Pharmacological Activities of *Ballota nigra* (L.) Benth: A Mini Review

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**Abstract**—The *Ballota* L. genera belonging to the Lamiaceae family found mainly in the Mediterranean area, Middle East, and North Africa. This genus has been largely explored from the ancient times for their biological properties. The phytochemical investigations revealed that diterpenoids are the main constituents of the genera. A large number of flavonoids and other metabolites were also identified. This mini review, covers the traditional and pharmacological properties of *Ballota nigra* L. species.

**Index Terms**—*Ballota*, medicinal use, pharmacology, traditional use

I. **INTRODUCTION**

From the ancient time several plants have been explored for their medicinal purposes. More recently, plant extracts have been developed and proposed for various biological process. In developing countries herbal medicine has been improved as a substitute solution to health problems and costs of pharmaceutical products. The development of drug resistance pathogens against antibiotics has required a search for new antimicrobial substances from other sources, including plants. Plants contain a wide range of substances that are used to treat chronic as well as infectious diseases [1].

The genus *Ballota* L. (Lamiaceae) consists of about 33 species growing mainly in the Mediterranean region. In Turkey, the genus *Ballota* is represented by 11 species, 6 subspecies, 10 of which are endemic [2]. *B. nigra* was described by Carl Von Linnaeus in 1753 [3] and the epithet “*nigra*” is derived from Latin word ’*nigra*’ which refers to means ‘blackish’ [4]. *B. nigra* contains a characteristic phyto-constituent, namely, betaines. Traditionally it has been used to cure various diseases especially neuro-sedative [5]. Dioscoreides, the Greek physician recommended its leaves plaster with salt in dog bites treatment. A balm prepared from its dried leaves and honey purified infected wounds and ulcer [6].

II. **DISTRIBUTION**

The native range of this plant is Macaronesia, Europe, Mediterranean to West Asia and introduced into Alabama, Argentina, Kirgizstan and New Zealand [7].

III. **BOTANICAL DESCRIPTION**

Perennial herb, with hairy stems to c. 1 m tall. Petioles 1–3 cm long. Lamina of upper cauline lvs 2.5–5 × 2–3 cm, ovate or ovate-oblong, densely hairy on both sides, strongly crenate; base subcordate; apex acute. Verticels dense; bracts cuneate, serrate or crenate-serrate. Bracteoles <calyx, ± filiform. Calyx 6–9 mm long, with nerves densely hairy; teeth ovate, acuminate. Corolla 12–15 mm long, pinkish to purple or white, almost glabrous outside; middle lobe ovate and slightly reflexed. Filaments hairy at base. Nutlets not seen [8].

IV. **TRADITIONAL USES**

*B. nigra* leaves were used as an antidote for rabid dog bites. In Balkanic area it was used as a sedative/tranquilizer in cases of hysteria and hypochondria [9]–[12]. It is also used for wound-healing properties in Italy [13], [14]. It used to treat various disease like whooping cough, to increase bile flow, sedative, nervousness, vomiting, upset stomach and nausea [12], [15]. In Moldova it is used against worm infestation in the form of enemas and suppositories [9] and as insecticide and repellent against fleas in northern Spain [16]. Various ethnopharmacological uses of *B. nigra* in different countries are provided in Table I.

V. **PHARMACOLOGICAL EFFECTS**

A. **Antioxidant Effect**

Matkowski and coworkers studied the antioxidant activity of *B. nigra* aerial parts by using DPPH and HO scavenging and phosphomolybdenum reduction methods. The ethyl acetate and n-butanol fraction of *B. nigra* showed maximum inhibition of deoxyribose degradation (79.32 ± 1.62% and 82.04 ± 2.28%, respectively). They concluded that plant antioxidant activity is not only influenced by secondary metabolites such as carotenoids,
vitamins, volatile oils and diterpenes but also by phenolics (including flavonoids). Plant polyphenols possess an ideal structural chemistry for free radical scavenging activity which makes them important dietary antioxidants [19]. In Turkish folk medicine various Ballota species have been used to treat hemorrhoids, gastrointestinal disorders, wounds and burns, as diuretics and to prevent coughs. Citoğlu et al., investigated the antioxidant properties of 16 Ballota species on lipid peroxidation and superoxide anion formation. The B. nigra subsp. anatolica extract showed significant anti-superoxide anion formation [20]. In the south Italian pharmacopoeia B. niger aerial parts are drunk to promote circulation and used as a rinse for skin rashes. Various phytochemical studies [21]-[24] have been executed on B. niger, and numerous phenylpropanoid glycosides have been recognized and related to moderate growth inhibition in Staphylococcus aureus [25]. B. niger contains diterpenes (marubiin), furolic acid derivatives and caffeic [26]. Quave and coworkers observed that aqueous extraction of the aerial parts of B. niger was the most effective at inhibiting both biofilm growth and adherence [27]. B. nigra has many neurosedative properties. Caffeoyl malic acid, verbascoside, ballotetraside, forsythiside, arenaroside are its active substances possess scavenging properties against hydroxyl radicals, hypochlorite, hydrogen peroxide and superoxide generated in cell-free systems and released from stimulated neutrophils. Their inhibitory concentrations were equivalent to mesna and N-acetyl cysteine [28]. Based on the information of traditional use and potent antioxidant activities, Rigano and coworkers studied the inhibitory effect of B. undulata (Sieber ex Fresen.) Benth, B. saxatilis (Sieber ex C.Presl) and B. nigra ssp. foetida (Vis.) Hayek on human breast cancer MCF-7 and human hepatoma HepG2 cell lines. They concluded the effectiveness in vitro of the B. undulata, B. saxatilis, B. nigra ssp. foetida EOs by inhibiting the human hepatoma HepG2 cell proliferation in a dose dependent way [29]. Makowczynskas et al. [30], studied the antioxidant properties, total phenolic and flavonoid contents of B. nigra extracts in methanolic extracts initiated in vitro (from nodal explants) and in vivo (from seeds). They observed that antioxidant potential of the B. nigra extracts may be due to their scavenging of free radicals (DPPH assay) and metal reducing (FRAP test). The shoot extracts of in vitro derived exhibit the greatest antioxidant properties (EC50 - 56 μg/mL), characterized by the highest content of phenolic compounds. The cardiac tissues can absorb polyphenolic substances, which are responsible for radical scavenging and reducing activities [31].

### TABLE I. ETHNOPHARMACOLOGICAL USES OF B. NIGRA L.

| Country                  | Uses                                      |
|--------------------------|-------------------------------------------|
| Mt., Macedonia           | digestive [15].                           |
| Moldova                  | sedative, antispasmodic stimulant, vermintuge [9]. |
| Northeast Bosnia-Herzegovina | nervous system disorders, sedation [10]. |
| Lucca, Italy             | wounds and sprains [13].                  |
| Mediterranean Area       | skin disorders, sore throat in horses [17].|
| Albanians, North Basilicata, Italy | diuretic, hemostatic [14], [18]. |
| Bosnia-Herzegovina       | hysteria [11].                            |
| Jadovnik Mt., Serbia     | remedy for upset stomach, nausea, and vomiting; symptomatic, treatment of nervous disorders, sleep disorders, coughs, inflammation, gout [12]. |
| North Spain              | insecticides and repellents against fleas [16]. |

### B. Hypoglycemic Effect

Nusier et al., studied hypoglycemic effect of B. nigra extract and observed significant reduction in glucose level in both healthy and diabetic Albino rats. The decrease in glucose level (32% and 22.3% in normoglycemic and alloxeinated rats, respectively) was time-dependent and was observed 6 hours after administration of the B. nigra extract [32].

### C. Neurosedative Effect

B. nigra contains various phenylpropanoid derivatives which showed remarkable neurosedative and antioxidative activities which are of curative interest [21], [33]. Phenylpropanoid glycosides might act as a neuroleptic drug increases sleeping time, reduce locomotor activity and produce a slowing of the electroencephalographic activity [34]. Some studied discover the antidepressant activities of B. nigra var. anatolica [35] and neurosedative activities of B. nigra [28]. Daels-Rakotoarison et al., [28] studied the antioxidant properties of phenylpropanoid derivatives such as verbascoside, forsythiside B, arenaroside, ballotetraside, and caffeoyl malic acid isolated from B. nigra using cell-free experiments and cellular experiments including isolated polymorphonuclear neutrophils (Inhibitory concentrations at 50% were 0.4 - 4.7 mg/mL).

### D. Antitumor Activity

In Italy the essential oils of B. undulate, B. saxatilis, and B. nigra was examined for their in vitro cytotoxicity toward the Hep-G2 hepatocarcinoma and MCF-7 breast carcinoma cell lines (IC50: 54.7, 65.4, and 69.9 μg/mL, respectively) [29].

### E. Anti-Cancer Activity

B. nigra contains 7α-Acetoxyroyleanone (73) [36] which showed promising anticancer activities against MIAPaCa-2 and melanoma (MVI-3) cancer cell lines (IC50 = 4.7 and 7.4 μg/mL) [38] and cytotoxic activities against breast (MCF-7), human leukemia (CEM and HL-60), murine skin (B16), and colon cancer (HCT-8) cell lines (IC50 = 0.9–7.6 μg/mL). It seemed that its cytotoxic activity may be related to inhibition of DNA synthesis [38].

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F. Hepatoprotective Effects

The crude n-Hex extract of B. niger subsp. kurdica was examined for tyrosinase inhibitory activity by the colorimetric tyrosinase inhibition assay (IC50 = 3.67 μg/mL); however, no individual active molecules were isolated [39].

G. Antifungal and Antimicrobial Activity

The antifungal activity Aspergillus niger, A. flavus, A. fumigatus, and F. solani and antimicrobial activity against Escherichia coli, Staphylococcus aureus, Proteus mirabilis, Klebsiella pneumoniae, Enterococcus faecalis, and Salmonella typhi of root, stem, and leaves extract of B. niger were examined in Pakistan by using Agar tube dilution method and well assay method. The crude extract, ethyl acetate, and chloroform fractions were the most active fractions against all pathogens [40].

Fraternelle and Ricci collected aerial parts of B. niger ssp foetida at flowering and fruiting times to evaluate their antifungal activity against Fusarium oxysporum, F. solani, F. coeruleum, F. sporotrichioides, F. tabacinum, F. verticillioides, Botrytis cinerea, and Alternaria solani using the agar dilution method. The major compounds identified in the flowering and fruiting aerial parts oils respectively were β-caryophyllene (22.6% and 21.8%), caryophyllene oxide (18.0% and 20.5%) and germacrene-D (16.5 and 13.1%). The oils showed in vitro antifungal activity against some species of Fusarium (300-350 ppm), B. cinerea (600 ppm), and A. solani (750 ppm) [41].

| Table II. Various Phytochemicals Isolated from B. nigri L. |
|-----------------|-----------------|
| **Names**       | **Compounds**   |
| Labdane diterpenes | 7α-acetoxyarrunubin [43]. |
|                  | Ballongrin [43]. |
|                  | 13-hydroxyballongrinolide [44, 45]. |
| Diterpenes       | 7α-acetoxyoleanone [36]. |
| Flavones         | Ladanein [36]. |
|                  | Luteolin [46]. |
|                  | Chrysoeriol [46]. |
|                  | tangeretin [47]. |
| Acyl flavonoid glycosides | luteolin-7-O-[2-O-β-D-glucopyranosyl]-lactate [21]. |
| Triterpenoids     | Urosoic acid [48]. |
| Steroids         | β-stigmasterol [36, 49]. |
| Carboxylic acids | Caffeic acid [33, 46]. |
|                  | Fumaric acid [33]. |
|                  | Laballenic acid [51]. |
| Nitrogen-containing compounds | Quinic acid [33]. |
|                  | Shikimic acid [33]. |
| Penylpropanoids   | 4-hydroxyprolinebetaine [51]. |
|                  | Stachydrine [51]. |
|                  | Allysinoside [25, 33]. |
|                  | Angoroside A [25]. |
|                  | Arenaroside [25, 45, 53]. |
|                  | Balleotetroside [23, 25, 33, 45]. |
|                  | Forsythoside B [25, 33, 36, 45, 50, 55]. |
|                  | Lavandulifolioside [25]. |
| Other metabolites | Martynoside [36]. |
| Glycosides        | Phytol [49]. |
| Essential oils    | Caryophyllene oxide (7.9), epi-α-murolol (6.6), 6-cadinene (6.5), α-cadinol (6.3), γ-amorphene (4.3), β-bourbonene (4.1), 6,10,14-trimethyl-2-pentadecanone (4.0), (E)-caryophyllene (4.0), germacrene D (3.8), aromadendrene (3.4), γ-muurolene (3.2), germacrene D-4-ol (3.2), α-bisabolol (3.2), α-amorphene (3.0) [54]. |
|                  | β-caryophyllene (35.4), germacrene D (27.4), α-humulene (7.4), δ-cadinene (3.8), (E)-phytol (2.5) [55]. |
|                  | β-caryophyllene (39.1), germacrene D (35.7), α-humulene (10.4), (E)-phytol (3.8) [55]. |
|                  | p-vinylguaiacol (9.2), borneol (7.5), myrtenol (7.1), trans-pinocarveol (5.2), 1-octen-3-ol (5.1), pinocarvone (4.4), 2-methyl-3-phenylpropanal (4.3), p-cymen-8-ol (4.3), trans-carveol (3.5) [55]. |
|                  | β-pinene (39.0), α-pinene (34.5), sabinen (7.7), α-phellandrene (4.1) [56]. |
|                  | Palmitic acid (573)°, 2,6,6-trimethyl-4-methylene-2H-pyran (172)°, hexahydrofarnesylacetone (167)°, myristic acid (100)°, caryophyllene oxide (57)°, pentadecanoic acid (50)°, palmitoleic acid (40)°, germacrene D (40)° amg/kg [57]. |
|                  | Palmitic acid (1620)°, dodecane (519)°, palmitoleic acid (306)°, myristic acid (271)°, pentadecanoic acid (185)°, lauric acid (67)°, trans-isoelaidin (67), hexahydrofarnesylacetone (60)°, pentadecene (54)°, methylungelogen (40)° amg/kg [57]. |
|                  | Palmitic acid (656)°, palmitoleic acid (197)°, myristic acid (187)°, pentadecanoic acid (121)°, farnesylacetone (69)°a, dihydroactinidiolide (44)°a amg/kg [57]. |
|                  | Methylsalicylate (313)°, palmitic acid (130)°, 2,2,6-trimethyl-4-methylene-2H-pyran (42)°, myristic acid (42)° amg/kg [57]. |
**H. Insecticide**

The whole plant of *B. nigra* L. is used in repellent fumigation against insects and its diterpenes compounds are well known for its insecticidal and antifeedant activities [42].

**VI. PHYTOCHEMICAL CONTENTS**

The phytochemical research of *B. nigra* and its subspecies led the isolation and identification of several groups of phytochemical constituents. We have briefly summarized various phytochemicals of *B. acutabilosa* in Table II and Table III.

| TABLE III. VARIOUS PHYTOCHEMICALS ISOLATED FROM VARIOUS SUBSPEICES OF *B. NIGRA* |
|---------------------------------|---------------------------------|
| Names                           | Compounds                      |
| Nitrogen-containing compounds   |                                |
|                                |                                |
| Other metabolites               |                                |
| Labdane diterpenes              |                                |
| Essential Oils                  |                                |
| Germacrene D (18.1), noradolin epoxideacetate (15.4), sceroleoacetate (12.1), linaly acetate (11.5), β-caryophyllene (10.5), spathulenol (9.0), linalool (5.2), longipinene epoxide (4.7) [70]. | Germacrene D (18.1), noradolin epoxideacetate (15.4), sceroleoacetate (12.1), linaly acetate (11.5), β-caryophyllene (10.5), spathulenol (9.0), linalool (5.2), longipinene epoxide (4.7) [70]. | Germacrene D (18.1), noradolin epoxideacetate (15.4), sceroleoacetate (12.1), linaly acetate (11.5), β-caryophyllene (10.5), spathulenol (9.0), linalool (5.2), longipinene epoxide (4.7) [70]. |
| Hexadecanoic acid (40.9), β-bisabolene (13.4), hexahydrofarnesyl acetone (7.9), 1-isobutyl-4-isopropyl-2,2-diethyl succinate (6.6), β-eudesanol (3.5) [1]. | Hexadecanoic acid (40.9), β-bisabolene (13.4), hexahydrofarnesyl acetone (7.9), 1-isobutyl-4-isopropyl-2,2-diethyl succinate (6.6), β-eudesanol (3.5) [1]. |
| 1-Hexacosanol (26.7), caryophyllene oxide (9.3), germacrene-D (9.3), α-selinene (8.7), Z-8-octadecen-1-ol acetate (7.1), 2,5-di-tert-octyl-p-benzoquinone (7.3), arachidic acid (6.0), tercascene (4.5), heneicosane (4.4), heptacosane (4.3), 2-methyl-1-hexadecanol (3.3), octadecane (3.0), butyl phthalate (3.0) [71]. | 1-Hexacosanol (26.7), caryophyllene oxide (9.3), germacrene-D (9.3), α-selinene (8.7), Z-8-octadecen-1-ol acetate (7.1), 2,5-di-tert-octyl-p-benzoquinone (7.3), arachidic acid (6.0), tercascene (4.5), heneicosane (4.4), heptacosane (4.3), 2-methyl-1-hexadecanol (3.3), octadecane (3.0), butyl phthalate (3.0) [71]. |
| Other metabolites               |                                |
| Essential Oils                  |                                |
| Germacrene D (23.1), β-caryophyllene (20.3), caryophyllene oxide (6.2), caryophylladene I (3.3), (E)-2-hexenal (3.3), hexadecanoic acid (3.1), α-humulene (3.0) [29]. | Germacrene D (23.1), β-caryophyllene (20.3), caryophyllene oxide (6.2), caryophylladene I (3.3), (E)-2-hexenal (3.3), hexadecanoic acid (3.1), α-humulene (3.0) [29]. |
| B. nigra subsp. uncinita (Fiori & Beg.) Patzak | Germacrene D (23.1), β-caryophyllene (20.3), caryophyllene oxide (6.2), caryophylladene I (3.3), (E)-2-hexenal (3.3), hexadecanoic acid (3.1), α-humulene (3.0) [29]. |

**VII. CONCLUSION**

In this mini review we have briefly summarized the traditional uses, ethnobotanical description, ethnopharmacological properties and phytochemical constituents that have been isolated from *B. nigra* and their subspecies. Further research should be conducted to explore new potential therapeutic agents and their ethnopharmacological properties of *B. nigra* for the treatment of life-threatening diseases.

**CONFLICT OF INTEREST**

The authors declare no conflict of interest.

**AUTHOR CONTRIBUTIONS**

Sanjay Kumar and Reshma Kumari conducted the research, analyzed the data, wrote the paper and approved the final version.

**REFERENCES**

[1] B. S. Yılmaz, “Antilisterial activity of Ballota species growing in Turkey,” *Ankara Üniversitesi Eczacılık Fakültesi Dergisi*, vol. 34, no. 6, pp. 159-164, 2005.
[2] P. H. Davis, *Flora of Turkey and the East Aegean Islands*, Edinburgh: Edinburgh University Press, 1982.
[3] C. Limne, *Species Plantarum*, Laurentius Salvius, 1753, p. 582.
[4] A. B. Martin, *The Vocabulary of Orchids: An Amateur Perspective*, 2005.
[5] A. E. Al-Snafi, “The pharmacological importance of Ballota nigra—A review,” *Indian Journal of Pharmaceutical Science & Research*, vol. 5, no. 4, pp. 249-256, 2015.
[6] A. Chevalier, *Encyclopedia of Herbal Medicine: 550 Herbs and Remedies for Common Ailments*, Penguin, 2016.
[7] D. Rigano, et al., “GC and GC-MS analysis of volatile compounds from Ballota nigra subsp. uncinita collected in Aeolian Islands, Sicily (Southern Italy),” *Natural Product Communications*, vol. 15, no. 4, pp. 1-7, 2020.
[8] C. J. Webb, W. R. Sykes, and P. J. Garmock-Flora, *Flora of New Zealand: DSIR Botany Div.*, 1988.
[9] N. Ciarcarlino, “Family lamiaceae: Main important spontaneous medicinal and aromatic species in the Republic of Moldova,” *J. Bot.*, vol. 8, pp. 86-91, 2016.
V. Vrchovská, et al., “Antioxidative properties and phytochemical composition of Ballota nigra infusion.” Food Chem., vol. 105, pp. 1396-1403, 2007.

S. Peretti, et al., “Pharmacological effects of phenylpropanoid glycosides from Orobanche hederae,” Phytotherapy Research, vol. 6, no. 2, pp. 89-93, 1992.

K. Vural, et al., “Anxiolytic and antidepressant activities of some Ballota species,” Eczacilik Fakultesi Dergisi-Gazi Universitesi, vol. 13, pp. 29-32, 1996.

E. Töth, et al., “Martynoside, forsythoside B, ladanein and 7-acetoxy-royeleanone from Ballota nigra L.” Planta Medica, vol. 73, pp. 2007.

M. Franzon, et al., “In vitro cytotoxic activity of abietane diterpenes from Peltodon longipes as well as Salvia mitiorrhiza and Salvia sahendica.” Bioorg. Med. Chem., vol. 19, pp. 4876-4881, 2011.

E. C. D. C. Araújo, et al., “Cytotoxic abietane diterpenes from Hypiptis martiusi Benth.” Z. Naturforsch. C. Biosci., vol. 61, pp. 177-183, 2006.

F. Hashemi and M. A. Zarei, “Tyrosinase inhibitory activity within hexane extract of ten screened plants from Kurdistan Province of Iran,” Int. J. Adv. Biol. Biomed. Res., vol. 2, pp. 2795-2799, 2014.

N. Ullah, I. Ahmad, and S. Ayaz, “In vitro antimicrobial and antiprotozoal activities, phytochemical screening and heavy metals toxicity of different parts of Ballota nigra.” Biomed. Res. Int., pp. 1-9, 2014.

D. Fraternalle and D. Ricci, “Essential oil composition and antifungal activity of aeral parts of Ballota nigra sps foetida collected at flowering and fruiting times,” Natural Product Communications, vol. 9, no. 7, pp. 1015-1018, 2014.

P. D. Sanzo, et al., “Medicinal and useful plants in the tradition of Rotonda, Pollino National Park, Southern Italy.” Journal of Ethnobiology and Ethnomedicine, vol. 9, no. 1, pp. 19, 2013.

G. Savona, et al., “Structures of three new diterpenoids from Ballota species.” Journal of the Chemical Society, Perkin Transactions, vol. 1, no. 3, pp. 322-324, 1977.

V. Seidel, F. Bailleul, and F. Tillequin, “Isolation from Ballota nigra L. of 13-hydroxyballotinolin, a diterpene useful for the standardization of the drug.” Journal de pharmacie de Belgique, vol. 51, no. 2, pp. 72-73, 1996.

V. Seidel, F. Bailleul, and F. Tillequin, “Diterpenes et esters heterosidiques phenylpropanoiques de Ballota nigra L.” Annales Pharmaceutiques Francaises, vol. 56, no. 1, pp. 31-35, 1998.

I. M. Zhukov and V. V. Belikov, “Chromatospectrophotometric determination of flavonoids and dihydroxyacids in the above-ground part of Ballota nigra L.” Farmatsevtichni Zhurnal (Kiev), vol. 5, pp. 55-58, 1989.

W. Kissel and F. Piozzi, “Tangeretin from Ballota nigra.” Polish J. Chem., vol. 69, pp. 476-477, 1995.

G. Janicsak, et al., “Study of the oleanolic and ursolic acid contents of some species of the Lamiaceae.” Biochem. System Ecol., vol. 34, pp. 392-396, 2006.

D. P. Popa and G. S. Pasechnik, “Higher terpenoids of some species of Labiatae.” Chem. Nat. Compd., vol. 10, pp. 529-530, 1974.

E. Töth, et al., “Determination of phenylpropanoids in three Ballota species.” J. Planar Chromatogr.--Modern TLC, vol. 22, pp. 293-296, 2009.

G. Blunden, et al., “Betaine distribution in the Labiatae.” Biochem. System Ecol., vol. 24, pp. 71-81, 1996.

G. Janicsák, E. Tóth, and I. Mathé, “TLC-densimetric investigations of phenylpropanoid glycosides in black horehound (Ballota nigra L.).” J. Planar Chromatogr.--Modern TLC, vol. 20, pp. 443-446, 2007.

V. Seidel, F. Bailleul, and F. Tillequin, “Phenylpropanoid glycosides from Ballota nigra.” Planta Med., vol. 62, no. 2, pp. 186-187, 1996.

K. Morteza-Semnani, M. Saeedi, and M. Akbarzadeh. “The essential oil composition of Ballota nigra,” Chem. Nat. Compd., vol. 43, pp. 722-723, 2007.

N. Vukovic, et al., “Antimicrobial activity of the essential oil obtained from roots and chemical composition of the volatile constituents from the roots, stems, and leaves of Ballota nigra from Serbia.” J. Med. Food, vol. 12, no. 2, pp. 435-41, 2009.
M. Jamzad, et al., “Essential oil composition of Salvia indica L., Thymus caucasicus Wind. Ex Ronnier subsp. grossheimii (Ronnier) Jalal. and Ballota nigra L. three Labiatae species from Iran,” J. Ess. Oil Bearing Plants, vol. 14, pp. 76-83, 2011.

Y. S. Kolisnyk, A. M. Kovaleva, and O. V. Goryachka, “The study of the volatile oils composition obtained from vegetative and generative organs of Ballota nigra L.,” Visnik Farmatii, vol. 78, pp. 59-62, 2014.

J. Balansard, “Pharmacological study of Ballota foetida,” C. R. Seances Soc. Biol., vol. 113, pp. 1295-1297, 1934.

L. Psaltis, “The lactone of some Labiatae,” J. Pharm. Chim., vol. 1, pp. 248-255, 1911.

B. Yilmaz and G. Çitoğlu, “High performance liquid chromatographic analysis of some diterpenoids of the Ballota species,” Chemistry of Natural Compounds, vol. 28, pp. 13-17, 2003.

G. Çitoğlu, et al., “Chromatography of Ballota species,” Chemistry of Natural Compounds, vol. 41, no. 3, pp. 299-302, 2005.

G. Savona, et al., “New diterpenoids from species of genus Ballota,” Chim. Ind., vol. 58, p. 378, 1976.

G. Savona, et al., “The structure of ballotenol, a new diterpenoid from Ballota nigra,” J. Chem. Soc. Perkin I, pp. 497-499, 1977.

G. Savona, et al., “Structure of ballotenone, a diterpenoid from Ballota nigra,” J. Chem. Soc. Perkin I, pp. 1607-1609, 1976.

J. Balansard, “The lactone of some Labiatae,” C. R. Seances Soc. Biol., vol. 117, pp. 1014-1015, 1934.

A. Bader, et al., “Composition of the essential oil of Ballota undulata, B. nigra ssp. foetida and B. saxatalis,” Flavour Fragr. J., vol. 18, no. 6, pp. 502-504, 2003.

D. Fraternali, et al., “Essential oil composition and antimicrobial activity of Ballota nigra L. ssp foetida,” Natural Product Communications, vol. 4, no. 4, p. 193, 2010.

A. S. Dordović, et al., “Chemical composition of Ballota macedonica Vandas and Ballota nigra L. ssp. foetida (Vis.) Hayek essential oils—The chemotaxonomic approach,” Chem. Biodivers., vol. 13, no. 6, pp. 782-788, 2016.

A. Kaya, et al., “Compositions of the essential oils of Ballota nigra subsp. uncinita and subsp. anatolica from Turkey,” vol. 51, pp. S185-S189, 2017.

Z. Kazemizadeh, et al., “Volatile constituents of Ballota nigra subsp. anatolica from Iran,” Chemistry of Natural Compounds, vol. 45, no. 5, p. 737, 2009.

A. Ertas, M. Boğa, and Y. Yeşil, “Phytochemical profile and ABTS cation radical scavenging, cupric reducing antioxidant capacity and anticholinesterase activities of endemic Ballota nigra L. subsp. anatolica P.H. Davis from Turkey,” J. Coast Life Med., vol. 2, pp. 555-559, 2014.

M. Majdi, D. Dastan, and H. Maroofi, “Chemical composition and antimicrobial activity of essential oils of Ballota nigra subsp. kurdica from Iran,” Jundishapur Journal of Natural Pharmaceutical Products, vol. 12, p. e36314, 2017.

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