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Artículo original

Bibliometric Analysis of Research on *Boesenbergia rotunda*, Pinostrobin, and Their Derivatives: Dominance of Southeast Asian Researchers

Análisis bibliométrico de la investigación sobre *Boesenbergia rotunda*, Pinostrobin y sus derivados: dominio de los investigadores del sudeste asiático

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ABSTRACT

Pinostrobin, marker compounds from *Boesenbergia rotunda* with various pharmacological activities, have been studied extensively, including synthesizing its derivatives, which have potent pharmacological activities. This study aims to describe research related to *B. rotunda*, pinostrobin, and their derivatives. Metadata information was collected from Scopus in August 2022, with three keywords searched for article titles, abstracts, and keywords. Analysis and research mapping were carried out with VOSviewer. The most widely used synonym for the plant name was "*Boesenbergia rotunda*", in which Norzulaani Khalid from the University of Malaya, Malaysia, mostly reported research with the keywords "*Boesenbergia rotunda*", "pinostrobin", and "derivative". The majority of researchers come from institutions in Southeast Asia, such as Malaysia, Thailand, and Indonesia. Interestingly, no Chinese researchers have reported studies on this topic. The journals and publishers that publish the most articles with these three keywords are Bioorganic and Medicinal Chemistry Letters and Elsevier, respectively. This information will make it easier for researchers on this topic to find partners for collaboration and determine journals to publish their research results.

Keywords: bibliometrics; *Boesenbergia rotunda*; *Boesenbergia pandurate*; derivative; fingerroot; medicinal plant; Pinostrobin; references; Scopus; Southeast Asia.

RESUMEN

La pinostrobina, compuesto de marcadores de *Boesenbergia rotunda* con diversas actividades farmacológicas, se ha estudiado ampliamente, incluida la síntesis de sus derivados que tienen potentes actividades farmacológicas. Este estudio tuvo como objetivo describir investigaciones relacionadas con *B. rotunda*, pinostrobina y sus derivados. La información de metadatos se recopiló de Scopus en agosto de 2022, con tres palabras clave buscadas para títulos de artículos, resúmenes y palabras clave. El análisis y el mapeo de la investigación se realizaron con VOSviewer. El sinónimo más utilizado para el nombre de la planta fue "*Boesenbergia rotunda*", en el que Norzulaani Khalid de la Universidad de Malaya, Malasia, informó principalmente sobre investigaciones con las palabras clave "*Boesenbergia rotunda*", "pinostrobina" y "derivado". La mayoría de los investigadores provienen de instituciones del sudeste asiático como Malasia, Tailandia e Indonesia. Curiosamente, ningún investigador chino ha informado de estudios sobre este tema. Las

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revistas y editoriales que más artículos publican con estas tres palabras clave son *Bioorganic and Medicinal Chemistry Letters* y Elsevier. Esta información facilitará a los investigadores sobre este tema encontrar colaboraciones y determinar las revistas para publicar los resultados de sus investigaciones.

Palabras clave: bibliometría; *Boesenbergia rotunda*; *Boesenbergia pandurate*; derivado; *fingerroot*; planta medicinal; Pinostrobin; referencias; Scopus; Sudeste de Asia.

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Introduction

Research to find new medicinal compounds is currently being reported more frequently by researchers, especially during the current COVID-19 pandemic.(1) Many scientists have tried various approaches, such as repurposing existing drugs,(2) exploring secondary metabolites from medicinal plants,(3) also *in silico* design and synthesis of new medicinal compounds.(4) Each approach has benefits and drawbacks, and to overcome this, researchers often combine several of these methods. One often tried and reported approach is the design and synthesis of metabolite derivatives isolated from medicinal plants.(5)

The synthesis of active metabolite derivatives from medicinal plants has long been known in the world of medicine,(6) and several drugs available on the market today were discovered through this approach.(7) Generally, the lead compounds' metabolites have some deficiencies, such as low potency(8) and properties that are not ideal for drug development.(9) Therefore, the development of these lead compounds' derivatives aims to increase their potential and improve their physicochemical properties.(10) One example is artesunate, an artemisinin derivative isolated from *Artemisia annua*.(11) Also, *Curcuma longa* has curcumin, in which some of its derivatives show increased pharmacological activity and improved drug-like properties.(12) Another metabolite whose derivative compounds are also being developed is pinostrobin, a flavonoid isolated from *Boesenbergia rotunda*.(13)

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Pinostrobin is a marker compound and is present in relatively large quantities in the rhizome of *B. rotunda*.[14] Those flavanone compounds have various potential pharmacological activities, such as antiviral, antioxidant, anticancer, and anti-inflammatory.[15,16] Several studies,[17,18,19] including our previous research[20,21] have derivatized pinostrobin with various other compounds, and the results showed improvement in physicochemical properties and reported an increase in pharmacological activity. The high pinostrobin yield of *B. rotunda*,[22] as well as the success story of previous studies related to the synthesis of pinostrobin derivatives, make this research topic still appealing to be investigated until now. However, determining a follow-up research topic from a major issue certainly needs to consider several factors. Apart from novelty, the research topic must also have clear and compelling research history. One sign is that other research teams are also interested in and researching the topic. A popular method that can be used to analyze the research scope that has been carried out related to a topic is to do bibliometric analysis.[23,24]

Bibliometric analysis is not a new method in literature-related research. Research using this method has been reported since the early 1970s.[25] However, advances in information technology have made it easier to obtain information, which has enabled bibliometric analysis in sciences to be increasingly developed today.[26] Besides, the development and digitization of research results databases as sources of bibliographic information such as Scopus, Web of Science, and PubMed provide complete and comprehensive search results.[27] Furthermore, various software is currently available to help visualize the bibliometric study results to be easier to analyze. One of the most widely used bibliometric analysis software is the VOSviewer developed by the Center for Science and Technology Studies, Leiden University. Apart from being free and its user-friendly interface, the features offered by VOSviewer are also complete, with a variety of communicative and eye-catching visualizations.[28] Combining a comprehensive database with attractive analysis software is the primary tool for researchers in bibliometric analysis, apart from a capable computer.[29] Several studies have reported various uses of this bibliometric analysis in medicinal chemistry to find research gaps and collaborative partners.[30,31] In general, the approach used is based on plants,[32] metabolites,[33] geographic location,[34] or analysis of particular scientific journals.[35] However, no bibliometric studies were reported using various combinations of plants, metabolites, and processes as search keywords, especially those related to *B. rotunda* and pinostrobin. Therefore, this study aims to describe research related to *B. rotunda*, pinostrobin, and their derivatives.

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Methods

The approach used is bibliometric analysis with the Scopus database. Search keywords are created in three search levels in order to get relevant results. Apart from analyzing articles and journals, an analysis of authorship and countries of origin of researchers was also conducted. These bibliometric analysis results are expected to provide an overview of the development of research that has been reported for that scope and information about potential collaborative partners, including the appropriate scientific journals to publish related research reports.

All articles analyzed were obtained from the Scopus database on August 30th, 2022. As one of the largest scientific article databases with the highest number of documents indexed, Scopus offers comprehensive journal peer-reviewed information for bibliometric studies. However, access to this information was not available to the public and requires access from an institution that was subscribed to and has access to Scopus.(36) In this study, access to Scopus was provided by Universitas Airlangga, Surabaya, Indonesia. This study adopted a five-stage method with several modifications as reported by Hudha *et al*.(37) as follows:

Determination of Search Keywords

Determining search keywords plays a vital role in bibliometric studies because a slight difference could give significantly different results,(38) especially for searching for a plant with various synonyms, both scientific and local names. In this study, the keywords used were divided into three levels, in which each increase in the search level would be added with the following keyword. The first keyword was the plant used, "*Boesenbergia rotunda*". There were eight variations of the first keyword that were determined based on the plant's synonyms, which consist of "*Boesenbergia rotunda*"; "*Boesenbergia pandurata*"; "*Kaempferia pandurata*"; "*Curcuma rotunda*"; "*Boesenbergia cochinchinensis*"; "*Kaempferia cochinchinensis*"; "*Kaempferia ovata*"; and "fingerroot".(39,40) The first keywords were used interchangeably, and the three synonyms with the highest number of document search results were used for the next stage. The second keyword was "pinostrobin", while the third keyword was "derivative". The criteria chosen for these keywords were article titles, abstracts, and keywords, assuming articles that specifically address the topic should contain keywords specified in one of the three criteria.(41)

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Initial Search Results

The search results with each keyword-level were presented as a whole in the Scopus database. The data collection on the number of Scopus documents was carried out without any restrictions, and no metadata was downloaded.

Refinement of Search Results

The initial search results obtained were refined based on several categories. Several parameters could be limited in the Scopus database, including access type, year of publication, author name, subject area, document type, publication stage, source title, keywords, affiliation, funding sponsor, country, source type, and language. No refinement was made for these parameters to obtain comprehensive results, except for the source type, which was limited to journals. The restriction was made assuming that other types of source forms such as books, book series, and book chapters contain tertiary information already available in journal form articles. Simultaneously, some conference proceedings were republished as articles in journals after receiving suggestions and criticism from other peers.(42)

Compile Preliminary Data Statistics

The refined data was then downloaded in CSV format. The exported information including citations, bibliography, abstract and keywords, funding details, and other information.

Data Analysis

Bibliometric analysis of downloaded data was performed and visualized using VOSviewer 1.6.18 (https://www.vosviewer.com/). The advantages of VOSviewer were its work efficiency with large and small data sets, supported by various types of exciting and informative visualizations. Additionally, the final results were grouped into publication clusters based on precisely defined categories.(43)

Three types of visualization could be analyzed with VOSviewer, consisting of network, overlays, and density visualization.(44) The visualization network emphasizes the research team's cluster division that publishes articles together marked by interconnected nodes. The color difference in the visualization network reflects the different clusters of the research team. However, there were times when multiple authorship clusters would link to each other due to the existence of a specific author linking multiple clusters.(45) The author, who acts

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as a liaison, had a research that collaborates with more than one research team and tends to have a history of publication with more than one institution. Slightly different from network visualization, overlay visualization focuses more on the timeline of the document published. Here we could see the difference when a research team published the article, so it could be seen which research team was currently researching the topic. The interesting point was that the author, who acts as the liaison of several research teams, would have a marker color that was not always the same as one of the linked research teams. In contrast, density visualization did not show networks but rather the intensity of a research team. The increase in the yellow color intensity shows the increase in number, while the area's width shows the number of authors in a cluster. This visualization style provides an advantage for quantitative comparisons of several research team clusters, such as comparing the number of documents and citations.(46)

Results and Discussion

Publications and citation structures

The initial search results for eight synonym names with three keyword levels showed that the number of documents with the keyword "*Boesenbergia rotunda*" gave the most results than other synonym names. Consistently, the number of documents had decreased with the addition of second and third keywords. From these results, the search and analysis would be focused on the first keywords of "*Boesenbergia rotunda*"; "*Boesenbergia pandurata*"; and "fingerroot". After refinement by limiting the search to source-type journals, fewer results but not too much difference were obtained. The complete results of metric data comparison from initial and refined search were presented in table 1.

Table 1 - Comparison metrics from initial and refined search

Keywords			**Number of articles**	
1	**2**	**3**	**Initial**	**Refinement**
Boesenbergia rotunda	-	-	179	169
Boesenbergia rotunda	Pinostrobin	-	32	29
Boesenbergia rotunda	Pinostrobin	Derivative	10	9
Boesenbergia pandurata	-	-	113	104
Boesenbergia pandurata	Pinostrobin	-	16	16

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Boesenbergia pandurata	Pinostrobin	Derivative	10	10
Fingerroot	-	-	56	51
Fingerroot	Pinostrobin	-	11	11
Fingerroot	Pinostrobin	Derivative	6	6
Kaempferia pandurata	-	-	78	71
Kaempferia pandurata	Pinostrobin	-	10	9
Kaempferia pandurata	Pinostrobin	Derivative	4	3
Curcuma rotunda	-	-	43	42
Curcuma rotunda	Pinostrobin	-	1	1
Curcuma rotunda	Pinostrobin	Derivative	1	1
Kaempferia cochinchinensis	-	-	5	5
Kaempferia cochinchinensis	Pinostrobin	-	0	0
Kaempferia cochinchinensis	Pinostrobin	Derivative	0	0
Boesenbergia cochinchinensis	-	-	4	4
Boesenbergia cochinchinensis	Pinostrobin	-	0	0
Boesenbergia cochinchinensis	Pinostrobin	Derivative	0	0
Kaempferia ovata	-	-	2	2
Kaempferia ovata	Pinostrobin	-	0	0
Kaempferia ovata	Pinostrobin	Derivative	0	0

Fuente: https://www.scopus.com

One of the challenges in bibliometric studies with medicinal plants was that most plants have synonyms, both in their scientific and local names. Therefore, using a particular name in a country or region could not be associated with assurance because the same plant in the same place could be known by different names.[47] Furthermore, even researchers from the same institution could use different names for the same plant. Hence, it was essential to carry out a search using all the plant name synonyms, ranked according to the names that appear most frequently in the study.

After the plant synonyms were determined, analysis was carried out on all documents containing the three levels of keywords. Of the three types of searches with plant name synonyms, it was known that several articles could be searched for more than one plant synonym. The article's complete results from the search results for these three keywords were presented in tables 2 to 4.

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Tabla 2 - Articles on Scopus with the keyword "*Boesenbergia rotunda*", "pinostrobin" and "derivative"

No.	Publication year	Authors	Title	Journal	Publisher	Cited by
1	2006	Kiat TS, Pippen R, Yusof R, Ibrahim H, Khalid N, Rahman NA.	Inhibitory activity of Cyclohexenyl chalcone derivatives and flavonoids of fingerroot, *Boesenbergia rotunda* (L.), towards dengue-2 virus NS3 protease	Bioorganic and Medicinal Chemistry Letters	Elsevier	196
2	2002	Tuchinda P, Reutrakul V, Claeson P, Pongprayoon U, Sematong T, Santisuk T, Taylor WC.	Anti-inflammatory Cyclohexenyl chalcone derivatives in *Boesenbergia pandurata*	Phytochemistry	Elsevier	145
3	2012	Tan EC, Karsani SA, Foo GT, Wong SM, Abdul Rahman N, Khalid N, Othman S, Yusof R.	Proteomic analysis of cell suspension cultures of *Boesenbergia rotunda* induced by phenylalanine: Identification of proteins involved in flavonoid and phenylpropanoid biosynthesis pathways	Plant Cell, Tissue and Organ Culture	Springer Nature	21
4	2016	Ng TLM, Karim R, Tan YS, Teh HF, Danial AD, Ho LS, Khalid N, Appleton	Amino acid and secondary metabolite production in embryogenic	PLoS ONE	Public Library of Science	18

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		DR, Harikrishna JA.	and non-embryogenic callus of fingerroot ginger (*Boesenbergia rotunda*)			
5	2015	Tan BC, Tan SK, Wong SM, Ata N, Rahman NA, Khalid N.	Distribution of flavonoids and Cyclohexenyl chalcone derivatives in conventional propagated and in vitro-derived field-grown *Boesenbergia rotunda* (L.) Mansf.	Evidence-based Complementary and Alternative Medicine	Hindawi	17
6	2007	Sukari MA, Ching AYL, Lian GEC, Rahmani M, Khalid K.	Cytotoxic constituents from *Boesenbergia pandurata* (Roxb.) Schltr.	Natural Product Sciences	Korean Society of Pharmacognosy	15
7	2019	Youn K, Jun M.	Biological evaluation and docking analysis of potent BACE1 inhibitors from *Boesenbergia rotunda*	Nutrients	MDPI	13
8	2020	Kanchanapiboon J, Kongsa U, Pattamadilok D, Kamponchaidet S, Wachisunthon D, Poonsatha S, Tuntoaw S.	*Boesenbergia rotunda* extract inhibits Candida albicans biofilm formation by pinostrobin and pinocembrin	Journal of Ethnopharmacology	Elsevier	4
9	2021	Break MKB, Chiang M,	Cytotoxic Activity of	Nutrition and Cancer	Taylor and Francis	3

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		Wiart C, Chin C-F, Khoo ASB, Khoo T-J.	*Boesenbergia rotunda* Extracts against Nasopharyngeal Carcinoma Cells (HK1). Cardamonin, a *Boesenbergia rotunda* Constituent, Inhibits Growth and Migration of HK1 Cells by Inducing Caspase-Dependent Apoptosis and G2/M–Phase Arrest			
Total						432

Fuente: https://www.scopus.com

Tabla 3 - Articles on Scopus with the keyword "*Boesenbergia pandurata*", "pinostrobin", and "derivative"

No.	Publication year	Authors	Title	Journal	Publisher	Cited by
1	2002	Tuchinda P, Reutrakul V, Claeson P, Pongprayoon U, Sematong T, Santisuk T, Taylor WC.	Anti-inflammatory Cyclohexenyl chalcone derivatives in *Boesenbergia pandurata*	Phytochemistry	Elsevier	145
2	2001	Trakoontivakorn G, Nakahara K, Shinmoto H, Takenaka M, Onishi-Kameyama M, Ono H, Yoshida M, Nagata T, Tsushida T.	Structural analysis of a novel antimutagenic compound, 4-hydroxypanduratin A, and the antimutagenic activity of flavonoids in a	Journal of Agricultural and Food Chemistry	American Chemical Society	108

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			Thai spice, fingerroot (*Boesenbergia pandurata* Schult.) against mutagenic heterocyclic amines			
3	2002	Fahey JW, Stephenson KK.	Pinostrobin from honey and Thai ginger (*Boesenbergia pandurata*): A potent flavonoid inducer of mammalian phase 2 chemoprotective and antioxidant enzymes	Journal of Agricultural and Food Chemistry	American Chemical Society	87
4	2010	Poerwono H, Sasaki S, Hattori Y, Higashiyama K.	Efficient microwave-assisted prenylation of pinostrobin and biological evaluation of its derivatives as antitumor agents	Bioorganic and Medicinal Chemistry Letters	Elsevier	30
5	2016	Patel NK, Jaiswal G, Bhutani KK.	A review on biological sources, chemistry and pharmacological activities of pinostrobin	Natural Product Research	Taylor and Francis	21
6	2009	Wangkangwan W, Boonkerd S, Chavasiri W, Sukapirom K, Pattanapanyasat K, Kongkathip N, Miyakawa T.	Pinostrobin from *Boesenbergia pandurata* Is an inhibitor of Ca 2+-Signal-Mediated Cell-Cycle regulation in the Yeast *Saccharomyces cerevisiae*	Bioscience, Biotechnology and Biochemistry	Taylor and Francis	17

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7	2007	Sukari MA, Ching AYL, Lian GEC, Rahmani M, Khalid K.	Cytotoxic constituents from *Boesenbergia pandurata* (Roxb.) Schltr.	Natural Product Sciences	Korean Society of Pharmacognosy	15
8	2017	Ajmala Shireen P, Abdul Mujeeb VM, Muraleedharan K.	Theoretical insights on flavanones as antioxidants and UV filters: A TDDFT and NLMO study	Journal of Photochemistry and Photobiology B: Biology	Elsevier	13
9	2021	Suryadi A, Siswodihardjo S, Widiandani T, Widyowati R.	Structure modifications of pinostrobin from temu kunci (*Boesenbergia pandurata* roxb. schlecht) and their analgesic activity based on *in silico* studies	Research Journal of Pharmacy and Technology	A and V Publication	0
10	2021	Praditapuspa EN, Siswandono, Widiandani T.	In silico analysis of pinostrobin derivatives from *Boesenbergia pandurata* on ErbB4 kinase target and QSPR linear models to predict drug clearance for searching anti-breast cancer drug candidates	Pharmacognosy Journal	Pharmacognosy Network Worldwide	0
Total						436

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Tabla 4 - Articles on Scopus with the keyword "fingerroot", "pinostrobin", and "derivative"

No.	Publication year	Authors	Title	Journal	Publisher	Cited by
1	2006	Kiat TS, Pippen R, Yusof R, Ibrahim H, Khalid N, Rahman NA.	Inhibitory activity of Cyclohexenyl chalcone derivatives and flavonoids of fingerroot, *Boesenbergia rotunda* (L.), towards dengue-2 virus NS3 protease	Bioorganic and Medicinal Chemistry Letters	Elsevier	196
2	2001	Trakoontivakorn G, Nakahara K, Shinmoto H, Takenaka M, Onishi-Kameyama M, Ono H, Yoshida M, Nagata T, Tsushida T.	Structural analysis of a novel antimutagenic compound, 4-hydroxypanduratin A, and the antimutagenic activity of flavonoids in a Thai spice, fingerroot (*Boesenbergia pandurata* Schult.) against mutagenic heterocyclic amines	Journal of Agricultural and Food Chemistry	American Chemical Society	108
3	2002	Fahey JW, Stephenson KK.	Pinostrobin from honey and Thai ginger (*Boesenbergia pandurata*): A potent flavonoid inducer of mammalian phase 2 chemoprotective and antioxidant enzymes	Journal of Agricultural and Food Chemistry	American Chemical Society	87
4	2010	Poerwono H, Sasaki S, Hattori Y, Higashiyama K.	Efficient microwave-assisted prenylation of pinostrobin and biological	Bioorganic and Medicinal Chemistry Letters	Elsevier	30

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			evaluation of its derivatives as antitumor agents			
5	2016	Kicuntod J, Khuntawee W, Wolschann P, Pongsawasdi P, Chavasiri W, Kungwan N, Rungrotmongkol T.	Inclusion complexation of pinostrobin with various cyclodextrin derivatives	Journal of Molecular Graphics and Modelling	Elsevier	28
6	2016	Ng TLM, Karim R, Tan YS, Teh HF, Danial AD, Ho LS, Khalid N, Appleton DR, Harikrishna JA.	Amino acid and secondary metabolite production in embryogenic and non-embryogenic callus of fingerroot ginger (*Boesenbergia rotunda*)	PLoS ONE	Public Library of Science	18
Total						467

Fuente: https://www.scopus.com

Apart from authorship, data collection and analysis were carried out on journals and publishers in which the articles were published. The analysis was carried out on these three keyword combinations, in which the results showed that there were 16 journals and 10 publishers that published articles with the combination of the three keywords. The complete data were presented in table 5.

Tabla 5 - Comparison of each journal and publisher with the keywords "*Boesenbergia rotunda*"/" *Boesenbergia pandurata*"/" fingerroot", "pinostrobin", and "derivative"

No.	Journal	Publisher	Total articles	Total citations
1	*Bioorganic and Medicinal Chemistry Letters*	Elsevier	2	226
2	*Journal of Agricultural and Food Chemistry*	American Chemical Society	2	195
3	*Phytochemistry*	Elsevier	1	145

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4	*Journal of Molecular Graphics and Modelling*	Elsevier	1	28
= 5	*Natural Product Research*	Taylor and Francis	1	21
= 5	*Plant Cell, Tissue and Organ Culture*	Springer Nature	1	21
7	*PLoS ONE*	Public Library of Science	1	18
= 8	*Bioscience, Biotechnology and Biochemistry*	Taylor and Francis	1	17
= 8	*Evidence-based Complementary and Alternative Medicine*	Hindawi	1	17
10	*Natural Product Sciences*	Korean Society of Pharmacognosy	1	15
= 11	*Journal of Photochemistry and Photobiology B: Biology*	Elsevier	1	13
= 11	*Nutrients*	MDPI	1	13
13	*Journal of Ethnopharmacology*	Elsevier	1	4
14	*Nutrition and Cancer*	Taylor and Francis	1	3
15	*Research Journal of Pharmacy and Technology*	A and V Publication	1	0
16	*Pharmacognosy Journal*	Pharmacognosy Network Worldwide	1	0
Total			18	736

Fuente: https://www.scopus.com

The journals with the highest number of articles (two each) were Elsevier's Bioorganic and Medicinal Chemistry Letters and the Journal of Agricultural and Food Chemistry from the American Chemical Society, with 226 and 195 citation counts, respectively. This finding implies that articles published in the two journals on the topics related to these three keywords received the most attention and were referred to the most by their peers.(48) On the other hand, Elsevier became the publisher with the highest number of journals publishing articles on these keywords with five journals, followed by Taylor and Francis with two journals. This finding explicitly suggests that the chances of publishing articles with topics related to these three keywords would be higher if they are submitted to journals managed by Elsevier. Indeed, this was an estimate because the article's topic must be reconciled with the journal's aims and scope.(49) Still, this approach's results would help future researchers choose the most appropriate journal for their research articles that match the topic and keywords.

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Authors and co-authorship relations

Each of the three keyword combinations used was separately analyzed because although there are overlapping documents, they had documents that only appear specifically through a search with that keyword combination. However, the Scopus database has a shortcoming, in which the Scopus data for the institution/organization has not been harmonized, so it tends to display the institution's name in an inconsistent format (e.g., department, faculty, university).(50) Therefore, author institutional analysis with the Scopus database was frequently not carried out, except in certain conditions, such as a small number of documents and consistent institutional writing.

The combination of the keywords "*Boesenbergia rotunda*", "pinostrobin", and "derivative", six research team clusters were shown in different colors, as shown in figure 1. Of the six teams, three of them had slices connected by the collaboration of Norzulaani Khalid from the University of Malaya, Malaysia. The three teams were also known to have not carried out research simultaneously but took turns in different periods in the last ten years. Apart from Norzulaani Khalid as the principal liaison, Noorsaadah Abdul Rahman, Rohana Yusof, and Sher Ming Wong from the University of Malaya connect the two large research teams' clusters. The difference with Norzulaani Khalid was that they did not directly relate to the cluster of research teams from Universiti Putra Malaysia, Malaysia, and the University of Rajshahi, Bangladesh, for research on this topic. This illustration also shows that combining the two clusters of the research team gave many documents, exceeding the other clusters.

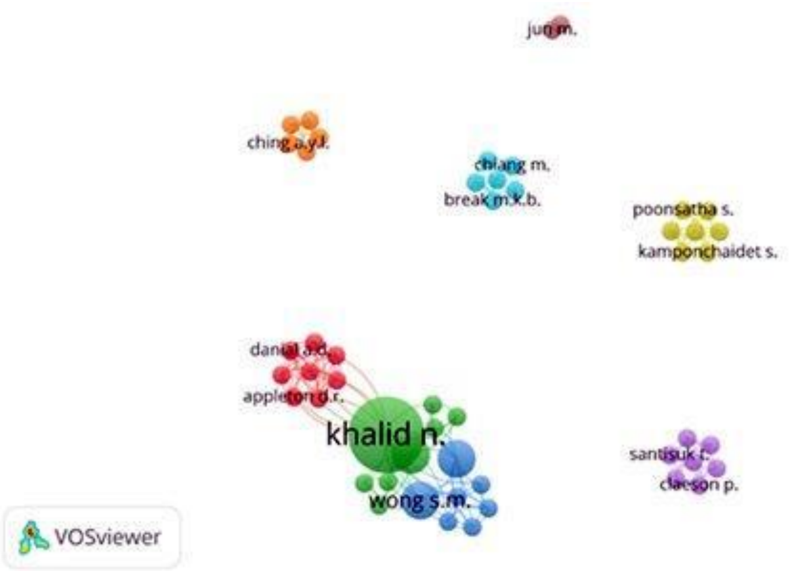

Fig. 1 – Network visualization of authorship with keywords "*Boesenbergia rotunda*", "pinostrobin", and "derivative".

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Replacing the keyword "*Boesenbergia rotunda*" with "*Boesenbergia pandurata*" gave very different results, as seen in figure 2. Also, the majority of research was carried out over the past ten years, except for those reported by the research team from the University of Calicut, India; National Institute of Pharmaceutical Education and Research, India; Universitas Airlangga, Indonesia; and Hoshi University, Japan. Meanwhile, nothing particularly stands out in terms of intensity, in which the number of documents across the cluster did not differ in number.

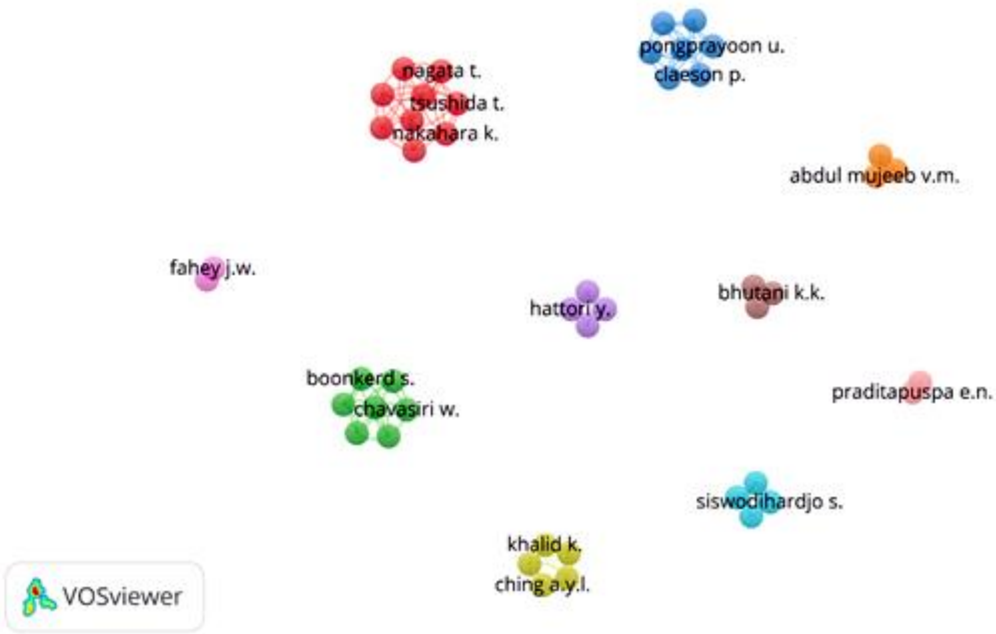

Fig. 2 – Network visualization of authorship with keywords "*Boesenbergia pandurata*", "pinostrobin", and "derivative".

Lastly, a search with the keyword combination of "fingerroot", "pinostrobin", and "derivative" shows results in a mixture of previous searches, where there was only one document that is different from the previous two searches. As before, Norzulaani Khalid liaised with the two research team clusters and engaged the two research teams at different times, as shown in figure 3. Combining the two research team clusters resulted in high document intensity but could still be distinguished from one another.

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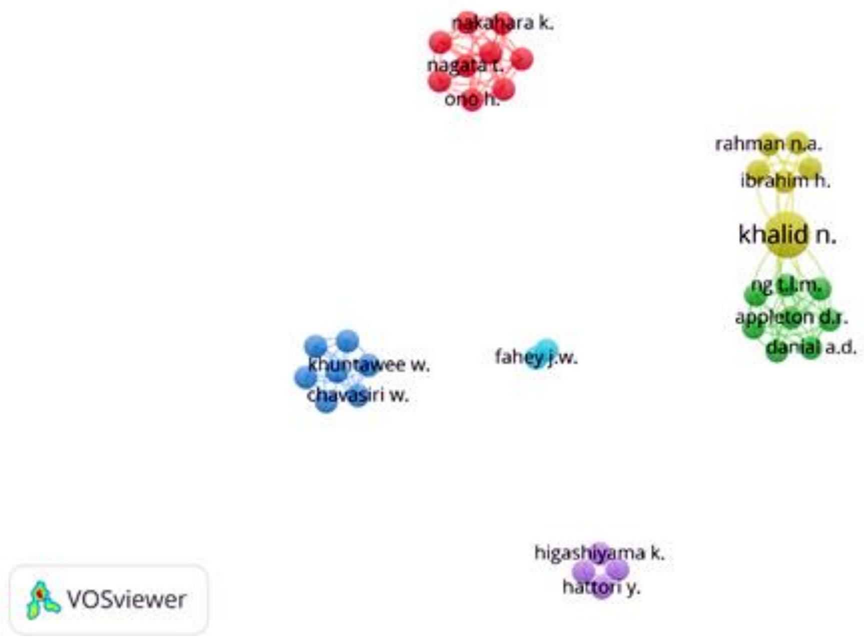

Fig. 3 – Network visualization of authorship with keywords “fingerroot”, “pinostrobin”, and “derivative”.

Country of study location

Combining the keywords “*Boesenbergia rotunda*”, “pinostrobin”, and “derivative”, six countries were registered with three clusters, as shown in figure 4. Meanwhile, replacing “*Boesenbergia rotunda*” with “*Boesenbergia pandurata*” gives different results, where there were seven countries in five clusters. Finally, the keyword “fingerroot” would generate seven countries divided into three clusters.

Fig. 4 – Network visualization of countries with keywords “*Boesenbergia rotunda*”, “pinostrobin”, and “derivative”.

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Authorship analysis was conducted to outline the network of researchers on related topics and conduct profiling of each researcher's identity, including the year the article was published, the number of documents produced, and the origin of each author's institution/organization and country.(51) The analysis of the keyword "*Boesenbergia rotunda*" shows that of the seven existing documents, four of them were written by Norzulaani Khalid from the University of Malaya, Malaysia. Similar results were shown for the keyword "fingerroot", of which Norzulaani Khalid wrote two of six existing documents. Meanwhile, in the keyword "*Boesenbergia pandurata*", all the authors only appear their names once, and Norzulaani Khalid was absent. From these results, it can be concluded that the researchers who wrote the most Scopus indexed documents with the keywords "*Boesenbergia rotunda*"; "pinostrobin"; and "derivative" was Norzulaani Khalid. In line with that, the University of Malaya and Malaysia became the institutions and countries that published the most articles on this topic. *Boesenbergia rotunda* grows in many Southeast Asian countries such as Malaysia, Thailand, and Indonesia, so it was not surprising that researchers from institutions in Southeast Asia dominate research related to this plant.(52)

Of the three clusters teams in research with keywords "*Boesenbergia rotunda*"; "pinostrobin"; and "derivative", researchers from Malaysia dominated with a history of collaboration with researchers from the United States and Bangladesh. However, the previous research was reported by researchers from Thailand, which was published in 2020.(53) Uniquely, if a research team from Malaysia dominated the previous search, most searches with "*Boesenbergia pandurata*"; "pinostrobin"; and "derivative" keyword combination came from Thailand, Japan, and India, with the latest research published by researchers from Indonesia in late-2021.(54) The differences in the research location had a considerable impact on using a synonym for the plant in published articles.(55) Of the eight documents, only two were the same as the previous search. None of the eight research team clusters were related to each other, so that no research team cluster dominates. Interestingly, the two country clusters with the most documents were Japan-Indonesia (red) and Thailand-Australia (green) had a very close cluster relationship due to the history of collaboration between researchers from Japan and Thailand.(56,57)

However, the Japan-Indonesia and Thailand-Australia clusters were close together, almost become one large cluster of research countries. The number of documents combined between the two clusters was almost comparable to the large cluster of researchers from Malaysia-United States-Bangladesh. Interestingly, the number of documents produced with keyword "fingerroot" was less than the previous search, even though the fingerroot was the

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common name used by this plant in English articles. One reason was that the authors often use scientific names in the titles, abstracts, keywords, while common and local names were usually mentioned in the introduction.[58] This finding confirms that research on combining the three keywords was dominated by research teams from countries where *B. rotunda* grows, especially countries in Southeast Asia.[59]

Besides bibliometric analysis, VOSviewer could also provide network visualizations from the researchers' home countries, including analyzing collaborative researchers across countries. This data would provide valuable information for researchers, especially researchers who want to find collaborative partners across countries.[60] The surprising thing was that none of the researchers reported studies with a combination of these three keywords who came from China. This was interesting because *B. rotunda* could be found growing in southern China, and this plant was even known as Chinese ginger or Chinese keys in some countries. This finding indicates that it was likely that in China, the plant was not as popular as in Southeast Asia, both for cooking and traditional medicine.

This study has limitations, of which only one database is used: Scopus. This method had to be used because authors need special access to other reputable databases such as Web of Science, while databases such as PubMed are less relevant to the topics discussed, so the number of articles found is minimal and mostly overlaps with Scopus. Therefore, further research using other reputable databases is highly recommended. The Scopus database also has a drawback, in which the institutional metadata is not harmonized. As a result, metadata of different departments from the same institution may be considered as two different institutions. Not to mention the inconsistent naming of institutions, such as using local names (not English). Thus, a bibliometric analysis of the institutions or organizations of the authors could not be performed.

To the best of our knowledge, no bibliometric research has been explicitly reported about this plant and its metabolites. Thus, this finding is expected to provide a good novelty for the development of science, especially related to *B. rotunda* and pinostrobin. With the information from this study, researchers primarily focused on developing a pinostrobin derivative isolated from *B. rotunda* will be able to find the right collaboration partner. Besides, this bibliometric study's approach can also be replicated for other topics concerning medicinal chemistry research.

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Conclusion

Bibliometric studies generally aim to outline various studies related to a theme and find gaps for specific topics from previous studies. However, this bibliometric study also found other impressive results about Southeast Asian countries' dominance and China's absence in carrying out research related to the keywords "*Boesenbergia rotunda*", "pinostrobin", and "derivative". Such information is helpful for medicinal chemistry researchers to find new research topics related to the derivatization of pinostrobin isolated from *B. rotunda* and plays a role in outlining opportunities for future research collaborations with other researchers.[a]

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Conflict of interest

The authors declare that they have no conflict of interest.

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[a]**Data availability:** The research dataset can be accessed at https://doi.org/10.5281/zenodo.4970180

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