ETHNOMEDICINAL USES, PHYTOCHEMISTRY AND BIOLOGICAL ACTIVITIES OF TALGHOUDA (*BUNIUM FONTANESII* BATT. AND RELATED SYNONYMS): A REVIEW

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Abstract: *The purpose of this review is to provide comprehensive scientific information on Talghouda (Bunium fontanesii), the geographical distribution, botanical description, its chemistry, pharmacological properties of species are stated. As much data on B. fontanesii was gathered using several scientific search engines as: Google Scholar, Science Direct, PubMed, SpringerLink, Web of Science and Scopus. In this review, studies mentioned B. fontanesii and related synonyms and its phytopharmacological activities were cited, the data have been classified according to the ethnomedical use, the phytochemistry and the biological activities of Talghouda. Previous ethnobotanical studies have reported that Talghouda has been used in many folk medicines, especially in thyroid dysfunction, their essential oils and seeds are used in foods in the form of bread. Compositional analysis in different parts of B. fontanesii shows different classes of compounds, including terpenoids and non-terpenoids, as caryophyllene oxide and caryophyllene, (Z)-farnesene, germacrene B, spathulenol, nonacosane and palmitic acid. Phenolic compounds, fatty acids and alkaloids. Polar and non-polar extracts like essential oils have a wide variety of pharmacological activities, i.e., antioxidant, antifungal, antibacterial, anti-inflammatory, anticancer, enzyme inhibition, antiglycation, phytotoxic activity, hypoglycemic effect, estrogenic effects activities. This review confirms the important ethnobotanical and pharmacological potential of Talghouda.*

Keywords: *Ethnobotany, Talghouda (Bunium fontanesii), ethnobotanical investigations, thyroid dysfunction*

1. Introduction

Medicinal plants have been used in healthcare and for food since time immemorial. Currently, almost 80% of the world's population depend on herbal medicines to answer their basic primary health needs for the management of numerous diseases [1].

Among these plants we find Talghouda (*B. fontanesii* Batt. and related synonyms: *B. incrassatum*, *B. mauritanicum*), *Bunium* (Apiaceae) is a widely distributed medicinal plant in Algeria (Quézel and Santa, 1963) [2]. The genus name derives from the Greek term βούνιον (boúnion) [2], which means fatness due to the typical large shape of its tubers. With about 50 species, the genus *Bunium* is distributed in North Africa, Asia and Europe [4]. Among 212 arid or sub-arid geophytes, this genus includes 128 synonymous species and 31 unresolved species. In particular, four species of *Bunium* are endemic among seven species found in the Algerian flora [2]. The name of the genus is fixed on *Bunium*, in rare cases the genus *Carum* is cited as an equivalent [5]. Regarding Talghouda, we find B. incrassatum, common in the fields; *B. fantanesii* having as synonym *B. mauritanicum* [6]. The names of species bring out at the beginning B. mauritanicum but these are other names cited in Quézel and Santa [2].

The database ''The plant List'' cites *B. mauritanicum* as being a synonym of *B. bulbocastanum*, Nevertheless, Miara et al [7] and Benkhalifa et al. [8] specify that it is rather *B.*

bulbocastanum L wich is named Talghouda. Talghouda or Terghouda or Nut or earth gland plant familiar to rural areas in all regions of the tell in Algeria [9]. Talghouda is a perennial plant (geophytes), common in fields and harvests. It is an herbaceous perennial of 30-70 cm, with port of umbelliferous. The stem is slender, furrowed especially towards the top. Its leaves are alternate, 2-3 times divided in narrow strips of general triangular outline and its fruits approximately 2 times longer than broad, with protruding sides, aromatic.

Underground part is a brownish tuber, generally rounded, 1-2 cm in diameter, brownish outside, white inside [10]. The species of *Bunium* genus are aromatic plants with medicinal properties, their grains as well as their essential oil are often used in food and medicine [11]. The use of Talghouda in herbal medicine is very old and is currently experiencing a resurgence of interest among the public. Talghouda (*B. mauritanicum*) plant is well known for its therapeutic virtues among Algerians.

It is found in several regions of Algeria, especially in the North. Talghouda tubers are traditionally and widely used to relieve bronchitis and thyroid disease; and in the treatment of inflammatory hemorrhoids and as antidiarrheals, they are also nutritious and therefore used as food [12]. Talghouda (B. incrassatum), was reported for the first time as medicinal plants in the north Africa and Algeria. It was used to treat asthma, cysts, thyroid disorders and tonsillitis [13]. The chemistry of Talghouda (*B. mauritanicum, B. incrassatum, B. bulbocastanum*) has been studied before [12,14-17].

While several researchers have studied the chemical composition of species of the genus *Bunium* such as: *B. hissaricum* [18], *B. persicum* [19-29] *B. cylindricum* [23], *B. alpinum* [15], B. *brachyactis, B. pinnatifolium, B. sayai and B. microcarpum subsp. Microcarpum* [30], *B. brachyactis, B. pinnatifolium, B. sayaii and B. microcarpum* [31], *B. elegans* [32,33], *B. crassifolium* [34]. Algeria has an important biodiversity of Binum species, which constitutes an opportunity for screening of multiple interests like Talghouda (*B. fontanesii*).

The current review aims to document the ethnomedicinal uses, phytochemistry and biological activities of Talghouda (*B. fontanesii* Batt. and related synonyms). This review is intended to enrich national and global databases of traditional knowledge. To our knowledge, this study represents the first review performed on Talghouda (*B. fontanesii Batt*. and related synonyms).

Research methodology

All relevant information about the botanical description, ethnomedicinal uses, phytochemicals and pharmacological activities of Talghouda (B. fontanesii Batt.) were collected from published literature. Therefore, we did not include literature related to molecular, physiological and anatomical aspects. Different sources such as Web of Science, Medline, Scopus, Science-Direct and Google-Scholars were used to explore the published papers on B. fontanesii Batt.

Furthermore, and in order to collect as much data as possible, the different homotypic and heterotypic synonyms of the taxon were used in the research, in particular: *Laserpitium fontanesii Pers., B. bulbocastanum auct., Bunium bulbocastanum var. bulbocastanum auct., Laserpitium peucedanoides Desf., Bunium bulbocastanum var. peucedanoides (Desf.) J.M. Monts., Bunium fontanesii var. aphyllum Negro, Bunium fontanesii var. Mayor glaucum, Bunium fontanesii var. litorale Maire, Weiller & Wilczek, Carum mauritanicum Boiss. & Reut., Bunium mauritanicum (Boiss. & Reut.) Batt., Bunium fontanesii var. mauritanicum (Boiss. & Reut.) Maire, Bunium perrotii Braun-Blanq. & Mayor, Bunium fontanesii var. perrotii (Braun-Blanq. & Maire) Maire, Bunium mauritanicum var. aphyllum Negro, Bunium mauritanicum var. glaucum Maire, Carum retractum Durieu*.

In this research, several terms of every synonym of the plant were used: essential oils, antibacterial activity, antifungal activity, antidiabetic activity, Anticancer activity, antioxidant activity.

The work published in French or English mentioning the plant were cited in this review.

The collected manuscripts were identified and examined for relevance based on their titles and abstracts. Reference lists of the retrieved papers were also examined to identify further relevant papers.

Chemical structures were drawn using ChemDraw Pro 8.0 software. PubChem database was used to check the IUPAC names of phytochemicals reported from the plant.

3. Results and discussion

3.1. Botanical description

It is an herbaceous perennial Bulbous plant of 30-70 cm, with an umbelliferous habit, Umbels 5-7 cm wide. the stems less thick, and slender, poorly developed; furrowed, especially towards the top, pedicels not indurated, not spreading in a star; the leaves are alternate, 2-3 times divided into narrow strips with a general triangular outline and its fruits about twice as long as wide, bipinnatisect with linear or linear-lanceolate segments, with prominent sides, aromatic. Underground part generally rounded brownish tuber, 1-2 cm in diameter, brownish outside, white inside [10]. White flowers. fruit of 3-4 mm, without rostrum, with fine primary ribs, well-marked at least on the dry side, with mericarps remaining contiguous to the mattness, 4-5 times longer than wide, reaching 4-5 mm; calyx teeth inconspicuous. Flowering: March-July.

Fig.1. *Talghouda (B. fontanesii)*

(**[1]**https://www.flickr.com/photos/20945389@N00/156565744**)**
(**[2]**https://www.aujardin.info/plantes/*Bunium*-bulbocastanum.php)

3.2. Taxonomy and geographic distribution

3.2.1. Taxonomy and nomenclature

According to Trabut and Marès [35], talghouda is claimed to be *B. incrassatum* and *B. Mauritanicum*, this umbellifer very common in the harvests of the Tell, has a bulky starchy tuber which the natives harvest in years of scarcity. The dried and lightly roasted tubers give an edible flour.

Fresh, the tuber contains an essential acrid product causing intestinal and nervous disorders. In the mountains, B. Alpinum and B. Macuca giving a pleasant tasting tuber. In the oldest flora of Algeria, Battandier et al. [5] give *B. mauritanicum* as a synonym of Carum mauritanicum Boiss. and Reut. for Algeria (Bousmail, Atlas and high plateaus). Subsequently, Quézel and Santa [2] rather retain *B. fontanesii* (Pers.) Maire as endemic to North Africa. Commonly a spontaneous and uncultivated plant except in trials such as those of its introduction in France for a test of adaptation in mountainous regions. This evokes a very interesting case of domestication in progress! If the genus name is fixed on *Bunium*, in rare cases the genus Carum is cited as an equivalent. The names of species bring out at the beginning *B. mauritanicum* but these are other names cited in Quézel and Santa [2].

We find *B. incrassatum*, common in the fields; *B. fantanesii* having as syn. B. mauritanicum, here and there in the fields; *B. chaberti*, endemic to Lalla Khedidja in Djurdjura; *B. elatum* very rare and endemic to Bibans*; B. crassifolium*, also very rare and endemic to El-Kala; B. macua, very rare in Zaccar and Bou Maâd, and *B. alpinum* under the cedars of the Tell Atlas (Algiers, Kabylia and Aurès). Other names are affiliated and accepted, these are *B. atlanticum* (syn. *B. alpium*) and *B. macuca*. Dobignard et al. [36] in (African Plant DB) confirm the maintenance of these taxa. with the addition of others such as *B. carvi*, *B. pachypodium* also existing in Algeria.

The database ‘‘The plant list’’ cites *B. mauritanicum* as being a synonym of *B. bulbocastanum* L. *Bunium* taxa are attached to the Apiaceae family with an umbelliferous inflorescence. This attachment to the Apiaceae

family must evoke the toxic nature even if, for the moment, the aspect of the toxic molecules is not well elucidated [8]. More recently, Dobignard et al. [36] retained B. fontanesii for Algeria, Morocco, Tunisia and Libya.

3.2.2. Geographic distribution

B. mauritanicum Batt. (Apiaceae, Apiales, Magnoliospida) occurs spontaniously in Europe: It can be found in North England [37], Italy and Sicilia [38], Spain [39], Balkan Peninsula, and in the Mediterranean region where it is very commun [40]. In North Africa, *B mauritanicum* grows natively in Morocco [37]. It can be found in Easthern Algeria especially in Oum Elbouaghi where it is very common [41]. In Tunisia, known as « telghoudi » [42,43], it is considered as a misery food [44]. *B. mauritanicum* grows on several habitats: in clearings and edges of Mediterranean scrublands and brushlands, on chalky, clayey-limestone and rocky soils [45]. It is fairly common on ruderal fields [2].

Fig.1. *Bunium fontanesii* tubers
([1] Fresh tuber: https://inpn.mnhn.fr/espece/cd_nom/86983/tab/fiche)
([2]Cut and dried tubers: Photo DAOUD N., 25.11.2021)

3.3. Ethnomedicinal uses

In general, *Bunium* species are herbal plants with healing properties, their essential oils and tubers are used in food and folk medicine all over the world [31,32]. In Algeria, the tubers of this plant are eaten as potato. Dried and powdered, it is considered astringent and antidiarrheal, anti-inflammatory especially for hemorrhoids, and a treatment for bronchitis and cough [12].

In Algeria, B. fontanesii is widely known under the vernacular name of Talghouda. Halimi [46] reports that the flour of this plant is used in medicinal preparations, which is a mildly toxic plant. The plant is known as a laxative, digestive, eliminate flatulence and diuretic. It is also used against angina, stomach aches, kidney stones and tumors. During difficult years, people make bread that is eaten with butter.

The bread of the plant can cause moderate hypnosis, and if it were eaten raw without a veil of fat, the tongue would swell, and the throat would be rough, and if the tumors which were in the legs were bandaged with it, at night they would dissolve. And it was very beneficial. The effects of eating Talghouda are sleepy and numb, and drinking milk fixes them.

In the Mascara region, Benarba et al. [47] states that the plant is used to treat Respiratory tract diseases. Nevertheless, Miara et al [7] report that Talghouda (B. bulbocastanum) is used against flatulence and intestinal worms. Indeed, this phenomenon of one vernacular name attributed to several species of close plants is very common in North Africa, particularly in Algeria, where a single vernacular name such as "Zaater" is given for a sevral species of *Thymus* [48].

Ethnobotanical investigations of *B. mauritanicum* have proposed their potential applications in many disorders, the most advanced use in Algeria is that of the treatment of hypothyroidism by the oral route [9]. The harvested tubers must be dried and then reduced

to flour by means of a mill, the consumption of this flour either in the form of galette, or fresh. However, Djahafi et al. [13] mentionnes that B. *incrassatum* have not been previously reported as medicinal plants in the North Africa and Algeria.

As a therapeutic property the plant has an emollient property. This character marks that Talghouda not only as a food but also as a source of this care. Elsewhere, the seeds constitute a substitute for cumin and also give an oil evoked in traditional treatments.

This plant is also used or the treatment of bronchitis and cough. In the native system of medicine, the dried and powdered tubers are considered antidiarrheal and astringent and have been found useful against inflammatory hemorrhoids. They used talghouda flour in medicinal preparations and they are a small poisonous plant. It eliminates bloating and diuresis treats constipation and swelling (Seeds). Dugast [49] analyzed a sample taken from the heights of Arbâa (Blida) and presented the composition in the following %: Water: 15.66; Ashes: 5.50; Nitrogenous matter: 7.00; Fatty matter: 1.34; Starch and congeners: 63.12; Cellulose: 6.40; Undosed materials: 0.98. He drew the conclusion of the resemblance to barley.

By comparing it to the potato, Talghouda seems less rich in starch but better for the rate of fat and nitrogenous matter. He concludes that Talghouda is food. The tuber being the organ harvested in the mountains or in the fields. It can only be eaten when dried and pounded into flour. The dough is then cooked as a mash or in a thicker form to make patties.

By analogy, the tuber is often presented by amateurs as being or resembling Jerusalem artichoke by the shape of its tuber and its turnip taste. On the other hand, Talghouda flour, and after cooking, recalls the taste of barley but probably more refined by its relatively higher level of amino acids. Consumption is specified around the months of February-March, once the supplies are exhausted and the harvest is not yet ready for beans, peas and Mermez (Barley) [8].

4. Phytochemistry

The chemical compounds of the Talghouda have not been studied enough, there was a vew data for phytochemical characterization of Talghouda extracts and oils like Bousetla et al. [14] on B. *incrassatum* fruits essential oil from Algeria and Bousetla et al. [12] on *B. incrassatum* cholоromethane methanol roots extract from Algeria, Hayet et al. [15] on *B. incrassatum* aerial parts essential oils from Algeria, Karouche et al. [16] on *B. mauritanicum* tubers methanol and aqueous extract and Khadidja et al. [17] on *B. incrassatum* acetone and hexane extracts from Algeria.

But several studies were on essential oil composition and extract *from some Bunium* like: Appendino et al. [18] on *B. hissaricum* petroleum ether extract from Central Asia, Khalid et al. [23] on *B. cylindricum* seed oil Hexane extract from Pakistan, B. persicum from Iran by Rakhimov et al. [19], Azizi et al. [22] and Jalilzadeh-Amin et al. [25] and Sanei-Dehkordi et al. [27] on essential oil and methanolic extract, Hayet et al. [15] on *B. alpinum* aerial parts essential oils from Algeria, Talebi et al [28] on *B. persicum* fruits Essential oil, Sharafati Chaleshtori et al. [30] on *B. brachyactis (Post) Wolff, B. pinnatifolium Kljuykov, B. sayai Yıld* and *B. microcarpum subsp. microcarpum (Boiss.) Freyn* aerial parts including flowers methanolic extracts from Turkey.

Zengin et al. [31] on methanolic extract, Majidi et al. [29] on *B. persicum* (Boiss.) and *B. Fedtsch* essential oil and methanolic extract, Souilah et al. [34] on *B. crassifolium methanolic extract from Algeria.*

Table 1. *Ethnomedicinal use of Talghouda and most important species of the Bunium genus*

Species	*Used part*	*Mode of preparation*	*Traditional use*	***References***
B. incrassatum Talghouda *Algeria*	Amo/roots		In local Algerian cookery	**[12]**
	Amo/tubers		Astringent against cough, bronchitis, diarrhea and hemorrhoids	
Talghouda ***B. mauritanicum Batt.*** *Algeria*	*Bulbes*		*Cough*	**[50]**
B. incrassatum ***Talghouda*** *Algeria*	tubers		Galactagogues to improve breast milk production in the farm animals. Against inflammatory hemorrhoids, bronchitis and cough.	**[51]**
Talghouda ***B. mauritanicum*** *Algeria*	*Whole plant*	*Trituration*	*Flu*	**[52]**
Talghouda *Algeria* ***B. mauritanicum L.***	*Seeds*	*Decoction Raw*	*Early-stage cancer*	**[53]**
		Maceration Oral SMSD: bones pain	*Stomach ache*	
		Raw Topical	*Anxiety disorders and hypochondria*	
Talghouda ***B. incrassatum (Boiss.) Batt. &Trab.,*** ***Pig Nut*** *Algeria*	*Tuber*	*Powder*	*Stomach ache*	**[54]**
Talghouda ***B. incrassatum Amo*** *Algeria*	*Tubers*	*Infusion, powder Oral*	*Allergy, asthma, cough, cysts, tonsillitis, thyroid disorders.*	**[13]**
B. persicum (Boiss). B. *Central Asia*	Fedtsch/fruits		To season dishes before the preparation of meat-based foods	**[55]**
B. persicum (Boiss). *Iran*	Fedtsch/ whole plant		Gastrointestinal disorders involving indigestion, stomach ache, diarrhea and headache, urinary and respiratory tract infections and colic, diuretic, flatulent, antidiabetic, antiepileptic, antiseptic, anti-parasitic, antispasmodic, anticonvulsant and antiasthma remedy, regulate liver function and body weight, increase the milk of lactating mothers	**[56,57,58]**
			Relieve terrible pains after delivery	**[59]**
			A parasite repellent	**[57]**
			Against insomnia, Parkinson, nausea, constipation, convulsion, inflammatory bowel, the blood lipids and cholesterol	**[60]**
B. bulbocastanum Morocco			Treatment of musculoskeletal and gynecological malfunctions	**[61]**
B. persicum (Boiss). *Iran*	Fedtsch/seeds		Stimulant, toxic, address stomach and intestine problems with expectorant, carminative, emmenagogue and galactogogue properties, toothache, jaundice, epilepsy, diarrhea and dyspepsia, appetizer	**[56]**
			as a spice, condiment and additive to foods and beverages	**[62]**
B. persicum (Boiss). B. *Iran*	Fedtsch/fruits		Treat flatulence, dyspepsia, indigestion, colic and dysmenorrhea; anticonvulsant, diuretic, analgesic, anthelmintic and anti-asthma agent	**[63,64]**

Essential oils

The extraction of essential oils of the genus *Bunium* leads to a wide range of compounds belonging to different classes such as terpenoids and non-terpenoids (Table 1 and Fig.1). The study conducted by Hayet et al. [15] on essential oils composition of Talghouda (*B. incrassatum*), revelated that the main component was palmitic acid. Baser et al. [20] found that p-mentha-1,3-dien-7-al, γ-terpinene, β– pinene, cuminaldehyde and p-mentha-1,4-dien-7-al they the major components of this cumin- smelling B. persicum fruits. Jassbi et al. [32] in another study identified germacrene D and β-caryophyllene as main components for B. elegans oil.

The oil of B. caroides contained α-pinene and (Z)-β-ocimene as major constituents. Previously, Shahsavari et al. [21] found caryophyllene, γ-terpineneand cuminyl acetate as major components for B. persicum essential oil.

The study of Hayet et al. (2017) [15] on essential oils composition of B. alpinum, revelated that caryophyllene oxide was the main component for B. alpinum oil.

Some other species of *Bunium* (*B. pinnatifolium, B. brachyactis, B. sayaii, B. microcarpum, B. crassifolium* and *B. persicu*m) have been analyzed with LC-MS/MS and showed the presence of phenolic compounds like: Quinic acid, Pantothenic acid, Syringic acid, Naringenin-6.8-di-C-glucoside, Apigenin-C-hexoside-C-pentoside isomer1, Apigenin-C-hexoside-C-pentoside isomer 2, Luteolin-O-glucuronide, Apigenin-O-glucuronide, Rutin and Kaempferol [31].

In a recent work, Öztürk et al. [33] found, caryophyllene oxide, myristicin, caryophyllenol II and hexadecanoic acid as major components of essential oil for B. elegans (Fenzl) Freyn var. aerial parts collected from Turkey.

Although β-pinene, P-cymene, γ- terpinene and α-pinene, limonene, Z-β-ocimene and E-caryophyllene were the dominant monoterpenes observed predominantly in the fruits oil of B. paucifolium, B. persicum, B. wolffii and B. paucifolium grown in Iran [65].

Phenolic compounds

Regarding Talghouda, few studies were performed and revelated that: The roots of Talghouda (*B. incrassatum*) from Algeria showed the presence of the oleic acid, β-sitosterol, scopoletin, scoparone and sucrose and β-Sitosterol [12]. The study of Ben Sonia & Zouina [66] on four extracts of methanol, aqueous, acetone and hexane for *B. incrassatum* roots showed that the highest amount of polyphenols in acetone extract and the hexane and acetone extracts showed the highest levels of flavonoids and also of tannins.

The results of Hayet et al. [15] study showed a highly Total phenolic compounds for Talghouda (*B. incrassatum*) aerial parts methanolic extracts. The acetone extract of Talghouda (B. incrassatum) from M'sila (Algeria) was rich in polyphenols, while the hexane fractions contained the highest amounts of flavonoids, tannins were more frequent in the acetone fraction [17].

Other hands, Talghouda (*B. mauritanicum*) have been studied by the team of Karouche et al. [16] to showed only the chemical screening such as the presence of sterols, triterpenes, saponins, tannins, alkaloids and aglycone flavones. to date, some *Bunium* species have been studied.

Only, we found six species of *Bunium* have been studied with LC-MS/MS and showed the presence of total number of phenolic compounds between 71 and 3 components (Table 1).

We found several classes of natural compounds such as [18] sesquiter- penes [67]. These species are: *B. pinnatifolium, B. brachyactis, B. sayaii, B. microcarpum, B. crassifolium* and *B. persicum*. And the main of components are: Quinic acid, Pantothenic acid, Syringic acid, Naringenin-6.8-di-C-glucoside, Apigenin-C hexoside-C-pentoside isomer1, Apigenin-C-hexoside-C-pentoside isomer 2, Luteolin-O-glucuronide Apigenin-O-glucuronide, Rutin and Kaempferol (**Table 1** and **Fig**.**2**).

Table 2. *Phytochemistry of Talghouda (B. fontanesii and related synonyms: B. incrassatum, B. mauritanicum, B. bulbocastanum) and somes species of Bunium*

Species & country	Used part	*Chemical composition / Main compounds*	*Extract / Method*	*References*
Talghouda ***B. incrassatum*** *Algeria*		*oil from fruit: caryophyllene oxide, (Z)--farnesene, -caryophyllene, and germacrene B as the principal constituents.* *oil from fruit-bearing branches: caryophyllene oxide, nonacosane, germacrene B, -caryophyllene, (Z)- -farnesene, caryophyllenol II, and spathulenol as the principal constituents.* *Thickened branches: nonacosane, spathulenol, eudesm-4,7-dien-1-ol, caryophyllenol II, (Z)--farnesene, germacrene B, and -caryophyllene as the principal constituents.*	fruits essential oil	**[14]**
Talghouda ***B. incrassatum*** *Algeria*	*Roots*	*Oleic acid, β-sitosterol, scopoletin, scoparone, sucrose and β-Sitosterol*	*Choloromethane- methanol / Mass Spectroscopy (MS) and Nuclear Magnetic Resonance Spectroscopy (NMR)*	**[12]**
Talghouda ***B. incrassatum*** *Algeria*	Aerial parts	The main component was palmitic acid	Essential oils GC/MS	**[15]**
Talghouda **B. mauritanicum** *Algeria*	tubers	presence of sterols, triterpenes, saponins, tannins, alkaloids and aglycone flavones.	methanol and aqueous extract	**[16]**
Talghouda (B. incrassatum) *Algeria*		Contain the highest amounts of flavonoids, tannins	Acetone and hexane	**[17]**
B. brachyactis (Post) ***Wolff*** *Turkey*	*Aerial parts including flowers)*	*Quinic acid, chlorogenic acid,pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin*	*Methanol extracts / HPLC-MS/MS analysis*	**[30]**
B. pinnatifolium ***Kljuykov*** *Turkey*	*Aerial parts/ flowers*	*Quinic acid, chlorogenic acid,pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin*	*Methanol extracts HPLC-MS/MS analysis*	**[30]**
B. sayai Yld *Turkey*	*Aerial parts/ flowers*	*Quinic acid, chlorogenic acid,pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin*	*Methanol extracts HPLC-MS/MS analysis*	**[30]**
B.microcarpum subsp. microcarpum (Boiss.) ***Freyn*** *Turkey*	*Aerial parts/ flowers*	*Quinic acid, chlorogenic acid,pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin*	*Methanol extracts HPLC-MS/MS analysis*	**[30]**
B. pinnatifolium *Turkey*	*Aerial parts*	*Quinic acid,chlorogenic acid, pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin, B, vicenin-2, Naringenin, kaempferol, Afzelin,*	*Methanol extract / HPLC-MS/MS*	**[31]**
B. brachyactis *Turkey*	*Aerial parts*	*Quinic acid,chlorogenic acid, pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin. Vitexin, cosmosiin, diosmin, luteolin, angelicin, salcolin B, vicenin-2, Naringenin, orientin,*	*Methanol extract / HPLC coupled (HPLC-MS/MS)*	**[31]**

B. sayaii *Turkey*	*Aerial parts*	*Quinic acid,chlorogenic acid, pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin, Vitexin, cosmosiin, diosmin, luteolin, angelicin, salcolin B, vicenin-2, Naringenin, kaempferol, Afzelin,*	*Methanol extract / HPLC-MS/MS*	**[31]**
B. microcarpum *Turkey*	*Aerial parts*	*Quinic acid,chlorogenic acid, pantothenic acid, esculin, isoquercitrin, rutin, apigenin, scopoletin, Vitexin, cosmosiin, diosmin, luteolin, angelicin, salcolin B, vicenin-2, B, vicenin-2, Naringenin, Naringenin, kaempferol, orientin*	*Methanol extract / HPLC-MS/MS*	**[31]**
B. persicum ***B. Fedtsch*** *Iran*	*Seed (EO) Fruit (FA, CH and PC*	***Essential oil (EO):*** *γ-terpinene (0.8-46.1%), cuminaldehyde (5.96-40.66%), α-terpinene-7-al (0.4-37.2%), caryophyllene (0.08-27.81%), γ-terpinene-7-al (8.3-26.91%), ρ-cymene (2.8-19.15%), limonene (0.5-15.7%), β-pinene (0.2-15.62%).* ***Carbohydrates (CH):*** *monosaccharides and oligosaccharides (glucose, fructose, mannitol, sucrose, and raffinose), water-soluble polysaccharides, pectin substances, and hemicellulose.* ***Fatty acids (FA):*** *linoleic acid, octadecanoic acid, palmitic acid, petroselinic acid and 8, 11, 14-eicosatrienoic acid.* ***Phenolic compounds (PC):*** *Caffeic acid, ρ-coumaric acid and kaempferol*	*Methanol extract/ HPLC-MS CH/ PC/ Essential oil /GC and GC/MS*	**[19,25,27,29]**
B.persicum *Iran*	*fruit*	*The main constituents were g-terpinene, cuminaldehyde, g-terpinen-7-al*	*Essential oil GC and GC/MS*	**[22]**
B. persicum *Iran*	*fruits*	*The major compounds: γ-terpinene, cuminic alcohol, cumin aldehyde, p-cymene, safranal and limonene*	*Essential oil GC-FID and GC/MS*	**[28]**
B. crassifolium *Algeria*	*Aerial parts*	*Chlorogenic, gallic, ferulic acids were the most abundant phenolic acids detected, rhoifolin, quercitrin and rutin were the most abundant flavonoids, fumaric acids, quinic and malic as a non-phenolic organic acid*	*Methanol extract (70% and 100%) / HPLC-MS/MS*	**[34]**
B. hissaricum *Central Asia*	*Seed oil*	*Capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid, petroselinic acid, octadec-7enoic acid, octadec-8-enoic acid.*	*Petroleum ether / Gas-Liquid Chromatography (GLC)*	**[18]**
B. cylindricum *Pakistan*	*Seed oil*	*Capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, petroselinic acid, oleic acid, linoleic acid, linolenic acid*	*Hexane / Soxhlet Extraction and Gas-Liquid Chromatography (GLC)*	**[23]**
B. incrassatum		*Oleic acid, β-sitosterol, scopoletin, scoparone, sucrose*		
B. alpinum *Algeria*	Aerial parts	The main component caryophyllene oxide	Essential oils GC/MS	**[15]**
B. cylindricum ***B. paucifolium*** ***B. persicum*** ***B. wolffii*** *Iran*	*Fruit (EO)*	The main component of *oil: myristicin, β-pinene, α-pinene, apiole, β-selinene, E-caryophyllene, α-selinene, γ-terpinene, γ-terpinene-7-al, cumin aldehyde, myristicin, β-pinene, Z-β-ocimene*	Essential oils *GC/MS-GC-FID*	**[65]**
B. persicum *(Boiss Iran)*	*Aerial parts*	*Essential Oil: The major components were caryophyllene (27.81%), γ-terpinene (15.19%), cuminyl acetate (14.67%).*	Essential oils/ *Hydro-distillation/ Gas Chromatography coupled with FID*	**[21]**
B. persicum *(Boiss*	*Seed Oil*	*Essential Oil (EO): The major components were cuminaldehyde (21.23%),*	*Hydro-distillation and GC/MS*	**[68]**

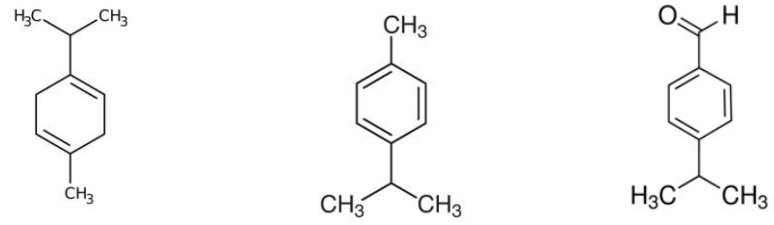
India)		*sabinene (14.66%), and γ-terpinen (12.49%). C-Sources // Chemical compounds: D-Arabinose, L-Arabinose, Dextrin, D-Fructose, L-Fucose, D-Galactose, D-Galacturonic acid, α-D-Glucose, Glucuronamide, D-Glucuronic acid, 2-Keto-D-Gluconic acid, DMannose, Palatinose, D-Psicose, L-Rhamnose, D-Ribose, D- Tagatose, D-Xylose, c-Hydroxy-butyric acid, L-Alanine, L-AlanylGlycine, L-Asparagine, L-Ornithine*	*equipped with FID*	
B. persicum (Boiss.) *India*	*Seed Oil*	*Essential Oil (EO): carvone, Cumin aldehyde, γ-terpinene, α-terpinen-7-al, γ-terpinen-7-al, p-cymene, Limonene, α-pinene, β-pinene, Anisole, Apiole, Carvacrol, Caryophyllene, Cuminic alcohol, Germacrene D, Trans-dihydrocarvone, α-methylebenzenemethanol,*	-	**[69]**
B. persicum *Iran*	*Seed Oil*	*Essential Oil (EO): The main constituents were γ-terpinene (24.02%), cuminaldehyde (20.1%), paracymene (13.09%), benzenemethanol alpha-propyl (13.01%), cyclopentane, 2-methyl-1-methylene-3-(1-methylethenyl) (3.57%).*	*Hydro-distillation and GC/MS equipped with FID*	**[70]**
B.kuhitangi ***B. microcarpum*** *Iran*	*Aerial parts*	*Essential Oil (EO): Main components from B. kuhitangi were 9-epi-(E)-caryophyllene (35.38%), α- copaene (8.38%) and δ- selinene (7.35%). * Main components for B. microcarpum. were 9-epi-(E)- caryophyllene (73.61%), γ- cuprenene (8.37%) and α-cadinene (5.75%).*	*Hydro-distillation and GC/MS*	**[71]**
B. Persicum *(Boiss) Iran*	*Seed*	*Essential Oil: Tricyclene, α-thujene, sabinene, β-pinene, myrcene, p-cymene, Limonene, γ-Terpinene, linalool, terpioneole, cuminaldehyde, α-terpinene-7-al, γ -terpinene-7-al,*	*Hydro-distillation (HD), ultrasound-assisted extraction (UAE with nhexane) and Soxhlet extraction (SOX with n-hexane) and GC/MS equipped with FID*	**[72]**
B. persicum ***B. Fedtsch****. Iran*	*Seed*	*Major essential oil γ-terpinene, cuminaldehyde*	*Methanol with percolation method and Hydro-distillation*	**[73]**
B. persicum (Boiss.) Fedtch *Iran*	*Seed*	*Essential Oil: the γ-Terpinene (46.1%) and cuminaldehyde (15.5%)*	*Petroleum ether, chloroform, methanol and water with percolation method, to the essential oil isolated using water-distillation method/ GC/MS-FID*	**[74]**
B. persicum ***B. Fedtsh*** *Iran*	*Fruits*	*Essential Oil: 1,4-p-menthadien-7-al, p-menyha-1,3-dien-7-al, cuminal, trans-isocarveol, γ-terpinene, limonene, p-cymene, β-pinene, sabinene, α-pinene*	*Ethanol, Hydro-distillation, GC/MS*	**[63]**
B. persicum Boiss. *Iran*	*Seed*	*Volatile compounds: α-Thujene, α-Pinene, Sabinene, β –Pinene, Myrcene, p-Cymene, Limonene, γ –Terpinene, Terpinen-4-al, Cumin aldehyde, α-Terpinen-7-al, γ -Terpinen-7-al*	*Superheated water extraction (SWE), Hydrodistillations, Soxhlet extractions and GC/MS and GC-FID*	**[75]**
B. persicum Boiss *Iran*	*Seed*	**γ-terpinene(37.98%), cuminaldehyde (11.48%) and α-methyl-benzenemethanol (25.55%).* ρ-cymene in the hydrodistilled essential oil, also γ-terpinene and cuminaldehyde*	*Supercritical fluid extraction (SFE), Hydrodistillations and GC/MS*	**[76]**

Fatty acids

The main compounds of fatty acids are capric acid, lauric acid, myristic acid, palmitic acid and stearic acid (**Table 1 and Fig.3**) were found in the seed oil of B. hissaricum Korovin and B. cylindricum (Boiss. & Hohen.) Drude by GLC (Appendino et al., [18] and Khalid et al. [23].

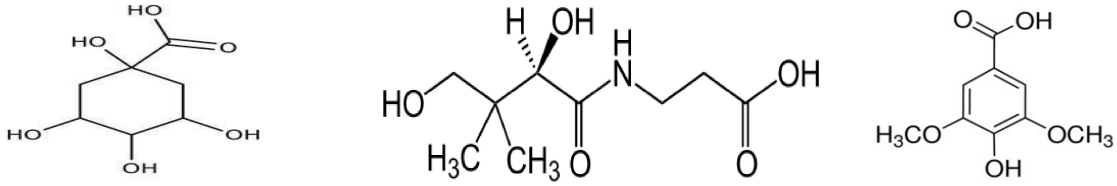
Carbohydrates

The main compounds of carbohydrates are monosaccharides and oligosaccharides (glucose, fructose, mannitol, sucrose, and raffinose) (**Table 1 and Fig.4**), water-soluble polysaccharides, pectin substances, and hemicellulose were found in B. persicum seed oil [19,29].

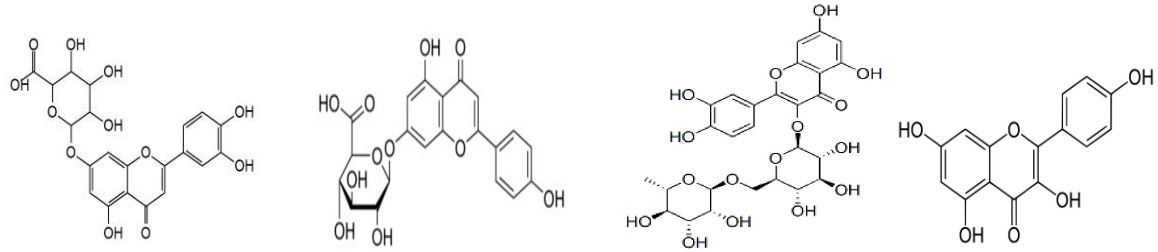


γ-terpinene *p-cymene* *cumin-aldehyde*

Fig.1. Chemical structure of the main compounds of essential oil of some *Bunium* species *studied*

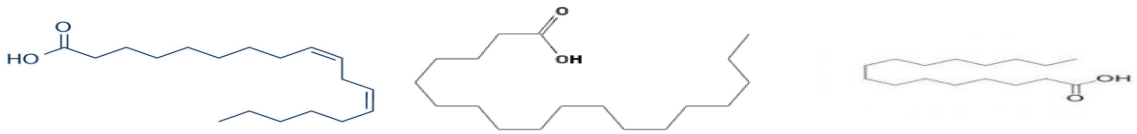


Quinic acid *Pantothenic acid* *Syringic acid*



Luteolin-O-glucuronide *Apigenin-O-glucuronide* *Rutin* *Kaempferol*

Fig.2. *Chemical structures of the main phenolic compounds of some Bunium* species studied



Linoleic acid *Octadecanoic acid* *Palmitic acid*

Petroselinic acid *8,11,14-eicosatrienoic acid*

Fig.3. *Chemical structures of the fatty acids of B. persicum*

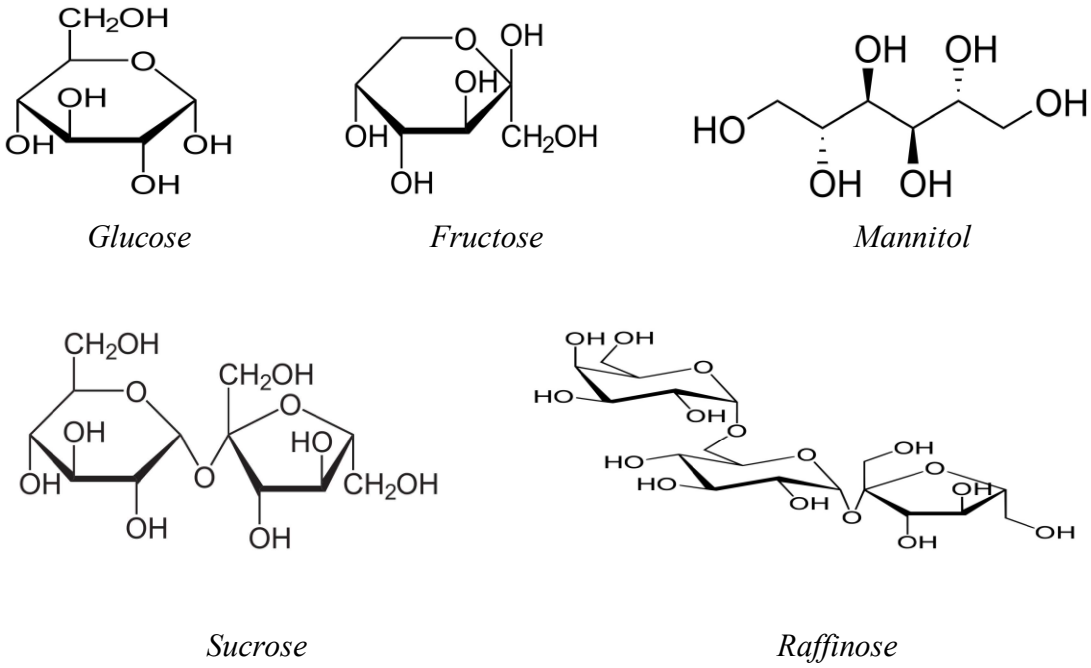


Fig.4. *Chemical structures of mono and oligosaccharides of B. persicum*

3.6. Biological activity

The extracts derived from Talghouda and other species of *Bunium* species are known to possess remarkable biological activities, which are discussed in the following subsections. Not all the biological properties have been studied and not all the *Bunium* species have been tested so far.

3.6.1. The antioxidant activity

The total capacity of antioxidants to scavenge the free radicals, via their hydroxyl substituents and their hydrogen donating ability may be defined as the antioxidant activity. This mechanism facilitates antioxidants to protect DNA or cell walls against the oxidative stress [77]. Therefore, it is associated with many other biological activities including antimutagenicity, anticarcinogenic and antiaging [65].

The antioxidant activity is mostly contributed to the secondary metabolites of the plants, as part of their defense mechanism. The antioxidant activity was depicted in Talghouda (Table 3). The research by Karouche et al. [16] revealed that the methanolic extract of B. mauritanicum tubers had a higher amount of total phenolics 4.031 mg QE/g of extract, although the water extract was had a higher antioxidant activity (IC50 of 0.14 mg/ml against the DPPH radical) than the methanolic extract.

Moreover, results of Hazarika and Das [78] suggests that all fractions of B. bulbocastanum extract (aqueous, crude methanolic, ethyl acetate, n-hexane and chloroform) had antioxidation potential with an encouraging finding of percent antioxidation inhibition.

Otherwise, Ahmad et al. [79] indicated that Ethyl acetate, aqueous, crude methanolic, n-hexane fraction of B. bulbocastanum fruits have an antioxidation potential. However, methanolic extracts of B. incrassatum and B. alpinum from Algeria exhibited a highest antioxidant activity, essential oil which gave the lowest values [15].

The same finding by Lefahal et al. [80] who evaluated the antioxidant activity of ethyl acetate and n-Butanol extracts and four flavonoids that had been isolated from the aerial parts of B. alpinum.

The n-Butanol fraction showed the best antioxidant activity. In contrast, the isolates demonstrated varying degrees of antioxidant activity. B. incrassatum from M'sila (Algeria) was also studied by Khadidja et al. [17] to evaluate the antioxidant abilities of the water, methanol, acetone and hexane fractions, the best scavenging activity was obtained by hexane followed by acetone and methanol fractions, acetone fractions showed the best iron reducing activity.

In other investigation, ethanol and ethyl acetate extracts of B. bulbocastanum were evaluated in term of total phenolic and flavonoid content of the seeds, highest TPC was observed

in B. bulbocastanum ethyl acetate extract while the lowest was observed in ethanol extract.

The seed essential oils of B. persicum Boiss from Iran were also revealed to have the antioxidant properties, with their relatively lower antioxidant activity (IC50 of 0.88 mg/mL against the DPPH radical) [21]. Among the 4 different methanolic extracts of B. species (B. brachyactis (Post) Wolff; B. pinnatifolium Kljuykov; B. sayai Yıld and B. microcarpum subsp. microcarpum (Boiss.) Freyn) from Turkey, the highest antioxidant activity was detected for *B. pinnatifolium and B. microcarpum* by most of the six assays used in scope of the study [31].

According to the research group, the relatively higher antioxidant activity results from these two species are mainly due to their higher total phenolic and flavonoid contents, as the highest amount of total phenolics was observed in the species B. pinnatifolium (35.94 mg GAE g−1) and the highest total flavonoids *were detected in B. microcarpum* and *B. pinnatifolium*, respectively (39.21 mg RE g-1 and (38.33 mg RE g−1) **[31].**

Although the differences among the total phenolic and total tannin contents of different parts (corm, leaf, stem and fruit) were not significant ($p>0.05$) for the 4 different *Bunium* species of Iran, the researchers revealed that the total phenolic content of the leaves and stems of *B. paucifolium* (6.10 and 6.03 mg GAE/g DW, respectively) and leaves of B. wolffii (6.07 mg GAE/g DW) were significantly higher than the others other 2 species *B. Cylindricum* (Boiss. & Hohen.) Drude and *B. persicum* (Boiss.) [65].

According to the same study, The IC50 values of the different parts of these 4 species against the DPPH radical changed from 27.15 to 71.31 mg/mL. The highest antioxidant activity results were measured in the methanolic extracts (leaves, fruits and stems) of species *B. persicum* (27.15, 27.33 and 27.76 mg/mL, respectively) [65].

These results may be considered as encouraging for the potential of unidentified species of the *Bunium* species, too. The antioxidant activity of the essential oil from certain *Bunium* species *(B. persicum Boiss*.) has also been determined.

According to the findings, the essential oil had a promising antioxidant activity (IC50 value of 15.12 µL/mL against the DPPH radical). Furthermore, nanoencapsulated *B. persicum Boiss*. essential oil (in a chitosan-cinnamic acid based nanoemulsion system) has a slightly lower IC50 value against the DPPH radical activity (12.64 µL/mL) in comparison to its free counterpart [68].

3.6.2. The antimicrobial activity

Talghouda tubers are endowed with antibacterial properties (Table 4), they can act against Gram+ Staphylococcus aureus and Gram- Pseudomonas aeroginus [16].

Table 3. *Antioxidant activity of Talghouda (B. fontanesii and related synonyms: B. incrassatum, B. mauritanicum, B. bulbocastanum) and species of Bunium*

Species	Part used	Extract	Methods	Keys results	Ref.
Talghouda ***B. bulbocastanum***	Fruits	Ethyl acetate, aqueous, crude methanolic, n-hexane fraction	*Antioxidation potential (Nitric Oxide (NO) free radical scavenging assay)	Ethyl acetate, aqueous, crude methanolic, n-hexane fraction has an antioxidation potential	**[79]**
Talghouda ***B. Bulbocastanum*** Kashmir/India	Fruits	Ethyl acetate, Aqueous, Crude methanolic, n-Hexane and Chloroform fractions	Nitric Oxide Method	* Ethyl acetate fraction had a potent antioxidation (30.34%) at 0.5 mg/ml * Aqueous fraction showed significant antioxidation potential of 26.07%. *The rest of the three fractions had a lower antioxidation activity.	**[78]**
Talghouda ***B. incrassatum*** Algeria	Aerial parts	*Methanolic extracts *Essential oils	Antioxidant activity DPPH technique	Methanolic extracts gave highest antioxidant activity compared to the Methanolic extracts	**[15]**
Talghouda ***B. mauritanicum*** Algeria	tubers	Methanolic extract	*Total phenolics content * Antioxidant activity (DPPH)	*4.031 mg QE/g of extract * IC50 of 0.14 mg/ml	**[16]**
Talghouda ***B. incrassatum*** Algeria		Methanol, acetone and hexane extracts	Antioxidant abilities	*The best activity by hexane extract followed by acetone and methanol extracts, *Acetone fractions showed the best iron reducing activity.	**[17]**
B. persicum **Boiss** Iran	Seed	Essential oils	Antioxidant properties DPPH	lower antioxidant activity IC50 of 0.88 mg/mL	**[21]**
B. alpinum Algeria	Aerial parts	methanolic extracts Essential oils	antioxidant activity DPPH technique	Methanolic extracts gave highest antioxidant activity compared to the Methanolic extracts	**[15]**
B. alpinum	Aerial parts	* Ethyl acetate and n-Butanol extracts *flavonoids that had been isolated	*Antioxidant activity	*n-Butanol extract showed the best antioxidant activity against ethyl acetate	**[80]**
B. brachyactis ***B.pinnatifolium B. sayai*** ***B.microcarpum*** **subsp. microcarpum** Turkey	Aerial parts	Methanolic extracts	* Total phenolic contents *Antioxidant properties DPPH, ABTS, CUPRAC, and FRAP assays	*Highest antioxidant activity for B. pinnatifolium and *B. microcarpum* *Higher total phenolic contents in B. pinnatifolium (35.94 mg GAE g−1) *Highest total flavonoids in B. microcarpum and B. pinnatifolium, respectively (39.21 mg RE g-1 and (38.33 mg RE g−1)	**[31]**
Bunium species ***B.persicum*** ***B. persicum***		Essential oil	*Antioxidant activity DPPH	* Essential oil had a promising antioxidant activity (IC50 value of 15.12 µL/mL * Lower IC50 value against the DPPH radical activity (12.64 µL/mL)	**[68]**
B. paucifolium ***B. wolffii*** ***B. cylindricum B. persicum*** Iran	Corm, Leaf, Stem and Fruit	Methanolic extracts	*Total phenolic and total tannin contents * Antioxidant activity DPPH radical	*Total phenolic content of leaves and stems of *B. paucifolium* (6.10 and 6.03 mg GAE/g DW, respectively) * Leaves of *B. wolffii* (6.07 mg GAE/g DW) higher than the others 2 species *B. Cylindricum* and *B. persicum* * IC50 values of 4 species changed from 27.15 to 71.31 mg/mL.	**[65]**
B. crassifolium *Algeria*		Methanol and methanol water (70:30) extracts.	*Antioxidant activities: DPPH, ABTS, β-carotene, CUPRAC, Fe+2 assays	*The methanol:water extract showed the high value of antioxidant activities.	**[34]**

These antimicrobial properties are due to the presence of couramins in its chemical content [12]. Plants have used against the infections for ages. However, the current emergence of infectious diseases and the rise of microbial resistance, revalue them as antimicrobial agents.

According to the findings from the study by Zengin et al. [31], the antimicrobial activity was evident and found as variable among the different *Bunium* species of B. brachyactis (Post) Wolff; B. pinnatifolium Kljuykov; B. sayai Yıld and B. microcarpum subsp. microcarpum (Boiss.) Freyn) from Turkey [31].

The certain bioactive components found in the *Bunium* species, was previously found to possess antimicrobial activity against *P. aeruginosa*, *S. Typhimurium,* and *P. mirabilis* and/or antioxidant activity [81,82].

Therefore, their findings revealed that although these species depicted a wide range of antimicrobial activity against different bacteria in the scope of the study, they were efficient against P. mirabilis and E. coli, mainly [31]. The results for antibacterial study of Khan et al. [83] aimed at screening the B. bulbocastanum for its antibacterial and antifungal, activities.

The methanolic extract and n-hexane fraction showed significant activity against Staphylococcus aureus while, the cloroforme fraction was moderately active against S. aureus. A moderate activity was shown by the ethyl acetate fraction against B. subtilis. This fraction was inactive against P.aerogenosa and S.aureus. The aqueous extract showed significant activity against B. subtilis, and moderate activity against S. aureus and E. coli and low activity against P.aerogenosa. regarding the antifungal assay, the same stydy indicated that all the test extracts were inactive against all the test fungi.

The study of Bousetla et al. [12] reveals that the crude extract (Cholоromethane-methanol: 1/1) from B. incrassatum exhibited stronger activity against fungi than bacteria strains. EOs of B. incrassatum and B. alpinum showed wide array of antibacterial activity against bacteria [15].

Particularly the essential oil from some *Bunium*, such as B. persicum depicted also antibacterial activity against E. Coli [84] and antifungal activity against different species of *Fusarium oxysporum* [70], although the difficulties in its food applications have also been mentioned referring to its high volatility, strong odor, hydrophobic nature, and unknown mode of action.

Therefore, these researchers hypothesized that, the antifungal efficacy of B. persicum essential oil might be increased by encapsulating in a chitosan-cinnamic acid based nanoemulsion system [68]. Fungal contamination is a major food safety issue. It is mainly related with the improper post-harvest storage.

Other activities

From the investigation of Hazarika and Das [78] using MTT assay, we are able to conclude that aqueous and ethyl acetate extract of *B. bulbocastanum* fruit has a noteworthy anticancer activity.

Another study of the enzyme inhibitory test of aerial parts methanol extracts of B. sayai, B. pinnatifolium, B. brachyactis and B. macrocarpum, showed a high activity against cholinesterase, tyrosinase, amylase, glucosidase and lipase [31].

The findings of Ahmad et al. [79] for the antiglycation *in vitro* assay of the ethyl acetate, aqueous, crude methanolic and n-hexane fraction of B. bulbocastanum fruits showed that, among the tested samples, chloroform fraction was the most effective antiglycation agent with MIC50 of 132.88 µg/ml followed, and the percent inhibition of glycation is concentration dependent.

The finding of khan et al. [83] for phytotoxic activity of B. bulbocastanum showed that all the test samples were unable to agglutinate red blood cells of the human blood indicating that this species lack phytolectins. Also, Hammoudi et al. [51], in its study, evaluated the effect of the treatment of pregnant rabbits of B. incrassatum by roots organic extract, on hematological and histological parameters of the adrenal gland during the last third of pregnancy, results suggests that B. incrassatum had a hypoglycemic effect and is safe for use up to 100 mg/kg/day for both nutritional and medicinal purposes which open new perspectives for this plant in the bioactive materials technology.

In a recent study on B. incrassatum and B. alpinum from Algeria, methanolic extracts were used in studying in vitro anti-inflammatory activity using egg albumin technique and in vitro anti-hemolytic activity using HBRC technique [15] findings exhibited a significant antihemolytic and anti-inflammatory activity [41].

Table 4. *Antimicrobial activity of Talghouda (B. fontanesii and related synonyms: B. incrassatum, B. mauritanicum, B. bulbocastanum) and some species of Bunium*

Species	Part used	Extract	tested/ compound	Tested strains	Keys results	References
Talghouda ***B. bulbocastanum***		Methanolic extract and n-Hexane fraction	Antibacterial activities	**Staphylococcus aureus* ; *B. subtilis* ; *P. aerogenosa* ; *E. coli* *Fungi.*	* CHCl3 not active against S. aureus * Low activity against B. subtilis (ethyl acetate fraction) * Moderate activity against Aeruginosa and S. aureus (ethyl acetate fraction) * Aqueous extract showed significant activity against B. subtilis, moderate against S. aureus and E. coli and low activity against P. aerogenosa. * All the test samples were inactive against all fungi.	**[83]**
Talghouda ***B. incrassatum***		Cholorommethanol	Antimicrobial activities		*Stronger activity against fungi than bacteria strains	**[12]**
Talghouda ***B. incrassatum*** ***B. alpinum***			Antibacterial activities		Essential oil showed wide array of antibacterial activity against Gram-positive and Gram-negative bacteria.	**[15]**
B. persicum		Essential oil	Antifungal activities	*Fusarium oxysporum*	Antifungal activity against six different species of *Fusarium oxysporum*	**[70]**
B. brachyactis ***B. pinnatifolium*** ***B. sayai*** ***B. microcarpum*** ***Turkey***	Aerial parts	Methanol extracts	Antibacterial activity Antifungal, activities.	*Proteus mirabilis* *E. coli* Aspergillus *versicolor* *Trichoderma viride* *Aspergillus fumigatus*	**P. mirabilis* active against *E. coli* (MIC and MBC <1 mg mL−1). **B. brachyactis* effective against A. *versicolor* * *B. brachyactis* effective against *Trichoderma viride*. **B. sayai* effective in inhibiting *A. fumigatus*.	**[31]**
B. persicum		Essential oil	Antibacterial activities	*E. Coli*	Antibacterial activity against *E.Coli*	**[84]**

Table 5. *Other activities of Talghouda (B. fontanesii and related synonyms: B. incrassatum, B. mauritanicum, B. bulbocastanum) and somes species of Bunium*

Species	**Part used**	**Extract**	Methods	**Keys results**	**References**
Talghouda *B.bulbocastanum*	Fruit	Ethyl acetate and aqueous fraction	Anticancer activity using MTT assay	Ethyl acetate and aqueous fraction has a noteworthy activity on human cell lines	**[78]**
Talghouda *B.bulbocastanum*		methanolic extract	Phytotoxic activity		**[83]**
Talghouda B. incrassatum B. alpinum Algeria		Methanolic extracts	In vitro anti-inflammatory activity In vitro anti-hemolytic activity using HBRC technique	significant antihemolytic and anti-inflammatory activity	**[15]**
Talghouda *B. incrassatum*			Estrogenic effects	*Decrease in the level of Triglyceride cholesterol *Significant increase in growing of follicles accompanied by decrease in atretic follicles	**[41]**
Talghouda *B. incrassatum*	roots		Hypoglycemic effect/ egg albumin technique	Hypoglycemic effect	**[51]**
Talghouda *B. bulbocastanum*	Fruits	Ethyl acetate, aqueous,methanolic, n-hexane	Antiglycation in vitro assay	*Chloroform fraction most effective antiglycation agent with MIC50 of 132.88 µg/ml	**[79]**
***B. sayai*, *B.pinnatifolium*, *B. brachyactis* *B. macrocarpum*,**	Aerial parts	Methanol extracts	Enzyme inhibitory test	*High enzyme inhibition against cholinesterase, Tyrosinase, amylase, glucosidase, and lipase	**[31]**
B. crassifolium Algeria		Methanol and methanol water (70:30) extracts.	-Anticholinestrase -Antityrosinase	*The methanol extract showed a good acetylcholinesterase inhibitory, and butyrylcholinesterase inhibitory activity, demonstrated that the both extracts showed a weak activity. -The methanol extract showed a good tyrosinase inhibitory activity more than the methanol:water	**[34]**

In aim to evaluate the effect of the treatment of mature female rabbits by organic extract of *B. incrassatum* roots, cited that the treatment induces a significant decrease in the level of Triglyceride, Cholesterol and a significant increase in the number of growing follicles accompanied by a decrease in atretic follicles, compared to the control group. The study shows that the organic extract of B. Incrassatum has estrogenic effects (Table 5).

Conclusion and future perspectives

This survey reported a review of Talghouda concerning their ethno-medicinal use, geographic distribution, taxonomy and biological activities. Talghouda is a species complex of the Apiaceae family.

Its starchy tuber is harvested to extract a food flour reminiscent of old eating habits in rural. This tuber is still used in treatments by herbalists. Its interest in the treatment of thyroid dysfunction is also mentioned.

An analysis of biodiversity is needed to shed light on the differences observed between taxa to specify those due to genetics and those due to the effects of the environment. The phytochemical analysis showed the richness of this plant, especially terpenoids in the essential oils which were dominated by caryophyllene oxide and -caryophyllene, (Z)--farnesene, germacrene B, spathulenol, nonacosane, alkaloids and fatty acids and carbohydrates as monosaccharides and oligosaccharides.

However, there is a lack of data on flavonoids and phenolic acids in seeds, roots, and fruits. Thus, investigation of these chemical classes in these parts should be explored using different analytical tools such as HPLC, GC-MS, and LC-MS. Furthermore, pharmacological effects of Talghouda extracts and essential oils possessed many biological effects, including antioxidant, antifungal, antibacterial, anti-inflammatory, anticancer, enzyme inhibition, antiglycation, phytotoxic activity, hypoglycemic effect, estrogenic effects activities.

However, elaborating the antidiabetic, toxicological and other studies is necessary to prove these compounds' effects on human health.

Moreover, no literature informations are available on the toxicological of Talghouda. Therefore, to determine the safety of this plant, further toxicological studies are necessary.

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Disclosure Statement

The authors report no conflict of interest.

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