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

Elaheh Zibaee¹, Mohammad Sadegh Amiri², Zahra Boghrati¹, Faeghe Farhadi³, Mahin Ramezani⁴,⁵, Seyed Ahmad Emami¹*, Amirhossein Sahebkar⁶,⁷,⁸,⁹

¹Department of Traditional Pharmacy, School of Pharmacy, Mashhad University of Medical Sciences, Mashhad, Iran
²Department of Biology, Payame Noor University, Tehran, Iran
³Department of Pharmacognosy, School of Pharmacy, Mashhad University of Medical Sciences, Mashhad, Iran
⁴Nanotechnology Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
⁵Pharmaceutical Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
⁶Halal Research Center of IRI, FDA, Tehran, Iran
⁷Biotecnology Research Center, Pharmaceutical Technology Institute, Mashhad University of Medical Sciences, Mashhad, Iran
⁸Neurogenic Inflammation Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
⁹Polish Mother’s Memorial Hospital Research Institute (PMMHRI), Lodz, Poland

Received March 25, 2018
Reviewed July 31, 2020
Accepted August 28, 2020

*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

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 respiratory 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 ethnomedical and traditional uses, phytochemical and pharmacological activities of the genus Dorema.
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 unthickened, 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 psammophile [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 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 Nakhevan, 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
| Name of compound | Structure | Species | Plant part | Ref       |
|------------------|-----------|---------|------------|-----------|
| 1 α-pinene       | ![Structure](image1.png) | *D. ammoniacum* | Aerial parts | [14-18]   |
|                  |           |         | Flower     |           |
|                  |           |         | Stem       |           |
|                  |           |         | Seed       |           |
|                  |           |         | Leaf       |           |
|                  |           |         | Root       |           |
|                  |           |         | Leaves     |           |
|                  |           | *D. aucheri* | Aerial parts | [19, 20] |
|                  |           |         | Stem       |           |
|                  |           |         | Seed       |           |
|                  |           | *D. glabrum* | Aerial parts | [21]     |
| 2 camphene       | ![Structure](image2.png) | *D. ammoniacum* | Flower     | [14]  |
|                  |           |         | Stem       |           |
|                  |           |         | Root       |           |
|                  |           | *D. aucheri* | Seed       | [19, 20] |
|                  |           |         | Stem       |           |
| 3 β-pinene       | ![Structure](image3.png) | *D. ammoniacum* | Flower     | [14]  |
|                  |           |         | Stem       |           |
|                  |           |         | Root       |           |
|                  |           | *D. aucheri* | Seed       | [19, 20] |
|                  |           |         | Stem       |           |
| 4 β-myrcene      | ![Structure](image4.png) | *D. aucheri* | Seed       | [19, 20] |
|                  |           |         | Stem       |           |
|                  |           | *D. glabrum* | Aerial part | [21] |
|                  |           |         | *D. ammoniacum* | [14, 17, 18] |
|                  |           |         | Flower     |           |
|                  |           |         | Stem       |           |
|                  |           |         | Root       |           |
|                  |           |         | Leaves     |           |
| 5 p-cymene       | ![Structure](image5.png) | *D. ammoniacum* | Aerial parts | [14, 15, 18] |
|                  |           |         | Flower stem |           |
|                  |           |         | Root       |           |
| 6 limonene       | ![Structure](image6.png) | *D. ammoniacum* | Flower stem | [14, 16, 18] |
|                  |           |         | Seed       |           |
|                  |           |         | Root       |           |
|                  |           |         | Leaf       |           |
|                  |           |         | Leaves     |           |
|                  |           | *D. aucheri* | Aerial parts | [19, 20] |
|                  |           |         | Seed       |           |
|                  |           |         | Stem       |           |
|                  |           | *D. glabrum* | Aerial parts | [21] |
| 7 β-phellandrene | ![Structure](image7.png) | *D. ammoniacum* | Aerial parts | [15]  |
|                  |           |         | Root       |           |
| 8 1,3,8-β-menthatriene | ![Structure](image8.png) | *D. ammoniacum* | Aerial part | [22]  |
| Name of compound | Structure | Species        | Plant part | Ref      |
|------------------|-----------|----------------|------------|----------|
| 9  p-mentha-1,8-diene | ![P-mentha-1,8-diene](https://example.com/structure) | *D. ammoniacum* | Fruit      | [22]     |
| 10  (E)-β-ocimene | ![E-beta-ocimene](https://example.com/structure) | *D. ammoniacum* | Flower, Stem, Root, Leaves | [14, 18] |
|      |           | *D. aucheri* | Aerial parts | [19]     |
|      |           | *D. glabrum* | Aerial parts | [21]     |
| 11  (Z)-β-ocimene | ![Z-beta-ocimene](https://example.com/structure) | *D. glabrum* | Aerial parts | [21]     |
|      |           | *D. ammoniacum* | Stem, Leaves | [18]     |
| 12  terpinolene (δ-terpinene) | ![Terpinolene](https://example.com/structure) | *D. ammoniacum* | Aerial parts, Flower, Root, Stem, Leaf, Leaves | [14, 15, 17-19] |
|      |           | *D. aucheri* | Aerial parts, Seed, Stem | [19, 20] |
| 13  terpinene-4-ol | ![Terpinene-4-ol](https://example.com/structure) | *D. aucheri* | Aerial part | [20]     |
| 14  thymol methyl ether | ![Thymol methyl ether](https://example.com/structure) | *D. ammoniacum* | Flower, Stem, Root, Seed, Aerial parts | [14, 16] |
|      |           | *D. aucheri* | Aerial parts | [19]     |
| 15  thymol | ![Thymol](https://example.com/structure) | *D. ammoniacum* | Seed, Stem, Aerial part, Seed | [16]     |
|      |           | *D. aucheri* | Aerial part, Seed, Stem | [20]     |
| 16  methyl geranate | ![Methyl geranate](https://example.com/structure) | *D. aucheri* | Aerial part | [19]     |
| 17  carvacrol methyl ether | ![Carvacrol methyl ether](https://example.com/structure) | *D. ammoniacum* | Flower, Stem, Root, Root | [14]     |
|      |           | *D. glabrum* | Root | [23]     |
| 18  carvacrol | ![Carvacrol](https://example.com/structure) | *D. aucheri* | Stem, Seed | [20]     |
|      |           | *D. ammoniacum* | Stem, Seed | [16]     |
| 19  methyleugenol | ![Methyleugenol](https://example.com/structure) | *D. ammoniacum* | Seed | [16]     |
| Name of compound | Structure | Species | Plant part | Ref |
|-----------------|-----------|---------|------------|-----|
| 20 bornyl acetate | ![Structure](image1.png) | *D. ammoniacum* | Flower, Stem, Root, Leaves | [14, 18] |
| | | *D. aucheri* | Aerial parts, Seed, Stem | [19, 20] |
| 21 fenchyl acetate | ![Structure](image2.png) | *D. glabrum* | Aerial parts | [21] |
| 22 endo-fenchol | ![Structure](image3.png) | *D. ammoniacum* | Leaf | [18] |
| 23 α-fenchyl Acetate | ![Structure](image4.png) | *D. glabrum* | Root | [23] |
| 24 α-cubebe | ![Structure](image5.png) | *D. ammoniacum* | Flower, Fruit, Stem, Root | [14, 22] |
| | | *D. aucheri* | Aerial parts | [19] |
| 25 β-cubebe | ![Structure](image6.png) | *D. aucheri* | Aerial parts | [20] |
| 26 β-elemene | ![Structure](image7.png) | *D. aucheri* | Aerial parts | [20] |
| 27 α-copaene | ![Structure](image8.png) | *D. ammoniacum* | Flower, Fruit, Stem, Seed, Leaves, Root | [14, 16, 22] |
| | | *D. aucheri* | Aerial parts, Seed, Stem | [19, 20] |
| | | *D. glabrum* | Root | [23] |
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| 28 β-copaene     | ![Structure](image1) | *D. aucheri* | Aerial parts | [22] |
| 29 aristolene   | ![Structure](image2) | *D. ammoniacum* | Flower stem | [14] |
| 30 β-patchouline | ![Structure](image3) | *D. aucheri* | Aerial parts | [19] |
| 31 α-gurjunene   | ![Structure](image4) | *D. ammoniacum* | Flower stem | [14, 16] |
| 32 β-gurjunene   | ![Structure](image5) | *D. ammoniacum* | Flower stem | [14] |
|                  |           | *D. aucheri* | Stem | [19, 20] |
|                  |           | *D. aucheri* | Root | |
| 33 β-caryophyllene | ![Structure](image6) | *D. ammoniacum* | Flower stem | [14, 16, 17] |
|                  |           | *D. ammoniacum* | Seed | |
|                  |           | *D. ammoniacum* | Root | |
|                  |           | *D. ammoniacum* | Leaf | [19, 20, 24] |
| 34 caryophyllene | ![Structure](image7) | *D. ammoniacum* | Aerial parts | [15] |
| 35 α-santalene   | ![Structure](image8) | *D. aucheri* | Aerial parts | [19] |
### Table 2. Continued 4

| Name of compound | Species               | Plant part          | Ref   |
|------------------|-----------------------|---------------------|-------|
| aromadendrene    | D. ammoniacum         | Flower stem         | [14, 16] |
|                  |                       | Seed                |       |
|                  |                       | Root                |       |
|                  | D. aucheri            | Aerial parts        | [19]  |
| α-guaiene        | D. ammoniacum         | Flower stem         | [14]  |
|                  |                       | Root                |       |
| benzyl butanoate | D. ammoniacum         | Root                | [14]  |
| α-himachalene    | D. ammoniacum         | Flower stem         | [14]  |
|                  |                       | Root                |       |
| allo-aromadendrene | D. ammoniacum     | Flower stem         | [14]  |
|                  |                       | Root                |       |
| dehydroaromadendrane | D. ammoniacum | Flower stem         | [14, 16] |
|                  |                       | Root                |       |
| α-amorphene      | D. ammoniacum         | Flower stem         | [14]  |
|                  |                       | Root                | [20]  |
|                  | D. aucheri            | Seed                |       |
|                  |                       | Stem                |       |
| δ-amorphene      | D. ammoniacum         | Flower stem         | [14]  |
|                  |                       | Root                |       |
Table 2. Continued 5

| Name of compound | Structure | Species       | Plant part     | Ref       |
|------------------|-----------|---------------|----------------|-----------|
| 44 β-selinene    | ![Structure](image1) | *D. ammoniacum* | Flower stem    | [14, 16] |
|                  |           | *D. aucheri*  | Seed           | [20]      |
| 45 α-selinene    | ![Structure](image2) | *D. ammoniacum* | Aerial part    | [14, 15] |
|                  |           | *D. aucheri*  | Flower         | [20]      |
| 46 viridiflorene | ![Structure](image3) | *D. aucheri* | Aerial part    | [19]      |
| 47 α-murolene    | ![Structure](image4) | *D. ammoniacum* | Flower, stem   | [14]      |
|                  |           | *D. glabrum*  | Root           | [23]      |
| 48 γ-murolene    | ![Structure](image5) | *D. ammoniacum* | Stem          | [16]      |
| 49 cadalene      | ![Structure](image6) | *D. glabrum*  | Root           | [23]      |
| 50 δ-cadinene    | ![Structure](image7) | *D. ammoniacum* | Flower seed    | [14, 16, 17] |
|                  |           | *D. aucheri*  | Stem           | [18, 20, 24] |
|                  |           | *D. glabrum*  | Aerial parts   | [23]      |
| 51 γ-cadinene    | ![Structure](image8) | *D. aucheri* | Aerial parts   | [19]      |
|                  |           | *D. ammoniacum* | Seed           | [16]      |
Table 2. Continued 6

| Name of compound          | Structure | Essential oil components | Species | Plant part | Ref |
|---------------------------|-----------|--------------------------|---------|------------|-----|
| 52 cadina-1,4-diene       | ![Structure](image1) | D. aucheri               | Aerial part | [19]     |
| 53 trans-cadina-1(2),4-diene | ![Structure](image2) | D. ammoniacum            | Stem    | [16]      |
| 54 β-sesquiphellandrene   | ![Structure](image3) | D. ammoniacum            | Seed    | [16]      |
| 55 ledol                  | ![Structure](image4) | D. ammoniacum            | Stem    | [16]      |
| 56 liguloxide             | ![Structure](image5) | D. ammoniacum            | Flower, Root, Stem | [14] |
| 57 (E)-nerolidol          | ![Structure](image6) | D. ammoniacum            | Flower, Root, Leaf, Stem, Seed, Root | [14, 16, 17] |
| 58 3-n-butyl phthalide    | ![Structure](image7) | D. ammoniacum            | Root    | [14]      |
| 59 2-pentylfuran          | ![Structure](image8) | D. glabrum               | Aerial parts | [21]   |
| 60 myristicin             | ![Structure](image9) | D. glabrum               | Aerial parts | [21]   |
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| 61 elemicin      | ![Structure](image) | D. glabrum | Aerial parts | [21] |
| 62 methyl heptenone | ![Structure](image) | D. ammoniacum | Aerial parts | [15] |
| 63 trans-sesquisabinene hydrate | ![Structure](image) | D. aucheri | Aerial parts | [19] |
| 64 γ-eudesmol    | ![Structure](image) | D. ammoniacum | Seed, Stem, Aerial parts | [16, 19] |
| 65 α-eudesmol    | ![Structure](image) | D. ammoniacum, D. aucheri | Seed, Stem, Aerial parts | [16, 19, 24] |
| 66 β-eudesmol    | ![Structure](image) | D. ammoniacum | Seed, Stem | [16] |
| 67 sesquicineol-2-one | ![Structure](image) | D. ammoniacum | Seed, Stem | [16] |
| 68 germacrene D-4-ol | ![Structure](image) | D. aucheri | Aerial parts | [19] |
| 69 α-cadinol     | ![Structure](image) | D. ammoniacum, D. aucheri, D. glabrum | Stem, Seed, Aerial parts, Root | [16, 19, 23] |
| 70 δ-cadinol     | ![Structure](image) | D. glabrum | Root | [23] |
Table 2. Continued 8

| Name of compound | Structure | Species | Plant part | Ref  |
|------------------|-----------|---------|------------|------|
| 71 spathulenol    | ![Structure](image1) | *D. ammoniacum* | Fruit      | [16, 22] |
|                   |           | *D. aucheri* | Seed       | [20]  |
|                   |           |            | Stem       |       |
| 72 caryophyllene oxide | ![Structure](image2) | *D. ammoniacum* | Fruit      | [16, 17, 22] |
|                   |           | *D. aucheri* | Seed       | [20]  |
|                   |           |            | Stem       |       |
| 73 4-methylene-5-hexenal | ![Structure](image3) | *D. ammoniacum* | Stem      | [18]  |
| 74 6-methyl-5-hepten-2-one | ![Structure](image4) | *D. ammoniacum* | Stem      | [18]  |
| 75 allyl tiglate  | ![Structure](image5) | *D. ammoniacum* | Stem      | [18]  |
| 76 nerolidyl acetate | ![Structure](image6) | *D. ammoniacum* | Stem      | [16]  |
| 77 ammoresinol    | ![Structure](image7) | *D. ammoniacum* | Aerial parts | [25] |
| 78 nonanol        | ![Structure](image8) | *D. ammoniacum* | Aerial parts | [15] |
| 79 camphor       | ![Structure](image9) | *D. ammoniacum* | Aerial parts | [15] |
| 80 trans-2-caren-4-ol | ![Structure](image10) | *D. ammoniacum* | Fruit      | [22]  |
| 81 β-cyclocitral | ![Structure](image11) | *D. ammoniacum* | Fruit      | [22]  |
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| 82 piperitenone oxide | ![Structure](image) | *D. ammoniacum* | Fruit | [22] |
| 83 (E)-2-nonenal | ![Structure](image) | *D. ammoniacum* | Stem | [18] |
| 84 β-citronellol | ![Structure](image) | *D. ammoniacum* | Aerial parts | [15] |
| 85 β-damascenone | ![Structure](image) | *D. ammoniacum* | Aerial parts | [15] |
| 86 cedr-8[15]ene | ![Structure](image) | *D. ammoniacum* | Aerial parts | [15] |
| 87 cubenol | ![Structure](image) | *D. aucheri* | Aerial parts | [19] |
| 88 thujopsene | ![Structure](image) | *D. ammoniacum* | Aerial parts | [15] |
| 89 ylangene | ![Structure](image) | *D. glabrum* | Aerial parts | [21] |
| 90 nerylacetone | ![Structure](image) | *D. ammoniacum* | Aerial parts | [15, 17] |
| 91 geranyl acetone | ![Structure](image) | *D. glabrum* | Aerial parts | [21] |
### Table 2. Continued 10

| Name of compound                  | Structure | Species   | Plant part | Ref   |
|-----------------------------------|-----------|-----------|------------|-------|
| 92 (E)-tagetone                    | ![Structure](image1) | *D. ammoniacum* | Fruit      | [22]  |
| 93 (Z)-tagetone                    | ![Structure](image2) | *D. ammoniacum* | Fruit      | [22]  |
| 94 (Z)-ocimenone                   | ![Structure](image3) | *D. ammoniacum* | Fruit      | [22]  |
| 95 (E)-ocimenone                   | ![Structure](image4) | *D. ammoniacum* | Fruit      | [22]  |
| 96 α-bisabolene                    | ![Structure](image5) | *D. ammoniacum* | Aerial parts | [15]  |
| 97 β-bourbonene                    | ![Structure](image6) | *D. aucheri* | Seed       | [20]  |
|                                   | ![Structure](image7) | *D. ammoniacum* | Stem       | [22]  |
| 98 italicene                       | ![Structure](image8) | *D. ammoniacum* | Fruit      | [22]  |
| 99 di-epi-α-cedrene                | ![Structure](image9) | *D. ammoniacum* | Fruit      | [22]  |
| 100 α-longipinene                  | ![Structure](image10) | *D. ammoniacum* | Fruit      | [22]  |
| 101 α-cedrene                      | ![Structure](image11) | *D. ammoniacum* | Aerial parts | [15]  |
| 102 β-cedrene                      | ![Structure](image12) | *D. glabrum* | Aerial parts | [21]  |
|                                   | ![Structure](image13) | *D. ammoniacum* | Fruit      | [22]  |
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| 103 β-barbatene   | ![Structure](image) | *D. ammoniacum* | Fruit | [22] |
| 104 α-humulene   | ![Structure](image) | *D. aucheri* | Aerial parts Seed Stem Fruit | [17, 18] |
|                  |           | *D. ammoniacum* | Seed Stem Fruit | [22] |
| 105 ar-curcumene | ![Structure](image) | *D. ammoniacum* | Fruit | [22] |
| 106 germacrene D | ![Structure](image) | *D. aucheri* | Aerial parts Stem Seed Fruit | [17, 18] |
|                  |           | *D. ammoniacum* | Seed Stem Fruit | [16, 22] |
| 107 germacrene B | ![Structure](image) | *D. aucheri* | Aerial parts | [19] |
|                  |           | *D. glabrum* | Aerial parts Root | [21, 23] |
| 108 bicyclogermacrene | ![Structure](image) | *D. ammoniacum* | Fruit Seed | [16, 22] |
| 109 cuparene     | ![Structure](image) | *D. glabrum* | Aerial parts | [21] |
|                  |           | *D. aucheri* | Seed Stem Fruit | [20] |
|                  |           | *D. ammoniacum* | Fruit | [24] |
| 110 α-cadinene   | ![Structure](image) | *D. ammoniacum* | Fruit Stem | [16, 22] |
| Name of compound        | Structure | Species       | Plant part | Ref |
|-------------------------|-----------|---------------|------------|-----|
| 2-nonanone              | ![Structure](image1) | *D. ammoniacum* | Stem       | [16] |
| (Z)-hexadec-11-enal     | ![Structure](image2) | *D. ammoniacum* | Stem       | [16] |
| hexadecanal             | ![Structure](image3) | *D. ammoniacum* | Stem       | [16] |
| ethyl linoleate         | ![Structure](image4) | *D. ammoniacum* | Stem       | [16] |
| (Z,E)-farnesal          | ![Structure](image5) | *D. ammoniacum* | Aerial parts | [15] |
| pentadecanal            | ![Structure](image6) | *D. ammoniacum* | Aerial parts | [15] |
| dodecyl methacrylate    | ![Structure](image7) | *D. ammoniacum* | Aerial parts | [15] |
| 17-octadecenal          | ![Structure](image8) | *D. ammoniacum* | Aerial parts | [15] |
| 13-tetradecenal         | ![Structure](image9) | *D. ammoniacum* | Aerial parts | [15] |
| tetradecanal            | ![Structure](image10) | *D. glabrum* | Aerial parts | [21] |
|                        | ![Structure](image11) | *D. ammoniacum* | Stem       | [16] |
|                        | ![Structure](image12) | *D. ammoniacum* | Seed       |       |
| trans-sesquilavandulol  | ![Structure](image13) | *D. ammoniacum* | Seed       | [16] |
| neophytadiene           | ![Structure](image14) | *D. ammoniacum* | Aerial parts | [15, 17] |
| neocembren              | ![Structure](image15) | *D. ammoniacum* | Aerial parts | [15] |
| (E)-5-undecen-3-yne     | ![Structure](image16) | *D. ammoniacum* | Fruit      | [22] |
| (Z)-(E)-farnesene       | ![Structure](image17) | *D. ammoniacum* | Aerial parts | [22] |
| Name of compound                  | Structure | Species            | Plant part | Ref    |
|----------------------------------|-----------|--------------------|------------|--------|
| 126 trans-β-farnesene            | ![Structure](image) | *D. ammoniacum*    | Seed       | [16]   |
| 127 n-hexadecanoic acid         | ![Structure](image) | *D. ammoniacum*    | Aerial parts | [15] [19] |
| 128 kopetdaghin A                | ![Structure](image) | *D. kopetdaghense* | Aerial parts | [2, 26] |
| 129 kopetdaghin B                | ![Structure](image) | *D. kopetdaghense* | Aerial parts | [26]   |
| 130 kopetdaghin C                | ![Structure](image) | *D. kopetdaghense* | Aerial parts | [2, 26] |
| 131 kopetdaghin D                | ![Structure](image) | *D. kopetdaghense* | Aerial parts | [2, 26] |
| 132 kopetdaghin E                | ![Structure](image) | *D. kopetdaghense* | Aerial parts | [2, 26] |
| 133 hexadecan                    | ![Structure](image) | *D. aucheri*       | Aerial parts | [21]   |
| 134 decanol                      | ![Structure](image) | *D. ammoniacum*    | Stem       | [18]   |
| 135 heptadecanoic acid           | ![Structure](image) | *D. ammoniacum*    | Fruit      | [22]   |
| 136 oleic acid                   | ![Structure](image) | *D. ammoniacum*    | Aerial parts | [15]   |
| 137 2,5-dimethyltetrahydrofuran  | ![Structure](image) | *D. ammoniacum*    | Leaf, Stem | [17]   |
| 138 methylbenzene                | ![Structure](image) | *D. ammoniacum*    | Leaf, Stem | [17]   |
| 139 cyclohexane, 1,3-dimethyl, trans | ![Structure](image) | *D. ammoniacum*    | Leaf, Stem | [17]   |
| 140 valeraldehyde                | ![Structure](image) | *D. ammoniacum*    | Leaf, Stem | [17]   |
Table 2. Continued

| Name of compound | Structure | Species  | Plant part | Ref |
|------------------|-----------|----------|------------|-----|
| 141 octane       | ![Structure](image1.png) | *D. ammoniacum* | Leaf       | [17] |
| 142 imidazole-5-carboxylic acid, 2-amino | ![Structure](image2.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 143 butyl acetate | ![Structure](image3.png) | *D. ammoniacum* | Leaf       | [17] |
| 144 cyclohexane, 1,2-dimethyl, cis | ![Structure](image4.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 145 N,N-dimethyl cyclobutane-1,1-bis(methylamine) | ![Structure](image5.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 146 furfural     | ![Structure](image6.png) | *D. ammoniacum* | Leaf       | [17] |
| 147 deuteroacetone | ![Structure](image7.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 148 styrene      | ![Structure](image8.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 149 1-methyldodecylamine | ![Structure](image9.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 150 aziridine, 1-(2-buten-2-yl) | ![Structure](image10.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 151 sabinene     | ![Structure](image11.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 152 decane       | ![Structure](image12.png) | *D. ammoniacum* | Leaf, Stem | [17, 18] |
| 153 acetamide, 2-chloro | ![Structure](image13.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| Name of compound                        | Structure | Species      | Plant part | Ref |
|----------------------------------------|-----------|--------------|------------|-----|
| 2-butylamine                           | ![Structure](structure1.png) | D. ammoniacum | Leaf       | [17] |
| phenyl acetaldehyde                    | ![Structure](structure2.png) | D. ammoniacum | Leaf, Stem | [17] |
| 2-amino-4-hydroxypteridine-6-carboxylic acid | ![Structure](structure3.png) | D. ammoniacum | Leaf, Stem | [17] |
| benzenamine, N-methyl-2-(2-propenyl)   | ![Structure](structure4.png) | D. ammoniacum | Leaf, Stem | [17] |
| undecane                               | ![Structure](structure5.png) | D. ammoniacum | Leaf, Stem, Seed | [17, 18] |
| limonene oxide                         | ![Structure](structure6.png) | D. ammoniacum | Leaf, Stem | [17] |
| isopropyl isocyanate                   | ![Structure](structure7.png) | D. ammoniacum | Leaf, Stem | [17] |
| 2-hexanamine, 4-methyl                 | ![Structure](structure8.png) | D. ammoniacum | Leaf, Stem | [17] |
| 2,6-dimethyl-4-pyrene                  | ![Structure](structure9.png) | D. ammoniacum | Leaf, Stem | [17] |
| dodecane                               | ![Structure](structure10.png) | D. ammoniacum | Leaf, Stem | [17] |
| 2,4-hexadiene, 3-methyl                | ![Structure](structure11.png) | D. ammoniacum | Leaf, Stem | [17] |
| β-fenchyl alcohol                      | ![Structure](structure12.png) | D. ammoniacum | Leaf, Stem | [17] |
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| homarine | ![Structure](image1.png) | D. ammoniacum | Leaf | [17] |
| 2-(N,N-dimethyl hydrazino) cyclohexane carbonitrile | ![Structure](image2.png) | D. ammoniacum | Leaf | [17] |
| phenol, 4-(2-aminopropyl) | ![Structure](image3.png) | D. ammoniacum | Leaf | [17] |
| 2-oxo-3-methyl-cis-perhydro-1,3-benzoxazine | ![Structure](image4.png) | D. ammoniacum | Leaf | [17] |
| trans-carveol | ![Structure](image5.png) | D. ammoniacum | Leaf | [17] |
| benzene, (2-fluoro-2-methoxycyclopropyl) | ![Structure](image6.png) | D. ammoniacum | Leaf | [17] |
| 2(1H)-naphthalenone, octahydro-8a-methyl, trans | ![Structure](image7.png) | D. ammoniacum | Leaf | [17] |
| p-methoxyamphetamine | ![Structure](image8.png) | D. ammoniacum | Leaf | [17] |
| 2-cyclohexen-1-one, 2-methyl-5-(1-methylethenyl) | ![Structure](image9.png) | D. ammoniacum | Leaf | [17] |
| 2-methyl amphetamine | ![Structure](image10.png) | D. ammoniacum | Leaf | [17] |
| 2-methoxyamphetamine | ![Structure](image11.png) | D. ammoniacum | Leaf | [17] |
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| 177 tridecane    | ![Structure](image) | *D. ammoniacum* | Leaf | [17] |
|                  |           | *D. glabrum* | Stem | Aerial parts |
| 178 benzenemethanol, alpha-(1-aminoethyl) | ![Structure](image) | *D. ammoniacum* | Leaf | [17] |
| 179 naphthalene, 1,2-dihydro-1,1,6-trimethyl | ![Structure](image) | *D. ammoniacum* | Leaf | Stem | [17] |
| 180 rimantadine  | ![Structure](image) | *D. ammoniacum* | Leaf | Stem | [17] |
| 181 heptadecane  | ![Structure](image) | *D. ammoniacum* | Leaf | Stem | [17] |
| 182 calarene     | ![Structure](image) | *D. ammoniacum* | Leaf | Stem | [17] |
| 183 1-[a-(1-adamantyl) benzylidene] thiosemicarbazide | ![Structure](image) | *D. ammoniacum* | Leaf | Stem | [17] |
| 184 benzenemethanol, 3-hydroxy-alpha-[(methylamino) methyl] | ![Structure](image) | *D. ammoniacum* | Leaf | Stem | [17] |
| 185 1 S-cis-calamenene | ![Structure](image) | *D. ammoniacum* | Leaf | Stem | [17] |
| 186 calamene     | ![Structure](image) | *D. glabrum* | Root | [23] |
Table 2. Continued 18

| Name of compound                        | Structure          | Species       | Plant part | Ref |
|----------------------------------------|--------------------|---------------|------------|-----|
| 187 aptrol (4-Methylamphetamine)       | ![aptrol Structure](aptrol.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 188 farnesol                           | ![farnesol Structure](farnesol.png) | *D. ammoniacum* | Leaf, Stem, Seed, Seed, Stem | [17, 18] |
| 189 benzenemethanol, 4-hydroxy-alpha-[(methylamino) methyl] | ![benzenemethanol Structure](benzenemethanol.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 190 N-methyl-propylamine               | ![N-methyl-propylamine Structure](N-methyl-propylamine.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 191 pentadecane                        | ![pentadecane Structure](pentadecane.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 192 2-hexanamine, 5-methyl             | ![2-hexanamine Structure](2-hexanamine.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 193 benzenemethanol, 2-(2-aminopropoxy)-3-methyl | ![benzenemethanol Structure](benzenemethanol.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 194 2-propanamine                      | ![2-propanamine Structure](2-propanamine.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 195 2-aminononadecane                  | ![2-aminononadecane Structure](2-aminononadecane.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 196 methanimidamide, N,N-dimethyl-N-phenyl | ![methanimidamide Structure](methanimidamide.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 197 methylpent-4-ethylamine             | ![methylpent-4-ethylamine Structure](methylpent-4-ethylamine.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 198 cyclobutanol                        | ![cyclobutanol Structure](cyclobutanol.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 199 hexahydro farnesyl acetone          | ![hexahydro farnesyl acetone Structure](hexahydro farnesyl acetone.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| 200 n-hexylmethylamine | ![Structure](image1.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 201 ethylene bromohydrin | ![Structure](image2.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 202 didodecyl phthalate | ![Structure](image3.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 203 3-propoxyamphetamine | ![Structure](image4.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 204 glycine, N-(N-acetyl-L-alanyl) butyl ester | ![Structure](image5.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 205 2-propenamide | ![Structure](image6.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 206 2-heptanol, 6-amino-2-methyl | ![Structure](image7.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 207 benzene ethanamine, 4-fluoro-beta,3-dihydroxy-N-methyl | ![Structure](image8.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 208 1H-Indole-3-ethanamine, 6-fluoro-beta-methyl | ![Structure](image9.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 209 nonadecane | ![Structure](image10.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 210 eicosane | ![Structure](image11.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| 211 cyclotrisiloxane, hexamethyl | ![Structure](image12.png) | *D. ammoniacum* | Leaf, Stem | [17] |
| Name of compound          | Structure                  | Species     | Plant part | Ref   |
|---------------------------|----------------------------|-------------|------------|-------|
| 212 diglucosyl caffeoyl ester | ![Structure](image1.png) | *D. glabrum* | Fruit      | [27]  |
| 213 4-O-β-D-glucopyranosylcaffeic acid | ![Structure](image2.png) | *D. glabrum* | Fruit      | [27]  |
| 214 azeroside A           | ![Structure](image3.png)  | *D. glabrum* | Root       | [26-28]|
| 215 echioside             | ![Structure](image4.png)  | *D. glabrum* | Root       | [26-28]|
| 216 pleoside              | ![Structure](image5.png)  | *D. glabrum* | Root       | [26-28]|
| 217 hyrcanoside           | ![Structure](image6.png)  | *D. glabrum* | Root       | [26-28]|
| 218 azeroside B           | ![Structure](image7.png)  | *D. glabrum* | Root       | [26-28]|
| Name of compound | Structure | Species | Plant part | Ref |
|------------------|-----------|---------|------------|-----|
| 219 7,8-dihydroferulic acid-4-O-β-D-glucopyranoside | ![Structure](image1) | *D. glabrum* | Root | [29, 30] |
| 220 ferulic acid-4-O-β-D-glucopyranoside | ![Structure](image2) | *D. glabrum* | Root | [30, 32] |
| 221 4-methoxy-6-hydroxyacetophenone-2-O-β-D-gentiobioside | ![Structure](image3) | *D. hyrcanum* | Root | [33] |
| 222 1(2-Hydroxy-4-methoxy)-3,7,11-trimethyl-3-vinyl-6(E), 10 dodecadiene-1-dione | ![Structure](image4) | *D. hyrcanum* | Root | [33] |
| 223 chlorogenic acid | ![Structure](image5) | *D. glabrum* | Root | [30] |
| 224 cynarin | ![Structure](image6) | *D. glabrum* | Root | [30] |
| 225 4,5-diCQA (4,5-dicaffeoylquinic acid) | ![Structure](image7) | *D. glabrum* | Root | [30] |
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-
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].

| No | *Dorema* species | Vernacular name | Country | Part used | Ethnobotanical and traditional uses | Ref |
|----|------------------|-----------------|---------|-----------|--------------------------------------|-----|
| 1  | *D. aitchisonii*  | -               | The former Soviet Union | Shoot | The water extract from the young shoots is used to treat diseases of the stomach. | [7] |
| 2  | *D. ammoniacum*  | 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] |
|    |                  | Zou             | Iran    | Root      | Burn healing, cornicide | [43] |
| 4  | *D. aureum*      | Oshtork         | Iran    | Gum       | Abortion, infection | [49] |
| 5  | *D. glabrum*     | -               | Azerbaijan Republic | Gum-resin | Diuretic and anti-diarrheal agent as well as for the treatment of bronchitis and catarrh, cure of cancer | [15] |
| 6  | *D. hyrcanum*    | -               | The former Soviet Union | Resin | As plasters to stop bleeding and to treat injuries in horses. | [7] |
| 7  | *D. sabulosum*   | 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] |
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 (mohalleh), desiccant, deobstruent (mofatteh), laxative and attractive agent [50-57].

*Droma 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 hemorroids and anal disorders because of its deobstuent 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,

| Book                      | Language | Author           | Living period |
|---------------------------|----------|------------------|---------------|
| Al-Qânun fi al-Tibbe      | Arabic   | Ibn Sina        | 980-1037 A.D. |
| Zakhireh khârazmshâhi     | Persian  | Jorjâni         | 1042-1136 A.D.|
| Al-Aghrâz al-Tibbe wa al-Mabâhethi al-Âlâiiah | Persian | Jorjâni      | 1042-1136 A.D.|
| Al-Jâmee le Mofradât al-Adwiah wa al-Aghziah | Arabic | Ibn Al-Baytâr | 1193-1248 A.D.|
| Tadhkirat Oli al-Âlbâb wa al-Jâmee le al-Âjb al-Ujâb | Arabic | Antaki        | 1535-1599 A.D.|
| Hadîqat al-Âzhâr 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.|
| Tohfa al-Momenin          | Persian  | Husseini Tonekaboni | 17th century |
| Makhzan al-Adwiah         | Persian  | Âqili Khorasani | 18th century  |
| Species          | Part used   | Type of extraction | Activity                      | Tested pathogen/cell                          | Result(s)                          | Ref   |
|------------------|-------------|--------------------|-------------------------------|----------------------------------------------|------------------------------------|-------|
| *D. aucheri*     | Gum         | Dichloromethane, methanol extract | Anti-microbial activity | *E. coli, K. pneumoniae, P. aeruginosa, C. albicans* | MIC: 20 and 40 mg/mL | [59]  |
| *D. ammoniacum* | Oleogum resin | Dichloromethane and methanol extract | Anti-bacterial and anti-fungal | G+ and G−                                    | C: 500 and 1000 µg/mL            | [60]  |
| *D. ammoniacum* | Aerial parts | Methanol extract | Anti-microbial activity | *S. aureus* Enterococcus sp. *C. albicans* | MIC: 78 µg/mL                       | [61]  |
| *D. aucheri*     | Aerial parts | Methanol extract | Anti-microbial and anti-oxidative | *B. cereus, S. aureus, E. coli* S. enterica | MIC: 10-50 mg/mL                   | [62]  |
| *D. ammoniacum* | Ripe fruit  | Essential oil      | Anti-microbial activity | *B. subtilis* S. epidermidis | MIC: 3.75 mg/mL                   | [22]  |
| *D. aucheri*     | Leaf        | Ethanol extract    | Anti-bacterial activity | *S. pyogenes* *P. aeruginosa* | MIC and MBC. 30 and 40 mg/mL      | [63]  |
| *D. aucheri*     | Aerial parts | Hydro-alcoholic extract | Cytotoxicity | *Artemia urmiana larve* (lethaling brine shrimp) | LC50 76.50 ± 0.60 µg/mL         | [64]  |
| *D. kopetdagense* | Aerial parts | Kopetdaghins A, C and E | Anti-inflammatory effect | *J774A.1 murine macrophages* | IC50: 474.1 ± 0.9, 496.4 ± 0.7 and 514.3 ± 0.4 µg/mL | [2]   |
| *D. aucheri*     | Aerial parts | Water/ethanol extract | Anti-coccidial effects | Fecal samples | lowest (1.60) and the highest body weight (1.75) FCR | [65]  |
| *D. aucheri*     | Roots       | EtOAc extract      | No scavenging, and anti-bacterial activities | *E. coli, S. flexneri S. aureus B. subtilis* | MIC: 0.156, E. coli IC50: 113.74 ± 0.21 and 597.64 ± 0.33 µg/mL | [66]  |
| *D. aucheri*     | Aerial parts | Hydroalcoholic and aqueous extracts | Genotoxicity evaluation | HepG2 cell line | Genotoxic effect: 500 µg/mL | [67]  |
| *D. glabrum*     | Root        | n-hexane extracts | Apoptosis and cell cycle arrest | Cancer cells | IC50: 6.4,4.6 µg/mL | [68]  |
| *D. glabrum*     | Seed        | Methanol extracts | Apoptotic effects | WEHI-164 cells | Apoptosis and antiproliferative properties | [69]  |
| *D. ammoniacum* | Oleogum resin | Methanol extracts | Cytotoxic effects | *Saccaromyces cerevisiae* | IC50: 3.14 µg/mL | [70]  |
| *D. aucheri*     | Aerial part | Methanol extracts | Cytotoxic activity | HepG2 and A549 cells | IC50: 20.09, 48.65 µg/mL | [71]  |
| *D. glabrum*     | Seed        | Methanol extracts | Cytotoxic effects | WEHI-164 cells, mouse Fibrosarcoma cell line and L929 normal cells | IC50: 50 µg/mL in 36 hours | [72]  |
| *D. glabrum*     | Seeds       | Methanol extract | Geno/cytotoxicity and apoptotic | *CAOV-4 cells* | IC50: 99.7, 87.3, 70.03 µg/mL at 48 h | [73]  |
| *D. glabrum*     | Roots       | Essential oil | Free radical scavenging | DPPH assay | RC50: 2.24 mg/mL | [23]  |
| *D. glabrum*     | Aerial parts | Methanol fraction | Antioxidant | DPPH assay | IC50: 53.3 ± 4.7 µg/mL | [21]  |
Tohfah al-Momenin and others [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 sty [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   |
|---------------|------------|-----------------------------|-----------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-------|
| *D. aucheri*  | 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]  |
| *D. hyrcanum* | Roots      | Methanol extract            | Antiplasmodial effect | Mice model; injection; 10 mg/mL for 4 days; 4-day suppressive test against nicid strain of in mice | Good suppression *Plasmodium berghei* infection activity, inhibiting 68.1% of the parasite growth     | [33]  |
| *D. aucheri*  | 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]  |
| *D. aucheri*  | Aerial parts | Essential oil              | Anti-diabetic effect  | Patients with type ii diabetes; randomized clinical trial; 500 mg for 45 days                   | Biological effects through PPAR-γ activation                                                       | [24]  |
| *D. urmiana*  | Aerial parts | Hydro alcohol extract       | Cytotoxicity          | Larvae of *artema urmiana*; 24 hours; 12 mg rutin/g extract                                      | Lc50 76.50 ± 0.60 μg/mL potent brine shrimp lethality                                              | [64]  |
| *D. aucheri*  | Leaves     | Water/ethanol 95° mixture   | Anti-coccidial        | Chickens model; orally; after 22 day of age; 30 mg/kg                                           | Effective in control of coccidiosis                                                               | [65]  |
| *D. ammoniacum* | Gum       | Water extract              | Anticonvulsant activity | Male albino mice model; 700 mg/kg; injection                                                     | Showed significant anticonvulsant activity                                                        | [75]  |
| *D. aucheri*  | Root       | Hydroalcoholic extract      | Effects on pituitary  | 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, antiplasmodial, 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.

ACKNOWLEDGEMENTS

This work was supported by grants from Research Affairs of Mashhad University of Medical Sciences, Mashhad, Iran.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

ORCID

Elaheh Zibaee, 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

REFERENCES

1. Mozaffarian V. [Flora of Iran]. Tehran: Research Institute of Forests and Rangelands; 2007. Chapter 54, Umbelliferae; p. 368-74. Persian.
2. Rabe SZT, Iranshahi M, Rastin M, Rabe SZT, Mahmoudi M. Anti-inflammatory effect of new kopetdaghins A, C and E from Dorema kopetdaghense. Food Agric Immunol. 2015;26(3):430-9.
3. Amin GR. Popular medicinal plants of Iran. 1. Tehran: Iranian Research Institute of Medicinal Plants; 1991. 230 p.
4. Ali GB, Mahdi F. The possibility of crop cultivation and utilization of edible gum from herb (Dorema ammoniacum D. Don) in dryland farming. J Agric Sci. 2015;60(3):369-80.
5. Langenheim JH. Plant resins: chemistry, evolution, ecology and ethnobotany. Portland: Timber Press; 2003. p. 123-9.
6. Amiri MS, Joharchi MR. Ethnobotanical investigation of traditional medicinal plants commercialized in the markets of Mashhad, Iran. Avicenna J Phytomed. 2013;3(3):254-71.
7. Schischkin BK. [Flora SSSR. 17]. Leningrad: Izd-vo Akademii Nauk SSSR; 1951. p. 155-65. Russian.
8. Pimenov MG, Leonov MV, Constance L. The genera of the Umbelliferae: a nomenclator. London: Royal Botanic Gardens; 1993. 156 p.
9. Ajani Y, Ajani A, Cordes JM, Watson MF, Downie SR. Phylogenetic analysis of nrDNA ITS sequences reveals relationships within five groups of Iranian Apiaceae subfamily Apioidae. Taxon. 2008;57(2):383-401.
Ethnopharmacology of Dorema Species

10. Rechinger KH. Umbelliferae. Graz: Akademische; 1987. p. 379-85.
11. Amiri MS, Joharchi MR. Ethnobotanical knowledge of Apiaceae family in Iran: a review. Avicenna J Phytomed. 2016;6(6):621-35.
12. Mosaddegh M, Naghibi F, Moazzeni H, Pirani A, Esmaeili S. Ethnobotanical survey of herbal remedies traditionally used in Khooghiluyeh va Boyer Ahmad province of Iran. J Ethnopharmacol. 2012;141(1):80-95.
13. Memariani F, Akhani H, Joharchi MR. Endemic plants of Khorrassan-Kopet Dagh floristic province in Irano-Turanian region: diversity, distribution patterns and conservation status. Phytotaxa. 2016;249(1):31-117.
14. Sadeghei Takallo M, Sajjadifar S, Avval MM. Chemical composition of the essential oils from flowers, stems and roots of Dorema ammoniacum D.Don from Iran. Res J Pharm Biol Chem Sci. 2013;4(4):640-4.
15. Delnavazi MR, Tavakoli S, Rustaie A, Batooli H, Yassa N. Antioxidant and antibacterial activities of the essential oils and extracts of Dorema ammoniacum roots and aerial parts. Res J Pharmacogn. 2014;1(4):11-8.
16. Hosseini SAR, Naseri HR, Azarnivand H, Jafari M, Rowshan V, Panahian AR. Comparing stem and seed essential oil in Dorema ammoniacum D. Don from Iran. J Essent Oil Bear Plants. 2014;17(6):1287-92.
17. Zandpour F, Vahabi MR, Allafchian AR, Farhang HR. Phytochemical investigation of the essential oils from the leaf and stem of (Apiaceae) in Central Zagros, Iran. J Herb Drugs. 2016;7(2):109-16.
18. Masoudi S, Kakavand S. Volatile constituents of the aerial parts of Terataenium lasiopentalum (Boiss.) Manden., stems and leaves of Dorema ammoniacum D. Don. and leaves, fruits and stems of Leutea petiolare (DC.) M. Pimen from Iran. J Herb Drugs. 2016;7(2):109-16.
19. Masoudi S, Esmaeili A, Ali khaliilzadeh M, Rustaiyan A, Moazami N, Akhtar MR, et al. Volatile constituents of Dorema aucheri Boiss., Seseli libanotis (L.) W. D. Koch var. ammoniacum Bordz. and Conium maculatum L. three Umbelliferae herbs growing wild in Iran. Flavour Fragr J. 2006;21(5):801-4.
20. Akbarian A, Rahimmalek M, Sabzialian MR. Variation in essential oil yield and composition of Dorema aucheri Boiss., an endemic medicinal plant collected from wild populations in natural habitats. Chem Biodivers. 2016;13(12):1756-66.
21. Delnavazi MR, Hadjiakhoondi A, Delazar A, Ajani Y, Tavakoli S, Yassa N. Phytochemical and antioxidant investigation of the aerial parts of Dorema glabrum Fisch. & C.A. Mey. Iran J Pharm Res. 2015;14(3):925-31.
22. Yousefzadi M, Mirjalili HM, Alnajar N, Zeinali A, Parsa M. Composition and in vitro antimicrobial activity of the essential oil of Dorema ammoniacum D. Don. fruit from Iran. J Serbian Chem Soc. 2011;76(6):857-63.
23. Asnaashari S, Dadizadeh E, Talebpour AH, Eskandani M, Nazemiyeh H. Free radical scavenging potential and essential oil composition of the Dorema glabrum Fisch. C.A. Mey roots from Iran. Bioimpacts. 2011;1(4):241-4.
24. Nahvinejad M, Pourrajab F, Hekmatmoghaddam S. Extract of Dorema aucheri induces PPAR-γ for activating reactive oxygen species metabolism. J Herb Med. 2016;6(4):171-9.
25. Behpour M, Ghoreishi SM, Khayatkashani M, Soltani N. The effect of two oleo-gum resin exudate from Ferula assa-foetida and Dorema ammoniacum on mild steel corrosion in acidic media. Corros Sci. 2011;53(8):2489-501.
26. Iranshahi M, Shaki F, Mashlab A, Wessjohann LA. Kopetdaghins A-E, sesquiterpene derivatives from the aerial parts and the roots of Dorema kopetdaghense. J Nat Prod. 2007;70(8):1240-3.
27. Eskandani M, Dadizadeh E, Hamishehkar H, Nazemiyeh H, Barar J. Geno/cytotoxicity and apoptotic properties of phenolic compounds from the seeds of Dorema glabrum fisch. C.A. Bioimpacts. 2014;4(4):191-8.
28. Nurmukhamedova MR, Nikonov GK. Glycosides of Dorema hyrcanum. Chem Nat Compd. 1976;12(1):92-3.
29. Bukreeva TV, Pimenov MG. 2,6-Dihydroxy-4-methoxyacetophenone 2-O-β-D-gentiobioside from the roots of Dorema aitchisonii. Chem Nat Compd. 1991;27(5):638-9.
30. Delnavazi MR, Hadjiakhoondi A, Delazar A, Ajani Y, Yassa N. Azerosides A and B: two new phloroacetophenone glycosides from the roots of Dorema glabrum Fisch. & C.A. Mey. Med Chem Res. 2015;24(2):787-96.
31. Nylkolov N, Iossifova T, Vassileva E, Kostova I, Stoev G. Reverse-phase high pressure liquid chromatographic analysis of hydroxycoumarins in plant extracts. Quantitative determination of hydroxycoumarins in Fraxinus ornus. Phytochem Anal. 1993;4(2):86-8.
32. Morikawa T, Imura K, Miyake S, Ninomiya K, Matsuda H, Yamashita C, et al. Promoting the effect of chemical constituents from the flowers of Poacynum hendersonii on adipogenesis in 3T3-L1 cells. J Nat Med. 2012;66(1):39-48.
33. Naghibi F, Ghafari S, Esmaeili S, Jenett-Siems K. Naghibione; a novel sesquiterpenoid with antiplasmodial effect from Dorema hyrcanum Koso-Pol. Root, a plant used in traditional medicine. Iranian J Pharm Res. 2015;14(4):961-8.
34. Kraus C, Spiteller G. Comparison of phenolic compounds from galls and shoots of Picea glauca. Phytochemistry. 1997;44(2):86-8.
122

https://doi.org/10.3831/KPI.2020.23.3.91
S. Genotoxicity evaluation of hydroalcoholic and aqueous extracts of *Dorema aucheri* by the comet assay. Adv Biomed Res. 2016;5:199.

68. Jafari N, Zargar SJ, Yassa N, Delnavazi MR. Induction of apoptosis and cell cycle arrest by *Dorema glabrum* root extracts in a gastric adenocarcinoma (AGS) cell line. Asian Pac J Cancer Prev. 2016;17(12):5189-93.

69. Bannazadeh Amirkhiz M, Rashtchizadeh N, Nazemiyeh H, Abdolalizadeh J, Mohammadnejad L, Baradaran B. Investigating apoptotic effects of methanolic extract of *Dorema glabrum* seed on WEHI-164 cells. ISRN Pharmacol. 2013;2013:949871.

70. Shahidi GH, Moein MR, Foroumadi AR, Rokhbakhsh ZF. Cytotoxic activity of medicinal plants used in Iranian traditional medicine on two strains of *Saccharomyces cerevisiae*. Daru J Pharm Sci. 2002;10(4):162-4.

71. Mosaddegh M, Esmaeili S, Naghibi F, Moghadam MH, Haeri A, Pirani A, et al. Ethnomedical survey and cytotoxic activity of medicinal plant extracts used in Kohgiluyeh and Boyerahmad province in Iran. J Herbs Spices Med Plants. 2012;18(3):211-21.

72. Bannazadeh Amirkhiz M, Rashtchizadeh N, Nazemiyeh H, Abdolalizadeh J, Mohammadnejad L, Baradaran B. Cytotoxic effects of alcoholic extract of *Dorema glabrum* seed on cancerous cells viability. Adv Pharm Bull. 2013;3(2):403-8.

73. Ahangarpour A, Zamaneh HT, Jabari A, Nia HM, Heidari H. Antidiabetic and hypolipidemic effects of *Dorema aucheri* hydroalcoholic leave extract in streptozotocin-nicotinamide induced type 2 diabetes in male rats. Iran J Basic Med Sci. 2014; 17(10):808-14.

74. Mostafavi SH, Fazilati M, Mostafavi SA, Vahhabi MR, Mostafavi F, Omidvarinia S, et al. Hepatotoxicity of *Dorema aucheri* (Bilhar) in albino mice. Arch Iran Med. 2013;16(9):530-2.

75. Motevalian M, Mehrzadi S, Ahadi S, Shojaii A. Anticonvulsant activity of *Dorema ammoniacum* gum: evidence for the involvement of benzodiazepines and opioid receptors. Res Pharm Sci. 2017;12(1):53-9.

76. Khatamsaz S, Azarnioshan F, Sadeghi H. Effects of hydroalcoholic extract of *Dorema aucheri* on pituitary-gonad axis hormones in adult male rats. Nat Environ Pollut Technol. 2010;9(3):507-11.