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Research Article

Cacao and Cocoa as Functional Foods: Insights into the Research Landscape, Current Gaps and Future Opportunities

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ABSTRACT

Cacao and Cocoa have attracted growing scientific and commercial interest as candidate functional foods because of bioactive compounds. At a time when demand for functionally substantiated food products is increasing, a clear understanding of how research on cacao/cocoa is distributed across agricultural, food science, and health-related domains has become increasingly necessary. Using a scientometrics approach applied to Scopus (search date: September 17, 2025) and standardized AGROVOC descriptors, we analyzed publication trends, co-authorship patterns by country, region, and income group, and thematic clusters derived from titles and keywords. Results showed sustained growth in publications since 2000, with research activity concentrated in post-harvest processing, fermentation, plant pathology, and agroforestry systems. Functional and health-related studies, including clinical outcomes, bioavailability, and regulatory substantiation, represented a smaller yet emerging segment. Safety issues such as cadmium and mycotoxins appeared consistently, while geographic asymmetries were notable: high-income and upper-middle-income countries, led by the United States and Brazil, concentrated most of the scientific output, whereas low- and lower-middle-income economies contributed marginally despite representing a substantial share of global cacao production, particularly in West Africa and parts of Latin America. These findings indicate that cacao/cocoa research is expanding but thematically fragmented and unevenly distributed across geographies, limiting progress toward evidence-based functional food applications. Building on these gaps, we propose an evidence-based roadmap comprising seven strategic steps, from mapping and diagnosing knowledge gaps to interdisciplinary integration, clinical validation, producer engagement, and policy translation. This framework highlights priority opportunities for coordinated global research efforts in cacao/cocoa research.

Keywords: Bibliometrics, Cacao, Cocoa, Knowledge Discovery, Research.

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CURRENT KNOWLEDGE GAPS IN CACAO/ COCOA RESEARCH

Cacao (*Theobroma cacao* L.) is a globally traded commodity with significant economic, cultural, and nutritional relevance (Food and Agriculture Organization of the United Nations, 2026). Global production exceeds 5 million metric tons annually, with the majority concentrated in West Africa, particularly Côte d'Ivoire and Ghana, followed by countries in Latin America such as Ecuador and Brazil (Food and Agriculture Organization of the United Nations, 2026). In contrast, the largest consumer markets and industrial processors are located in Europe and North America, where cocoa is transformed into a wide range of food products (Food and Agriculture Organization of the United Nations, 2026). This geographical dissociation between production and consumption has implications not only for global trade but also for how research priorities and innovation pathways are defined (Food and Agriculture Organization of the United Nations, 2026).

In recent years, they have increasingly been framed within the broader category of functional foods, alongside other botanicals and dietary ingredients with the ability to influence physiological processes relevant to health promotion and disease prevention (Tan *et al.*, 2021). Flavanols, polyphenols, and methylxanthines such as theobromine have attracted sustained attention (Mengjuan *et al.*, 2024), with evidence ranging from *in vitro* analyses to early

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clinical investigations linking cocoa intake to improvements in vascular function, blood pressure, and cognitive performance (Mengjuan *et al*., 2024).

Despite this progress, the research field remains fragmented. The majority of publications has focused on agronomic aspects (Balcázar-Zumaeta *et al*., 2023), post-harvest processing (Velásquez-Reyes *et al*., 2025), and the management of plant diseases that threaten global production (Díaz-Valderrama *et al*., 2020). While these areas are critical for crop sustainability, they do not directly address the translation of cocoa bioactives into validated functional food applications (Food and Agriculture Organization of the United Nations, 2026). Conversely, studies addressing health outcomes, bioavailability, and mechanisms of action in humans are comparatively limited and often disconnected from advances in food science and processing (Martin and Ramos, 2021).

This disconnects between agricultural sciences, food technology, and nutrition/health research constrains the ability of cocoa to move from commodity status to evidence-based functional food (Food and Agriculture Organization of the United Nations, 2026). These disparities likely reflect broader structural differences in research capacity, funding allocation, and scientific priorities between producing and consuming regions (Food and Agriculture Organization of the United Nations, 2026). While cacao-producing countries often prioritize agronomic challenges related to yield, disease control, and post-harvest quality, high-income consumer regions tend to drive research agendas focused on nutrition, health outcomes, and functional food development (Antolinez Sandoval *et al*., 2020).

At the global level, it has long been assumed that research efforts may not align with production realities: regions where cocoa cultivation underpins livelihoods, such as West Africa or parts of Latin America, appear to be less represented in functional food-oriented research (Food and Agriculture Organization of the United Nations, 2026), while countries with stronger scientific infrastructures but less direct production involvement may dominate the literature. If such disparities exist, they carry important consequences (Odoms-Young *et al*., 2021). They would limit the inclusiveness of global research agendas and raise questions about the applicability and equity of evidence across different consumption and production contexts (Odoms-Young *et al*., 2021). Moreover, these potential thematic and geographical asymmetries could hinder the development and substantiation of functional food claims.

Policy frameworks, consumer trust, and innovation pipelines all require a coherent and multidisciplinary evidence base, one that integrates plant biology, food chemistry, clinical research, and regulatory science (Blanchard *et al*., 2024). Without such integration, promising functional ingredients like cocoa risk being underutilized, with opportunities for health promotion, value generation, and producer-country benefit potentially lost due to the absence of comprehensive knowledge mapping (Lozada-Martinez *et al*., 2025a).

In this perspective, we aim to address this gap by mapping the research landscape of cacao and cocoa through a scientometrics approach. By identifying where knowledge has accumulated and where it is lacking, we provide a structured overview of the field, highlighting both strengths and vulnerabilities (Lozada-Martinez *et al*., 2025a; Lozada-Martinez *et al*., 2025b; Lozada-Martinez *et al*., 2025c; Ninkov *et al*., 2020; Vaishya and Gupta, 2025). Our goal is to outline priority areas for future research that can bridge existing divides, between production and consumption geographies, between agricultural and health sciences, and between discovery and regulatory substantiation. In doing so, we contribute to positioning cacao and cocoa more firmly within the functional food paradigm, grounded in evidence that is both scientifically robust and globally inclusive (Ninkov *et al*., 2020; Vaishya and Gupta, 2025).

METHODOLOGY

A structured scientometrics approach was employed to map the global research landscape on cacao and cocoa. To ensure terminological accuracy and reproducibility, keywords were selected from the AGROVOC Multilingual Thesaurus (Food and Agriculture Organization, 2025), the official controlled vocabulary for agriculture and food sciences. This strategy enabled the use of standardized descriptors and the systematic identification of synonyms. The final search string was: "TITLE(cacao) OR TITLE("Theobroma cacao") OR TITLE("chocolate tree") OR TITLE(cocoa) OR TITLE("cocoa tree")".

To optimize the balance between sensitivity and specificity, preliminary pilot searches were conducted using broader query strategies (e.g., TITLE-ABS). These approaches substantially increased the number of retrieved records but introduced a high proportion of irrelevant documents, particularly studies in which cacao or cocoa were mentioned peripherally rather than as a central research focus.

Given the objectives of this study, which aimed to characterize the core research landscape of cacao/cocoa, a TITLE-based search strategy was ultimately selected to prioritize specificity and conceptual relevance. This approach ensured that the included publications had a primary focus on cacao/cocoa, thereby improving the interpretability and validity of subsequent thematic and scientometrics analyses.

The search was conducted in Scopus on September 17, 2025. Scopus was chosen as it hosts the most comprehensive collection of peer-reviewed scientific literature across disciplines, making it suitable for cross-cutting analyses of food, agricultural, and health research. This strategy is consistent with exploratory

scientometrics approaches aimed at identifying emergent themes and knowledge gaps across a broad research domain.

To improve the specificity of the dataset, non-peer-reviewed and non-article formats were excluded. Specifically, conference papers, conference reviews, book chapters, books, book series, trade journals, errata, data papers, articles in press, and conference proceedings were removed. Only peer-reviewed articles published in regular journal issues were included. This filtering step ensured consistency and comparability in the analysis corpus.

Bibliographic metadata (titles, abstracts, author keywords, source information, country affiliations, and citation details) were downloaded and standardized. Data cleaning included the removal of duplicates, unifying country names, and harmonizing terminologies for co-authorship and keyword analyses. World Bank regional and income classifications (The World Bank, 2025) were used with country-level data to allow stratified analysis by geography and economic grouping.

The analysis was performed in two stages. First, descriptive scientometrics indicators were computed, including annual publication frequency, co-authorship distribution by country, region, and income group, and thematic clustering of keywords and titles. Second, inferential visualization techniques were applied to identify research gaps and opportunities. Keyword normalization and clustering were performed to reduce redundancy and enhance interpretability of thematic maps.

Data analysis and visualization were performed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA), R (R Foundation for Statistical Computing, Vienna, Austria), and Python (Python Software Foundation, Wilmington, DE, USA). Analyses were conducted using the latest stable versions of each software available at the time of the study. In R, the bibliometrix package was used for bibliometric analysis and science mapping. In Python, data visualization and network analysis were performed using the matplotlib, seaborn, and network libraries. All packages corresponded to stable releases available at the time of analysis, ensuring compatibility and reproducibility of the workflows.

To enhance the robustness of thematic clustering, keyword normalization and co-occurrence mapping were performed using established bibliometric approaches. Clusters were derived based on co-occurrence frequency and network structure, and their internal consistency was assessed through manual inspection of high-frequency terms within each cluster. This approach ensured that clusters reflected coherent thematic domains rather than arbitrary groupings.

Given the absence of prior comprehensive mappings of cacao/cocoa research within the functional food framework, this study was designed as an exploratory, hypothesis-generating analysis. As such, the emphasis was placed on identifying patterns, asymmetries, and emerging thematic structures rather than testing predefined hypotheses.

RESULTS

Temporal trends in scientific production

The initial search identified 11,361 documents related to cacao and cocoa. After excluding conference papers, book chapters, errata, and other non-relevant categories, the number was reduced to 9912 documents. A further refinement that excluded articles in press, trade journals, and book series yielded a final dataset of 9745 documents for analysis.

Considering 2000-2024, publications rose from 66 in 2000 to 729 in 2024 Figure 1A, which corresponded to an approximate compound annual growth rate of approximately 10.5%. The peak year was 2024 (729 records), followed by a slight drop in 2025 that likely reflected incomplete indexing. By decades since 1980, the field accumulated 4.1% of records in the 1980s, 6.2% in the 1990s, 14% in the 2000s, 33.4% in the 2010s, and 42.3% in the 2020s Figure 1A, underscoring that most work had been published in the last fifteen years, with the 2020s already exceeding the 2010s despite being a partial decade Figure 1A.

Geographical distribution and co-authorship patterns

A total of 13,350 co-authorships across 147 countries were identified in Figure 1B. Research activity was strongly concentrated: the top five countries account for 34.2% of all co-authorships, the top ten for 54%, and the top twenty for 75.6%. The United States (n=1366) and Brazil (n=1115) lead the global landscape, followed by Ghana (n=767), France (n=666), and the United Kingdom (n=654), Figure 1B. Additional contributions were observed in countries such as Indonesia and India Figure 1B. Numerous countries register only a single publication, indicating minimal participation in international cacao/cocoa research networks Detailed country-level participation frequencies are provided in Supplementary Material 1, enabling a more granular assessment of the disparities underlying the global distribution of research activity.

Notably, this distribution does not fully align with global cacao production patterns. Major producing regions, particularly in West Africa (e.g., Côte d'Ivoire and Ghana), contribute a relatively limited share of the scientific literature compared to high-income consumer countries, where research output is disproportionately concentrated (Food and Agriculture Organization of the United Nations, 2026). This suggests a structural misalignment between production capacity and knowledge generation in the cacao/cocoa domain.

This discrepancy between production and scientific output reflects broader global inequalities in research systems. While cacao-producing countries play a central role in the global supply

chain, their participation in knowledge generation remains limited, which may constrain locally relevant innovation and reduce their capacity to benefit from higher-value segments of the cocoa economy, such as functional food development (Food and Agriculture Organization of the United Nations, 2026).

Distribution by world regions and income groups

By World Bank region, Europe and Central Asia contribute the largest share with 30.8% of global co-authorships (*n*=4117), followed by Latin America and the Caribbean with 23.8% (*n*=3177), and East Asia and Pacific with 15.7% (*n*=2093) Figure 1C. Other regions (North America, South Asia and Middle East, and North Africa) have collectively contributed less than 15% of the total global scientific output Figure 1C. The leading countries within each region are United States in North America, Brazil in Latin America and the Caribbean, Ghana in Sub-Saharan Africa, France in Europe and Central Asia, Indonesia in East Asia and Pacific, India in South Asia, and Iran in the Middle East and North Africa.

High-income economies account for 49.4% of all co-authorships (*n*=6598), upper-middle-income countries for 31.6% (*n*=4219), and lower-middle-income countries for 17.6% (*n*=2353), Figure 1D. Low-income economies contribute 0.38% (*n*=51), Figure 1D. Overall, the distribution indicates that cacao/cocoa research output is disproportionately generated in a relatively small set of countries, led by the United States and Brazil, and is concentrated in regions and income strata with more robust scientific infrastructures.

In Latin America, contributions extend beyond Brazil to countries such as Ecuador, Peru, and Colombia, although with comparatively lower participation frequencies, reflecting a broader but uneven regional involvement Figure 1B; Supplementary Material 1.

Thematic structure of cacao/cocoa research

Topic mining (titles and keywords, after filtering out generic terms and core cacao/cocoa words) indicated several clusters, Figure 2A. Post-harvest and processing biology was prominent. Fermentation appeared most frequently in titles, and phrases such as "during fermentation" recurred. Plant pathology also dominated, led by *Phytophthora palmivora* and *Moniliophthora species* (notably *M. perniciosa* and *M. roreri*), together with hallmark syndromes such as witches' broom and black pod. In parallel, agroforestry systems, farm-level perspectives (e.g., references to farmers and soils), and regional signals (e.g., Ghana,

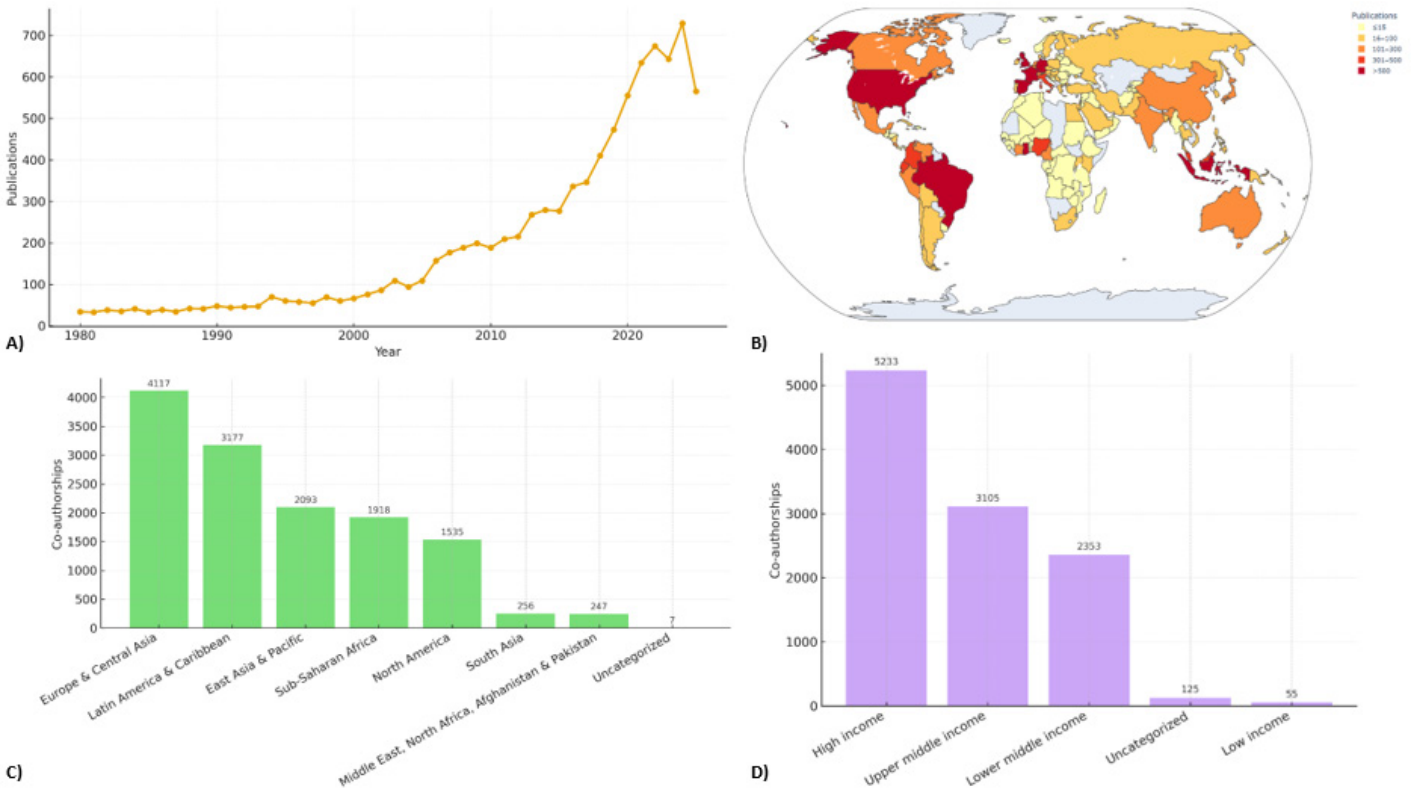

Figure 1: Research output and co-authorship patterns in cacao/cocoa research. A) Annual frequency of publications, showing the temporal growth of the field. B) Geographic distribution of publications by country, visualized as a heatmap. C) Distribution of co-authorships by world regions, highlighting regional asymmetries. D) Distribution of co-authorships by World Bank income groups, showing disparities in research participation.

West Africa, Bahia-Brazil) featured prominently, which aligned with production geographies and disease pressure.

Health- and functionality-related terms were also well represented. Titles referenced antioxidant outcomes and specific bioactives, polyphenols and flavanols (including epicatechin), and there was a measurable footprint of clinical trial language (e.g., randomized/trial), alongside cardiometabolic outcomes such as blood pressure and cardiovascular outcomes. On the safety/regulatory side, cadmium and ochratoxin recurred, reflecting sustained attention to heavy metals and mycotoxins along the value chain Figure 2B. Collectively, the profile suggested that recent growth had been carried by three broad threads: a) Processing and microbial/biochemical transformations (especially fermentation); b) Plant disease ecology and control; and c) Functional/health claims and safety, with an evident concentration of case studies in major producing regions Figure 2B.

These thematic domains collectively illustrate the multidisciplinary nature of cacao/cocoa research and its relevance to functional

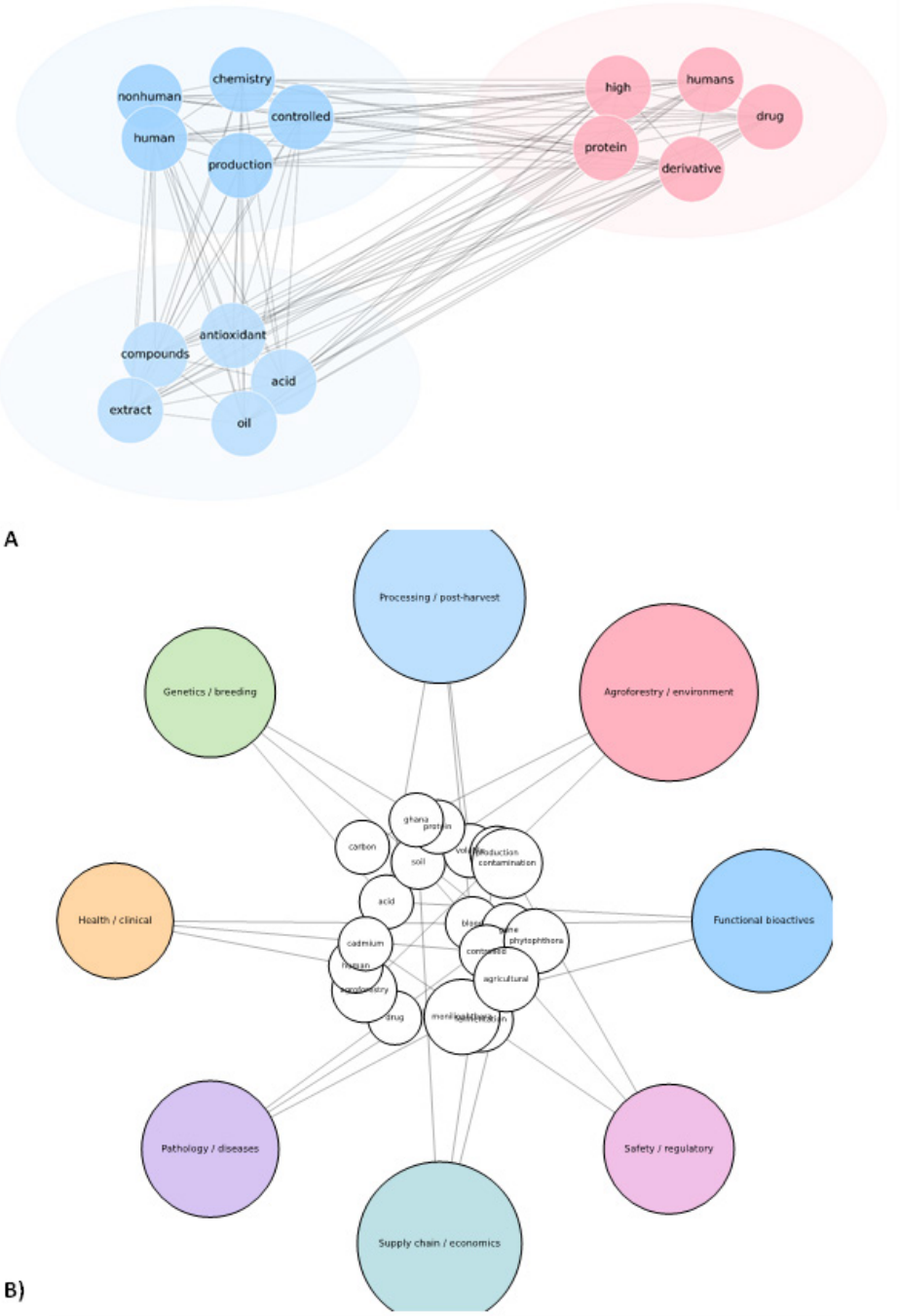

Figure 2: Thematic focus of cacao/cocoa research. A) Clustered network of research topics derived from titles and keywords, with the top five terms displayed in each cluster. B) Thematic areas of cacao/cocoa research (e.g., functional bioactives, health/clinical, processing/post-harvest, pathology/diseases, genetics/breeding, agroforestry/environment, supply chain/economics, safety/regulatory) visualized as clusters, with node sizes proportional to publication frequency and internal bubbles representing the most frequent terms in each area.

food development Figure 2B. While clusters such as processing, pathology, and agroforestry reflect foundational aspects of production and quality, they directly influence the biochemical composition and safety of cocoa-derived products. In turn, these factors are critical for the development and validation of functional food applications, linking upstream agricultural processes with downstream health-related outcomes.

To facilitate interpretation of these thematic clusters, representative examples can be briefly highlighted. In the domain of post-harvest processing, fermentation-related studies commonly focus on microbial dynamics and their impact on flavor development and biochemical composition of cocoa beans (Senthil and Janve, 2025; Velásquez-Reyes *et al*., 2025). In plant pathology, research frequently addresses diseases such as witches' broom and black pod, which significantly affect yield and crop sustainability. Within the functional and health-related cluster, studies typically explore the role of cocoa flavanols in cardiometabolic outcomes, including blood pressure regulation and endothelial function (Tan *et al*., 2021).

New insights about global research+ on cocoa/cacao

Our mapping of the cacao and cocoa literature illustrates a field that has expanded substantially yet remains uneven in both thematic orientation and geographical distribution. The marked growth of publications in recent decades reflects a growing recognition of cocoa as a source of nutritional and functional interest. Investigations have concentrated on fermentation, post-harvest processes, plant pathology, and agroforestry systems, areas that are central to maintaining crop productivity and addressing technological challenges (Senthil and Janve, 2025).

Alongside these domains, research on bioactive compounds has gained visibility, particularly regarding polyphenols, flavanols, and associated cardiometabolic outcomes, while safety concerns such as cadmium and mycotoxin contamination have also attracted attention. Collectively, these emphases confirm cocoa's potential trajectory as a functional food resource (González-Garrido *et al*., 2023).

Yet, the evidence base remains incomplete. The biochemical and compositional richness of cocoa bioactives is well documented, but the progression toward rigorous human studies and validated health claims is limited (Ried *et al*., 2017). Few clinical or translational investigations bridge the gap between laboratory findings and population-level outcomes. This gap underscores the need for integrated approaches that link food science and nutrition research with regulatory and public health agendas (Blanchard *et al*., 2024). Without such integration, the promise of cocoa as a functional ingredient risks being only partially realized.

The geographical profile of research output further highlights disparities. High- and upper-middle-income countries, led by the United States and Brazil, dominate the literature, whereas contributions from low-income economies remain marginal. This imbalance is particularly striking given that major producing regions, such as West Africa, contribute relatively little to the functional food dimension of cocoa research. The implications are significant: evidence generation is not fully aligned with the realities and needs of producer countries, potentially limiting their ability to capitalize on cocoa's value beyond commodity markets (Essa *et al*., 2023).

High-income countries tend to concentrate research infrastructure, funding availability, and publication capacity, which may explain their disproportionate representation in the literature. In contrast, many cacao-producing regions, particularly in low-and lower-middle-income countries, face systemic constraints that limit research output, including reduced access to funding, infrastructure, and international collaboration networks.

This asymmetry is particularly consequential in the context of functional foods, where the translation of agricultural products into health-related applications requires multidisciplinary integration. The underrepresentation of producer countries may therefore not only reflect disparities in research capacity but also contribute to a misalignment between knowledge generation and real-world production contexts. Such asymmetries may translate into missed opportunities for public health innovation, economic diversification, and more equitable participation in the global functional food sector (Essa *et al*., 2023).

Figure 3 synthesizes the key gaps identified in the scientometrics analysis and translates them into a structured conceptual framework. By linking empirical patterns with strategic research priorities, this analysis serves as an intermediate step between the descriptive results and the proposed roadmap, facilitating a clearer understanding of how identified gaps can inform future directions.

Research opportunities and future perspectives

Closing these gaps will require deliberate shifts in research agendas, toward interdisciplinary designs, equitable collaborations between producing and consuming nations, and a stronger emphasis on clinical validation (Lozada-Martinez *et al*., 2025a; Lozada-Martinez *et al*., 2025b; Lozada-Martinez *et al*., 2025c). Only then can cacao/cocoa research evolve from dispersed efforts into a coherent body of evidence capable of substantiating health claims and supporting its integration into strategies for disease prevention and health promotion.

Building on the scientometrics findings, future progress in cacao/cocoa research will depend on articulating a coherent and staged research agenda capable of addressing both thematic and geographical gaps. As illustrated in Figure 4, the proposed stepwise framework not only summarizes the conceptual

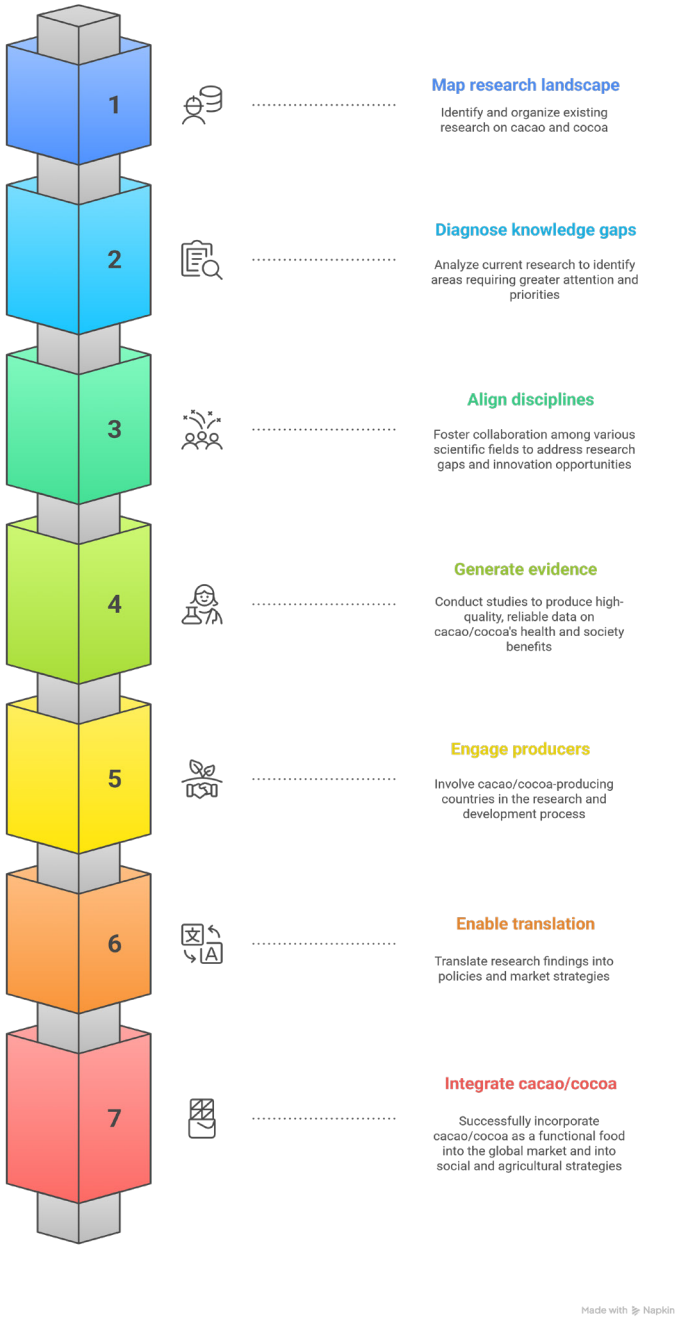

Figure 3: Evidence-based roadmap for advancing cacao/cocoa as a functional food, derived from scientometrics gaps and global research asymmetries. This Figure synthesizes the critical components of a proposed strategic roadmap grounded in the scientometrics analysis. The central node represents the overarching goal: advancing cacao/cocoa as a scientifically validated functional food. Four interconnected domains structure this roadmap: 1) Evidence landscape diagnostics summarize the main weaknesses identified in the global research corpus, including thematic imbalance, geographical asymmetry, fragmented research areas, and persistent safety constraints; 2) Priority research gaps translate these diagnostics into actionable deficits requiring immediate attention, such as the limited clinical evidence base, the functional-food translation gap, the disconnect between processing variables and bioactivity, underrepresentation of producer countries, and insufficient regulatory substantiation; 3) Strategic axes outline the high-level directions needed to address these gaps, emphasizing interdisciplinary integration, equitable global participation, clinical and translational acceleration, safety and regulatory alignment, and producer-economy innovation; and 4) Target outcomes reflect the indicators and desired long-term impacts expected from implementing this roadmap, including a robust evidence base, validated health claims, global research equity, and a sustainable cacao/cocoa economy. Together, these components illustrate how the identified scientometrics gaps can be transformed into a coordinated, evidence-driven agenda for future research and policy development in the field of cacao/cocoa functional foods.

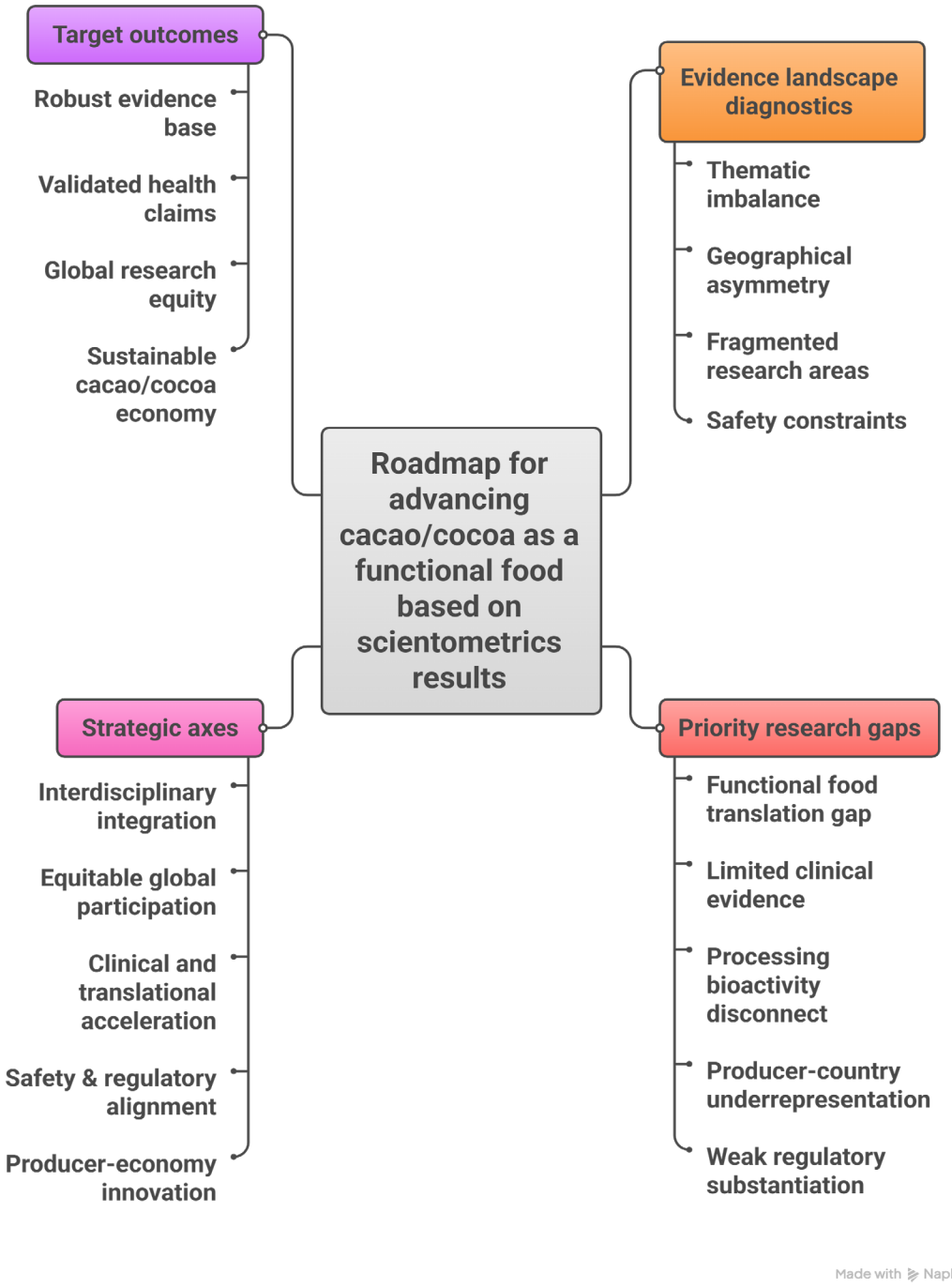

Figure 4: Stepwise research and implementation agenda for advancing cacao/cocoa as a functional food. This Figure presents a sequential roadmap outlining the research-to-implementation continuum required to transform cacao/cocoa from a predominantly agronomic commodity into a globally relevant, evidence-based functional food. The agenda begins with mapping the research landscape (Step 1) to systematically organize existing scientific output. It then progresses to diagnosing knowledge gaps (Step 2) by identifying quantitative deficits and thematic asymmetries revealed through scientometrics analysis. Aligning disciplines (Step 3) emphasizes the need for coordinated collaboration among agricultural sciences, food technology, nutrition, clinical research, and regulatory science. Generating evidence (Step 4) calls for high-quality studies (including biochemical, translational, and clinical investigations) to validate functional claims. Engaging producers (Step 5) highlights the importance of integrating cacao/cocoa-producing countries into research and innovation pipelines. Enabling translation (Step 6) focuses on converting scientific findings into policies, regulatory frameworks, and market-oriented strategies. Ultimately, integrating cacao/cocoa (Step 7) into global functional food systems represents the final goal: a cohesive model that aligns scientific evidence, public health needs, economic opportunity, and sustainable development.

progression from evidence mapping to implementation but also highlights specific intervention points where research, policy, and industry stakeholders can actively contribute to advancing cacao/cocoa as a functional food. The stepwise framework presented was derived through an integrative synthesis of the scientometrics findings and the thematic gaps identified in the analysis. Specifically, the seven steps reflect the sequential translation of key deficiencies observed in the research landscape, including thematic fragmentation, limited clinical validation, and geographical asymmetries.

This integration is essential for generating high-quality, reproducible evidence capable of supporting functional claims and informing regulatory processes. Equally important is the intentional participation of producer countries, which remain underrepresented despite their central role in global supply. Engaging these regions in research and innovation not only promotes equity but also enhances the relevance and applicability of findings (Pérez-Fontalvo *et al.*, 2021).

The final stages of the agenda emphasize knowledge translation and implementation science, mechanisms through which validated evidence can shape public policy, guide industry innovation, and generate sustainable economic and health benefits (Lozada-Martinez *et al.*, 2022). Collectively, this stepwise approach provides a strategic framework to transform cacao/cocoa into a scientifically substantiated functional food, supporting global health priorities while strengthening producer economies.

To enhance the practical applicability of this roadmap, each step can be associated with concrete research actions and measurable outputs. For instance, the initial mapping and gap diagnosis stages can be operationalized through periodic scientometrics audits and standardized evidence mapping protocols. The alignment of disciplines may be facilitated through the creation of interdisciplinary research consortia integrating agronomy, food science, and clinical research.

Similarly, the evidence generation phase should prioritize well-designed translational and clinical studies, including randomized controlled trials and bioavailability assessments, aligned with regulatory requirements. Engagement of producer countries can be operationalized through targeted funding schemes, capacity-building programs, and inclusion in international collaborative networks.

Finally, knowledge translation may be supported by the development of policy briefs, regulatory frameworks, and industry guidelines aimed at integrating cocoa-based functional products into public health and market systems. Importantly, the successful implementation of this roadmap depends on the coordinated involvement of multiple stakeholders, including academic institutions, industry actors, regulatory agencies, and producer communities. Each of these actors plays a distinct role in bridging the gap between scientific discovery and real-world application, reinforcing the need for a multi-sectoral approach to functional food development.

CONCLUSION

In conclusion, while research activity on cacao/cocoa has expanded considerably, the evidence remains fragmented, with limited translation of biochemical discoveries into clinical validation and regulatory substantiation. The concentration of output in high-income countries, alongside the relative underrepresentation of major producer regions, underscores a misalignment between knowledge generation and global production realities. Bridging these thematic and geographical divides is essential if cocoa is to realize its potential as a scientifically grounded functional ingredient. Future progress will depend on fostering interdisciplinary collaborations, prioritizing translational and clinical research, and engaging producer countries more fully in agenda setting. Such efforts are critical to transforming cocoa from an economic commodity into an evidence-based contributor to human health.

ABBREVIATIONS

AI: Artificial Intelligence; **AGROVOC:** Agricultural Vocabulary (FAO Multilingual Thesaurus); **USA:** United States of America; **R:** R Statistical Software; **Scopus:** Elsevier's Abstract and Citation Database; **FAO:** Food and Agriculture Organization; **WA:** Washington; **DE:** Delaware; **n:** Number/Frequency; **L.:** Linnaeus (in *Theobroma cacao* L.).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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