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GLOBAL RESEARCH TRENDS IN CASSAVA VALUE CHAIN, PROCESSING, AND VALUE ADDITION: A BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW

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ABSTRACT
Cassava (*Manihot esculenta Crantz*) is a strategically important root crop that contributes significantly to food security, rural livelihoods, and industrial development in tropical and subtropical regions. Growing demand for processed cassava products and sustainable value chain development has stimulated substantial research on processing technologies, value addition, and commercialization. This study aimed to evaluate the global research landscape on cassava value chain, processing, and value addition through a combined bibliometric analysis and systematic literature review. A comprehensive literature search was conducted using the Scopus database following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. After applying predefined inclusion and exclusion criteria, 70 peer-reviewed publications published between 2000 and 2026 were selected for analysis. Bibliometric mapping was performed using VOSviewer (version 1.6.20) to analyse co-authorship networks, country collaborations, keyword co-occurrence, citation patterns, bibliographic coupling, and co-citation relationships. The findings indicate a steady increase in scientific publications, reflecting the growing importance of cassava in sustainable agriculture and the global bioeconomy. Nigeria and Brazil emerged as the leading contributors, while keyword analysis identified food security, sustainability, processing technologies, cassava flour, starch, and value addition as the dominant research themes. The study also revealed expanding international collaboration and a strong intellectual foundation underpinning advances in cassava breeding, post-harvest management, processing, and industrial utilization. Despite considerable progress, challenges related to post-harvest losses, limited processing infrastructure, weak market integration, and technology adoption continue to constrain value chain development. Future research should prioritize sustainable processing innovations, digital value chains, circular bioeconomy approaches, value-added product diversification, and stronger international collaboration to enhance the competitiveness and sustainability of the global cassava sector.

KEYWORDS: Bibliometric analysis, Cassava, Processing, Systematic literature review, Value addition, Value chain.

INTRODUCTION
Cassava (*Manihot esculenta Crantz*) is one of the world's most important tropical root crops and plays a critical role in ensuring food security, improving rural livelihoods, and supporting agricultural development in many developing countries. It serves as a staple food for more than 800 million people across Africa, Asia, and Latin America owing to its high carbohydrate content, adaptability to diverse agroecological conditions, and ability to produce satisfactory yields under drought and low-fertility soils (1-3). Compared with many cereal crops, cassava demonstrates greater resilience to climate variability, making it an important crop for climate-smart agriculture and sustainable food systems (4,5). Consequently, cassava has gained increasing attention from researchers, policymakers, and development agencies as a strategic crop capable of addressing food insecurity, poverty alleviation, and agricultural sustainability in tropical and subtropical regions.
The global importance of cassava has expanded considerably over the past two decades due to rapid population growth, urbanization, changing dietary preferences, and increasing industrial demand for cassava-derived products. According to the Food and Agriculture Organization (6), global cassava production exceeds 330 million

tonnes annually, with Nigeria, the Democratic Republic of the Congo, Thailand, Ghana, Indonesia, Brazil, Vietnam, and India ranking among the leading producers. While Africa accounts for nearly two-thirds of global cassava production, Southeast Asian countries, particularly Thailand and Vietnam, dominate the international export market for cassava starch and processed products. China has also emerged as one of the world's largest importers of cassava products, mainly for starch manufacturing, animal feed, and bioethanol industries (6). These developments highlight the growing economic significance of cassava beyond its traditional role as a subsistence food crop.

In recent years, the focus of agricultural development has shifted from increasing crop production alone to strengthening agricultural value chains that enhance productivity, market efficiency, and value creation. The agricultural value chain refers to the complete sequence of activities involved in the production, aggregation, processing, storage, transportation, marketing, distribution, and consumption of agricultural products (7). Within the cassava sector, an efficient value chain facilitates stronger linkages among farmers, processors, traders, industries, retailers, and consumers, thereby improving product quality, reducing transaction costs, enhancing market competitiveness, and increasing income opportunities for all stakeholders (8,9). The development of efficient cassava value chains has therefore become a priority in many developing countries seeking to promote rural industrialization, employment generation, and inclusive economic growth.

Processing and value addition have emerged as indispensable components of cassava commercialization because fresh cassava roots are highly perishable and undergo rapid post-harvest physiological deterioration (PPD), often within 24 to 72 hours after harvest (10-12). This rapid deterioration significantly reduces marketability, storage life, and economic returns to farmers. Processing fresh cassava into value-added products such as gari, fufu flour, tapioca, cassava flour, modified starch, glucose syrup, sweeteners, ethanol, animal feed, adhesives, biodegradable packaging materials, pharmaceutical ingredients, and industrial starch extends shelf life, improves product quality, increases profitability, and reduces post-harvest losses (13-15). Moreover, processing industries generate employment opportunities, stimulate rural entrepreneurship, strengthen agro-industrial development, and enhance export competitiveness, thereby contributing significantly to economic development.

The expanding industrial utilization of cassava has transformed it into one of the most versatile agricultural commodities in the global bioeconomy. Cassava starch is extensively utilized in food manufacturing, paper production, textile processing, pharmaceutical formulations, biodegradable plastics, adhesives, sweeteners, and biofuel production owing to its favourable physicochemical properties and cost-effectiveness (5,11). Growing consumer demand for gluten-free foods, renewable bio-based materials, sustainable industrial inputs, and environmentally friendly products has further accelerated research on cassava processing technologies and product diversification. Simultaneously, innovations in biotechnology, starch modification, fermentation technologies, mechanized processing, waste valorization, and circular bioeconomy approaches have opened new opportunities for maximizing value addition throughout the cassava value chain.

Despite its enormous economic potential, the cassava sector continues to face numerous production, processing, and marketing challenges that constrain its competitiveness. Poor rural infrastructure, inadequate processing facilities, limited access to improved technologies, weak market integration, fragmented supply chains, high transportation costs, inadequate storage systems, quality deterioration during post-harvest handling, and limited access to financial services remain significant barriers to value chain development, particularly in developing countries (8,16,17). Smallholder farmers, who constitute the majority of cassava producers worldwide, often receive only a small proportion of the value generated within the supply chain due to limited processing capacity and weak bargaining power. Addressing these constraints requires coordinated interventions involving technological innovation, institutional strengthening, investment in infrastructure, policy support, and enhanced collaboration among value chain actors.

Scientific research on cassava has increased substantially over the last two decades, reflecting its growing importance in global agriculture, food security, industrial development, and sustainable bioeconomy initiatives. Research has expanded across diverse disciplines including agronomy, crop improvement, plant breeding, biotechnology, food science, post-harvest management, agricultural engineering, economics, supply chain management, environmental sustainability, and industrial processing. (18), through a comprehensive bibliometric analysis of global cassava research, reported a remarkable increase in scientific publications between 2000 and 2023, with major research themes focusing on cassava starch, food security, fermentation, hydrolysis, processing technologies, bioenergy, and sustainable utilization. The growing volume and diversity of scientific literature indicate that cassava research has evolved from traditional crop production studies toward multidisciplinary investigations encompassing technological innovation, industrial applications, sustainability, and value chain development.

Although numerous review articles have examined cassava production, genetic improvement, processing technologies, post-harvest deterioration, food applications, and industrial utilization, studies comprehensively synthesizing global research on cassava value chains, processing, and value addition remain limited. Existing reviews generally focus on specific technologies, regional production systems, or individual industrial applications, while evidence regarding global publication trends, influential authors, collaborative networks, institutional productivity, thematic evolution, and emerging research frontiers remains fragmented. Bibliometric analysis has become an increasingly valuable research methodology for quantitatively evaluating scientific productivity, citation performance, collaboration networks, research hotspots, and knowledge evolution (19-20).

When integrated with a systematic literature review, bibliometric analysis provides a comprehensive understanding of existing knowledge, identifies research gaps, highlights emerging research themes, and supports evidence-based decision-making for future research, policy formulation, and sustainable value chain development. Recent global initiatives promoting sustainable food systems, climate-resilient agriculture, circular bioeconomy, renewable industrial raw materials, and inclusive rural development have further increased the strategic importance of cassava. International organizations, national governments, research institutions, and private industries continue to invest in improved processing technologies, product diversification, digital value chains, waste utilization, and sustainable market development to enhance the competitiveness of the cassava sector (3,18). Consequently, understanding the evolution of scientific research on cassava value chains, processing, and value addition is essential for identifying emerging trends, technological advancements, collaboration opportunities, and future research priorities that can contribute to sustainable agricultural transformation and global food security.

METHODOLOGY

This study employed a combined bibliometric analysis and systematic literature review (SLR) to examine global research trends in cassava value chain, processing, and value addition. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a transparent and reproducible literature selection process. The Scopus database was selected as the primary source of bibliographic data because of its comprehensive coverage of peer-reviewed scientific publications and its compatibility with bibliometric analysis software. A comprehensive search was conducted using a predefined search string, and the detailed search strategy used for data retrieval is presented in Table 2. The search initially retrieved 356 publications relevant to the study.

To ensure the quality and relevance of the selected literature, predefined inclusion and exclusion criteria were established before the screening process. The selection criteria included publication period, document type, language, subject area, publication stage, and access type. Only peer-reviewed journal articles and review papers published in English under the Agricultural and Biological Sciences subject area were included, whereas conference papers, book chapters, editorials, non-English publications, and other irrelevant documents were excluded. The complete inclusion and exclusion criteria adopted for this study are presented in Table 1.

The study selection process followed the PRISMA framework. After removing ineligible records through title, abstract, keyword, and eligibility screening, 70 publications were retained for the final bibliometric analysis and systematic literature review. The complete screening procedure is illustrated in the PRISMA flow diagram (Figure 1).

The selected publications were exported from Scopus in CSV format and analysed using VOSviewer (version 1.6.20). Bibliometric analyses included co-authorship analysis, co-occurrence analysis of author keywords, citation analysis, bibliographic coupling, and co-citation analysis. Appropriate threshold values were applied for each analysis based on the number of documents, keyword occurrences, or citation frequency. In the generated network maps, node size represents the relative importance of an item, connecting lines indicate the relationships among items, line thickness denotes the strength of these relationships, and different colours represent distinct clusters within the network. In addition to the bibliometric analysis, a systematic literature review was undertaken to synthesise the findings of the selected studies. The retrieved publications were critically analysed to identify major research themes, processing technologies, value addition strategies, supply chain issues, marketing practices, and emerging research directions in cassava research. The integration of bibliometric mapping with qualitative synthesis provided a comprehensive understanding of the evolution of scientific research, collaboration patterns, intellectual structure, research hotspots, and future opportunities for sustainable development of the cassava value chain.

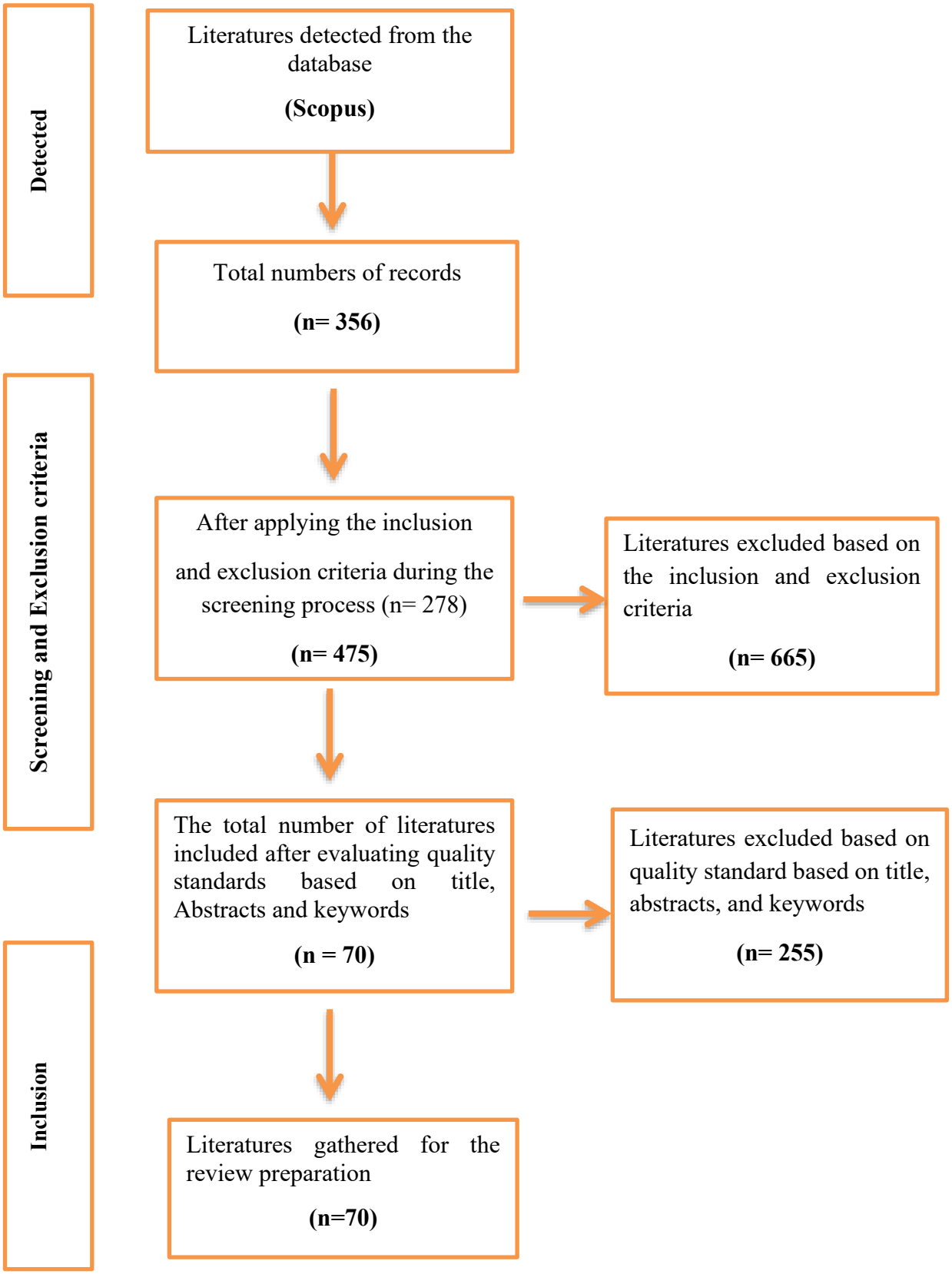

Fig. 1. The PRISMA flowchart.

Table 1. Inclusion and exclusion criteria

Databases	Inclusion	Exclusion
year	2000 – 2026	<2000
Subject area	Agricultural and Biological sciences	Others
Document type	Articles, Review	Conference papers, Book chapters, Books, Editorials, Conference reviews

Languages	English	Non- English And others all
Source type	Journal	Trade journal Book series Book Conference proceeding
Publication stage	Final	Article in press
Open access	All open access	Others

Table 2. The list of keywords employed during the database literature searches

DATABASES	KEYWORDS	TOTAL NUMBER OF ARTICLE
Scopus	(cassava OR tapioca OR "Manihot esculenta") AND ("value chain" OR "supply chain" OR marketing OR commercialization OR agribusiness OR trade) AND (processing OR "value addition" OR "value-added" OR starch OR flour OR fermentation)	356

Justification for inclusion criteria

The inclusion criteria were established to ensure the selection of high-quality, relevant, and scientifically reliable publications for the bibliometric analysis and systematic literature review. Publications published between 2000 and 2026 were included to capture the evolution of global research on cassava value chain, processing, and value addition. Only peer-reviewed journal articles and review papers within the Agricultural and Biological Sciences subject area were considered to ensure scientific quality and thematic relevance. Furthermore, only English-language, final-stage, and open-access publications were included to improve consistency, accessibility, and reproducibility of the dataset. Although these criteria may have excluded relevant studies published in other languages or subscription-based journals, they provided a reliable, consistent, and high-quality database for bibliometric mapping, network visualization, and systematic synthesis of the literature.

RESULT AND DISCUSSION

Co-authorship Analysis of Authors

The co-authorship network of authors involved in research on cassava value chain, processing, and value addition is presented in Figure 2. The network was generated using VOSviewer by applying a minimum threshold of two documents per author. Among the 39 authors identified in the dataset, 23 authors satisfied the threshold and were included in the visualization, resulting in a Total Link Strength (TLS) of 444. The network is divided into seven clusters, each represented by a different colour, indicating distinct groups of researchers who have collaborated frequently on this research topic. The visualization demonstrates a well-established collaborative structure with several influential authors acting as central nodes within the network. In VOSviewer, the size of each node reflects the relative influence of an author based on publication output and collaborative relationships, while the connecting lines represent co-authorship links. Authors positioned closer together indicate stronger collaborative relationships, whereas thicker connecting lines denote greater collaboration strength.

Among the identified authors, Geneviève Fliedel and Dominique Dufour occupy the most central positions in the network, indicating their significant contributions and extensive collaborations in cassava-related research. These authors are strongly connected with multiple clusters, suggesting that they function as key knowledge hubs linking different research groups and facilitating interdisciplinary collaboration. Their prominent positions highlight their important role in advancing research on cassava processing, post-harvest management, and value chain development.

The cyan cluster, centred on Geneviève Fliedel and Dominique Dufour, represents one of the largest collaborative groups and serves as a bridge connecting several other research clusters. This cluster includes collaborators such as Laure Prin and reflects extensive cooperation among researchers working on cassava processing technologies and value addition.

The red cluster is dominated by Clair Hershey, together with Teresa Sánchez, Hernán Ceballos, and Bianca Coelho, indicating a closely connected research community with strong internal collaboration. Similarly, the yellow cluster comprises Dominique Dufour, Simon Lukombo, and Adebayo Abass, demonstrating another active collaborative group contributing to cassava value chain research.

The blue cluster includes authors such as Esther Biaton Njeufa and Tessy Madu, who exhibit dense collaborative relationships and maintain strong links with the central research network. Likewise, the green cluster, led by Durodola Owoade, along with Béla Teeken, Moshood Bakare, and Adeline Muheebwa, represents an emerging collaborative community focusing on value chain development and socio-economic aspects of cassava research.

The orange cluster, comprising Busie Maziya-Dixon, Ayodele A. Adenitan, and Hakeem Oyedele, forms another active collaboration group with direct connections to neighbouring clusters. In contrast, the purple cluster, consisting of Andrew Westby, Kolawole Adebayo, and Louise Abayomi, represents a comparatively smaller but well-connected research group linked to the broader collaboration network through central authors. Overall, the co-authorship network reveals a moderately strong international collaboration pattern, characterised by several influential researchers serving as bridges between different collaborative communities. The existence of multiple interconnected clusters indicates that research on cassava value chain, processing, and value addition is increasingly multidisciplinary and collaborative. However, the presence of relatively independent clusters also suggests opportunities to strengthen cross-institutional and international collaborations, thereby enhancing knowledge exchange and accelerating innovation in the global cassava research community.

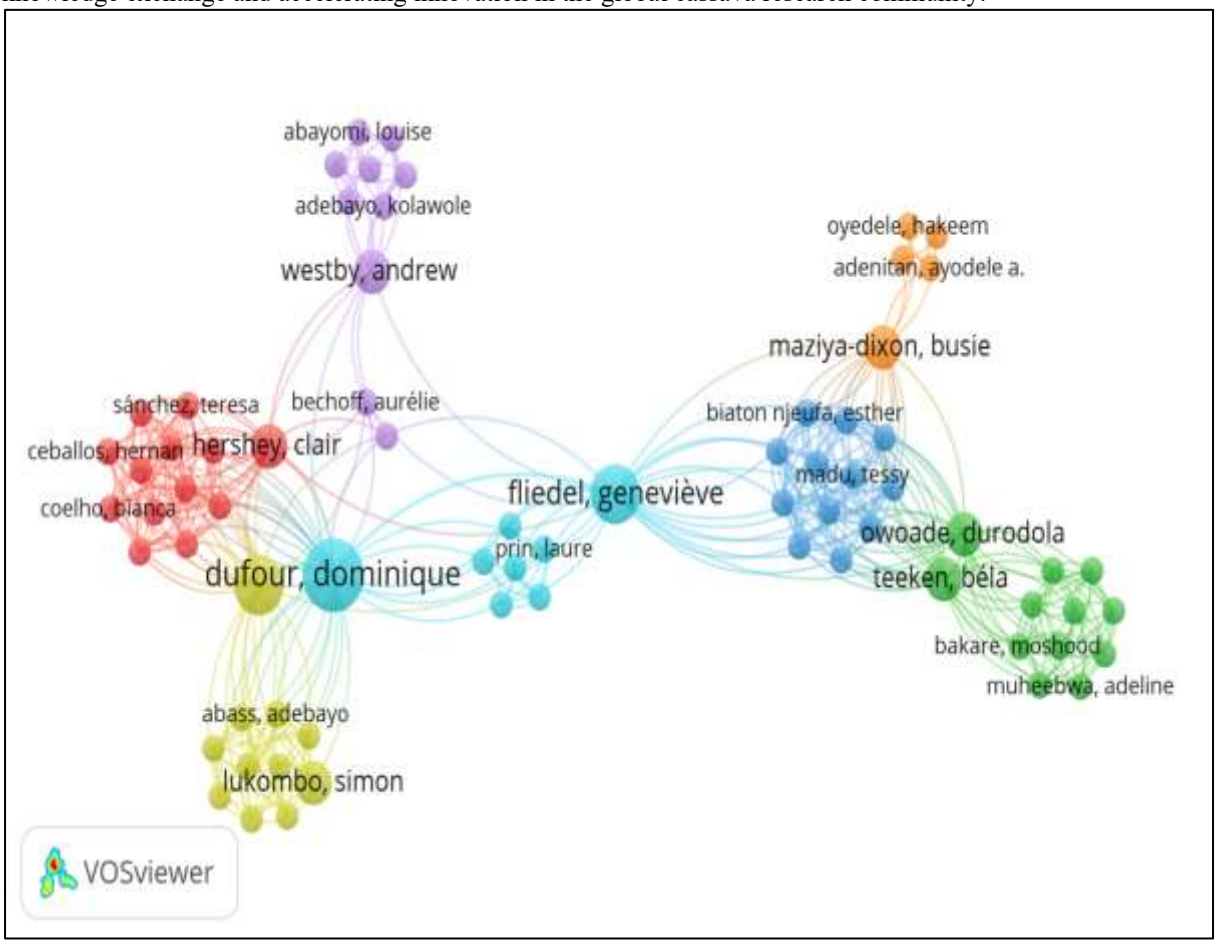

Fig. 2. Co-authorship Analysis of Authors.

Co-authorship Analysis of Countries

The co-authorship network among countries contributing to research on cassava value chain, processing, and value addition is presented in (Figure 3). The network was generated using VOSviewer by applying a minimum threshold of two documents per country. Among the 39 countries identified in the dataset, 23 countries satisfied the threshold and were included in the analysis. The visualization is organised into five clusters, each represented by a distinct colour, illustrating the international collaborative relationships among countries involved in cassava research. The co-authorship map reveals a moderately interconnected global collaboration network, with several countries occupying central positions and acting as major contributors to international research partnerships. In the VOSviewer network, the size of each node represents the relative contribution of a country in terms of publication output and collaborative activities, while the connecting lines indicate co-authorship relationships. Countries positioned closer together exhibit stronger research collaborations, whereas thicker connecting lines indicate greater collaboration strength.

Among the participating countries, Nigeria emerges as the most influential and centrally positioned country within the network. Nigeria exhibits extensive collaborative links with several countries, reflecting its leading role in global cassava research. As one of the world's largest producers of cassava, Nigeria has established strong international research partnerships, particularly with countries in Africa and Latin America, contributing substantially to studies on cassava production, processing technologies, value addition, and food security.

The green cluster is centred on Nigeria, together with Uganda and the Democratic Republic of the Congo, representing a strong African research collaboration. The close proximity among these countries indicates active

partnerships in addressing cassava production, value chain development, and sustainable agricultural practices across the African continent.

The red cluster is dominated by Brazil and Colombia, with Portugal serving as an important connecting country. Brazil occupies another major hub within the network, demonstrating extensive collaborations with both African and European research partners. This cluster reflects strong cooperation in research related to cassava processing technologies, industrial utilization, and product development.

The purple cluster comprises the United States, which is connected primarily with Brazil and other collaborating countries. Although relatively isolated compared with the larger clusters, the United States maintains important international collaborations, highlighting its contribution to scientific research and technological advancement in cassava-related studies.

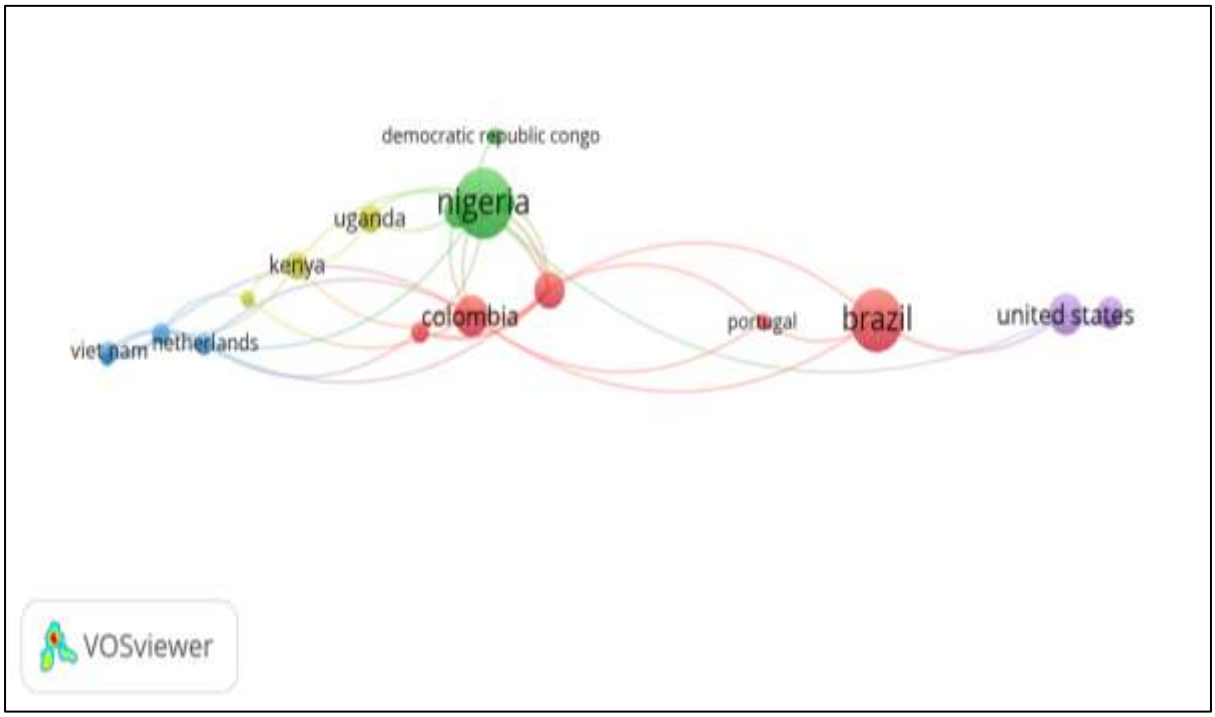

Fig. 3. Co-authorship Analysis of Countries.

The blue cluster, consisting of the Netherlands and Vietnam, represents another collaborative group linked with the broader international network. These countries contribute to knowledge exchange through collaborative research in cassava processing, trade, and value addition. Similarly, the yellow cluster, represented mainly by Kenya, acts as an intermediary between the African and European collaboration networks, indicating its growing role in international cassava research. Overall, the country co-authorship network demonstrates that research on cassava value chain, processing, and value addition is supported by a broad international collaboration involving countries from Africa, South America, Europe, Asia, and North America. The prominent positions of Nigeria and Brazil highlight their leadership in global cassava research, while the interconnected clusters indicate increasing multidisciplinary and multinational cooperation. Nevertheless, the relatively limited participation of several countries suggests that further expansion of international collaborations could enhance knowledge sharing, technology transfer, and innovation for sustainable development of the global cassava value chain.

Co-occurrence Analysis of Author Keywords

The co-occurrence network of author keywords related to cassava value chain, processing, and value addition is presented in Figure 4. The analysis was performed using VOSviewer by applying a minimum threshold of three keyword occurrences. Among the 553 author keywords identified in the dataset, 22 keywords met the threshold and were included in the network visualization. These keywords were grouped into four distinct clusters, each represented by a different colour, illustrating the major thematic areas and their interrelationships within the research field. The visualization reveals that "cassava" is the largest and most influential keyword, occupying the central position in the network. Its prominent node size and extensive connections with other keywords indicate that it serves as the core research theme linking multiple areas of investigation. The strong interconnections demonstrate that research on cassava has evolved beyond crop production to encompass food security, processing technologies, value addition, genetics, sustainability, and socio-economic development.

The green cluster represents the largest thematic group, centred on cassava, and includes keywords such as Manihot esculenta, food security, crop production, sustainability, and Africa. The close association among these keywords indicates that a substantial proportion of the literature focuses on the contribution of cassava to sustainable agriculture, food security, and crop production systems, particularly in African countries where

cassava is a major staple crop. The presence of Manihot esculenta, the scientific name of cassava, further highlights the integration of agronomic and biological research within this thematic cluster.

The blue cluster comprises keywords including Nigeria, gari, starch, and constraints. This cluster reflects research emphasizing cassava processing, traditional value-added products, industrial starch utilization, and the production and marketing challenges associated with cassava value chains. Nigeria, being one of the world's leading cassava-producing countries, occupies a prominent position within this cluster, indicating its significant contribution to studies on cassava processing and commercialization.

The red cluster includes keywords such as Manihot esculenta Crantz, cassava flour, genetics, and Manihot. This cluster primarily represents research related to genetic improvement, species characterization, flour production, and technological innovations for value-added cassava products. The strong connections among these keywords suggest increasing research interest in improving cassava quality and expanding its industrial applications through breeding and product development.

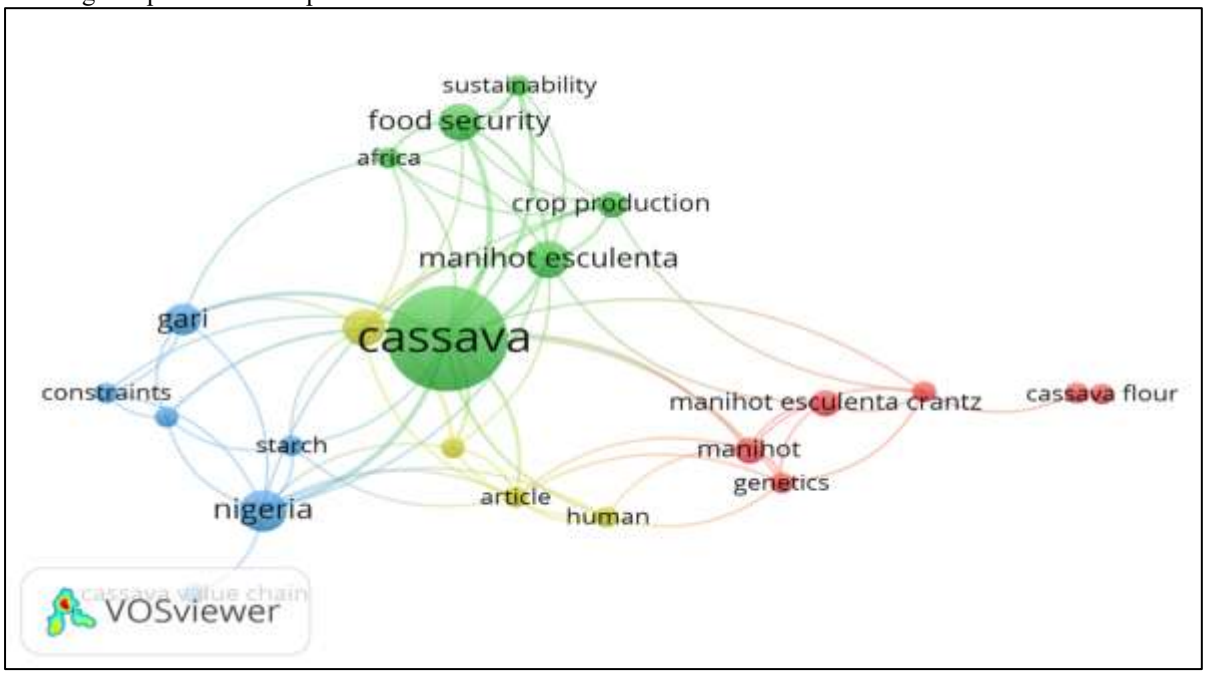

Fig. 4. Co-occurrence Analysis of Author Keywords.

The yellow cluster consists of keywords including article and human, which act as connecting nodes linking multiple thematic areas within the network. Although these keywords are relatively generic, their central positions indicate their frequent occurrence across diverse studies and their role in connecting interdisciplinary research themes. The network also demonstrates strong relationships between keywords associated with food security, sustainability, crop production, processing technologies, and value-added products, highlighting the multidisciplinary nature of cassava research. The close proximity among the major keywords suggests that recent studies increasingly integrate agricultural production, food systems, industrial utilization, and socio-economic aspects to address the growing demand for sustainable cassava value chains. Overall, the keyword co-occurrence network indicates that contemporary research on cassava value chain, processing, and value addition is primarily centred on food security, sustainable crop production, processing technologies, industrial utilization, and value-added products. The dominance of keywords such as cassava, food security, Manihot esculenta, Nigeria, and cassava flour reflects the broad scope of current research and demonstrates a progressive shift from traditional production-oriented studies toward multidisciplinary investigations addressing sustainability, technological innovation, and value chain development.

Citation Analysis of Countries

The citation analysis of countries contributing to research on cassava value chain, processing, and value addition is presented in Figure 5. The analysis was performed using VOSviewer by applying a minimum threshold of three documents per country. Among the 39 countries represented in the dataset, 16 countries satisfied the threshold and were included in the visualization. The map illustrates the relative citation impact of each country, where the size of each node represents its citation performance within the research field. The visualization indicates considerable variation in the citation impact of different countries. Nigeria is represented by the largest node, indicating that it has received the highest citation impact among the countries included in the analysis. This finding reflects Nigeria's prominent contribution to research on cassava production, processing, value addition, and food security. As one of the world's largest cassava-producing countries, Nigeria has generated a substantial body of influential research that has attracted considerable academic attention.

Brazil also appears as a major contributor with a relatively large node size, demonstrating its significant scientific influence in cassava research. Brazilian studies have contributed extensively to areas such as cassava genetics,

crop improvement, processing technologies, industrial utilization, and value-added product development. Together, Nigeria and Brazil represent the leading countries in terms of citation impact, highlighting their dominant roles in advancing global cassava research. Other countries including the United States, Colombia, France, United Kingdom, Indonesia, Ghana, Kenya, Uganda, Cameroon, Thailand, Vietnam, Spain, and Benin also appear in the citation map, although with comparatively smaller node sizes. Their presence indicates continued contributions to cassava-related research across diverse disciplines, including agricultural production, food science, biotechnology, genetics, processing, and value chain development. While these countries exhibit lower citation impacts than Nigeria and Brazil, they collectively contribute to the global expansion of cassava research. The absence of citation links between countries in the visualization indicates that the analysis primarily reflects citation performance rather than citation relationships or collaboration patterns. Consequently, the map highlights the relative scientific influence of individual countries based on citation frequency instead of illustrating inter-country citation networks. Overall, the citation analysis demonstrates that Nigeria and Brazil are the most influential countries in terms of citation impact in research on cassava value chain, processing, and value addition. Their strong scientific contributions underscore their leadership in generating high-impact research, while the participation of several other countries reflects the growing international interest in sustainable cassava production, processing technologies, and value chain development.

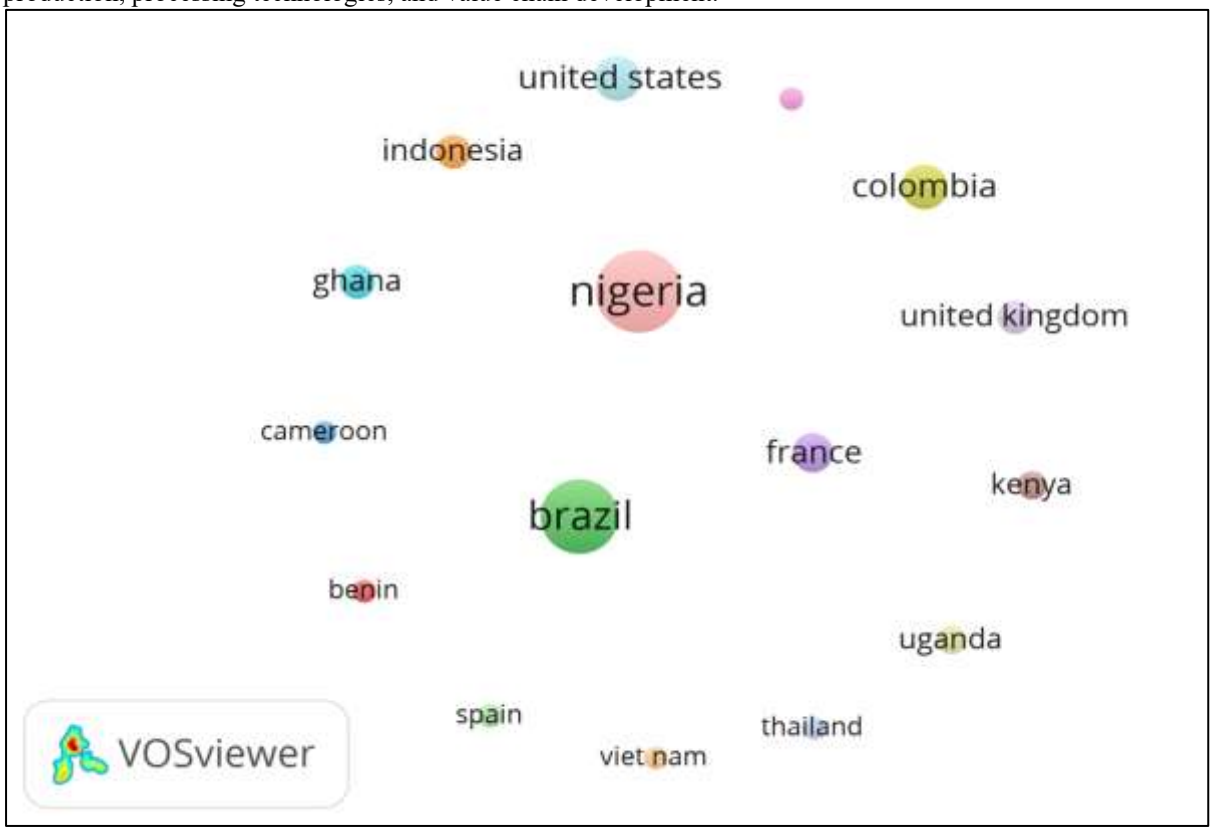

Fig. 5. Citation Analysis of Countries.

Bibliographic Coupling Analysis of Countries

The bibliographic coupling network of countries contributing to research on cassava value chain, processing, and value addition is presented in Figure 6. The analysis was performed using VOSviewer by applying a minimum threshold of four citations per country. Among the 39 countries identified in the dataset, 36 countries met the specified threshold and were included in the analysis. The resulting network is organised into four distinct clusters, representing groups of countries that share similar citation patterns and common research references. The bibliographic coupling map illustrates the intellectual relationships among countries based on the references cited in their publications. In the VOSviewer visualization, the size of each node represents the relative citation influence of a country, while the connecting lines indicate the strength of bibliographic coupling. Countries connected by thicker lines share a greater number of common references, suggesting similar research interests and closely related scientific knowledge bases.

Among the participating countries, Nigeria and Brazil emerge as the most prominent nodes, indicating their dominant influence in global cassava research. Their large node sizes and extensive bibliographic connections demonstrate that publications originating from these countries frequently cite similar foundational literature and contribute substantially to the development of knowledge on cassava value chains, processing technologies, and value addition. Their central positions further indicate that these countries serve as major knowledge hubs within the global research landscape.

The red cluster, centred on Nigeria, represents one of the strongest bibliographic groups in the network. Nigeria exhibits extensive coupling relationships with several countries, highlighting the broad influence of its scientific publications and their shared intellectual foundations with international research. Indonesia, positioned within the same cluster, also contributes to this research community, although with comparatively lower influence.

The green cluster is dominated by Brazil, with Ghana and Spain forming closely connected nodes. The strong bibliographic relationships among these countries indicate that their research frequently draws upon similar scientific literature, particularly in studies related to cassava production, processing technologies, crop improvement, and sustainable agricultural development.

The yellow cluster comprises Colombia, France, and Benin, representing another important knowledge group within the network. The close proximity of these countries suggests substantial overlap in their cited references, reflecting common research interests in cassava value addition, genetics, processing, and food systems.

The blue cluster includes Vietnam, the Netherlands, and Kenya, forming a collaborative knowledge group characterised by shared citation patterns. The connections between these countries and the other clusters indicate the growing integration of Asian, European, and African research efforts in cassava-related studies. Overall, the bibliographic coupling analysis demonstrates a well-connected global knowledge structure, with Nigeria and Brazil emerging as the most influential countries based on shared citation patterns. The presence of multiple interconnected clusters indicates that research on cassava value chain, processing, and value addition is supported by a common scientific foundation despite geographical diversity. The strong bibliographic relationships among countries also reflect increasing international convergence in research priorities, emphasizing sustainable production, processing innovations, food security, and value chain development.

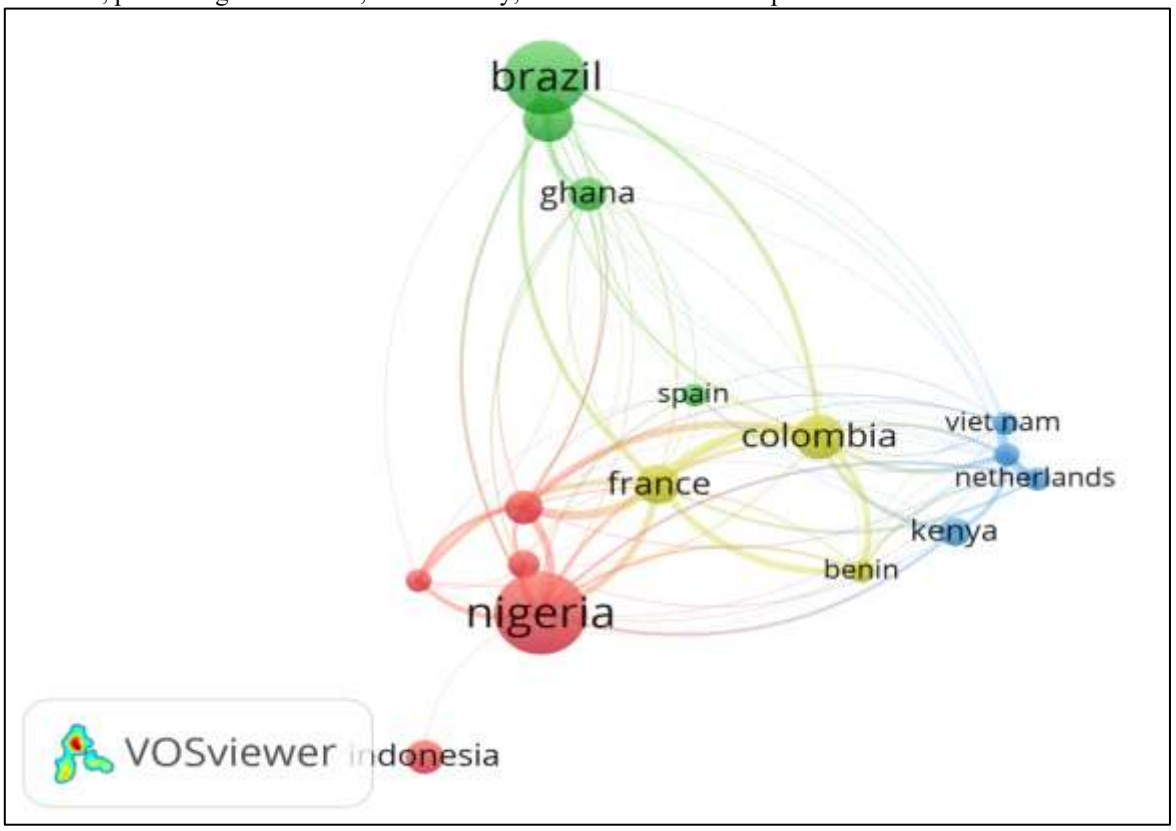

Fig. 6. Bibliographic Coupling Analysis of Countries

Co-citation Analysis of Cited References

The co-citation network of cited references related to cassava value chain, processing, and value addition is presented in Figure 7. The analysis was conducted using VOSviewer by applying a minimum threshold of two citations per cited reference. Among the 3,186 cited references identified in the dataset, 17 references met the specified threshold and were included in the co-citation network. The resulting visualization is organised into five clusters, each represented by a different colour, illustrating groups of frequently co-cited references that constitute the intellectual foundation of cassava research. The co-citation map demonstrates the relationships among influential references that are frequently cited together within the literature. In the VOSviewer network, the size of each node represents the relative influence of a cited reference based on its co-citation frequency, while the connecting lines indicate the strength of co-citation relationships. Larger nodes represent highly influential references, whereas thicker links indicate stronger intellectual associations between references.

Among the cited references, Westby A. occupies the most prominent and central position in the network, indicating the highest co-citation frequency and a substantial influence on the development of research concerning

cassava processing, post-harvest handling, and value addition. The central location of Westby A. suggests that this reference serves as a key knowledge source linking multiple research themes within the field.

The red cluster, centred on Westby A., represents the largest intellectual group in the network. This cluster includes closely associated references such as Fregene M., together with several other highly connected references, reflecting a strong knowledge base related to cassava breeding, processing technologies, and post-harvest research. The dense interconnections within this cluster indicate that these references are frequently cited together in studies addressing cassava improvement and industrial utilization.

The green cluster is represented by Dixon A.G.O., whose publications have contributed significantly to cassava breeding, genetic improvement, and sustainable crop production. The close association between Dixon A.G.O. and the central cluster suggests that genetic improvement and processing research are closely integrated within the cassava literature.

The blue cluster includes Passoth V. and McClements D.J., highlighting another important body of literature focusing on food processing, biotechnology, fermentation, and food science applications. These references contribute to expanding the technological aspects of cassava processing and value-added product development.

The purple cluster is represented by Hanley-Bowdoin L., which appears relatively isolated but maintains direct connections with the central network through Fregene M. This pattern indicates that although Hanley-Bowdoin L. contributes to a specialised research area, the reference remains an important component of the broader intellectual structure of cassava research. Similarly, the cyan cluster, represented by Hounhouigan D.J., and the yellow cluster, represented by De Oliveira E.J., constitute specialised knowledge groups focusing on cassava processing, food quality, and crop improvement. Although these clusters contain fewer references, their connections with the central network demonstrate their continued relevance within the research domain. Overall, the co-citation network reveals a well-established intellectual structure underpinning global research on cassava value chain, processing, and value addition. The dominance of Westby A., together with influential references such as Dixon A.G.O., Fregene M., Hanley-Bowdoin L., Passoth V., and De Oliveira E.J., indicates that research in this field is built upon a strong foundation encompassing cassava breeding, genetics, processing technologies, post-harvest management, biotechnology, and value addition. The presence of multiple interconnected clusters further demonstrates the multidisciplinary nature of cassava research and the integration of agricultural, food science, and industrial perspectives.

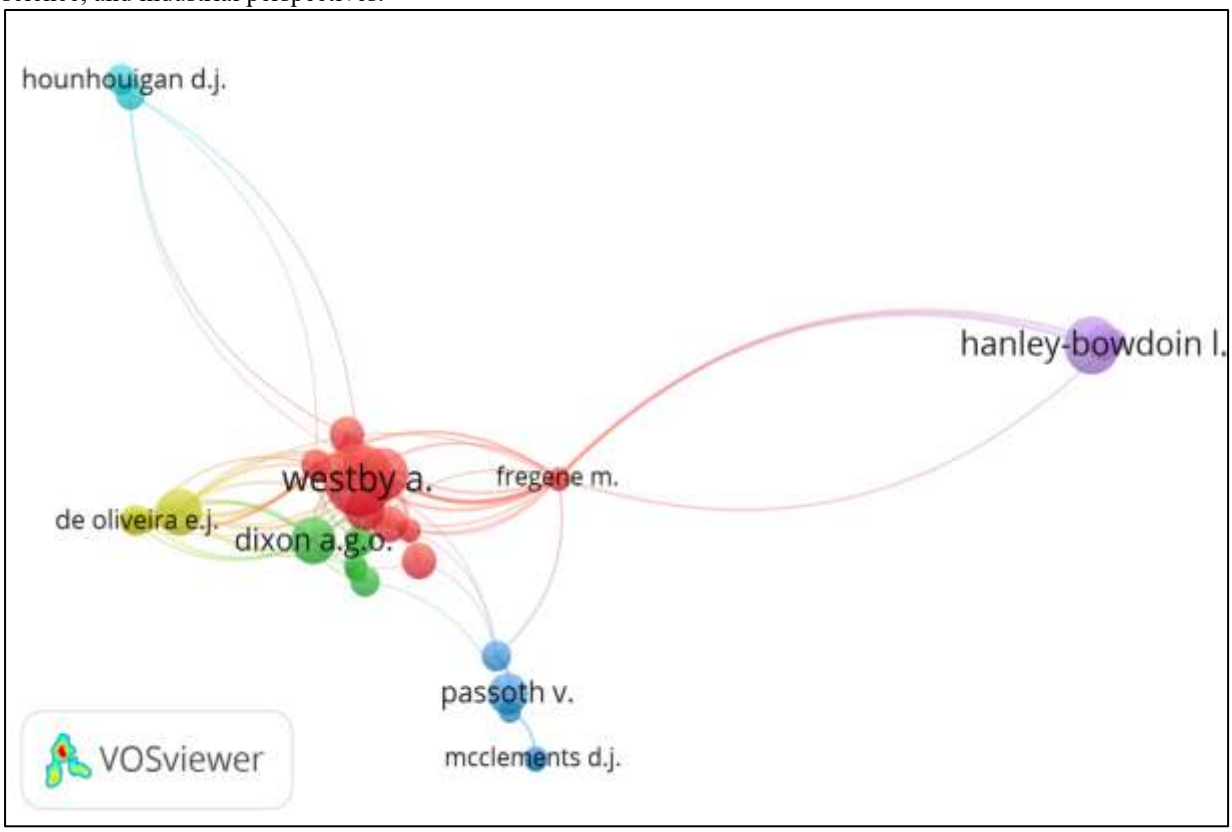

Fig. 7. Co-citation Analysis of Cited References

CONCLUSION

This study provides a comprehensive overview of the global research landscape on cassava value chain, processing, and value addition by integrating bibliometric analysis with a systematic literature review. The findings demonstrate a growing research interest in cassava, driven by its increasing importance for food security, sustainable agriculture, rural livelihoods, and industrial applications. The bibliometric analysis identified Nigeria and Brazil as the leading contributors, while collaboration and keyword analyses revealed expanding international

research networks and a shift towards multidisciplinary themes such as food security, sustainability, processing technologies, genetics, and value-added products. Despite significant scientific progress, challenges related to post-harvest losses, inadequate processing infrastructure, weak market integration, and limited technology adoption continue to constrain the development of efficient cassava value chains. Future research should focus on sustainable processing innovations, digital and climate-smart value chains, circular bioeconomy approaches, value-added product diversification, and stronger international collaborations to enhance the competitiveness and sustainability of the global cassava sector. Overall, this study provides valuable insights into the evolution of cassava research, identifies existing knowledge gaps and emerging research priorities, and serves as a useful reference for researchers, policymakers, and industry stakeholders involved in promoting sustainable cassava value chain development and value addition.

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Authors' contributions

- A. Harini Suganya-Article collection, Analysis and Interpretation
- M. Malarkodi- Contributed by developing ideas, validating and reviewing the manuscript
- K. Divya- Drafting
- M. Anjugam - Reviewing
- S.R. Padma– Validating

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