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Review article

From tradition to biomedical innovation: A bibliometric review of *Nigella sativa* research

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Abstract

Nigella sativa, also referred to as "black cumin" or "black seed," is a medicinal plant that has been used therapeutically by humans for generations in many different cultures. In contemporary scientific research, experimental and clinical analyses reveal new and promising methods of assessing its use, and increasing attention has been given to the use of compounds from *Nigella sativa*. In this paper, we conduct an extensive bibliometric analysis of literature on *Nigella sativa*. An analysis of research trends, identification of primary contributors, and mapping of global partnerships can be done using bibliometric analysis, a quantitative survey of the scientific literature. The Scopus database returned 2472 papers published from 2000 to 2025 for this research. Data was processed using the R program Bibliometrix, and results were illustrated using Biblioshiny and VOSviewer. The number of publications on *Nigella sativa* has increased substantially over time, with a notable intensification within the past 10 years. These research topics, together with the prevailing and emerging related issues in the discipline, are presented, as well as the most active countries, organizations, writers, and journals. This study provides an improved mapping of the scientific field in *Nigella sativa* that will serve as an important tool for both researchers and policymakers to guide future work, promote partnerships, and bridge the scientific knowledge gap of this plant with multiple medicinal uses.

Keywords: *Nigella sativa*; Bibliometric analysis; Co-authorship; Co-occurrence.

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1. Introduction

Nigella sativa is an ancient medicinal plant that belongs to the Ranunculaceae family. Its uses in medicine, nutrition, and cosmetics have been recognized and practiced since antiquity (Ahmad et al., 2013; Ekor, 2014). Its use has been recorded for several millennia, especially in ancient civilizations of ancient Egypt, Greece, Rome, and the Muslim world (Zohary et al., 2012). Ancient manuscripts (such as prophetic Islamic medicine) referred to it as a "remedy for everything except death," a phrase which serves to highlight the fundamental role in conventional pharmacopoeia (Hosseinzadeh et al., 2007). In ethnobotanical terms, *Nigella sativa* is a cornerstone in phytotherapy and traditional medicine, as evidenced by its application in the treatment of numerous diseases, such as skin disorders, respiratory disorders, metabolic disorders, bacterial and viral infections, digestive disorders, and chronic inflammations (Ali & Blunden, 2003; Ahmad et al., 2013).

These traditional practices are widely practiced in many parts of the world, including Asia, the Middle East, North Africa, and Eastern Europe (Nasir & Saleem, 2021). The biological activities of *Nigella sativa* are mainly attributed to the diverse range of bioactive compounds produced in its seeds. Thymoquinone is the most researched and well-known of these, and has anti-inflammatory, antioxidant, anticancer, and immunomodulatory features (Khader & Eckl, 2014; Tavakkoli et al., 2017).

Also, the plant contains antioxidants (flavonoids, tocopherols), vital fatty acids (linoleic acid, oleic acid), vitamins, and minerals, which contribute to the enhanced medicinal value of the plant (Ahmad et al., 2013; Ekor, 2014). Several pharmacological and clinical investigations prove its beneficial roles regarding the prevention or treatment of chronic diseases, such as diabetes, hypertension, asthma, cardiovascular diseases, and some cancers (Boskabady et al., 2011; Tavakkoli et al., 2017).

Nonetheless, the effectiveness is still to be scientifically proven, optimal dosages need to be defined, and possible

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contraindications are to be evaluated (Nasir & Saleem, 2021). At a time of revived interest in natural remedies and search for alternatives to conventional drug therapy (Ekor, 2014), *Nigella sativa* has attracted increased scientific interest. This need is mirrored by the growing number of academic papers about the topic covering a range of disciplines, from molecular pharmacology to ethnobotany, including analytical chemistry and clinical trials (Rahman et al., 2021).

Given this increasing corpus of literature, the systematic methodology of assessing, integrating, and making sense of the current body of knowledge is paramount. Bibliometric analysis (Donthu et al., 2021; Moed, 2005) is an efficient tool for examining scientific literature, identifying research trends, mapping global partnerships, and identifying new topics. This dynamic also applies to the present work that seeks to produce a comprehensive summary of the academic literature on *Nigella sativa*.

This article aims to investigate the evolution of scientific production, recognize significant contributors (e.g., countries, institutions, authors), identify collaborative networks, and identify prominent research axes via the combination of Bibliometrix (R), Biblioshiny, and VOSviewer. It enables future research to follow a promising trajectory in their work and offers useful insights into the state of the art.

2. Methodological Approach

This study intends to provide an extensive, comprehensive bibliometric analysis of research published on *Nigella sativa*, characterizing scientific trends, identifying key research participants and visualizing collaborative networks (Donthu et al., 2021; Moed, 2005).

2.1. Concept of bibliometric analysis

The systematic manner to review scientific literature is classified into quantitative studies with the use of bibliometric analysis (Pritchard, 1969; Aria & Cuccurullo, 2017), which allows studying the relationships and trends between different authors, institutions, countries, thematic domains, citations, and keywords. The method can be especially beneficial for isolating key actors, the most prominent journals, and emerging research themes, both mainstream and emerging in particular (Van Eck & Waltman, 2010).

2.1. Literature Search Strategy

Data collection took place on 14 August 2024 using the Scopus database, which has a vast coverage of scientific literature (Falagas et al., 2008). A searching technique was used consisting of a single keyword "*Nigella sativa*" (titles, abstracts, keywords). The data was subjected to strict filtering to maintain the validity and quality of the data. Only documents published between 2000 and 2024 were considered, which are mainly in English. A study specific to medicine, pharmacology, toxicology, pharmaceutics, chemistry, and other disciplines relevant to the research related to medicinal plants, were analyzed. In addition, only published original research articles were considered without reviews, notes, editorials, and conference abstracts (Donthu et al., 2021).

2.3. Data Processing and Analysis

The metadata extracted from Scopus (titles, authors, affiliations, abstracts, keywords, references and bibliometric indicators) was turned into CSV format in order for the next stages of processing to take place (Figure 1). Bibliometrix (Aria & Cuccurullo, 2017), its graphical interface Biblioshiny (Aria & Cuccurullo, 2017), allowing for descriptive analysis (annual evolution of publications, distribution by country and institution, most prolific authors, most productive journals, and most cited articles), while the visualization capabilities of the VOSviewer model (Van Eck & Waltman, 2010; Waltman et al., 2010) for building and mapping bibliometric networks (co-authorship, keyword co-occurrence, and co-citation networks) all provide a well-rounded and integrated overview of the evolution and composition of global research for *Nigella sativa*.

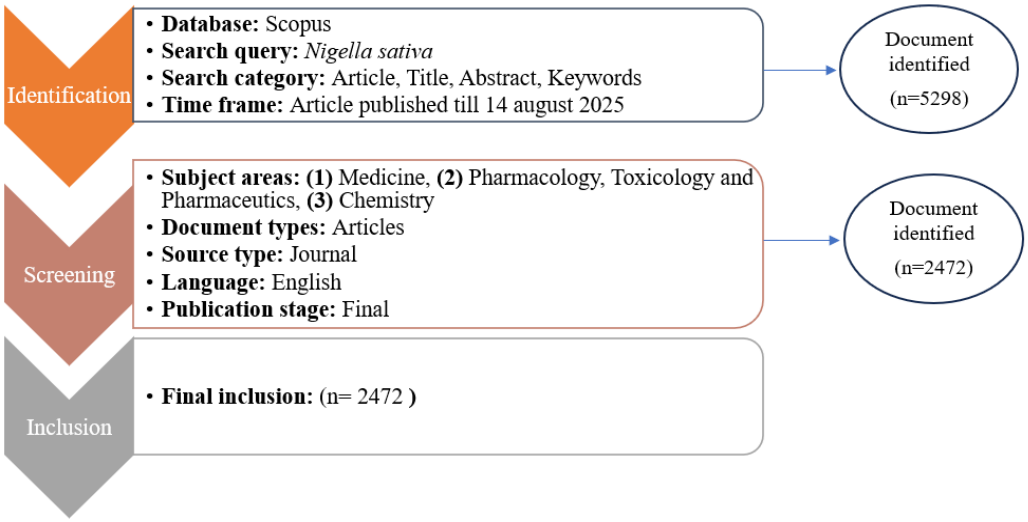

Figure 1. PRISMA diagram describing the study selection process

3. Results

3.1. General Characteristics of the Corpus

The analysis covered 1,686 documents that were published from 1943 to 2025, and collected 714 scientific sources. These articles included 6,840 authors with an average of 5 co-authors per article, exhibiting a firm trend of collaborative research (Figure 2). But there are only 79 articles written by a single researcher, showing that individual work in this area is uncommon. Internationally, 22.18% of the publications were carried out in cross-country association, establishing the international dissemination of *Nigella sativa* research. The corpus has more than 61,996 references with 30.75 citations (on average) per document, showing its important scientific impact. The average age of these documents stands at 9.12 years, suggesting that the field remains dynamic and continues to attract sustained attention from the scientific community.

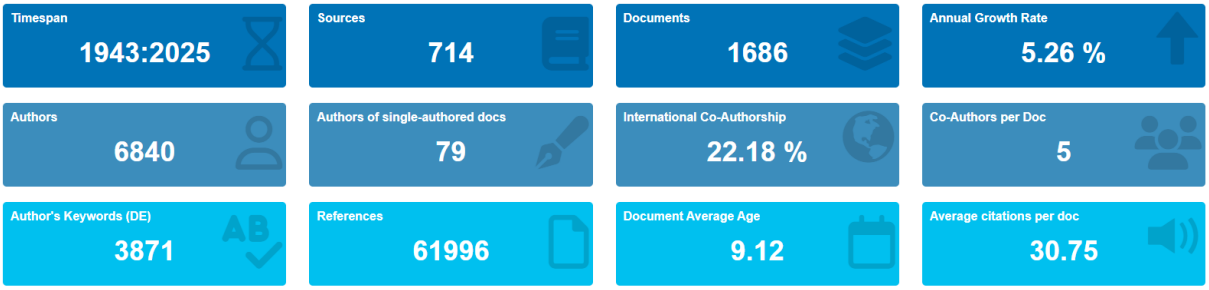

Figure 2. Descriptive bibliometric indicators of research on *Nigella sativa*

3.2. Evolution of publications over time

Chronological data from the time period of *Nigella sativa* as well as science, the earliest publication dates back to 1943 and scientific material appears until the early 2000s (Figure 3). However, steady growth was noted from 2005 to the present, reflecting an increasing scientific interest. This trend was especially evident between 2010 and 2022, in a time when there was a big surge in publications, reaching an apex around 2022-2023, after which more than 120 articles were published per annum. However, a moderate decrease is observed in 2025, attributed to the delay in indexing of newly published articles in the Scopus database. In general, *Nigella sativa* research indicates an average annual growth rate of 5.26%, thereby validating this field's thriving and ever-expanding scope.

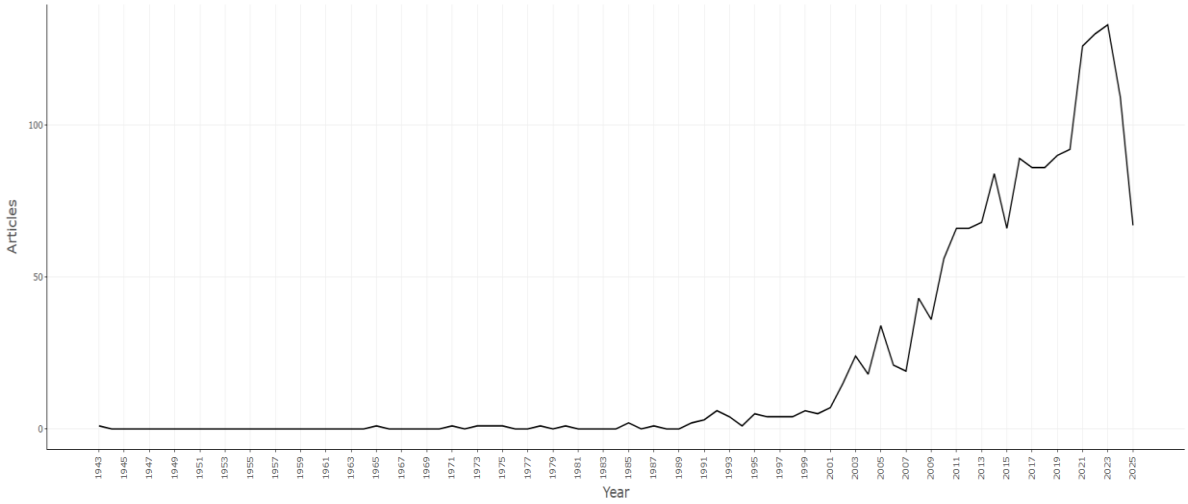

Figure 3. Annual evolution of scientific publications on *Nigella sativa*

3.3. Relationships between References, Authors, and Keywords

The Three-Field Plot highlights the relationships among cited references, the most active authors, and dominant themes identified by keywords.

3.3.1. Cited References

Among the most frequently cited works are seminal studies such as those by Ramadan M. F. on the nutritional and functional properties of *Nigella sativa*, as well as the contributions of Ali B. H. and Blunden G. on the pharmacological and toxicological aspects of the plant. These references represent solid theoretical and experimental foundations that continue to guide contemporary research.

3.3.2. Influential Authors

Authors such as Hosseini M., Kanter M., and Boskabady M. H. emerge as central figures in the field. Their research spans a wide spectrum, from pharmacological studies to experimental investigations using animal models. Their strong connections to both cited references and keywords

illustrate their pivotal role in structuring the scientific landscape.

3.3.3. Dominant Keywords

The most frequently represented keywords include "*Nigella sativa*," "black cumin," "thymoquinone," "controlled study," "drug effect," and "animal experiment." This distribution demonstrates the strong emphasis placed on pharmacological and toxicological research, particularly on the effects of thymoquinone, the plant's principal bioactive compound. The presence of terms such as "male," "rat," and "nonhuman" further underscores the importance of preclinical experimental models in exploring the properties of *Nigella sativa* (Figure 4).

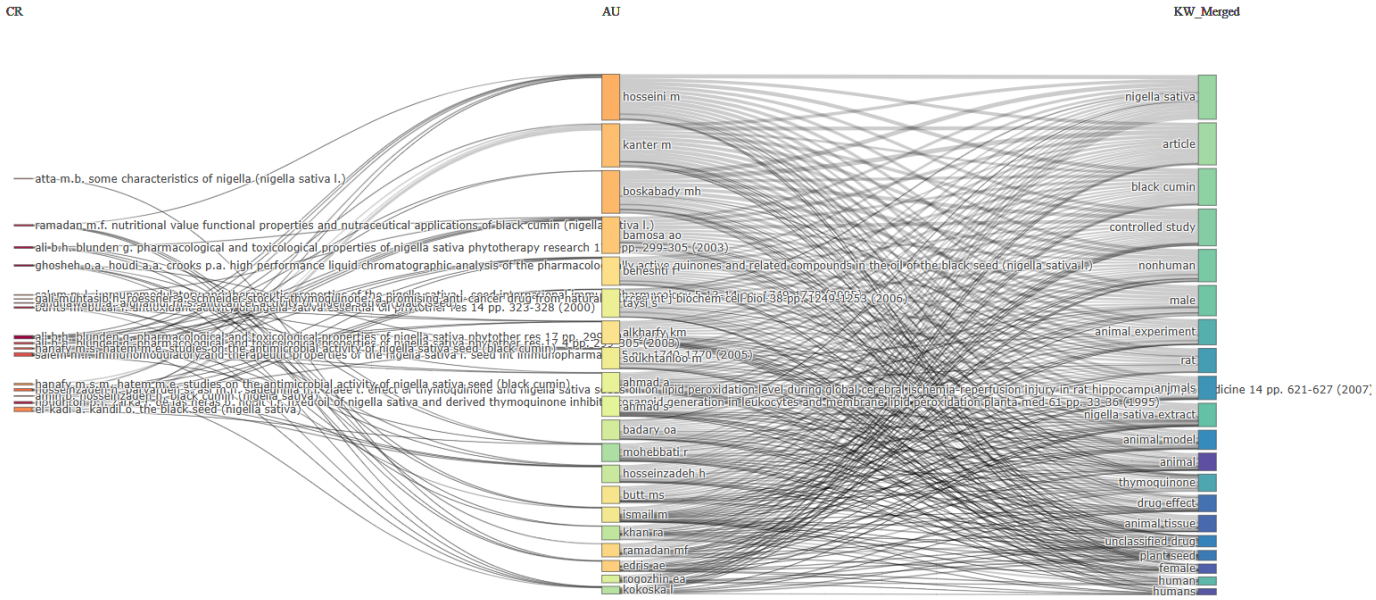

Figure 4. Three-Field Plot: Relationships between references, authors, and keywords in publications on *Nigella sativa*

3.4. Most Productive Journals

Most Productive Journals (Figure 5). From the sources analysis, *Nigella sativa* research has been published in numerous specialized journals, including, but not limited to, pharmacology, complementary medicine, biology, and food chemistry. Molecules is ranked top with 39 articles, followed by Evidence-Based Complementary and Alternative Medicine (33).

The two journals are key venues for circulating research in the bioactive and therapeutic effects of *Nigella sativa*. The Egyptian Journal of Histology (23 articles), Pharmaceutical Biology (22), BMC Complementary and Alternative Medicine (21), and others have demonstrated higher interest in conducting experimental and clinical studies.

The reference to scientific journals Food Chemistry (20) and the Journal of the American Oil Chemists' Society (17) further demonstrates that approaches focused on the chemistry of biologically active constituents and their nutritional applications are essential.

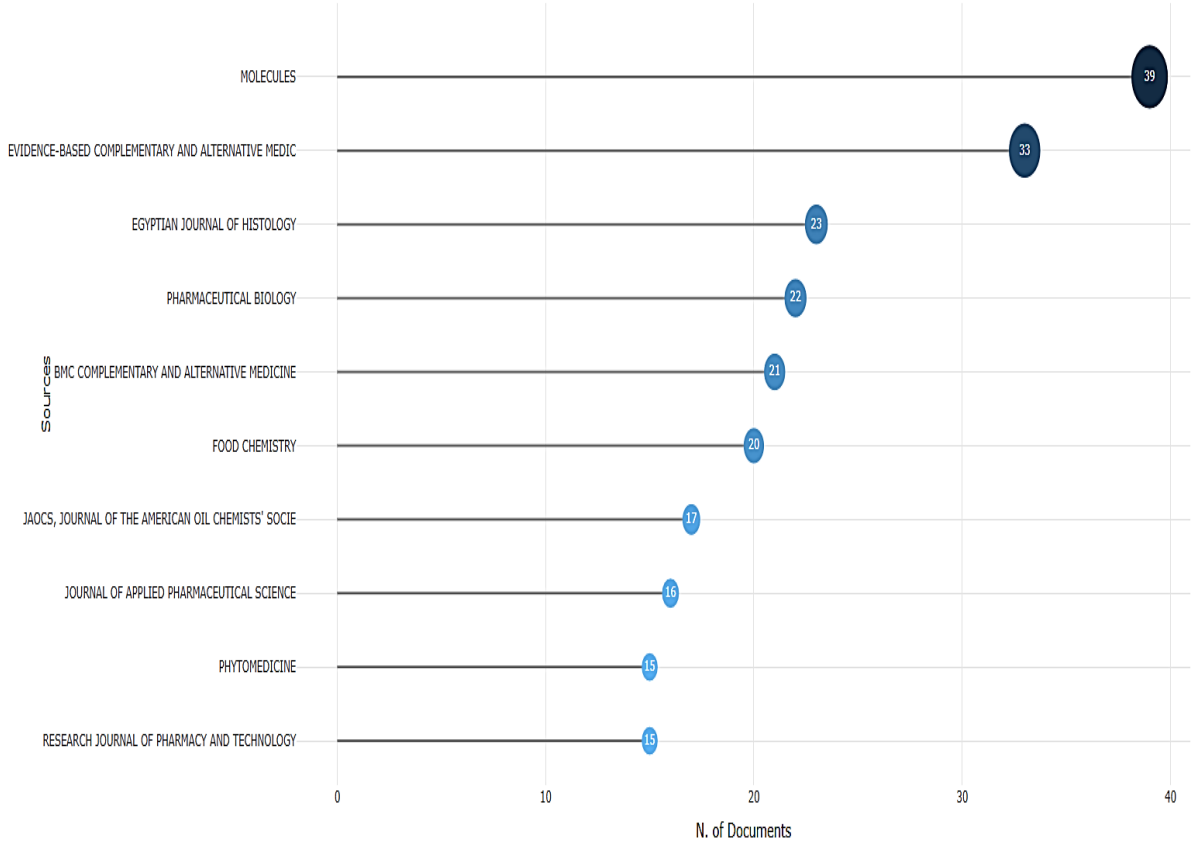

Figure 5. Most productive journals on *Nigella sativa* (2000–2025)

3.5. Geographical Distribution of Scientific Production

The geographical distribution of corresponding authors reveals that research on *Nigella sativa* is particularly concentrated in the Middle East and South Asia, regions where the plant has been historically used in traditional medicine.

3.5.1. Corresponding Authors by Country

Iran overwhelmingly dominates scientific production, with more than 200 articles, confirming its central role in the development of pharmacological and clinical knowledge on *Nigella sativa*. Egypt and Turkey follow with similarly high volumes of publications, while India and Saudi Arabia also hold notable positions. Together, these five countries form the core of global research on this plan (figure 6).

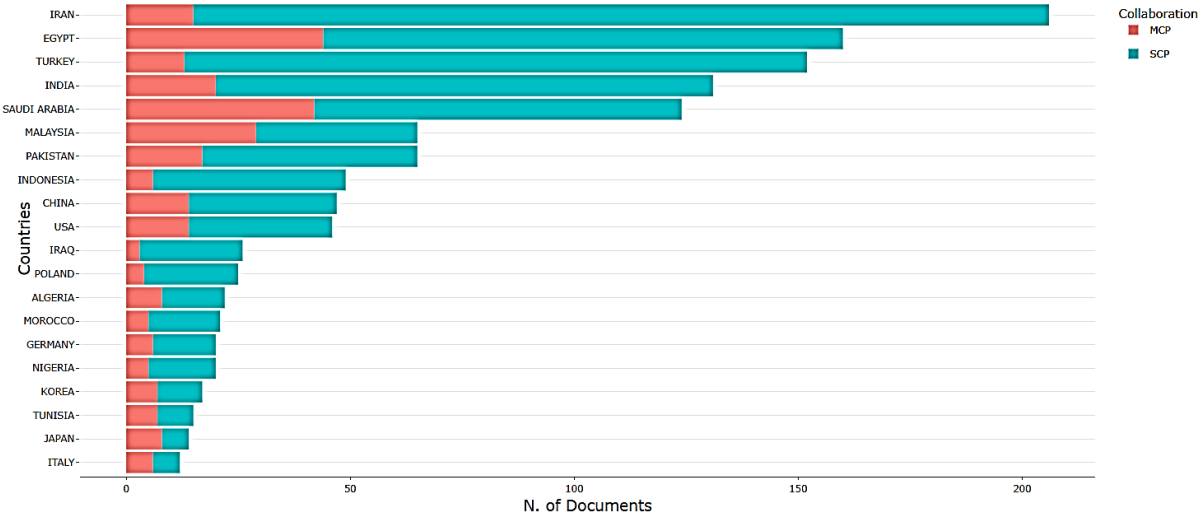

Figure 6. Distribution of corresponding authors by country in publications on *Nigella sativa* (2000–2025)

3.5.2. Scientific Production by Country

Significant contributions also come from Malaysia, Pakistan, and Indonesia, reflecting growing interest in Southeast Asia.

Beyond this region, China, the United States, and several European countries (Germany, Poland, Italy) also provide regular contributions, highlighting the international expansion of this research field.

3.4. Thematic Analysis

3.4.1. Main Themes and Applications

The thematic mapping confirms that research on *Nigella sativa* is structured around two main axes. The first concerns pharmacological mechanisms, including antioxidant effects, induction of apoptosis, modulation of inflammatory processes, and toxicity assessment. The second axis relates to therapeutic applications, with particular attention given to diabetes, cancer, COVID-19, as well as hepatic and renal diseases (Figure 7).

This diversity of approaches highlights the importance of the plant as a biomedical resource and underscores its potential in the development of new therapeutic strategies.

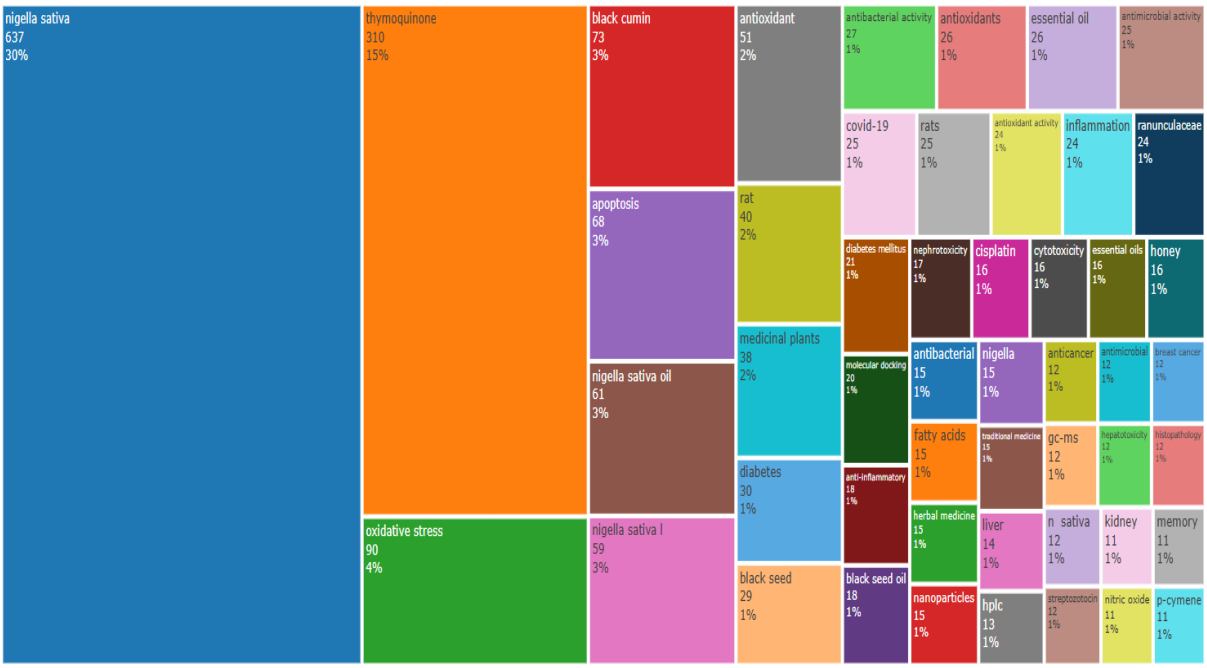

Figure 7. Tree Map of the most frequent keywords in publications on *Nigella sativa* (2000–2025)

3.4.2. Evolution of Research Themes

Trend topic analysis shows a progressive development of *Nigella sativa* research topics over two decades. Earlier investigations, before 2000, concentrated largely on generic terms such as essential oil or antioxidant, emphasizing an exploratory method of research. Between 2000 and 2010, the focus moved toward experimental pharmacological studies, which began to feature keyword applications such as animal experiment, controlled research, and toxicology.

The following decade (2010–2020) revealed substantial diversification with themes related to biological mechanisms, focusing on oxidative stress, apoptosis, antibacterial activity, inflammation, and cancer. Finally, the most recent period (2020–2025) displays innovative approaches, with the inclusion of current topics: COVID-19, nanoparticles, drug delivery, and molecular docking (Figure 8).

This evolution epitomizes the change from descriptive research to mechanistic and technological strategies, reaffirming the continued vigor and significance of research dedicated to *Nigella sativa*.

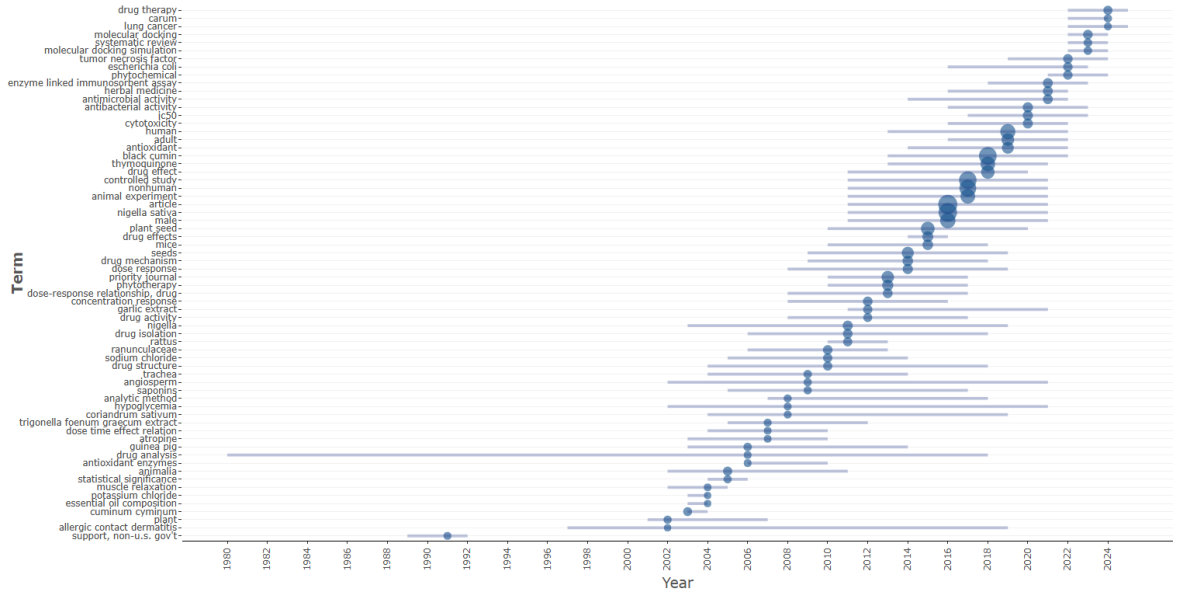

Figure 8. Evolution of research themes on *Nigella sativa* (2000–2025)

3.5. Bibliometric Networks

3.5.1. Co-citation Network

The co-citation network illustrates the most influential authors in *Nigella sativa* science and their clustering into thematic communities. The red cluster, the largest, brings together authors such as Ahmad A., Burits M., Ali B. H., and Balem M. I., whose work has focused on the pharmacological and biological properties of *Nigella sativa*, especially on thymoquinone and mechanisms of action (Figures 9).

The green cluster includes researchers such as Zoorob R., Adakhanh M., and Hosseinzadeh H., whose contributions are more oriented toward clinical and experimental applications, particularly animal models and studies of physiological systems. The blue cluster, smaller but highly interconnected, is related to authors who prioritize more recent and specific approaches, notably molecular pharmacology and some emergent uses. The network is characterized by tight connections of links within clusters, signalling cohesiveness between scientific communities, but also high connectivity between clusters.

This is indicative of an area of research that is growing — and evolving — in tandem. This mapping demonstrates that studies of *Nigella sativa* are based on key authors whose work is frequently cited and that co-citation dynamics aid in building a foundation in evidence.

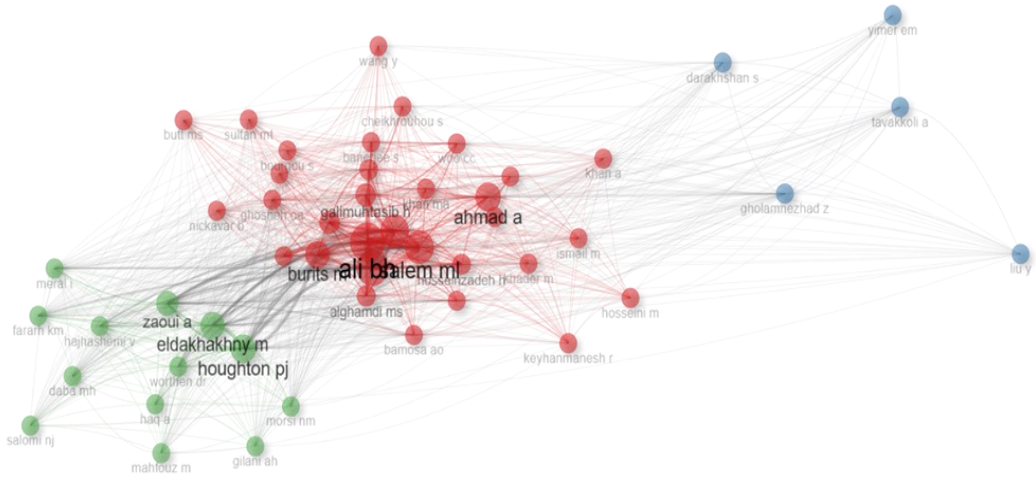

Figure 9. Co-citation network of authors in *Nigella sativa* research (2000–2025)

3.5.2. Keyword Co-occurrence Network

The focus of the keyword co-occurrence network reveals the theme-oriented structure of research on *Nigella sativa* and its primary relationships (Figure 10). Three major clusters emerge as obvious exemplars:

- The first cluster, based on animal experimental models, has more words dominated (rat, control group, serum, and oxidative stress), which indicates a large literature used in preclinical studies.
- The second cluster is based on biological and pharmacological mechanisms with search keywords like

apoptosis, inhibition, gene expression, and anticancer activity, demonstrating an interest in knowing the molecular activities of the plant.

• In the third cluster, terms are associated with bioactive compounds and formulations (e.g., extract, essential oil, thymoquinone, assay, and nanoparticles), emphasizing their increasing importance for medical and pharmaceutical engineering.

The high density of relationships between these clusters indicates that an interrelated research space exists where laboratory, pharmaceutical, and applied research work complement each other to broaden knowledge and to try out new therapeutic applications of *Nigella sativa*

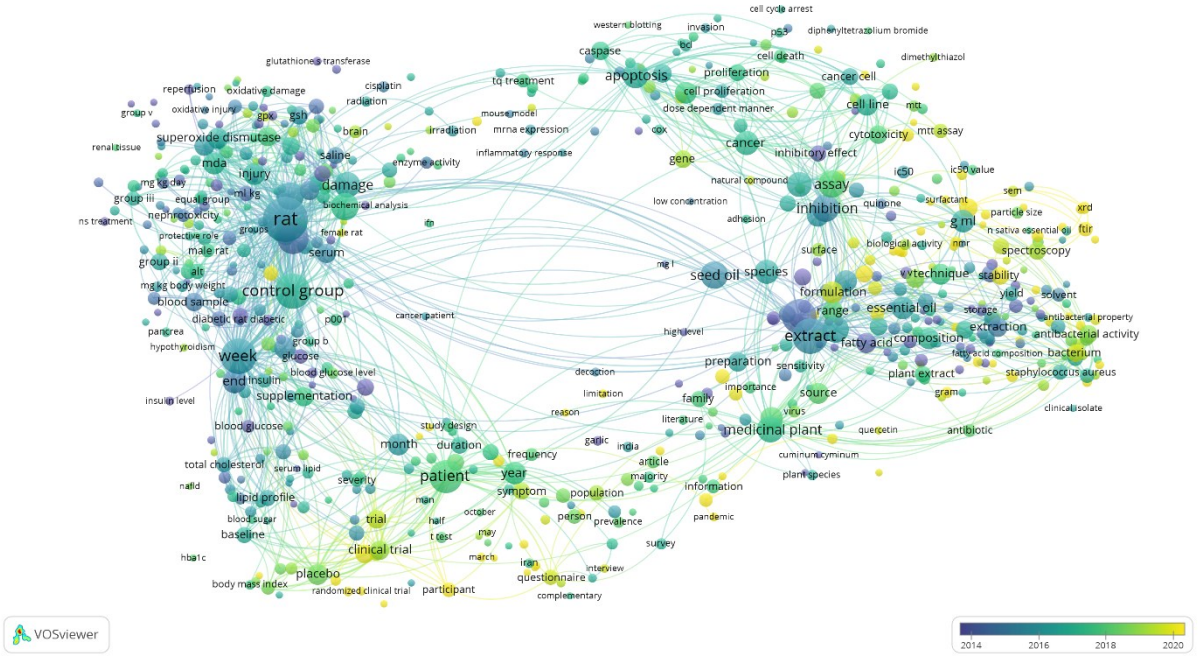

Figure 10. Keyword co-occurrence network in *Nigella sativa* research (2000–2025)

3.5.3. Thematic Network and Emerging Concepts

This thematic mapping highlights the centrality of the term *"Nigella sativa"*, which constitutes the core around which several groups of keywords revolve. The main network brings together terms related to experimental models and biological mechanisms, such as streptozotocin, cytokine, NF-kB, and mitochondria, reflecting the importance of preclinical studies (Figure 11).

The appearance of recent keywords like *COVID-19*, associated with immunological themes, illustrates the adaptation of research to contemporary issues. Other thematic subsets, such as peptidomimetics, protein, or fibrinolytic system, indicate more specialized approaches in molecular pharmacology. Finally, the presence of terms related to therapeutic applications (diabetes mellitus type 2, ischemia, combination therapy) demonstrates the translational orientation of this research.

Overall, the network confirms that research on *Nigella sativa* combines a strong experimental foundation with an increasing openness toward innovative biomedical applications.

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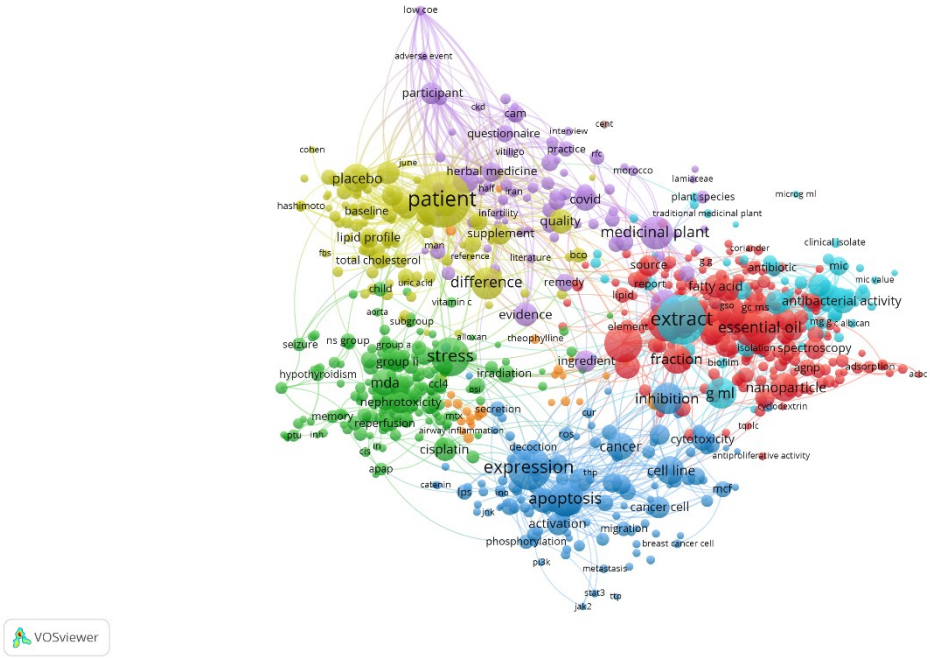

Figure 11. Thematic keyword network related to *Nigella sativa* (2000–2025)

3.5.4. Author Collaboration Network

In the publication, the 'author collaboration network' shows several similar thematic clusters bringing together scholars who are often linked up in the publications (Figure 12).

A central core emerges with authors including Saadia Mubshara, Qadir Rahman and Fatima Hina as key persons leading the federating of several co-authors. A second cluster, evidenced by the figures of Ahmad Abdul, Alkharfy Khalid M. and Al-Mohaize Abdullah M., is a smaller but highly interconnected network. Finally, a third group, dense and homogeneous, including such authors as Zahra Nureen, Anwer Ayesha, and Al-Asmari Fahad, is evidence of research communities that are very active, probably aiming at certain themes. In general, this picture illustrates that *Nigella sativa's* research is based on proper cooperation in networks, in which some authors are scientific pivots, facilitating exchanges and strengthening the field's visibility as a subject of interest at the international level.

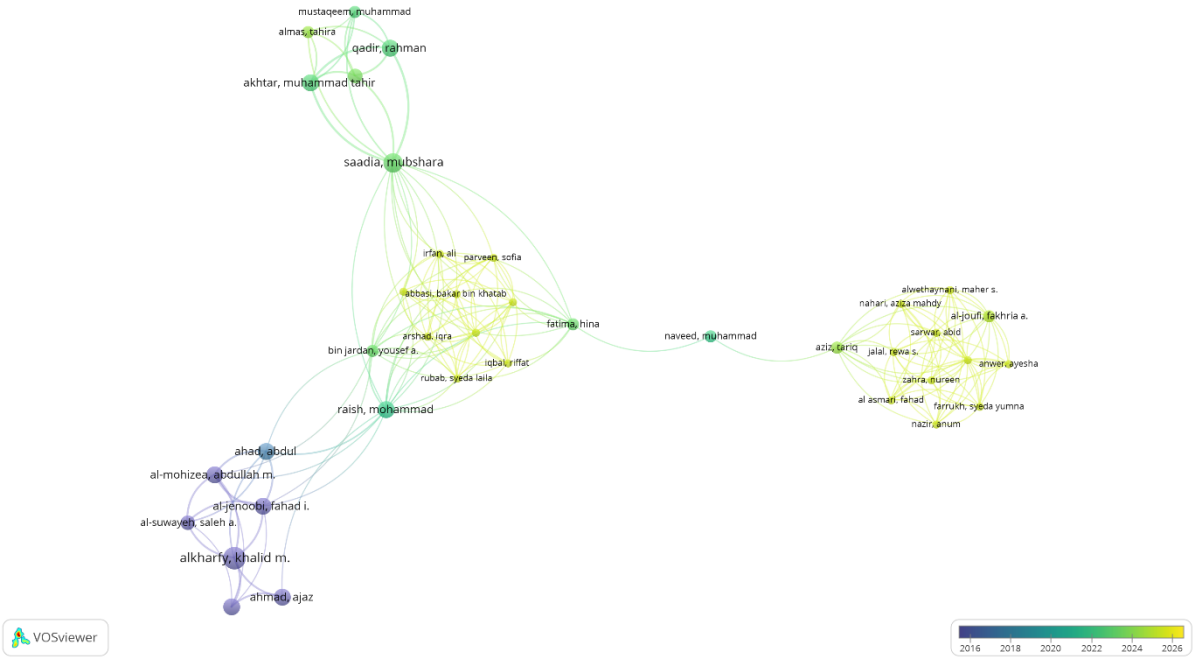

Figure 12. Author collaboration network in *Nigella sativa* research

5.5. Thematic Mapping of Keywords Associated with Nigella sativa

The thematic mapping underscores that "*Nigella sativa*" is the primary component of the network, consolidating the majority of the relationships (Figure 13).

There are several clusters of keywords around this nucleus. One cluster is associated with experimental and pathophysiological applications, encompassing streptozotocin, cytokine, NF-kB, mitochondria, and ischemia, indicating the value of animal models and mechanistic work. Recent terms, such as "COVID-19", indicate research adapting to current challenges and focusing on the immunomodulatory and antiviral aspects of the plant itself. More specialized subgroups (peptidomimetics, protein, and fibrinolytic system) suggest a more focused approach to molecular pharmacology as well as biotechnologies.

On the whole, this network indicates that *Nigella sativa* research is evidence-based, while also embracing novel medical and technical uses.

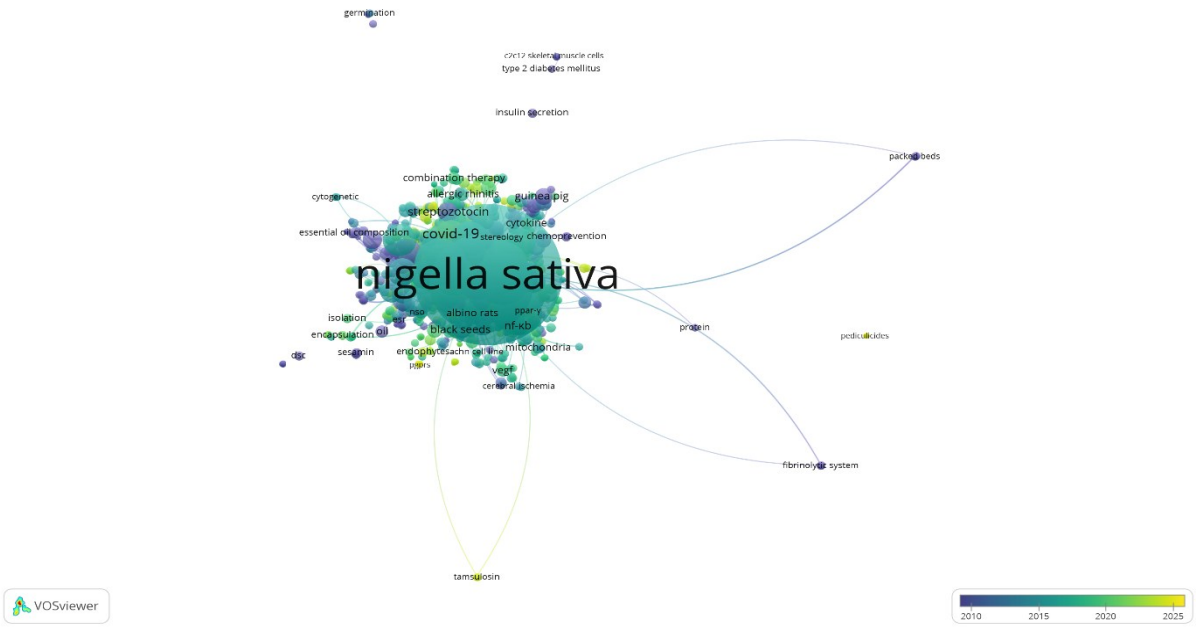

Figure 13. Thematic network of keywords related to *Nigella sativa* (2000–2025)

4. Discussion

Bibliometric analysis reveals a steady and sustained increase in the number of publications devoted to *Nigella sativa* over the last twenty years, highlighting the growing scientific interest in this medicinal plant (Figure 14). The figure provides a visual summary of the main characteristics of *Nigella sativa*, which is known for its multiple therapeutic effects (Alberts et al., 2024). Various products are developed for medical purposes from its seeds and extracts, particularly oil. The pharmacological activity of this plant is mainly attributed to its rich phytochemical composition, including thymoquinone, essential oils and other bioactive compounds (Mostofa et al., 2017). These constituents give *Nigella sativa* a variety of properties: anti-inflammatory, antioxidant, antimicrobial, immunomodulatory, analgesic, gastroprotective, antitumour and antispasmodic (Anaeigoudari et al., 2021). It is also of particular interest for its potential in the prevention and treatment of metabolic disorders such as diabetes and obesity.

This progression is not only the result of a general enthusiasm for natural medicines and medicinal plants (Ekor, 2014) but also of a strong desire to scientifically validate traditional knowledge using modern methods (Nasir & Saleem, 2021). Thus, publications reveal a dual movement: on the one hand, the experimental confirmation of empirical uses known since Antiquity, and on the other hand, the exploration of new therapeutic applications adapted to contemporary public health needs (Ahmad et al., 2013).

Furthermore, the thematic evolution shows a clear shift from predominantly descriptive and ethnobotanical research, focused on chemical composition and general properties (Ali & Blunden, 2003), toward more mechanistic and applied approaches. Current studies rely on molecular pharmacology, biotechnology, and clinical research, confirming the growing maturity of the field (Goreja, 2003; Tavakkoli et al., 2017). This dynamic reflects a process of "scientification" of traditional medicine, where ancestral practices are integrated within a modern biomedical framework (Nasir & Saleem, 2021).

The geographical distribution of publications shows that research is strongly concentrated in the Middle East and South Asia, particularly in Iran, Egypt, Turkey, India, and Saudi Arabia (Boskabady et al., 2011). This regional dominance is explained by the cultural anchoring of the plant in these countries, where it has been used for centuries in traditional medicine (Ahmad et al., 2013). Universities and research centers in these regions act as scientific drivers, benefiting both from direct access to the plant resource and from societal interest in valorizing local medical heritage (Hosseinzadeh et al., 2007).

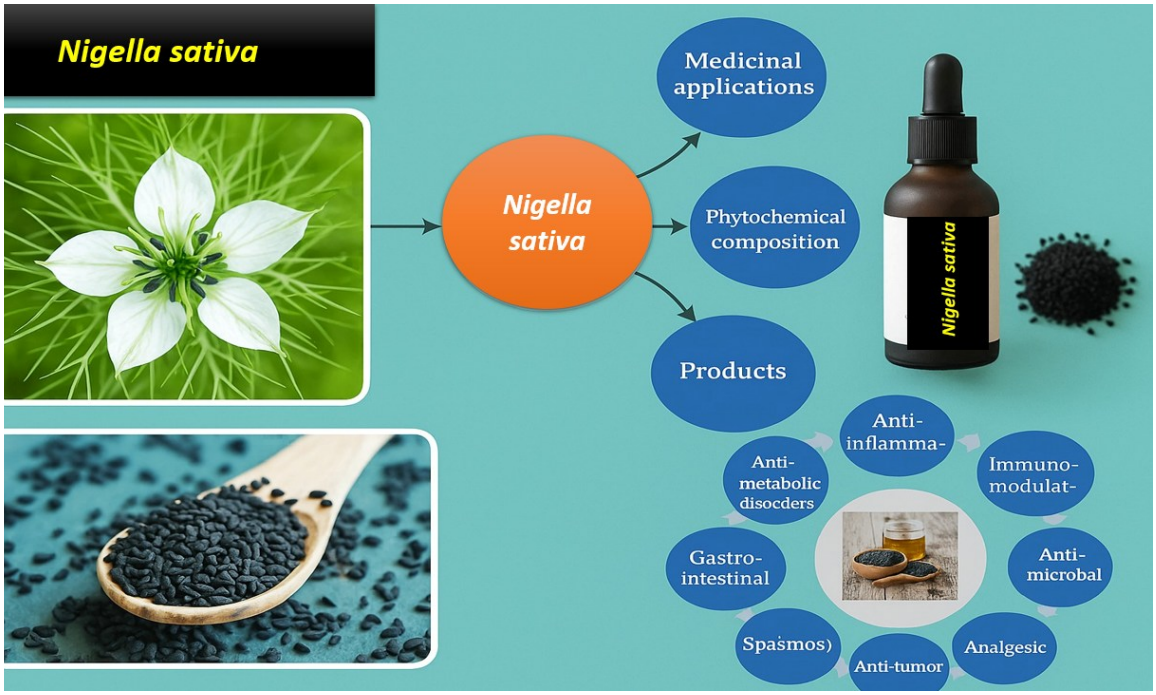

Figure 14. Overview of the Therapeutic Benefits of *Nigella sativa*

However, there is also a noticeable rise in new research hubs. Countries such as Malaysia, Indonesia, and Pakistan are strengthening their presence (Rahman et al., 2021), benefiting from both strong traditional consumption of the plant and public policies promoting pharmaceutical research. At the same time, significant contributions are emerging from the United States and several European countries (Germany, Italy, Poland), indicating a progressive internationalization of the field (Khader & Eckl, 2014). This geographical expansion contributes to diversifying approaches and enhancing the scientific credibility of the research being conducted.

International collaborations, while still relatively limited, are gradually increasing and represent a promising trend (Donthu et al., 2021). Multi-country publications (MCP), although still in the minority, are on the rise, fostering methodological exchange, data sharing, and the pooling of experimental resources. In the long term, such cooperation is expected to enhance the scientific quality and international recognition of research on *Nigella sativa* (Moed, 2005).

The author analysis shows the existence of a core group of prolific researchers, such as Hosseini M., Kanter M., Boskabady M. H., and Ahmad A., who play a structuring role in the field (Hosseinzadeh et al., 2007; Ahmad et al., 2013). Their widely cited works constitute essential references and guide future research directions. These authors distinguish themselves by their ability to cover a broad range of topics, from pharmacological studies on animal models to clinical applications. Their role as "scientific pivots" is crucial, as they ensure continuity of research and contribute to consolidating the theoretical foundations of the field.

On the editorial side, journals such as *Molecules* and *Evidence-Based Complementary and Alternative Medicine* stand out as major platforms for dissemination (Donthu et al., 2021). Their impact is linked to their editorial policy, which is favorable to interdisciplinary studies on natural products and pharmacology. Other specialized journals, such as *Pharmaceutical Biology* and *Food Chemistry*, also contribute to the field's visibility (Rahman et al., 2021), confirming the multidisciplinary nature of research on *Nigella sativa*. This editorial diversity illustrates how the field lies at the intersection of several disciplines: pharmacology, chemistry, complementary medicine, and nutrition (Ekor, 2014).

In terms of themes, traditional research on oxidative stress, inflammation, cancer, and diabetes remains central (Tavakkoli et al., 2017; Khader & Eckl, 2014). However, new topics are emerging, reflecting the field's adaptation to contemporary scientific and societal needs. The appearance of COVID-19 in recent keywords illustrates this responsiveness: several studies have explored the antiviral and immunomodulatory potential of *Nigella sativa* as therapeutic leads in response to the pandemic (Bouchentouf & Missoum, 2020).

In addition, recent studies on nanoparticles, active compound delivery systems (drug delivery), and molecular docking highlight the growing integration of modern biomedical technologies (Rafati et al., 2019). These themes demonstrate a willingness to go beyond traditional use, developing innovative pharmaceutical formulations and personalized applications. The emergence of such research positions *Nigella sativa* as a privileged model for the convergence between traditional medicine and modern biotechnologies (Nasir & Saleem, 2021).

As with any bibliometric study, this analysis has certain limitations. First, it relies exclusively on the Scopus database, whose coverage, though extensive, remains selective and may omit certain regional or local journals, particularly those published in Arabic, Persian, or other non-

English languages (Moed, 2005). This may lead to an underrepresentation of local scientific production.

Second, the use of a language filter favoring English reduces the diversity of contributions and introduces linguistic bias (Donthu et al., 2021). Some studies published in local journals in national languages, potentially rich in ethnobotanical information, may have been excluded.

Third, the use of a single keyword (*Nigella sativa*) restricts the search to articles that mention this exact scientific name. However, the plant is also referred to by other vernacular terms, such as *black cumin* or *black seed*, which may have resulted in the exclusion of relevant publications (Ahmad et al., 2013).

Finally, as with any bibliometric analysis, the results reflect the structure of the database and the applied methodology, rather than the entirety of global scientific production (Moed, 2005). These limitations do not invalidate the findings, but they do call for caution in interpretation and underline the importance of complementing this approach with other methods (systematic reviews, meta-analyses, ethnobotanical surveys).

5. Conclusion

This bibliometric review provides an overview of research on *Nigella sativa* between 2000 and 2025, revealing a rapidly growing scientific dynamic, particularly over the last decade. The analysis highlights the main players, themes and international collaborations, demonstrating a diversification of approaches to this medicinal plant. Beyond the specific case of *Nigella sativa*, this study illustrates the growing role of medicinal plants in contemporary biomedical research. Their therapeutic potential is attracting renewed interest, particularly in light of the limitations of conventional treatments. However, challenges remain: a low number of clinical trials, a lack of standardisation, and scientific validation that is still incomplete. *Nigella sativa* thus appears to be an emblematic example of the dialogue between traditional knowledge and scientific innovation. To strengthen this convergence, future research should promote interdisciplinary approaches, encourage clinical validation, and explore new fields of application. This review thus provides a useful framework for guiding future research and contributing to the better integration of medicinal plants into evidence-based health strategies.

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