Antibacterial Activity of *Nigella Sativa*

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ABSTRACT

Nigella sativa, commonly known as black seed or kalonji, is a widely used medicinal plant with a long history in traditional healthcare systems. Recent studies have confirmed its significant antimicrobial properties, particularly against multidrug-resistant bacteria, fungi, and viruses. The antimicrobial activity is largely attributed to its bioactive components, such as thymoquinone, which disrupt microbial membranes, inhibit enzyme activity, and generate reactive oxygen species. In vitro experiments have demonstrated the effectiveness of various seed extracts against both Gram-positive and Gram-negative bacteria, as well as clinical fungal and viral strains. These findings support the growing interest in *N. sativa* as a promising candidate for the development of novel antimicrobial drugs. Future research focusing on mechanisms of action, nano-delivery systems, and clinical trials could help transition this traditional remedy into modern therapeutics.

Keywords: *Nigella sativa*, Thymoquinone, Antimicrobial activity, Multidrug resistance.

INTRODUCTION

During their peak (from the 1950s to the 1970s), antibiotics—the wonderful drugs of the 20th century successively decreased human mortality and morbidity (Gupta & Birdi, 2017). Pathogens have, however, gradually become resistant to these wonder medications. Antibiotic resistance has recently emerged as a significant global health issue, putting a significant financial strain on society by driving up the cost of care and hospitalization rates, particularly in developing nations that already struggle with economic hardship, sanitation, and the misuse of antibiotic medications (Arti, 2005). As microorganisms rabidly acquire resistance to these new antibiotics, it appears that the expensive and time-consuming process of developing new antibiotics is currently futile (Ahmad et al., 2013). This has increased interest in looking for efficient substitutes for the present antibiotics with various microbe-targeting mechanisms. As a result, the best alternative source for developing new antibacterial medications seemed to be medicinal plants (Emad, 2011).

Because of the urgent demand for new antimicrobial medications, efforts to develop novel antibiotics must adopt novel strategies and reap the benefits of medicinal plants untapped potential (Tariq et al, 1995). The bioactivity and therapeutic benefits of *Nigella sativa* seeds have been extensively studied by scientists (Al-Jassir et al, 1992). This mini-review emphasises the significance of this plant product as a potential replacement and source for novel antimicrobial medications (Hajhashemi et al., 2004). The annual herbaceous plant *Nigella sativa*, which is a member of the Ranunculaceae family, is grown around the world, but is most popular in the Mediterranean region, North Africa, the Middle East, and some regions of Asia. (Hosseinzadeh et al., 2007).

Figure 1. Kalonji seed (*Nigella sativa*).

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(Source: Emeka et al., 2015)

Interestingly, these tiny seeds contain a lot of bioactive substances (Forouzanfar et al, 2014). Typically, it contains 0.4-0.45% volatile oil and 32-40% fixed oils (Ugur et al., 2016). Along with several vitamins and carbs, there are 8–9 different kinds of necessary amino acids. The black seed was also used to isolate some intriguing derivatives of alkaloids, steroids, saponins, terpenes, monoterpenes, and phenolic chemicals (Khan MA et al, 1999).

BLACK SEED AS AN ANTIBACTERIAL AGENT

In summary, Oils extracted from had a substantial antibacterial action against *Staphylococcus aureus* that was isolated from injured diabetic patients in Southeast Nigeria and was multidrug resistant (Gholamnezhad et al, 2016). When the safety of the oil was investigated, it was found to have effective antibacterial activity against a significant number of methicillin-resistant and coagulase negative *Staphylococcus aureus* (Khan. T. M et al, 2015). Additionally, there was no cytotoxic effect on the proliferation of gingival fibroblasts. It was advised to utilize black seed oil as an antibacterial agent in food production to stop food from spoiling (Hannan et al, 2008). According to the findings, this oil at a concentration of 2.0% was able to stop the growth of 24 pathogenic, spoilage, and lactic acid bacteria (Ugur et al., 2016).

Black seed extracts in ethanol and n-hexane demonstrated impressive dose-dependent antibacterial activity against a variety of gram-positive and gram-negative strains, including *Bacillus cereus, Bacillus subtilis, Escherichia coli, Staphylococcus epidermidis, Klebsiella pneumonia,* and *Salmonella typhmurium*. *Pseudomonas aeruginosa* and *Enterobacter aerogens*, however, show no antibacterial action (KhanAR et al, 2016). *Salmonella typhi* was resistant to the antibacterial properties of the black cumin seeds (Amalia Tri Utami et al, 2016). *Streptococcus pyogenes, Pseudomonas aeruginosa, Klebsiella pneumoniae,* and *Proteus vulgaris* exhibited remarkable antibacterial efficacy when extracted with methanol and water; however, the gram-positive bacteria showed the strongest antibacterial effects (Hasan et al., 2013).

Black Seed As An Antifungal Agent

A study was done to examine the possible antifungal effects of several black seed oils on 20 distinct fungi, including industrial and pathogenic strains (Shokri H et al, 2016). All oils demonstrated varyingly high levels of antifungal activity, but the essential oil had the most impact (Malek MA etal 1989). In vivo and in vitro tests against various pathogenic yeasts, including *Candida albicans*, dermatophytes, non-dermatophytes, and some fungi that produce aflatoxin, revealed a modest inhibitory impact from some of the black seed's constituents, oils, and extracts (Shokri H, 2016). *Aspergillus flavus, Aspergillus fumigates, Issatchenkia orientalis, Cryptococcus laurentii, Cryptococcus albidus, Candida parapsilosis, Candida albicans, and Candida tropicalis* were all effectively inhibited by the methanol and ethanol extracts of black cumin seeds, and these extracts were more effective than the common antibiotic Amphotericin-B (Ganure AL et al, 2010).

Black Seed As An Antiviral Agent

Unlike antibacterial pharmaceuticals, there are fewer antiviral medications available, and those that are have a limited efficacy (Ali et al, 2003). In a fascinating study, mice infected with the DNA virus known as "Murine cytomegalovirus (MCMV)" which is peculiar to mice as a host, were given *Nigella sativa* oil. Surprisingly, on day 3 of infection, black seed oil completely inhibited the virus titers in the spleen and liver, while the MCMV virus was still detectable in control mice (Salem ML et al, 2000). In a clinical investigation, *Nigella sativa* was given to Hepatitis C virus (HCV)-positive Egyptian patients for up to three months at a dose of 450 mg three times daily, including those diabetic and HCV-positive individuals who were ineligible for IFN/ribavirin therapy (Zaher et al, 2011). After the course of treatment, patients exhibited a variety of recovery and improvements in oxidative stress, clinical condition, and glycemic control in diabetes patients (Hagag RS et al, 2013).

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Mechanisms Of Antimicrobial Action

The antimicrobial efficacy of *Nigella sativa* is largely attributed to its major active constituent, thymoquinone (TQ), along with other volatile and fixed oils. These compounds exert multifaceted mechanisms against a wide range of pathogens. Thymoquinone has been shown to integrate into microbial lipid bilayers, disturbing membrane integrity and leading to leakage of cellular contents, thereby compromising microbial viability (Forouzanfar et al., 2014). Additionally, TQ interferes with bacterial efflux systems, reducing the expulsion of antibiotics and restoring microbial sensitivity to conventional drugs (Ahmad et al., 2013). Another important mechanism involves the generation of reactive oxygen species (ROS), which causes oxidative damage to microbial DNA, proteins, and lipids, ultimately leading to cell death (Gholamnezhad et al., 2016). Furthermore, TQ inhibits essential bacterial enzymes that are crucial for microbial metabolism and replication (Hosseinzadeh et al., 2007). In eukaryotic pathogens such as fungi and viruses, *N. sativa* extracts have demonstrated the ability to trigger apoptosis-like mechanisms, disrupting their cellular activities and propagation (Shokri, 2016; Salem & Hossain, 2000). These combined actions make *N. sativa* a highly promising candidate for combatting antimicrobial resistance.

Future Directions And Research Prospects

Although in vitro studies have strongly supported the antimicrobial potential of *Nigella sativa*, its translation into clinical applications remains limited. One significant future direction involves the development of nano-formulations incorporating thymoquinone, such as nanoparticles or liposomal systems, to enhance its bioavailability, targeted delivery, and safety profile (Forouzanfar et al., 2014). Another promising approach includes evaluating synergistic effects between *N. sativa* and conventional antibiotics to overcome resistance mechanisms and enhance antimicrobial efficacy (Gupta & Birdi, 2017). Standardization of *N. sativa* extracts also demands attention, as variations in phytochemical content among different seed sources affect consistency and reproducibility; thus, formulations with well-defined thymoquinone concentrations are essential (Ahmad et al., 2013). Furthermore, preclinical and clinical trials are urgently needed to validate its safety and efficacy in human populations, beyond the preliminary findings in animal models (Barakat et al., 2013). Finally, adopting integrative 'omics' approaches such as genomics, transcriptomics, and metabolomics can help unravel the precise molecular pathways affected by *N. sativa*, guiding its therapeutic use in personalized medicine. Collectively, these directions hold immense potential for harnessing *Nigella sativa* as a natural antimicrobial agent in modern pharmacology and public health.

CONCLUSION

Referring to the vast amount of information in the scientific literature, there are numerous indications that the black seed has potent antimicrobial properties against a variety of bacteria, fungi, and viruses, and is a relatively safe drug with a long and notable history in traditional medicine. The black seed's mechanism and mode of action on microbial cells (prokaryotic or eukaryotic) and viruses must be thoroughly understood before new technologies like nanotechnology can be applied to design and develop novel antimicrobial drugs from *Nigella sativa* seeds. The world's health authorities must encourage the study and development of this innovative plant product. Governments and nations must initiate research initiatives and provide financial assistance for the development of new antimicrobial medications. The major pharmaceutical industries ought to adopt a different mindset and business plan and make investments in organic goods with strong antibacterial properties. Implementing these suggestions might help address this global threat.

Conflicts Of Interest

The authors declare that they have no conflicts of interest.

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REFERENCE

1. Ahmad, A., Husain, A., Mujeeb, M., Khan, S. A., Najmi, A. K., Siddique, N. A., & Anwar, F. (2013). A review on therapeutic potential of Nigella sativa: A miracle herb. Asian Pacific Journal of Tropical Biomedicine, 3(5), 337–3352. https://doi.org/10.1016/S2221-1691(13)60075-1
2. Ali, B. H., & Blunden, G. (2003). Pharmacological and toxicological properties of Nigella sativa. Phytotherapy Research, 17(4), 299–305. https://doi.org/10.1002/ptr.1309
3. Al-Jassir, M. S. (1992). Chemical composition and microflora of black cumin (Nigella sativa L.) seeds growing in Saudi Arabia. Food Chemistry, 45(4), 239–242. https://doi.org/10.1016/0308-8146(92)90068-A
4. Amalia, T. U., Pratomo, B., & Noorhamdani. (2016). Study of antimicrobial activity of black cumin seeds (Nigella sativa L.) against Salmonella typhi in vitro. Tropical Biomedicine, 1(3), Article ID: 2472-4971. (DOI or page number missing)
5. Arti, K. (2005). The challenge of antibiotic resistance: Need to contemplate. Indian Journal of Medical Research, 121(2), 83–91. https://doi.org/10.4103/0971-5916.26402
6. Barakat, E. M. F., El Wakeel, L. M., & Hagag, R. S. (2013). Effects of Nigella sativa on outcome of hepatitis C in Egypt. World Journal of Gastroenterology, 19(16), 2529–2536. https://doi.org/10.3748/wjg.v19.i16.2529
7. Emad, M. A. (2011). Black seed (Nigella sativa) as antimicrobial drug: A mini review. International Journal of Health Sciences, 3(2), Article ID: 2575-8942. (Missing pages and DOI)
8. Emeka, L. B., Emeka, P. M., & Khan, T. M. (2015). Antimicrobial activity of Nigella sativa L. seed oil against multidrug resistant Staphylococcus aureus isolated from diabetic wounds. Journal of Medicinal Plants Research, 28(6), 1985–1990.
9. Forouzanfar, F., Bazzaz, B. S. F., & Hosseinzadeh, H. (2014). Black cumin (Nigella sativa) and its constituent (thymoquinone): A review on antimicrobial effects. Iranian Journal of Basic Medical Sciences, 17(12), 929–938.
10. Gholamnezhad, Z., Havakhah, S., & Boskabady, M. H. (2016). Preclinical and clinical effects of Nigella sativa and its constituent, thymoquinone: A review. Journal of Ethnopharmacology, 190, 372–386. https://doi.org/10.1016/j.jep.2016.06.061
11. Hajhashemi, V., Ghannadi, A., & Jafarabadi, H. (2004). Black cumin seed essential oil, as a potent analgesic and anti-inflammatory drug. Phytotherapy Research, 18(3), 195–199.
12. Hannan, A., Saleem, S., Chaudhary, S., Barkat, A., & Arshad, M. U. (2008). Antibacterial activity of Nigella sativa against clinical isolates of methicillin-resistant Staphylococcus aureus. Journal of Ayub Medical College Abbottabad, 20(3), 72–74.
13. Hasan, N. A., Nawahwi, Z., & Malek, H. A. B. (2013). Antimicrobial activity of Nigella sativa seed extract. Tropical Biomedicine, 42(2), 143–147.
14. Hosseinzadeh, H., Fazly Bazzaz, B. S., & Motevaly Haghi, M. (2007). Antibacterial activity of total extracts and essential oil of Nigella sativa L. seeds in mice. Iranian Journal of Pharmaceutical Research, 2, 429–435.
15. Islam, S. K., Ahsan, M., Hassan, C. M., & Malek, M. A. (1989). Antifungal activities of the oils of Nigella sativa seeds. Mycopathologia, 2(1), 25–28. (Verify correct journal title)
16. Khan, M. A. (1999). Chemical composition and medicinal properties of Nigella sativa Linn. Inflammopharmacology, 7(1), 15–35. https://doi.org/10.1007/s10787-999-0021-7
17. Khan, A. R., & Kou, K. (2016). Wide spectrum antibacterial activity of Nigella sativa L. seeds. Journal of Pharmaceutical Research, 6(7), 12–16. (Journal needs verification)
18. Najib, M. S., Walli, R. R., Wali, F. M., Alareiba, M. S., & Doro, B. M. (2014). Studies of the antimicrobial activity of black seed oil from Nigella sativa on Staphylococcus aureus and Escherichia coli. Journal of Infectious Diseases and Immunity, 8(1), Article ID: 2312-5365. (Missing page number or DOI)
19. Gupta, P. D., & Birdi, T. J. (2017). Development of botanicals to combat antibiotic resistance. Journal of Ayurveda and Integrative Medicine, 8(4), 266–275. https://doi.org/10.1016/j.jaim.2017.05.004

20. Raval, B. P., Shah, T. G., Suthar, M. P., & Ganure, A. L. (2010). Screening of Nigella sativa seeds for antifungal activity. Journal of Pharmacognosy and Phytochemistry, 1(1), 164–171.
21. Salem, M. L., & Hossain, M. S. (2000). Protective effect of black seed oil from Nigella sativa against murine cytomegalovirus infection. International Journal of Immunopharmacology, 22(9), 729–734. https://doi.org/10.1016/S0192-0561(00)00029-9
22. Shokri, H. (2016). A review on the inhibitory potential of Nigella sativa against pathogenic and toxigenic fungi. Journal of Mycology and Medical Research, 6(1), 21–33.
23. Tariq, M., Moutaery, K. A., Al-Deeb, S. A., Al-Tahir, M. A., & Ageel, A. M. (1995). Anticonvulsant activity of the volatile oil of Nigella sativa seeds. International Journal of Pharmacognosy, 33(1), 1–5.
24. Ugur, A. R., Dagi, H. T., Ozturk, B., Tekin, G., & Findik, D. (2016). Assessment of in vitro antibacterial activity and cytotoxicity effect of Nigella sativa oil. Journal of Clinical and Analytical Medicine, 12(4), S471–S474.
25. Zaher, K. S., Abdel-Moneim, A. M., & Sharaf, M. M. (2011). Role of Nigella sativa in the amelioration of lung lesions induced by experimental Newcastle disease virus in chickens. International Journal of Poultry Science, 10(8), 612–620.