Review

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Abstract

Studies on *Carica papaya* have focused on solving challenges related to its cultivation, postharvest management, and medicinal properties. Given the extensive volume of information produced, a quantitative analysis is required to delineate the intellectual framework and development of *C. papaya* research. This study presents the first comprehensive bibliometric analysis of 45 years of scientific research on *C. papaya*. Our analysis examined 6,544 documents from 1,737 journals, consisting of 6,076 articles, 379 reviews, and 91 conference papers. The United States, India, Brazil, and China lead scientific production, maintaining robust international partnerships. The main research domains were applied sciences (40.9%), analytical studies (36.6%), and experimental research (16.9%), with topics including postharvest quality, disease resistance, genomic sequencing, and the biological activities of secondary metabolites. A co-occurrence analysis revealed an association between polar leaf extracts and phenolic and flavonoid compounds, which are linked to antioxidant, anticancer, and antimicrobial properties. Furthermore, antioxidant activity was the most frequent finding (945 articles). In conclusion, scientific knowledge of *C. papaya* primarily comprises studies on the plant genome, crop diseases, and bioactive compounds. Research highlights the plant as a valuable resource for sustainable agriculture and, specifically, its leaves as a source of novel phytopharmaceuticals.

Keywords: *Carica papaya*; bibliometric analysis; plant; bioactive compounds

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1. Introduction

Carica papaya is a tropical plant of great agronomic, commercial, and nutritional importance. It is cultivated in warm regions due to favorable conditions and global demand [1]. However, its productivity, ripening, and the commercial quality of *C. papaya* are threatened by various diseases and environmental challenges. Particularly, papaya ringspot virus (PRSV) is a viral disease that poses a significant threat, being the most devastating to the global papaya industry [2]. Furthermore, during ripening, spatial changes occur in the fruit composition and nutrient content, influencing its quality and commercial value [3]. All these problems have led to the growth of several scientific fields aimed at characterizing the species and developing solutions for it. In this respect, genomic studies have

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used molecular methods to examine how plants respond to viral infections [4]. Likewise, the use of plant biotechnology has enabled the evaluation of micropropagation and grafting techniques for the development of improved cultivars [5].

The value of *C. papaya* is enhanced by its traditional applications in the treatment of various diseases, supported by scientific evidence of phytochemical compounds present. Existing evidence suggests that alkaloids, glycosides, saponins, tannins, flavonoids, isothiocyanates, and lycopene exhibit anticancer, antidiabetic, antimicrobial, antioxidant, and anti-inflammatory properties. [6]. Additionally, papaya leaf extracts may increase platelet counts in patients with dengue infection [7]. Other recent applications highlight the use of leaf extracts in the synthesis of metallic nanoparticles with water decontamination capabilities [8]. In agriculture, poultry farmers use leaf extracts to prevent parasites and promote growth [9].

The diversity of research approaches produces an extensive knowledge of the scientific advancements related to this plant species. Therefore, our study employs bibliometric analysis, a methodology that summarizes the intellectual structure of a field of study, traces its evolution, and quantifies the scholarly impact of publications, authors, institutions, and countries [10]. In contrast to other types of reviews, bibliometric analysis offers a structured, visualizable, and concise representation of extensive research data [11]. Furthermore, text mining was incorporated to investigate the metabolites and biological activities of papaya leaves, a natural language processing tool that extracts hidden data and relationships from large volumes of text [12]. The present research employed a bibliometric methodology to document the scientific landscape and summarize research advances on *C. papaya*. The analysis considered citation metrics, authorship patterns, sources, collaborations, and thematic trends, in addition to a co-occurrence analysis designed to identify associations between secondary metabolites and bioactivities in the leaves. The findings clarify the research trajectory of this plant, providing a reference framework for future studies. Specifically, they summarize the knowledge on leaf metabolites, establishing the groundwork for upcoming therapeutic applications and the development of phytomedicines.

2. Materials and Methods

2.1. Data Collection

The bibliometric analysis of the literature on *C. papaya* was conducted using information from the Web of Science (WoS) Core Collection in March 2025, with the terms "*Carica papaya*" and "*papaya*" searched in the title, abstract, and keyword fields. The research included articles, reviews, and conference papers published up to December 2024. A total of 6,544 documents were exported in plain text (.txt) format and analyzed using the Bibliometrix R package (version 4.0.0) and its Biblioshiny interface [13].

2.2. Bibliometric Measurement

The research impact of authors and journals was evaluated using the h-index, calculated through the number of publications and citations; the g-index, obtained from highly cited articles, is calculated when the cumulative citations exceed the square of the ranking; and the m-index, defined as the h-index divided by the number of years since the first publication. In addition, the relevance of articles was assessed through Local Citations (LC), Global Citations (GC), and the LC/GC ratio [14].

Collaborative networks were constructed from co-authorship data to identify the most influential authors. Betweenness Centrality (BC) and PageRank (PR) were used to determine the key nodes that connect disparate groups [15].

Keyword analysis was used to identify the research areas and thematic priorities focused on *C. papaya*. In this regard, a thematic map was created using words with a frequency of at least 30; these words were then grouped using the Walktrap algorithm [16]. The groups were represented in bubbles on a map divided into four themes (motor, niche, emerging or declining, and basic) [17].

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2.3. Text Mining for Content Analysis

The title, abstract, and keywords of articles were combined into a single text field in R to create a classification system. These articles were categorized as analytical, applied, experimental, or review studies. Similarly, the biological activities investigated in *C. papaya* were identified as antimicrobial, antioxidant, anti-inflammatory, anticancer, neuroprotective, cardioprotective, antidiabetic, hepatoprotective, immunomodulatory, antiviral, wound-healing, analgesic, and other relevant properties. A compendium of English terms, their terminological variants, and synonyms was utilized to maximize the detection of specific relationships within the scientific literature in both cases.

A subsequent analysis was conducted to explore terms related specifically to the phytochemical and pharmacological properties of *C. papaya* leaves. A new set of search patterns was designed to address categories of biological activities, extract types, and metabolite classes. The co-occurrences of terms in the articles were cross-tabulated to calculate the association frequencies, which were represented in a bubble plot.

3. Results

This bibliometric analysis examined 45 years of research on *C. papaya* (1980–2024). A total of 6,546 documents were retrieved from 1,737 journals. Of these documents, 6,076 were articles (37 of which were in early access), 379 were reviews, and 91 were conference presentations. The documents had an average age of 12.8 years, received 193,525 citations (23.81 per document on average), and had 21,363 authors (4.9 per document on average). The research area experienced an annual growth rate of 7.77%.

3.1. Growth and Citation Trends in the Research of C. papaya over Time

The annual production of articles on *C. papaya* increased from 17 in 1980 to 457 in 2024 (Figure 1). A significant increase was observed in the number of annual documents, from 96 articles in 2003 to 184 in 2010. Subsequently, between 2019 and 2023, the publications increased, from 359 to 449 articles per year. Furthermore, the citation analysis showed that studies published before 2000 had an average of less than one citation per document (Figure 1). Notably, the average number of citations per article was 3.58 in 2001, reaching a peak of 3.65 in 2017.

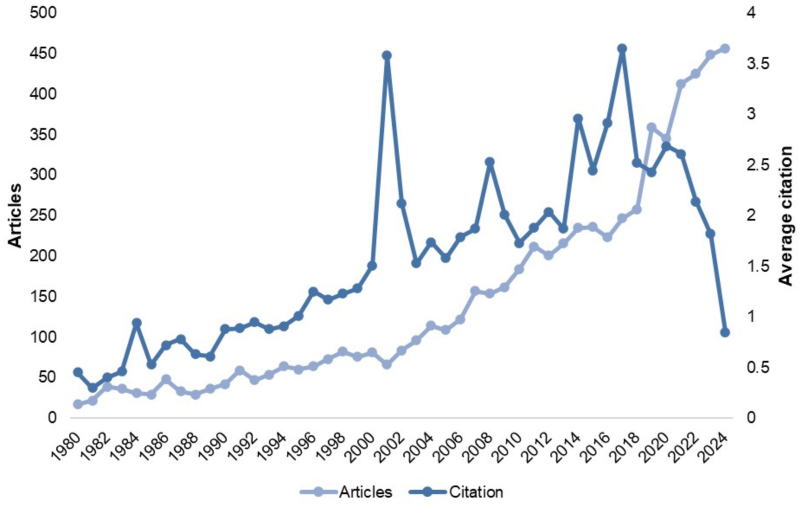

Figure 1. Annual scientific production and citation trends in *C. papaya* research.

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3.2. Journals in Scientific Research on C. papaya

Productivity and citation metrics identified the highest-impact journals. Among them, Food Chemistry led in production (103 articles) with the greatest scientific impact, demonstrating the highest h-index (41) and g-index (78), suggesting that it is consistently cited (Table 1). Postharvest Biology and Technology published 78 articles and achieved the highest m-index (1.26), demonstrating the most impactful recent production. The Journal of Agricultural and Food Chemistry had a similar number of articles, but its bibliometric indices were comparatively lower (h-index: 35; m-index: 0.80). Remarkably, the journal LWT – Food Science has a strong recent impact, with a high m-index of 1.21, with only 37 articles.

Table 1. Bibliometric indices of leading journals in *C. papaya* research.

Journals	H-index	G-index	M-index	Citations	Number of publications	Publication year start
Food Chemistry	41	78	0.89	6268	103	1980
Postharvest Biology And Technology	39	64	1.26	4213	78	1995
Journal Of Agricultural And Food Chemistry	35	67	0.80	4612	80	1982
Journal Of Ethnopharmacology	29	46	0.94	2690	46	1995
Plant Disease	29	42	0.63	2297	91	1980
Phytopathology	26	45	0.57	2119	57	1980
Journal Of The American Society For Horticultural Science	24	35	0.52	1337	44	1980
Journal Of Economic Entomology	23	32	0.52	1190	57	1982
Journal Of The Science Of Food And Agriculture	23	39	0.50	1630	49	1980
Lwt-Food Science And Technology	23	37	1.21	1464	37	2007

3.3. Global Scientific Production and Collaborations in C. papaya

According to Figure 2, the global distribution of *C. papaya* scientific productivity is principally concentrated in four countries: the United States (2,048 articles), India (1,970), Brazil (1,953), and China (1,671). Other prolific countries were Mexico (818 publications), Malaysia (689), Nigeria (533), Australia (426), and Japan (395). International collaborations also contributed to this scientific productivity; the United States, China, Brazil, and India are leading collaborative countries (Figure 4). Notable partnerships include the United States and China (99 joint publications), China and Pakistan (25), Brazil and Spain (21), and India and China (15).

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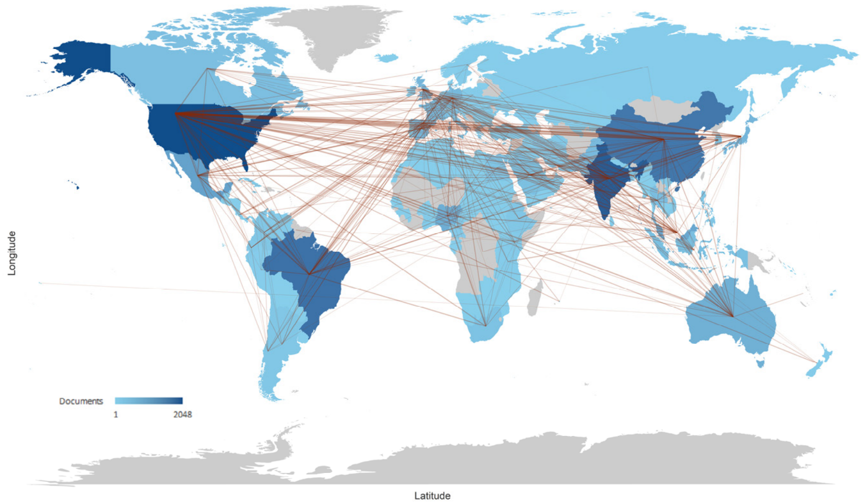

Figure 2. Global scientific production and collaboration network of *C. papaya* research.

3.4. Leading Organizations in C. papaya Research

The most productive organizations in *C. papaya* research include the United States Department of Agriculture with 298 articles, the Indian Council of Agricultural Research with 291, Putra University Malaysia with 207, University of Hawaii System with 205, and University of São Paulo with 154 (Figure 3).

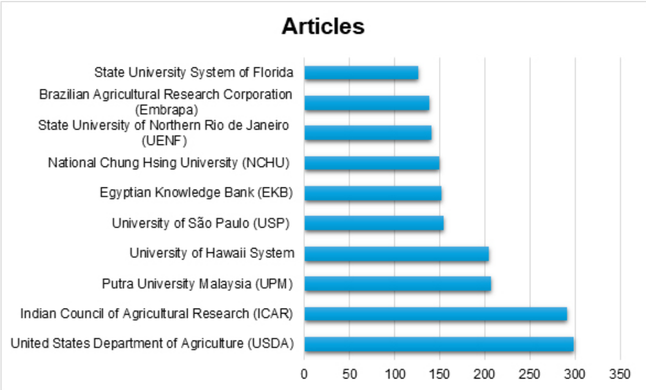

Figure 3. Ranking of institutions with the highest scientific production in *C. papaya*.

3.5. Author Impact Metrics and Collaborative Networks

Our analysis identified Ming R. as the most cited and productive author in *C. papaya* research, with 65 publications and 3,707 cumulative citations, along with the highest h (29) and g (60) values, complemented by a strong m-index (1.16) reflecting his contemporary contribution (Table 2). Yeh S.D.M. published an equal number of articles, but they obtained fewer citations (1,823), resulting in lower indices (h-index of 27, g-index of 41, and m-index of 0.64). On the other hand, Gonsalves D., with a total of 40 publications, had a higher citation count (3,276) compared to Yeh S.D., resulting in an h-index of 26. Also, Chen W.X. had a significant recent research trajectory, with the highest m-index (1.19), compared to the other authors.

Table 2. Bibliometric indices of leading researchers in *C. papaya* studies.

Author	H-index	G-index	M-index	Citations	Number of publications	Publication year start
Ming, R.	29	60	1.16	3707	65	2001

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Yeh, S. D.	27	41	0.64	1823	65	1984
Gonsalves, D.	26	40	0.57	3276	40	1980
Paull, R. E.	26	39	0.60	2722	39	1983
Moore, P. H.	25	36	1.00	2747	36	2001
Yu, Q. Y.	23	37	1.05	2587	37	2004
Ali, A.	19	30	0.86	1602	30	2004
Chen, W. X.	19	31	1.19	1264	31	2010
Drew, R. A.	19	28	0.48	808	30	1986
Leclerc, D.	19	32	0.95	1120	32	2006

In the author cooperation networks (Figure 4), Ming R. was the center figure, with a BC of 82.24 and a PR of 0.06, representing the largest cluster (red). This principal cluster also included other authors mentioned in Table 2, such as Yeh S.D., Gonsalves D., Paull R.E., Moore P.H., and Yu Q.Y. In addition, a small cluster, consisting solely of Kumar S., Kumar A., and Prakash J. (with a BC of 36.0 and PR of 0.022), was connected to this main group. Another notable, though less central, collaboration group (gray cluster) was represented by Pereira, M.G., who had a BC of 6.00 and a PR of 0.05. The remaining six clusters were smaller and less central.

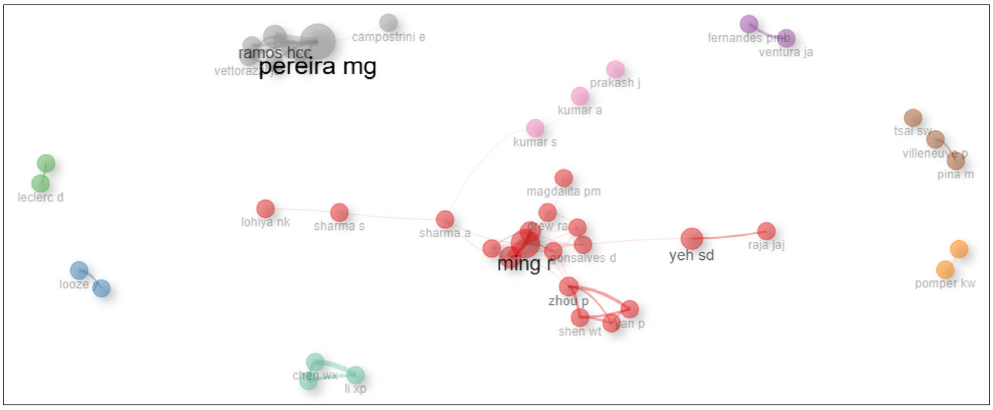

Figure 4. Author collaboration networks in *C. papaya* research.

3.6. Most Influential and Specialized Articles

The most influential articles in *C. papaya* research were listed in order of LC (Table 3) [18–27]. The first was "The draft genome of the transgenic tropical fruit tree papaya (*Carica papaya* Linnaeus)" by Ming et al. (2008), with 203 LC and 775 GC. Next is the work by Gonsalves et al. (1998), "Control of papaya ringspot virus in papaya: A Case Study," which received 154 LC and 362 GC. The article by Otsuki et al. (2010), titled "Aqueous extract of *Carica papaya* leaves exhibits anti-tumor activity and immunomodulatory effects," received 133 LC and 204 GC. Also, in terms of the LC/GC ratio, the work by De Oliveira et al. (2011), titled "Papaya: Nutritional and Pharmacological Characterization," was the highest at 86.27%, making it the most specialized in the field. The second highest was "Complete Nucleotide Sequence and Genetic Organization of Papaya Ringspot Virus RNA No Access" by Yeh et al. (1992), at 67.69%.

Table 3. Ranking of publications by number of local citations.

Authors/Years	Title	Journal	Local Citations	Global Citations	LC/GC Ratio (%)
Ming et al. (2008) [18]	The draft genome of the transgenic tropical fruit tree papaya (*Carica papaya* Linnaeus)	Nature	203	775	26.19

Gonsalves et al. (1998) [19]	Control of papaya ringspot virus in papaya: A Case Study	Annu Rev Phytopathol	154	362	42.54
Otsuki et al. (2010) [20]	Aqueous extract of *Carica papaya* leaves exhibits anti-tumor activity and immunomodulatory effects	J Ethnopharmacol	133	204	65.2
Fitch et al. (1992) [21]	Virus Resistant Papaya Plants Derived from Tissues Bombarded with the Coat Protein Gene of Papaya Ringspot Virus	Bio-Technol	111	226	49.12
Yeh et al. (1992) [22]	Complete Nucleotide Sequence and Genetic Organization of Papaya Ringspot Virus RNA No Access	J Gen Virol	88	130	67.69
De Oliveira et al. (2011) [23]	Papaya: Nutritional and pharmacological characterization, and quality loss due to physiological disorders. An overview	Food Res Int	88	102	86.27
Liu et al. (2004) [24]	A primitive Y chromosome in papaya marks incipient sex chromosome evolution	Nature	85	298	28.52
Canini et al. (2007) [25]	Gas chromatography–mass spectrometry analysis of phenolic compounds from *Carica papaya* L. leaf	J Food Compos Anal	82	159	51.57
El Moussaoui et al. (2001) [26]	Revisiting the enzymes stored in the laticifers of *Carica papaya* in the context of their possible participation in the plant defence mechanism	Cell Mol Life Sci	79	127	62.2

Azarkan et al. (2003) [27]	Fractionation and purification of the enzymes stored in the latex of *Carica papaya*	J Chromatogr B	79	128	61.72

3.7. Key Research Themes and Term Frequency Analysis

The word cloud analysis shows an emphasis on research in plant biology, harvesting, and molecular analysis (Figure 5). The most frequently occurring terms were *C. papaya* (384 occurrences), identification (285), quality (280), growth (278), fruit (257), expression (239), and resistance (175).

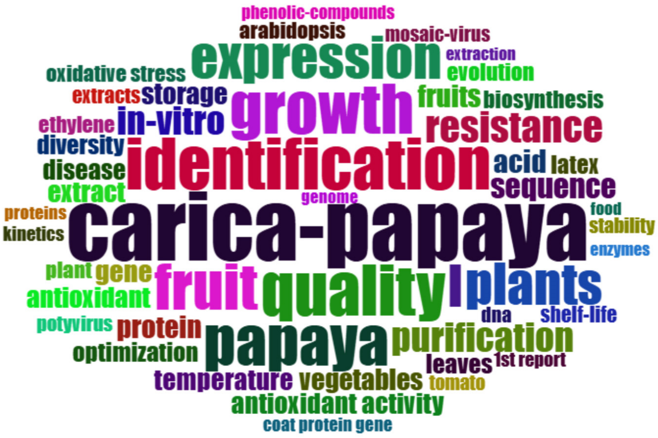

Figure 5. The 50 most frequently used research keywords.

Additionally, we identified five clusters of research themes for *C. papaya*, which are represented in a thematic map (Figure 6). The "Quality" cluster (light pink) represents a central and developed theme, with an emphasis on postharvest science and food chemistry. It is primarily comprised of the terms "fruit," "acid," "in vitro," and "in vivo." Another cluster, labeled "Identification" (light blue), encompasses terms such as "growth," "gene expression," and "resistance," and is a well-established theme that specializes in plant biology, genetics, and disease resistance. Furthermore, the "Sequence" cluster (light green) contains terms such as "gene," "diversity," "DNA," "molecular," and "protein," and thus acts as a connecting theme primarily encompassing virology and genomic studies. On the other hand, the "*Carica papaya*" cluster (lavender) emphasizes the biological activities of papaya compounds, characterized by terms that include "purification," "latex," "proteins," and "enzymatic activity." Finally, the "Adsorption" group (light orange) forms a narrow but specialized line of research focused on environmental applications, as evidenced by the term "removal."

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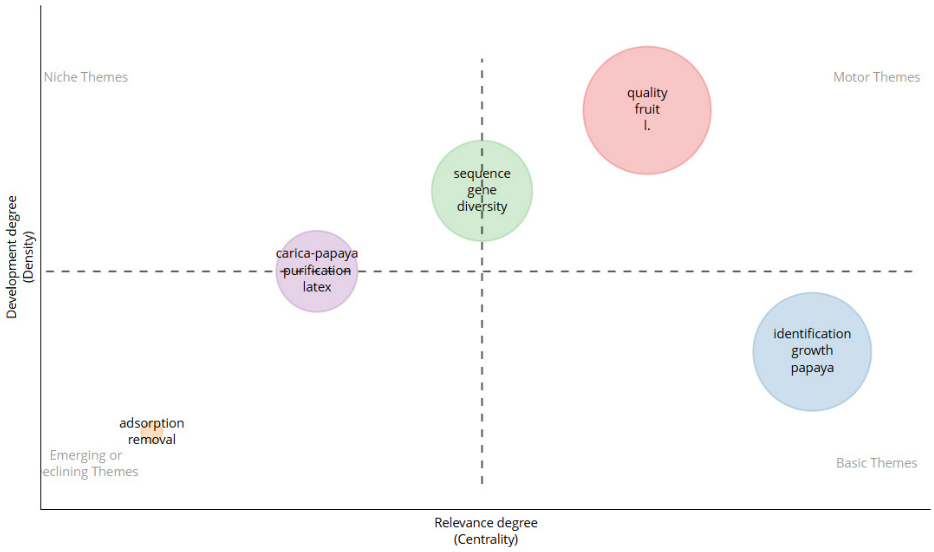

Figure 6. Thematic map for keywords in *C. papaya* research.

3.8. Types of Studies and Biological Activities Investigated in C. papaya

Our analysis of *C. papaya* publications revealed that applied sciences constituted the majority of research (40.9%; Table 4), followed by analytical studies (36.6%), experimental research (16.9%), and review articles (5.6%). Within the applied sciences category, the focus is on plant pathology (16.8% of total articles) and agricultural applications (12.9%). Analytical studies consist of general analyses (13.2%) and genomic/proteomic research (12.6%). Experimental research includes in vitro studies (6.2%), animal models (5.3%), and clinical research (3.1%). Finally, review articles are primarily narrative (5.1%).

Table 4. Distribution and frequency of study types.

Category	Type of study	n	Total (%)	Category (%)
Analytical	General analysis	862	13.2	36
	Genomics/Proteomics	826	12.6	34.5
	Characterization	173	2.6	7.2
	Biochemical analysis	164	2.5	6.9
	Chemical analysis	157	2.4	6.6
	Phytochemical analysis	139	2.1	5.8
	Optimization	48	0.7	2
	Materials analysis	24	0.4	1
Applied	Phytopathology	1097	16.8	40.9
	Agricultural	846	12.9	31.6
	Postharvest	632	9.7	23.6
	Ecological	105	1.6	3.9
Experimental	In vitro	409	6.2	37
	Animal models	348	5.3	31.5
	Clinical	202	3.1	18.3
	In silico	78	1.2	7.1
	Other	67	1	6.1
Review	Narrative	333	5.1	90.2
	Systematic	36	0.5	9.8

Table 5 summarizes the analysis of the most studied biological activities, ranked by the number of publications. The antioxidant properties lead with 945 publications, followed by metabolic

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regulation (747), anti-infective activity (427), anticancer activity (224), wound healing (62), anti-inflammatory (45), cardiovascular (12), neurological (13), and hepatoprotective activities (10).

Table 5. Biological activities reported for *C. papaya*.

Classification	Studies (n)	Key Activities/Mechanisms
Antioxidant	945	Free radical scavenging and ROS inhibition.
Metabolic regulation	747	Anti-obesity and antidiabetic.
Antimicrobial	427	Antibacterial, antifungal, antiviral, and antiparasitic.
Anticancer	224	Cytotoxic, antiproliferative, chemopreventive, and antitumor.
Wound healing	62	Wound healing and tissue regeneration.
Gastrointestinal	47	Digestive enzyme stimulation, antiulcer, and gastroprotective.
Anti-inflammatory	45	Anti-inflammatory, analgesic, and antinociceptive.
Immunomodulation	40	Immunomodulatory.
Renal protection	14	Nephroprotective and diuretic.
Neurological	13	Neuroprotective.
Cardiovascular	12	Cardioprotective and vasodilation.
Hepatoprotective	10	Hepatoprotective.

3.9. Extracts, Metabolites, and Bioactivities of C. papaya Leaves

Aqueous and ethanolic extracts from *C. papaya* leaves have been found to have a greater diversity and quantity of metabolites (Figure 7). These polar extracts are associated with phenolic compounds, flavonoids, and alkaloids, which were linked to antioxidant, anti-inflammatory, anticancer, and antimicrobial activities. In contrast, nonpolar extracts (hexane and chloroform) were less common and more specific. They are primarily associated with terpenoids and sterols in antimicrobial activity. On the other hand, terpenes and sulfur compounds associated with essential oils were correlated with antiviral and hepatoprotective properties. Furthermore, saponins and sulfur compounds are involved in antidiabetic and anticancer effects.

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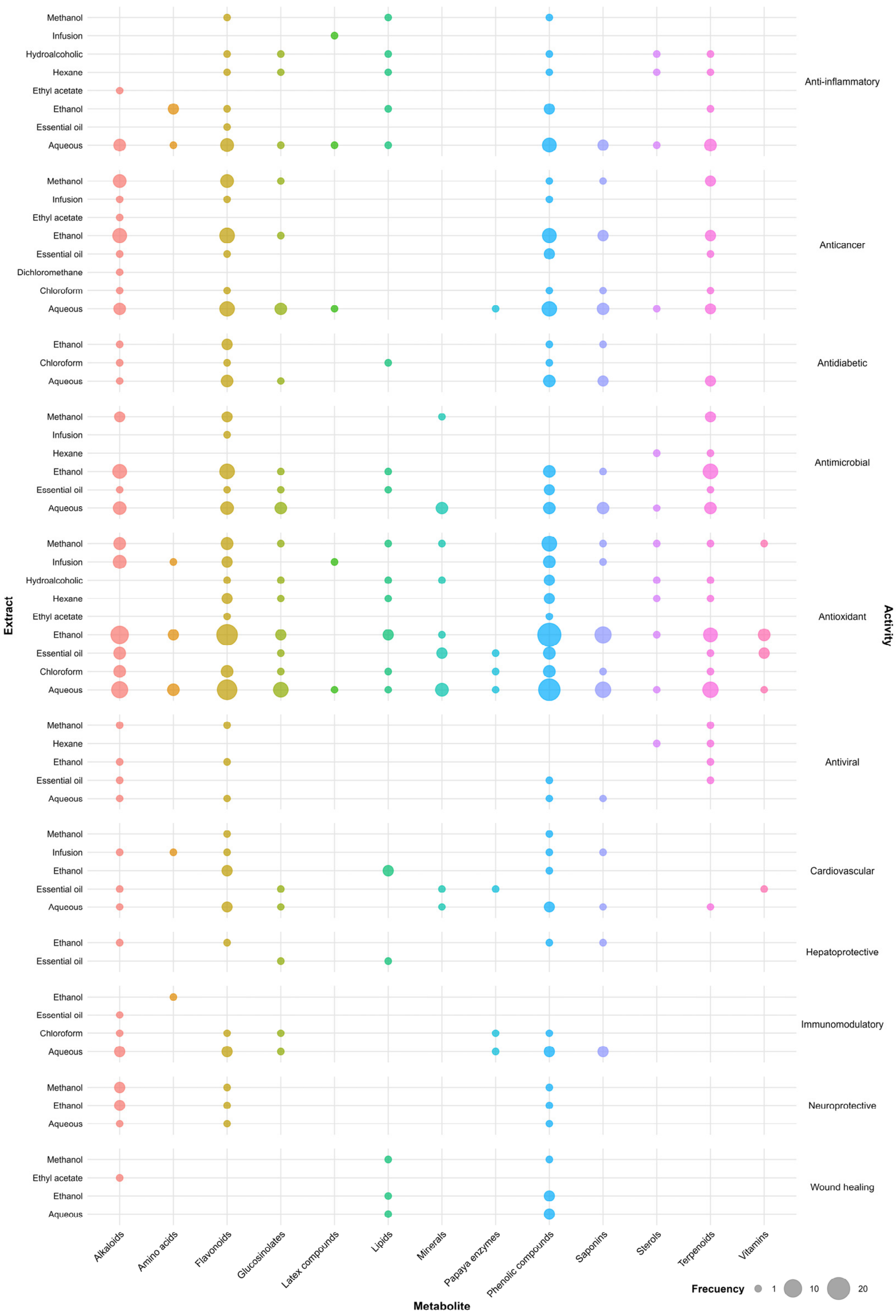

Figure 7. Co-occurrence of metabolites according to biological activity and extract type in *C. papaya* leaves.

4. Discussion

Research on *C. papaya* has undergone significant diversification in recent decades, with contributions from many areas, including agronomy, botany, genomics, phytochemistry, and pharmacology. To the best of our knowledge, this bibliometric analysis is the first to provide an overview of the global scientific landscape of this plant, exploring publication trends, leading authors, research topics, and a detailed examination of biological activities and metabolites.

The annual increase of 7.77% in publications regarding the plant indicates an expanding engagement from the scientific community. Advancements in agricultural practices, contemporary medicinal applications, nutritional attributes, phytochemical analysis, disease etiology, post-harvest techniques, genomics, biotechnological approaches, and the development of value-added papaya products for food and health security have been influenced by progress [28]. Moreover, the average citations per document showed an upward trend, reaching a peak in 2017. The observed limitation on citation growth may result from the period required for articles to accumulate citations, suggesting that the number may continue to rise. Comparable results have been observed in plant species, including watermelon [29].

The distribution of the papaya crop in tropical regions agrees with the highly productive countries in papaya research, including India, Brazil, China, and Mexico [1]. This is represented by institutions such as the Indian Council of Agricultural Research and the University of São Paulo (Figure 3). Remarkably, the United States is the most prolific contributor to the scientific literature, with the United States Department of Agriculture being the most representative institution, with 298 articles. In addition, it is the nation with the most international collaborations, despite not being a significant agricultural producer of the species. In this sense, international collaboration has been described as a mutually beneficial global scientific trend in which countries with high confidence and reciprocity develop strong relationships to conduct research [30]. This indicates that natural resources enhance research in productive nations, and the United States, by establishing international partnerships, has emerged as a leader in research.

We observed a focus on food science and technology due to the predominance of journals such as Postharvest Biology and Technology and LWT—Food Science and Technology. Primarily, these journals publish papers that investigate the integrity of plant components and postharvest processes [31]. By means of phytopathological investigation, this contributes to the development of strategies that address diseases affecting agricultural productivity. His research has been published in journals such as Plant Disease and Phytopathology [2]. Additionally, the journal Food Chemistry demonstrates the interest of pharmacology in exploring the therapeutic applications of plant-derived bioactive metabolites [32].

The integration of author collaboration networks and publication impact reveals that knowledge regarding this plant is distributed among specialized research groups. The most prominent cluster is represented by Ming R. (Figure 2), who published "The draft genome of the transgenic tropical fruit tree papaya", a work that defines the research line focused on genomics for crop improvement. Integrated into this line is the research of Gonsalves and Yeh on the control and characterization of PRSV. This collaboration demonstrates that genomics and phytopathology have converged to address the most devastating problem for this crop worldwide, as commercial varieties lack natural resistance to PRSV. This result shows that experiments produced transgenic varieties that exhibited resistance to virus coat proteins [33]. Occupying a more isolated position within the collaboration network, a cluster led by Pereira M.G. is focused on conventional plant breeding and cultivar development [34]. Therefore, both research groups are attempting to solve the problem of plant infections and, in turn, produce healthy papaya.

Research on *C. papaya* has also explored its pharmaceutical properties. Some of the literature is based on experimental studies, such as in vitro studies, animal models, and clinical trials (Table 4). As part of their metabolism, plants generate chemical substances that interact with the environment and may have therapeutic uses. Many of these substances are found in various plant organs at largely unknown concentrations [35]. Consistent with this, the "*Carica papaya*" cluster on the thematic map and Table 3 shows interest in the biological activities of papaya compounds and efforts to isolate and characterize the active principles responsible. This has been supported by the finding of several bioactive compounds in various plant components, including leaves, fruit, roots, seeds, and latex [36].

The leaves of *C. papaya* are of interest due to diverse bioactive metabolites. Our analysis revealed that antioxidant activity had the highest number of publications (Table 5), and text mining indicated that phenolic compounds and antioxidant activity have been associated (Figure 8). This aligns with

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the existing literature, which identifies phenolic compounds, particularly flavonoids, as the main contributors to the antioxidant capacity of *C. papaya* leaves. These compounds act as potent free-radical scavengers and metal chelators, neutralizing reactive oxygen species and reducing oxidative stress [37].

The existing literature suggests that the efficiency of phytochemical extraction is highly influenced by solvent polarity [1]. Our analysis revealed a greater frequency of bioactive metabolites and associated activities in the polar extracts. The extracts have been found to contain flavonoids, such as quercetin and kaempferol, as well as phenolic acids, including chlorogenic and caffeic acids. The association of these compounds with antioxidants and anti-inflammatory properties has been documented [38], which we identified as co-occurring in our study. Additionally, the polar extracts contained carpaine, which has shown different biological effects (antiplasmodial, antidengue, anticancer, anthelmintic, and thrombocytopenic) [39]. Furthermore, the antidiabetic effects are attributed to the phenolic glycosides present in the extracts, which inhibit carbohydrate-digesting enzymes [37]. Conversely, less polar extracts were less numerous in our analysis and were mostly associated with metabolites, such as terpenes. According to the literature, these compounds found in leaves exhibit various biological activities. In particular, sterols (β-sitosterol and phytosterols) exhibit antimicrobial, hepatoprotective, and anti-inflammatory properties. Besides, triterpenoids and sterols (stigmasterols, betulinic, and oleanolic acid) demonstrate antiviral properties [40]. The metabolites are correlated with biological properties, which contribute to the scientific development of plant-based pharmaceutical and nutraceutical products.

This article presents limitations in the categorization system used to process a large volume of literature (6,546 articles): text mining analyses of biological activity, extract type, and metabolite class required articles to include key terms in their titles, abstracts, or keywords, 2–3% difference across several categories when performing manual checks. Consequently, studies that did not report these terms adequately in these areas were excluded from the analysis.

5. Conclusions

This bibliometric analysis reveals the growing exploration of the bioactive metabolites of *C. papaya*, as well as the progression from agricultural and food research to strategic scientific collaborations that have successfully addressed critical crop diseases. This approach has enabled us to map the entire research landscape, showing that *C. papaya* has transcended its role as a tropical fruit to become a key model for genomics and a promising source of pharmacological compounds. Our study suggests that *C. papaya* is a fundamental subject at the intersection of agriculture, genomics, and applied medicine. These contributions require further research to understand the various properties of *C. papaya* leaves that could be used as an alternative in nutrition and disease treatment.

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Abbreviations

The following abbreviations are used in this manuscript:

PRSV	Papaya ringspot virus
WoS	Web of Science
LC	Local citations
GC	Global citations
BC	Betweenness centrality
PR	PageRank

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