Research Article

Türk Fen ve Sağlık Dergisi
Turkish Journal of Science and Health

Volume 7
Number 2
Year 2026
Pages 69-88

e-ISSN: 2717-7173 https://dergipark.org.tr/tr/pub/tfsd

Received: 08.11.2025 *Accepted:* 28.04.2026 https://doi.org/10.51972/tfsd.1800212

A Bibliometric Analysis of Chalcones with Antimicrobial Potential

Nisanur Pekgöz [1]*, Gülay Demir [2], Hayreddin Gezegen [3]

[1]Sivas Cumhuriyet University, Institute of Health Sciences, Department of Nutrition and Dietetics, Sivas, Türkiye
[2]Sivas Cumhuriyet University, Vocational School of Health Services, Sivas, Türkiye
[3]Sivas Cumhuriyet University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Sivas, Türkiye

ABSTRACT:
Purpose: Chalcones are secondary metabolites that occur naturally in plants and cannot be synthesized in the human and animal body. Its structure is 1,3-diaryl-2-propen-1-one and is the precursor of flavonoids. It has many important activities such as antimicrobial, antidiabetic, antiviral, antifungal, anti-inflammatory, antituberculosis and antitumor. The aim of this study was to conduct first time a bibliometric analysis on chalcones and their antimicrobial effects. It aims to reveal the trends and main findings in the academic literature on this subject.
Material and Methods: This article performs a detailed bibliometric analysis of the antimicrobial activity of chalcones using the Biblioshiny application from the Bibliometric package with the R program and the VOSviewer tool. The Scopus database was searched for 571 relevant articles published between 2014 and 2024.
Results: India is the most important country, followed by Brazil and then China. The article "A Review: The Pharmacology of Isoliquiritigenin" by Peng et al. (2015) published in PHYTOTHER RES was the most contributing study with 222 citations. With 23 articles, JOURNAL OF MOLECULAR STRUCTURE is the most important journal and OSMANIA UNIVERSITY is the most important institution with 77 articles.
Conclusion: 571 English-language publications on chalcones and antimicrobials were identified within the relevant time frame. The results were as follows: the average age of the articles was 5.18 years, and there was an average of 13.93 citations per document. Of the 2,447 authors, 13 were sole authors. International co-authorship accounted for 18.74% of all co-authored articles. According to the three-field graph, the top country is "Brazil," the leading author parameter is "Bandeira Pn.," and the keyword is "antimicrobial activity."
Keywords: *Chalcones; antimicrobial; bibliometric analysis; biblioshiny; vosviewer*

**Corresponding author: Nisanur Pekgöz, email: nisanurpkgz5858@gmail.com*

INTRODUCTION

Chalcones are a group of polyphenolic compounds synthesized by plants that are precursors to the flavonoid family (Yücel et al., 2023). The structure of chalcones, known as precursors of flavonoids and isoflavonoids, is in the form of two aromatic rings joined by an α,β-unsaturated carbonyl bridge. Various plants, such as vegetables, fruits, spices, and teas, commonly contain chalcones (Nguyen et al., 2024; Zhuang et al., 2017). Chalcone derivatives can be synthesized in simple and diverse ways via the Claisen-Schmidt condensation (Claisen, 1881; Schmidt, 1881).

Chalcones are a group of naturally occurring compounds with various biological effects that show promise in drug design. They serve as lead compounds in the development of new drugs (Gomes et al., 2017). Additionally, chalcones and chalcone derivatives, particularly hydroxy-functionalized chalcones, have demonstrated a high capacity for scavenging free radicals (Kudličková et al., 2023; Chu and Guo, 2016).

Due to the number and positions of various substituents, including hydroxy, methoxy, methyl,

prenyl, geranyl, lavandulyl, pyran, furan, and glucosyl derivatives, chalcones have a central skeleton consisting of 1,3-diaryl-2-propen-1-one with great structural diversity (Ferreira et al., 2021). Due to the presence of three rotatable bonds in their structure and the ability of the linker between the two aromatic rings to act as a Michael acceptor, chalcones can reach different enzyme targets (Matos et al., 2015). Therefore, many pharmacologically active compounds containing chalcones can function as antitumor (Sharma et al., 2016), antidiabetic (Rocha et al., 2019), cytotoxicity (Reddy et al., 2012) and anti-inflammatory agents (Nowakowska, 2007). In addition, chalcones exhibit important therapeutic pharmacological activities such as antioxidant (Anto et al., 1995), antihypertensive (Kumar et al., 2015), antimalarial (Li et al., 1995), antiulcer (Kyogoku et al., 1979), antiviral (Mazumder et al., 1996), and antituberculosis activity (Lin et al., 2002).

In a study, various chalcones and chalcone-like compounds were found to exhibit more than 90% inhibitory activity against Mtb (Mycobacterium tuberculosis) (Lin et al., 2002). Lycochalcones have been tested and found to exhibit antibacterial effects against a variety of Gram-positive bacteria, including spore-forming bacteria, and toxin-producing bacteria (Tsukiyama et al., 2002). It is emphasized that the antifungal potential of chalcones is currently maintained, especially in studies conducted on resistant strains (Dos Santos et al., 2023). In addition, the antidepressant properties of chalcones have been demonstrated in various synthesized chalcone derivatives (Guan et al., 2013).

In chalcone and dihydropyrazoles, the nature and position of substituents on the phenyl ring are very important factors for antimicrobial activity (Shaik et al., 2020). Antimicrobial activity tests were conducted on hydroxy derivatives of synthetically produced chalcones. The hydroxy chalcones significantly inhibited the growth of Escherichia coli, Staphylococcus aureus, and Candida albicans yeast strains (Krawczyk-Łebek et al., 2024).

Current research and bibliometric analyses are crucial for understanding the antimicrobial activity of chalcones and for new drug discovery. This article presents a bibliometric analysis to assess the antimicrobial activity of chalcones and guide future research in this area.

Bibliometrics is an innovative technique for conducting comprehensive literature studies on a given topic, offering a significant advantage. In recent years, the application of bibliographic analysis has gained popularity, supported by the use of software tools such as Google Ngram, CiteSpace, Carrot 2, Gephi, Leximancer, VOSviewer, and Bibliometrix (Demir, Chatterjee and Pamucar, 2024a). Based in part on the premise that a field's published literature represents its knowledge, bibliometric analysis can provide statistical descriptions of publications, providing data on productivity rates, publication patterns, and publication characteristics. It uses computerized analytical techniques with the individual publication as the unit of analysis and draws data from sources such as MEDLINE, Google Scholar, or Journal Citation Reports (JCR; Clarivate Analytics) (Wilson et al., 2021). It is a valuable tool for uncovering the current status and future trends of a given academic field (Zhang et al., 2023). Scholars use bibliometric analysis for a variety of reasons, including to uncover emerging trends in article and journal performance, collaboration patterns and research components, and to explore the intellectual structure of a particular field in existing literature (Donthu et al., 2021).

This study used the Scopus abstract and citation database for its search and analysis capabilities. We chose Scopus because it is the most powerful search engine in the social sciences. Scopus is a comprehensive and multidisciplinary database that covers a vast range of scientific journals, conference proceedings, books, and other scholarly publications (Martín-Martín et al., 2018).

This study used the keywords "chalcones" and "antimicrobial" in the Scopus database, using R Studio, Biblioshiny, and VOSviewer. This study will provide guidance for other researchers by providing suggestions for future research using these keywords, including the number of authors conducting research, the status of international author collaborations, the annual status of publications, the status of citations, the most important countries, authors, universities, and subject headings. This study will contribute

significantly to the literature, as there are no bibliometric studies on chalcones covering the period between 2014 and 2024. The research results will help us understand the current status and potential for research into changes related to chalcones. Furthermore, by evaluating the antimicrobial components of chalcones, it will guide developments in this region.

This study is organized as follows: First, a brief literature review on chalcones is provided. It then provides an introduction to the research methodology. It then presents a discussion and analysis of the research results, identifying and summarizing research issues, research gaps, and research trends related to chalcones. The final section presents conclusions and limitations.

Literature Review

This paper is the first to systematically analyze the antimicrobial potential of chalcones using bibliometric methods. Bibliometric methods were extensively applied between 2014 and 2024 for in-depth research and analysis of the antimicrobial activity of chalcones.

Medicinal plant extracts have attracted great interest from a phytochemical and pharmacological perspective throughout history. Many studies have focused on these therapeutic properties. Using a PRISMA methodology, widely adopted in Brazil, a detailed search was conducted in databases such as PubMed, ScienceDirect, Scopus, and Web of Science for articles published between 2012 and 2022. Various keywords were used, including "plant extracts," "wound healing," "medicinal plant," "Brazil," and "Northeast Brazil" (Coelho et al., 2024). The medicinal plant hops, Humulus lupulus L., contains xanthohumol (XN), a prenylated chalcone. A comprehensive literature review on the effects of this chalcone compound on cancer revealed that xanthohumol is effective against aging, diabetes, inflammation, microbial infections, and cancer. Bibliometric analysis was performed using VOSviewer and RStudio, yielding a dataset of 291 documents from the SCOPUS database. The keywords "xanthohumol" and "cancer" were selected for the electronic search query (Girisa et al., 2021).

Peer-reviewed articles published in English between January 1980 and December 2019 concerning the antimicrobial activity of medicinal plants against pathogenic microorganisms were systematically searched using the Web of Science and Scopus databases. Combinations of the keywords “antimicrobial activity”, “medicinal plants”, and “Africa” were used in the literature search. The obtained data were analyzed using VOSviewer, CiteSpace, and RStudio software. A total of 5218 publications were found during the search; however, 2174 studies were included in the evaluation based on the specified inclusion criteria (Achilonu and Udensi, 2022).

The antimicrobial, antibacterial, antifungal, antimalarial, antiviral, and anti-inflammatory activities of natural and synthetic chalcones, which are abundant in plants, are being investigated with great interest. Studies published in the European Journal of Medicinal Chemistry (EJMC), one of the leading journals in the field of medicinal chemistry, were scientifically analyzed using bibliometric tools. The Web of Science Core Collection (WoSCC) was used as the data source, and the data was accessed on September 6, 2022. The analysis evaluated 12,424 research articles and 962 reviews. The obtained publications were analyzed using VOSviewer (1.6.18), CiteSpace (6.1.R3), and R (4.1.2) software (Zhang et al., 2023).

A comprehensive systematic review covering the years 1972-2020 was conducted to evaluate the in vivo antiviral potential of natural components. A search was carried out using keywords encompassing specific phenolic classes such as 'chalcone', 'flavonoid', 'anthocyanidin', and 'auron' across PubMed, SciFinder, and Scopus databases, resulting in a total of 15,786 records. Based on established elimination criteria, 186 articles were selected for analysis and subjected to bibliometric mapping using VOSviewer software (Ponticelli et al., 2023).

Due to its rich phytochemical profile and diverse therapeutic potential, the main bioactive compounds of white mulberry (Morus alba) exhibit various pharmacological activities. For bibliometric analysis, a comprehensive literature search was conducted using VOSviewer software with the

keywords “mulberry”, “flavonoids”, and “phytochemistry” in PubMed and Scopus databases. The search results were limited to research articles published from 2000 onwards, with a total of 1107 articles providing an overview of mulberry flavonoids (Fatima et al., 2024).

Current literature trends examining the effects of medicinal plant-derived antimicrobial agents on human and animal pathogens were evaluated through a systematic bibliometric analysis conducted using the Scopus database. This search, covering the period 1999-2020 and conducted within the parameters of 'antimicrobial' and 'medicinal plants', identified 5,044 indexed records; the obtained data were analyzed using VantagePoint software (Muñoz-Acevedo et al., 2022).

In the literature examining the effects of flavonoids on anxiety, the keywords “flavonoid”, “elevated plus-maze”, “light-dark test”, “open-field test”, “hole board”, “zebrafish”, “anxiety”, “rat”, and “mouse” were searched in pairs and ternary combinations. Bibliometric analysis was conducted on May 18, 2024, using the PubMed database, and the obtained data were analyzed using the bibliometrix package in R software. The documents examined cover a 30-year period between 1994 and 2024 and consist of a total of 197 publications (Machado et al., 2024).

There are studies on the antiproliferative effect of chalcones in human colon cancer cells. One study reported that melatonin (MLT) derivatives containing oxdiazole bioisosters and chalcone compounds showed a significant antiproliferative effect on the SW480 human colon cancer cell line. In this study, which was performed with bibliometric analysis, the Scopus database was accessed on August 16, 2023, and the time range was selected as 1973-2023. A total of 2,792 articles were retrieved from Scopus. VOSviewer was used for data analysis and visualization. The search was performed using the keywords "melatonin", "cancer", "hybrid", and "molecular docking" (Yepes, Galeano and Ramírez-Malule, 2024).

Aspalathin (Aspalathus linearis-rooibos), consumed worldwide as an herbal tea, is a naturally occurring dihydrochalcone. A bibliometric study was conducted on aspalathin, which contains a wide variety of phenolic compounds such as dihydrochalcones, flavones, flavonols, and phenolic acids, using the Scopus database hosted by Elsevier to retrieve relevant publications. The Scopus search yielded 140 publications between 1965 and 2020. The search was performed using the keyword "aspalathin". VOSviewer was used for maps and visualizations (Chaudhary et al., 2021).

Coumarins are compounds belonging to the benzopyrone family and are associated with various beneficial effects on human health, including reducing cancer risk. Coumarin-chalcone hybrid compounds have been reported to exhibit approximately 30-fold higher selectivity against the cervical carcinoma C33A cell line compared to normal fibroblast NIH3T3 cells. In this context, a search of the Scopus database using the keywords “coumarin” and “anticancer activity” yielded a total of 458 publications between 1993 and 2022. The obtained data were analyzed and visualized using VOSviewer (1.6.18) software (Cardona-Galeano, Ramirez-Malule, and Gómez-Ríos, 2023).

There are current studies on the microwave-assisted synthesis of flavanone derivatives. A study conducted for this purpose involved searching the Scopus database using the keywords “microwave”, “synthesis”, and “flavanone”. Data was obtained on June 30, 2023, and analysis and scientific mapping were performed using VOSviewer software. A total of 33 publications were evaluated as part of the bibliometric review; the oldest study in this field dates back to 1999, and as of 2023, only two publications on the subject were found (Poerwono and Rudyanto, 2023).

Considering that acacia catechu bark extract contains flavonoids, studies on these compounds were bibliographically analyzed covering the period from 1975 to March 8, 2024. A search of the Dimensions database using the keyword combinations “Flavonoid of Acacia catechu bark extract” and related keywords yielded a total of 2,972 publications. The obtained data were evaluated in terms of co-authorship, co-occurrence, and citation analyses using VOSviewer software (Tiwari and Tiwari, 2024).

According to bibliometric data from the Web of Science Core Collection database, the volume of literature focusing on 'resveratrol' has reached

17,561 publications. Frequency analysis of the keyword indexes of these publications reveals that trans-resveratrol, polyphenols, flavonoids, and curcumin are the phytochemical classes with the highest correlation to resveratrol studies (Yeung et al., 2019).

Additionally, the biological and pharmacological profile of pinocembrin, a product of the chalcone synthase enzyme, was analyzed through a systematic search of the Scopus, PubMed, Web of Science, and Science Direct databases. This literature mining, conducted using the parameters 'pinocembrin' and 'biological/pharmacological activities', resulted in the identification of 576 scientific publications documenting the therapeutic potential of the compound (Elbatreek et al., 2023).

Within the scope of the literature review, no direct bibliometric attack on chalcones and antimicrobial activity was found. This situation reveals its originality. For this reason, studies in which similar methodological approaches were applied to different compounds and biological activities were examined and evaluated comparatively.

Table 1. Methodological characteristics and comparison of bibliometric studies on natural compounds and biological activities

Authors	Year	Keywords	Time range	Number of publications included	Database	Package programs used
Girisa et al.	2021	“xanthohumol” and “cancer”	1998-2020	291	Scopus	VOSviewer RStudio
Mannino et al.	2021	“Plant Biostimulant”	1958-2021	1680	PubMed	VOSviewer
Yepes, Galeano and Ramírez-Malule	2024	melatonin”, “cancer”, “hybrid” and “molecular docking	1973-2023	2.792	Scopus	VOSviewer
Machado et al.	2024	“flavonoid”,” elevated plus-maze”, “light-dark test”, “open-field test”, “hole board”, “anxiety”	1994-2024	197	PubMed	R package ‘bibliometrix’
Poerwono and Rudyanto	2023	“microwave”, “synthesis” and “flavanone”	1999-2023	33	Scopus	VOSviewer
Achilonu and Udensi	2022	“antimicrobial activity”, “medicinal plants”	1980-2019	2174	Web of Science and Scopus	VOSviewer, CiteSpace, Rstudio
Cardona-Galeano, Ramirez-Malule and Gómez-Ríos	2023	“coumarin” and” anticancer activity”	1993-2022	458	Scopus	VOSviewer
Yeung et al.	2024	“anthocyanin”	1970-2022	44.121	Web of Science	VOSviewer
Fatima et al.	2024	"Mulberry", "Flavonoids", "Phytochemistry”	2000-2024	1107	PubMed and Scopus	VOSviewer
Muñoz-Acevedo et al.	2022	“antimicrobial” and “medicinal plants”	1999-2020	5.044	Scopus	VantagePoint
Ponticelli et al.	2023	“antiviral”, “benzoic acid”, “anthocyanidin”, “catechin”, “chalcone”, “cinnamic acid”, “flavonoid”	1972-2020	186	PubMed, SciFinder, Scopus	VOSviewer

When Table 1 is examined, it is seen that bibliometric analyzes mostly focus on different natural products such as flavonoids, coumarins, anthocyanins and various plant compounds and their biological activities (Girisa et al., 2021; Mannino et al., 2021; Cardona-Galeano et al., 2023). However, although the keyword "antimicrobial activity" is included in some studies, no bibliometric analysis has been found in which it is directly associated with chalcones. It is also noteworthy that in the majority of studies, Scopus and Web of Science databases were preferred as data sources and VOSviewer software was widely used in analyses. This shows that the methods used in the current study are compatible with the literature and supports the original value of the study.

Chalcones are chemical compounds with a 1,3-diaryl-2-propen-1-one structure belonging to the flavonoid family. Studies have reported that chalcones exhibit anti-inflammatory, antimicrobial, antioxidant, anticancer, cytotoxic, analgesic, antidiabetic, antihepatotoxic, antimalarial, and antiallergic properties, and that these compounds have broad therapeutic potential (Nowakowska, 2007; Anto et al., 1995; Reddy et al., 2012; Sharma et al., 2016; Kumar et al., 2015; Li et al., 1995; Mazumder et al., 1996). Moreover, chalcones and their derivatives are widely investigated for their versatile pharmacological and biological activities, such as antimicrobial, antibacterial, and antiviral effects (Nematollahi et al., 2023). Chalcones are widely found in bioactive natural products and pharmaceuticals and have become one of the most popular approaches in drug development due to their significant therapeutic potential (Aydoğan and Deveci, 2024). Especially in the last few years, chalcones have been increasingly used as starting materials for various chemical transformations and to provide novel heterocyclic scaffolds with potentially interesting biological activities (Marotta et al., 2022). Within the scope of this study, research on chalcones and antimicrobial activity was evaluated with the bibliometric analysis method in line with the data obtained from the Scopus database, and it was aimed to determine scientific trends, collaborations and research focuses in the field.

MATERIAL and METHODS

In this study, the relationships between scientific studies were examined using bibliometric analysis. The Scopus database was searched for the keywords "chalcones, antimicrobial".

Purpose and Type of the Study

Bibliometrics allows us to comprehensively analyze trends in a given field. It also allows us to explore the contributions of individuals from different institutions and countries. Medical fields have widely used bibliometrics as a research method in recent years (Cheng et al., 2022; Han et al., 2023).

Research Questions and Research Gaps

- What is the growth trend and citation status of articles related to chalcone studies?
- Who are the most cited leading authors in the field?
- What are the most cited journals, documents, countries, and organizations?
- What are the main research topics and thematic studies in this field?

The primary objective of this research is to answer these identified questions.

Sampling and participant

The population of this study consisted of 1000 articles obtained by searching the Scopus database with the keywords "chalcones, antimicrobial". However, when limited by inclusion factors such as document type, publication language, and publication year, 571 articles were used as a sample.

Data Collection Tools

The data collection process for the bibliometric analysis was carried out as follows: The Scopus database was accessed. Publications were filtered and evaluated using inclusion and exclusion criteria. The query period was determined between 2014 and 2024, and the data was downloaded on November 12, 2024. 571 scientific articles were accessed for the data to be used in the bibliometric analysis. The bibliometric analysis was conducted using RStudio (Biblioshiny), an application designed for bibliometric analysis with a web interface that does not require coding, and the VOSviewer mapping program, one of the software programs developed for bibliometric purposes (Demir et al., 2024b; Baş, 2023). Through performance analysis of the studies, basic information, annual status of publications, annual status of citations, three-field chart, status of journals, membership status, author status, country status, and article status were determined. The process steps in the bibliometric analysis are summarized in Figure 1.

Scopus is considered the largest database in the social sciences and is used by numerous authors for comparable studies (Bashar, Singh and Pathak, 2022; Hassan et al., 2022). While the WoS and Scopus databases are fundamentally similar, Scopus is considered a comprehensive index of existing social scientific literature (Ferreira and Santos, 2021).

Analysis of Findings

The diagram showing the steps of the research shows the number of publications, citation status, countries' activity and collaboration networks, most important authors, most productive countries, keyword network map, thematic and factor analysis studies were conducted using RStudio (biblioshiny) and VOSviewer programs. The data obtained in the results section was interpreted and evaluated.

Ethical Approval

This study did not require ethics committee approval because it did not involve any direct intervention on human or animal subjects and used only previously published studies as the data source.

RESULTS

The study's Scopus database consists of 1000 publications. Filtering between 2014 and 2024 resulted in a total of 571 publications.

Performance Analysis

Between 2014 and 2024, 571 articles were found in 230 journals. 2,447 authors published studies using the keywords "chalcones" and "antimicrobial," and 13 of these authors contributed individually to the literature. This indicates that the field largely has a multi-authored and collaborative research structure. The international collaboration rate among authors is 18.74%. The fact that the rate of international collaboration among the authors is 18.74% reveals that there is a limited but developing international collaboration network in the field of chalcones and antimicrobial activity. The average age of the studies being 5.18 years indicates that the field is a relatively current and active research topic.

Annual Status of Publications

Figure 1.b shows that 571 articles were published in the literature between 2014 and 2024. According to the graph, the number of articles showed a variable trend. However, the general trend suggests that chalcones and their antimicrobial activity remain a research area of continuity, though not showing a steady increase.

Status of Citations

The annual citation rates for publications show a fluctuating trend, according to the graph. While publications published in 2014 received 12.67% of their citations, publications published in 2024 received 1.54%. This change stems from the fluctuation in the number of articles using the keywords "chalcones" and "antimicrobial" on this topic (Figure 1.c). This situation can be explained by the fact that older publications accumulate more citations over time, as well as by changes in the number of publications in the field. Therefore, citation distribution reflects both the effect of time and changes in publication density.

Three-Field Diagram

Three parameters were examined in this three-field diagram, also known as a Sunkey diagram. Using the Biblioshiny package, the author, country, and keyword parameters were studied. The size of the tiles in Figure 1.d indicates the magnitude of the relationship between the parameters. In this diagram, the size of the boxes represents the effective parameters in the literature (Demir, Chatterjee and Pamucar, 2024a). According to this diagram, the most important country is "Brazil," the most important author is "Bandeira Pn," and the most important keyword is "antimicrobial activity." This situation highlights that Brazil is one of the leading research centers in this field, and that studies are largely focused on antimicrobial activity.

The Most Productive Countries and Their Cooperation Map

Figure 1.e shows the countries with the highest number of publications and citations related to chalcones and antimicrobials. The map shows the countries with the most articles published, the countries with the fewest articles published, and the countries with no articles published. The dark blue color on the world map represents the countries that have conducted the most studies. Blue and its shades represent countries that have conducted fewer studies, and gray represents countries that have not conducted any studies at all (Demir et al., 2024b). Since a single article may include authors or researchers from more than one country, a single

article is attributed to multiple countries. In this case, while the total number of articles is the total number of country contributions exceeds 571. Since the total count method is used in the analysis of country productivity, multi-country co-authored publications are counted separately for each country. Therefore, the total number of publications attributed to a country may exceed the total number of articles analyzed.

The top 10 countries publishing articles on chalcones are shown in the table in Figure 1.e According to the table, India ranks first with 1,184 articles, Brazil second with 399 articles, and China third with 175 articles.

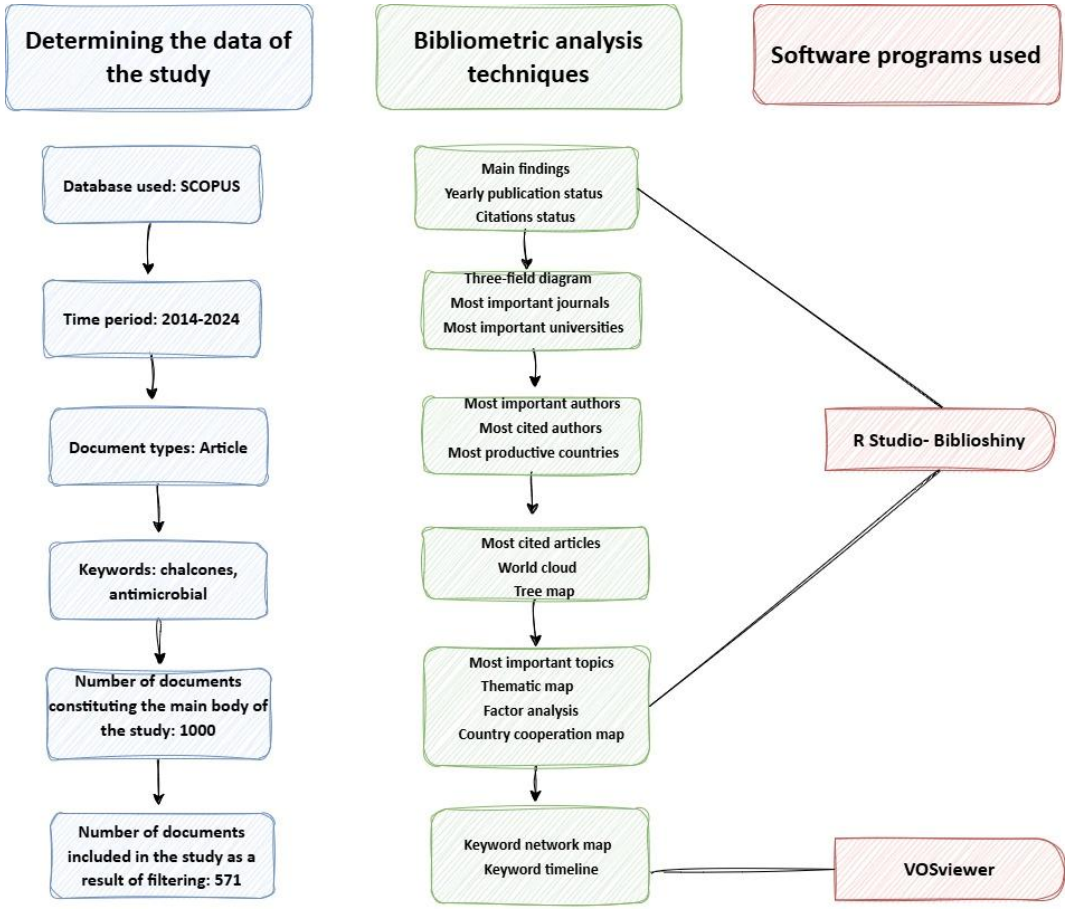

Figure 1. Bibliometric analysis methodological flow chart

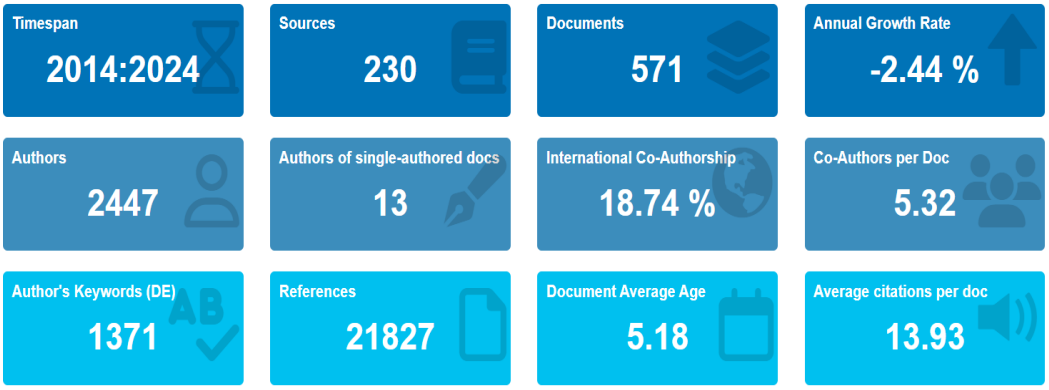

Figure 1.a. Main findings

India's leadership in this field is linked not only to the number of publications but also to its tradition of research based on plant-derived compounds. In particular, it is well established that studies rooted in Ayurveda contribute to modern pharmaceutical research (Elahee et al., 2019). Furthermore, rising antimicrobial resistance is a key factor driving the search for new compounds (Laxminarayan et al., 2013). Thus, given India's rich biodiversity and strong tradition in natural product chemistry, a connection can be drawn between its numerous native plant species and research on chalcone derivatives.

Figure 1.f shows a map of global collaboration among countries in chalcone-related studies. Such a map can be used to showcase collaborations between researchers or institutions in different countries for academic research purposes (Demir et al., 2024b).

Thick brown lines or lines with high connections indicate greater cooperation, while thin brown lines indicate less cooperation (Demir et al., 2024b). Egypt and Saudi Arabia ranked first with 22 collaborations, India and Saudi Arabia ranked second with 12 collaborations, and India and the USA ranked third with 6 collaborations. India is the world's best country in terms of cooperation.

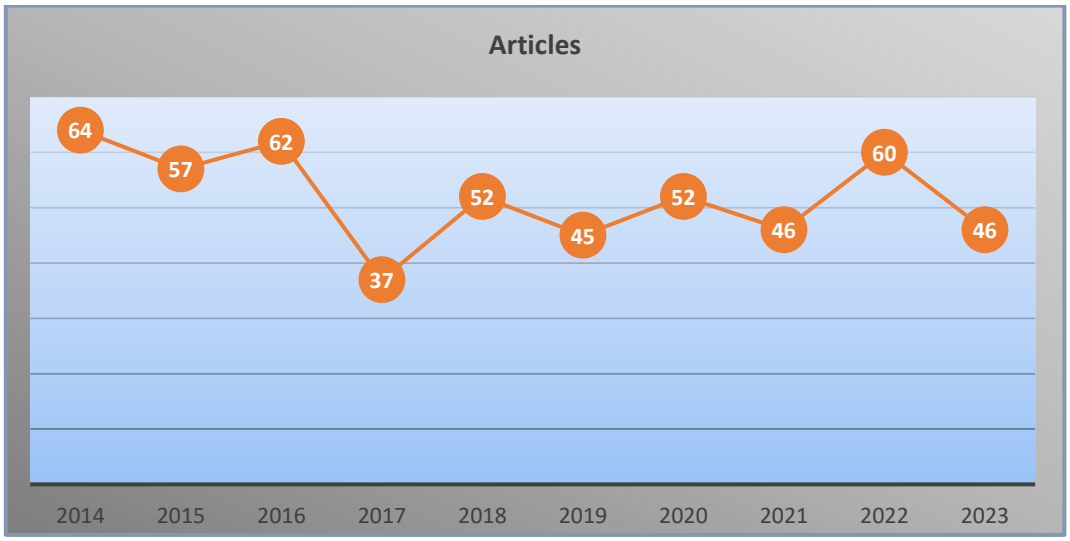

Figure 1.b. Annual status of publications

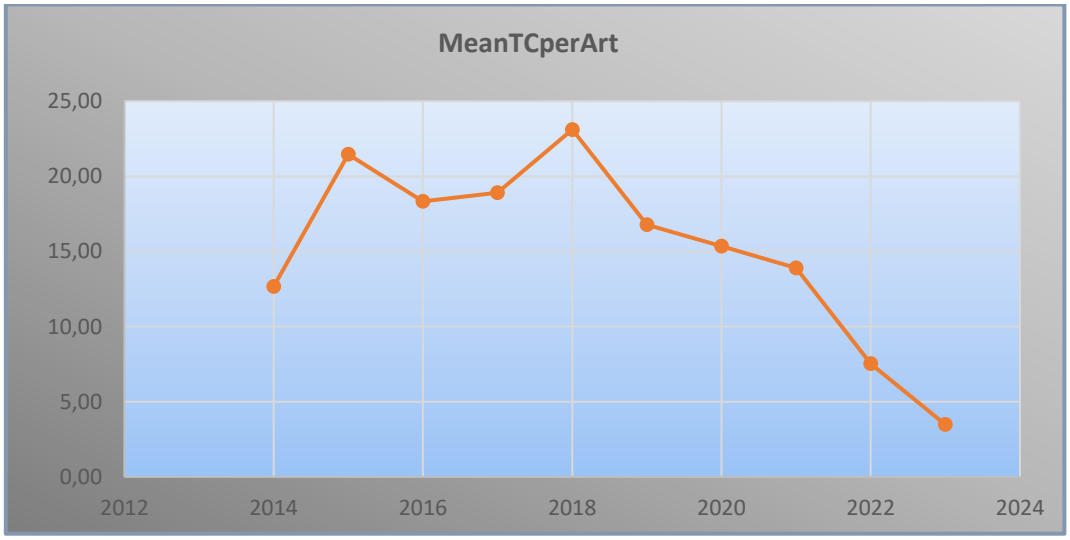

Figure 1.c. Status of citations

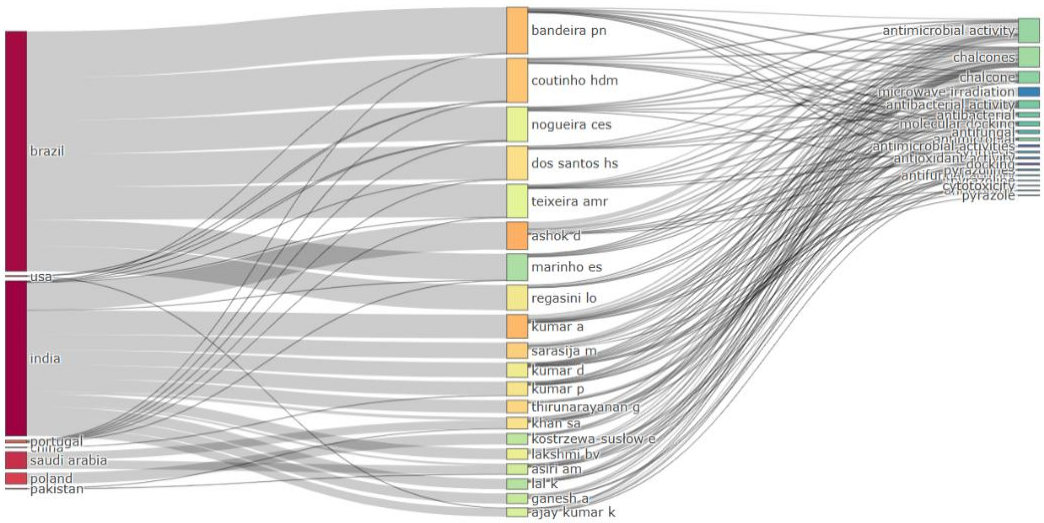

Figure 1.d. Three-field diagram

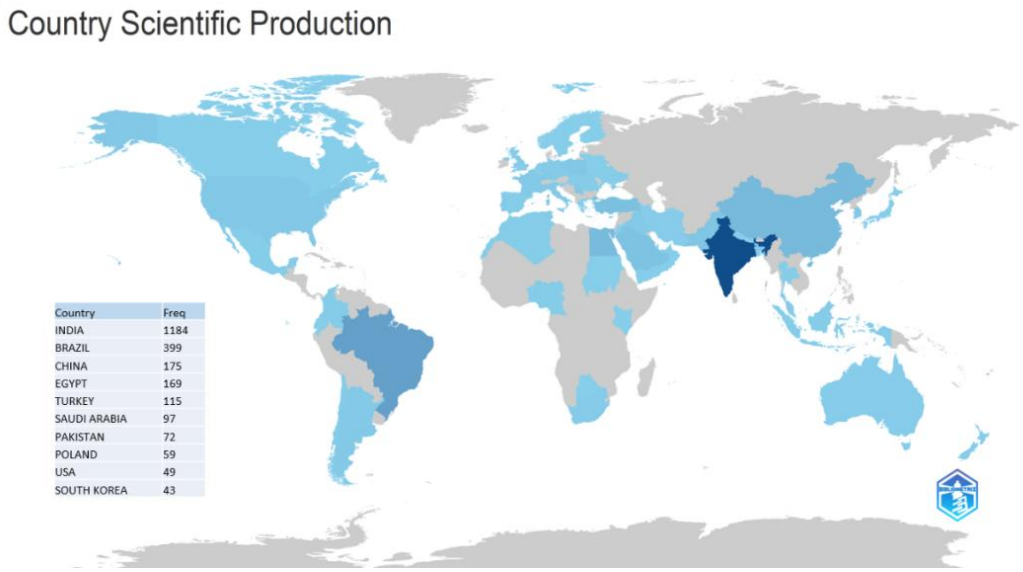

Figure 1.e. The most productive countries

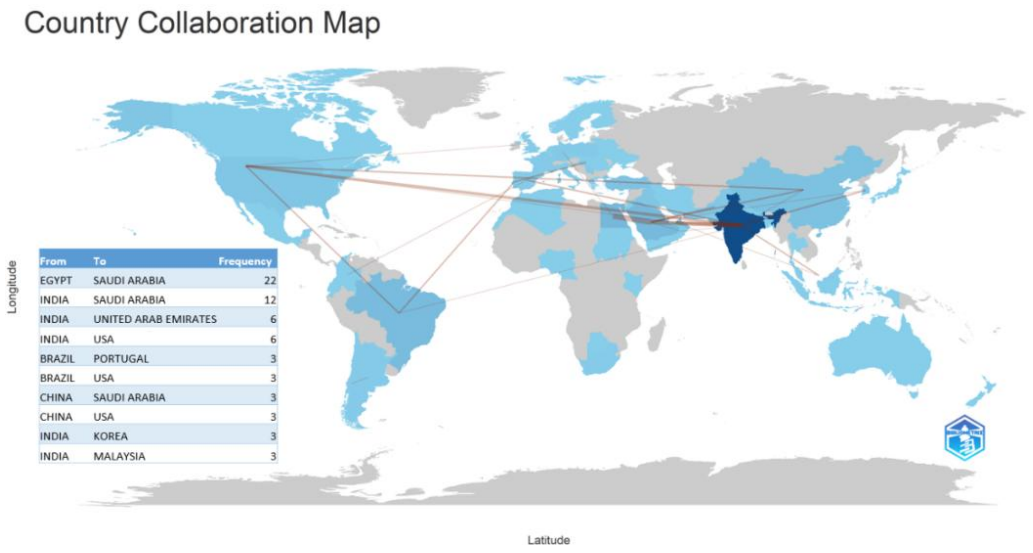

Figure 1.f. Country cooperation map

Table 2. The most important journals

SOURCES	ARTICLES
JOURNAL OF MOLECULAR STRUCTURE	23
ASIAN JOURNAL OF CHEMISTRY	21
DER PHARMA CHEMICA	20
MOLECULES	17
RUSSIAN JOURNAL OF GENERAL CHEMISTRY	17
MEDICINAL CHEMISTRY RESEARCH	16
ARABIAN JOURNAL OF CHEMISTRY	12
EUROPEAN JOURNAL OF MEDICINAL CHEMISTRY	10
INDIAN JOURNAL OF HETEROCYCLIC CHEMISTRY	10
RESEARCH JOURNAL OF PHARMACY AND TECHNOLOGY	10

Table 2.a. The most important universities

AFFILIATION	ARTICLES
OSMANIA UNIVERSITY	77
UNIVERSITY OF MYSORE	40
WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES	39
KING ABDULAZIZ UNIVERSITY	36
REGIONAL UNIVERSITY OF CARIRI	34
UNIVERSIDADE REGIONAL DO CARIRI	34
GOVERNMENT ARTS COLLEGE	31
GURU JAMBHESHWAR UNIVERSITY OF SCIENCE AND TECHNOLOGY	30
NITTE UNIVERSITY	29
UNIVERSITY OF PORTO	28

Table 2.b. Most important authors

AUTHORS	ARTICLES
ASHOK D	18
KUMAR A	15
BANDEIRA PN	10
COUTINHO HDM	10
SARASIJA M	10
THIRUNARAYANAN G	9
DOS SANTOS HS	8
KHAN SA	8
KUMAR P	8
REGASINI LO	8

Table 2.c. Most cited authors

AUTHORS	TOTALCITATION
KUMAR A	350
CHEN J	283
PENG F	244
KUMAR D	237
DU Q	222
PENG C	222
SHEN J	222
TANG H	222
WANG N	222
XIE X	222

Table 2.d. Most cited articles

PAPER	DOI	TOTAL CITATIONS
PENG F, 2015, PHYTOTHER RES	10.1002/ptr.5348	222
KANT R, 2016, EUR J MED CHEM	10.1016/j.ejmech.2016.02.041	173
EL SHEHRY MF, 2018, EUR J MED CHEM	10.1016/j.ejmech.2017.10.046	169
YIN B-T, 2014, EUR J MED CHEM	10.1016/j.ejmech.2013.11.003	140
KOCYIGIT UM, 2018, ARCH PHYSIOL BIOCHEM	10.1080/13813455.2017.1360914	126
KWON SS, 2015, EUR J PHARM BIOPHARM	10.1016/j.ejpb.2015.02.025	122
BUENO-SILVA B, 2017, NAT PROD RES	10.1080/14786419.2016.1239088	108
SHAIK A, 2020, MOLECULES	10.3390/molecules25051047	106
YADAV P, 2018, EUR J MED CHEM	10.1016/j.ejmech.2018.05.055	102
INSUASTY B, 2015, EUR J MED CHEM	10.1016/j.ejmech.2015.02.040	92

Table 2.e. Most important topics

TERM	FREQUENY	YEAR (Q1)	YEAR (MEDIAN)	YEAR (Q3)
Chalcone Derivative	243	2016	2019	2022
Article	242	2015	2018	2021
Antiinfective Agent	216	2015	2018	2021
Nonhuman	202	2015	2018	2021
Unclassified Drug	192	2015	2017	2020
Chalcones	190	2017	2020	2022
Drug Synthesis	155	2015	2017	2020
Antifungal Activity	108	2015	2016	2019
Chalcone	103	2018	2022	2022
Human	92	2016	2019	2022

The Most Important Journals

According to Table 2, as a result of the analysis conducted with the keywords "chalcones" and "antimicrobial" between 2014 and 2024, the first place is JOURNAL OF MOLECULAR STRUCTURE with 23 articles, the second place is ASIAN JOURNAL OF CHEMISTRY with 21 articles and the third place is DER PHARMA CHEMICA with 20 articles. The high contribution of these journals supports the idea that the field is concentrated in the axes of synthetic chemistry and pharmaceutical chemistry.

Most Important Universities

According to the table, OSMANIA UNIVERSITY is in the first place with 77 articles, UNIVERSITY OF MYSORE is in the second place with 40 articles, and WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES is in the third place with 39 articles (Table 2.a). Universities based in India have a strong production capacity in this field, and contributions from Europe also show that the research has a global distribution.

Most Important Authors

According to the table, ASHOK D is in the 1st place with 18 articles, KUMAR A is in the 2nd place with 15 articles and BANDEIRA PN, COUTINHO HDM, SARASIJA M authors are in the 3rd place with 10 articles (Table 2.b). The equal contribution of authors such as Bandeira PN, Coutinho HDM, and Sarasija M suggests that collaborative research networks are strong.

Most Cited Authors

According to the table, KUMAR A. is in first place with 350 citations, CHEN J. is in second place with 283 citations, and PENG F. is in third place with 244 citations (Table 2.c). This result shows that not only productivity but also the scientific visibility and impact of studies are concentrated around certain researchers.

Most Cited Articles

Peng et al.'s article “A Review: The Pharmacology of Isoliquiritigenin,” published in the journal

PHYTOTHER RES in 2015, ranked first with 222 citations. Kant et al.'s article “Synthesis of newer 1,2,3-triazole-linked chalcone and flavone hybrid compounds and evaluation of their antimicrobial and cytotoxic activities,” published in the journal EUR J MED CHEM in 2016, ranked second with 173 citations. EL Shehry MF et al.'s article “Pyrazol moiety-bearing quinoline derivatives: Synthesis and biological evaluation as potential antibacterial and antifungal agents,” published in the journal EUR J Med Chem in 2018, ranked third with 169 citations (Table 2.d). This situation demonstrates that compilation studies have a high impact because they provide knowledge synthesis in the field. The second and third-ranked studies appear to focus on the synthesis and biological activities of hybrid compounds such as triazole and quinoline derivatives.

Most Important Topics

In Table 2.e, the word "chalcone dervative" was a significant word in the first quarter of 2016, the second quarter of 2019, and the third quarter of 2022. The word "article" was a significant word in the first quarter of 2015, the second quarter of 2018, and the third quarter of 2021. The word "antiinfective agent" was a significant word in the first quarter of 2015, the second quarter of 2018, and the third quarter of 2021. The word "chalcones" is currently actively used in literature. According to keyword analysis, the consistent prominence of the term "chalcone derivative" in 2016, 2019, and 2022 indicates the continuity of research interest and the periodic refocusing of the topic. The prominence of terms like "anti-infective agent" in certain years suggests that antimicrobial research, in particular, progresses with periodic shifts in focus. Furthermore, the active use of the term "chalcones" in the current literature shows that the field remains relevant and its research potential continues.

Word Cloud

The word cloud represents the importance of the keyword based on the size of each word and the number of documents in which it is used (Aparicio-Martinez et al., 2019). Words such as "chalcone derivatives," "chalcones," "eschericha coli," "anti-infective agent," "non-human," "controlled study," "unclassified drug," and "antimicrobial activity" were more frequently repeated in the literature (Figure 2).

Thematic Map

A thematic search of articles on chalcones was conducted using bibliometrics and author keywords to identify the main research topics in the field. Figure 2.a shows that, despite the different outbreaks related to chalcones, they are grouped under four themes. The motor theme section of the diagram displays clusters related to the most basic operating temperatures of the key studied, while the clusters in the basic theme section indicate the key's fundamental and evolving state. In other words, they represent clusters in continuous development. The emerging or declining theme section of the diagram displays newly emerging or declining keywords, while the niche theme section displays keywords for which there is considerable research on the topic but which are hidden from other sources. Therefore, it is important to consider which records related to which themes are highlighted in the keywords studied, and the main theme and motor theme sections of the diagram (Demir, Chatterjee and Pamucar, 2024a; Demir et al., 2024c).

When the author's keywords are considered, keywords such as "chalcones, molecular docking, bacteria, unclassified drug, Escherichia coli" are prominent in scientific studies.

Factor Analysis

Factor analysis is a statistical technique often used to reduce complexity and uncover hidden structures in multivariate data sets. It is a method used to understand the relationships between variables in a data set and make it more understandable and manageable. This analysis is often expressed in terms of coefficients called factor loadings. These loadings indicate which factors variables are associated with or which factors explain the commonality between specific variables (Demir et al., 2024b). A factor analysis generated using keywords is shown in Figure 2.b.

According to factor loadings, the red cluster included the words "chalcone derivative," "aspergillus niger," "carbon nuclear magnetic resonance,"

"ciprofloxacin," and "antiinfective agent." The blue cluster included the words "antimicrobial activity," "microbial sensitivity test," "chemistry," and "humans." The green cluster included the words "structure activity relation," and "ic50."

Keyword Network Map and Timeline

In this visualization, the size of a cluster reflects the number of publications in that cluster. Larger clusters contain more publications. The distance between two clusters roughly indicates the relationship between them in terms of citations. Clusters located close to one another tend to be strongly related in terms of citations. The connections represent the degree to which two keywords are used together (Van Eck and Waltman, 2017).

In the keyword network map in Figure 2.c, each color represents a different keyword cluster. According to the analysis, there are 21 different clusters. The green cluster focuses on the keywords “antimicrobial activity,” “chalcones,” “antifungal,” “antibacterial,” and “bioactive compounds,” and represents studies investigating the direct biological effects of chalcone derivatives. These studies primarily focus on the antibacterial effects of chalcones against Gram-positive and Gram-negative bacteria, as well as their antifungal activity against fungal pathogens. Additionally, the pharmacological potential of chalcones, evaluated within the context of plant-derived bioactive compounds, is also addressed within this cluster. Consequently, this cluster constitutes one of the primary areas of focus in pharmaceutical and phytochemical studies investigating the therapeutic effects of chalcones. The blue cluster is centered around the keywords “cyclocondensation,” “synthesis,” “derivatives,” “structure–activity relationship (SAR),” and “FT-IR (Fourier transform infrared spectrometer),” and represents studies focused on the chemical synthesis and structural optimization of chalcone derivatives. Within this scope, the primary emphasis is on the systematic investigation of the relationship between the structural properties and biological activities of these derivatives, achieved through the development of new chalcone derivatives using various synthetic methods, particularly cyclocondensation. Through structure-activity relationship analyses, the effects of specific functional groups or molecular modifications on biological activity are evaluated, and the design of more effective compounds is targeted accordingly. Thus, this cluster encompasses rational drug design and chemical development studies aimed at enhancing the biological activity of chalcones. The brown cluster is centered around the key terms “IR spectroscopy,” “NMR,” and “synthesis,” and represents studies in which synthesized chalcone derivatives are examined using analytical and spectroscopic methods. In this context, techniques such as infrared spectroscopy (IR) and nuclear magnetic resonance (NMR) are particularly used to confirm the structures of the relevant compounds and to elucidate their chemical properties. The yellow cluster includes the keywords “benzimidazole,” “1,2,3-triazole,” “antibacterial activity,” and “chalcones,” and represents studies that examine the biological and pharmacological effects of chalcone derivatives combined with various heterocyclic structures from a broad perspective. In this context, it is understood that the various biological effects—particularly antibacterial activity—of hybrid compounds obtained by integrating pharmacophore groups such as benzimidazole and 1,2,3-triazole into the chalcone skeleton have been investigated. The purple cluster includes the keywords “molecular docking,” “anticancer,” and “quinone,” and represents studies in which chalcone and similar structures are evaluated alongside quinone derivatives to investigate their anticancer potential using computer-aided approaches. The orange-colored words are “flavonoids, propolis, Candida bicornis, and docking studies.” Among the red-colored words, “dihydrochalcones, antimalarial, cytotoxicity, and S. aureus” are more frequently associated with one another.

The VOSviewer visualization in Figure 2.d shows the keyword network of academic studies on “chalcones” and changes in these keywords over time (Timeline). The largest nodes at the center of the network map represent the most established and widely used terms in this field (Van Eck and Waltman, 2010). As indicated in the lower right

corner of the figure, the color scale covers the period from 2012 (dark blue) to 2020 (bright yellow). According to Figure 2.d, extensive studies have been conducted on the terms “antimicrobial activity,” “chalcones,” “antifungal activity,” “pyrazolines,” “benzofurans,” “flavonoids,” and “isoxazoles.” Currently, the terms “molecular binding,” “antibiotic resistance,” “1,2,3-triazoles,” “anticancer activity,” “binding studies,” “Beauveria bassiana,” and “antioxidant” are actively used in the literature. Terms such as “antimicrobial activity,” “chalcones,” and “antibacterial activity” are predominantly represented in turquoise and green tones.

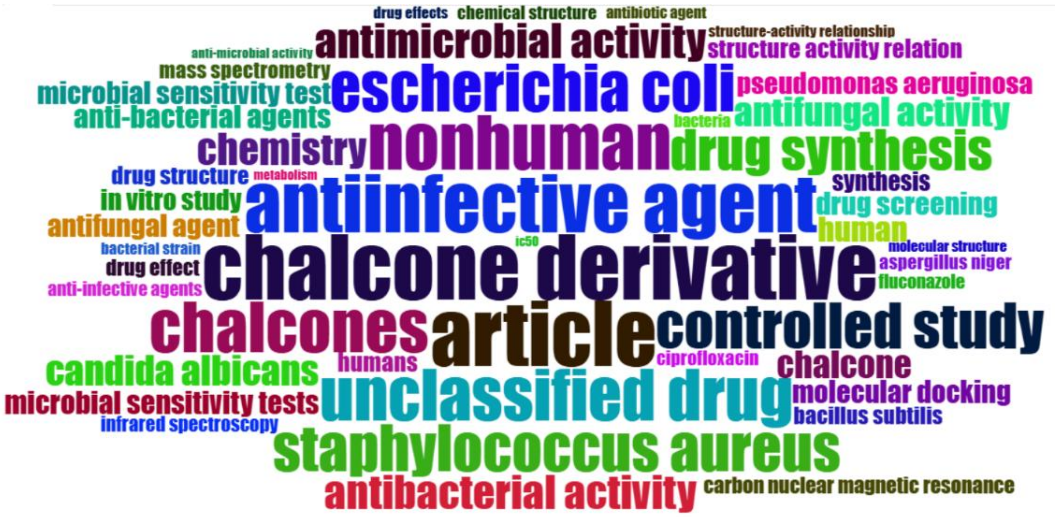

Figure 2. Word cloud

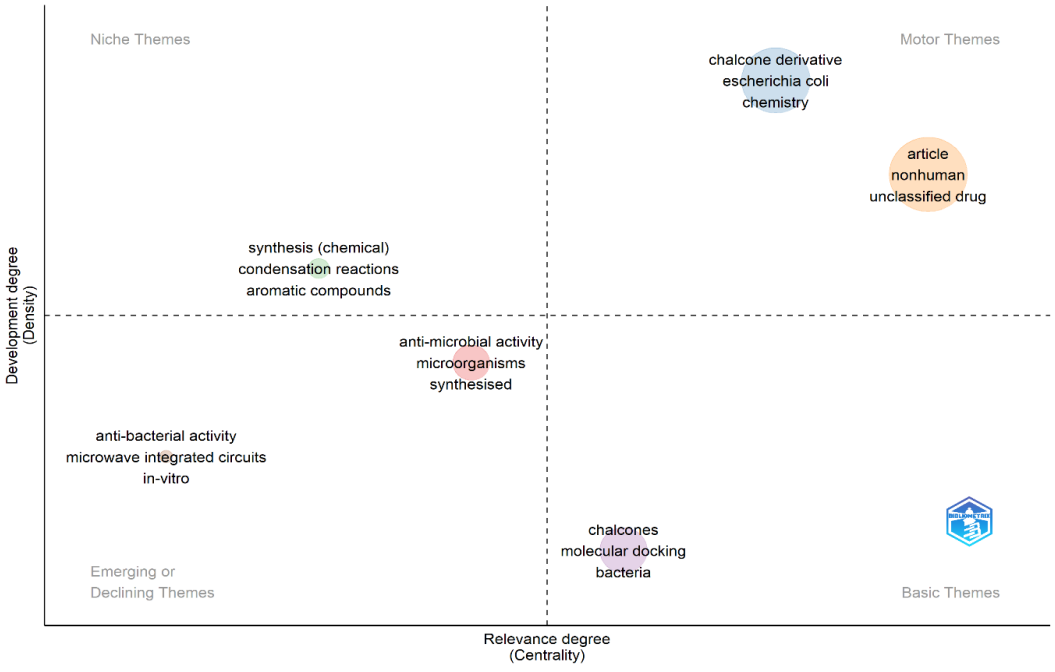

Figure 2.a. Thematic map

These terms cover the period between 2014 and 2016. This indicates that basic research on the biological activities of chalcones was particularly concentrated between 2014 and 2016 and forms the backbone of the literature. Terms such as “molecular binding” and “binding studies” are shown in lighter green shades closer to yellow; words like “indole,” “1,2,3-triazole,” “cytotoxicity,” and “antifungal” are depicted in darker green shades. This indicates that the research shifted from the “experimental” phase to computer-aided drug design and mechanism elucidation (in silico) in 2016 and beyond. The terms located at the outer edges of the map and marked in bright yellow represent the most current topics in the field. Terms such as “antibiofilm activity,” “antibiotic resistance,” “density functional theory” (dft), “beauveria bassiana,” “molInspiration,” “microwave irradiation,” and “drug design” indicate that these have recently gained popularity.

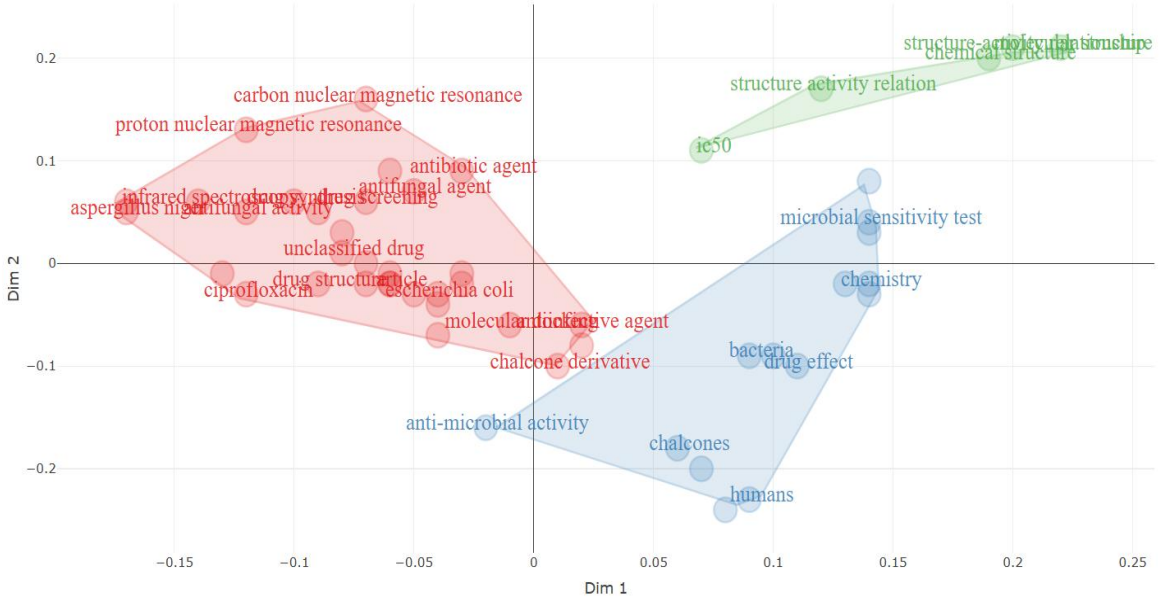

Figure 2.b. Factor analysis

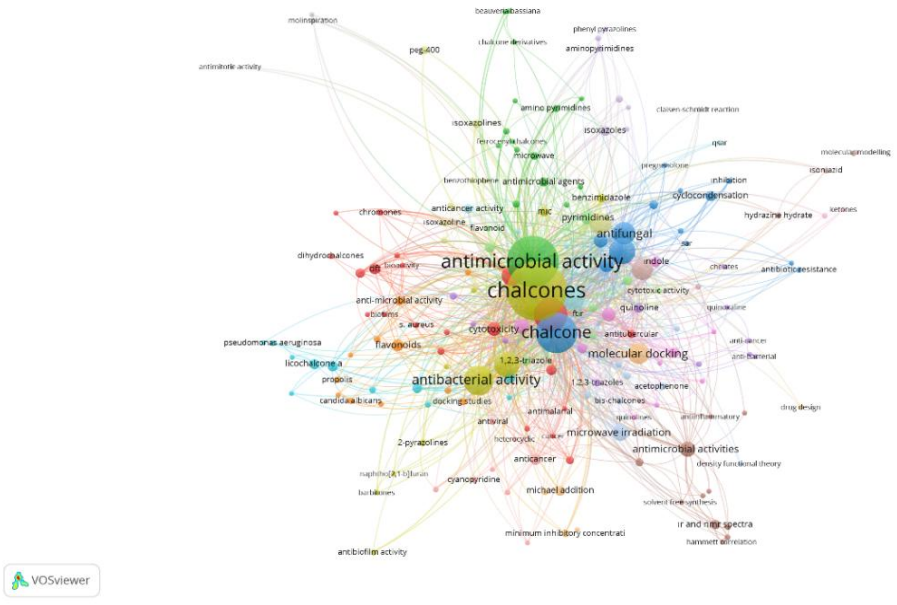

Figure 2.c. Keyword network map

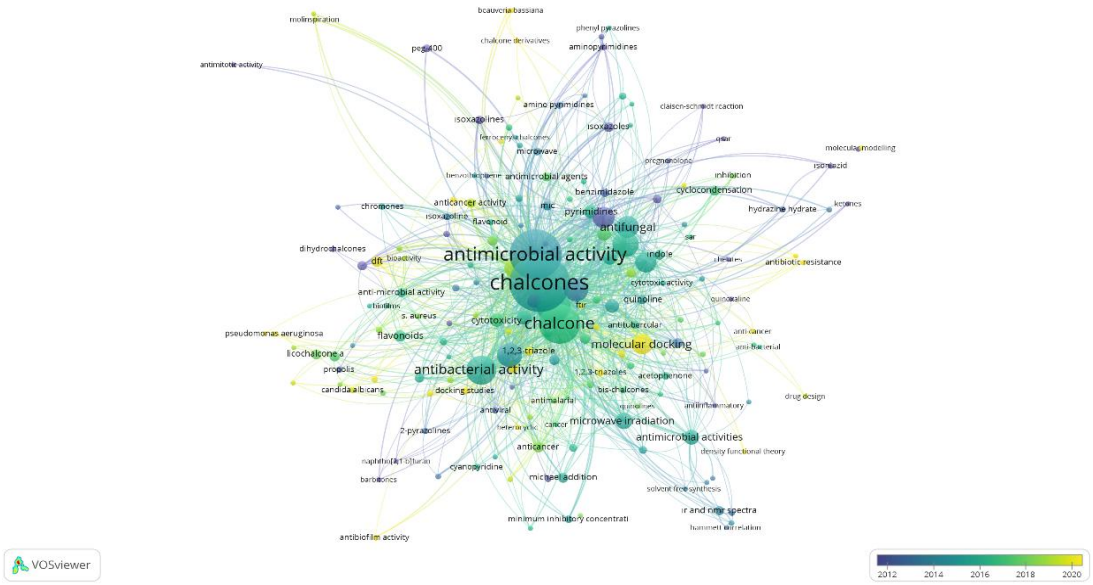

Figure 2.d. Timeline of keywords

DISCUSSION

This is the only bibliometric study conducted to identify the most productive authors, reference articles, organizations, nations, and academic fields on chalcones and their antimicrobial activity. The Scopus database was searched for articles. According to previous research, the countries that produce the most academic studies in this field are India, Brazil, and China. The most productive journals are "JOURNAL OF MOLECULAR STRUCTURE," "ASIAN JOURNAL OF CHEMISTRY," and "DER PHARMA CHEMICA." According to our research, "OSMANIA UNIVERSITY" has the most studies on the topic. The most cited author is "KUMAR A." The most cited article is "A Review: The Pharmacology of Isoliquiritigenin," by Peng et al., published in the journal PHYTOTHER RES in 2015. According to the keyword analysis, the largest cluster is "chalcones," the second largest is "antimicrobial activity," and the third largest is "chalcone."

This study used scientific analyses to provide a complete overview of the main trends and findings in research on chalcones and their antimicrobial activity. Factor analysis revealed three clusters of keywords related to antimicrobial activity in studies on chalcones. The first cluster with high factor loadings included "chalcone derivative," "aspergillus niger," "carbon nuclear magnetic resonance," "ciprofloxacin," and "antiinfective agent."

Considering the authors' keywords, keywords such as "antimicrobial activity," "chalcones," "antifungal activity," "pyrazolines," "cytotoxicity," "flavones," and "indole" are prominent in scientific research. While the most frequently searched keywords between 2018 and 2020 were "inhibition," "antimicrobial agents," "antimalarial," and "antcancer," keywords such as "molecular docking," "antibiotic resistance," "1,2,3-triazoles," "anticancer activity," "docking studies," "beauveria bassiana," "antioxidant," and "density functional theory" have begun to be researched in recent years.

CONCLUSION

A search was conducted in the Scopus database. Initially, 571 English-language publications on chalcones and antimicrobials were identified during the relevant time period. The average age of the articles was 5.18 years, and there were an average of 13.93 citations per document. Thirteen of the 2,447 authors worked as sole authors. International co-authorship accounts for 18.74% of all article co-authorship. According to the Three Field Plot, the top country is "Brazil," the leading author parameter is "Bandeira Pn.", and the keyword is "antimicrobial activity."

Overall, bibliometric findings reveal that chalcone and antimicrobial research is strongly shaped by chemical synthesis, pharmaceutical development,

and biological activity programs. While the field is concentrated in specific countries and research centers, it shows increasing collaboration and publication diversity at the global level.

Our study is limited by using only the Scopus database. The Scopus database is limited to biblioshiny with data from 2014 to 2024. Innovative research is needed to better understand the use of chalcones as antimicrobial agents. The analyses from this bibliometric study will be an important tool for researchers and pharmaceutical companies in planning and directing future research. This study can provide new scientists with a quick overview of research centers and future trends and encourage them to pursue more creative work.

Conflict of Interest

The authors of this study do not have any situation that could create a conflict of interest.

Authors Contributions:

Conceptualization: Nisanur Pekgöz, Hayreddin Gezegen, Gülay Demir. Literature search: Nisanur Pekgöz. Original draft: Nisanur Pekgöz, Hayreddin Gezegen, Gülay Demir.

REFERENCES

Achilonu, C. C., Udensi, O. U. (2022). Systematic review of antimicrobial activities of medicinal plants against bacterial and fungal microbes: a research trend in africa from 1980 to 2019. https://orcid.org/0000-0002-3016-5004

Anto, R. J., Sukumaran, K., Kuttan, G. et al. (1995). Anticancer and antioxidant activity of synthetic chalcones and related compounds. Cancer letters, 97(1), 33-37. https://doi.org/10.1016/0304-3835(95)03945-S

Aparicio-Martinez, P., Perea-Moreno, A. J., Martinez-Jimenez, M. P. et al. (2019). A bibliometric analysis of the health field regarding social networks and young people. International journal of environmental research and public health, 16(20), 4024. https://doi.org/10.3390/ijerph16204024

Aydoğan, L., Deveci, K. Laparotomi Uygulanan Siçanlarda Kalkon-İmid Kullaniminin Oksidatif Stres Üzerine Etkisinin Değerlendirilmesi. Gaziosmanpaşa Bilimsel Araştırma Dergisi, 13(2), 31-38. http://dergipark.gov.tr/gbad

Baş, H. (2023). Beyin Göçüne İlişkin Yayınların VOSviewer ile Bibliyometrik Analizi. Toplumsal Politika Dergisi, 4(1), 52-65.

Bashar, A., Singh, S., Pathak, V. K. (2022). A bibliometric review of online impulse buying behaviour. International Journal of Electronic Business, 17(2), 162-183. https://doi.org/10.1504/IJEB.2022.121963

Cardona-Galeano, W., Ramirez-Malule, H., Gómez-Ríos, D. (2023). Hybrids based on coumarins and their anticancer activities: A bibliometric analysis. Journal of Applied Pharmaceutical Science, 13(9), 204-212. https://dx.doi.org/10.7324/JAPS.2023.150232

Chaudhary, S. K., Sandasi, M., Makolo, F. et al. (2021). Aspalathin: A rare dietary dihydrochalcone from Aspalathus linearis (rooibos tea). Phytochemistry Reviews, 1-32. https://doi.org/10.1007/s11101-021-09741-9

Cheng, K., Zhang, H., Guo, Q. et al. (2022). Emerging trends and research foci of oncolytic virotherapy for central nervous system tumors: A bibliometric study. Frontiers in immunology, 13, 975695. https://doi.org/10.3389/fimmu.2022.975695

Chu, J., & Guo, C. L. (2016). Design and Discovery of Some Novel Chalcones as Antioxidant and Anti-Inflammatory Agents via Attenuating NF-κB. Archiv der Pharmazie, 349(1), 63-70. https://doi.org/10.1002/ardp.201500349

Claisen, L., & Claparede, A. (1881). Condensationen von ketonen mit aldehyden. Berichte der deutschen chemischen Gesellschaft, 14(2), 2460-2468. DOI: 10.1002/cber.188101402192

Coelho, C. B., Alves, C. D. S. C., Tavares, Y. K. S. C. et al. (2024). Healing effect of medicinal plant extracts in Northeast Brazil: A systematic review on phytochemistry and preclinical studies. Phytochemistry Letters, 62, 6-13. https://doi.org/10.1016/j.phytol.2024.05.013

Demir, G., Chatterjee, P., Zakeri, S. et al. (2024c). Mapping the Evolution of Multi-Attributive Border Approximation Area Comparison Method: A Bibliometric Analysis. Decision Making: Applications in Management and Engineering, 7(1), 290–314. https://doi.org/10.31181/dmame7120241037

Demir, G., Chatterjee, P., Kadry, S. et al. (2024b). Measurement of Alternatives and Ranking according to Compromise Solution (MARCOS) Method: A Comprehensive Bibliometric Analysis. Decision Making: Applications in Management and Engineering, 7(2), 313-336. https://doi.org/10.31181/dmame7220241137

Demir, G., Chatterjee, P., Pamucar, D. (2024a). Sensitivity analysis in multi-criteria decision making: A state-of-the-art research perspective using bibliometric analysis. Expert Systems with Applications, 237, 121660. https://doi.org/10.1016/j.eswa.2023.121660

Donthu, N., Kumar, S., Mukherjee, D. et al. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of business research, 133, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070

Dos Santos, A. T. L., de Araújo-Neto, J. B., da Silva, M. M. C. et al. (2023). Synthesis of chalcones and their antimicrobial and drug potentiating

activities. Microbial Pathogenesis, 180, 106129. https://doi.org/10.1016/j.micpath.2023.106129

Elbatreek, M. H., Mahdi, I., Ouchari, W. et al. (2023). Current advances on the therapeutic potential of pinocembrin: an updated review. Biomedicine & Pharmacotherapy, 157, 114032. https://doi.org/10.1016/j.biopha.2022.114032

Fatima, M., Dar, M. A., Dhanavade, M. J. et al. (2024). Biosynthesis and pharmacological activities of the bioactive compounds of white mulberry (Morus alba): Current Paradigms and Future Challenges. Biology, 13(7), 506. https://doi.org/10.3390/biology13070506

Ferreira, F. A., Santos, S. P. (2021). Two decades on the MACBETH approach: A bibliometric analysis. Annals of Operations Research, 296, 901-925. https://doi.org/10.1007/s10479-018-3083-9

Ferreira, M. K. A., da Silva, A. W., dos Santos Moura, A. L. et al. 2021). Chalcones reverse the anxiety and convulsive behavior of adult zebrafish. Epilepsy & Behavior, 117, 107881. https://doi.org/10.1016/j.yebeh.2021.107881

Ferreira, M. K. A., Freitas, W. P. O., Barbosa, I. M. et al. (2023). Heterocyclic chalcone (E)-1-(2-hydroxy-3, 4, 6-trimethoxyphenyl)-3-(thiophen-2-yl) prop-2-en-1-one derived from a natural product with antinociceptive, anti-inflammatory, and hypoglycemic effect in adult zebrafish. 3 Biotech, 13(8), 276. https://doi.org/10.1007/s13205-023-03696-8

Girisa, S., Saikia, Q., Bordoloi, D. et al. (2021). Xanthohumol from Hop: Hope for cancer prevention and treatment. IUBMB life, 73(8), 1016-1044. https://doi.org/10.1002/iub.2522

Gomes, M. N., Muratov, E. N., Pereira, M. et al. (2017). Chalcone derivatives: promising starting points for drug design. Molecules, 22(8), 1210. https://doi.org/10.3390/molecules22081210

Guan, L. P., Zhao, D. H., Chang, Y. et al. (2013). Synthesis of 2, 4-dihydroxychalcone derivatives as potential antidepressant effect. Drug research, 63(01), 46-51. https://doi.org/10.1055/s-0032-1333229

Han, Q., Li, Z., Fu, Y. et al. (2023). Analyzing the research landscape: mapping frontiers and hot spots in anti-cancer research using bibliometric analysis and research network pharmacology. Frontiers in Pharmacology, 14, 1256188. https://doi.org/10.3389/fphar.2023.1256188

Hassan, M. K., Alshater, M. M., Rashid, M. et al. (2022). Ten years of the Journal of Islamic Marketing: a bibliometric analysis. Journal of Islamic Marketing, 13(10), 2047-2068. https://doi.org/10.1108/JIMA-10-2020-0322

Kim, Y. J., Qian, L., Aslam, M. S. (2021). Bibliographic analysis of Clinacanthus nutans papers in Scopus database (2000–2019). https://doi.org/10.12688/f1000research.52946.1

Krawczyk-Łebek, A., Żarowska, B., Janeczko, T. et al. (2024). Antimicrobial Activity of Chalcones with a Chlorine Atom and Their Glycosides. International Journal of Molecular Sciences, 25(17), 9718. https://doi.org/10.3390/ijms25179718

Kudličková, Z., Michalková, R., Salayová, A. et al. (2023). Design, synthesis, and evaluation of novel indole hybrid chalcones and their antiproliferative and antioxidant activity. Molecules, 28(18), 6583. https://doi.org/10.3390/molecules28186583

Kumar, H., Devaraji, V., Joshi, R. et al. (2015). Antihypertensive activity of a quinoline appended chalcone derivative and its site specific binding interaction with a relevant target carrier protein. RSC advances, 5(80), 65496-65513. https://doi.org/10.1039/C5RA08778C

Kyogoku, K., Hatayama, K., Yokomorı, S. et al. (1979). Anti-ulcer effect of isoprenyl flavonoids. II. Synthesis and anti-ulcer activity of new chalcones related to sophoradin. Chemical and pharmaceutical bulletin, 27(12), 2943-2953. https://doi.org/10.1248/cpb.27.2943

Li, R., Kenyon, G. L., Cohen, F. E. et al. (1995). In vitro antimalarial activity of chalcones and their derivatives. Journal of medicinal chemistry, 38(26), 5031-5037.

Lin, Y. M., Zhou, Y., Flavin, M. T. et al. (2002). Chalcones and flavonoids as anti-tuberculosis agents. Bioorganic & medicinal chemistry, 10(8), 2795-2802. https://doi.org/10.1016/S0968-0896(02)00094-9

Machado, J. A., Araújo, D. B., Lima-Maximino, M. et al. (2024). Flavonoids as anxiolytics in animal tests: Bibliometry and meta-analysis of the effects of flavonoids on anxiety-like behavior in animal tests. bioRxiv, 2024-05. https://doi.org/10.1101/2024.05.27.596117

Mannino, G., Gentile, C., Ertani, A. et al. (2021). Anthocyanins: Biosynthesis, distribution, ecological role, and use of biostimulants to increase their content in plant foods—A review. Agriculture, 11(3), 212. https://doi.org/10.3390/agriculture11030212

Marotta, L., Rossi, S., Ibba, R. et al. (2022). The green chemistry of chalcones: Valuable sources of privileged core structures for drug discovery. Frontiers in chemistry, 10, 988376. https://doi.org/10.3389/fchem.2022.988376

Martín-Martín, A., Orduna-Malea, E., Thelwall, M. et al. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. Journal of informetrics, 12(4), 1160-1177. https://doi.org/10.1016/jjoi.2018.09.002

Matos, M. J., Vazquez-Rodriguez, S., Uriarte, E., & Santana, L. (2015). Potential pharmacological uses of chalcones: a patent review (from June 2011–2014). Expert opinion on therapeutic patents, 25(3), 351-366. https://doi.org/10.1517/13543776.2014.995627

Mazumder, A., Wang, S., Neamati, N., Nicklaus, M. et al. (1996). Antiretroviral agents as inhibitors of both human immunodeficiency virus type 1 integrase and protease. Journal of medicinal chemistry, 39(13), 2472-2481.

https://pubs.acs.org/doi/10.1021/jm960074e

Muñoz-Acevedo, A., González, M. C., Castillo, O. J. et al. (2022). Promising antimicrobial agents from some Latin American medicinal plants against disease-causing pathogens in humans and animals. In Promising Antimicrobials from Natural Products (pp. 241-279). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-83504-0_11

Nematollahi, M. H., Mehrabani, M., Hozhabri, Y. et al. (2023). Antiviral and antimicrobial applications of chalcones and their derivatives: From nature to greener synthesis. Heliyon, 9(10), e20428. https://doi.org/10.1016/j.heliyon.2023.e20428

Nguyen, D. V., Muanprasat, C., Kaewin, S. et al. (2024). Synthesis and biological evaluation of 2'-hydroxychalcone derivatives as AMPK activators. Bioorganic Chemistry, 143, 107048. https://doi.org/10.1016/j.bioorg.2023.107048

Nowakowska, Z. (2007). A review of anti-infective and anti-inflammatory chalcones. European journal of medicinal chemistry, 42(2), 125-137.

Poerwono, H., Rudyanto, M. (2023). Bibliometric Study of Microwave-Assisted Synthesis of Flavanone Derivatives. Borneo Journal of Pharmacy, 6(4), 339-348. https://doi.org/10.33084/bjop.v6i4.5602

Ponticelli, M., Bellone, M. L., Parisi, V. et al. (2023). Specialized metabolites from plants as a source of new multi-target antiviral drugs: a systematic review. Phytochemistry Reviews, 22(3), 615-693. https://doi.org/10.1007/s11101-023-09855-2

Reddy, M. V. B., Shen, Y. C., Ohkoshi, E. et al. (2012). Bis-chalcone analogues as potent NO production inhibitors and as cytotoxic agents. European journal of medicinal chemistry, 47, 97-103. https://doi.org/10.1016/j.ejmech.2011.10.026

Rocha, S., Sousa, A., Ribeiro, D. et al. (2019). A study towards drug discovery for the management of type 2 diabetes mellitus through inhibition of the carbohydrate-hydrolyzing enzymes α-amylase and α-glucosidase by chalcone derivatives. Food & function, 10(9), 5510-5520. https://doi.org/10.1039/c9fo90045d

Schmidt, J. G. (1881). Ueber die Einwirkung von Aceton auf Furfurol und auf Bittermandelöl bei Gegenwart von Alkalilauge. Berichte der deutschen chemischen Gesellschaft, 14(1), 1459-1461. https://doi.org/10.1002/cber.188101401306

Shaik, A., Bhandare, R. R., Palleapati, K. et al. (2020). Antimicrobial, antioxidant, and anticancer activities of some novel isoxazole ring containing chalcone and dihydropyrazole derivatives. Molecules, 25(5), 1047. https://doi.org/10.3390/molecules25051047

Sharma, R., Kumar, R., Kodwani, R. et al. (2016). A review on mechanisms of anti tumor activity of chalcones. Anti-Cancer Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry-Anti-Cancer Agents), 16(2), 200-211. http://dx.doi.org/10.2174/1871520615666615051809

3144

Tıwarı, A., Tıwarı, A. (2024). Flavonoids in Acacia catechu bark extracts and bibliographic analysis in Guna, Madhya Pradesh, India. Int J Pharm Pharm Sci, 16(6), 46-55. https://dx.doi.org/10.22159/ijpps.2024v16i6.50939

Tsukiyama, R. I., Katsura, H., Tokuriki, N. et al. (2002). Antibacterial activity of licochalcone A against spore-forming bacteria. Antimicrobial agents and chemotherapy, 46(5), 1226-1230. https://doi.org/10.1128/aac.46.5.1226-1230.2002

Van Eck, N. J., Waltman, L. (2017). Citation-based clustering of publications using CitNetExplorer and VOSviewer. Scientometrics, 111(2), 1053-1070. https://doi.org/10.1007/s11192-017-2300-7

Van Eck, N., Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

Wilson, M., Sampson, M., Barrowman, N. et al. (2021). Bibliometric analysis of neurology articles published in general medicine journals. JAMA Network Open, 4(4), e215840-e215840. doi:10.1001/jamanetworkopen.2021.5840.

Yepes, A. F., Galeano, W. C., Ramírez-Malule, H. (2024). Scientific landscape of melatonin, its hybrids, and its derivatives as anti-tumor agents: A bibliometric analysis. Journal of Applied Pharmaceutical Science, 14(10), 205-218. https://dx.doi.org/10.7324/JAPS.2024.169632

Yeung, A. W. K., Aggarwal, B. B., Orhan, I. E. et al. (2019). Resveratrol, a popular dietary supplement for human and animal health: Quantitative research literature analysis-a review. Animal Science Papers and Reports, 37(2), 103-118. http://eprints.bmsu.ac.ir/id/eprint/2816

Yeung, A. W. K., Solka, M., Jóźwik, A. et al. (2024). Anthocyanins-dietary natural products with a variety of bioactivities for the promotion of human and animal health. Animal Science Papers and Reports, 42(1), 5-34. https://doi.org/10.2478/aspr-2023-0020

Yücel, T. B., Fandaklı, S., Demir, İ. vd. (2023). 2-, 3-, 4-Bromo azaflavanonların amino kalkonlardan katı faz ortamında mikrodalga destekli sentezi, antimikrobiyal ve antioksidan aktivitelerinin tayini. Journal of Advanced Research in Natural and Applied Sciences, 9(2), 465-476. https://doi.org/10.28979/jarnas.1174437

Zhang, H., Gao, Y., Fu, G. et al. (2023). Trends and hotspots for European Journal of Medicinal Chemistry: A bibliometric study. European Journal of Medicinal Chemistry, 247, 115041. https://doi.org/10.1016/j.ejmech.2022.115041

Zhuang, C., Zhang, W., Sheng, C. et al. (2017). Chalcone: a privileged structure in medicinal chemistry. Chemical reviews, 117(12), 7762-7810. https://doi.org/10.1021/acs.chemrev.7b00020