parts	[15]
79 camphor		<i>D. ammoniacum</i>	Aerial parts	[15]
80 <i>trans</i> -2-carene-4-ol		<i>D. ammoniacum</i>	Fruit	[22]
81 β -cyclocitral		<i>D. ammoniacum</i>	Fruit	[22]

Table 2. Continued 9

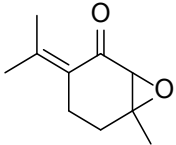
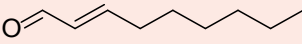
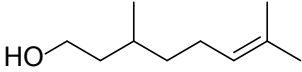
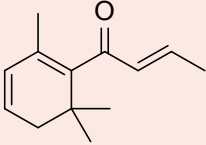
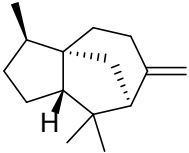
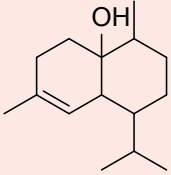
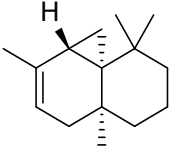
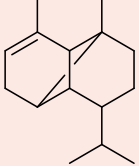
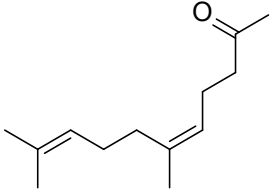
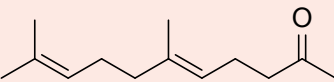
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
82 piperitenone oxide		<i>D. ammoniacum</i>	Fruit	[22]
83 (E)-2-nonenal		<i>D. ammoniacum</i>	Stem	[18]
84 β-citronellol		<i>D. ammoniacum</i>	Aerial parts	[15]
85 β-damascenone		<i>D. ammoniacum</i>	Aerial parts	[15]
86 cedr-8[15]-ene		<i>D. ammoniacum</i>	Aerial parts	[15]
87 cubenol		<i>D. aucheri</i> <i>D. glabrum</i>	Aerial parts Root	[19] [23]
88 thujopsene		<i>D. ammoniacum</i>	Aerial parts	[15]
89 ylangene		<i>D. glabrum</i> <i>D. aucheri</i>	Aerial parts Seed Stem	[21] [20]
90 nerylacetone		<i>D. ammoniacum</i>	Aerial parts	[15, 17]
91 geranyl acetone		<i>D. glabrum</i>	Aerial parts Root	[21] [23]

Table 2. Continued 10

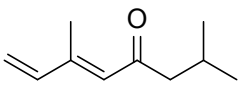
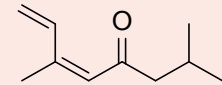
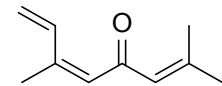
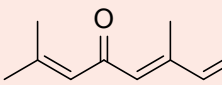
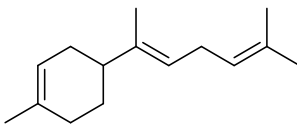
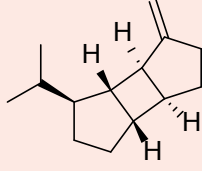
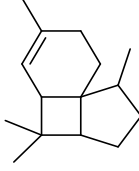
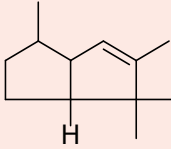
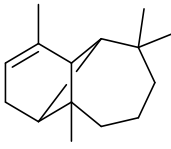
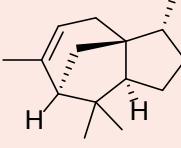
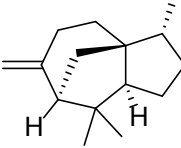
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
92 (E)-tagetone		<i>D. ammoniacum</i>	Fruit	[22]
93 (Z)-tagetone		<i>D. ammoniacum</i>	Fruit	[22]
94 (Z)-ocimenone		<i>D. ammoniacum</i>	Fruit	[22]
95 (E)-ocimenone		<i>D. ammoniacum</i>	Fruit	[22]
96 α-bisabolene		<i>D. ammoniacum</i>	Aerial parts	[15]
97 β-bourbonene		<i>D. aucheri</i> <i>D. ammoniacum</i>	Seed Stem Fruit	[20] [22]
98 italicene		<i>D. ammoniacum</i>	Fruit	[22]
99 di-epi-α-cedrene		<i>D. ammoniacum</i>	Fruit	[22]
100 α-longipinene		<i>D. ammoniacum</i>	Fruit	[22]
101 α-cedrene		<i>D. ammoniacum</i>	Aerial parts	[15]
102 β-cedrene		<i>D. glabrum</i> <i>D. ammoniacum</i>	Aerial parts Fruit	[21] [22]

Table 2. Continued 11

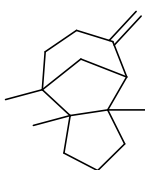
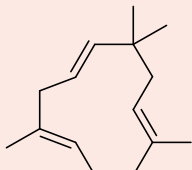
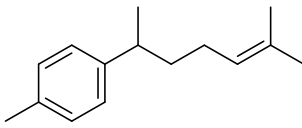
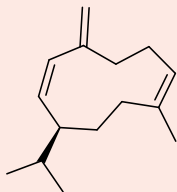
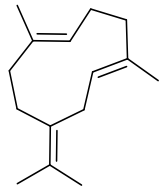
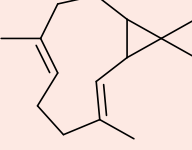
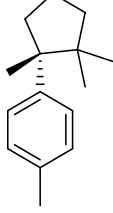
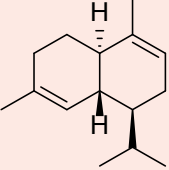
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
103 β -barbatene		<i>D. ammoniacum</i>	Fruit	[22]
104 α -humulene		<i>D. aucheri</i>	Aerial parts Seed	[17, 18]
		<i>D. ammoniacum</i>	Stem Fruit	[22]
105 <i>ar</i> -curcumene		<i>D. ammoniacum</i>	Fruit	[22]
106 germacrene D		<i>D. aucheri</i>	Aerial parts Stem	[17, 18]
		<i>D. ammoniacum</i>	Seed Seed Stem Fruit	[16, 22]
107 germacrene B		<i>D. aucheri</i>	Aerial parts	[19]
		<i>D. glabrum</i>	Aerial parts Root	[21, 23]
108 bicyclogermacrene		<i>D. ammoniacum</i>	Fruit Seed	[16, 22]
109 cuparene		<i>D. glabrum</i>	Aerial parts	[21]
		<i>D. aucheri</i>	Seed Stem	[20]
		<i>D. ammoniacum</i>	Fruit	[24]
110 α -cadinene		<i>D. ammoniacum</i>	Fruit Stem	[16, 22]

Table 2. Continued 12

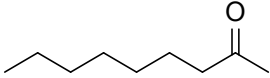
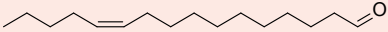

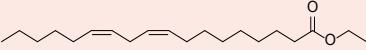
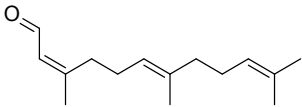
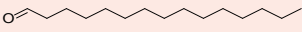
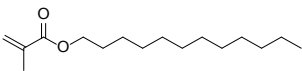
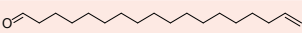
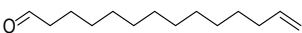
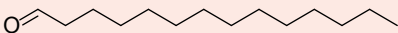
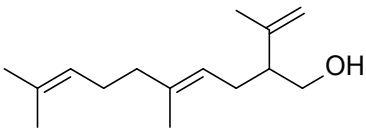
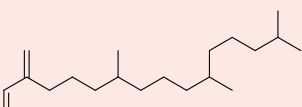
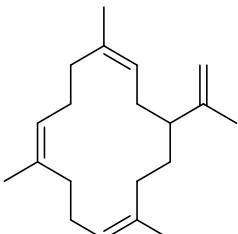
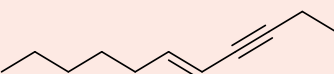
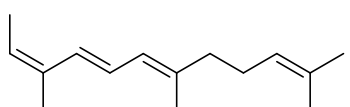
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
111 2-nonanone		<i>D. ammoniacum</i>	Stem	[16]
112 (Z)-hexadec-11-enal		<i>D. ammoniacum</i>	Stem	[16]
113 hexadecanal		<i>D. ammoniacum</i>	Stem	[16]
114 ethyl linoleate		<i>D. ammoniacum</i>	Stem	[16]
115 (Z,E)-farnesal		<i>D. ammoniacum</i>	Aerial parts	[15]
116 pentadecanal		<i>D. ammoniacum</i>	Aerial parts	[15]
117 dodecyl methacrylate		<i>D. ammoniacum</i>	Aerial parts	[15]
118 17-octadecenal		<i>D. ammoniacum</i>	Aerial parts	[15]
119 13-tetradecenal		<i>D. ammoniacum</i>	Aerial parts	[15]
120 tetradecanal		<i>D. glabrum</i> <i>D. ammoniacum</i>	Aerial parts Stem Seed	[21] [16]
121 trans-sesquilandulol		<i>D. ammoniacum</i>	Seed Stem	[16]
122 neophytadiene		<i>D. ammoniacum</i>	Aerial parts	[15, 17]
123 neocembren		<i>D. ammoniacum</i>	Aerial parts	[15]
124 (E)-5-undecen-3-yne		<i>D. ammoniacum</i>	Fruit	[22]
125 (Z)-(E)-farnesene		<i>D. ammoniacum</i>	Aerial parts	[22]

Table 2. Continued 13

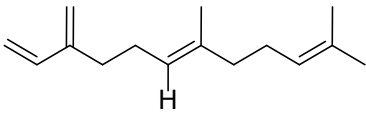
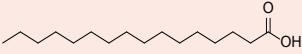
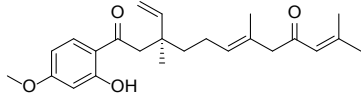
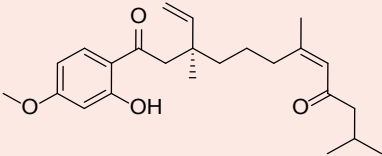
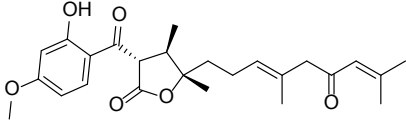
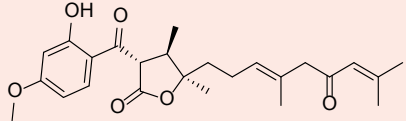
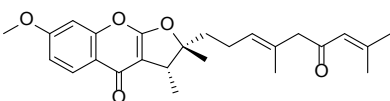
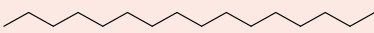
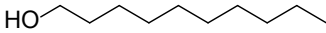
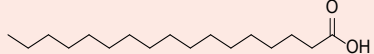
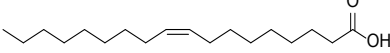
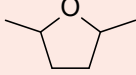
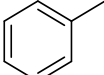
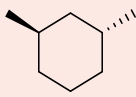
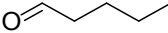
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
126 <i>trans</i> - β -farnesene		<i>D. ammoniacum</i>	Seed	[16]
127 <i>n</i> -hexadecanoic acid		<i>D. ammoniacum</i> <i>D. aucheri</i>	Aerial parts	[15] [19]
128 kopetdaghin A		<i>D. kopetdaghense</i>	Aerial parts	[2, 26]
129 kopetdaghin B		<i>D. kopetdaghense</i>	Aerial parts	[26]
130 kopetdaghin C		<i>D. kopetdaghense</i>	Aerial parts	[2, 26]
131 kopetdaghin D		<i>D. kopetdaghense</i>	Aerial parts	[2, 26]
132 kopetdaghin E		<i>D. kopetdaghense</i>	Aerial parts	[2, 26]
133 hexadecan		<i>D. aucheri</i>	Aerial parts	[21]
134 decanol		<i>D. ammoniacum</i>	Stem	[18]
135 heptadecanoic acid		<i>D. ammoniacum</i>	Fruit	[22]
136 oleic acid		<i>D. ammoniacum</i>	Aerial parts	[15]
137 2,5-dimethyltetrahydrofuran		<i>D. ammoniacum</i>	Leaf Stem	[17]
138 methylbenzene		<i>D. ammoniacum</i>	Leaf Stem	[17]
139 cyclohexane, 1,3-dimethyl, <i>trans</i>		<i>D. ammoniacum</i>	Leaf Stem	[17]
140 valeraldehyde		<i>D. ammoniacum</i>	Leaf Stem	[17]

Table 2. Continued 14

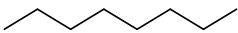
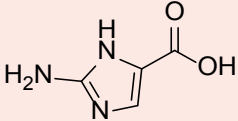
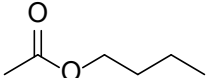
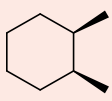
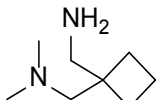
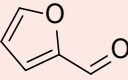
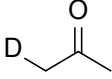
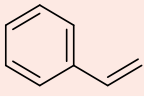
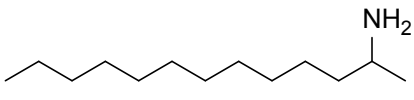
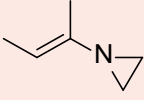


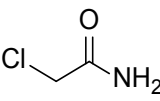
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
141 octane		<i>D. ammoniacum</i>	Leaf Stem	[17]
142 imidazole-5-carboxylic acid, 2-amino		<i>D. ammoniacum</i>	Leaf Stem	[17]
143 butyl acetate		<i>D. ammoniacum</i>	Leaf Stem	[17]
144 cyclohexane, 1,2-dimethyl, cis		<i>D. ammoniacum</i>	Leaf Stem	[17]
145 N,N-dimethyl cyclobutane-1,1-bis(methylamine)		<i>D. ammoniacum</i>	Leaf Stem	[17]
146 furfural		<i>D. ammoniacum</i>	Leaf Stem	[17]
147 deuterioacetone		<i>D. ammoniacum</i>	Leaf Stem	[17]
148 styrene		<i>D. ammoniacum</i>	Leaf Stem	[17]
149 1-methyldodecylamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
150 aziridine, 1-(2-buten-2-yl)		<i>D. ammoniacum</i>	Leaf Stem	[17]
151 sabinene		<i>D. ammoniacum</i>	Leaf Stem	[17]
152 decane		<i>D. ammoniacum</i>	Leaf Stem Seed	[17, 18]
153 acetamide, 2-chloro		<i>D. ammoniacum</i>	Leaf Stem	[17]

Table 2. Continued 15

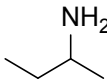
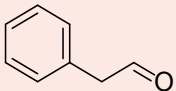
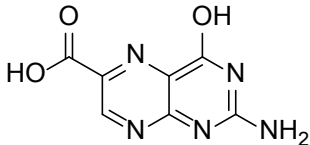
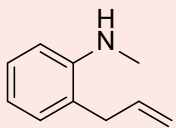
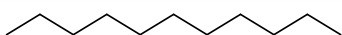
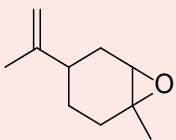
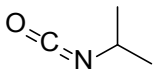
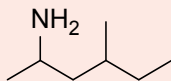
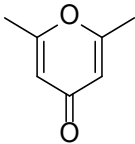
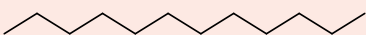
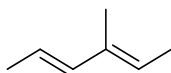
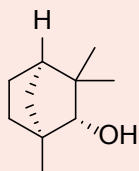
No.	Name of compound	Structure	Species	Plant part	Ref
		Essential oil components			
154	2-butylamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
155	phenyl acetaldehyde		<i>D. ammoniacum</i>	Leaf Stem	[17]
156	2-amino-4-hydroxypteridine-6-carboxylic acid		<i>D. ammoniacum</i>	Leaf Stem	[17]
157	benzenamine, N-methyl-2-(2-propenyl)		<i>D. ammoniacum</i>	Leaf Stem	[17]
158	undecane		<i>D. ammoniacum</i>	Leaf Stem Seed	[17, 18]
159	limonene oxide		<i>D. ammoniacum</i>	Leaf Stem	[17]
160	isopropyl isocyanate		<i>D. ammoniacum</i>	Leaf Stem	[17]
161	2-hexanamine, 4-methyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
162	2,6-dimethyl-4-pyrone		<i>D. ammoniacum</i>	Leaf Stem	[17]
163	dodecane		<i>D. ammoniacum</i>	Leaf Stem	[17]
164	2,4-hexadiene, 3-methyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
165	β -fenchyl alcohol		<i>D. ammoniacum</i>	Leaf Stem	[17]

Table 2. Continued 16

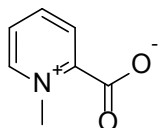
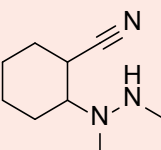
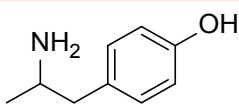
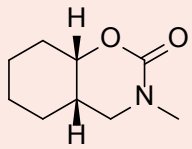
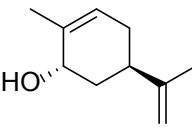
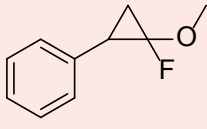
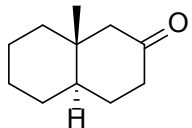
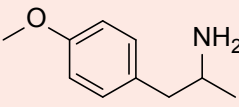
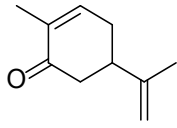
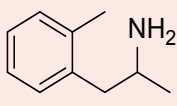
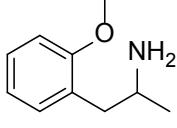
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
166 homarine		<i>D. ammoniacum</i>	Leaf Stem	[17]
167 2-(<i>N,N</i> -dimethyl hydrazino) cyclohexane carbonitrile		<i>D. ammoniacum</i>	Leaf Stem	[17]
168 phenol, 4-(2-aminopropyl)		<i>D. ammoniacum</i>	Leaf Stem	[17]
169 2-oxo-3-methyl-cis-perhydro-1,3-benzoxazine		<i>D. ammoniacum</i>	Leaf Stem	[17]
170 <i>trans</i> -carveol		<i>D. ammoniacum</i>	Leaf Stem	[17]
171 benzene, (2-fluoro-2-methoxycyclopropyl)		<i>D. ammoniacum</i>	Leaf Stem	[17]
172 2(1H)-naphthalenone, octahydro-8a-methyl, <i>trans</i>		<i>D. ammoniacum</i>	Leaf Stem	[17]
173 <i>p</i> -methoxyamphetamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
174 2-cyclohexen-1-one, 2-methyl-5-(1-methylethenyl)		<i>D. ammoniacum</i>	Leaf Stem	[17]
175 2-methyl amphetamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
176 2-methoxy amphetamine		<i>D. ammoniacum</i>	Leaf Stem	[17]

Table 2. Continued 17

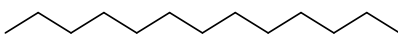
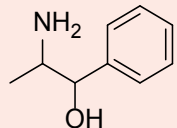
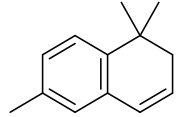
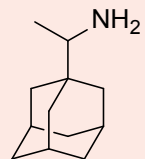
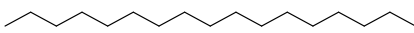
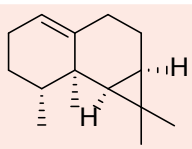
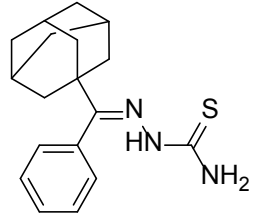
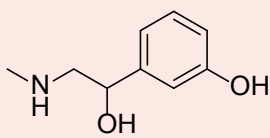
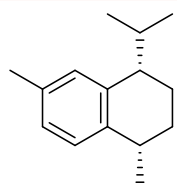
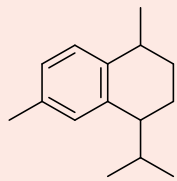
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
177 tridecane		<i>D. ammoniacum</i>	Leaf Stem	[17]
		<i>D. glabrum</i>	Aerial parts	[21]
178 benzenemethanol, alpha-(1-aminoethyl)		<i>D. ammoniacum</i>	Leaf Stem	[17]
179 naphthalene, 1,2-dihydro-1,1,6-trimethyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
180 rimantadine		<i>D. ammoniacum</i>	Leaf Stem	[17]
181 heptadecane		<i>D. ammoniacum</i>	Leaf Stem	[17]
182 calarene		<i>D. ammoniacum</i>	Leaf Stem	[17]
183 1-[a-(1-adamantyl)benzylidene]thiosemicarbazide		<i>D. ammoniacum</i>	Leaf Stem	[17]
184 benzenemethanol, 3-hydroxy-alpha-[(methylamino) methyl]		<i>D. ammoniacum</i>	Leaf Stem	[17]
185 1 S-cis-calamenene		<i>D. ammoniacum</i>	Leaf Stem	[17]
186 calamenene		<i>D. glabrum</i>	Root	[23]

Table 2. Continued 18

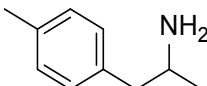
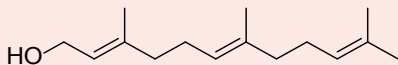
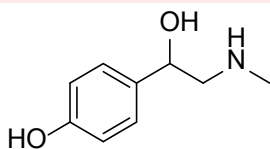
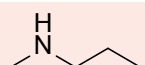
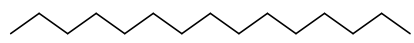
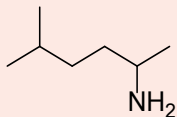
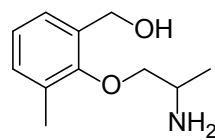

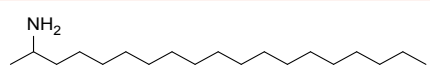
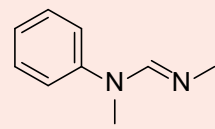
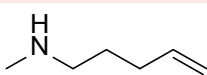
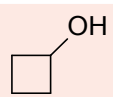
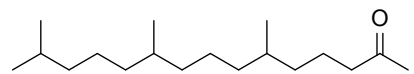
No.	Name of compound	Structure	Species	Plant part	Ref
		Essential oil components			
187	aptrol (4-Methylamphetamine)		<i>D. ammoniacum</i>	Leaf Stem	[17]
188	farnesol		<i>D. ammoniacum</i>	Leaf Stem Seed	[17, 18]
			<i>D. aucheri</i>	Seed Stem	[20]
189	benzenemethanol, 4-hydroxy-alpha- [(methylamino) methyl]		<i>D. ammoniacum</i>	Leaf Stem	[17]
190	N-methyl-propylamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
191	pentadecane		<i>D. ammoniacum</i>	Leaf Stem	[17]
192	2-hexanamine, 5-methyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
193	benzenemethanol, 2-(2-aminopropoxy)-3- methyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
194	2-propanamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
195	2-aminononadecane		<i>D. ammoniacum</i>	Leaf Stem	[17]
196	methanimidamide, N,N- dimethyl-N-phenyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
197	methylpent-4-enylamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
198	cyclobutanol		<i>D. ammoniacum</i>	Leaf Stem	[17]
199	hexahydro farnesyl acetone		<i>D. ammoniacum</i>	Leaf Stem	[17]

Table 2. Continued 19

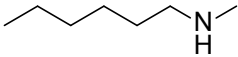
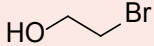
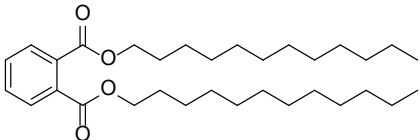
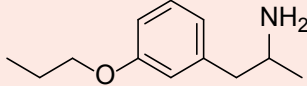
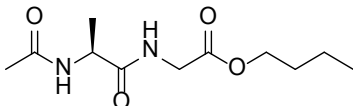
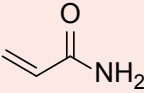
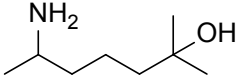

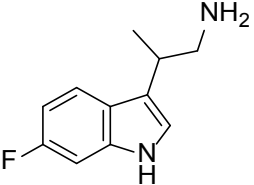
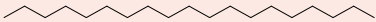
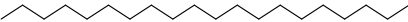
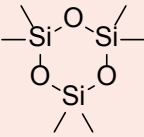
Name of compound	Structure	Species	Plant part	Ref
	Essential oil components			
200 n-hexylmethylamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
201 ethylene bromohydrin		<i>D. ammoniacum</i>	Leaf Stem	[17]
202 didodecyl phthalate		<i>D. ammoniacum</i>	Leaf Stem	[17]
203 3-propoxyamphetamine		<i>D. ammoniacum</i>	Leaf Stem	[17]
204 glycine, N-(N-acetyl-L-alanyl) butyl ester		<i>D. ammoniacum</i>	Leaf Stem	[17]
205 2-propenamide		<i>D. ammoniacum</i>	Leaf Stem	[17]
206 2-heptanol, 6-amino-2-methyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
207 benzene ethanamine, 4-fluoro-beta,3-dihydroxy-N-methyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
208 1H-Indole-3-ethanamine, 6-fluoro-beta-methyl		<i>D. ammoniacum</i>	Leaf Stem	[17]
209 nonadecane		<i>D. ammoniacum</i>	Leaf Stem	[17]
210 eicosane		<i>D. ammoniacum</i>	Leaf Stem	[17]
211 cyclotrisiloxane, hexamethyl		<i>D. ammoniacum</i>	Leaf Stem	[17]

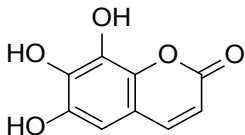
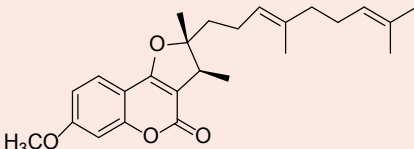
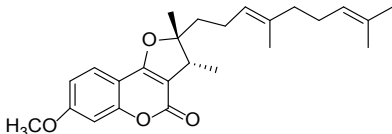
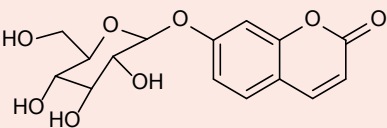
Table 2. Continued 20

Name of compound	Structure	Species	Plant part	Ref
	Phenolic compounds			
212 diglucosyl caffeoyl ester		<i>D. glabrum</i>	Fruit Seed	[27]
213 4-O-β-D-glucopyranosylcaffeic acid		<i>D. glabrum</i>	Fruit Seed	[27]
214 azeroside A		<i>D. glabrum</i>	Root	[26-28]
215 echiside		<i>D. glabrum</i>	Root	[26-28]
216 pleoside		<i>D. glabrum</i>	Root	[26-28]
217 hycanoside		<i>D. glabrum</i>	Root	[26-28]
218 azeroside B		<i>D. glabrum</i>	Root	[26-28]

Table 2. Continued 21

Name of compound	Structure	Species	Plant part	Ref
	Phenolic compounds			
219 7,8-dihydroferulic acid-4-O- β -D-glucopyranoside		<i>D. glabrum</i>	Root	[29, 30]
220 ferulic acid-4-O- β -D-glucopyranoside		<i>D. glabrum</i>	Root	[30, 32]
221 4-methoxy-6-hydroxyacetophenone-2-O- β -D-gentiobioside		<i>D. hyrcanum</i>	Root	[33]
222 1(2-Hydroxy-4-methoxy-3,7,11-trimethyl-3-vinyl-6(E), 10 dodecadiene-1-dione		<i>D. hyrcanum</i>	Root	[33]
223 chlorogenic acid		<i>D. glabrum</i>	Root	[30]
224 cynarin		<i>D. glabrum</i>	Root	[30]
225 4,5-diCQA (4,5-dicafeoylquinic acid)		<i>D. glabrum</i>	Root	[30]

Table 2. Continued 22

Name of compound	Structure	Species	Plant part	Ref
	Coumarin compounds			
226 6,7,8-trihydroxycoumarin		<i>D. glabrum</i>	Root	[30, 34]
227 2,3-dihydro-7-methoxy-2 <i>S</i> *,3 <i>R</i> *-dimethyl-2-[4,8-dimethyl-3(<i>E</i>),7-nonadienyl]-furo[3,2- <i>c</i>] coumarin		<i>D. hyrcanum</i>	Root	[33]
228 2,3-dihydro-7-methoxy-2 <i>R</i> *,3 <i>R</i> *dimethyl-2-[4,8-dimethyl-2283(<i>E</i>),7-nonadienyl]-furo[3,2- <i>c</i>] coumarin		<i>D. hyrcanum</i>	Root	[33]
229 umbelliferone 7- <i>O</i> -β-D-glucoside (skimmin)		<i>D. glabrum</i>	Fruit Seed	[27]

natural treasures within the next few decades.

PHYTOCHEMICAL CONSTITUENTS

The instrumental analysis was revealed that a range of various compounds were identified in *Dorema* species, including essential oil structure that made up hydrocarbon molecules and classified as terpenes, alcohols, esters, aldehydes, ketones and phenols, also contain phenolic and coumarin compounds (Table 2). These phytochemicals derived from different parts of *Dorema* species such as flower, fruit, leaf, stem and root.

ETHNOBOTANICAL USES OF *Dorema* spp.

Among 12 species of *Dorema*, seven have been used in ethnobotany for many decades as a remedy for various human and animal illnesses. These applications of individual *Dorema* species are shown in Table 3. The most popular species, with the highest number of citations were *D. ammoniacum* and *D. aucheri*.

Dorema ammoniacum has been historically reputed in the folk medicine as a natural remedy for a variety of diseases and known as a rich source of a medicinal gum-resin commonly

known as ammoniacum or gum ammoniac. The gum-resin is found in cavities in stems, roots and petioles [5]. In Persia, *D. ammoniacum* (commonly known as Kandal, Vasha and Ushagh.), has a broad spectrum ethnobotanical applications such as anticolic, antifuruncle, expectorant, anthelmintic, emmenagogue agent, anticonvulsant, analgesic, antidote for toxins and laxative. Also, it has been used for treating asthma, bronchitis, stomachache, high blood sugar, infected wounds and infections, acne, abscess, and sciatic pain [6, 35-38].

Western and Indian herbalists recommended it as an anti-spasmodic, expectorant, diaphoretic and emmenagogue agent and also for treatment of catarrh, asthma, chronic bronchitis and persistent coughing [39, 40].

Jordanian herbalist recommended the usage of the resin of *D. ammoniacum* as incense and blood sugar reducer [35].

In Afghanistan, herbal medicine has been used under the name of Unani medicine for centuries. In different parts of Kabul, there are numerous Unani or Loqmani pharmacies locally called "Attari" where Hakims are prescribing the flowers of *D. ammoniacum* for the treatment of diarrhea, peptic ulcer, and other gastric diseases [41].

In Pakistan, *D. ammoniacum* has been used to treat dysentery and skin diseases by local people particularly in Baluch-

Table 3. Some of the most important ethnobotanical and traditional uses of *Dorema* species in different countries

No	<i>Dorema</i> species	Vernacular name	Country	Part used	Ethnobotanical and traditional uses	Ref
1	<i>D. aitchisonii</i>	-	The former Soviet Union	Shoot	The water extract from the young shoots is used to treat diseases of the stomach.	[7]
2	<i>D. ammoniacum</i>	Kandal	Iran	Gum, root	Cystitis, digestive, treatment of colic, treatment of furuncles, expectorant, anthelmintic, emmenagogue, anticovulsion	[6]
		Koma	Iran	Resin	Antacid, digestive, treatment of colic, furuncles, expectorant, anthelmintic, emmenagogue and anticovulsion	[46]
		Anghuzeh	Iran	Latex	Asthma, expectorant, bronchitis, stomachache	[37]
		Ammoniacum	Jordan	Resin	Incense, blood sugar reduction	[35]
		Kama eshterk	Iran	Gum	Healing infected wound and infection, acne and abscess	[36]
		Ganda ferooza	Afghanistan	Flowers	Treatment of diarrhea, peptic ulcer and other gastric diseases	[41]
		Ooshi	Pakistan	Gum	Abortifacient	[47]
		Oshagh	Iran	Gum	Analgesic, antidote for toxins, laxative, sciatic pain	[38]
		Kama eshterk	Iran	Gum	Improvement of infectious wounds and infection, abscess in sheep and goats	[48]
		3	<i>D. aucheri</i>	Kal	Iran	Latex
Bilhar	Iran			Young aerial part	Parasites of digestive system, constipation, use as vegetable, young stems are pickled	[12]
Kama, Eshterk, Balhareshterk	Iran			Gum	Healing infected wound and infection, gasteralgia	[36]
Balhar, Kama, eshterk	Iran			Gum	Improvement of infectious wounds and infection in sheep	[48]
Zou	Iran			Root	Burn healing, cornicide	[43]
4	<i>D. aureum</i>	Oshtork	Iran	Gum	Abortion, infection	[49]
5	<i>D. glabrum</i>	-	Azerbaijan Republic	Gum-resin	Diuretic and anti-diarrheal agent as well as for the treatment of bronchitis and catarrh, cure of cancer	[15]
6	<i>D. hyrcanum</i>	-	The former Soviet Union	Resin	As plasters to stop bleeding and to treat injuries in horses.	[7]
7	<i>D. sabulosum</i>	Ilyan	Uzbekistan	Root and stem	Roots used as diuretic and for head and respiratory organs. tincture from green stem used as a remedy for head and heart illnesses.	[45]

istan province [42].

In Iranian folk medicine, *D. aucheri* is used against asthma, bronchitis, parasites of digestive system, constipation, burns and infected wounds young leaves and branches are used for making a locally popular pickle called “Bilhar Pickle” and soups [12, 36, 37, 43].

Based on the folk beliefs of Azerbaijan and Armenian people, *Dorema* species can treat many abnormalities especially

catarrh, bronchitis and diarrhea and also can act as diuretic [44]. Besides, they use *D. glabrum* for many illnesses especially various types of cancer [23].

In former times, some *Dorema* species were consumed in the former Soviet Union. The resins of *D. hyrcanum* were used by the local population as plasters to stop bleeding and to treat injuries in horses. The water extract from the young shoots of *D. aitchisonii* is used to treat diseases of the stomach [7].

In Uzbekistan, milky latex from the roots of *D. sabulosum* is used as diuretic and for head and respiratory organs. Tincture from green stem is useful for head and heart diseases [45].

NATURE OF *D. ammoniacum* DESCRIBED IN ITM

In all of ITM literatures the Mizaj (temperament) of *Dorema* is mentioned as hot and dry [50-57]. Avicenna and other ITM scientists believed that *Dorema* is a purgative (for bile, yellow bile, and phlegm), resolvent (mohallel), desiccant, deobstruent (mofatteh), laxative and attractive agent [50-57].

Dorema ammoniacum has been known as a rich source of ammoniacum or gum ammoniac. This medicinal gum-resin has been described by Dioscorides as following:

“It is also called “agasyllon”, “criotheos”, or “heliastrus”, and the Romans call it “gutta”. Its smell is similar to castor odor with bitter taste. It has a good color, is not woody, without stones, similar to frankincense in little clots, clear and thick, without filth, this type is called “thrausma” and its earthy or stony kind is called “phurama” [51].

USES OF *D. ammoniacum* IN ITM

According to ITM texts, *D. ammoniacum*, *D. aucheri* and *D. aureum* are the most usable species with similar effects, so in the following sections, we have only mentioned and categorized *D. ammoniacum* medicinal activities on target organs according to the text books, listed in Table 4.

1. Liver and spleen

One of the most traditional uses of *Dorema* is in liver and spleen disorders.

The liniment of *D. ammoniacum* with vinegar (acetum) on the skin of spleen and liver is an effective remedy for hepatitis, splenitis and sclerosis of liver and stiffness of spleen. Oral administration of this combination has the same effect for mentioned disease. Besides, *Dorema* has been used for treating liver obstructions [52, 55, 57].

2. Gastrointestinal system

In the most of the investigated ITM books, *Dorema* spp. has been recommended as an anthelmintic agent against gastrointestinal worms and tinea [52, 54, 55, 57], as a laxative for treating constipation [56] and as a purgative agent for cleansing the stomach from the phlegmatic excreta [53, 58]. In addition, many ITM scientists believed that *Dorema* spp. treats hemorrhoids and anal disorders because of its deobstruent effect on the rectal veins [54, 57].

3. Upper respiratory tract

The therapeutic properties of *Dorema* spp. on the upper respiratory tract are paid attention by many scientists in ITM. They described it as a good remedy for orthopnea, dyspnea, diphtheria and specifically asthma. Ibn Nafis Qarashi in his book (Al-Mujaz fi'l-Tibb) recommended that a linctus of *Dorema* with honey or mucilage of barley is useful for the mentioned diseases, as well as scrofula [55]. This mixture is frequently mentioned in other ITM books such as Makhzan al-Adwiah,

Table 4. Major ITM books and their authors that described medicinal properties of *Dorema* spp.

Book	Language	Author	Living period
Al-Qânun fi al-Tibbe	Arabic	Ibn Sina	980-1037 A.D.
Zakhireh khârazmshâhi	Persian	Jorjâni	1042-1136 A.D.
Al-Aghrâz al-Tibbe wa al-Mabâhethi al-Âlâiiah	Persian	Jorjâni	1042-1136 A.D.
Al-Jâmee le Mofradât al-Adwiah wa al-Aghziah	Arabic	Ibn Al-Baytâr	1193-1248 A.D.
Tadhkirat Oli al-Albâb wa al-Jâmee le al-Ajb al-Ujâb	Arabic	Antaki	1535-1599 A.D.
Hadiqat al-Azhâr fi Mâhiyyat al-ushb wa al-uqqâr	Arabic	Ghasani	1547-1611 A.D.
Al-Mujaz fi'l-Tibb	Arabic	Ibn Nafis Qarshi	1213- 1288 A.D.
Tohfah al-Momenin	Persian	Husseini Tonekaboni	17 th century
Makhzan al-Adwiah	Persian	Aqili Khorasani	18 th century

Table 5. In vitro studies of *Dorema* spp.

Species	Part used	Type of extraction	Activity	Tested pathogen/cell	Result(s)	Ref
<i>D. aucheri</i>	Gum	Dichloromethane, methanol extract	Anti-microbial activity	<i>E. coli</i> , <i>K. pneumoniae</i> , <i>P. aeruginosa</i> , <i>C. albicans</i>	MIC: 20 and 40 mg/mL	[59]
<i>D. ammoniacum</i>	Oleogum resin	Dichloromethane and methanol extract	Anti-bacterial and anti-fungal	G+ and G-	C: 500 and 1000 µg/mL	[60]
<i>D. ammoniacum</i>	Aerial parts	Methanol extract	Anti-microbial activity	<i>S. aureus</i> <i>Enterococcus</i> sp. <i>C. albicans</i> <i>E. coli</i>	MIC:78 µg/mL	[61]
<i>D. aucheri</i>	Aerial parts	Methanol extract	Anti-microbial and anti-oxidative	<i>B. cereus</i> , <i>S. aureus</i> , <i>E. coli</i> <i>S. enterica</i>	MIC: 10-50 mg/mL	[62]
<i>D. ammoniacum</i>	Ripe fruit	Essential oil	Anti-microbial activity	<i>B. subtilis</i> <i>S. epidermidis</i>	MIC: 3.75 mg/mL	[22]
<i>D. aucheri</i>	Leaf	Ethanol extract	Anti-bacterial activity	<i>S. pyogenes</i> <i>P. aeruginosa</i>	MIC and MBC. 30 and 40 mg/mL	[63]
<i>D. aucheri</i>	Aerial parts	Hydro-alcoholic extract	Cytotoxicity	<i>Artemia urmiana larve</i> (lethaling brine shrimp)	LC ₅₀ 76.50 ± 0.60 µg/mL	[64]
<i>D. kopetdaghense</i>	Aerial parts	Kopetdaghins A, C and E	Anti-inflammatory effect	J774A.1 murine macrophages	IC ₅₀ : 474.1 ± 0.9, 496.4 ± 0.7 and 514.3 ± 0.4 µg/mL	[2]
<i>D. aucheri</i>	Aerial parts	Water/ethanol extract	Anti-coccidial effects	Fecal samples	lowest (1.60) and the highest body weight (1.75) FCR	[65]
<i>D. aucheri</i>	Roots	EtOAc extract	No scavenging, and anti-bacterial activities	<i>E. coli</i> , <i>S. flexneri</i> <i>S. aureus</i> <i>B. subtilis</i>	MIC: 0.156, <i>E. coli</i> IC ₅₀ : 113.74 ± 0.21 and 597.64 ± 0.33 µg/mL	[66]
<i>D. aucheri</i>	Aerial parts	Hydroalcoholic and aqueous extracts	Genotoxicity evaluation	HepG2 cell line	Genotoxic effect: 500 µg/mL	[67]
<i>D. glabrum</i>	Root	<i>n</i> -hexane extracts	Apoptosis and cell cycle arrest	Cancer cells	IC ₅₀ : 6.4,4.6 µg/mL	[68]
<i>D. glabrum</i>	Seed	Methanol extracts	Apoptotic effects	WEHI-164 cells	Apoptosis and antiproliferative properties	[69]
<i>D. ammoniacum</i>	Oleogum resin	Methanol extracts	Cytotoxic effects	<i>Saccaromyces cerevisiae</i>	IC ₁₂ : 3.14 mg/mL	[70]
<i>D. aucheri</i>	Aerial part	Methanol extracts	Cytotoxic activity	HepG2 and A549 cells	IC ₅₀ : 20.09, 48.65 µg/mL	[71]
<i>D. glabrum</i>	Seed	Methanol extracts	Cytotoxic effects	WEHI-164 cells, mouse Fibrosarcoma cell line and L929 normal cells	IC ₅₀ : 50 µg/mL in 36 hours	[72]
<i>D. glabrum</i>	Seeds	Methanol extract	Geno/cytotoxicity and apoptotic	CAOV-4 cells	IC ₅₀ : 99.7, 87.3, 70.03 µg/mL at 48 h	[73]
<i>D. glabrum</i>	Roots	Essential oil	Free radical scavenging	DPPH assay	RC ₅₀ : 2.24 mg/mL	[23]
<i>D. glabrum</i>	Aerial parts	Methanol fraction	Antioxidant	DPPH assay	IC ₅₀ : 53.3 ± 4.7 µg/mL	[21]

Tohfah al-Momeninand etc. [52, 54, 55, 57]. The above mixture was used for purgation of the lungs from phlegmatic humors, too [52, 57].

4. Eyes

In all ITM records, treating ocular problems by *Dorema* preparations have been reported. A collyrium (kohl) of *Dorema* was used for improving the thickness of eyelids, treating trachoma, leukoma (opacity of the cornea) ophthalmia and stye [52, 55, 57, 58]. *Dorema* is an effective remedy for moisturizing roughness of eyelids [52, 55, 58]. In addition, it dries up eye moisture [52, 55, 57].

5. Central nervous systems

Due to descanting effects of *Dorema*, it was described as a purgation agent to clean the brain from phlegm and other humors [52]. Taking a combination of *Dorema* with honey or beer

is a useful remedy for epilepsy and insensibility (numbness) spasms [52, 57]. Also gurgling a warm watery solution of the plant is suitable for cleaning the brain from waste phlegm and humors, dizziness, paralysis, facial paralysis and vertigo [52].

6. Genitourinary system

Dorema spp. has diuretic and emmenagogic properties, therefore, it has been used as a treatment for dysuria and as an abortifacient agent [52, 54, 55]. *Dorema* preparations have also been reported to be useful for nephrolith and cystolith [52, 57]. Some ITM scientists have recommended it as a remedy for the hardness of testicles and orchitis as well [52].

7. Skin

Dorema has been described to have the property of improving complexion; Therefore, it was particularly used for vitiligo, melisma and freckles [52, 57]. For this purpose, the herb was

Table 6. In vivo studies of *Dorema* spp.

Species	Parts used	Type of extraction	Activity	Study design	Result(s)	Ref
<i>D. aucheri</i>	Leaves	Hydroalcoholic extract	Hypolipidemic	Diabetic rats model; orally; 200 mg/kg for 4 weeks; a randomized controlled clinical trial	Useful in treatment of diabetes, remarkable change in serum lipid profiles	[73]
<i>D. hyrcanum</i>	Roots	Methanol extract	Antiplasmodial effect	Mice model; injection ; 10 mg/mL for 4 days 4-day suppressive test against nicd strain of in mice	Good suppression <i>plasmodium berghei</i> infection activity, inhibiting 68.1% of the parasite growth	[33]
<i>D. aucheri</i>	Leaves	Ethanol95%	Hepatotoxicity	Albino mice model; injections; 3.2 mL/kg; three times every 48 hours	Inflammation of the liver tissue, cell proliferation, cholestasis, and a great release of liver enzymes	[74]
<i>D. aucheri</i>	Aerial parts	Essential oil	Anti-diabetic effect	Patients with type ii diabetes; randomized clinical trial; 500 mg for 45 days	Biological effects through <i>PPAR-γ</i> activation	[24]
<i>D. urmiana</i>	Aerial parts	Hydro alcohol extract	Cytotoxicity	Larvae of <i>artemia urmiana</i> ; 24 hours; 12 mg rutin/g extract	lc50 76.50 ± 0.60 µg/mL potent brine shrimp lethality	[64]
<i>D. aucheri</i>	Leaves	Water/ethanol 95° mixture	Anti-coccidial	Chickens model; orally; after 22 day of age; 30 mg/kg	Effective in control of coccidiosis	[65]
<i>D. ammoniacum</i>	Gum	Water extract	Anticonvulsant activity	Male albino mice model; 700 mg/kg; injection	Showed significant anticonvulsant activity	[75]
<i>D. aucheri</i>	Root	Hydroalcoholic extract	Effects on pituitary gonad axis hormones	Adult male rat model; orally; 200 mg/kg for 28 days	Increased lh concentrations	[76]

applied with olive oil on the affected area. Furthermore, many ITM scientists such as Ibn Nafis Qarshi and Jorjani have mentioned the plant as a cure for various types of wounds, ulcers and specifically scars; as Jorjani has written: "Dorema plaster wears away decayed flesh and regenerates new one" [52, 55, 57].

8. Joints and muscles

There are several records on the traditional use of *Dorema* spp. for joints. For instance, Jorjani has mentioned it for sciatic nerve pain (sciatica). It is also claimed as a cure for arthralgia and stiffness of joints, particularly when prescribed topically with honey [52, 55].

PHARMACOLOGICAL ASPECTS

So far, various pharmacological activities have been reported from *Dorema* spp., including anti-microbial, anti-bacterial, anti-plasmodial, anti-fungal, cytotoxic, anti-inflammatory, free radical scavenging, hypolipidemic, anticonvulsant and anti-diabetic activities, as well as effects on pituitary gonad axis hormones. These reports have been mentioned in Tables 5 and 6.

CONCLUSION

Ethnobotanical and traditional medicines are considered as valuable approaches for discovering new medicines because of antiquity medical usage of them over generations. In the current review, the beneficial properties and applications of *Dorema* spp. Was investigated in ITM books and modern pharmacological studies. The genus *Dorema*, especially *D. ammoniacum* known as "ushaq" has been used in folklore and Islamic traditional medicine as a treatment for a wide range of disorders, such as gastrointestinal, upper respiratory tract and central nervous systems' problems. Besides, many pharmacological activities including anti-microbial, anti-inflammatory, antioxidant, cytotoxicity, anticonvulsant, anti-diabetic and hypolipidemic activities have been reported in modern medicine. These species contain various constituents such as terpenes, coumarins and phenolic compounds. However, more studies, particularly clinical trials, are necessary to fill existing gaps in our knowledge of various aspects of these species.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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