Two Decades of Palm Oil Research: A Global Bibliometric Analysis

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ABSTRACT

Over the past two decades, palm oil has emerged as one of the most widely studied commodities due to its central role in global food, energy, and sustainability debates. This study conducts a comprehensive bibliometric analysis of palm oil research published between 2005 and 2025, drawing on data retrieved from the Scopus database. Using tools such as VOSviewer and Excel, the study maps publication trends, influential authors, leading journals, thematic clusters, and patterns of international collaboration. The results reveal that early research was dominated by studies on biodiesel production and chemical conversion processes, while more recent years have seen a shift toward sustainability, environmental management, and waste valorization. Malaysia and Indonesia emerge as the two central hubs of research output and collaboration, reflecting their positions as global leaders in palm oil production. Influential journals, particularly the Journal of the American Oil Chemists' Society (JAOCS) and the Journal of Oil Palm Research, serve as intellectual anchors in the field. The co-occurrence and density visualizations highlight the expansion of palm oil studies from engineering and agronomic concerns to broader interdisciplinary discourses linking agriculture, energy, and global development. This study contributes to the literature by offering both theoretical insights into the intellectual structure of palm oil research and practical implications for policymakers, industry stakeholders, and scholars seeking to align future research with sustainability and international collaboration agendas.

Keywords: Palm Oil Research, Bibliometric Analysis, Sustainability, Biodiesel, Scopus

1. INTRODUCTION

Over the past two decades, palm oil has emerged as one of the most critical commodities in the global agricultural and economic landscape. As the most widely consumed vegetable oil in the world, palm oil has found its way into a diverse array of products, from food and cosmetics to biofuels and industrial lubricants. This widespread utility has led to exponential growth in both the production and consumption of palm oil, particularly in Southeast Asia, where countries like Indonesia and Malaysia have become dominant global producers [1]. The expansion of oil palm plantations has not only reshaped national economies but also redefined trade patterns, foreign investment flows, and global commodity markets [2].

The growing prominence of palm oil has been matched by a proliferation of academic research aimed at understanding its multifaceted implications. Scholars from environmental sciences, economics, agribusiness, sustainability studies, and political ecology have increasingly turned their attention to palm oil as a site of both promise and controversy. On one hand, it has been lauded for its productivity and economic benefits, particularly in alleviating rural poverty and boosting export revenues (Feintrenie et al., 2010). On the other, it has been sharply criticized for contributing to deforestation, biodiversity loss, and greenhouse gas emissions [3], [4]. This duality has stimulated intense academic debate and policy scrutiny, resulting in a highly dynamic and interdisciplinary research domain.

The past twenty years have also witnessed the rise of transnational sustainability frameworks and certification mechanisms such as the Roundtable on Sustainable Palm Oil (RSPO), which have further galvanized scholarly attention. These developments have introduced new themes into palm oil research, including governance, certification credibility, traceability, and the

role of corporate social responsibility in plantation management [3]. Simultaneously, the digital revolution and the proliferation of bibliographic databases have enabled researchers to track, map, and analyze scholarly output at a scale and precision never before possible. Bibliometric analysis has thus become an invaluable tool to assess trends, hotspots, and the evolution of knowledge in the palm oil domain.

Despite the availability of a large and growing body of literature, there remains a lack of comprehensive syntheses that trace the intellectual trajectory of palm oil research globally. Much of the existing literature reviews focus narrowly on specific themes such as environmental degradation, land use change, or smallholder livelihoods without offering a macroscopic view of how palm oil scholarship has evolved over time or how different disciplinary contributions interact [5], [6]. In a rapidly changing global context, shaped by climate change concerns, shifting trade policies, and emerging technological innovations, such a holistic overview is urgently needed. Understanding where the field has been and where it is heading is essential for identifying research gaps, avoiding redundancy, and informing evidence-based policy interventions.

Moreover, bibliometric mapping allows scholars to go beyond narrative reviews by offering empirical insights into the structure of knowledge production. It enables the identification of influential authors, institutions, countries, journals, and keywords that shape the field. When applied longitudinally over a 20-year period, such analysis can illuminate patterns of scientific collaboration, thematic shifts, and the emergence of new paradigms in palm oil research. For instance, have sustainability and climate justice overtaken productivity and economic efficiency as dominant themes? What countries are leading the discourse? How have the academic networks expanded or consolidated over time? These questions are best addressed through a rigorous bibliometric lens that quantifies and visualizes the knowledge landscape of palm oil.

Although research on palm oil has grown exponentially, there is currently no comprehensive bibliometric synthesis that systematically maps two decades of global scholarship in this field. Existing reviews often lack the methodological breadth to capture cross-disciplinary evolution, influential actors, or thematic trends, thereby limiting our ability to understand the intellectual dynamics shaping palm oil discourse. This gap not only constrains academic progress but also hampers the translation of research into policy and practice, especially in regions most affected by palm oil-related issues. This study aims to conduct a global bibliometric analysis of palm oil research published between 2005 and 2025.

2. METHODS

This study employs a quantitative bibliometric approach to systematically analyze global scientific publications on palm oil over a 20-year period, from 2005 to 2025. Bibliometric analysis is a proven method for evaluating the evolution, structure, and dynamics of academic literature through objective indicators such as publication counts, citation patterns, author productivity, and keyword trends [7]. The analysis provides a macro-level overview of the research landscape, allowing the identification of key contributors, thematic clusters, and collaboration networks. This approach is particularly well-suited to capturing the interdisciplinary and fast-evolving nature of palm oil research, which spans multiple domains such as environmental science, agriculture, economics, and sustainability.

Data were retrieved from the Scopus database, one of the most comprehensive and widely used bibliographic platforms for peer-reviewed literature. The search was conducted using the keyword string "palm oil" in the article title, abstract, or keywords field. To ensure relevance

and accuracy, only journal articles, conference papers, and reviews published in English were included. Document types such as editorials, notes, and errata were excluded from the dataset. After initial retrieval, a manual screening process was conducted to remove false positives and duplicates. The final dataset consisted of [insert number] valid records. These records were exported in RIS and CSV formats for subsequent analysis using VOSviewer and Microsoft Excel.

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3. RESULTS AND DISCUSSION

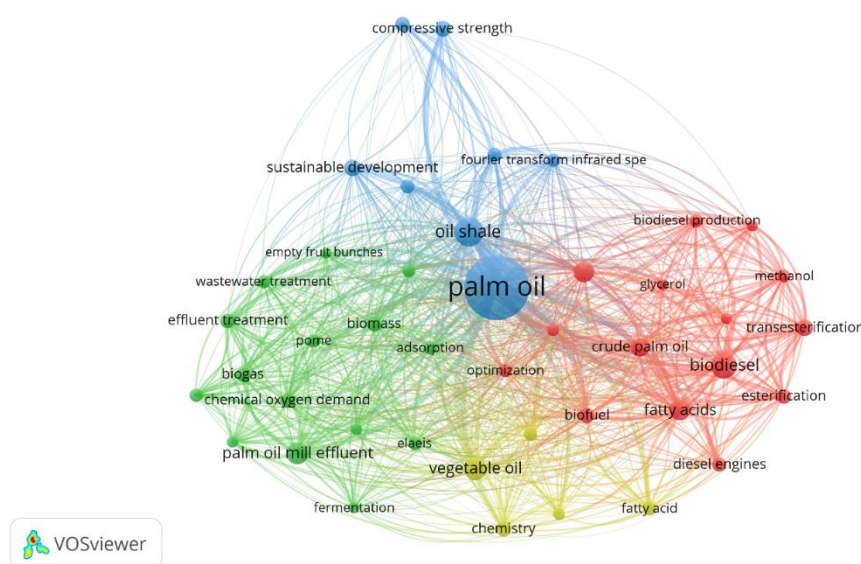### 3.1 Keyword Co-Occurrence Analysis

Figure 1. Network Visualization
Source: Data Analysis

The central node *"palm oil"* dominates the map, signifying its role as the core research term connecting all clusters. Its large size reflects the high frequency and centrality of the keyword across two decades of scholarship. Radiating from this core are distinct but interconnected clusters (colored red, green, blue, and yellow) that demonstrate how palm oil research has diversified into multiple disciplinary directions. The dense network of linkages also suggests strong interdisciplinarity, where environmental, technological, and economic aspects converge around palm oil as a unifying theme. The red cluster highlights themes related to *biodiesel, transesterification, fatty acids, esterification, methanol,* and *diesel engines*. This reflects the prominence of research on palm oil as a feedstock for biofuel production, particularly biodiesel, over the past two decades. The presence of keywords like *glycerol* and *crude palm oil* shows attention to both upstream raw material and downstream processing. This cluster underscores how energy security concerns and renewable energy policies

have driven scientific exploration of palm oil's potential as a sustainable energy source, though often contested for its environmental trade-offs.

On the left side, the green cluster encompasses terms such as *palm oil mill effluent, effluent treatment, wastewater treatment, biomass, chemical oxygen demand,* and *biogas.* This reflects a strong line of inquiry into the environmental externalities of palm oil production and technological solutions to mitigate them. Research here focuses on valorizing waste streams, such as converting effluents and empty fruit bunches into energy or value-added products. The network density indicates that environmental management and waste valorization are deeply integrated into broader sustainability debates surrounding palm oil. The blue cluster links sustainable development, oil shale, compressive strength, and Fourier transform infrared spectroscopy (FTIR). This cluster combines two thematic directions: first, the framing of palm oil within global sustainability and development discourses, and second, more specialized applications in material science and engineering (e.g., using palm oil derivatives in composites or as binders). The coexistence of these themes suggests that while much research stresses sustainability governance, a parallel track emphasizes experimental and technical innovation in non-food uses of palm oil. The yellow cluster, connecting terms like vegetable oil, biofuel, fatty acid, and chemistry, indicates the comparative and cross-disciplinary context of palm oil research. Here, palm oil is situated alongside other vegetable oils in studies of chemical properties, conversion technologies, and comparative efficiency for industrial and energy purposes. This cluster serves as a bridge between the biodiesel-focused red cluster and the waste-management green cluster, emphasizing palm oil's role within the broader vegetable oil and renewable energy research landscape.
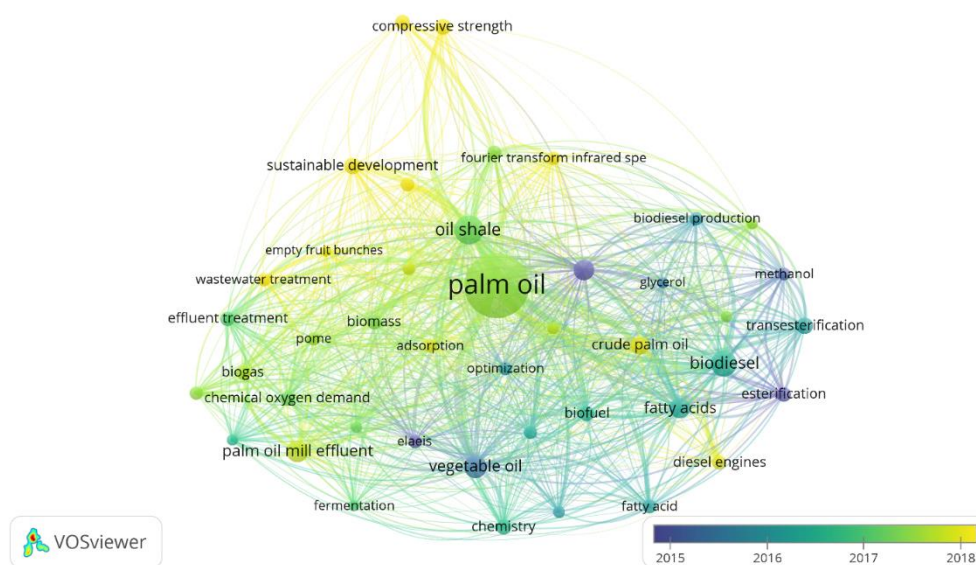

Figure 2. Overlay Visualization
Source: Data Analysis

Figure 2 introduces a temporal dimension, as shown by the color gradient (from dark blue = earlier years, to yellow = more recent years). The centrality of "palm oil" remains strong, but the timeline overlay allows us to observe how research themes have evolved between 2015 and 2018. Earlier studies (in blue) focused heavily on fundamental chemical and engineering processes such as biodiesel, esterification, methanol, transesterification, and diesel engines. These topics reflect the initial dominance of energy-related research where palm oil was primarily investigated as a biodiesel feedstock to meet renewable energy targets. Moving into the mid-phase (green nodes around 2016–2017), research broadened to include environmental and technological applications. Terms like *palm oil mill effluent, wastewater treatment, biomass, biogas,* and *chemical oxygen demand* highlight a growing

emphasis on mitigating the ecological consequences of palm oil production while valorizing waste. This indicates a shift in scholarly attention from production efficiency alone toward sustainability practices, circular economy approaches, and resource recovery. The prominence of terms like *optimization* and *adsorption* further underscores an experimental and applied-science focus, bridging palm oil with environmental engineering innovations. The most recent themes (yellow nodes, close to 2018) reveal the rise of broader sustainability and interdisciplinary concerns. Keywords such as *sustainable development, empty fruit bunches, oil shale,* and *compressive strength* suggest that palm oil research increasingly intersects with global sustainability agendas and material science applications. The inclusion of *sustainable development* reflects the integration of palm oil debates into international discourses like the UN Sustainable Development Goals (SDGs). Meanwhile, material science terms show experimental extensions of palm oil derivatives into construction and composite materials.
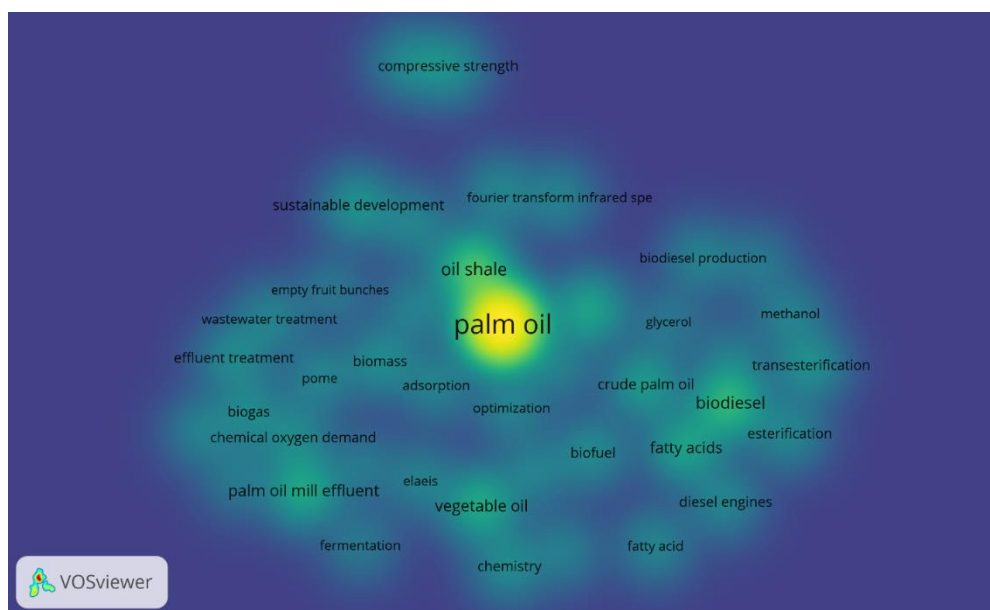

Figure 3. Density Visualization
Source: Data Analysis

This density visualization highlights the intensity and frequency of research themes in palm oil studies. The bright yellow core around "palm oil" shows that it is the dominant and most frequently occurring term, acting as the central anchor of the research field. Surrounding this core, the areas with greenish hues, such as biodiesel, crude palm oil, fatty acids, vegetable oil, and palm oil mill effluent represent high-density clusters where scholarship is particularly concentrated. These terms reflect the major directions of palm oil research: energy production, chemical processing, and environmental management. The heat distribution confirms that biodiesel production and effluent treatment are the most intensively studied topics alongside the general focus on palm oil itself. On the periphery, the lower-density zones with bluish tones such as *compressive strength, fermentation, sustainable development,* and *Fourier transform infrared spectroscopy,* indicate emerging or niche areas of study. Although less central, these topics demonstrate diversification of research toward sustainability, technological innovation, and non-traditional applications of palm oil derivatives. The spread of density from the bright core outward suggests that while energy and environmental aspects dominate the discourse, the field is expanding into interdisciplinary and experimental domains.
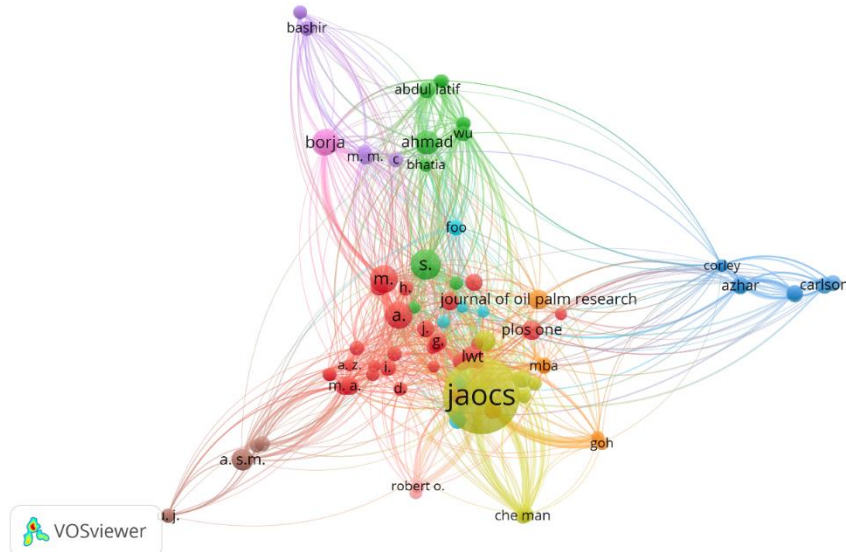
4.2 Co-Authorship Analysis

Figure 4. Author Visualization
Source: Data Analysis

Figure 4 illustrates the intellectual structure of palm oil research by showing clusters of frequently co-cited authors and journals. At the center, *JAOCS (Journal of the American Oil Chemists' Society)* appears as the largest and most influential node, indicating its pivotal role as a core outlet for palm oil–related publications. Surrounding it are other key journals like *Journal of Oil Palm Research, LWT, PLOS ONE,* and clusters of prominent authors such as Ahmad, Wu, Corley, Carlson, and Borja, each representing distinct research traditions. The different color clusters reveal thematic or disciplinary communities—for instance, the green cluster emphasizes applied and chemical studies, the red cluster represents engineering and process optimization research, while the blue cluster (e.g., Carlson, Corley) links to ecological and sustainability-oriented studies.
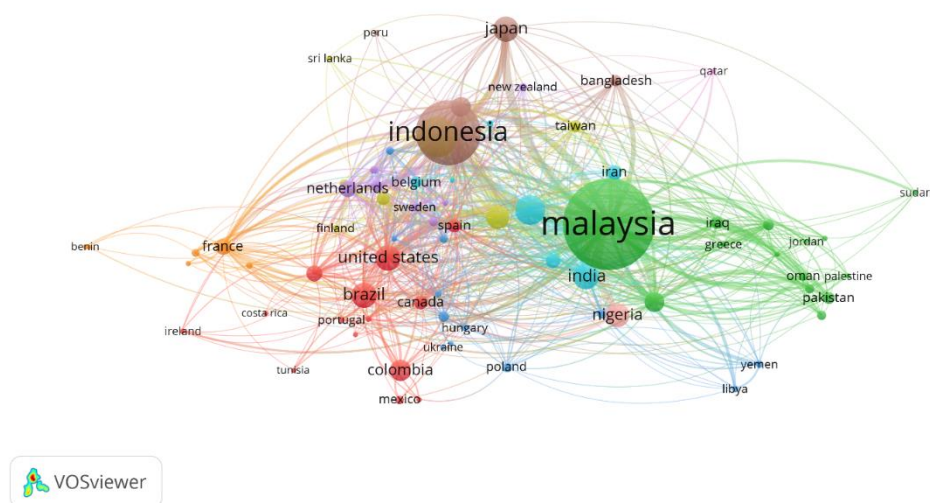

Figure 5. Country Visualization
Source: Data Analysis

Figure 5 shows the global research network on palm oil, with Malaysia and Indonesia emerging as the two dominant hubs, reflecting their roles as the world's largest palm oil producers and research contributors. Malaysia, represented by the largest node, demonstrates extensive collaborations with countries across Asia (India, Pakistan, Iran), Africa (Nigeria, Sudan), and Europe (Netherlands, United Kingdom, France). Indonesia also occupies a central position, with strong ties to Japan, the United States, and several European partners, reflecting its growing scientific engagement beyond production-related studies. Other notable contributors include India, Nigeria, Brazil, and the United States, which serve as secondary hubs connecting regional research networks. The dense interlinkages suggest that palm oil research is highly internationalized, with collaborations spanning agriculture, sustainability, energy, and policy domains.

4.3 Citation Analysis

Table 1. Top Cited Literature

Citations	Author	Title
468	[8]	Palm oil production through sustainable plantations
435	[9]	Renewable energy from palm oil - Innovation on effective utilization of waste
429	[10]	Performance and combustion characteristics of a DI diesel engine fueled with waste palm oil and canola oil methyl esters
429	[11]	Basic properties of palm oil biodiesel-diesel blends
427	[12]	Fourier transform infrared (FTIR) spectroscopy for analysis of extra virgin olive oil adulterated with palm oil
407	[13]	Biological and nutritional properties of palm oil and palmitic acid: Effects on health
394	[14]	Palm oil: Processing, characterization and utilization in the food industry - A review
389	[15]	Comparison of palm oil, Jatropha curcas and Calophyllum inophyllum for biodiesel: A review
370	[16]	Exploring land use changes and the role of palm oil production in Indonesia and Malaysia
362	[17]	A comparative study of KOH/Al2O3 and KOH/NaY catalysts for biodiesel production via transesterification from palm oil

Source: Data Analysis

Practical Implications

The findings of this bibliometric study provide several actionable insights for policymakers, industry stakeholders, and researchers engaged in palm oil–related activities. First, by identifying Malaysia and Indonesia as the central hubs of global palm oil research, the study highlights the strategic importance of strengthening regional research capacity, technology transfer, and international collaborations to ensure sustainable practices in the industry. Policymakers can use this evidence to design targeted interventions that align research agendas with sustainability frameworks, such as the UN Sustainable Development Goals (SDGs). Second, the clustering of keywords around biodiesel, effluent treatment, and sustainability underscores areas where technological innovation can be directly applied to improve environmental management and reduce carbon footprints. This is particularly relevant for industry practitioners seeking to enhance certification standards, reduce waste, and diversify palm oil–based products. Finally, for global supply chains, the collaborative patterns observed in the study demonstrate the value of cross-country partnerships, offering opportunities for joint ventures in renewable energy, green chemistry, and eco-friendly agriculture.

Theoretical Contributions

This study makes a significant contribution to the theoretical understanding of palm oil research by mapping its intellectual structure, thematic evolution, and global collaboration patterns over two decades. It extends the literature on agribusiness and sustainability studies by

demonstrating how palm oil research has transitioned from a narrow focus on production efficiency and biodiesel applications toward broader discourses on environmental sustainability, waste valorization, and sustainable development. By applying bibliometric techniques, the study provides empirical evidence of how research fields evolve, showing that palm oil is not just an agricultural commodity but a site of interdisciplinary knowledge creation across energy studies, environmental science, and global trade. The co-citation and country collaboration networks also enrich the theoretical discourse on knowledge diffusion, illustrating how producing and consuming nations co-shape academic debates. In doing so, the study reinforces the relevance of bibliometric analysis as a methodological contribution, offering a replicable model for analyzing other commodity-based research domains.

Limitations

Despite its comprehensive scope, this study has certain limitations that should be acknowledged. First, the reliance on a single bibliographic database (Scopus) may exclude relevant publications indexed elsewhere, such as Web of Science or regional databases, potentially leading to dataset bias. Second, the analysis was limited to English-language publications, which might underrepresent research output from producing countries where significant findings are published in local languages. Third, bibliometric indicators such as citation counts and co-occurrence networks capture structural patterns of knowledge but do not fully reflect the qualitative depth, policy relevance, or societal impact of individual studies. Finally, while this study maps trends up to 2025, the fast-paced developments in palm oil governance, climate change policies, and biofuel technologies mean that emerging themes may shift quickly, requiring ongoing updates and longitudinal follow-ups. Addressing these limitations in future research would provide a more holistic and inclusive picture of the palm oil research landscape.

CONCLUSION

This study provides a comprehensive overview of the evolution of palm oil research over the past two decades, revealing its dynamic, interdisciplinary, and increasingly global character. Through bibliometric analysis, the findings highlight how scholarship has transitioned from early emphases on biodiesel production and chemical processing toward broader concerns with environmental sustainability, waste management, and global development agendas. Malaysia and Indonesia emerge as central hubs in both publication output and international collaboration, reflecting their dual role as leading producers and research contributors. Influential journals such as JAOCS and Journal of Oil Palm Research serve as key intellectual anchors, while diverse thematic clusters underscore the integration of palm oil studies across agriculture, energy, environmental science, and sustainability discourses. The study not only maps the intellectual and collaborative structure of the field but also underscores the need for continued interdisciplinary approaches, stronger North–South partnerships, and policy-relevant research. In doing so, it advances both academic understanding and practical pathways for ensuring that palm oil research contributes meaningfully to sustainable and equitable global development.

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