

REVIEW

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# Medicinal uses, phytochemistry and pharmacology of *Ammodaucus leucotrichus*

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## Abstract

This review summarizes selected scientific evidence on phytochemistry and pharmacological properties of *Ammodaucus leucotrichus*. Information was gathered via the Internet (using Scopus, PubMed, Google Scholar, Elsevier, Springer, Science Direct, Researchgate and Web of Science) as well as from libraries and local books. *Ammodaucus leucotrichus* (*A. leucotrichus*), belongs to the family Apiaceae, has been reported to possess a wide range of traditional medicinal uses including in diarrhea, cough, pulmonary diseases, anorexia, allergy, tachycardia, helminthiasis, stomach pain, gastralgias, otitis, indigestion, cold, fever, anorexia and cardiac diseases. Phytochemical investigations revealed that this plant possesses many bioactive chemical constituents including monoterpenes and their derivatives, sesquiterpenes and their derivatives, tannins, anthracenes compounds, sterols, triterpenes, reducing compounds, alkaloids, phenol acids, saponins, flavonoids and coumarins. The most important pharmacological activities are antioxidant, antibacterial, antifungal, antidiabetic, anti-inflammatory, anticholinesterase and cytotoxicity activities. *Ammodaucus leucotrichus* has potential for the treatment of a wide range of diseases and has been well studied for its phytochemical properties. However, further scientific studies are needed to explore mechanisms of actions, adverse effects of the extracts, toxicity and the therapeutic effect of major secondary metabolites.

**Keywords:** Phytochemistry, Pharmacology, Medicinal, Biological activity, *Ammodaucus leucotrichus*

## Background

The flora of Morocco with its 7000 species and sub-species belonging to several botanical families is not widely explored in the pharmacological aspects as well as in the phytochemical characteristics [1]. Therefore, the valorization of the medicinal plants of the Moroccan flora will be a great contribution to the pharmaceutical industry for selecting plants with potential pharmaceutical properties.

The Apiaceae (Umbelliferae), in the order Apiales, is one of the largest families with about 300 genera and more than 2500 species, distributed in a variety of habitats, principally in the temperate regions of the world [2, 3]. *Ammodaucus leucotrichus* Coss. & Dur. (= *Cuminum maroccanum* P.H.Davis & Hedge) is the only specie of the genus *Ammodaucus* in the Apiaceae family is referred to as 'Kamune es sufi or akâman' in most of the north African countries, while in Algeria

it is commonly known as "Moudrayga" and known as "Cumin chevelu" in French [4, 5]. It inhabits the maritime sands of the Saharan and sub-Saharan countries of North Africa, including Morocco, Algeria and Tunisia extending to Egypt and the tropical Africa. Its best implantation is in desert regions, often down a hill or a dune [5, 6]. It is a small glabrous annual plant with finely striated stems, branched from the base (Fig. 1). The leaves are fleshy, finely divided forming flat narrow ridges with sheathing petioles. The white flowers, with five free petals, are grouped in composed umbels of two to four branches. The fruit is a di-achene with 8–10 mm long and is covered with very dense and fuzzy hairs [2, 5]. This plant plays a major role in herbal medicine in North African countries.

Current paper aims to provide an overview on the ethnobotanical uses along with recent studies concerning the ethnopharmacology, phytochemistry and therapeutic activities of *Ammodaucus leucotrichus*.

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**Fig. 1** *Ammodaucus leucotrichus* in natural habitat

### Traditional uses

*Ammodaucus leucotrichus* is used in the North African countries as a condiment or spice and for varied medical applications [6].

In Morocco, different parts of this plant, especially fruits and seeds, are often used to treat gastric-intestinal pains, gastralgias, otitis, hypotensive, indigestion, cold, fever, pulmonary diseases, labor pains, anorexia and cardiac diseases [3]. The fruits, in infusion, are used in various infantile diseases of the digestive system. They are also mixed with *Thymus satureioides* to treat stomach pains [7]. The decoction of flowers and seeds is used for abdominal pain for children and adults. The fruits in infusion are indicated to treat intestinal pain for infants [8]. Seeds prepared as soup or infusion, are used to soothe abdominal pain, nausea, vomiting in newborns. The infusion is recommended to help the elderly for sleeping [9]. A preparation based on the seeds of *Ammodaucus leucotrichus* and those of *Petroselinum sativum*, powdered and mixed with apple vinegar and pure honey, is used for cystitis and nephritic colics. The patient takes a teaspoon of the mix in a glass of hot water on an empty stomach. A preparation based on the seeds of *Ammodaucus leucotrichus*, *Zea mays* style, *Opuntia ficus-indica* flowers and *Zizyphus lotus* fruits, decocted in water, are used for pyelonephritis. The patient drinks two glasses everyday [10]. The seeds of *Ammodaucus leucotrichus*, powder of *Myristica fragrans*, *Euphorbia falcata* (1 spoon), *Herniaria hirsuta* (1 spoon), a lemon fruit and a cup of olive oil, decocted in water are used for the treatment of kidney stones [11]. The decoction of fruits and seeds is also used for diarrhea, emetic, cough, pulmonary diseases,

anorexia, allergy, tachycardia, pains of tiredness, helminthiasis and gastroenteritis [12].

*Ammodaucus leucotrichus*, known in Algeria as “Moudrayga or El massoufa”, is a medicinal plant sold to herbalists in local markets, particularly in the Southern Algerian Sahara. The nomads collect the seeds and leaves for their own use, usually in the spring, when the fruits are ripe [13]. In the southern Algerian Sahara, the leaves of this plant are used as a flavoring herbal in teas and fruits are often used as a spice during culinary preparation. The leaves and seeds are consumed in the form of decoction or infusion for several therapeutic cases, such as blood pressure, chest pain, liver and digestive system ailments, gastroenteritis, as also for diabetes [14]. In Tassili (Algeria), the fruits and the leaves are commonly consumed in infusion. The powder form is also an appreciated spice for foodstuff. The leaves consumed for their flavoring characteristics in tea, and the fruits for their bioactive capacity mainly in the treatment of heart palpitations [15]. The fruits of this plant are widely used as sugar regulator for diabetics and for stomach and colon diseases. The seeds are used to treat stomach diseases, wounds infections, cutaneous allergies, genital disorders, abdominal pains, for scorpion stings, snakebites, and liver diseases. The leaves are used infused or used as a powder to avoid indigestion, to recover the appetite and for chest complaints [3]. *Ammodaucus leucotrichus* is also frequently used in the treatment of allergy symptoms, diarrhea, indigestion, vomiting, spasms and colic, intestinal worms, fever, constipation, coughing and for anorexia [15]. Moreover, aphrodisiac, emmenagogue and abortive properties are attributed to this species [16].

### Phytochemistry

Various bioactive compounds are isolated from aqueous, acetone, methanolic, or ethanolic extracts of the plant. They are grouped as monoterpenes and their derivatives, sesquiterpenes and their derivatives, tannins, anthracenes compounds, sterols, triterpenes, reducing compounds, alkaloids, phenol acids, saponins, flavonoids and coumarins [5]. In addition, reports on the isolation, and identification of individual chemical constituents have revealed the presence of perillaldehyde and limonene as major compounds. The new guainolide lactone, ammolacone and new monoterpene 3-hydroxyperillaldehyde, methylperillate, borneolangelate and  $\gamma$ -decalactone were also found in this species [2, 17]. The presence of such metabolites indicates the importance of plant extracts, for examples terpenes are considered as suitable penetration enhancers in pharmaceutical industries [18], alkaloids are considered to be the primary active ingredients in plant-derived medicines [19], flavonoids are considered important due to

their antioxidant, anti-inflammatory, antimicrobial, anti-cancer, anti-HIV, anticoagulant, immunomodulatory, anti-tubercular and anti-allergic activities [20], Perillaldehyde, the major compound in *Ammodaucus leucotrichus* extracts, has the potential to conserve the quality and safety of foods and fresh produce. Additionally, perillaldehyde is widely used in flavour, cosmetics, perfumery, and pharmaceutical industry [3]. Table 1 shows the isolated phytochemicals from different parts of the plant in detail.

### Pharmacological activities

*Ammodaucus leucotrichus* has been studied regarding their bioactive characteristics. Several extracts and isolated compounds have been evaluated for their biological activities, namely, antioxidant, antibacterial, antifungal, antidiabetic, anti-inflammatory, anticholinesterase and cytotoxicity activities.

### Antioxidant activities

Louail et al. [25] assessed antioxidant activities of essential oil of seeds of *Ammodaucus leucotrichus* by measuring the inhibition of conjugated diene hydroperoxides arising from linoleic acid oxidation. It appeared that the essential oil obtained from the seeds of *Ammodaucus leucotrichus* demonstrated antioxidant activity, by inhibiting the  $\beta$ -carotene bleaching due to retarding/inhibiting of linoleic acid hydroperoxide-derived, which attack the chromophore- $\beta$ -carotene. The value of the essential oil of seeds showed a better antioxidant activity than that shown by Ascorbic acid. In another experiment, Dahmane et al. [17] assessed antioxidant activities of essential oils obtained from the fruits of *Ammodaucus leucotrichus* using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) assay and the  $\beta$ -carotene bleaching assay. Essential oils of *Ammodaucus leucotrichus* exhibited weak antioxidant abilities to reduce DPPH radicals. When compared to BHT and ascorbic acid, oils have been found significantly less effective than these antioxidant agents ( $p < 0.05$ ). However, essential oils exhibited significantly lower inhibition against linoleic acid oxidation and weak antioxidant abilities for reduce DPPH radicals [17].

Sebaa et al. [5] evaluated antioxidant activities of oils essential, aqueous, and methanol extracts of fruits of *Ammodaucus leucotrichus* using the reducing power method and the DPPH method. The result of antioxidant activity by the ferric reducing was detected in all the extracts: weak in the aqueous extract, oils essential and strong in the extract methanolic of *Ammodaucus leucotrichus* fruits. Free radical scavenging activity of all the extracts and references antioxidants increased with the increase in concentration. Antioxidant activity dosing by using DPPH whitening assesses that methanol extract has the best performance. All extracts have a free radical reduction capacity. Required concentrations to

neutralize and stabilize 50% of DPPH concentration goes from 2 to 4  $\mu\text{g/ml}$  [5]. A potential antioxidant effect of the aqueous extract from the fruits of *Ammodaucus leucotrichus* has been shown, in vitro, by the method of trapping of free radical 2,2-diphenyl-1-picrylhydrazyl [26].

### Antimicrobial activities

The essential oil of seeds of *Ammodaucus leucotrichus* was screened for its antimicrobial activity against different microorganisms, including Gram-positive bacteria *Bacillus subtilis*, Gram-negative bacteria *Escherichia coli* and two yeast species *Candida albicans* and *Saccharomyces cerevisiae*, in addition *Aspergillus flavus* and *Penicillium expansum*. *Ammodaucus leucotrichus* oil exhibited strong inhibitory action against most tested organisms with MIC values ranged from 0.37 to 0.92 mg/ml. Furthermore, the essential oil showed significant antibacterial activity against Gram negative and Gram positive bacteria at doses of 1.29 mg/disc. The antibacterial activity of essential oils also tested for yeast such as *Candida albicans* and *Saccharomyces cerevisiae* showed moderate to good activity. The antifungal results revealed good, clear zones of growth inhibition against *Aspergillus flavus* and *Penicillium expansum* [25].

Dahmane et al. [17] evaluated antibacterial activities of the essential oil acquired from the fruits of *Ammodaucus leucotrichus* using disc diffusion and agar dilution methods against nine bacterial strains, 5 Gram positive and 4 Gram negative. The essential oils exerted a broad antibacterial spectrum with diameter of inhibition zones ranging from 9.66 to 52.66 mm, while it was 10.66–39.00 mm for the positive control.

Mbanga et al. Sebaa et al. [5] assessed antimicrobial activities of different fractions and extracts of *Ammodaucus leucotrichus* fruits against eight bacteria and three fungi strains: *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsilla pneumonia*, *Salmonella typhimurium*, *Proteus vulgaris*, *Bacillus cereus*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Candida albicans*, *Aspergillus niger* and *Trichophyton rubrum* using the disk diffusion method. The inhibition zones of disc for strains were in the ranges 7.0–18.0 mm. Generally, the extracts of the plant were moderately active against Gram positive and negative bacteria. All the extracts and fractions from *Ammodaucus leucotrichus* announced an antifungal activity and the greatest effect was obtained by butanic fraction on *Trichophyton rubrum* and methanolic extract on *Candida albicans* whose zones of inhibition were of 20 and 15 mm respectively [5].

The essential oil obtained from the seeds of *Ammodaucus leucotrichus* showed significant antibacterial activity against *Micrococcus luteus* while moderately active against *Klebsiella pneumonia*, *Staphylococcus*

**Table 1** Phytochemicals isolated from different parts of *Ammodaucus leucotrichus*

No.	Chemical compound	Part of plant	References
1	(+)-limonene	Seed	[21]
2	(+)-perillaldehyde	Seed	[21]
3	(+)-3-hydroxyperillaldehyd	Seed	[21]
4	$\alpha$ -fenchene	Fruit	[22]
5	Cis-Limonene oxide	Fruit	[3, 17]
6	$\delta$ -2-Carene	Seed	[16]
7	$\beta$ -Phellandrene	Seed, fruit	[3, 6, 16]
8	<i>cis</i> -Ocimene	Seed	[16]
9	Linalool	Seed, fruit	[6, 16]
10	$\gamma$ -Terpineol	Seed	[16]
11	Myrtenal	Seed, fruit	[6, 16, 17]
12	<i>cis</i> -Carveol	Seed, fruit	[16, 17]
13	$\alpha$ -Terpinene-7-al	Seed	[16]
14	Piperitenone	Seed	[16]
15	$\beta$ -Myrcene	Seed, fruit	[13, 23]
16	3-Carene	Seed, fruit, aerial part	[3, 4, 13, 15, 23, 24]
17	Borneol	Seed, fruit	[6, 13]
18	$\alpha$ -Phellandrene	Fruit	[6, 17]
19	$\alpha$ -Terpinene	Fruit	[6]
20	<i>p</i> -Cymene	Fruit	[6, 17]
21	<i>cis</i> -Sabinene hydrate	Fruit	[6]
22	Camphor	Fruit	[3, 6, 17]
23	<i>p</i> -Cymen-8-ol	Fruit	[6]
24	Thymol methyl ether	Fruit	[6]
25	$\alpha$ -Thujene	Seed, fruit	[17, 25]
26	$\alpha$ -Pinene	Seed, fruit, aerial part	[4, 6, 13, 15–17, 24, 25]
27	Camphene	Seed, fruit, aerial part	[6, 13, 15, 17, 24, 25]
28	Sabinene	Seed, fruit	[3, 6, 16, 17]
29	$\beta$ -Pinene	Seed, fruit, aerial part	[3, 4, 6, 13, 15, 17, 23–25]
30	Myrcene	Seed, fruit, aerial part	[4, 6, 15, 17, 24, 25]
31	$\delta$ -3-Carene	Seed, fruit	[6, 17, 25]
32	<i>o</i> -cymene	Seed	[25]
33	Limonene	Seed, fruit	[3, 4, 6, 13, 15–17]
34	$\gamma$ -Terpinene	Seed, fruit	8–4-2 -[6, 16, 25]
35	Terpinolene	Seed, fruit	[6, 16, 17, 25]
36	$\alpha$ -pinene oxide	Seed, fruit	[3, 25]
37	Bornyl acetate	Seed, fruit	[6, 13, 17]
38	Eugenol	Fruit	[17]
39	Perilla alcohol	Seed, fruit, aerial part	[3, 6, 13, 15–17, 24, 25]
40	Perillaldehyde	Seed, fruit, aerial part	[3, 4, 6, 13, 15–17, 24, 25]
41	D-Limonene	Fruit, aerial part	[23, 24]
42	l-perrillaldehyde	Fruit	[23]
43	3-Thujanone	Aerial part	[24]
44	<i>p</i> -cymene	Fruit	[3]

**Table 1** Phytochemicals isolated from different parts of *Ammodaucus leucotrichus* (Continued)

No.	Chemical compound	Part of plant	References
45	Thymol	Fruit	[6]
46	Cuminal	Seed	[25]
47	$\alpha$ -Terpineol	Seed, fruit	[3, 6, 13, 17]
48	Terpen-1-ol	Fruit	[22]
49	<i>trans</i> -Verbenol	Fruit	[17]
50	<i>trans</i> -Carveol	Fruit	[17]
51	$\alpha$ -Copaene	Seed, fruit	[6, 13, 25]
52	$\beta$ -Cubebene	Seed, fruit	[6, 17, 25]
53	$\beta$ -elemene	Seed	[25]
54	Caryophyllene	Seed, aerial part	[13, 24, 25]
55	$\alpha$ -caryophyllene	Seed	[25]
56	$\alpha$ -selinene	Seed	[25]
57	$\alpha$ -Muurolene	Seed, fruit	[6, 17, 25]
58	$\delta$ -Cadinene	Seed, fruit	[6, 16, 17, 25]
59	Spathulenol	Seed, fruit	[13, 15, 17, 25]
60	Caryophyllene oxide	Seed	[25]
61	T-Muurolol	Seed, fruit	[6, 25]
62	$\alpha$ -Curcumene	Seed	[13]
63	Bicyclogermacrene	Seed, fruit	[13, 17]
64	$\beta$ -Dihydroagarofuran	Seed	[13]
65	$\alpha$ -Cubebene	Fruit	[6]
66	ar-Curcumene	Fruit	[6]
67	$\alpha$ -Zingiberene	Fruit	[6]
68	$\beta$ -Bisabolene	Fruit	[6]
69	$\gamma$ -Cadinene	Fruit	[6, 17]
70	Germacrene B	Fruit	[6]
71	$\beta$ -Calacorene	Fruit	[6]
72	Germacrene d-4-ol	Fruit	[6, 17]
73	1- <i>epi</i> -Cubenol	Fruit	[6]
74	Chamazulene	Fruit	[6]
75	<i>trans</i> - $\alpha$ -Bergamotene	Fruit	[17]
76	$\alpha$ -Humulene	Fruit	[17]
77	$\beta$ -Selinene	Fruit	[17]
78	$\alpha$ -Bulnesene	Fruit	[17]
79	10- <i>epi</i> -Cubebol	Fruit	[17]
80	$\tau$ -Cadinol	Fruit	[17]
81	$\beta$ -Eudesmol	Fruit	[17]
82	11-Acetoxyeudesman-4- $\alpha$ -ol	Fruit	[17]
83	$\beta$ -Caryophyllene	Seed	[16]
84	<i>cis</i> - $\beta$ -Farnescene	Seed	[16]
85	<i>trans</i> -Muurola-3,5-diene	Seed	[16]
86	Germacrene D	Seed, fruit	[16, 17]
87	B -Selinene	Seed	[16]
88	Globulol	Seed, aerial part	[16, 24]

**Table 1** Phytochemicals isolated from different parts of *Ammodaucus leucotrichus* (Continued)

No.	Chemical compound	Part of plant	References
89	$\alpha$ -Eudesmol	Seed, fruit	[16, 17]
90	Longifolol	Seed, fruit	[16, 17]
91	Ammolactone-A	Seed	[21]
92	$\alpha$ -Cadinol	Seed	[6, 13, 17, 25]
93	$\alpha$ -Muurolol	Fruit	[6, 17]
94	Terpinen-4-ol	Seed, fruit	[6, 17, 25]
95	1-Pentadecene	Fruit	[23]
96	1-Nonadecene	Fruit	[23]
97	Cuminaldehyde	Seed, aerial part, fruit	[4, 13, 16, 17, 24]
98	$\alpha$ -Campholenal	Seed	[16]
99	Benzaldehyde	Seed	[25]
100	Allyl isovalerate	Seed, fruit	[16, 17]
101	( <i>Z,E</i> )-Farnesol	Fruit	[6]
102	Methyl eugenol	Seed, fruit	[17, 25]
103	$\gamma$ -Decalactone	Seed, fruit	[6, 17, 25]
104	<i>cis-p</i> -Mentha-2,8-dien-1-ol	Seed	[16]
105	Allocimene B	Seed	[16]
106	<i>p</i> -Cymen-8-ol	Seed	[16]
107	<i>cis</i> -Pinocarveol	Seed	[16]
108	<i>trans</i> -Isocarveol	Seed	[16]
109	11-Acetoxyeudesman-4-a-ol	Seed	[16]
110	<i>p</i> -mentha- <i>trans</i> -2,8-dien-1-ol	Seed	[25]
111	<i>cis</i> -limonene oxide	Seed	[16, 25]
112	<i>Trans-p</i> -mentha-1(7),8-dien-2-ol	Seed	[25]
113	Carvacrol methyl ether	Fruit	[6]
114	3-Hydroxyperillaldehyde	Fruit	[6]
115	10-nor-Calamenen-10-one	Fruit	[6]
116	$\alpha$ -Terpinen-7-al	Fruit	[4]
117	$\gamma$ -Terpinen-7-al	Fruit	[4]
118	Dehydro- Sabina ketone	Fruit	[17]
119	<i>Trans-p</i> -Mentha-2,8-dien-1-ol	Fruit	[17]
120	<i>Cis-p</i> -Mentha-2,8-dien-1-ol	Fruit	[17]
121	<i>Trans</i> -Limonene oxide	Fruit	[17]
122	Shybunol	Fruit	[17]
123	Caryophyllene acetate	Fruit	[17]
124	<i>cis-p</i> -mentha- <i>trans</i> -2,8-dien-1-ol	Fruit	[3]
125	Pyranon	Fruit	[23]
126	Rosifoliol	Fruit	[23]
127	<i>z</i> -5-Nonadecene	Fruit	[23]
128	$\alpha$ -copaen-11-ol	Aerial part	[24]
129	Isolongifolan-8-ol	Aerial part	[24]

*aureus* and *Bacillus subtilis*. The hydro-distilled oil it was inactive against *Escherichia coli*, *Pseudomonas aeruginosa* and *Salmonella typhi* [16]. *Botrytis cinerea*

and *Penicillium expansum* showed a strong sensitivity to *Ammodaucus leucotrichus* essential oil at all concentrations [4].



The Essential oil showed in vitro, important antifungal activities against germination and sporulation spores. *Aspergillus ochraceus* was most sensitive, being inhibited at minimum sporulation inhibitory concentration as weak as 1/8000 (v/v). The Essential oil was found to be fungicidal at minimal fungicidal concentration against *Aspergillus flavus* [13].

The essential oil, acquired from the fruits were most active against *Escherichia coli*, *Enterobacter cloacae*, *Bacillus cereus*, *Salmonella typhimurium*, *Klebsiella pneumoniae* and *Staphylococcus aureus*, and moderate active against *Enterococcus faecium*. The essential oil exhibited a strong antifungal activity against *Fusarium oxysporum* *Aspergillus flavus*, *Candida albicans* and *Saccharomyces cerevisiae* strain [3, 23, 27]. The hydro-ethanolic extract and aqueous decoction from the aerial parts of *Ammodaucus leucotrichus* were moderately active against Gram-negative and Gram-positive bacteria. Both extracts obtained from the plant had no effect on *Proteus mirabilis* and very low effect on *Klebsiella pneumoniae*, even at the highest concentration tested (20 mg/mL) [14].

#### Antidiabetic activities

El-Ouady et al. [26] evaluated anti-diabetic activities of aqueous extract of *Ammodaucus leucotrichus* fruits in streptozotocin-induced diabetic rats. Blood glucose was significantly reduced after 15 days of oral administration of the plant extract at a dose of 10 mg/kg. In addition, *Ammodaucus leucotrichus* fruit aqueous extract was able to exhibit a beneficial effect on histological structure of liver and a remarkable influence on glucose tolerance [26].

#### Anti-inflammatory activities

The anti-inflammatory effect of the essential oil extracted from *Ammodaucus leucotrichus* fruits has been demonstrated using a dose of 100 mg/kg to evaluate the anti-edematogenic response of essential oils in Carrageenan-induced hind paw edema in mice. The inhibitory activity of the essential oils was compared with that of diclofenac used as a standard drugs in this model. The mean increase in paw edema weight in control treated group mice (Group I) was  $31.06 \pm 0.27$  mg. The groups II, III, IV and V treated with essential oils have shown similar inhibition percentages (18.7%, 21.6, 19.4 and 24.5%) of Carrageenan-induced edema as compared with control group [3]. In another Study, Ziani et al. [14] assessed anti-inflammatory property of hydroethanolic extract from the aerial parts of *Ammodaucus leucotrichus* through the determination of the concentration of nitrite NO produced by lipopolysaccharide (LPS)-stimulated murine macrophages RAW 264.7 cell lines in culture medium, treated with different concentrations of the plant extracts. The plant extracts, effectively reduced the expression of ant-inflammatory

enzymes iNOS in LPS-activated murine macrophages, and this reduction was accompanied by the decrease of the nitric oxide (NO) levels [14].

#### Anticholinesterase activities

The anticholinesterase activity of the *Ammodaucus leucotrichus* and the individual main compounds of the essential oil were compared to Donepezil, used as a standard drug against Alzheimer's disease. Essential oil and perillaldehyde have not exhibited an activity against the acetylcholinesterase. In contrast, limonene induced high acetylcholinesterase inhibitory activity with an IC<sub>50</sub> of about 51.6 µg/ mL. Essential oil appeared to be effective compared to inhibition results of Donepezil. For anti-butrylcholinesterase activity, all samples have a high inhibitory activity and the lowest value of IC<sub>50</sub> was obtained with perillaldehyde followed by limonene and essential oil [24].

#### Cytotoxicity activities

Ziani et al. [14] evaluated cytotoxicity activities of aqueous decoction and aerial parts hydroethanolic extracts of *Ammodaucus leucotrichus*. The inhibitory growth activity of four human tumor cell lines: NCI-H460 (non-small cell lung cancer), HeLa (cervical carcinoma), HepG2 (hepatocellular carcinoma), and MCF-7 (breast carcinoma), was determined by the sulforhodamine B colorimetric assay. The hepatotoxicity was determined using a primary culture of nontumor liver cells (PLP2), which were prepared from a freshly harvested porcine liver. The GI<sub>50</sub> values for the hydroethanolic extract were in general lower than the ones exhibited by decoction extracts, showing a significant dose dependent cytotoxic effect. The cell lines MCF-7, HeLa, and NCI-H460 were the most susceptible for the hydroethanolic extract of *Ammodaucus leucotrichus* [14].

#### Conclusions

The available literature on *Ammodaucus leucotrichus* has shown that it is an important medicinal plant used in a wide range of ethnomedical treatments, especially for diarrhea, cough, pulmonary diseases, anorexia, allergy, tachycardia, helminthiasis, gastric-intestinal pains, gastralgias, otitis, indigestion, cold, fever, pains of tiredness, anorexia and cardiac diseases. Monoterpenes and their derivatives, sesquiterpenes and their derivatives, tannins, anthracenes compounds, sterols, triterpenes, reducing compounds, alkaloids, phenol acids, saponins, flavonoids and coumarins are the major chemical constituents which have been demonstrated in *Ammodaucus leucotrichus*. Studies have shown that various extracts of *Ammodaucus leucotrichus* possess a range of pharmacological actions, such as antioxidant, antibacterial, antifungal, antidiabetic, anti-inflammatory, anticholinesterase and cytotoxicity activities supporting its

traditional use. However, the most prominent and the well studied activities are the antimicrobial and antioxidant activities of *Ammodaucus leucotrichus* extracts, fractions and secondary metabolites isolated from various parts in different experimental models. Therefore, considering its versatile medicinal uses. Further improvements are required to encourage research interest on *Ammodaucus leucotrichus*.

#### Abbreviations

BHT: Butylated hydroxytoluene; DPPH: 2,2-Diphenyl-1-picrylhydrazyl; IC50: Minimum inhibition concentration for inhibiting 50% of the pathogen; LPS: Lipopolysaccharide; MIC: Minimum inhibitory concentration; NO: Nitric oxide

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#### Authors' contributions

El Manuscript preparation. FM Manuscript review. KC Supervising the whole work. All authors read and approved the final manuscript.

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