Original Article

Scientometric Mapping of Royal Jelly Supplementation or Oxidative Stress and Inflammatory Mediators: Networking, Emerging Patterns, and Trends

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Abstract

Objective: To perform a scientometric mapping analysis of the published literature on royal jelly (RJ) supplementation, oxidative stress (OS), and inflammatory mediators. **Materials and Methods:** A comprehensive search of Scopus was performed using a targeted search strategy on July 13, 2024. All manuscripts published from January 2019 to July 2024 that addressed RJ supplementation and OS or inflammatory mediators were selected. Data extracted from the selected manuscripts were analyzed using various metrics in SciVal and R studio version 4.3.2. **Results:** Antioxidants and foods had the highest academic output, with three articles each and a citation count of 184 and 71, respectively. Antioxidants also showed a high CiteScore of 10.6 in 2023. Biomedicine and pharmacotherapy had a remarkably high CiteScore of 11.9 with two published articles. Despite having only two articles, the Journal of Asia-Pacific Entomology had an impressive citation count of 73. Cyrus Jalili of Kermanshah University of Medical Sciences in Iran had the highest academic output with six publications. Amira Mohammed Ali of Alexandria University in Egypt had the highest number of views per publication, with 37.3. **Conclusion:** The most productive authors and institutions were identified, with Cyrus Jalili from Kermanshah University of Medical Sciences in Iran and Alexandria University in Egypt. Lotka's law was confirmed, and most authors contributed a single article. In addition, extensive international collaboration was observed, underscoring the importance of global collaboration in this area of research.

Keywords: Inflammatory mediators, oxidative stress, royal jelly, scientometric study

Introduction

Oxidative stress (OS) and inflammatory mediators play crucial roles in the development and progression of various chronic diseases, including neurodegenerative, cardiovascular, and cancer.[1] OS is a result of an imbalance in the generation of reactive oxygen species (ROS) and the body's ability to counteract them.[2] This event is linked to cellular aging, which damages DNA, proteins, and lipids, leading to cellular dysfunction. It plays a significant role in the development of diseases such as atherosclerosis, cancer, and neurodegenerative disorders like Alzheimer's disease and Parkinson's.[3] On the other hand, inflammation can be acute as a necessary response to infections or injuries or chronic as a prolonged and sustained response of the immune system related to the development of many diseases.[4] In general, it has been observed that OS and inflammation feedback on each other, forming a cycle that aggravates pathological conditions.

Royal jelly (RJ) is a thick, acidic, yellowish-white substance produced by the hypopharyngeal and mandibular glands of worker bees (*Apis mellifera*). It serves as nourishment for young worker larvae and queen bees.[5] RJ has historically

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been used in health in the field of traditional medicine, and it is currently used as a functional food or supplement.[5] The criteria for the use of RJ were originally established in Argentina in 1979 and currently[6,7], although there is no exact data on global production. China is the largest producer of RJ[6] and exports almost all of it to countries in Europe, the United States, Japan, and other countries.[8] The main constituents include water (60%–70%), proteins, sugar, and fats, in addition to minor compounds such as minerals, amino acids, and vitamins.[5,6,9] These components are the key substances for their different biological properties, especially 10-hydroxy-2-decenoic acid (10-HDA), which has antimicrobial, immunomodulatory, and cancer growth inhibitory activities.[6] In this sense, RJ has been reported to be useful in reducing inflammation in different diseases. This has drawn worldwide attention and highlights the need to evaluate the current landscape in the medical literature, which can be achieved using bibliometric studies.[10] Previously, a steady growth of its scientific productivity has been reported in the last decades[8], and similarly, the productivity of RJ has been evaluated within the context of apitherapy.[11] However, there remains a need to directly evaluate the potential of RJ through its antioxidant and anti-inflammatory effects.

The results of this study aim to provide a better picture of the antioxidant and anti-inflammatory benefits of RJ, its application in the medical practice of various diseases, and the subsequent development of new and more focused health policies. Therefore, the objective of this study was to perform a scientometric mapping of RJ supplementation, OS, and inflammatory mediators through network analysis and identify emerging patterns and trends.

Materials And Methods

This study followed the recommendations of the Guidelines for Reporting and Measurement of Items for Bibliometric or Scientometric Studies[12] (Supplementary Material 1).

Supplementary Material 1: Checklist for Reporting and Measurement of Items for Bibliometric or Scientometric Studies (RAMIBS)

Section	Item	Recommendations	Reported on Page #
1. Title and abstract	1	(a) It should have an explanatory title that reflects the main variables and purpose of the study and should emphasize the "bibliometric" approach. (b) The abstract should be structured to provide a global view of the study.	1
2. Introduction	2	(a) The authors must have identified antecedents after a rigorous search: if they have not been able to find them, specify the bases consulted; if they do find them, they must specifically state the differences with respect to the research proposal they are making. (b) Relevance and originality (c) Research question (d) Justification of the study (e) Objective	2
3. Materials and methods			
Database	3	(a) In the case of working with only one database, the choice should be justified. (b) In the case of working with several databases, the choice should also be justified, and how the data will be processed to avoid including duplicate studies (inclusion and exclusion criteria, declaring duplicate selection and independently, with the participation of a third person as a decision-maker) should also be defined. (c) Database (d) Inclusion and exclusion criteria (e) Time period (f) Collection/discharge date (g) Establish metric indicators	3
Search strategy	4	(a) The author must detail the process of construction of the search strategy, specifying (b) The sources he/she consulted to identify all possible terms related to his/her objective, which he/she would include in his/her search. (c) Demonstrate an adequate use of Boolean operators (AND, OR, and NOT) and truncators (* and $) in such a way as to guarantee, to the greatest extent possible, the specific inclusion of the articles to be identified. (d) In the event that you decide to work with productions, clinical trials, observational studies, Latin American authors, some years, a particular institution, a particular institution, or a particular author should be adequately reflected in the search strategy.	3
Search filters	5	(a) Specify the exact date on which the final search was carried out. (b) The period in which the search will be carried out should never include the current year. (c) Justify the types of documents to be included in the analysis (whether all of them will be included or only some of them in particular). (d) If it is decided to apply language restrictions, this should be adequately justified.	3

(*Continued*)

Supplementary Material 1 (*Continued*)

Section	Item	Recommendations	Reported on Page #
Bibliometric indicators	6	(a) The four basic dimensions of bibliometric indicators should be taken into account, and depending on the objective set (to describe a particular aspect and to analyze a possible relationship), those with which it is desired to work should be selected. (b) The four dimensions of bibliometric indicators are as follows: (c) Production (quantity per year, author, and subject matter). (d) Impact (journals, citations, H index, and H5 index) (e) Collaboration (national, international, local, and non-collaborative). (f) Alternative. Altimetric indicatorsIn general, a graph showing the annual trend of scientific production during the entire period evaluated should always be included either as the main result or as an annex.	3
Unit of analysis	7	(a) Macro: Country or group of countries. (b) Meso: Analysis of institutions or topics.Micro: Authors, for this case, it is recommended to use the following: H Index, H5, and if feasible, gender analysis to complement the indicators.	3
Data extraction	8	(a) In the case of manual data extraction, an extraction matrix should be predefined and validated by the other authors/advisors to ensure that the data in the matrix will allow the construction of the predefined indicators. (b) In the case that platforms for complex indicators (SciVal or InCites) are used, the characteristics and limitations offered by each must be stated. (c) Analysis techniques (d) Justification of these techniques	3
Presentation of data	9	(a) The name and version of each of the programs used for the data presentation must be declared.In the event that you make graphs for data visualization with programs such as VOSviewer, you must declare the parameters used to achieve the visualization, as well as additional measures you have taken to normalize the information being processed (ideally, the creation of a thesaurus).	3–4
Results	10	In the case of having used manual extraction of data, (a) provide, as an annex, the final version of the complete matrix, from which all the results were constructed in the form of a table or graph. (b) Provide as an annex the total number of articles that were excluded and the reason for their exclusion. (c) Interpretation of the results.In the case of having used any processing platform, provide as an appendix the files from which all the results were constructed.	4–5
Discussion	11	(a) Specify to what extent the results presented comply with what the work wanted to address and with the gaps in knowledge it was trying to answer. (b) Discusses the importance of the results and their implications. (c) Compare the results with those of other bibliometric studies. (d) Limitations. (e) Suggestions. Transparency	5–7
Conclusion	12	Summarizes the main findings of the study	7

Study Design

A descriptive study was conducted using a scientometric mapping analysis of the published literature on RJ supplementation and OS and inflammatory mediators.

Data Collection

A comprehensive search of the Scopus database was conducted on July 13, 2024; using the following search strategy: TITLE-ABS ("royal jelly" OR "apilak" OR "bee milk" OR "queen bee larvae" OR "queen bee secretion" OR "Bee Milk" OR "Royal Bee Jelly" OR "Apicultural Gelée Royale" OR "Queen Bee's Milk" OR "Honeybee Milk") AND TITLE-ABS ("oxidative stress" OR "Free Radical Damage" OR "Reactive Oxygen Species" OR "ROS" OR "Oxidative Damage" OR "Antioxidant Defense" OR "Oxidative Imbalance" OR "Oxidative Injury" OR "Oxidative Degradation" OR "Oxidative Modification"). The search of the Scopus database from January 2019 to July 2024 resulted in a total of 102 manuscripts. Of these, 90 were identified as research articles and 12 as reviews.

Selection Criteria

For this study, specific selection criteria were established to identify relevant manuscripts. All manuscripts published from January 2019 to July 2024 that were found in the Scopus database and reported on RJ supplementation and OS or inflammatory mediators were included. Manuscripts were selected without regard to language of publication, country of origin, or scientific discipline.

Procedure

A search was conducted in Scopus using the relevant search criteria. Once the results were obtained, they were exported to a compatible format for further analysis. These exported data, including detailed information on authors, article titles, year of publication, and journals, were imported into SciVal. Several analyses were performed using Scopus data. These included the creation of collaboration maps to visualize collaboration networks between countries, co-citation analysis to identify citation patterns, and performance analysis to assess the productivity and impact of research in this field. This process of exporting from Scopus and analysis in SciVal provided a comprehensive and detailed view of existing research on RJ supplementation, OS, and inflammatory mediators, allowing us to identify emerging trends and patterns in this field.

Data Analysis

The data collected from the chosen manuscripts underwent a thorough analysis using various metrics. For each source, we calculated the scholarly output, SNIP 2023, CiteScore 2023, and citation count. Similarly, for each country or region, the scholarly output, views per publication, field-weighted citation impact, and citation count were determined. We also applied Lotka's and Bradford's laws to examine the distribution of document production among authors and sources. Lotka's law helped us establish the proportion of authors who contributed a certain number of papers, while Bradford's law facilitated the division of sources into zones based on their publication frequency. These analyses provided a detailed understanding of emerging trends and patterns in this field. The primary tools used in this study were R Studio and SciVal.

Results

The Antioxidants and Foods journal had the highest academic output with three articles each, and the citation count was 184 and 71, respectively. Antioxidants also showed a high CiteScore of 10.6 in 2023. Biomedicine and Pharmacotherapy had a remarkably high CiteScore of 11.9 with two published articles. Despite having only two articles, the Journal of Asia-Pacific Entomology had an impressive citation count of 73. These results highlight the growing importance and impact of RJ supplementation in the context of OS and inflammatory mediators [Table 1].

Quartile 1 (Q1), representing the top 25%, had the highest number of articles, with 43 during the study period. The year with the highest number of articles in Q1 was 2021, with 11 articles, followed by 2022 and 2023, with eight articles each. Quartile 2 (Q2) included 28 articles, with the highest number of articles published in 2020 and 2021, both with eight articles. Quartile 3 (Q3) and quartile 4 (Q4) included the same number of articles, with 12 each during the study period. However, the distribution of articles in these quartiles varied from year to year. In total, 95 articles were published during the study period, with the highest number of articles published in 2021 (21 articles) and the lowest number in 2024 (10 articles). These results provide a detailed view of the distribution of articles across CiteScore quartiles, which may be useful for understanding emerging trends and patterns in this field of study [Table 2].

Table 1: Top 10 Most Productive Journals

Scopus Source	Scholarly Output	SNIP 2023	CiteScore 2023	Citation Count
Antioxidants	3	1.38	10.6	184
Foods	3	1.23	7.4	71
Biological Trace Element Research	2	1.14	8.7	9
Biomedicine and Pharmacotherapy	2	1.41	11.9	60
Frontiers in Nutrition	2	0.88	5.2	61
Gaceta Sanitaria	2	0.83	4.1	8
Heliyon	2	1.26	4.5	32
Iranian Journal of Basic Medical Sciences	2	0.62	4	15
Journal of Asia-Pacific Entomology	2	0.57	2.7	73
Journal of Chemical Neuroanatomy	2	0.64	4.5	4

Table 2: Impact of Scientific Publications by Quartile

CiteScore Quartile	Overall	2019	2020	2021	2022	2023	2024
Q1	43	6	5	8	11	8	5
Q2	28	4	6	8	3	4	3
Q3	12	2	1	2	3	2	2
Q4	12	4	1	1	4	2	0
Total	95	16	13	19	21	16	10

Table 3: Top 10 Most Representative Authors and Affiliations

Author	Affiliation	Country	Scholarly Output	Views per Publication	*h*-Index	Citation Count
Jalili, Cyrus	Kermanshah University of Medical Sciences	Iran	6	24.5	23	37
Salahshoor, Mohammad Reza	Kermanshah University of Medical Sciences	Iran	4	28.5	30	29
Ali, Amira Mohammed	Alexandria University	Egypt	3	37.3	20	111
Aslan, Abdullah	Firat University	Turkey	3	63	17	19
Beyaz, Seda	Firat University	Turkey	3	63	8	19
Choi, Yong-soo	National Institute of Agricultural Sciences	South Korea	3	28.3	16	83
Gok, Ozlem	Firat University	Turkey	3	63	9	19
Hu, Fuliang	Zhejiang University	China	3	24.7	36	84
Jin, Byungrae	Dong-A University	South Korea	3	28.3	37	83
Kim, Bo-yeon	Dong-A University	South Korea	3	28.3	21	83

Cyrus Jalili of Kermanshah University of Medical Sciences in Iran had the highest academic output with six publications. Amira Mohammed Ali of Alexandria University in Egypt had the highest number of views per publication, with 37.3. Mohammad Reza Salahshoor, also from Kermanshah University of Medical Sciences in Iran, obtained the highest h-index value of 30. Amira Mohammed Ali had the highest citation count of 111. Each of these authors has demonstrated excellence in different aspects of academic publishing, either in terms of scholarly output, research visibility, research impact, or recognition by the scientific community [Table 3].

The Kermanshah University of Medical Sciences in Iran had the highest scholarly output with seven publications. Alexandria University in Egypt had the highest number of views per publication with 36. Dong-A University in South Korea had the highest field-weighted citation impact, with 3.4. Alexandria University in Egypt had the highest citation count of 125. These results highlight the significant contribution of these institutions to this field of study and their impact on the scientific community. Each of these institutions has demonstrated excellence in different aspects of academic publishing in terms of scholarly output, research visibility, research impact, and recognition from the scientific community [Table 4].

According to the graphs obtained in the R studio software, the sources were divided into three zones. Zone 1 included sources with the highest frequency of publications, such as "Antioxidants," "Foods," and "Biological Trace Element Research," each contributing three publications to the total scholarly output. Zone 2 included sources with a moderate frequency of publications, such as "Analyst," "Andrologia," and "Animal Models and Experimental Medicine," each contributing one publication to the total scholarly output. Zone 3 included sources with the lowest frequency of publications, such as "Journal of Ethnopharmacology," "Journal of Experimental Biology," and "Journal of Food Science," each contributing one publication to the total

Table 4: Top 10 Most Representative Institutions

Institution	Country/ Region	Scholarly Output	Views per Publication	Field-Weighted Citation Impact	Citation Count
Kermanshah University of Medical Sciences	Iran	7	31.3	0.74	58
Alexandria University	Egypt	6	36	2.13	125
Islamic Azad University	Iran	4	25	0.65	16
Zagazig University	Egypt	4	9.8	1.09	19
Zhejiang University	China	4	26	1.06	84
Al-Azhar University	Egypt	3	31	0.99	25
Bingol University	Turkey	3	59.3	0.76	25
Chinese Academy of Agricultural Sciences	China	3	40	2.43	100
Dong-A University	South Korea	3	28.3	3.4	83
Firat University	Turkey	3	63	0.58	19

scholarly output. These results provide valuable insight into the distribution of scholarly output across different sources in this field of study, highlighting the core journals in Zone 1 that are most active in publishing research on RJ supplementation and OS and inflammatory mediators [Figure 1].

Most authors (434, representing 88.8% of the total) wrote only one paper. A significantly fewer number of authors (47, representing 9.6% of the total) contributed to two papers. Only a few authors contributed three or more papers. Specifically, six authors (1.2% of the total) wrote three papers, one author (0.2% of the total) wrote four papers, and one author (0.2% of the total) wrote six papers. This provides valuable insight into the distribution of paper production among authors in this field of study, highlighting that most authors contribute only one paper, which is consistent with Lotka's law [Figure 2].

Egypt and Saudi Arabia had the highest frequency of collaboration, with five joint publications. Egypt also frequently collaborated with Japan (three publications) and Poland and Sweden (two publications each). China has extensively collaborated with several countries, including Egypt, Saudi Arabia, Sweden, the UAE, and the United Kingdom, each with one joint publication. Other notable collaborations include Australia and the United States, Italy and Greece, Italy and Greece, Italy and Portugal,

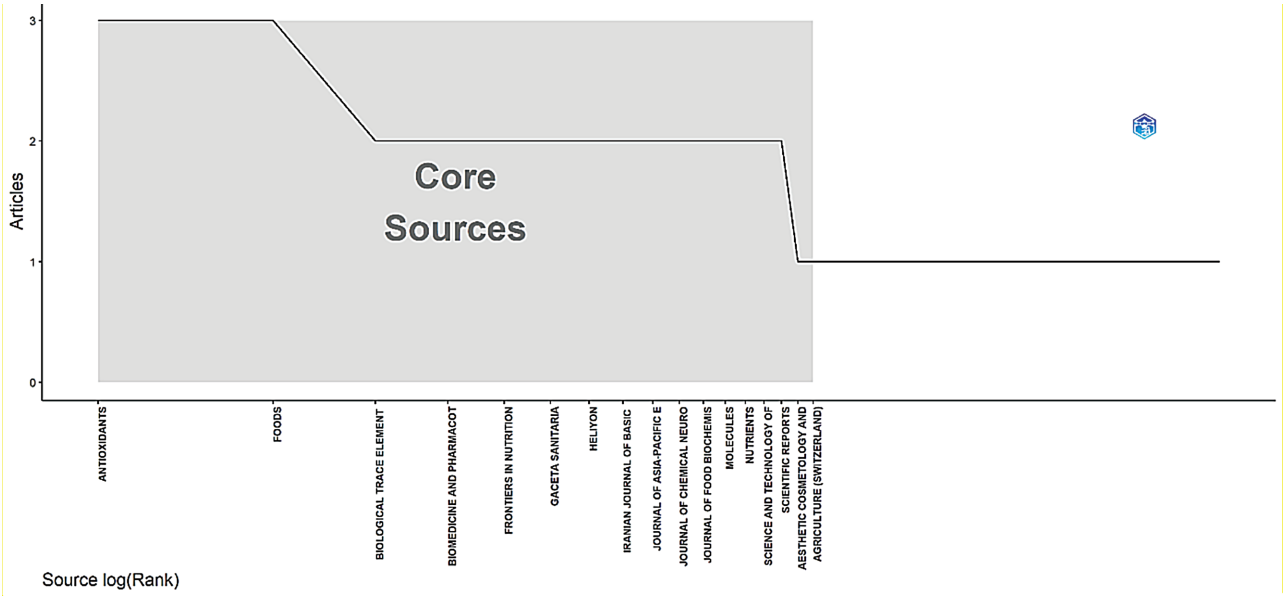

Figure 1: Core sources.

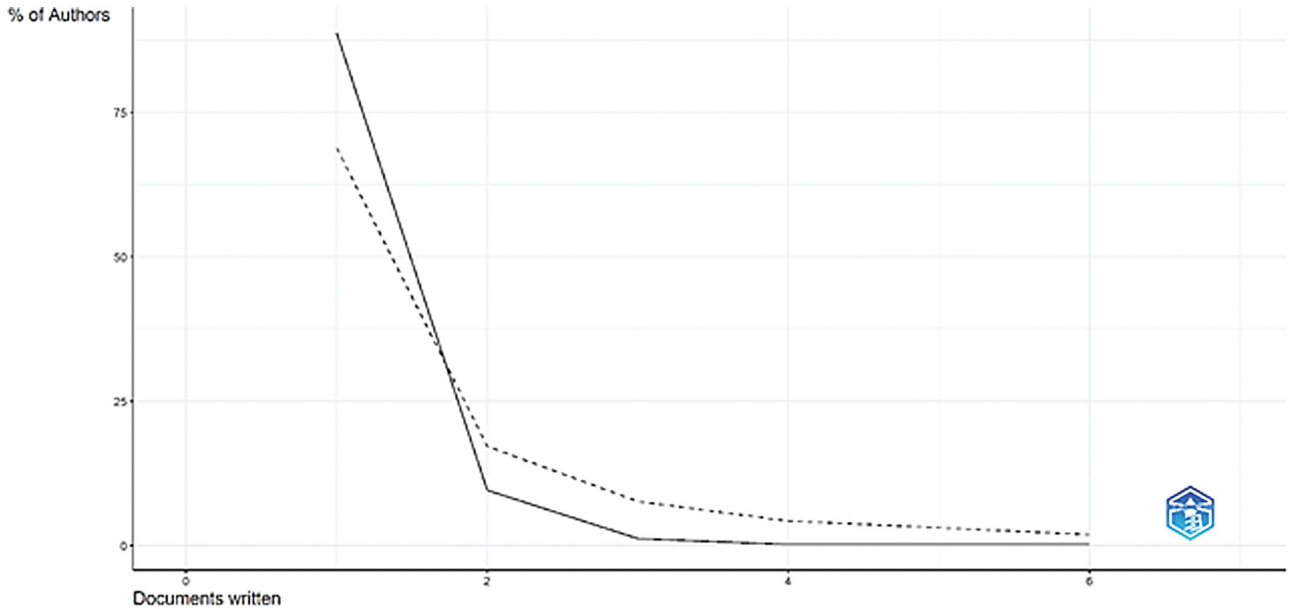

Figure 2: Author productivity.

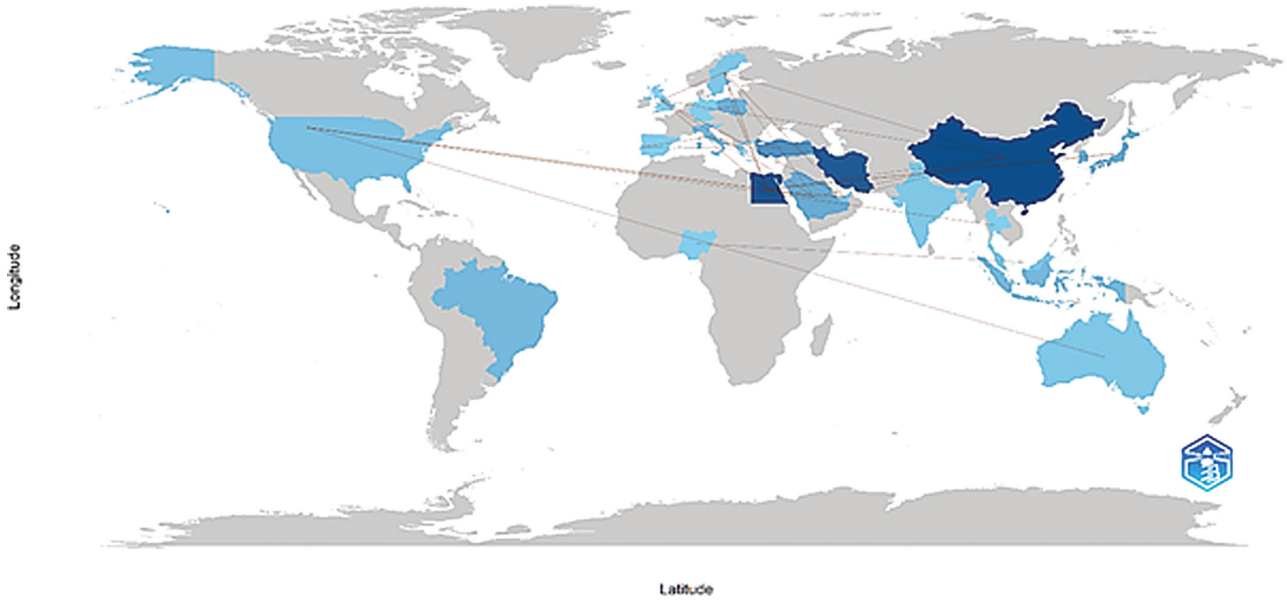

Figure 3: Country collaboration map.

Malaysia and Nigeria, Poland and Germany, Poland and Germany, Poland and Sweden, and Thailand and the United States, each with one joint publication. This finding provides valuable insight into international collaborative networks in this field of study, highlighting the importance of global collaboration in research on RJ supplementation and OS and inflammatory mediators [Figure 3].

Discussion

Between 2019 and 2024, a total of 95 studies evaluating the antioxidant and anti-inflammatory potential of RJ were reported. Articles and reviews published mainly in high-impact journals stand out. Although most studies were published by one single author, the contributions of authors and institutions from Eastern countries such as Turkey and Egypt stand out.

Productivity showed variable growth, especially in recent years, but remained largely on an upward trend. This agrees with what has been reported by other analyses of scientific publications on apitherapy,[11] in which constant growth has also been reported in the last 20 years, and on the antioxidant effects of honey, with a growth rate of 17.5%.[13] Similarly, the subject of RJ has been addressed generally and has reported increasing rates since the beginning of the century until 2019.[8] The previous fair results with the international collaboration in this study highlight the broad interest in the effects of RJ and its potential antioxidant and anti-inflammatory properties.[14]

The Antioxidants journal is the most relevant in terms of its production and impact on the environment. Among the most cited publications, a narrative review outlines the antioxidant properties of bee-derived products like honey, pollen, and RJ. The study also emphasizes the importance of developing standardized methods for assessing their inherent antioxidant features. On the other hand, the Egyptian authors Ali and Amira Mohammed and the Chinese Academy of Agricultural Sciences were the ones who reported the greatest impact on the environment. The first one stood out with 60 citations for a review published in 2020[15] describing the alarming increase in sarcopenia worldwide because of aging and poor diet and highlighting the effect of bee products such as RJ in the treatment and prevention of sarcopenia. Regarding the most productive institution, another review from 2022, with 56 citations, is notable. This review evaluated the effects of bee products on inflammatory and autoimmune diseases.[16]

Among the most productive countries, Middle Eastern countries such as Iran, Egypt, and China stand out. This result agrees with another bibliometric study in which the productivity of apitherapy was evaluated in general, where China stands out among the most productive countries.[11] Similarly, it was confirmed by another bibliometric study that highlighted the highest antioxidant and antimicrobial potential of honey in Eastern countries.[13] China is the largest producer of RJ, with more than 3500 tons/year (more than 90% of the world production)[6,8] because this country has selectively bred a strain of bees whose honey has a high RJ content from Italian bees (*Apis mellifera ligustica*).[17] This new strain of bees has a higher larval acceptance rate and can produce 10 times more RJ at higher quality.[18,19] It is for these reasons that it would be logical that the highest concentration of studies be located in this region. On the other hand, the high scientific production in Egypt may be because high-quality floral species have been reported in the region that ensures the development of good-quality honey[20], which would also improve the effect of RJ.

One aspect to consider is that, similar to previous results in other bibliometrics[11], the most evaluated topics were related

to pharmacology or biochemistry, with only a few studies on human populations. This highlights the need for further evaluation in humans to adequately establish the health benefits of such treatments. The results of this study are expected to help design policies aimed at preserving the environment and the bee ecosystem. In turn, they are expected to serve as a basis for future research aimed at fully understanding the pathways of RJ substances to develop new applications and applications for the pharmaceutical and health industries.

This study has both strengths and limitations. The primary limitations of this study include that the systematic search was confined to the Scopus database and to articles published between 2019 and 2024. This exclusion excludes any potentially relevant publications from other databases, such as PubMed and Web of Science, and those published before 2019. Another limitation is that the metrics of many authors and journals may not remain consistent with those found at the time of this study's publication. Despite these limitations, the study also has its strengths. The Scopus database was selected due to its ability to facilitate a more precise systematic search than other databases.[21] It indexes publications of high methodological quality, making it a recommended database for bibliometric analysis.[10,22] The last 5 years were selected to ensure an analysis of the most recent publications on the benefits of RJ. Despite these limitations, it is hoped that this study's results will stimulate future research and enhance health policies regarding the use of RJ as a supplement in medical practice.

Conclusion

Within the limitations of this scientometric study, the results highlighted the growing importance and impact of this research, with the journals "Antioxidants" and "Foods" leading the academic production. The distribution of articles along the CiteScore quartiles indicates emerging trends in the field. The most productive authors and institutions were identified, highlighting Cyrus Jalili from Kermanshah University of Medical Sciences in Iran and Alexandria University in Egypt. Lotka's law was confirmed, and most authors contributed a single article. In addition, extensive international collaboration was observed, underscoring the importance of global collaboration in this area of research. These findings provide valuable insights for future research and can guide researchers and stakeholders toward identifying areas of focus and collaboration.

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Nil.

Conflicts of interest

The authors declare there are no conflicts of interest.

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