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A Bibliometric Analysis of Cannabis-Related Research from 2010 To 2022

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ABSTRACT

Cannabis plant cultivation was prohibited for a period, but in recent times, there has been a shift in its perception. It is now being researched extensively to identify the best methods for its utilization. This article provides a bibliometric review of studies related to cannabis. Bibliometric analysis is a widely used technique for analyzing large volumes of scientific data. For this study, 3,761 documents were collected from the popular Scopus database, published between 2010 and 2022. The collected data was analyzed using the "Bibliometrics" package in the R programming language. "Biblioshiny" and "Vosviewer" were employed to visualize the results. The study found that productivity in cannabis research has increased over time. The article will assist researchers in identifying the countries, institutions, and authors engaged in cannabis research.

Keywords: Bibliometric analysis, *Cannabis sativa*, Co-authorship, Co-occurrence, Scopus.

INTRODUCTION

Cultivated for several millennia for its fibers, cannabis has gradually disappeared from our landscape [1, 2]. The man has used these fibers and seeds for a long time, its use going up with the origins of the civilizations as well for its agricultural interest and properties. Its trace was found in China more than a thousand years before our era: it is the starting point of the diffusion of cannabis towards the African and European continents from the XVIth century and then towards the Americas from the XVIIth century. It is the Arabs who introduced cannabis in Occident for the confection of fabrics and ropes. As for the psychotropic properties of this plant, they were known before the Christian era; the Chinese used it in the 15th century B.C. to treat rheumatic pains gout, as an antiemetic treatment, and as an anesthetic [3].

Identifying and evaluating problematic cannabis use among adolescents is a public health concern acknowledged by the World Health Organization (WHO) due to the potential health and societal implications, particularly when early experimentation is involved. Nevertheless, primary care professionals, such as general practitioners and school nurses, who play a crucial role in recognizing these addictive disorders, frequently express uncertainty regarding the appropriate strategies to employ when addressing at-risk cannabis users [4, 5].

In counseling sessions, individuals at risk of cannabis use rarely proactively raise this concern. Despite the growing demand for treatment in recent years, the percentage of cannabis users seeking treatment remains low, even among those diagnosed with dependence. Depending on the study and country, approximately one-third of individuals diagnosed as cannabis-dependent seek treatment, with general practitioners being the most commonly approached healthcare professionals [6-8]. One of the explanatory factors of this level of demand below the levels of cannabis use seems to be a supply factor: primary care professionals seem to be insufficiently equipped to deal with this type of demand, often feeling that they have only partial knowledge of the feasibility and efficiency of the different methods of treatment [9].

According to the WHO, 200 million men are addicted to cannabis. THC, one of the molecules contained in cannabis, binds to certain regions of the brain and has psychotropic properties [10-

12]. The perception of cannabis by doctors and politicians fluctuates considerably depending on the country. Many countries such as Canada, Germany, the Netherlands, Spain, thirteen states in the United States, the Czech Republic, Austria, and Israel use cannabis for its therapeutic potential. On the other hand, the climate and the situation in other countries remain difficult, such as France, Greece, and Sweden [13-17].

Today, Morocco is still considered a leading producer of cannabis. Until now, its cultivation was illegal and harmful to the environment. This should now change with the adoption of the new law 13-21 on the legal use of cannabis. This will allow the beginning of scientific studies on cannabis to determine the most suitable ways of valorization [18, 19]. State efforts in the fight against drugs have led to a sharp decrease in the area under cultivation (estimated at around 50,000 hectares) without significantly impacting the quantity produced due to the introduction of high-yielding hybrid varieties imported from America or Europe.

To this end, this investigation aims to analyze publications on cannabis indexed in Scopus using bibliometrics and visualization analysis. Data was collected from the world's leading peer-reviewed research abstracts and citations Scopus database. This analysis allowed us to see how cannabis research and application have developed. In addition, this research allowed us to visualize and study the scientific collaborations between key contributors.

METHODOLOGICAL APPROACH

This study aims to conduct a bibliometric analysis of published research about cannabis. Bibliometric analysis is a review technique used to understand the relationships between different scientific publications' elements (authors, countries, citations) on a selected topic [20, 21]. Fig. 1 presents the methodology adopted for this article. First, a search was performed on 17/01/2023 in the Scopus database for the keywords "Cannabis AND Sativa." Then, filtration of the primary results was carried out regarding research fields, language, and publication period. Then, the results (authors, countries, institutions) were analyzed using several bibliometric tools.

In this investigation, bibliometric tools were employed to analyze highly cited authors, the most prolific journals in terms of published articles, regions with significant contributions to the subject, and the associations between authors and countries [22]. VOS Viewer and Bibliometrix, two software programs, were utilized in this study.

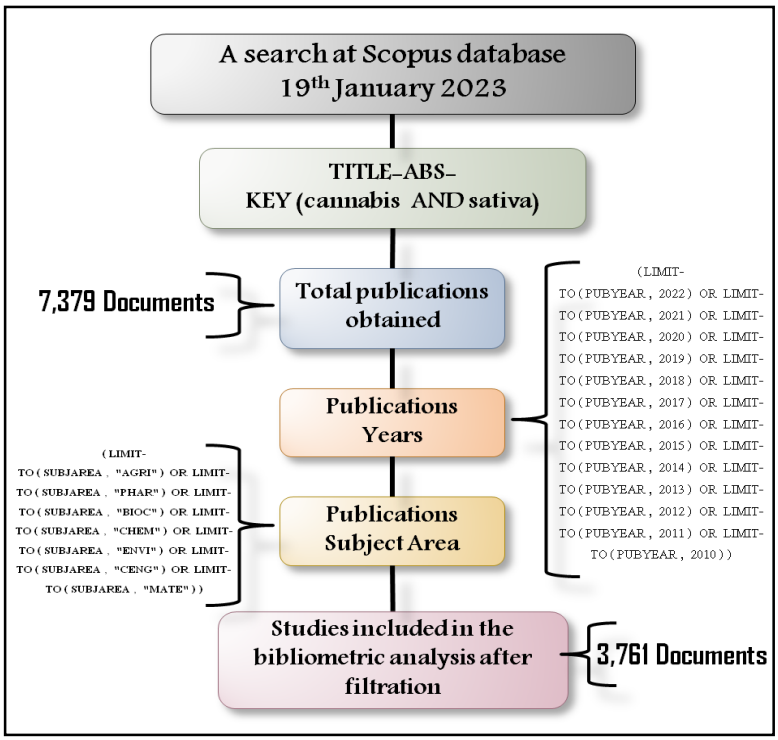

Figure (1): Study framework.

Results and discussions

Table 1 summarizes the main information retrieved. The total number of documents before data filtration was 7,379 publications. After filtering, the final number of studies is 3,761 from different types of manuscripts. The research period was set between 2010 and 2022. Articles are the most documented type, with a total of 2,902.

Table (1): Main information generated from Bibliometrix.

Description	Results
Main Information About Data	
Timespan	2010 - 2022
Sources (Journals, Books, Etc)	1,167
Documents	3,761
Annual Growth Rate %	12.72
Document Average Age	5.15
Average Citations Per Doc	22.91
References	1
Document Contents	
Keywords Plus (Id)	22,911
Author's Keywords (De)	9,213
Authors	
Authors	12,809
Authors Of Single-Authored Docs	162
Authors Collaboration	
Single-Authored Docs	206
Co-Authors Per Doc	5.13
International Co-Authorships %	21.86
Document Types	
Article	2,903
Book	5
Book Chapter	110
Conference Paper	98
Conference Review	1
Data Paper	1
Editorial	26
Erratum	10
Letter	11
Note	59
Retracted	1
Review	514
Short Survey	22

Annual publications

The first analysis was performed on the years of publications. The number of articles published between the period 2010 and 2022 is presented in Fig. 2. 2022 saw the publication of a total of 648 articles: 696 in 2021, 460 in 2020, 374 in 2019, and the remaining articles were spread over the other years (Fig. 2). The increase in the number of publications over time on cannabis is evidence of the attraction of researchers to this hot topic.

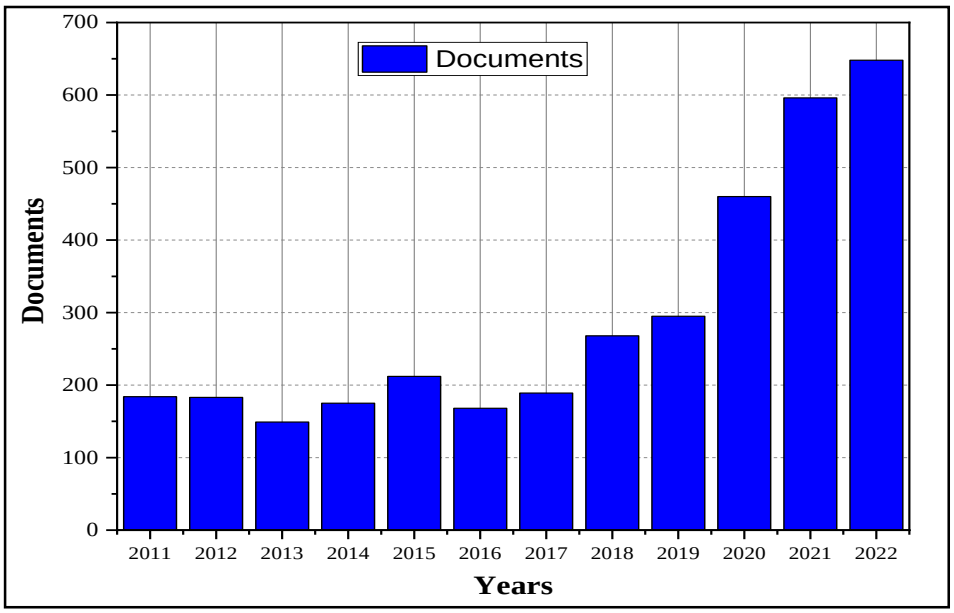

Figure (2): Documents published by years.

Research areas of publications

Prominent research domains encompass Agricultural and Biological Sciences, Pharmacology, Toxicology and Pharmaceutics, Biochemistry, Genetics and Molecular Biology, Chemistry, Environmental Science, Chemical Engineering, Engineering, and Materials Science (Fig. 3).

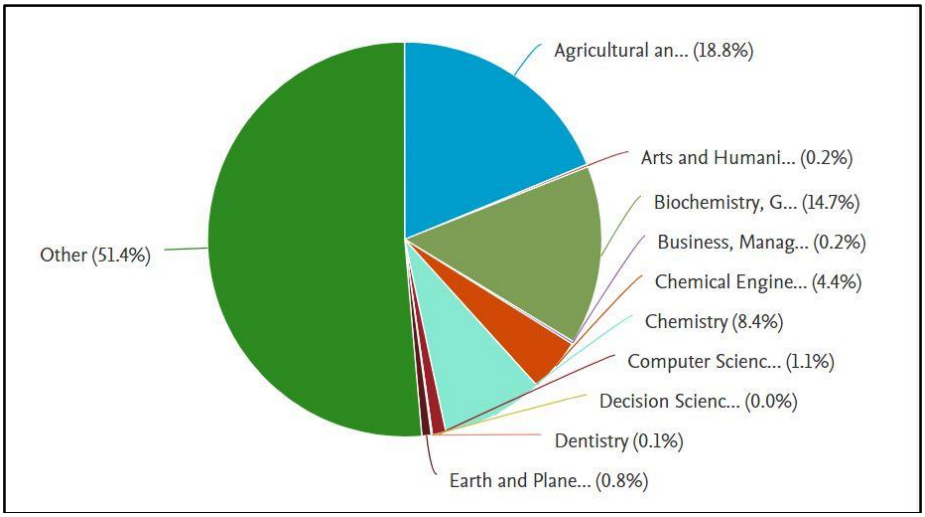

Figure (3): Publications research areas.

Most relevant countries

The analysis criteria chosen are "Total publications" and "Countries". The number of publications by country shows which countries have contributed to the field. Fig. 4 shows the top 10 most productive countries on cannabis. With a total of 762 publications (20.20% of the total), the USA is the most productive country, followed by Italy (432), Canada (214), India (173), China (162), Brazil (139), Spain (135), Germany (113), Poland (106), and Australia (92). The presence of both developed and developing nations is evident; however, it is noteworthy that research in developing countries is comparatively lagging. These countries would benefit from fostering collaborations with researchers from other nations to keep pace with the advancements in scientific research.

The most cited countries (Table 2) respectively are the USA (19,433), Italy (11,044), Canada (6,681), Brazil (4,988), Spain (3,433), U.K. (2,842), France (2,815), China (2,638), and Australia (2,088).

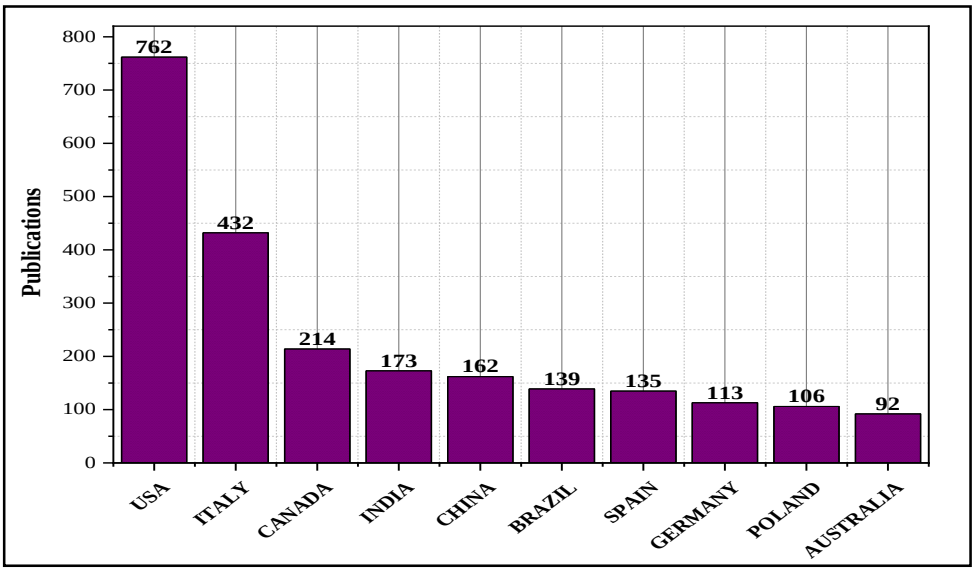

Figure (4): Most relevant countries.

Table (2): Most cited countries.

Country	Total Citations	Average Article Citations
USA	19,433	25.50
ITALY	11,044	25.56
CANADA	6,681	31.22
BRAZIL	4,988	35.88
SPAIN	3,433	25.43
UNITED KINGDOM	2,842	43.72
FRANCE	2,815	30.93
CHINA	2,638	16.28
AUSTRALIA	2,088	22.70
GERMANY	2,057	18.20

The collaboration between different countries was assessed using Vosviewer. Fig. 5 shows the collaboration network of countries. 30 countries related with 169 links. A link indicates a relation between countries. The bigger the nodes are, the higher the collaborations county has.

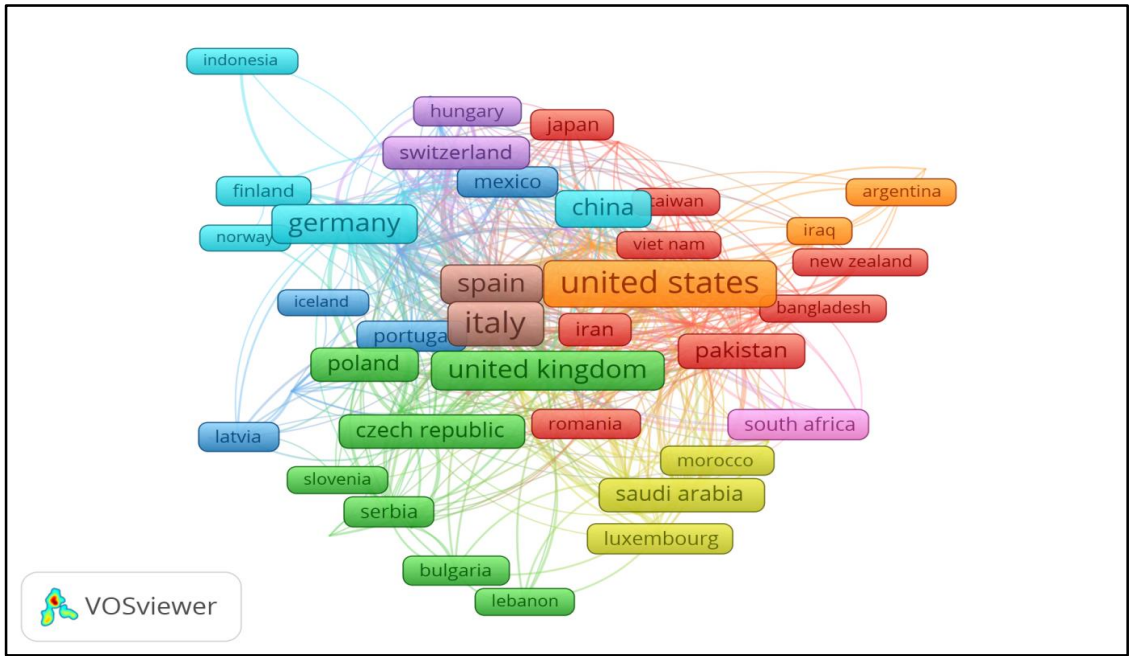

Figure (5): Collaboration network between countries.

Most relevant affiliations

835 institutions have worked on Cannabis and Sativa. Fig. 6 shows the 10 most productive institutions worldwide. This allowed researchers to find collaborators among these affiliations. In the first class, we find UNIVERSITY OF SÃO PAULO with 201 papers, followed by UNIVERSITY OF MISSISSIPPI (186), UNIVERSITY OF MODENA AND REGGIO EMILIA (186), INSTITUTE OF BAST FIBER CROPS (147), UNIVERSITY OF GUELPH (126), SAPIENZA UNIVERSITY OF ROME (111), UNIVERSITY OF NAPLES FEDERICO II (107), UNIVERSITY OF CALIFORNIA (105), UNIVERSITY OF MESSINA (105), and UNIVERSITÀ DEGLI STUDI DI MILANO (94). Italy is ranked first in number of universities among these 10.

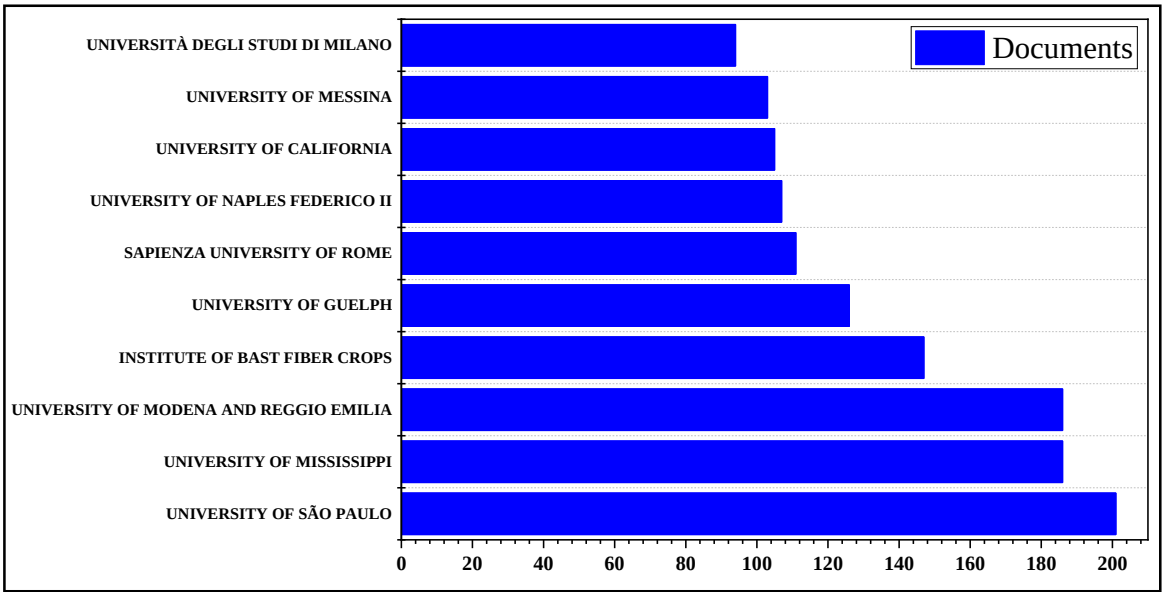

Figure (6): Top 10 documents published by affiliations.

Most relevant authors

Likewise, the author's productivity within the field of cannabis was examined. Table 3 presents the top 10 authors with the highest number of publications. In terms of publication count, the authors of utmost relevance are ranked as follows: ELSOHLY MA, GUIMARÃES FS, KHAN IA, CHANDRA S, CANNAZZA G, ZUARDI AW, GRASSI G, LATA H, WANG S, and KAYSER O. Notably, the research conducted by ELSOHLY MA stood out as the most emerging in this domain. GUIMARÃES FS, KHAN IA, and CHANDRA S introduced the most recent findings in this field.

Equation (1) depicts the adoption of a novel and more robust statistical calculation method, as implemented by Bibliometrix, which accurately reflects the true contribution of researchers based on the progress and evolution of the field.

$$\boldsymbol{Articles\ Fractionalized}\ (\boldsymbol{AUj}) = \sum \frac{1}{\boldsymbol{n\ of\ CoAuthors}\ (\boldsymbol{h})} \qquad \textbf{(Eq 1)}$$

The notation AUj represents the set of documents co-authored by author j, where h denotes a specific document within the set AUj.

This method confirms the results and the ranking of the authors according to the publication number. ELSOHLY MA is the most relevant, with a score of 7.71, followed by GUIMARÃES FS 7.49 (Table 3).

Table (3): Most relevant authors by document number.

Authors	Articles	Articles Fractionalized
ELSOHLY MA	44	7.71
GUIMARÃES FS	40	7.49
KHAN IA	29	5.29
CHANDRA S	28	5.52
CANNAZZA G	25	3.29
ZUARDI AW	25	2.71
GRASSI G	24	4.05
LATA H	24	4.75
WANG S	24	4.89
KAYSER O	23	6.34

Using Vosviewer, a collaboration network between authors was studied. 12,809 authors have published in this field of cannabis. As shown in Fig. 7, fifty-three authors constitute the collaboration network. These authors are divided into six groups: red, green, yellow, blue, orange, and purple.

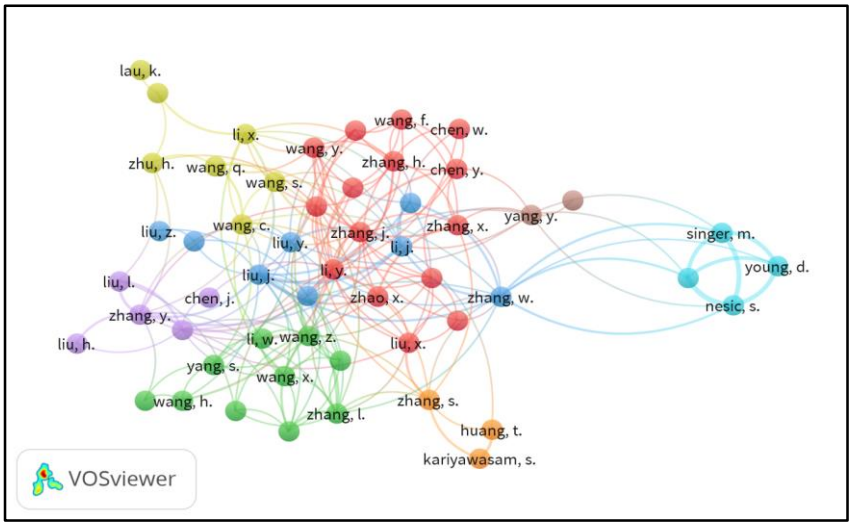

Figure (7): Collaboration network of authors.

The highest productive journals

Table 4 presents journals classified on article numbers. The table also presents the total publications, total citations, cites scores, most relevant articles, and publishers. Industrial Crops and Products occupy the first place with 180 articles, followed by Drug and Alcohol Dependence (173), Molecules (91), Frontiers in Plant Science (58), International Journal of Molecular Sciences (54), Plants (52), International Journal of Environmental Research and Public Health (51), Frontiers in Pharmacology (49), Cannabis and Cannabinoid Research (43), and Plant Disease (38), respectively.

Table (4): Top 10 highest productive journals.

Journal	Articles	Total publications	Total citations	Cite score	Most cited article	Times cited	H-Index	Publisher
Industrial Crops and Products	180	4,484	42,574	9.5	(Wadaugsorn, Panrong, Wongphan, & Harnkarnsujarit, 2022)	34	45	Elsevier
Drug and Alcohol Dependence	173	2,100	14,161	6.7	(Palamar et al., 2022)	11	54	Elsevier
Molecules	91	27,361	178,447	6.5	(Rahman et al., 2022)	81	23	Multidisciplinary Digital Publishing Institute (MDPI)
Frontiers in Plant Science	58	12,109	84,116	6.9	(Li & Chao, 2022)	26	20	Frontiers Media S.A.
International Journal of Molecular Sciences	54	45,379	342,276	7.5	(Fahed et al., 2022)	66	17	Multidisciplinary Digital Publishing Institute (MDPI)
Plants	52	8,690	45,080	5.2	(Ali et al., 2022)	46	47	Multidisciplinary Digital Publishing Institute (MDPI)
International Journal of Environmental Research and Public Health	51	44,769	231,224	5.2	(Liu, Yang, Li, & Zhong, 2022)	47	138	Multidisciplinary Digital Publishing Institute (MDPI)
Frontiers in Pharmacology	49	12,874	79,580	6.2	(Rudrapal et al., 2022)	40	20	Frontiers Media S.A.
Cannabis and Cannabinoid Research	43	192	1,143	6.0	(Liebling, Clarkson, Gibbs, Yates, & O'Sullivan, 2022)	18	18	Mary Ann Liebert
Plant Disease	38	1,844	8,090	4.4	(Salem, Sulaiman, Samarah, Turina, & Vallino, 2022)	14	17	American Phytopathological Society

Generally, the influence of a publication is determined by its number of citations. The most relevant documents locally are presented in Table 5. This table provides information on the title of the publication, the authors, the year of publication, the number of citations, and the year of publication. Andre, C.M. et al. had the most influential publication with the most citations (670). The three most relevant publications were published in 2015. All publications were journals except for three articles. These publications were generally related to the medical and pharmaceutical fields.

Table (5): Ten most cited articles.

Document Reference	Authors	Year	Type	Cited by
[23]	Andre, C.M., Hausman, J.-F., Guerriero, G.	2016	Article	670
[24]	Orsavova, J., Misurcova, L., Vavra Ambrozova, J., Vicha, R., Mlcek, J.	2015	Article	580
[25]	Zou, S., Kumar, U.	2018	Review	497
[26]	Bhattacharyya, S., Morrison, P.D., Fusar-Poli, P., (...), Atakan, Z., McGuire, P.K.	2010	Article	490
[27]	Maccarrone, M., Bab, I., Bíró, T., (...), Sharkey, K.A., Zimmer, A.	2015	Review	437
[28]	Bergamaschi, M.M., Queiroz, R.H.C., Chagas, M.H.N., (...), Zuardi, A.W., Crippa, J.A.S.	2011	Article	428
[29]	Adamson, S.J., Kay-Lambkin, F.J., Baker, A.L., (...), Kelly, B.J., Sellman, J.D.	2010	Article	407
[30]	Hanuš, L.O., Meyer, S.M., Muñoz, E., Taglialatela-Scafati, O., Appendino, G.	2016	Review	387
[31]	Berardi, U., Iannace, G.	2015	Article	377
[32]	van Bakel, H., Stout, J.M., Cote, A.G., (...), Hughes, T.R., Page, J.E.	2011	Article	351

Distribution of keywords

Using Vosviewer, a keyword analysis was performed to create specific links between terms. This analysis allows for recognizing hot spots in studying a specific topic. From 7,361 documents, 22,911 keywords, including author keywords, were identified. Fig. 8 shows the co-occurrence map, selecting words repeated 6 times. The nodes symbolize keywords, and two linked nodes mean both keywords exist in the same article. Larger nodes mean that the keyword occurs often. Closer nodes mean that they are closely related. A keyword with the highest connections means that it occurs most in articles. Three colors were chosen to rank the keywords: green, blue, and red. The most used keywords were cannabis (Oc = 2,460), *Cannabis sativa* (Oc = 2,035), article (Oc = 1,241), cannabidiol (Oc = 1,095), human (Oc = 1,079), non-human (Oc = 953), human (Oc = 922), hemp (Oc = 830), humans (Oc = 797), and controlled study (Oc = 747) (Fig. 9).

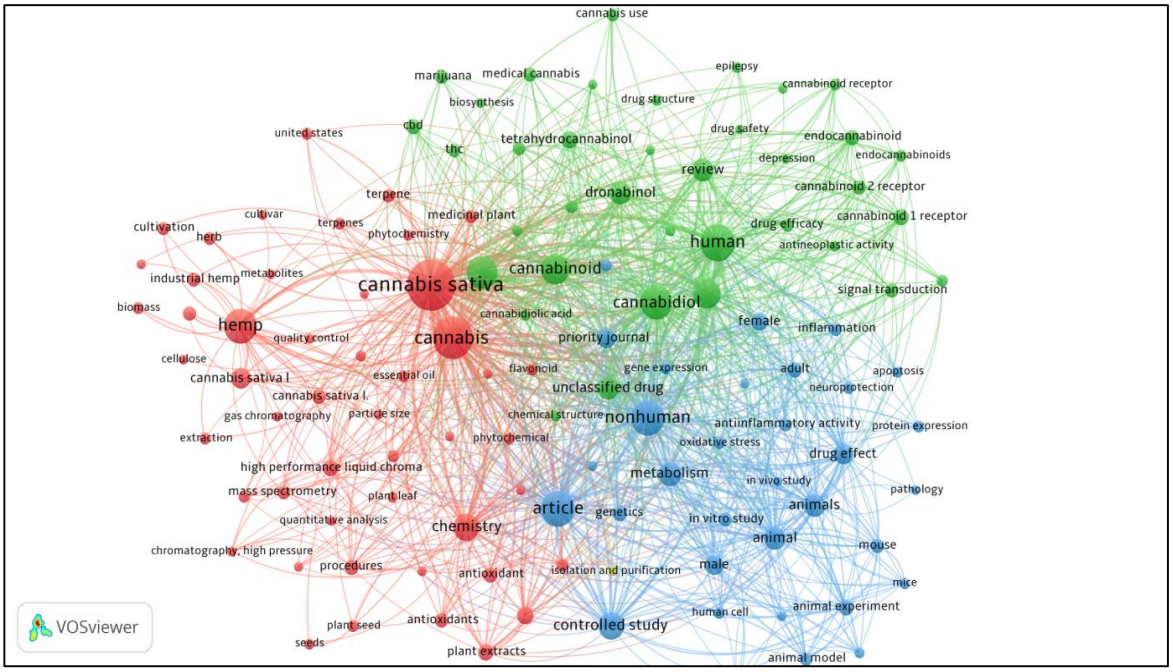

Figure (8): The co-occurrence of keywords.

Figure (9): The most used keywords.

LIMITATIONS

First, this bibliometric analysis can be the starting point for several studies, but it still has certain drawbacks. The Scopus database was the only one used to collect data. As a result, some journals from other databases were not included. Using all of the databases may result in different findings.

CONCLUSIONS

The work aims to perform a bibliometric analysis of the published literature on cannabis in the famous Scopus database. First, an analysis is performed to extract the number of publications, their characters, journals, countries, affiliations, and authors. After collection, a separate analysis is performed on the primary data to predict hot spots and trends in the field. There has been an increase in publications and citations on cannabis over time. 77.18% of publications were articles; the most popular fields are agriculture and biochemistry. Andre, C.M. et al. had the most relevant publication with several citations of 670, and ELSOHLY MA was the author with the highest number of publications (44). The most productive country is the USA, with 762 papers, followed by Italy 432. The most influential affiliation is UNIVERSITY OF SÃO PAULO, with 201 documents. The most frequent keywords are cannabis (Oc = 2,460), *Cannabis sativa* (Oc = 2,035). This study shows the increasing interest in cannabis in different research areas, especially materials, and eco-materials. This work can aid researchers interested in cannabis as it presents an analysis of publications from 2010 to 2022. The limitation of this document is that only one database was supported, which may cause the omission of some researchers and papers. In future studies, all databases should be considered.

Conflict of interest

The author affirms the absence of any conflicts of interest related to the publication of this manuscript. Furthermore, the authors have diligently adhered to ethical considerations encompassing plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Consent for publication

Not applicable.

Availability of data and materials

Most data generated or analyzed during this study are included in this manuscript. Other data analyzed during the current study are available from the corresponding author upon reasonable request.

AUTHOR'S CONTRIBUTION

F.D, N.J, S.J and K.H: review and editing. Y.E and C.H: Conceptualization; writing – original draft; formal analysis; writing and editing. Y.E: Software; writing–review and editing. K.H: Methodology; writing – review and editing. F.D: Conceptualization; Writing – original draft (supporting); Writing – review and editing.

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