

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

Elaheh Zibae<sup>1</sup>, Mohammad Sadegh Amiri<sup>2</sup>, Zahra Boghrati<sup>1</sup>, Faeghe Farhadi<sup>3</sup>, Mahin Ramezani<sup>4,5</sup>, Seyed Ahmad Emami<sup>1\*</sup>, Amirhossein Sahebkar<sup>6,7,8,9</sup>

<sup>1</sup>Department of Traditional Pharmacy, School of Pharmacy, Mashhad University of Medical Sciences, Mashhad, Iran

<sup>2</sup>Department of Biology, Payame Noor University, Tehran, Iran

<sup>3</sup>Department of Pharmacognosy, School of Pharmacy, Mashhad University of Medical Sciences, Mashhad, Iran

<sup>4</sup>Nanotechnology Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

<sup>5</sup>Pharmaceutical Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

<sup>6</sup>Halal Research Center of IRI, FDA, Tehran, Iran

<sup>7</sup>Biotechnology Research Center, Pharmaceutical Technology Institute, Mashhad University of Medical Sciences, Mashhad, Iran

<sup>8</sup>Neurogenic Inflammation Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

<sup>9</sup>Polish Mother's Memorial Hospital Research Institute (PMMHRI), Lodz, Poland

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## \*Correspondence

Seyed Ahmad Emami

Department of Traditional Pharmacy,  
School of Pharmacy, Mashhad University  
of Medical Sciences, Mashhad, Iran

Tel: +0985131801267

E-mail: emamia@mums.ac.ir

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

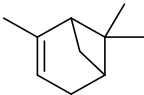

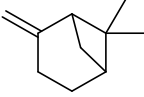
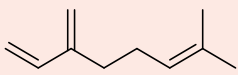
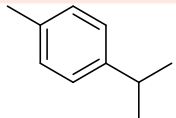
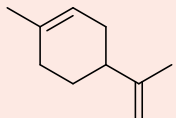
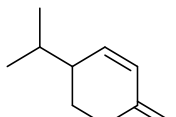
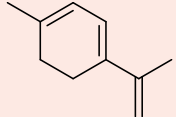
**Table 1.** Scientific names and synonyms of reported *Dorema* species worldwide [according to The Plant List (2013)]

| 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.<br><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 $\alpha$ -pinene              |    | <i>D. ammoniacum</i> | Aerial parts<br>Flower<br>Stem<br>Seed<br>Leaf<br>Root<br>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<br>Stem<br>Root  | [14]                 |
|                                 |   |                      |   | <i>D. aucheri</i>    | Seed<br>Stem  | [19, 20]             |
|                                 |   |                      |   | 3 $\beta$ -pinene    |  | <i>D. ammoniacum</i> |
| <i>D. aucheri</i>               | Seed<br>Stem  | [19, 20]             |   |                      |   |                      |
| 4 $\beta$ -myrcene              |  | <i>D. aucheri</i>    | Seed<br>Stem  |                      |   | [19, 20]             |
|                                 |   | <i>D. glabrum</i>    | Aerial part   | [21]                 |   |                      |
|                                 |   | <i>D. ammoniacum</i> | Flower<br>Stem<br>Root<br>Leaves  | [14, 17, 18]         |   |                      |
|                                 |   | 5 <i>p</i> -cymene   |  | <i>D. ammoniacum</i> | Aerial parts<br>Flower stem<br>Root   | [14, 15, 18]         |
| 6 limonene                      |  |                      |   | <i>D. ammoniacum</i> | Flower stem<br>Seed<br>Root<br>Leaf<br>Leaves                                     | [14, 16, 18]         |
|                                 |   |                      |   | <i>D. aucheri</i>    | Aerial parts  | [19, 20]             |
| 7 $\beta$ -phellandrene         |  | <i>D. ammoniacum</i> | Seed<br>Stem  | [21]                 |   |                      |
|                                 |   | <i>D. glabrum</i>    | Aerial parts  | [21]                 |   |                      |
| 8 1,3,8- <i>p</i> -menthatriene |  | <i>D. ammoniacum</i> | Aerial parts  | [15]                 |   |                      |
|                                 |   | <i>D. ammoniacum</i> | Aerial part   | [22]                 |   |                      |

**Table 2. Continued 1**

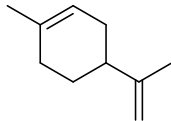
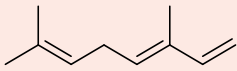
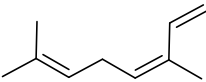
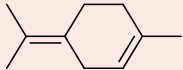
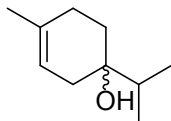
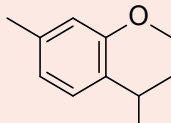
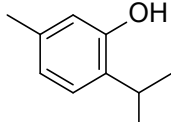
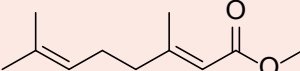
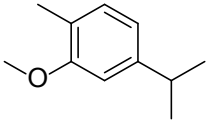
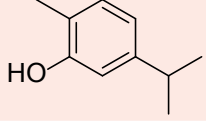
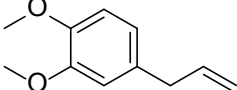
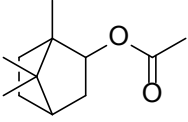
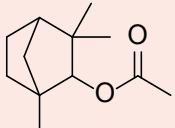
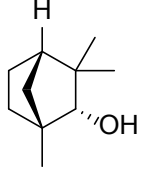
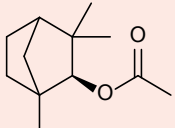
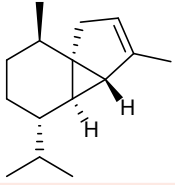
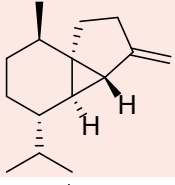
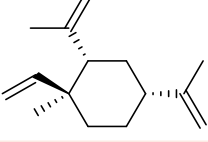
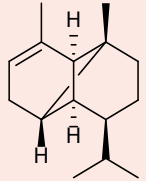
| Name of compound                      | Structure   | Species              | Plant part   | Ref             |
|---------------------------------------|---|----------------------|--|-----------------|
|                                       | Essential oil components  |                      |  |                 |
| 9 <i>p</i> -mentha-1,8-diene          |    | <i>D. ammoniacum</i> | Fruit  | [22]            |
| 10 ( <i>E</i> )- $\beta$ -ocimene     |    | <i>D. ammoniacum</i> | Flower<br>Stem<br>Root<br>Leaves                         | [14, 18]        |
|                                       |   | <i>D. aucheri</i>    | Aerial parts   | [19]            |
|                                       |   | <i>D. glabrum</i>    | Aerial parts   | [21]            |
| 11 ( <i>Z</i> )- $\beta$ -ocimene     |    | <i>D. glabrum</i>    | Aerial parts   | [21]            |
|                                       |   | <i>D. ammoniacum</i> | Stem<br>Leaves   | [18]            |
|                                       |   |                      |  |                 |
| 12 terpinolene ( $\delta$ -terpinene) |    | <i>D. ammoniacum</i> | Aerial parts<br>Flower<br>Root<br>Stem<br>Leaf<br>Leaves | [14, 15, 17-19] |
|                                       |   | <i>D. aucheri</i>    | Aerial parts<br>Seed<br>Stem                             | [19, 20]        |
|                                       |   |                      |  |                 |
|                                       |   |                      |  |                 |
|                                       |   |                      |  |                 |
|                                       |   |                      |  |                 |
| 13 terpinene-4-ol                     |  | <i>D. aucheri</i>    | Aerial part  | [20]            |
| 14 thymol methyl ether                |  | <i>D. ammoniacum</i> | Flower stem<br>Root<br>Seed                              | [14, 16]        |
|                                       |   | <i>D. aucheri</i>    | Aerial parts   | [19]            |
| 15 thymol                             |  | <i>D. ammoniacum</i> | Seed<br>Stem   | [16]            |
|                                       |   | <i>D. aucheri</i>    | Aerial part<br>Seed<br>Stem                              | [20]            |
|                                       |   |                      |  |                 |
|                                       |   |                      |  |                 |
| 16 methyl geranate                    |  | <i>D. aucheri</i>    | Aerial part  | [19]            |
| 17 carvacrol methyl ether             |  | <i>D. ammoniacum</i> | Flower<br>Stem<br>Root                                   | [14]            |
|                                       |   | <i>D. glabrum</i>    | Root   | [23]            |
| 18 carvacrol                          |  | <i>D. aucheri</i>    | Stem<br>Seed   | [20]            |
|                                       |   | <i>D. ammoniacum</i> | Stem<br>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<br>Stem<br>Root<br>Leaves                  | [14, 18]     |
|                              |   | <i>D. aucheri</i>    | Aerial parts<br>Seed<br>Stem                      | [19, 20]     |
| 21 fenchyl acetate           |    | <i>D. glabrum</i>    | Aerial parts                                      | [21]         |
| 22 endo-fenchol              |    | <i>D. ammoniacum</i> | Leaf  | [18]         |
| 23 $\alpha$ -fenchyl Acetate |    | <i>D. glabrum</i>    | Root  | [23]         |
| 24 $\alpha$ -cubebene        |  | <i>D. ammoniacum</i> | Flower<br>Fruit<br>Stem<br>Root                   | [14, 22]     |
|                              |   | <i>D. aucheri</i>    | Aerial parts                                      | [19]         |
| 25 $\beta$ -cubebene         |  | <i>D. aucheri</i>    | Aerial parts                                      | [20]         |
| 26 $\beta$ -elemene          |  | <i>D. aucheri</i>    | Aerial parts                                      | [20]         |
| 27 $\alpha$ -copaene         |  | <i>D. ammoniacum</i> | Flower<br>Fruit<br>Stem<br>Seed<br>Leaves<br>Root | [14, 16, 22] |
|                              |   | <i>D. aucheri</i>    | Aerial parts<br>Seed<br>Stem                      | [19, 20]     |
|                              |   | <i>D. glabrum</i>    | Root  | [23]         |

**Table 2. Continued 3**

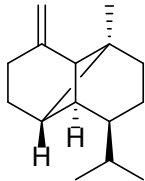
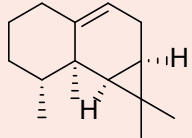
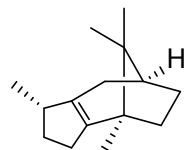
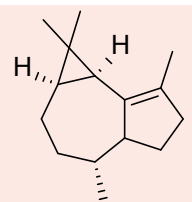
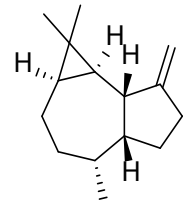
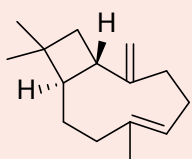
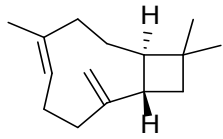
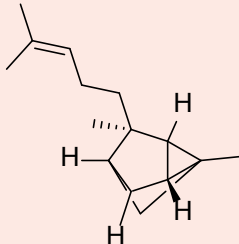
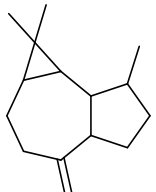
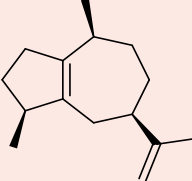
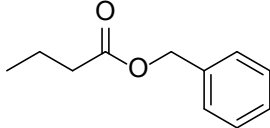
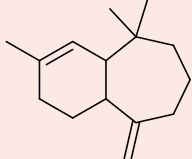
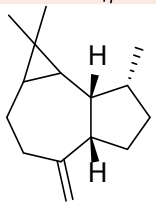
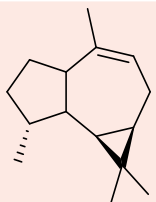
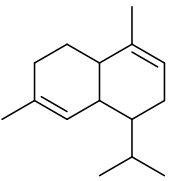
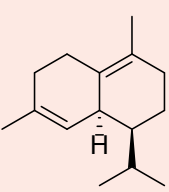
| Name of compound          | Structure   | Species              | Plant part                          | Ref          |
|---------------------------|---|----------------------|-------------------------------------|--------------|
|                           | Essential oil components  |             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

Table 2. Continued 4

| Name of compound         | Structure   | Species              | Plant part                  | Ref      |
|--------------------------|---|----------------------|-----------------------------|----------|
|                          | Essential oil components  |                      |                             |          |
| 36 aromadendrene         |    | <i>D. ammoniacum</i> | Flower stem<br>Seed<br>Root | [14, 16] |
|                          |   | <i>D. aucheri</i>    | Aerial parts                | [19]     |
| 37 $\alpha$ -guaiene     |    | <i>D. ammoniacum</i> | Flower stem<br>Root         | [14]     |
| 38 benzyl butanoate      |    | <i>D. ammoniacum</i> | Root                        | [14]     |
| 39 $\alpha$ -himachalene |   | <i>D. ammoniacum</i> | Flower stem<br>Root         | [14]     |
| 40 allo-aromadendrene    |  | <i>D. ammoniacum</i> | Flower stem<br>Root         | [14]     |
| 41 dehydroaromadendrane  |  | <i>D. ammoniacum</i> | Flower stem<br>Root         | [14, 16] |
| 42 $\alpha$ -amorphene   |  | <i>D. ammoniacum</i> | Flower stem<br>Root         | [14]     |
|                          |   | <i>D. aucheri</i>    | Seed<br>Stem                | [20]     |
| 43 $\delta$ -amorphene   |  | <i>D. ammoniacum</i> | Flower stem<br>Root         | [14]     |

**Table 2. Continued 5**

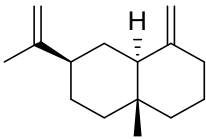
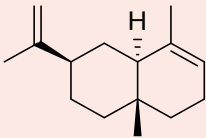
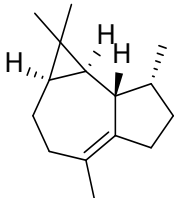
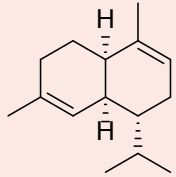
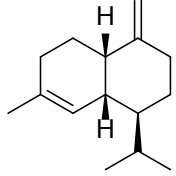
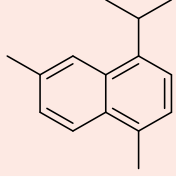
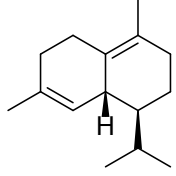
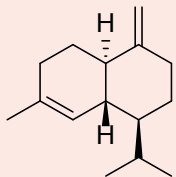
| Name of compound       | Structure   | Species              | Plant part                             | Ref          |
|------------------------|---|----------------------|--|--------------|
|                        | Essential oil components  |                      |  |              |
| 44 $\beta$ -selinene   |    | <i>D. ammoniacum</i> | Flower stem                            | [14, 16]     |
|                        |   | <i>D. aucheri</i>    | Seed<br>Root<br>Stem                   | [20]         |
| 45 $\alpha$ -selinene  |    | <i>D. ammoniacum</i> | Aerial part                            | [14, 15]     |
|                        |   | <i>D. aucheri</i>    | Flower<br>Root<br>Stem<br>Seed<br>Stem | [20]         |
| 46 viridiflorene       |    | <i>D. aucheri</i>    | Aerial part                            | [19]         |
| 47 $\alpha$ -muurolene |   | <i>D. ammoniacum</i> | Flower, stem                           | [14]         |
|                        |   | <i>D. glabrum</i>    | Root<br>Root                           | [23]         |
| 48 $\gamma$ -muurolene |  | <i>D. ammoniacum</i> | Stem                                   | [16]         |
| 49 cadalene            |  | <i>D. glabrum</i>    | Root                                   | [23]         |
| 50 $\delta$ -cadinene  |  | <i>D. ammoniacum</i> | Flower seed                            | [14, 16, 17] |
|                        |   | <i>D. aucheri</i>    | Stem<br>Aerial parts<br>Seed<br>Stem   | [18, 20, 24] |
|                        |   | <i>D. glabrum</i>    | Root                                   | [23]         |
| 51 $\gamma$ -cadinene  |  | <i>D. aucheri</i>    | Aerial parts                           | [19]         |
|                        |   | <i>D. ammoniacum</i> | Seed<br>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 $\beta$ -sesquiphellandrene       |                          | <i>D. ammoniacum</i> | Seed                                   | [16]         |
| 55 ledol                             |                          | <i>D. ammoniacum</i> | Stem                                   | [16]         |
| 56 liguloxide                        |                          | <i>D. ammoniacum</i> | Flower<br>Root<br>Stem                 | [14]         |
| 57 ( <i>E</i> )-nerolidol            |                          | <i>D. ammoniacum</i> | Flower<br>Root<br>Leaf<br>Stem<br>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**

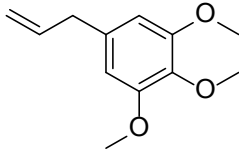
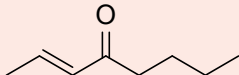
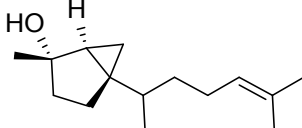
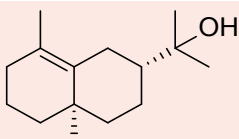
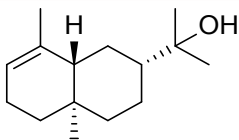
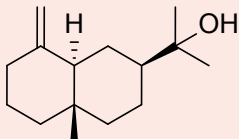
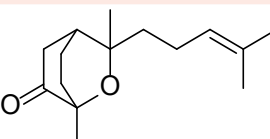
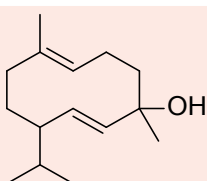
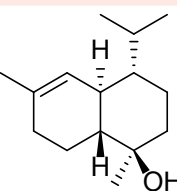
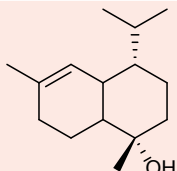
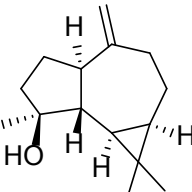
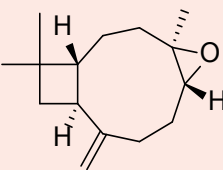
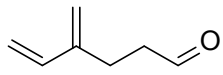
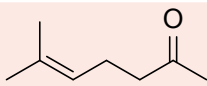
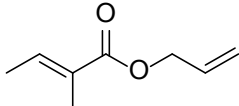
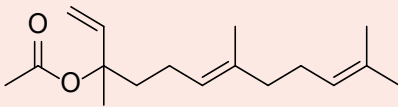
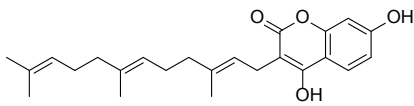

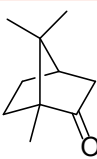
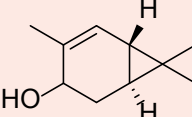
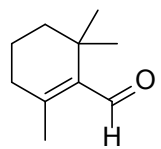
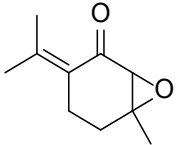
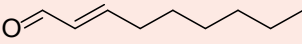
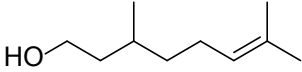
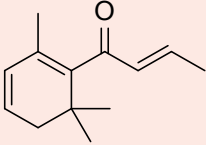
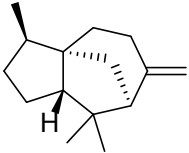
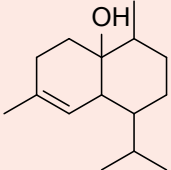
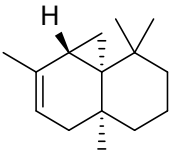
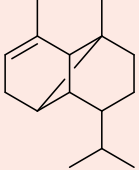
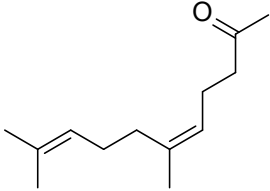
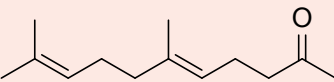
| Name of compound                        | Structure   |  | Species              | Plant part   | Ref      |
|---|---|--|----------------------|--------------|----------|
|   | Essential oil components  |  |                      |              |          |
| 61 elemicin                             |    |  | <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 $\gamma$ -eudesmol                   |    |  | <i>D. ammoniacum</i> | Seed<br>Stem | [16]     |
|   |   |  | <i>D. aucheri</i>    | Aerial parts | [19]     |
| 65 $\alpha$ -eudesmol                   |   |  | <i>D. ammoniacum</i> | Seed<br>Stem | [16]     |
|   |   |  | <i>D. aucheri</i>    | Aerial parts | [19, 24] |
| 66 $\beta$ -eudesmol                    |  |  | <i>D. ammoniacum</i> | Seed<br>Stem | [16]     |
| 67 sesquicineol-2-one                   |  |  | <i>D. ammoniacum</i> | Seed<br>Stem | [16]     |
| 68 germacrene D-4-ol                    |  |  | <i>D. aucheri</i>    | Aerial part  | [19]     |
| 69 $\alpha$ -cadinol                    |  |  | <i>D. ammoniacum</i> | Stem<br>Seed | [16]     |
|   |   |  | <i>D. aucheri</i>    | Aerial parts | [19]     |
|   |   |  | <i>D. glabrum</i>    | Root         | [23]     |
| 70 $\delta$ -cadinol                    |  |  | <i>D. glabrum</i>    | Root         | [23]     |

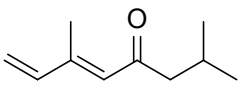
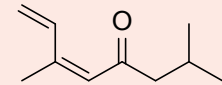
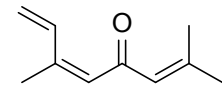
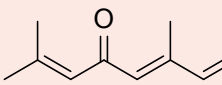
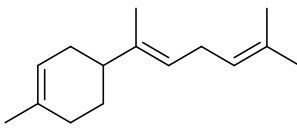
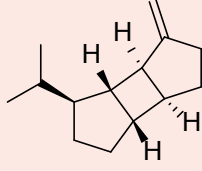
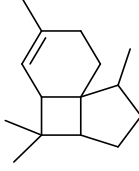
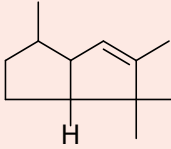
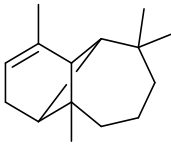
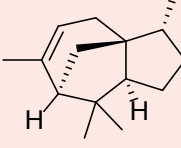
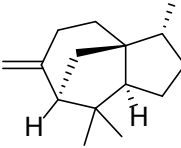
Table 2. Continued 8

| 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<br>Stem          | [20]         |
| 72 caryophyllene oxide         |    | <i>D. ammoniacum</i> | Fruit<br>Seed<br>Stem | [16, 17, 22] |
|                                |   | <i>D. aucheri</i>    | Leaf<br>Seed<br>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 $\beta$ -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><br><i>D. glabrum</i> | Aerial parts<br>Root         | [19]<br>[23] |
| 88 thujopsene         |  | <i>D. ammoniacum</i>                   | Aerial parts                 | [15]         |
| 89 ylangene           |  | <i>D. glabrum</i><br><i>D. aucheri</i> | Aerial parts<br>Seed<br>Stem | [21]<br>[20] |
| 90 nerylacetone       |  | <i>D. ammoniacum</i>                   | Aerial parts                 | [15, 17]     |
| 91 geranyl acetone    |  | <i>D. glabrum</i>                      | Aerial parts<br>Root         | [21]<br>[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 $\alpha$ -bisabolene      |    | <i>D. ammoniacum</i>                      | Aerial parts          | [15]         |
| 97 $\beta$ -bourbonene       |   | <i>D. aucheri</i><br><i>D. ammoniacum</i> | Seed<br>Stem<br>Fruit | [20]<br>[22] |
| 98 italicene                 |  | <i>D. ammoniacum</i>                      | Fruit                 | [22]         |
| 99 di-epi- $\alpha$ -cedrene |  | <i>D. ammoniacum</i>                      | Fruit                 | [22]         |
| 100 $\alpha$ -longipinene    |  | <i>D. ammoniacum</i>                      | Fruit                 | [22]         |
| 101 $\alpha$ -cedrene        |  | <i>D. ammoniacum</i>                      | Aerial parts          | [15]         |
| 102 $\beta$ -cedrene         |  | <i>D. glabrum</i><br><i>D. ammoniacum</i> | Aerial parts<br>Fruit | [21]<br>[22] |

**Table 2. Continued 11**

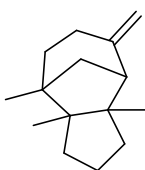
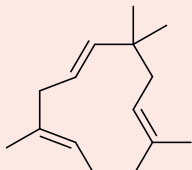
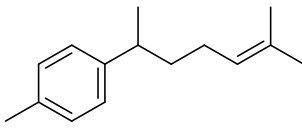
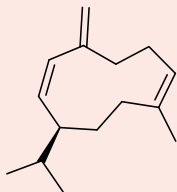
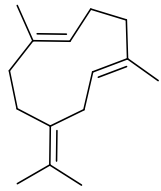
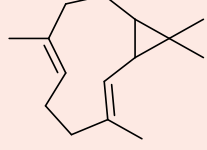
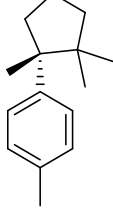
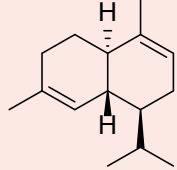
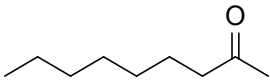
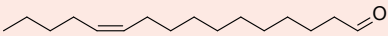
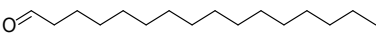
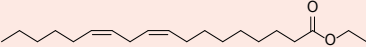
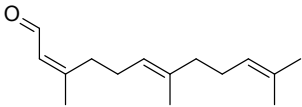
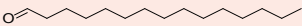
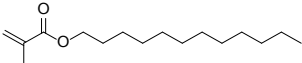
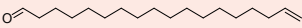
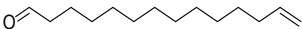
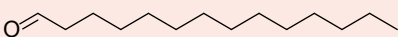
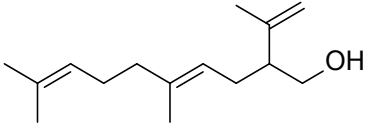
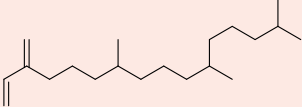
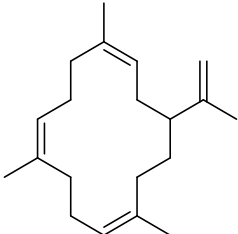
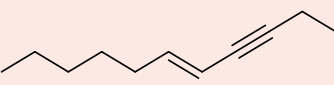
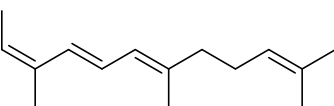
| Name of compound         | Structure   | Species              | Plant part                    | Ref      |
|--------------------------|---|----------------------|-------------------------------|----------|
|                          | Essential oil components  |                      |                               |          |
| 103 $\beta$ -barbatene   |    | <i>D. ammoniacum</i> | Fruit                         | [22]     |
| 104 $\alpha$ -humulene   |    | <i>D. aucheri</i>    | Aerial parts<br>Seed          | [17, 18] |
|                          |   | <i>D. ammoniacum</i> | Stem<br>Fruit                 | [22]     |
| 105 <i>ar</i> -curcumene |    | <i>D. ammoniacum</i> | Fruit                         | [22]     |
| 106 germacrene D         |   | <i>D. aucheri</i>    | Aerial parts<br>Stem          | [17, 18] |
|                          |   | <i>D. ammoniacum</i> | Seed<br>Seed<br>Stem<br>Fruit | [16, 22] |
| 107 germacrene B         |  | <i>D. aucheri</i>    | Aerial parts                  | [19]     |
|                          |   | <i>D. glabrum</i>    | Aerial parts<br>Root          | [21, 23] |
| 108 bicyclogermacrene    |  | <i>D. ammoniacum</i> | Fruit<br>Seed                 | [16, 22] |
| 109 cuparene             |  | <i>D. glabrum</i>    | Aerial parts                  | [21]     |
|                          |   | <i>D. aucheri</i>    | Seed<br>Stem                  | [20]     |
|                          |   | <i>D. ammoniacum</i> | Fruit                         | [24]     |
| 110 $\alpha$ -cadinene   |  | <i>D. ammoniacum</i> | Fruit<br>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><br><i>D. ammoniacum</i> | Aerial parts<br>Stem<br>Seed | [21]<br>[16] |
| 121 trans-sesquilandulol |  | <i>D. ammoniacum</i>                      | Seed<br>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**

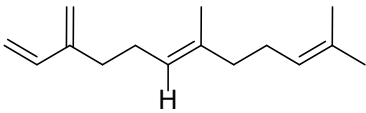
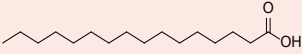
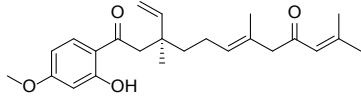
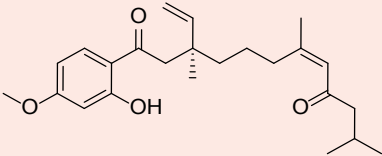
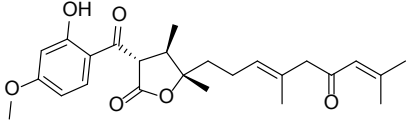
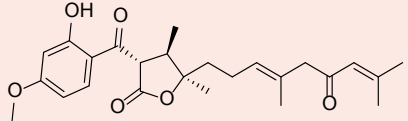
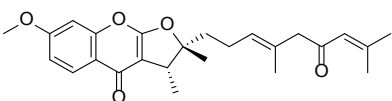
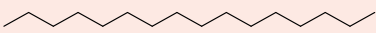
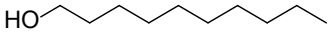
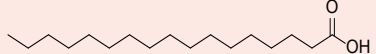
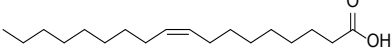
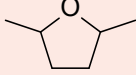
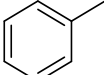
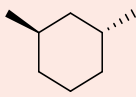
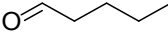
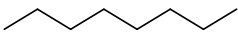
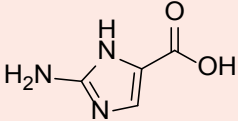
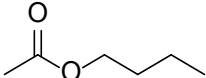
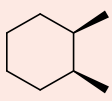
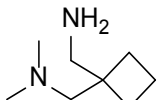
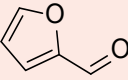
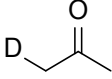
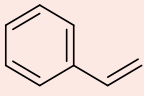
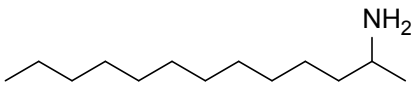
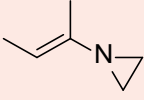


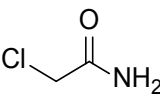
| Name of compound                            | Structure   | Species                                   | Plant part   | Ref          |
|---|---|---|--------------|--------------|
|   | Essential oil components  |   |              |              |
| 126 <i>trans</i> - $\beta$ -farnesene       |    | <i>D. ammoniacum</i>                      | Seed         | [16]         |
| 127 <i>n</i> -hexadecanoic acid             |    | <i>D. ammoniacum</i><br><i>D. aucheri</i> | Aerial parts | [15]<br>[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<br>Stem | [17]         |
| 138 methylbenzene                           |  | <i>D. ammoniacum</i>                      | Leaf<br>Stem | [17]         |
| 139 cyclohexane, 1,3-dimethyl, <i>trans</i> |  | <i>D. ammoniacum</i>                      | Leaf<br>Stem | [17]         |
| 140 valeraldehyde                           |  | <i>D. ammoniacum</i>                      | Leaf<br>Stem | [17]         |



Table 2. Continued 14

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

**Table 2. Continued 15**

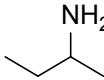
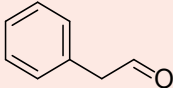
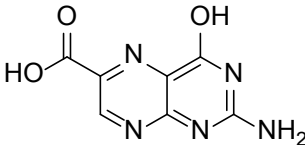
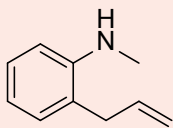
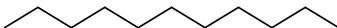
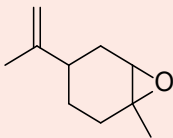
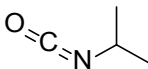
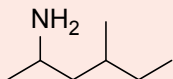
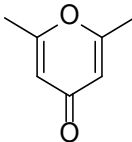
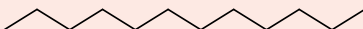
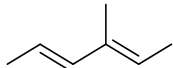
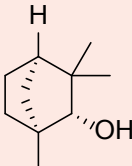
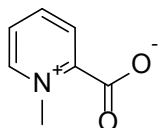
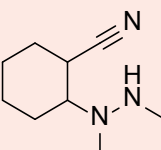
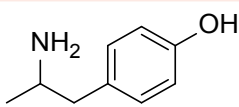
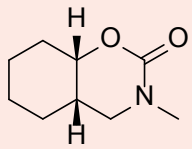
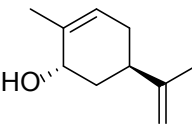
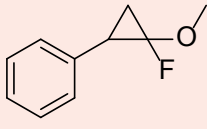
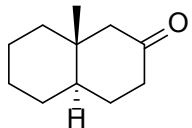
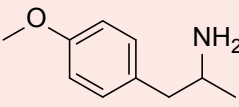
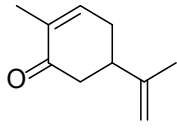
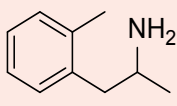
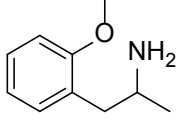
| No. | Name of compound                             | Structure   | Species              | Plant part           | Ref      |
|-----|--|---|----------------------|----------------------|----------|
|     |  | Essential oil components  |                      |                      |          |
| 154 |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

Table 2. Continued 16

| No. | Name of compound   | Structure   | Species              | Plant part   | Ref  |
|-----|--|---|----------------------|--------------|------|
|     |  | Essential oil components  |                      |              |      |
| 166 | homarine   |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 167 | 2-( <i>N,N</i> -dimethyl hydrazino) cyclohexane carbonitrile             |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 168 | phenol, 4-(2-aminopropyl)  |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 169 | 2-oxo-3-methyl-cis-perhydro-1,3-benzoxazine                              |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 170 | <i>trans</i> -carveol  |   | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 171 | benzene, (2-fluoro-2-methoxycyclopropyl)                                 |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 172 | 2(1 <i>H</i> )-naphthalenone, octahydro-8 <i>a</i> -methyl, <i>trans</i> |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 173 | <i>p</i> -methoxyamphetamine   |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 174 | 2-cyclohexen-1-one, 2-methyl-5-(1-methylethenyl)                         |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 175 | 2-methyl amphetamine   |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 176 | 2-methoxy amphetamine  |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |

**Table 2. Continued 17**

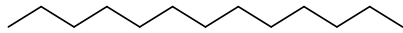
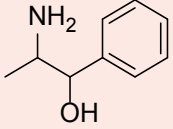
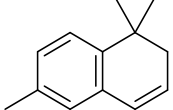
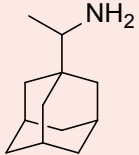
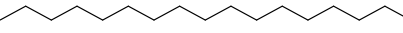
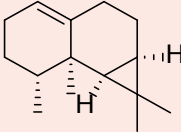
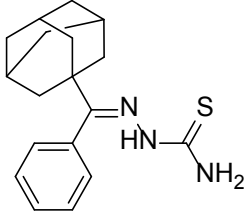
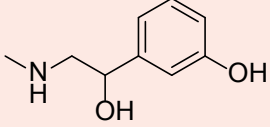
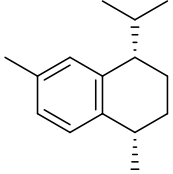
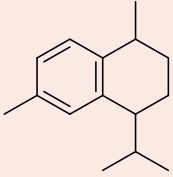
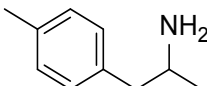
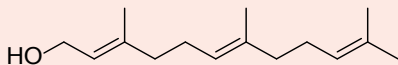
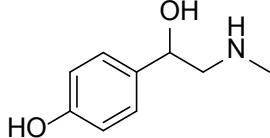
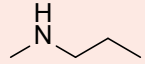
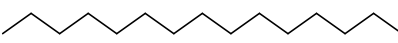
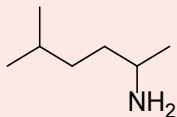
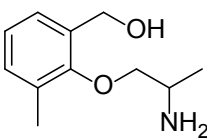

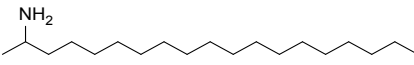
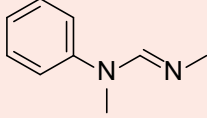
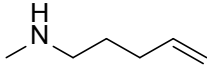

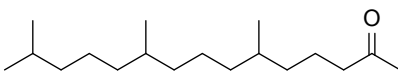
| Name of compound  | Structure   | Species              | Plant part   | Ref  |
|---|---|----------------------|--------------|------|
|   | Essential oil components  |                      |              |      |
| 177 tridecane   |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
|   |   | <i>D. glabrum</i>    | Aerial parts | [21] |
| 178 benzenemethanol, alpha-(1-aminoethyl)                   |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 179 naphthalene, 1,2-dihydro-1,1,6-trimethyl                |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 180 rimantadine   |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 181 heptadecane   |    | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 182 calarene  |   | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 183 1-[a-(1-adamantyl)benzylidene]thiosemicarbazide         |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 184 benzenemethanol, 3-hydroxy-alpha-[(methylamino) methyl] |  | <i>D. ammoniacum</i> | Leaf<br>Stem | [17] |
| 185 1 S-cis-calamenene                                      |  | <i>D. ammoniacum</i> | Leaf<br>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<br>(4-Methylamphetamine)                                |    | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 188 | farnesol   |    | <i>D. ammoniacum</i> | Leaf<br>Stem<br>Seed | [17, 18] |
|     |  |   | <i>D. aucheri</i>    | Seed<br>Stem         | [20]     |
| 189 | benzenemethanol,<br>4-hydroxy-alpha-<br>[(methylamino) methyl] |    | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 190 | N-methyl-propylamine   |    | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 191 | pentadecane  |    | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 192 | 2-hexanamine, 5-methyl   |   | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 193 | benzenemethanol,<br>2-(2-aminopropoxy)-3-<br>methyl            |  | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 194 | 2-propanamine  |  | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 195 | 2-aminononadecane  |  | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 196 | methanimidamide, N,N-<br>dimethyl-N-phenyl                     |  | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 197 | methylpent-4-enylamine   |  | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 198 | cyclobutanol   |  | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |
| 199 | hexahydro farnesyl acetone                                     |  | <i>D. ammoniacum</i> | Leaf<br>Stem         | [17]     |

**Table 2. Continued 19**

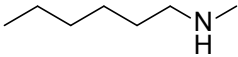
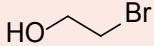
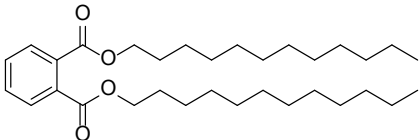
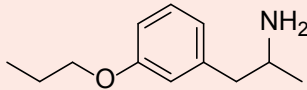
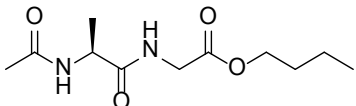
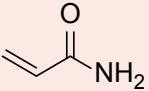
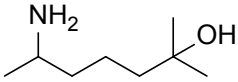

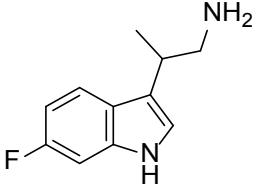
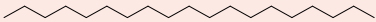
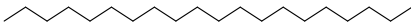
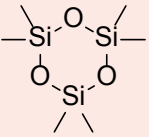
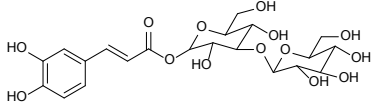
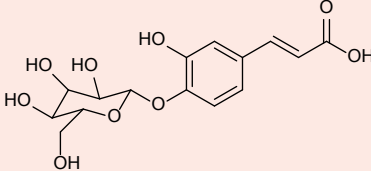
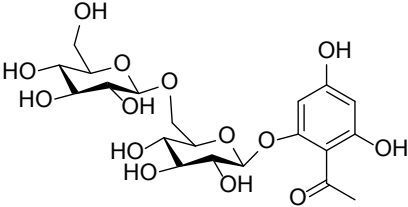
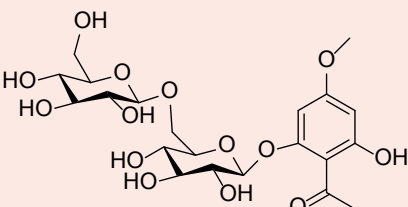
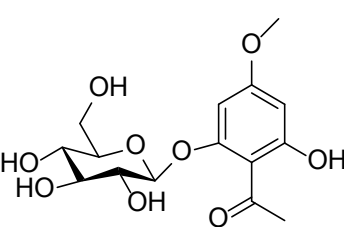
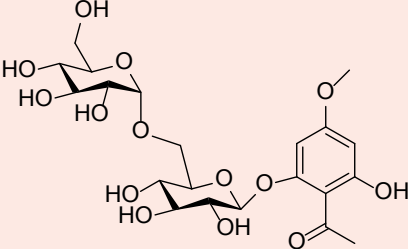
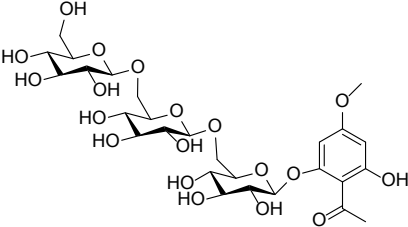
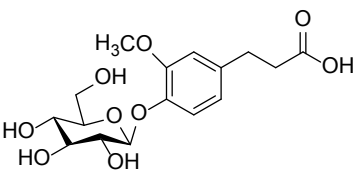
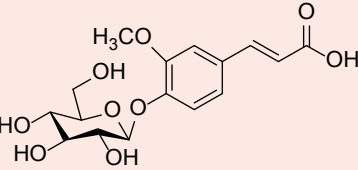
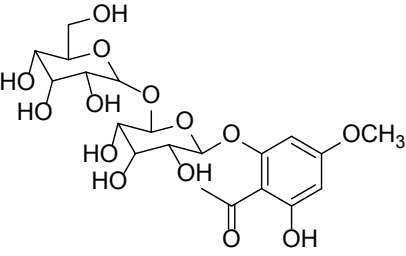
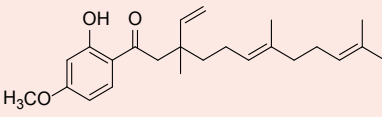
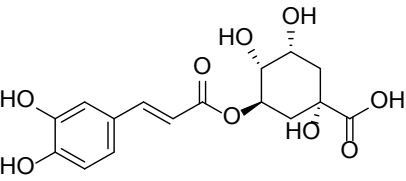
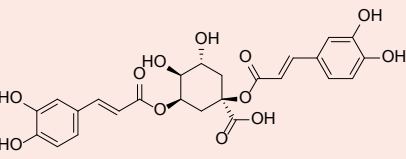
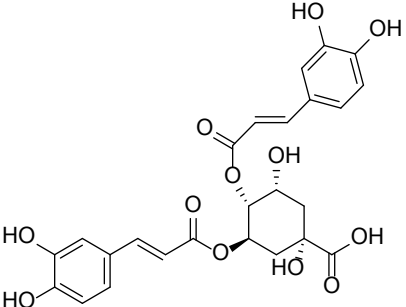
| Name of compound   | Structure   | Species              | Plant part   | Ref  |
|--|---|----------------------|--------------|------|
|  | Essential oil components  |                      |              |      |
| 200 n-hexylmethylamine                                     |    | <i>D. ammoniacum</i>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

Table 2. Continued 20

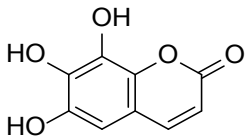
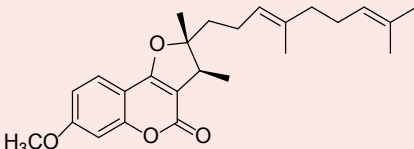
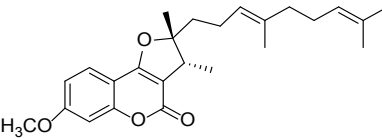
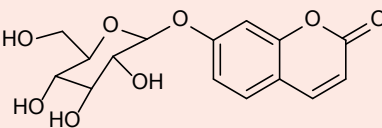
| Name of compound                       | Structure   | Species           | Plant part    | Ref     |
|--|---|-------------------|---------------|---------|
|  | Phenolic compounds  |                   |               |         |
| 212 diglucosyl caffeoyl ester          |    | <i>D. glabrum</i> | Fruit<br>Seed | [27]    |
| 213 4-O-β-D-glucopyranosylcaffeic acid |    | <i>D. glabrum</i> | Fruit<br>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- $\beta$ -D-glucopyranoside                     |    | <i>D. glabrum</i>  | Root       | [29, 30] |
| 220 ferulic acid-4-O- $\beta$ -D-glucopyranoside                                |    | <i>D. glabrum</i>  | Root       | [30, 32] |
| 221 4-methoxy-6-hydroxyacetophenone-2-O- $\beta$ -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<br>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-Alâiiah        | 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 <sup>th</sup> century |
| Makhzan al-Adwiah                                    | Persian  | Aqili Khorasani     | 18 <sup>th</sup> 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> ,<br><i>P. aeruginosa</i> ,<br><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><br><i>Enterococcus</i> sp.<br><i>C. albicans</i><br><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> ,<br><i>E. coli</i><br><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><br><i>S. epidermidis</i>   | MIC: 3.75 mg/mL   | [22] |
| <i>D. aucheri</i>       | Leaf          | Ethanol extract                      | Anti-bacterial activity                      | <i>S. pyogenes</i><br><i>P. aeruginosa</i>  | MIC and MBC.<br>30 and 40 mg/mL   | [63] |
| <i>D. aucheri</i>       | Aerial parts  | Hydro-alcoholic extract              | Cytotoxicity                                 | <i>Artemia urmiana larve</i><br>(lethaling brine shrimp)                                | LC <sub>50</sub> 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 <sub>50</sub> : 474.1 ± 0.9,<br>496.4 ± 0.7 and<br>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> ,<br><i>S. flexneri</i><br><i>S. aureus</i><br><i>B. subtilis</i>        | MIC: 0.156, <i>E. coli</i><br>IC <sub>50</sub> : 113.74 ± 0.21<br>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:<br>500 µg/mL  | [67] |
| <i>D. glabrum</i>       | Root          | <i>n</i> -hexane extracts            | Apoptosis and cell cycle arrest              | Cancer cells  | IC <sub>50</sub> : 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 <sub>12</sub> : 3.14 mg/mL   | [70] |
| <i>D. aucheri</i>       | Aerial part   | Methanol extracts                    | Cytotoxic activity                           | HepG2 and A549 cells  | IC <sub>50</sub> : 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 <sub>50</sub> : 50 µg/mL in 36 hours   | [72] |
| <i>D. glabrum</i>       | Seeds         | Methanol extract                     | Geno/cytotoxicity and apoptotic              | CAOV-4 cells  | IC <sub>50</sub> : 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 <sub>50</sub> : 2.24 mg/mL   | [23] |
| <i>D. glabrum</i>       | Aerial parts  | Methanol fraction                    | Antioxidant                                  | DPPH assay  | IC <sub>50</sub> : 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                                | Ic50 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.

## ORCID

Elaheh Zibae, <https://orcid.org/0000-0001-9272-7271>  
 Mohammad Sadegh Amiri, <https://orcid.org/0000-0003-2892-4523>  
 Zahra Boghrati, <https://orcid.org/0000-0002-4771-5690>  
 Faeghe Farhadi, <https://orcid.org/0000-0003-1332-3311>  
 Mahin Ramezani, <https://orcid.org/0000-0001-5933-6754>  
 Seyed Ahmad Emami, <https://orcid.org/0000-0003-4298-3132>  
 Amirhossein Sahebkar, <https://orcid.org/0000-0002-8656-1444>

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