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SYSTEMATIC LITERATURE REVIEW OF TRENDS AND DEVELOPMENT IN ANTIHYPERTENSIVE EFFECT OF SEAWEED RESEARCH: SCIENTOMETRIC ANALYSIS

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ABSTRACT

*[**Systematic Literature Review of Trends and Development In Antihypertensive Effect of Seaweed Research: Scientometric Analysis**] Hypertension is the most alarming disease that causes cardiovascular risk for human health Worldwide. Thus, the author has explored seaweed that possess antihypertension activity to lower blood pressure. Seaweed are tropical marine organisms from marine biodiversity that are distributed widely in the subtropic and tropical oceans. Seaweed have a significant role in preventing hypertension risk with a unique biochemical compound that is not contained in a terrestrial plant. However, antihypertension of seaweed research using scientometric analysis is limited. This study collected scientific information from relevant literature to determine the recent development and trends regarding antihypertension of seaweed research Worldwide. Many researchers, academia, and practitioners will have a wide understanding of the recent novelty finding in seaweed prospect to prevent antihypertension disease with a scientometric analysis approach to interpret data using CiteSpace. The literature review using scientometric analysis regarding antihypertension of seaweed research from 1991 until 2022. The result showed Suetsuna K is the most influential author (sigma score =1.52, centrality score =0.24 and degree score =51). Advances in Food and Nutrition Research is the leading journal. The most popular keywords in common cluster related antihypertension of seaweed research area are seaweed, hypertension, algae, in vitro, and dietary fiber. On the other hand, various stakeholders need to know the development and trends of a marine drug for antihypertensive effect from various seaweeds.*

Keywords: *Bioactive compound; Marine drug; Hypertension; Seaweed*

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BACKGROUND

Approximately 25% of the adult population have hypertension that a serious chronic disease in the World. This chronic disease is a trigger factor for stroke, cardiovascular disease, renal disease, and others (Ngo et al., 2015; Wang et al., 2018). The renin-angiotensin system (RAS) and Kallikrein-kinin system (KKS) regulate the blood pressure or hypertensive effect in the human body. To elevate blood pressure, convert angiotensin I to the powerful vasoconstrictor angiotensin II and the vasodilator bradykinin, they need angiotensin I-converting enzyme that has a significant role in renal angiotensin system (RAS) and kallikrein-kinin system (KKS) in inactivating those reactions (Rai et al., 2017). Therefore, Angiotensin 1-converting enzyme inhibitory activity is more effective to control blood pressure in normal circumstances (Lahogue et al., 2010).

Hypertension or blood pressure can be reduced with an Angiotensin I-converting enzyme inhibitor by inhibiting angiotensin II synthesis or bradykinin promotion. However, the commercial synthetic Angiotensin I-converting enzyme inhibitor such as captopril, enalapril, and lisinopril that are widely utilized for hypertension treatment has a side effect on the hu-man body including cough, increased potassium levels, and angioedema (Chevillard et al., 1988; FitzGerald et al., 2004). Therefore, many researchers have explored to figure out safe and effective ACE inhibitors derived from nature in recent decades. For instance, natural ACE inhibitors such as milk (López-Fandiño et al., 2006), bovine collagen (Fu et al., 2016), mushrooms (Lau et al., 2014), rice (Chen et al., 2013), fish, shellfish, and seaweed (Cao et al., 2017; Larsen et al., 2011) have been published.

Marine ecosystems contained rich sources of natural bioactive compounds. One of the marine resources that have prospects due to their unique chemical compounds is seaweed which yields some secondary metabolites that are needed for survival mechanisms and self-defense (Bleakley & Hayes, 2017; Kolanjinathan et al., 2014; Sánchez & Vázquez, 2017). According to previous studies, many chemical compounds are isolated from seaweed such as peptides, fats, and carbohydrates (Fitzgerald et al., 2011; Larsen et al., 2011). Therefore, seaweed can be utilized as a new beneficial source of Angiotensin I-converting enzyme inhibitory.

Nevertheless, antihypertension of seaweed research using scientometric analysis has not yet been published. The scientometric analysis is the scientific method to interpret the devel-opment trends of current knowledge and research with mapping visualization related to antihypertension research. Thus, this study collected scientific data from relevant articles to establish the recent development and trends regarding antihypertension of seaweed research Worldwide. The scientometric analysis are a crucial role to identify the pattern of development trends and recent challenges in antihypertension of seaweed research in the future and the connecting with drug development in hypertension chronic disease. it is becoming attention in recent years that many adult populations have unhealthy behavior that caused hypertension disease. Researchers, students, practitioners, and the pharmacology industry have to know the current trends and development of current antihypertension of seaweed research. For instance, the author's publication influenced the submission rate of the journal and the matching of the journal scope related to the antihypertension of seaweed research. The scientific journals available are able to

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access by the researcher, academia, and students depending on the submission rate by the author. The author will attract attention if the scientific journals have high ranks journals and are reputable. Thus, many researchers will conduct subsequent experimental studies related to the antihypertension of a seaweed research area. This will stimulate the productivity of this relevant research field in the future time for researchers and postgraduates involve in this research project related to the antihypertension of seaweed research and created potential collaboration in the research field. It also enhances the scientific reputation not only for the researcher but also for their universities or institution that benefit from increasing their accreditation

RESEARCH METHOD

Figure 1 displays the study framework

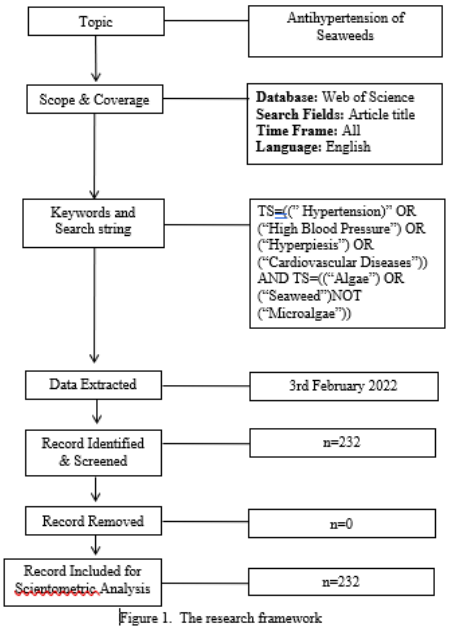

Figure 1. The research framework

Data Source

We gathered the scientific articles online via the Web of Science (WoS), Core Collection database. The WoS explores were based on the "topic" field, covering titles, abstracts, keywords, and "KeyWords plus" generated terms from the titles.

WoS hosts around 34,000 journals (around 1.8 billion citation). Thus, WoS is also one of the reputable scientific databases with a high quality journal and recognized indexed in a peer-reviewed publication and scoped by many disciplinary studies (Aryadoust & Ang, 2021).

Articles search

Validation of the keywords related to antihypertension of seaweed was based on the scientific articles from 1991 until 2022, the keywords recommended by the Web of Sciences (WoS), and keywords recommended by experts. The exploration of literature was conducted on February 03, 2022. The exploration of relevant literature string is presented below.

TS = (("hypertension") OR ("high blood pressure") OR ("hyperpiesis") OR ("cardiovascular disease")). TS = (("algae") OR ("seaweed") OR (alga) NOT ("microalgae")).

Eligibility criteria

Inclusion criteria

Scientific articles from Web of Science (WOS) explores were covered in the next step analysis only if they were in a peer-reviewed journal and in English.

Exclusion criteria

We will ignore an article if it was not original and published in a journal without peer-review or if not written in English. In this literature review, we also excluded proceedings, reviews, book reviews, abstracts, editorial materials, letters, or news.

Data Analysis

To answer research question number one, we conducted an analysis of our data

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that was retrieved from the WoS database. Descriptive analysis was conducted by Microsoft Excel for the publish journals, authors, universities/institutions, and countries. To answer research question number two, we used scientometric analysis techniques using CiteSpace tools.

Scientometric analysis

CiteSpace V 6.1 R6.2023 was employed for visualization and knowledge graph analysis since it can create multiple bibliometric networks and apply multiple analysis techniques (Chen, 2004a; Chen & Leydesdorff, 2014).

The threshold was defined to "Top 50 N" per slice, enabling the selection of the most frequently cited items to shape a network depending on the input and multiple node types. As a result, CiteSpace software displayed and ranked the top 50 most cited articles. "Time Slicing" was designated to 1991-2022, and "Years per slice" was assigned to one year. “The pruning” parameter was chosen in scientometric analysis. The term sources in WOS were the title, abstract, author keyword, and author plus to trim the resulting networks.

Co-citation analysis

The purpose is to stimulate the scientific development status and scientific structure change. It yields a visualization map with nodes, connections, and density complete values, describing main structure of variables representing the number of citations a variable gained from another similar variable. Centrality is demonstrating how close similar variables. High centrality means higher influence on the network because. Sigma is the sum of the centrality and burstness scores (0 to 1), the closer to 1 means the higher the value of research articles (Chen et al., 2009, 2010; Chen & Song, 2019).

Document cluster analysis

Previously, we retrieved the document with multidimensional clustering for research cluster identification in focusing research areas. The log-likelihood ratio (LLR) was used to automatically extract the cluster label because it allows the best results. Document cluster analysis’s “timeline view” and “cluster view” were employed to illustrate the network’s shape and form. The “timeline view” depicted some chronological time and “cluster view” depicted a spatial network of color-coded and labelled representations in a landscape format (Aryadoust & Ang, 2021; Chen, 2004b; Chen & Leydesdorff, 2014).

The homogeneity and quality of the cluster analysis from our document were estab-lished by the modularity Q index, average silhouette metric, and centrality metric, and the cluster was detected (Chen et al., 2009, 2010; Chen & Song, 2019). The modularity Q index is between 0 to 1; a higher index corresponds to greater reliability. The average silhouette metric is from -1 to 1, with higher values indicating greater homogeneity. Centrality shows the dis-tance between publications or journals. If the works have a high centrality, they have a greater influence on the network by connecting to more publications.

Burstness analysis

To determine influential publications and top keywords, citation burstness and sigma, both temporal metrics, were utilized. Detection of burst is described as the increase in the number of citations for a specific article, or "an abrupt elevation of the frequencies of citation over a specific time interval". A red ring surrounds the node to indicate this. (Chen et al., 2009, 2010; Chen & Song, 2019). Sigma is the sum of the burstness and centrality scores on a scale of 0 to 1. The

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higher the sigma the higher the quality of the articles. (Chen et al., 2009, 2010; Chen & Song, 2019).

Identification of Knowledge

The parameter for identification methods of knowledge map will be highlighted in this section. The node determines how frequently a variable cited. A large node indicates many citations. The number of connections between variables in the knowledge map is referred to as the degree. A higher degree is translated to more involvement between the same variables, such as institutions and countries. The red rings surrounding the node indicated its burstness. It demonstrates where the articles "burst" and how strong the "burst" strength is. The purple rings show the importance of the node. A high centrality node demonstrates a strategic advantage and the potential to connect different nodes in the selected networks.

RESULT AND DISCUSSION

Descriptive statistic

Publication evolution

The study was restricted to papers that were published between January 1991 to December 2022 (Figure 2). These 360 scientific papers were gathered during this time. After 2003, some publications slowly increased where 4 scientific papers already published between 2007 and 2022.

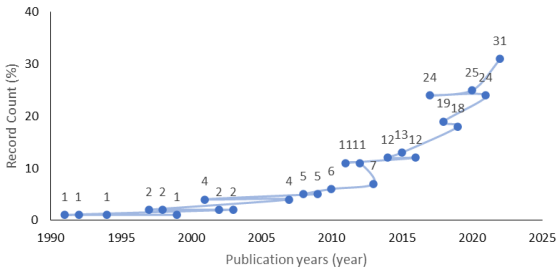

Figure 2. The number of research articles published annually since 1991

Productive Journal

The top 10 journals by publication members are shown in Figure 3. We have already obtained the scientific article that has eligibility in 145 sums of scientific journals. Nutrients had the most publications with 13 articles, followed by the Journal of applied phycology and the journal of functional foods and Marine Drugs with 6 publications respectively.

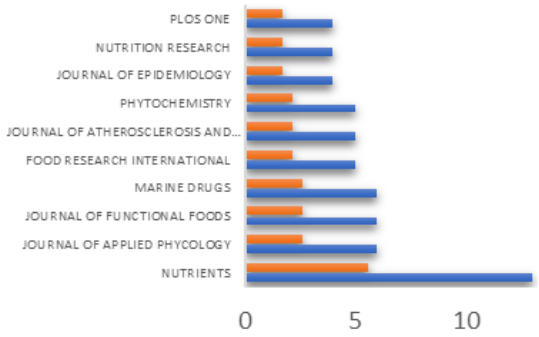

Figure 3. The top 10 journals of scientific publications number published between 1991 and 2022.

Regional Distribution

Figure 4 depicts the best 10 countries and regions with the highest articles. Forty-two countries have relevant publications, with the top 10 accounting for 24.56%. Japan had the most publications with 57 publications then followed by the United States of America with 37 publications and South Korea with 35 publications.

Our study aimed to present a scientometric analysis for research on the hypertension of the seaweed domain. We discuss our results in detail below. A descriptive analysis was performed on the number of publications, published journals, authors, universities/institutes, and countries/regions where authors were affiliated with when the papers were published to answer the question "What are the overall publication trends in terms of

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publication output?" The number of published articles encountered fluctuated in publication trend from 1991 until 2022. The number of publications has irregularly increased each year, eventually reaching more than 25 in 2022. These trends of publication depicted that the attention to the seaweed antihypertension domain is recently increased after 2010. We suppose that hypertension problem has a serious problem in the 21st century. Thus, many researchers strive to explore alternative drugs to prevent hypertension symptoms. On the other hand, some commercial drugs to prevent hypertension have side effects on human health. Japan had the most papers published in the field, with the United States of America coming in second most papers. The top ten countries varied by region, with developed countries and high-ranking institutions dominating the top ten publications. While this result may be due to developed countries and high-ranking institutions having more resources to conduct scientific analyses, we strongly recommend that in the future, more international scientific research exchanges and collaboration be conducted.

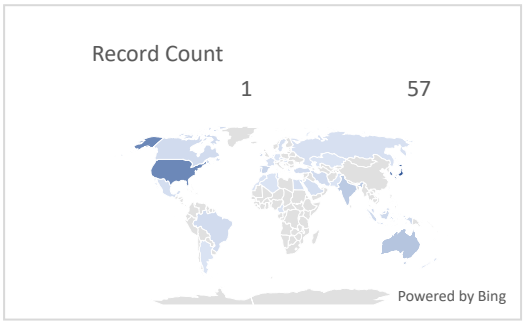

Figure 4. Regional and state distribution of antihypertension of seaweed in the World, dark blue displayed the highest total number of publications

Our study aimed to present a scientometric analysis for research on the hypertension of the seaweed domain. We discuss our results in detail below. A descriptive analysis was performed on the number of publications, published journals, authors, universities/institutes, and countries/regions where authors were affiliated with when the papers were published to answer the question "What are the overall publication trends in terms of publication output?" The number of published articles fluctuated in publication trend from 1991 until 2022. The number of publications has irregularly increased each year, eventually reaching more than 25 in 2022. These trends of publication depicted that the attention to the seaweed antihypertension domain is recently increased after 2010. We suppose that hypertension problem has a serious problem in the 21st century. Thus, many researchers strive to explore alternative drugs to prevent hypertension symptoms. On the other hand, some commercial drugs to prevent hypertension have side effects on human health. Japan had the most papers published in the field, with the United States of America coming in second most papers. The top ten countries varied by region, with developed countries and high-ranking institutions dominating the top ten publications. While this result may be due to developed countries and high-ranking institutions having more resources to conduct scientific analyses, we strongly recommend that in the future, more international scientific research exchanges and collaboration be conducted.

Scientometric Analysis Result

Analysis of Co-citation

Co-citation analysis produces a science map with nodes, connections dan density values, representing the main structure of a variable's development and

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changes. The co-citation analysis covers the author, journal country/region, institutions, research areas, and article document.

Author co-citation analysis

The network of author co-citation detected 454 nodes and 4247 connections. The density of the co-citation network was 0.0394. The most influential author is evaluated based on the degree, centrality, and sigma. The degree parameter represented the number of citations for the same articles. The centrality parameter is the number of times an author is located "between" two or more authors. A sigma above one suggests that the author is in the center of the domain.

Figure 5 demonstrates an author with a centrality score greater than 0.1. Suetsuna was the most connected author (centrality score=0.24), followed by Holdt SL (a sigma score = 1.39, centrality score = 0.16, and degree score = 29) and Hata Y (degree score =60, centrality = 0.37, and Sigma score =1.30). Suetsuna has a higher sigma score, centrality, and degree of citation than Suetsuna, meaning that she is more influential. Table 1 lists the ten leading authors in these fields.

Table 1. Top five author co-citation

Author	Degree	Centrality	Sigma
uetsuna K	51	0.24	1.52
Holdt SL	29	0.16	1.39
Hata Y	60	0.37	1.30
Ito K	48	0.18	1.17
Cian RE	32	0.05	1.12

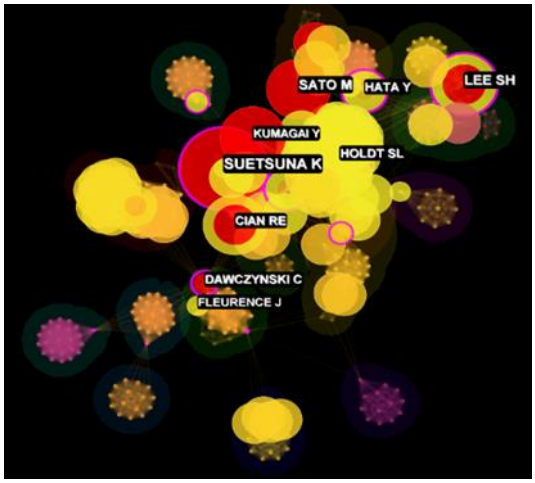

Figure 5. Network of authors co citation

"Who are the dominant knowledge carriers in these domains?" was the second research question. A co-citation analysis of the author, journal, country/institution, research areas, and articles was represented to address this question. Suetsuna K from the Department of Food Science and Technology, National Fisheries University, Japan. His work focuses on angiotensin I-converting enzyme inhibitors or antihypertensive effects from marine macroalgae. Hold SL is the second most influential author. She is a Associate Professor in National Food Institute, Technical University of Denmark, Denmark. She worked has a broad experience in (bioactive) components, ingredients, treshhold values and Danish and EU regulations of seaweeds. Research focuses on algal biomass production for food and ingredients with specific expertise in algal cultivation and breeding, components of algae and algal biomass utilization. The third most influential author is Hata Y. He is Researcher in Department of Geriatric Medicine, Kyorin University School of Medicine, Tokyo. He conducted experimental research about clinical effects of Brown Seaweed,

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Undaria pinnatifida (wakame), on blood pressure in

hypertensive subjects. The three leading researchers do not collaborate on research. Several of the ten leading authors are not connected with each other in this field.

Journal Co-Citation analysis

There are 480 nodes, 8029 connections, and a density of 0.0605 in the journal co-citation network. Figure 6 presents the knowledge map for the journal co-citation analysis covering the journal degree, centrality, and sigma score for the top 10 leading journals. The result revealed that Advances in Food and Nutrition Research was the most leading journal (degree score =53, centrality score = 0.05, and sigma score =1.09), followed by Asia Pacific Journal of Clinical Nutrition (degree score =91, centrality score = 0.03, and sigma score =1.05) and Archives of Pharmacal Research (degree score =49, centrality score =0.01, and sigma score =1.03).

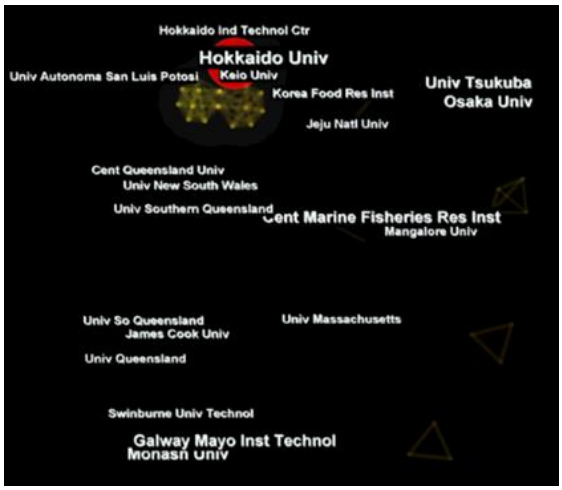

Figure 6. The knowledge maps for journal co-citation analysis

Table 2. Top five (5) Journal co-citation score.

Journal	Degree	Centrality	Sigma
Advances in Food and Nutrition Research	53	0.05	1.09
Asia Pacific Journal of Clinical Nutrition	91	0.03	1.05
Archives of Pharmacal Research	49	0.01	1.03
Botanica Marina	130	0.13	1.00
Food Chemistry	134	0.11	1.00

Institution analysis

The results had 109 nodes, 169 connections, and a density of 0.0284 in the institution's analysis network (a centrality score greater than 0.1). Hokkaido University is the leading institution (degree = 5, centrality = 0.01, and a sigma score = 1.02), followed by Tsukuba University (degree score = 15, a centrality score = 0.01, and sigma score = 1.01), and Osaka University (degree score =15, centrality score = 0.01 and sigma score = 1.01). Although, the United States of America is the domain's focus country, there are no institutions from this country included the top ten. This finding suggests that the research is broad and robust, with various countries and institutions concentrating on similar issues. Most research is independent and focuses on their own group, hence, collaboration and cooperation among countries and institutions is needed. Table 6 displays the best five institutions co-citation scores. Figure 7 presents a network map of institutional cooperation.

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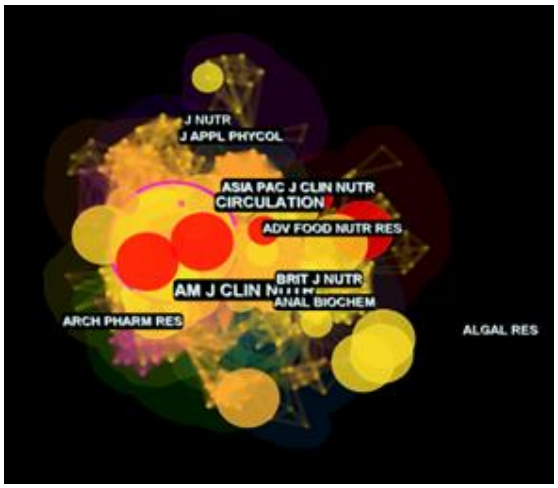

Figure 7. Network of Institutions Co-citation analysis

Table 6. Top five Institutions co-citation score

Institutions	Degree	Centrality	Sigma
Hokkaido University	5	0.01	1.02
Tsukuba University	15	0.01	1.01
Osaka University	15	0.01	1.01
Keio University	8	0.00	1.00
Fukushima Medicine University	8	0.00	1.00

The institution co-citation analysis is different from the country results and the institutions/universities from various countries. Hokkaido University, Japan is the leading institution, followed by Tsukuba University and Osaka University in Japan. All top ten institution co-citation from Japan. Japan is surrounded by water, and along its coast, more than 100 kinds of edible seaweed, such as nori, wakame, and konbu, can be cultivated. Seaweed, which is tasty and has been linked to enhance health, has been a staple of Japanese diets since ancient period. It shows that research affiliations are mostly of Japanese institutions emphazing on marine macroalgae or seaweed topics. The three leading research areas are plant sciences, applied chemistry, and medicinal chemistry. When we compared to the second rank, plant sciences research areas have higher sigma scores than the other two because the degree and centrality scores for the research areas are also higher. This result demonstrated consistency in the country co-citation, implying that most citations are one-sided with regard to research field. As the novelty idea is only in one area, the domain's progress may be hindered. Other areas are only followed without any publications pertinent.

Web of Science Research area Co-Citation analysis

The WoS Research area co-citation network had 26 nodes and 33 connections (the density of the co-citation network =0.0738). Figure 8 displays a network map of co-citation among research areas. Plant Sciences is the leading one (degree score = 4, centrality score =0.37, and a sigma score =1.26), followed by Applied Chemistry (degree score = 3, centrality score =0.17, and sigma score =1.21), and Medicinal Chemistry (degree score = 2, centrality score = 0.17, and sigma score = 1.19). This indicates most research is in these areas accounts for 37% of citations used in the research domain. The outcome demonstrates that collaboration between countries and institutions is no longer adequate, it should be also done between domains to develop additional scientific findings. Table 7 displays the co-citation score from the top ten research areas.

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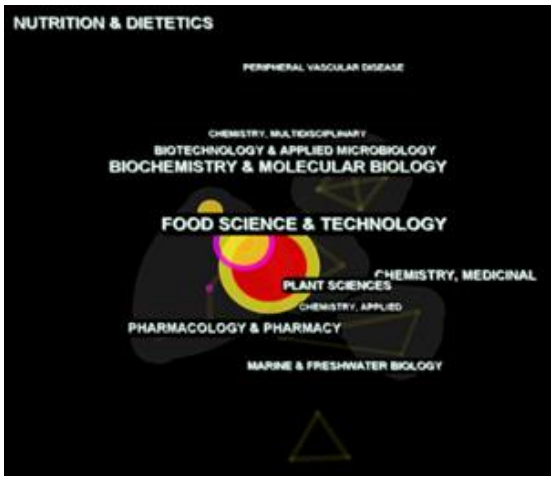

Figure 8. Network of research area Co-citation analysis

Table 7. Top five Research Area Co-Citation Score

Web of Science Category	Degree	Centrality	Sigma
Plant Sciences	4	0.37	1.26
Applied Chemistry	3	0.17	1.21
Medicinal Chemistry	2	0.17	1.19
Pharmacology & Pharmacy	2	0.09	1.15
Biochemistry & Molecular Biology	5	0.54	1.00

Document citation analysis

In document citation analysis, there are 456 nodes and 3879 connections with a density of 0.0372 (only articles with a centrality score above 0.1 inlcuded). In this study, a "central" article was the mediator. The article entitled "Angiotensin I-converting enzyme inhibitory peptides derived from Wakame (*Undaria pinnatifida*) and their anti-hypertensive effect in spontaneously hypertensive rats" were the leading article in the antihypertension of seaweed domain (degree score = 92, centrality = 0.40, and sigma score = 2.25), followed by article entitled "Antihypertensive effects of *Undaria pinnatifida* (wakame) peptide on blood pressure in spontaneously hypertensive rats" (degree score = 22, centrality score = 0.23, and sigma score = 1.60), and "Antihypertensive effects of two novel angiotensin i-converting enzyme (ACE) inhibitory peptides from *Gracilariopsis lemaneiformis* (Rhodophyta) in spontaneously hypertensive rats (SHRSa)," (degree score =32, centrality score = 0.40, and sigma score =1.52). All ten leading publications were published between 1991 and 2022. Figure 9 presents the document co-citation analysis for research areas.

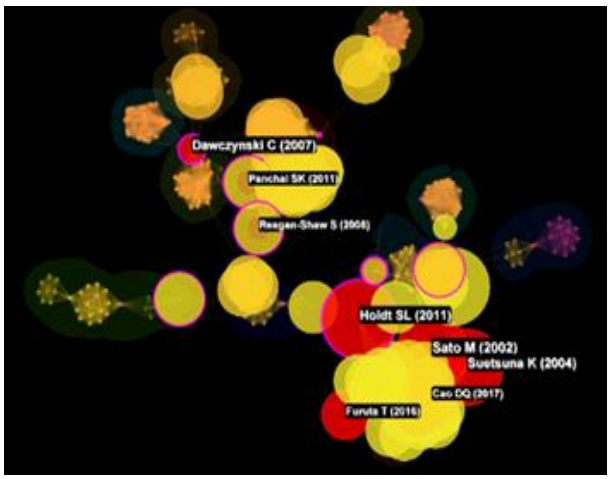

Figure 9. Network of document Co-citation analysis

The article entitled "Angiotensin I-converting enzyme inhibitory peptides derived from Wakame (*Undaria pinnatifida*) and their antihypertensive effect in spontaneously hypertensive rats" were the most leading, published in 2002 and has 253 citations so far. It developed the research methodology on how to conduct the antihypertension of seaweed-based analysis. It is one of the first to discuss the nutritional composition of 34 edible seaweed products the *Laminaria* sp.,

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Undaria pinnatifida, *Hizikia fusiform*, and *Porphyra* sp. The second leading article with a high co-citation score is "Antihypertensive effects of *Undaria pinnatifida* (wakame) peptide on blood pressure in spontaneously hypertensive rats". It discussed bioactive compounds mainly of nine genera or species of seaweed available in European temperate Atlantic water such as *Laminaria* sp., *Fucus* sp., *Ascophyllum nodosum*, *Chondrus crispus*, *Porphyra* sp., *Ulva* sp., *Sargassum* sp., *Gracilaria* sp., and *Palmaria palmata*. In addition, *Undaria pinnatifida* is included in this review. "Purification and identification of a novel ACE inhibitory peptide from marine alga *Gracilariopsis lemaneiformis* protein hydrolysate" are the third article with the highest number of co-citations. It reviews seaweeds as a novel source of compounds with the potential for human health applications. The leading articles have been around for over 15 years and continue to cite by recent papers

Table 8. Top 5 Documents Co-Citations Score

Title	Source	Year	Degree	Centrality	Sigma
Angiotensin I-Converting enzyme inhibitory peptides derived from Wakame (*Undaria pinnatifida*) and their antihypertensive effect in spontaneously hypertensive rats	Journal of Agricultural and Food Chemistry	2002	92	0.40	2.25
Antihypertensive effects of *Undaria pinnatifida* (wakame) peptide on blood pressure in spontaneously hypertensive rats	The Journal of Nutritional Biochemistry	2004	22	0.23	1.60
Antihypertensive effects of two novel angiotensin i-converting enzyme (ACE) inhibitory peptides from *Gracilariopsis lemaneiformis* (Rhodophyta) in spontaneously hypertensive rats (SHRsa)	Marine Drugs	2018	32	0.40	1.52
Angiotensin I Converting Enzyme Inhibitory Peptides Derived from Phycobiliproteins of Dulse *Palmaria palmata*	Journal of Agricultural and Food Chemistry	2016	13	0.04	1.10
Angiotensin I-converting enzyme (ACE) inhibitory activity of *Fucus spiralis* macroalgae and influence of the extract's storage temperature-A short report	Journal of Pharmaceutical and Biomedical Analysis	2016	20	0.14	1.11

Table 9. 11 Major Cluster emerged from Document Co-citation Analysis

Cluster ID	Size	Silhouette	Label (LLR)	Average Year
0	49	0.982	green algae mixture	2010
1	47	0.959	seaweed-derived bioactive compound	2011
2	31	0.950	non-communicable diseases	2002
3	30	0.995	seaweed reverse	2002
4	29	0.979	mediterranean sea coast Egypt	1999
5	29	1	elevated fasting LDL cholesterol	2007
8	26	0.996	DOCA	1992
9	25	0.977	various macroalgal species	2000
10	24	0.907	health-related beneficial properties	2010
11	20	0.969	15-octadecapentaenoic acid	1988
12	19	0.969	marine macroalgae-associated heterotrophic bacteria	2007

Document burst

Burst analysis for identifyng the most leading publications and keywords. A burst is the appearance of a keyword in a publication in a particular period. The blue line shows the time frame between 1991 and 2022, while the red line indicates the burst period. The article "Angiotensin I-converting enzyme inhibitory peptides derived from Wakame (*Undaria pinnatifida*) and their antihypertensive effect in spontaneously hypertensive Rats" (strength = 2.71; burst begin 2020 end 2022) is the strongest burst, published in the Journal of Agricultural and Food Chemistry in 2002. The article titled "Antihypertensive effects of *Undaria pinnatifida* (wakame) peptide on blood pressure in spontaneously hypertensive rats" has the second most recent burst, with a burst strength of 2.31. The article was published in 2004. The top 5 publications with the most powerful citation bursts are displayed in Table 10.

Keyword burst

The keywords with the highest citation burst are listed in Table 11. Over time, keyword analysis has been used to spot emerging trends and research hotspots. The burst represents the appearance of a keyword in the publication of a subject area during a specific period. The timeline (from 1991 to 2022) is represented by the

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blue line, while the burst period is represented by the red line. The term "seaweed" had the strongest burst strength between 2019 and 2020. (1.96). The following top keywords were" hypertension" (Strength = 1.64, 2015-2019) and "alga" (Strength = 1.55, 2019-2020). The keywords with the highest frequency are listed in Table 12. The most frequently used keyword is "blood pressure" which appears 9 times in the title, abstract, and keyword. The second most common keyword is "marine algae" which appears 8 times, and the third most common keyword is "brown algae," which appears 6 times.

Table 10. Top five publications with strongest citation Burst

Table 10. Top five publications with strongest citation Burst

Title	Journal	Year	Strength	Begin	End	1991 - 2022
Angiotensin I-Converting Enzyme Inhibitory Peptides Derived from Wakame (*Undaria pinnatifida*) and their antihypertensive effect in spontaneously hypertensive rats	Journal of Agricultural and Food Chemistry	2002	2.71	2020	2022	
Antihypertensive effects of *Undaria pinnatifida* (wakame) peptide on blood pressure in spontaneously hypertensive rats	The Journal of Nutritional Biochemistry	2004	2.31	2020	2022	
Purification and identification of a novel ACE inhibitory peptide from marine alga *Gracilariopsis lemaneiformis* protein hydrolysate	European Food Research and Technology	2017	1.53	2020	2022	
Angiotensin I Converting Enzyme Inhibitory Peptides Derived from Phycobiliproteins of Dulse *Palmaria palmata*	Marine Drugs	2016	1.53	2020	2022	

Table 11. Top five keyword with strongest citation burst

Table 11. Top five keyword with strongest citation burst

Keywords	Year	Strength	Begin	End	1991 - 2022
seaweed	2019	1.96	2019	2020	
hypertension	2015	1.64	2015	2019	
algae	2011	1.55	2019	2020	
in vitro	2017	1.39	2017	2019	
dietary fiber	2013	1.33	2013	2015	

Table 12. Top five keyword with highest frequency

Keywords	Frequency
blood pressure	9
marine algae	8
brown algae	6
algae	6
hypertension	5

CONCLUSION

We reviewed articles from the WOS databases only, which may be bias; however, it is known higher publication standards. They aimed at the sciences and social sciences, and it contains significantly bigger and broader databases compared to others (Adriaanse & Rensleigh, 2013; Bar-Ilan, 2008). Future research could review by comparing other databases to the Web of Science. Another potential limitation, we used CiteSpace instead manual method in collecting data. Thus, we may commit some errors, by including irrelevant subjects. However, our analysis is easily repeatable and finding an equilibrium between rigorous standards and excluding specific studies is challenging. next research with a high precision should use more restrictive keywords to minimize the chance of irrelevant studies. Finally, this study only used the names of the primary authors for analysing co-citation.

Although there was no such constraint on citing publications, the contributing authors were not in the databases of cited publications from WoS. In spite of this limitations, our study presents a thorough overview of the current research on seaweed's hypertensive effects. We highlight the importance of global collaboration as addressing seaweed's potential product for preventing antihypertension disease is a paramount

long-term research agenda to realize the sustainable development goals. In the coming years, studies in disciplines other than "seaweed, bioactive compound, and angiotensin I-converting enzyme" should be encouraged, as They may reveal crucial information that would be otherwise undetected. Finding the effective solutions to prevent antihypertension symptoms and examining safe alternative pharmaceutical products, which are free of side effects is challenging. We have compiled related research from various disciplines and identified the key research gaps and future directions. The gap found in our research is significant. Hence, further explorations and collaboration is necessary.

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