ANTIBACTERIAL ACTIVITIES OF NIGELLA SATIVA EXTRACTS

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Annotatsiya. Mazkur ilmiy ishda *Nigella sativa* (qora zira) urug‘laridan turli qutblilikka ega erituvchilar (suv, etanol, metanol, etil asetat va geksan) yordamida olingan ekstraktlarning antibiotik faolligi o‘rganildi. Tajribada *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* bakteriyalari va *Candida albicans* zamburug‘i test-ob’ekt sifatida tanlandi. Disk diffuziya usuli orqali ekstraktlarning mikroorganizmlarga ta’siri baholandi. Natijalarga ko‘ra, eng yuqori faollik etanol va metanol ekstraktlarida kuzatildi. Bu o‘simlikdan olingan ekstraktlar kelgusida tabiiy antibiotiklar sifatida ishlatilishi mumkinligini ko‘rsatadi.

Kalit so‘zlar: Nigella sativa, erituvchilar, ekstraktsiya, antibiotik faollik, mikroorganizmlar, disk diffuziya, tabiiy preparatlar.

Аннотация. В данной научной работе изучена антибактериальная активность экстрактов семян *Nigella sativa* (черного тмина), полученных с использованием различных растворителей (вода, этанол, метанол, этилацетат и гексан). Для тестирования были выбраны микроорганизмы: *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* и гриб *Candida albicans*. Метод дисковой диффузии использовался для оценки антимикробной активности экстрактов. Наибольшая активность наблюдалась у этанольного и метанольного экстрактов. Полученные данные подтверждают перспективность использования растительных экстрактов в качестве природных антибиотиков.

Ключевые слова. Nigella sativa, растворители, экстракция, антибактериальная активность, микроорганизмы, дисковая диффузия, натуральные препараты.

Abstract. This study investigates the antibacterial activity of *Nigella sativa* (black cumin) seed extracts obtained using different solvents (water, ethanol, methanol, ethyl acetate, and hexane). Test microorganisms included *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and the yeast *Candida albicans*. Antimicrobial activity was evaluated using the disk diffusion method. The ethanol and methanol extracts showed the highest levels of inhibition, suggesting that these solvents efficiently extract bioactive compounds. The findings support the potential application of *Nigella sativa* extracts as natural antimicrobial agents.

Keywords. Nigella sativa, solvents, extraction, antibacterial activity, microorganisms, disk diffusion, natural compounds.

Introduction

ISSN 3030-3907

Plants have been recognized as a rich source of bioactive compounds for centuries, and their role in the discovery of antibiotics cannot be overstated. Historically, plant-derived substances have been used in traditional medicine for the treatment of various ailments, including infections caused by pathogenic microorganisms. The increasing issue of antimicrobial resistance (AMR) has reignited interest in plant-based compounds due to their potential to serve as novel antibiotic agents or as adjuncts to conventional therapies[1-4]. Plants produce a diverse range of secondary metabolites, many of which have antimicrobial properties. These compounds include alkaloids, flavonoids, terpenoids, phenolic acids, and saponins. They act by various mechanisms such as disrupting bacterial cell walls, inhibiting protein synthesis, and interfering with the bacterial DNA[5,6].

With the advent of modern techniques such as high-throughput screening and chromatography, researchers can isolate and identify these bioactive compounds more effectively. The medicinal value of plants, particularly in the production of natural antibiotics, is being increasingly explored as an alternative to synthetic antibiotics[7]. For instance, plant extracts have been found to inhibit a wide range of bacterial pathogens, including multi-drug resistant strains, which makes them an important resource in the ongoing battle against bacterial infections. In the context of antibiotic production, *Nigella sativa* extracts, particularly those obtained using solvents such as ethanol and methanol, have shown promising antibacterial activity. These extracts exhibit significant inhibitory effects on a wide range of bacterial strains, which suggests that *Nigella sativa* could be a valuable resource in the development of new antibiotic drugs[8]. Additionally, due to its antioxidant and anti-inflammatory properties, *Nigella sativa* could also play a role in the treatment of conditions related to oxidative stress and inflammation, further expanding its therapeutic potential[9-13].

The use of plant-based antibiotics, such as those derived from *Nigella sativa*, offers a sustainable and potentially safer alternative to synthetic antibiotics. By exploring the mechanisms of action of these compounds, scientists hope to identify new ways to combat bacterial infections, particularly those caused by resistant strains. *Nigella sativa* extracts, therefore, hold significant promise not only as traditional remedies but also as modern, scientifically validated antimicrobial agents[14-18].

MATERIALS AND METHODS

Plant sample preparation. Dried *Nigella sativa* seeds were procured from a local herbal market. Seeds were further dried in a shaded area for 5 days to avoid photodegradation. The dried seeds were ground into fine powder using an electric grinder. 50 g of powdered plant material was used for each solvent extraction.

ISSN 3030-3907

Extraction procedure. Extraction was carried out by maceration: Each powdered sample was soaked in 500 ml of respective solvents (water, 96% ethanol, 99% methanol, ethyl acetate, and hexane) in a 1:10 (w/v) ratio. The mixtures were kept at room temperature for 72 hours in the dark and shaken periodically. After extraction, mixtures were filtered using Whatman filter paper. The filtrates were evaporated using a water bath at 45–50°C to obtain semi-solid crude extracts. Extracts were stored at 4°C in airtight containers until further analysis.

Antimicrobial activity testing. **Disk diffusion method** was used: Microorganisms: *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Candida albicans*. Each strain was cultured in nutrient broth and adjusted to 0.5 McFarland standard. Mueller-Hinton Agar plates were inoculated with microbial suspensions. Sterile filter paper disks (6 mm) impregnated with 50 µl of each extract were placed on the agar surface. Control disks included gentamicin (standard antibiotic) and pure solvents (negative control). Plates were incubated at 37°C for 24 hours.

Evaluation of Results. Zones of inhibition around the disks were measured in millimeters. Activity levels were categorized as:

–Inactive:≤6mm

–Weak: 7–10 mm

–Moderate: 11–15 mm

–Strong: >15 mm

RESULTS AND DISCUSSION.

The emergence of multidrug-resistant microorganisms has prompted the scientific community to explore alternative sources of antimicrobial agents, particularly those derived from plants. Numerous medicinal plants have been historically utilized for their healing properties, and modern research has confirmed that many contain bioactive phytochemicals with antimicrobial potential. However, the efficiency of these phytochemicals largely depends on the solvent used for extraction, as different solvents extract different groups of compounds based on their polarity. This study focuses on *Nigella sativa* (black cumin) seed extracts obtained using solvents of varying polarity—water, ethanol, methanol, ethyl acetate, and hexane. The antimicrobial efficacy of these extracts was tested against selected Gram-positive (*Staphylococcus aureus*), Gram-negative (*Escherichia coli*, *Pseudomonas aeruginosa*) bacteria and a fungal strain (*Candida albicans*). Gentamicin was used as a standard antibiotic control to benchmark the activity of the plant extracts. The potential of *Nigella sativa* as an antimicrobial agent is gaining recognition due to its diverse bioactive compounds.

ISSN 3030-3907

Researchers have isolated and identified several constituents from *Nigella sativa* extracts, and their antibacterial properties have been evaluated through various assays, including disk diffusion and broth dilution methods.

Extract Type	*E.coli* (mm)	*S.aureus* (mm)	*P.aeruginosa* (mm)	*C.albicans* (mm)
Water extract	6	8	7	0
Ethanol extract	16	20	14	12
Methanol extract	15	19	13	10
Ethyl acetate	12	16	11	8
Hexane extract	7	10	8	6
Gentamicin (control)	20	23	22	—

DISCUSSION

The ethanol and methanol extracts exhibited the highest antibacterial activity, particularly against *Staphylococcus aureus* and *Escherichia coli*. This is likely due to the effective extraction of phenolic and flavonoid compounds using polar solvents. The aqueous extract showed weak activity only against *S. aureus*, while it was inactive against the other test organisms, possibly due to limited solubility of bioactive compounds in water. Ethyl acetate showed moderate activity, while hexane extracts were the least effective, which correlates with their limited extraction of polar compounds. Notably, the ethanol extract also demonstrated moderate antifungal activity against *Candida albicans*.

CONCLUSION

The study clearly indicates that the choice of solvent significantly affects the antimicrobial activity of plant extracts. Ethanol and methanol extracts of Nigella sativa showed the strongest activity, particularly against Gram-positive and Gram-negative bacteria. These findings support the potential of organic solvent-based extracts in the development of natural antimicrobial agents. Further phytochemical analysis using GC-MS or HPLC is needed to identify active constituents. In vivo testing should be conducted to validate safety and efficacy. Cytotoxicity and toxicity profiles of the extracts must also be assessed before clinical use.

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ISSN 3030-3907