

Nigella sativa. L: From Traditional Medicine to Modern Applications

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Abstract

Nigella sativa. L, also known as black cumin, is a medicinal plant native to Western Asia, belonging to the Ranunculaceae family [1]. Used for thousands of years throughout the world for its therapeutic and nutritional properties, it has played a special role in the traditional medicines of many civilisations, including ancient Egypt, Greece, India and the Arab world. Its black seeds, rich in bioactive compounds such as thymoquinone, have attracted growing interest for their beneficial effects on health.

This review explores the many pharmacological and nutritional properties of *Nigella sativa*, highlighting its biochemical composition, traditional uses and modern applications in various fields, such as medicine, pharmacy and nutrition. Recent studies have highlighted the antioxidant, anti-inflammatory, antimicrobial and anticancer effects of this plant, making it a promising subject for research into new therapeutic approaches.

Keywords: *Nigella sativa*; Thymoquinone; Phytochemistry; Bioactive Compounds; Traditional Medicine; Modern Applications; Pharmacological Properties.

Introduction

For thousands of years, medicinal plants have played a fundamental role in the prevention and treatment of human diseases [1]. Among these, *Nigella sativa*, commonly known as 'black cumin', occupies an important place in traditional systems of medicine, particularly in the Middle East, South Asia and North Africa [2]. Known as the 'blessed seed' (Habbatul Barakah) in Islamic medicine, this plant has been revered for its versatile curative properties, ranging from the relief of respiratory disorders to the management of chronic diseases [3-4]. Over time, this empirical knowledge

paved the way for in-depth scientific research aimed at elucidating *Nigella sativa* active compounds and assessing its therapeutic potential in a modern setting [5].

Pharmacological studies carried out on *Nigella sativa* have confirmed many of the medicinal properties traditionally attributed to this plant [6-7]. *In vitro* and *in vivo* research has demonstrated impressive therapeutic activities, such as antioxidant, anti-inflammatory, antihypertensive, anti-diabetic and anti-cancer effects. In addition, the antimicrobial activities of *Nigella sativa*, particularly against multi-resistant bacterial strains, and

its antiviral effects, confirm the importance of this plant in the fight against infections [8-11]. Its promising role in immune regulation also makes it a candidate for more in-depth studies into its application in inflammatory and autoimmune diseases [12].

The modern application of *Nigella sativa* is no longer limited to traditional use. Thanks to accumulated scientific data, this plant is now incorporated into pharmaceutical and nutraceutical formulations [13-15]. It is widely used in cosmetics for its antioxidant and regenerative effects, as well as in food supplements to improve digestive and immune health [16-17]. Recent clinical studies have also demonstrated its effectiveness in the management of chronic diseases such as hypertension, diabetes and hypercholesterolaemia, with a growing number of clinical trials aiming to validate its role as a complementary treatment [18-20].

From traditional medicine to modern applications, *Nigella sativa* is a perfect example of how an ancestral medicinal plant can evolve thanks to modern scientific research. Advances in the extraction, biochemical characterisation and pharmacological evaluation of this plant have validated its many benefits, paving the way for new therapeutic applications and its integration into contemporary medicine. However, despite this progress, many questions remain as to the precise mechanisms of action of its bioactive compounds, requiring more in-depth studies to exploit its full therapeutic potential.

Origin and description of the *N. sativa* plant

Geographical origin: *Nigella sativa* originated in western Asia. Its initial roots spread from Asia to Africa and America. It is widely cultivated in India and Iraq, as well as in various Mediterranean countries such as Syria, Turkey and the nations of North Africa [21].

1. Scientific classification of the plant:

Kingdom: Plantae (Plants)

Superdivision: Spermatophyte (seed plants)

Order: Ranunculales

Family: Ranunculaceae (family Renonculaceae)

Genus: *Nigella*

Species: *Nigella sativa*. L

2. Description

Nigella sativa is a fast-growing annual herbaceous

plant, generally reaching a height of 30 to 60 cm. It is distinguished by its strongly indented leaves, which form compact, upright branches. Its white, star-shaped flowers are particularly rich in nectar. This plant is hermaphroditic and capable of reproducing independently. It produces fruit in the form of capsules made up of 3 to 6 carpels fused at the base. Each capsule contains several seeds which, after flowering, are white in colour, turning black when ripe (Figure 1). These seeds, between 2 and 3 mm long, are triangular and angular in shape, giving off a distinctive aroma [22].

3. Common Names

For thousands of years, the *Nigella* plant (*Nigella sativa*. L) has been used in different parts of the world for its medicinal and culinary properties. Because of its popularity, it has been given many different names in different countries and cultures. In ancient Egypt, it was known as 'Ach-chinqat', while in India and Pakistan it was known as 'Kalonji' (hot energy) or 'Al-Kamoun Al-Indi' (Indian cumin). In Chinese medicine, it was called 'Hak Jung Chou', and in Greco-Roman medicine, 'Melathion' (black flower) or 'Gith' [23].

In Old Latin, *Nigella* was known as 'Panacea' (heals all) or 'mecon agria melana'. The Hebrews called it 'Kezah'. In the Bible, it appeared under various names, such as 'Healing black cumin', 'Nielle', 'Aneth', 'Vesce' or 'Ach-Chawnîz', depending on the edition. In Persia (modern-day Iran), the names were 'Ach-Chounîz' or 'Siyâh Dâneh'. In Turkey, it was called 'çörek otu', and in the Arabian Peninsula, it went by several names, including 'Al-Kamoun Al-Aswad' (black

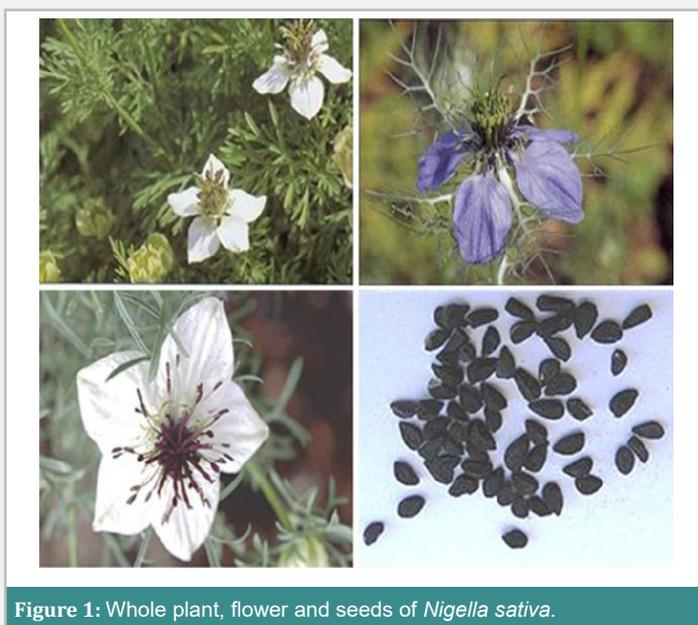


Figure 1: Whole plant, flower and seeds of *Nigella sativa*.

cumin), ‘Al-Habbat As-Sawdah’ (the black seed), “Al-Habbat Al-Moubâarakah” (the blessed seed), “As-Samîrah”, “Ach-Chounîz”, “Al-Qahtah”, “At-Tachmizaj”, “Al-Jamachak” and “Al-Bachamah”.

In Morocco, it was known as ‘As-Sinouj’ or ‘As-Sanouj’. The English used various names such as ‘Black seed’, ‘Black cumin’, ‘Black caraway’, ‘Common Fennel flower’, ‘Nutmeg flower’ or ‘Romain coriander’. In France, it was known as ‘Nigelle cultivée’, ‘Nigelle des jardins’, ‘Nigelle de Crète’, ‘Nielle’, ‘Nielle du Levant’, ‘Nielle romaine’, ‘Cumin noir’, ‘Faux cumin’, ‘Quatre-épice’, ‘Tout-épice’, ‘Sésame noir’, ‘Herbe aux épices’, ‘Poivrette’ and ‘Cheveux de Vénus’.

Its scientific name, *Nigella sativa*. L, comes from ‘Nigellus’, a diminutive of ‘Niger’ meaning black, in reference to the dark colour of its seeds. These seeds, renowned for their aroma and black colour, are used in traditional cooking and medicine in many cultures, thanks to their active compounds which are beneficial to health.

4. Biochemical composition of *Nigella sativa* seeds

The biochemical composition values of NS seeds according to literature data show a high content of total

lipids (36.8% DM), closely followed by proteins (25.09% DM) and carbohydrates (23.81% DM). These proportions indicate that black cumin seeds are an exceptional source of oil, protein and carbohydrates for human consumption Table 1. [24].

5. Nutritional components of *Nigella sativa*

In nutritional terms, *Nigella* is a real goldmine. It is packed with vitamins (A, B and E), carbohydrates, various minerals (such as iron and calcium), as well as omega 3, 6 and 9 fatty acids. Proteins, including essential amino acids, are also a major advantage of these seeds.

This classification makes it easier to understand the distinction between the pharmacological effects and nutritional benefits of black cumin. The chemical components are often linked to therapeutic effects, while the nutritional components contribute to overall dietary intake and health support Tables 2,3.

Conclusion

Nigella sativa, also known as black cumin, is a plant with remarkable pharmacological properties. Its use dates back more than two millennia in Eastern cultures, where it was initially used as a spice before becoming a remedy.

Table 1: Main categories and biochemical components of *Nigella sativa* extracts.

Category	Content (%)	Components	Quantity / Characteristics
Essential Oil	0.4 – 2.4	p-Cymene, α-Pinene, Limonene, Carvacrol, Thymoquinone	Varies by origin; Thymoquinone 1.65%, p-Cymene 43.58%, etc.
Fixed Oils	22 – 53.4	Contains unsaturated fatty acids, either monounsaturated (omega-9) or polyunsaturated (omega-3 and 6): Arachidonic acid, Linolenic acid, Eicosadienoic acid, Linoleic acid, Oleic acid, Palmitoleic acid, Palmitic acid, Stearic acid, and Myristic acid	Simple lipids account for about 97% of the total lipids in <i>Nigella sativa</i> oil. Complex lipids, represented by glycolipids and phospholipids, make up the remaining 3%.
Saponins		Melanthin, other saponosides	Main aglycone: Hederagenin
Alkaloids		Nigellicine, Nigellimine, Nigellimine N-oxide, Nigellidine, Nigellamine A1, A2, A3, A4, B1, B2, C	Present with different chemical structures
Phenolic Compounds		Gallic acid, Vanillic acid, p-Hydroxybenzoic acid, etc.	Includes flavonoids, flavanols, hydroxybenzoic acids, and hydroxycinnamic acids
Proteins	20 – 31.2	Alanine, Cystine, Aspartic acid, Glutamic acid, Phenylalanine, Glycine, Histidine, Isoleucine, Lysine, Leucine, Methionine, Proline, Arginine, Serine, Threonine, Valine, Tryptophan, and Tyrosine	Comprising about 20% of the seeds, <i>Nigella sativa</i> proteins provide essential amino acids for building and repairing tissues.
Flavonoids and Polyphenols		Quercetin, Kaempferol, etc.	Quercetin and Kaempferol in several glycosylated forms
Minerals	3.7 – 8	Calcium, Iron, Potassium, Sodium	Potassium (783 and 708 mg/kg), Magnesium (235 and 260 mg/kg), Phosphate (48.9 and 51.9 mg/kg), Sodium (20.8 and 18.5 mg/kg), Iron (8.65 and 9.42 mg/kg), Zinc (8.04 and 7.03 mg/kg), Manganese (4.43 and 3.37 mg/kg), and Copper (1.65 and 1.48 mg/kg)
Vitamins		Retinol (Vitamin A), Ascorbic acid (Vitamin C), Thiamine (Vitamin B1), Riboflavin (Vitamin B2), Niacin (Vitamin B3), Pyridoxine (Vitamin B6), Folic acid (Vitamin B9), and various tocopherol derivatives (Vitamin E).	

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Table 2: The main nutritional components of *Nigella sativa*.

Category	Components	Quantity / Characteristics	Ref.
Lipids and Sterols	Oleic acid, Linoleic acid, Palmitic acid, etc.	30-35% of total lipids. Also includes other acids.	[25]
Proteins	Essential amino acids, Glutamic acid, etc.	About 20% protein. Presence of 17 amino acids.	[26]
Carbohydrates and Fibers	Carbohydrates, Dietary fibers	Carbohydrates : 33-34%, Fibers: 4.5-6.5%	[27]
Minerals	Phosphorus, Calcium, Potassium, Magnesium, etc.	Potassium (1.18%), Calcium (0.188%), Iron (0.0575%), etc.	[28]
Vitamins	A, B (B1, B2, B3, B6), PP, Folic acid, E, C, K1, Tocopherols	Total tocopherols (0.05%), β-carotene, Vitamin K1	[26]

Table 3: Some Pharmacological Properties of *Nigella sativa* Seed Extracts.

Pharmacological Property	Types of Extracts	Study Type	Actions and Targets	Ref.
Antioxidant Properties	ExEt	<i>In vitro</i>	Delays the oxidation of corn oil triglycerides at 100°C	[29]
	ExAq	<i>In vitro</i>	Used as an antioxidant in cosmetics and as a preservative for unsaturated fatty acids in food	[30]
	EO	<i>In vitro</i>	Neutralizes hydroxyl radicals in non-enzymatic lipid peroxidation	[31]
	FF and its fractions	<i>In vitro</i>	Shows antioxidant activity against two stable free radicals	[32]
Anti-inflammatory Properties	FF	<i>In vitro studies</i>	Restores serum lipid profile and plays a protective role against hepatotoxicity; increases glutathione concentration and the renal cortex antioxidant defense system	[33]
	FF	<i>Clinical trial</i>	TQ prevents the production of pro-inflammatory cytokines by blocking transcription factor expression	[34]
Antitumor Properties	FF		Results show that <i>N. sativa</i> can reduce nasal congestion, nasal itching, runny nose, sneezing attacks, turbinate hypertrophy, and mucosal pallor (Day 15)	[35]
	TQ	<i>In vitro</i>	Thymoquinone enhances the detoxifying functions of the liver, increases glutathione levels, and reduces tumor growth	[36]
Antiallergic and Respiratory Effects	Dithymoquinone and ethanolic extracts	<i>In vitro</i>	Dithymoquinone and ethanolic extracts of seeds are cytotoxic to chemotherapy-resistant tumor cells	[37]
	Extract	<i>In vitro</i>	<i>Nigella</i> seed extracts reduce the development and growth of tumor cells	[38]
	Volatile oil	<i>In vitro</i>	<i>Nigellone</i> administered orally to patients with asthmatic bronchitis has a beneficial effect by suppressing symptoms	[39]
Respiratory Effects	<i>Nigellone</i>	<i>In vitro studies</i>	<i>NS</i> seed exhibits dose-dependent muscle-relaxing effects. It counteracts histamine and serotonin effects on smooth muscles of the trachea and duodenum, thus acting as a bronchodilator and spasmolytic	[40]
	Aqueous extract	<i>In vitro</i>	<i>In vitro</i> studies on isolated and pre-contracted tracheal chains demonstrate its relaxing and antihistamine effect	[41]
	Essential oil	<i>In vivo</i>	Intravenous administration of <i>N. sativa</i> essential oils increases intratracheal pressure	[42]
	methanolic extract		The crude methanolic extract of <i>NS</i> seeds exerts spasmolytic and bronchodilatory effects, likely involving calcium channel blockers	[43]
	<i>Nigellone</i>		Polythymoquinone is an effective protective agent against asthma and bronchitis	[44]
	Fixed oil	<i>In vitro</i>	Fixed oil and its fractions (neutral lipids, glycolipids, and phospholipids) show antioxidant activity against two stable free radicals (DPPH and galvinoxyl radicals). This antioxidant activity correlates with the content of polyunsaturated fatty acids, unsaponifiable compounds, phospholipids, and the initial peroxide value of the oil	[46]
	Essential oil	<i>In vitro</i>	Thymoquinone, carvacrol, trans-anethole, and 4-terpineol (major constituents of the essential oil) exhibit significant free radical scavenging activity	[46]
	Fixed oils	<i>In vivo</i>	Administration of <i>N. sativa</i> oil and thymoquinone to rats protects against methionine-induced hyperhomocysteinemia by blocking homocysteine accumulation, leading to protection against oxidative stress and lipid peroxidation	[47]

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	Fixed oils	<i>In vivo</i>	Treatment with <i>N. Sativa</i> oil in rats exposed to aflatoxin-contaminated diets significantly protects against hepatonephrotoxicity and oxidative alterations, including decreased GPx and SOD levels, increased lipid peroxidation, and DNA damage during aflatoxicosis. This protective effect is likely due to its free radical scavenging properties	[48]
Hepatoprotective Activities	Timoquinon	<i>In vivo</i>	In mice, thymoquinone (100 mg/kg, single dose) inhibits carbon tetrachloride-induced liver damage, attributed to its antioxidant properties (slowing lipid peroxidation)	[49]
Gastroprotective Activities	Aqueous extract	<i>In vivo</i>	Seeds reduce aspirin-induced ulcer index by 36%, decrease peptic activity, and reduce acid production in rats	[50]
	Fixed oils	<i>In vivo</i>	Administration of fixed oil at 0.88g/kg/day for two weeks increases gastric mucin while decreasing histamine levels	[51]
	Fixed oils + Timoquinon	<i>In vivo</i>	Protection against ischemia-reperfusion-induced gastric lesions through their antioxidant properties	[12]
	alcoholic extract		<i>N. sativa</i> seed alcoholic extract shows antiulcer activity attributed to its flavonoid content	[40]
Anticholesterolemic Properties	Fixed oils		<i>N. sativa</i> oil incorporated into rats' diet (800 mg/kg for 4 weeks) significantly reduces blood cholesterol, LDL, and triglyceride levels while increasing HDL levels	[29]
Antidiabetic Activity	Extract	<i>In vitro</i>	Extracts of seeds mixed with other plants like aloe and myrrh have therapeutic potential in treating insulin-dependent diabetes	[52]
	Extract	<i>In vivo</i>	Several studies have explored the effects of <i>N. sativa</i> seeds on experimental diabetes complications in rabbits	[53]
	Essentail oils	<i>In vivo</i>	<i>N. sativa</i> seed essential oil administered intraperitoneally (50 mg/kg) significantly lowers fasting blood glucose (15-23%) in normoglycemic and hyperglycemic animals. The insulin level remains unaffected, suggesting a hypoglycemic mechanism independent of insulin	[54]
	Aqueous extract	<i>In vivo and in vitro</i>	<i>N. sativa</i> aqueous extract dose-dependently inhibits sodium-dependent glucose transporters in vivo and in vitro through isolated rat jejunum	[55]
Hemolytic Activity	Extract	<i>In vitro</i>	<i>N. sativa</i> seed extract inhibits hemolytic activities of snake and scorpion venoms and protects erythrocytes from lipid peroxidation and protein degradation	[12]
Antibacterial Activity	Essentail oils	<i>In vitro</i>	<i>N. sativa</i> essential oil exhibits antibacterial activity against various bacterial strains, including <i>Escherichia coli</i> , <i>Bacillus subtilis</i> , <i>Streptococcus faecalis</i> , <i>Staphylococcus aureus</i> , and <i>Pseudomonas aeruginosa</i>	[56]
	ExMt and ExAq	<i>In vitro</i>	Methanolic and aqueous extracts of <i>N. sativa</i> seeds show highly effective activity against <i>Streptococcus pyogenes</i> , <i>Pseudomonas aeruginosa</i> , and <i>Klebsiella pneumonia</i>	[57]
	Ether extract	<i>In vitro</i>	Ether extract shows concentration-dependent inhibition of gram-positive <i>Staphylococcus aureus</i> , gram-negative <i>Pseudomonas aeruginosa</i> , and <i>Escherichia coli</i> . Additionally, it synergizes with various antibiotics and is more effective against resistant strains, including <i>Vibrio cholera</i> , <i>Escherichia coli</i> , and <i>Shigella dysenteriae</i> . The alcohol extract has activity against <i>Micrococcus pyogenes</i> , <i>Shigella dysenteriae</i> , <i>S. sonnei</i> , <i>S. boydii</i> , <i>Vibrio cholerae</i> , and <i>Escherichia coli</i>	[58]
Antifungal Activity	Fixed oisl	<i>In vitro</i>	Fixed oil exhibits excellent antifungal activity against <i>Aspergillus niger</i> , <i>Aspergillus species</i> , <i>Curvularia lunata</i> , and <i>Candida albicans</i>	[59]
Antiviral Activity	Essential oils	<i>In vitro</i>	<i>N. sativa</i> oil has antiviral activity, associated with improved immunity during viral infections	[60,61]
	Aqueous extract	<i>In vitro</i>	<i>N. sativa</i> seed aqueous extracts show significant antiviral activity against murine cytomegalovirus and hepatitis virus	[53]

Black cumin seeds contain a multitude of compounds, some of which are still being studied. The combination of these constituents could explain the diversity of the plant's pharmacological activities. Although all the potential applications of black cumin have not yet been fully explored, it

is already being marketed as a food supplement, particularly in the form of vegetable oil capsules, with claims of immunomodulatory activity. This highlights the potential of this plant as a natural resource for promoting human health.

Finally, it is important to note that black cumin appears to

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be relatively safe, particularly when administered orally, with a significant therapeutic margin in relation to any adverse effects.

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