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Mapping The Worldwide Knowledge of Jack Bean by A Bibliometric Approach

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ABSTRACT

Indonesia's indigenous inhabitants acknowledge the local legume plant known as jack bean. The Jack bean has various advantages, including increased production, a shorter lifespan, upright stems mimicking shrubs, and improved tolerance to biotic and abiotic stresses. Nonetheless, the jack bean plant is particularly vulnerable due to harmful compounds such as canavaliine, choline, hydroziamine acid, trogonelin, and cyanide. A bibliometric study was performed to locate studies on jack beans. The data collection procedure includes executing an extensive search in Scopus-indexed journals using the keywords "Jack Bean." It could limit the search to the article abstract, title, keywords, and country. The articles included in this study were published between 2000 and 2023. The search yielded a total of 999 items. The data was obtained on September 10, 2023; any later alterations are not considered in this research. According to the published literature, over the last 23 years, many studies have been conducted to develop urease inhibition and antioxidants from jack beans. However, little research has been done into the functional benefits of jack bean bioactive components for enhancing bodily health, such as antidiabetic, antihypertensive, and anticancer properties. This article contributes to helping researchers fill jack bean-related research gaps and apply technology to the industrialization process of jack beans in the functional food and nutraceutical industries.

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1. INTRODUCTION

An example of a legume that is not fully utilized is the jack bean (*Canavalia ensiformis*). The cultivation of jack beans is mostly concentrated in tropical and subtropical regions spanning South America, West Africa, Asia, and the South Pacific. It has a protein concentration ranging from 23% to 35%, a number of carbohydrates ranging from 46% to 65%, and a fibre content ranging from 5% to 11% (Purwandari, Westerbos, et al., 2023; Sridhar & Seena, 2006). In addition to their high nutrient content, jack beans possess a significant

abundance of anti-nutritional compounds, including trypsin inhibitors, tannins, and phytic acid. Hence, despite the elevated protein content of jack beans, their protein digestibility value was seen to be diminished due to the presence of substantial amounts of anti-nutritional compounds (Affandia et al., 2009; Kanetro et al., 2021; Sridhar & Seena, 2006).

The disparity between land productivity and the rising demand for soybeans necessitates the exploration of alternative commodities that can serve as nutritional substitutes for soybeans (Agustia et al., 2023; Andriati et al., 2018; Karoli et al., 2017; Purwandari, Westerbos, et al., 2023; Puspitojati et al., 2023). The utilization of jack beans as a substitute for soybeans in processed protein products has gained significant popularity in recent years. The government implemented a program aimed at achieving food self-sufficiency. This program harnesses the potential of several resources, including natural, human, socio-economic, and local wisdom. Leguminous plant species within the local vicinity possess promising promise as viable alternatives to soybeans. Indonesia possesses a significant abundance of biodiversity, encompassing several plant species, such as legumes, which have been traditionally cultivated as supplementary crops or utilized as hedgerows. The local legume plant, jack bean, is recognized by the indigenous population of Indonesia. The Jack bean possesses several advantageous traits, including increased yield, a shorter lifetime, upright stems resembling shrubs, and enhanced resistance to both biotic and abiotic factors. Nevertheless, the jack bean plant possesses a notable vulnerability due to the presence of various poisonous chemicals, including canavaliine, choline, hydroziamine acid, trogonelin, and cyanide. The removal of it can be achieved through a method involving soaking and boiling (Darini, 2021; Santos et al., 2021; Soares et al., 2011; Sridhar & Seena, 2006). The existence of many anti-nutritional and toxic chemicals undeniably impacts the diminished protein antinutritionality of jack beans. Consequently, numerous scholarly investigations have examined the protein digestibility value of jack beans and endeavoured to enhance it using diverse processing techniques (Arise et al., 2022; Purwandari et al., 2023; Yarlina et al., 2023).

Presently, extensive scholarly investigations have been conducted pertaining to the characterization of hazardous compounds found in jack beans (Sá et al., 2020), as well as the utilization of bioactive compounds derived from jack beans for the purpose of functional food production. Several studies have been conducted on various aspects of jack bean utilization. Kanetro et al. (2021) investigated the production of jack bean flour. The production of jack bean tempeh has been explored (Affandia et al., 2009; Andriati et al., 2018; Puspitojati et al., 2023; Yarlina et al., 2023). Agustia et al. (2023) focused on sprout production using jack beans. Sutedja et al. (2022) examined milk production from jack beans. Lastly, Ariyantoro et al. (2021) conducted research on the modification of jack bean starch. Multiple investigations have demonstrated the physiological impacts of antioxidants (Santos et al., 2021; Sutedja, Ito, et al., 2022), antihypertensive properties (Puspitojati et al., 2023), and antidiabetic benefits mediated by the inhibition of dipeptidyl peptidase IV (DPP IV) enzyme activity (Agustia et al., 2023).

A comprehensive body of knowledge pertaining to the utilization of jack beans has yet to be discovered. Nevertheless, bibliometric analysis has been a commonly utilized approach to spread the prospects in several study domains. For example, the functional food of *Myrciaria cauliflora* (Gabriel da Rosa et al., 2022), *Garcinia brasiliensis* fruits and their by-products (de Melo et al., 2021), bioactive peptide (Du & Li, 2022), antidiabetic peptide (Farias et al., 2022), antimicrobial substances produced by *Lactobacillus spp.* (Mörschbacher & Granada, 2022) Bibliometrics revealed the knowledge gaps and clarified the design of future studies to better grasp the state of the art in the research field. Nevertheless, there was no report of a bibliometric study in the literature to suggest future research paths on jack bean. In light of those mentioned above, this study completed a bibliometric assessment of research on jack beans conducted over the previous 23 years to identify opportunities for the long-term manufacture of bioactive chemicals. In addition to identifying potential knowledge gaps and research possibilities for

jack beans, this study is to provide a comprehensive overview of diverse research endeavours pertaining to the utilization of jack beans as a subject of investigation, as well as the extent of the topics that have been explored. Consequently, this paper aims to contribute to the identification of research deficiencies that can be utilized by other scholars seeking to advance the field of jack bean research.

2. MATERIALS AND METHODS

2.1. Data Collection

The data gathering process involved conducting an advanced search in Scopus-indexed journals, utilizing the keywords "Jack Bean." It was possible to restrict the search to the article abstract, title, keywords, and country. The articles incorporated in this research were conducted between 2000 to 2023. A total of 999 articles were obtained based on this search. The data was collected on September 10, 2023, and any subsequent modifications are not taken into account in this analysis.

2.2. Bibliometric Analysis

The data collection was acquired and examined via Scopus data analysis and Vos viewer (version 1.16.19) (van Eck & Waltman, 2010). Data were acquired from the Scopus database Utilizing the keywords "jack bean" and the time range 2000-2023. Subsequently, the results were depicted in the form of graphical representations. The procedure of this review is illustrated in Figure 1, which presents a flow chart.

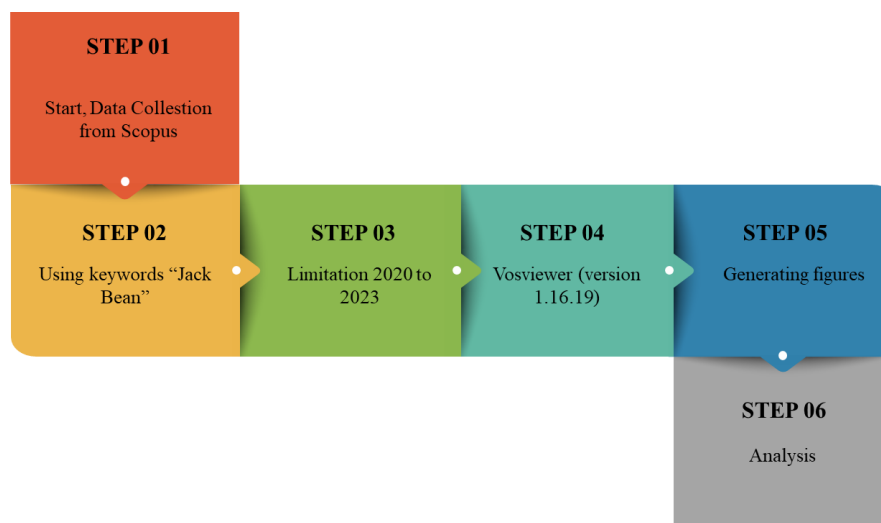


Figure 1. Diagram of the Bibliometric analysis procedure.

Figure 2 depicts a flowchart illustrating the records detected in each database, the total number of publications ($n = 1591$), the records screened and eligible, and the total number of studies included in this study ($n = 1591$). From a total of 1591 publications in the final selection, articles were found to be excluded ($n = 592$) because they were not research articles. So, the final articles used for further analysis totaled 999 articles.

3. RESULT AND DISCUSSION

3.1. General Results of Selected Articles in The Field of Research

Figure 3 illustrates the annual frequency of scholarly articles pertaining to the subject of jack beans. According to the depicted figure, the level of research and discourse pertaining to jack beans was very limited during the initial period of 2000. The quantity of articles showed a steady increase over subsequent years, culminating in its peak in the year 2020. The findings

align with the assertion made by Akpapunam & Sefa-Dedeh (1997). During that period, scholarly investigations on jack beans were relatively few despite the fact that this agricultural product was distributed over many geographical areas like Africa, Asia, India, Latin America, and the West Indies.

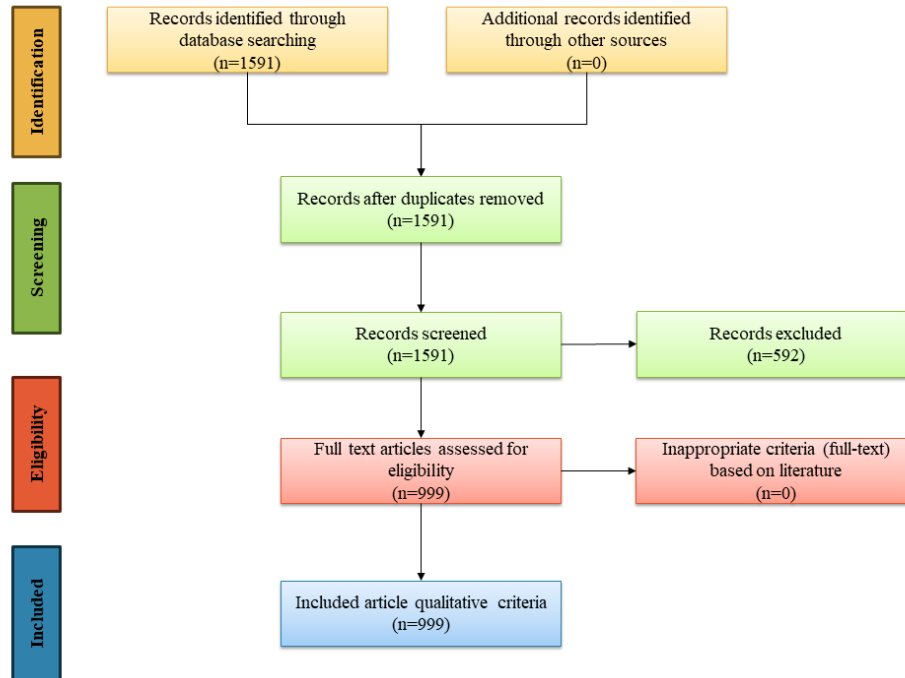


Figure 2. Prisma flow diagram of the article selection.

The increase in the number of studies conducted using jack beans as research objects from year to year shows that jack bean research in the early 2000s still had research gaps that could be exploited to answer several researchers' questions. In 2000, 27 articles were found. Most of the articles focus on plant urease (Kot et al., 2000; Marzadori et al., 2000) and chitinase (Hahn et al., 2000) from jack beans and the characterization of the canavalin protein found in jack beans (Ko, 2000). In 2020, 75 articles were found, most of which still discussed the extraction and isolation of urease from jack beans. The difference with previous studies is that many articles found in 2020 tried several types of organic and inorganic compounds to inhibit the jack bean urease activity (Grahl et al., 2020; Kaya et al., 2020; Svane et al., 2020; Taha et al., 2020). In fact, these studies have reached the stage of evaluating inhibition at the molecular level (Chaudhry et al., 2020; Hamad et al., 2020; Vanjare et al., 2020).

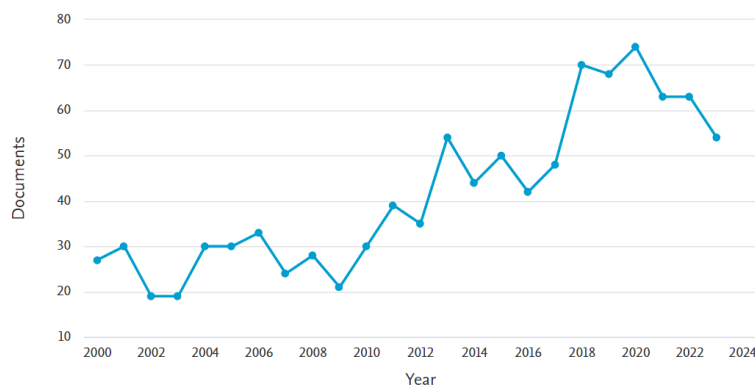


Figure 3. The amount of jack bean articles documented between 2020 and 2023.

3.2. Analysis of Country/Territory

The country analysis aims to evaluate articles produced in several countries related to Jack Bean. This data can contribute to determining research topics and subject areas that are often carried out in each country or can adopt research topics from other countries and modify them in the author's country, which is still rarely used. The geographical distribution of the documents was examined (Fig. 4). There are ten countries linked with the author who conducted the most extensive number of research studies on "jack beans." Among these, Brazil has the most documents (245 documents). Indonesia was rated seventh, with 50 documents. Data collected in the period 2000-2023 shows that research related to jack beans is dominated by Brazil. Detailed data produced by each country can be seen in Table 1.

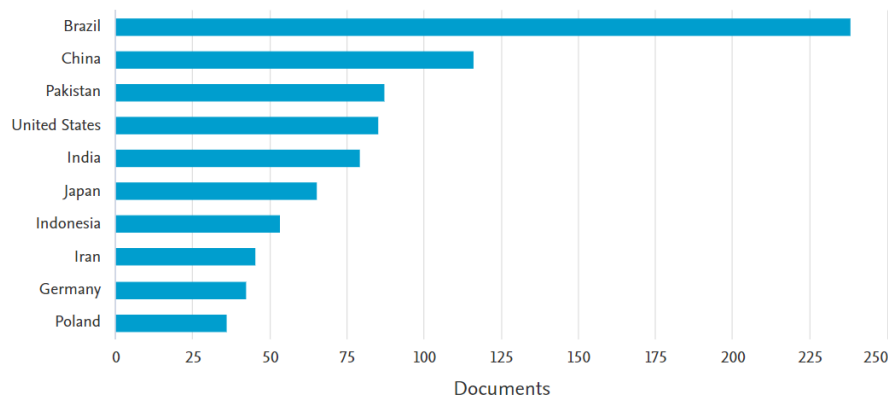


Figure 4. The amount of jack bean articles documented by country between 2020 and 2023.

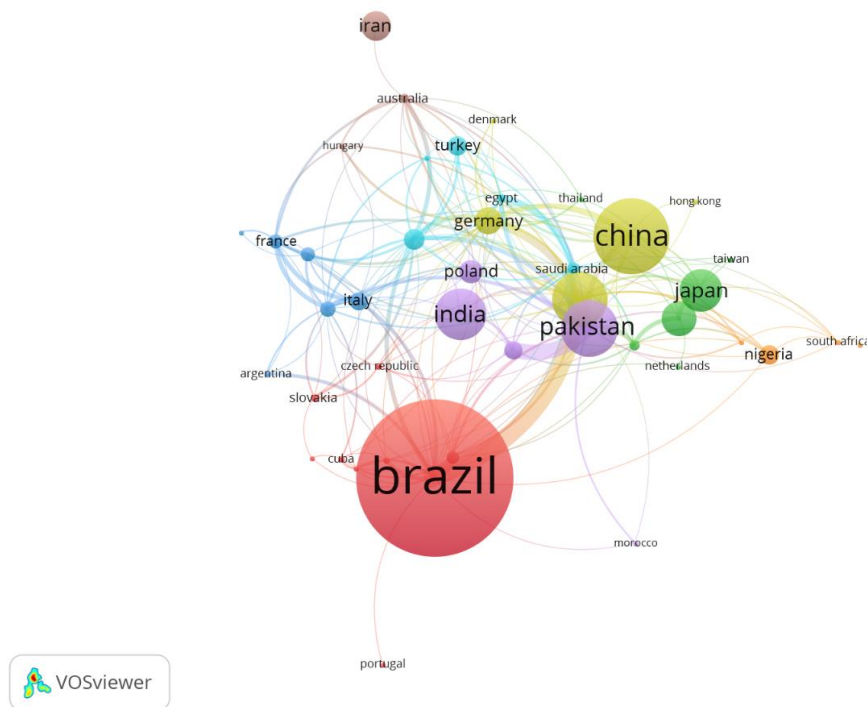


Figure 5. Network visualization of countries.

Figure 4 is supported by document analysis via the Vos viewer, which can be seen in Figure 5. If Figure 4 shows the number of documents in each country, Figure 5 depicts the relationship or connection of one country with other countries. In addition, the circle volume shown in Figure 5 represents the number of documents found in that country. The thickness of

the attachment line also has a similar meaning.

Table 1. Summary of the most explored topic areas in the ten countries with the most documents based on "jack bean" studies.

Numb	Country	Documents amount	Highest subject area		
			Subject area	Documents amount	Percentage (%)
1	Brazil	245	Agricultural and Biological Sciences	186	50.5
			Biochemistry, Genetics and Molecular Biology	41	11.1
			Environmental Science	32	8.7
2	China	119	Chemistry	87	37.2
			Materials Science	50	21.4
			Biochemistry, Genetics and Molecular Biology	23	9.8
3	Pakistan	98	Chemistry	60	37.3
			Pharmacology, Toxicology and Pharmaceutics	32	19.9
			Biochemistry, Genetics and Molecular Biology	27	16.8
4	United States	87	Biochemistry, Genetics and Molecular Biology	42	24.1
			Agricultural and Biological Sciences	33	19
			Chemistry	28	16.1
5	India	84	Biochemistry, Genetics and Molecular Biology	44	24
			Chemistry	29	15.8
			Agricultural and Biological Sciences	23	12.6
6	Japan	66	Biochemistry, Genetics and Molecular Biology	47	33.3
			Chemistry	27	19.1
			Immunology and Microbiology	14	9.9
7	Indonesia	65	Agricultural and Biological Sciences	35	28.9
			Environmental Science	15	12.4
			Earth and Planetary Sciences	13	10.7
8	Iran	45	Chemistry	23	28
			Pharmacology, Toxicology and Pharmaceutics	18	22
			Biochemistry, Genetics and Molecular Biology	11	13.4
9	Germany	42	Biochemistry, Genetics and Molecular Biology	19	22.1
			Chemistry	18	20.9
			Agricultural and Biological Sciences	12	14.0
10	Poland	36	Biochemistry, Genetics and Molecular Biology	20	31.3
			Pharmacology, Toxicology and Pharmaceutics	14	21.9
			Chemistry	12	18.8

Based on Table 1, it can be observed that the ten countries with the most jack bean research have similarities in several subject areas. The subject area, Agricultural and Biological Sciences, is the subject area with the most significant number of documents from the ten selected countries, namely 289 documents. Some of them are found in Brazil, the United States, India, Indonesia, and Germany. The second largest subject area is Chemistry, with a total of 284 documents, which were found in China, Pakistan, the United States, India, Japan, Iran, Germany, and Poland. The subject area with the third highest number of documents is

Biochemistry, Genetics, and Molecular Biology, with 274 documents found in all countries except Indonesia.

Based on the data obtained, document analysis can be deepened by looking at several research studies that focus on each subject area in each country. The Agricultural and Biological Sciences subject area in Brazil focuses a lot on research subjects related to jack bean urease (Barreto et al., 2023; Carrazoni et al., 2018; dos Santos et al., 2019; Moyetta et al., 2021; Sá et al., 2020), and jack bean cultivation (Cargnelutti Filho et al., 2016; de Araújo et al., 2017; da Melo et al., 2018; Seidel et al., 2016; Valadão et al., 2020). In contrast, Indonesia has more varied research topics related to jack beans in the Agricultural and Biological Sciences subject area. Some of them are the chemical properties of processed jack beans (Agustia et al., 2023; Purwandari et al., 2023; Purwandari et al., 2023), jack beans as functional foods (Agustia et al., 2023; Yusuf et al., 2023), and jack bean cultivation (Krisnawati et al., 2023; Uge et al., 2023).

3.3. Analysis of The Subject Area

Three topic area categories had the largest percentages, according to 999 filtered documents, Agricultural and Biological Sciences (20%), Chemistry (19.8%), and Biochemistry, Genetics, and Molecular Biology (17.5%). Figure 6 shows a pie chart depicting the percentage of various subject areas related to the keyword jack bean. A wide range of study topics were identified based on the subject area of agricultural and biological sciences. These included the assessment of jack beans' antioxidant activity and their usage as a raw material for kefir manufacturing (Yusuf et al., 2023), encapsulated protein concentrate of jack bean tempeh (Yarlina et al., 2023), jack bean flour (Anuntagool & Soonthonsun, 2023; Kanetro et al., 2021; Praseptianga & Wandansari, 2022), cooked and processed jack bean (Arise et al., 2022; Purwandari et al., 2023; Purwandari et al., 2023), jack bean cultivation (Darini et al., 2023; Krisnawati et al., 2023; Sunaryo & Prasetyowati, 2023; Uge et al., 2023), nutrition and anti-nutrition of germinated jack bean (Agustia et al., 2023), jack bean urease (Barreto et al., 2023; Liu et al., 2023; Zolghadr et al., 2022), Production of Dipeptidyl Peptidase-IV Inhibitory Peptides from Germinated Jack Bean (Agustia et al., 2023), Mold characterization in jack beans tempeh (Yarlina et al., 2023), ACE-inhibitory peptide formation from jack bean tempeh (Puspitojati et al., 2023), indigenous microbial diversity in soaking process of making jack bean tempeh (Yarlina et al., 2022), jack bean starch modification (Ariyantoro et al., 2022), α -Glucosidase inhibition of jack bean (Sutedja et al., 2022), jack bean tempeh protein isolate (Yarlina et al., 2022), bioactive compounds and antioxidant activity of jack bean milk (Sutedja et al., 2022), jack bean concavalin (Nonis et al., 2021).

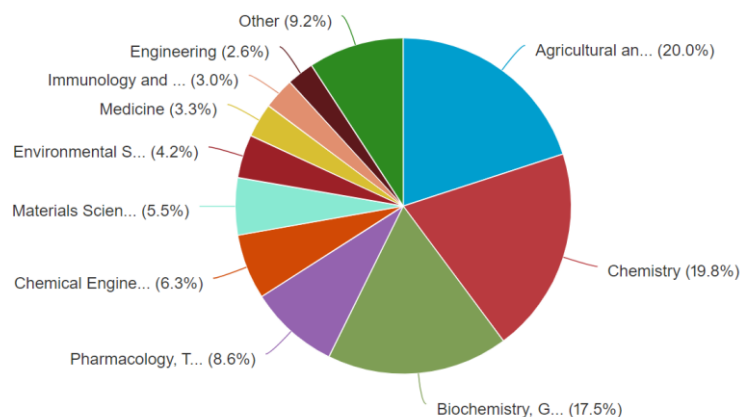


Figure 6. The percentage of jack bean articles documented by the subject area between 2020 and 2023.

The subject area with the next highest number of documents is chemistry, with a total of 367 articles. In the subject area of chemistry, research topics related to jack bean are dominated by the synthesis of jack bean urease (Arise et al., 2022; He et al., 2023; Mutahir et al., 2023), inactivation of jack bean urease (Larik et al., 2019; Long et al., 2015; Lu et al., 2021; Shah et al., 2021; Vanjare et al., 2020), jack bean-starch nanoparticle (Oladebeye et al., 2023), α -Glucosidase inhibition of jack bean (Farooq et al., 2022; Sutedja et al., 2020; Sutedja, Yanase, et al., 2022), jack bean α -mannosidase inhibitors (Vanni et al., 2021), thermal properties of jack bean seeds (Oriola et al., 2021).

3.4. Analysis of Keywords

According to the literature, keyword research is one of the most significant components of a bibliometric study. This analysis is vital for examining information and filtering file searches (Gabriel da Rosa et al., 2022). As a result, Figure 7 shows the 77 most often used author keywords in the field, each with a minimum of five occurrences. The map based on distinct clusters shows that the size of the circles is directly proportional to the keyword's total link strength. In comparison, the distance between two terms indicates whether they are closely linked or not. The top 20 keywords in the field are displayed in Table 2. The most common keywords were "urease" (107 occurrences), "molecular docking" (65 occurrences), "*Canavalia ensiformis*" (61 occurrences), and "Jack bean" (61 occurrences). This suggests that these terms are important and frequently occur together with a variety of other terms, as shown by the quantity of linkages (lines) in Figure 7a.

Table 2. The top 20 keywords in the field (ranked according to the strength of all links).

Ranking	Keyword	Occurrences	Total link strength
1	Molecular docking	65	117
2	Urease	107	113
3	Urease inhibition	58	91
4	Jack bean urease	58	82
5	Crystal structure	36	80
6	<i>Canavalia ensiformis</i>	61	48
7	Urease inhibitors	34	48
8	Inhibition	30	44
9	Jack bean	61	37
10	Copper complex	10	35
11	Hydrazone	9	32
12	Schiff base	14	32
13	Inhibitor	15	30
14	Urease inhibitor	28	30
15	Isothermal titration calorimetry	13	27
16	Synthesis	12	26
17	Kinetics	12	23
18	Antioxidant	13	21
19	<i>Helicobacter pylori</i>	16	20
20	Immobilization	17	19

Based on the examination of the keywords, Table 3 displays the clusters. Three clusters and the most significant keywords related to the biological characteristics of the bioactive chemicals from jack bean may be found. Furthermore, the most important keywords indicated that research focused on jack bean urease. Jack bean can, therefore, be promising in extracting bioactive compounds for technological applications, as shown by the keywords "urease inhibition," "antioxidants," and "cytotoxicity." Given that the majority of keywords are

connected to antioxidants, urease inhibitor activity is pertinent to its possible application in the food business, according to the keywords analysis. Chemical groups, including concavalin A, which are generally beneficial to human health, are examples of these qualities.

Network visualizations (Figure 7a) use labels and circles to represent entities. An item's weight determines the size of its label and circle. The label and circle of an item increase in size as its weight increases. For some things, the label may not appear. This is done to prevent overlapping labels. The colour of an item is determined by its cluster. Lines connecting elements signify links. The visualization's distance between the two journals demonstrates their co-citation relationship. In general, the closer two journals are to each other, the greater their relationship. Lines reflect the strongest co-citation linkages between journals (Jan van Eck & Waltman, 2018).

Nevertheless, the term average year map—a tool to track the evolution of publications based on keyword analysis—is shown in Figure 7b. According to Figure 7b, the most popular themes in the field are related to the isolation of bioactive molecules in order to assess their urease inhibition, antioxidant, and cytotoxicity, such as concavalin A. The findings demonstrated that the extraction of bioactive substances for human health using environmentally friendly technology was the highest priority subject for research on jack beans. Several studies on the functional benefits of jack bean bioactive components, as indicated in the introduction, yield different results based on Scopus document data analysis. It turns apparent that research recorded using Scopus data focuses on the extraction and synthesis of jack bean urease, and research focuses on inhibiting jack bean urease.

Table 3. Cluster identification using the keyword analysis.

Clusters*	Number of items	Keywords
1	18	Antioxidant activity, <i>Cajanus cajan</i> , <i>Canavalia ensiformis</i> , cover crops, cover plants, <i>Crotalaria juncea</i> , fabaceae, green manure, intercropping, jack beans, legume, legumes, nitrogen, <i>Pennisetum glaucum</i> , <i>Phaseolus vulgaris</i> , soil fertility, soil management, <i>Zea mays</i>
2	13	Docking, enzyme inhibition, enzyme kinetics, <i>Helicobacter pylori</i> , inhibition, nickel, triazole, urea, urease, urease activity, urease enzyme, urease inhibitor, x-ray structure
3	11	Ammonia, antibacterial, antioxidant, complex, copper(ii) complexes, cytotoxicity, docking studies, kinetic mechanism, molecular docking, synthesis, urease inhibitors,
4	9	Binding parameters, crystal structures, enzyme, <i>Helicobacter pylori urease</i> , inhibitor, isothermal titration calorimetry, jack bean urease, kinetics, sulfhydryl group
5	9	Copper complex, crystal structure, hydrazone, metal complexes, nickel complex, Schiff base, urease inhibition, urease inhibitory activity, zinc complex
6	8	Aggregation, enzymes, glycosidase inhibitors, iminosugars, inactivation, inhibitors, multivalency, α -mannosidase
7	5	Allelopathy, functional properties, germination, jack bean, soybean
8	4	Concavalin A, immobilization, lectin, peroxidase

*Cluster represented in Figure 7a

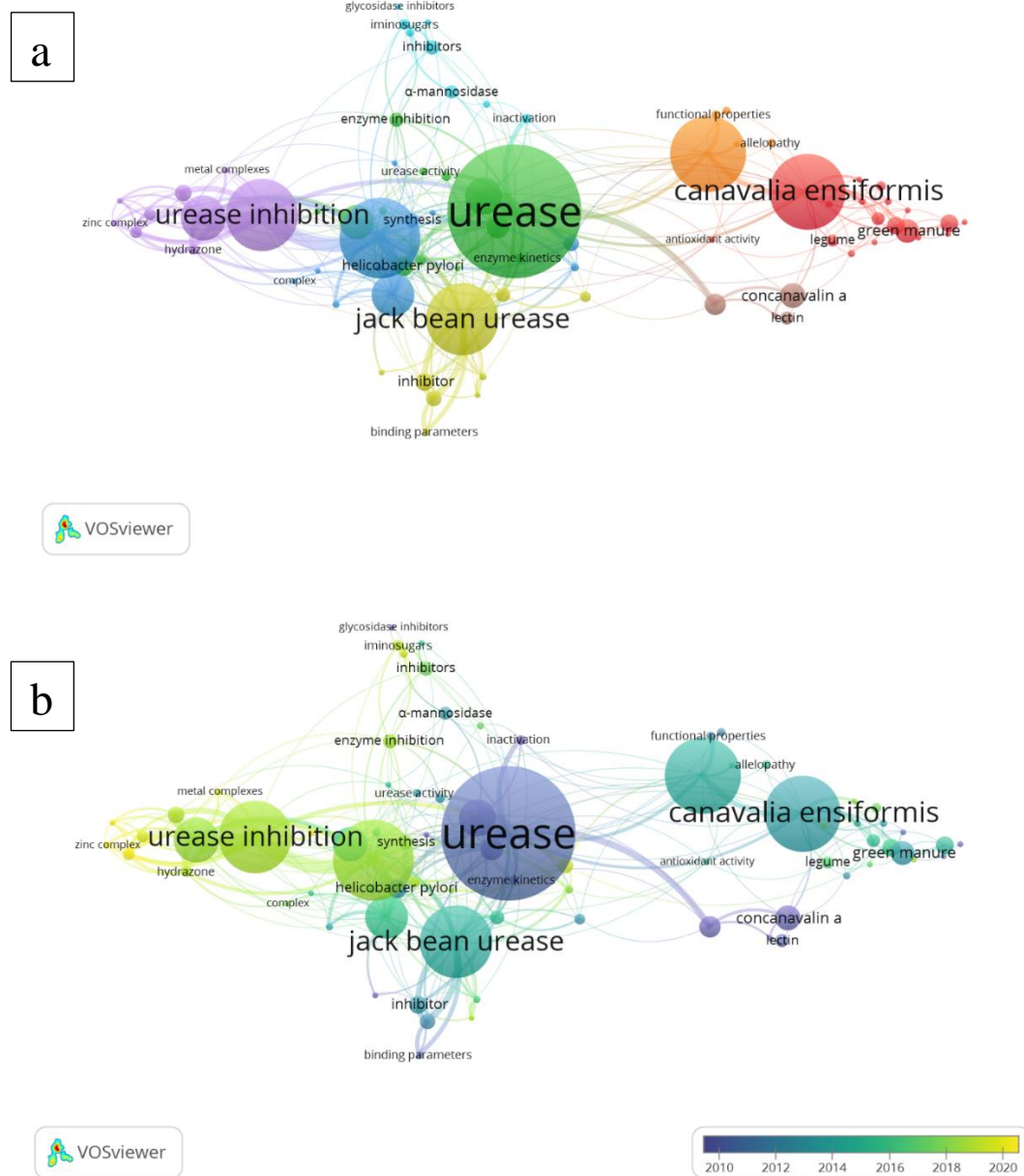


Figure 7. (a) Scientific research bibliometric network map on jack bean. (b) Identifies a time range during which the keyword was present.

4. CONCLUSIONS

A bibliometric analysis was conducted to find studies on jack bean. According to the published literature over the previous 23 years, various research has been undertaken to produce urease inhibition and antioxidants from jack bean. However, there is still limited research on the functional benefits of jack bean bioactive components for improving bodily health such as antidiabetic, antihypertensive, anticancer, antibacterial, and antitumor. Researchers can use this research gap to continue doing research in these disciplines and to apply technology to the jack bean industrialization process in the functional food and nutraceutical fields.

According to the analysis, Brazil, China, Pakistan, the United States, and India are the top five countries that contribute the most to jack bean research outputs. The most common subjects were Chemistry, Biological and Agricultural Sciences, and

Biochemistry/Genetics/Molecular Biology. *Canavalia ensiformis*, urease, molecular docking, and jack bean were shown to be some of the most commonly occurring and centrally linked terms by keyword analysis.

This bibliometric analysis indicates that jack bean research has been increasing, particularly in recent years, but it also highlights significant research gaps that need to be filled. More thorough research is needed to determine the potential use of jack bean-derived bioactive chemicals in functional foods and nutraceuticals beyond its antioxidant and urease-inhibiting qualities. Based on the research that has been collected thus far, their potential health-promoting advantages in relation to diabetes, hypertension, cancer, microbial infections, and other illness situations are still not well understood.

This study contributes to the research community by compiling a comprehensive data-driven landscape analysis to inform future research agendas and priorities for jack beans. Illuminating the white spaces and opportunities in this area is crucial for bridging current knowledge gaps and driving wider valorization of this nutritious yet underutilized legume crop. Interdisciplinary collaborations among agricultural researchers, food scientists, chemists, and biomedical researchers could catalyze advances by combining complementary expertise to fully unleash the functional food and pharmaceutical potentials of jack beans through sustainable processing technologies.

Overall, this bibliometric assessment presents a comprehensive picture of the progress of jack bean research while highlighting areas that are very productive and should get continued intense attention. It establishes the foundation for directing scientific research on jack beans toward more lucrative and high-value applications that have the potential to enhance global food security, nutritional quality, and public health outcomes.

This study is limited to the use of the Scopus database. Consequently, research results on jack beans that are not included in the Scopus database are not correctly documented. As a result, the dataset may contain some underrepresentation or gaps when compared to the total amount of research published on jack beans across the 23-year period studied. It is critical to recognize that bibliometric indications obtained from databases such as Scopus, while comprehensive, do not provide a whole picture. As a result, the findings of the analysis do not accurately represent all research results on jack beans all over the world.

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