

Herbal Approaches to Dairy Cattle Health Control: A Decade of Scopus Bibliometric Insights (2015-2025)

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Abstract. The study conducts a bibliometric analysis of research on herbal approaches to dairy cattle health control published in Scopus-indexed journals from 2015 to 2025. Data were retrieved from the Scopus database and analysed using RStudio with the Bibliometrix package and OpenRefine for data cleaning and harmonisation. The dataset included 661 documents from 243 sources after deduplication and screening processes. The analysis revealed an annual growth rate of 9.53% in publications, indicating increasing academic interest in herbal alternatives for dairy cattle health management. The dominant research themes focused on essential oils, plant extracts, and bioactive compounds, with mastitis treatment emerging as a major health application. Leading authors included Casper DP and Da Silva AS, who had the highest publication counts, while Zhang H, Walkenhorst M, and Sharma AK showed greater citation impact, indicating their influential contributions to the field. Brazil, China, and Italy led in publication output, though collaboration patterns revealed fragmented research networks with limited international integration. The most cited papers demonstrated efficacy in improving milk yield, feed efficiency, and disease control. Research gaps were identified in reproductive health applications, standardised protocols, novel delivery systems, nanotechnology, encapsulation approaches, and long-term impact assessments. The findings support the potential of herbal approaches to address antimicrobial resistance and consumer demand for natural dairy products. Future research should prioritise developing standardised herbal formulations, exploring innovative delivery mechanisms such as nanoparticle systems, and conducting comprehensive long-term studies to establish evidence-based protocols for sustainable dairy cattle health management.

Keywords: bibliometric, dairy cattle, herbs, veterinary

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1 Introduction

The global dairy industry faces increasing challenges in meeting growing milk demand while ensuring product quality and safety. Dairy cattle are highly susceptible to various health conditions, including mastitis, metabolic disorders, reproductive problems, and parasitic infections, directly impacting milk production and quality.

Prevention and treatment of the diseases typically rely on synthetic drugs, but their overuse can lead to microbial resistance, chemical residue in milk, and environmental pollution. It can harm animal health, human health, and ecological sustainability. As the world moves toward natural and sustainable food products, phytotherapy represents a promising alternative that is more environmentally friendly and safer for consumers [1]. Research and validation of herbal therapy for dairy cattle health management has become essential to address both production needs and the growing demand for sustainable agricultural practices.

The therapeutic potential of herbs in dairy cattle health management extends beyond simple disease treatment. Most herbs have multifaceted benefits, such as antimicrobial and immunomodulatory properties relevant to milk production systems, as well as acting as growth promoters, digestive stimulants, and stress reducers, which contribute to improved health, productivity, and milk quality in livestock [2]. Recent studies have delved into various herbal treatments' specific applications and efficacy in livestock health management. The combination of plantain (*Plantago lanceolata* L.) and lemongrass (*Cymbopogon citratus*) enhanced immunity and prevented metabolic diseases in dairy cattle [3]. Surjowardojo et al. [4] examined the antibacterial activity of *Piper betle* Linn. against dairy mastitis pathogens like *Escherichia coli* and *Streptococcus agalactiae*.

Research on herbal applications in dairy cattle health remains fragmented, with studies often focusing on specific herbs or isolated conditions. A comprehensive mapping of this research landscape is needed to identify patterns and future directions. This study conducts a bibliometric analysis of herbal approaches to dairy cattle health control published in Scopus-indexed journals, aiming to provide a comprehensive overview of the field's evolution, key contributions, and research gaps to guide future studies.

2 Materials and methods

2.1 Literature search strategy

The review focused on the application of herbs for dairy health and disease control. Metadata was collected from the Scopus databases in August 2025. Data covered the past ten years (2015-2025). The advanced search utilised the following terms: ("dairy" OR "dairy cattle" OR "dairy cattle") AND ("herbs" OR "herbs extract" OR "plant extract" OR "plant oil" OR "essential oils" OR "phytotherapy" OR "bioactive compounds") AND ("health" OR "disease"). The search was conducted using title, abstract, and author keywords. The inclusion criteria for selecting the literature were:

1. Documents were published only within the time frame of 2015 to the middle of 2025;
2. Document type limited to research articles (excluding books, conference proceedings, chapters, and review articles);
3. Subject areas related to agricultural science, biological sciences, and veterinary;
4. The topic focuses solely on the application of herbs in dairy health and disease control.

Raw data was extracted in "BibTeX" formats using the "database web" extraction tool, including information fields such as citation information (authors, title, year, EID, source title, volume, issues, pages, citation count, source, document type, publication stage, DOI, and access), bibliographical information (affiliations, serial identifier, publisher, editor,

language, correspondence address, and abbreviated source title), also abstract and keywords (abstract, author keywords, and indexed keywords).

2.2 Cleaning and harmonising data

Data screening and harmonization were conducted to merge synonymous terms with similar meanings but different representations, such as "flavonoid" and "flavonoids," "cow" and "cattle," or "Universitas Brawijaya" and "Brawijaya University." The process also involved eliminating non-informative keywords that do not contribute to meaningful pattern discovery, including generic terms such as "article," "analysis," "review," and "controlled study." The screening procedure was performed using OpenRefine 3.8.4, an open-source data cleaning tool. The metadata was imported into OpenRefine, and specific columns containing keywords, affiliations, and country information were selected for editing. The "cluster and edit" function was systematically applied to identify and merge synonymous terms based on similarity algorithms, followed by manual verification to ensure accuracy. The cleaned and harmonised dataset was subsequently exported and saved as an .xlsx file for further bibliometric analysis in RStudio.

2.3 Data analysis

Bibliometric analysis was conducted using RStudio 4.4.0 software with the bibliometrix package. The analysis began by calling the biblioshiny() function to launch the interactive web application. The .xlsx file from the data cleaning and harmonising stage was loaded and imported into the application. The bibliometric analysis was performed systematically using several analytical modules available in biblioshiny, including: (1) overview analysis for general dataset statistics, (2) source analysis for journal-level metrics, (3) author analysis for productivity and collaboration patterns, (4) document analysis for citation metrics and content evaluation, (5) clustering analysis for research groupings, and (6) conceptual structure analysis for thematic mapping. Data validation was performed after import to ensure data integrity and completeness. For each analytical module, the processed results were downloaded and documented. The comprehensive report function compiled all analytical results into a single Excel worksheet for systematic documentation. Finally, the bibliometric analysis results were interpreted, synthesised, and integrated into the scientific manuscript following established bibliometric reporting standards.

3 Results and discussion

3.1 General outputs and publications trend

Table 1 provides a publication dynamics during the 2015–2025 period, demonstrating a positive growth trajectory with a relatively high rate, reflecting increasing academic attention to this topic. Sjögärde & Didegah [5] stated that the relatively recent characteristics of the documents indicate that research in this field is still in its expansion phase, thus offering extensive potential for further exploration. Moreover, the significant average citation rate suggests that published works have successfully attracted the attention of the global scientific community.

Collaborative patterns emerge as the most prominent feature based on the perspective of author contributions. The substantially large number of authors compared to single documents demonstrates that research is more frequently conducted through team collaboration at national and international levels. The high proportion of cross-country

collaboration reinforces the existence of productive global academic networks, which can enrich perspectives and broaden the reach of findings. Meanwhile, the volume of keywords reflects the breadth of issues addressed while opening opportunities for more comprehensive research mapping.

Table 1. Overview of collected data details from Scopus database (2015-2025).

Description	Results	Unit
<i>Primary information about the data</i>		
Timespan	2015:2025	-
Sources	243	Documents
Total document	661	Documents
Annual growth rate	9.53	%
Document average age	3.97	Years
Average citations per doc	15.69	Times
<i>Document contents</i>		
Keywords plus (ID)	5,286	Words
Author's keywords (DE)	2,082	Words
<i>Authors</i>		
Authors	3,663	Authors
Authors of single-authored docs	8	Authors
<i>Authors collaboration</i>		
Single-authored docs	8	Documents
Co-Authors per Doc	6.25	Authors
International co-authorships	27.38	%

Note: Data summarised using RStudio.

Fig. 1 reveals two critical contradictory phenomena between annual growth (left graph) and average citations (right graph). The number of publications shows an increasing trend over the past ten years. Although fluctuations occurred after 2020, they still reflect stable and rapid growth in interest in this topic. Herbal studies on dairy cattle health have become more popular, with more researchers engaging in related research. Conversely, citations per document demonstrate a declining trend over the same decade. Despite the increase in publication numbers, the average citations per document have decreased drastically. This decline more likely indicates that research topics are increasingly focused on more specific and in-depth subtopics, which tend to attract attention from smaller audiences. Nevertheless, this does not mean that the topic is less relevant or of lower quality, but rather represents a natural phenomenon in scientific development. Research often focuses on narrower niches as topics evolve, leading to more limited but still significant influence within more specific contexts. Recent research may also require more time to gain broader recognition.

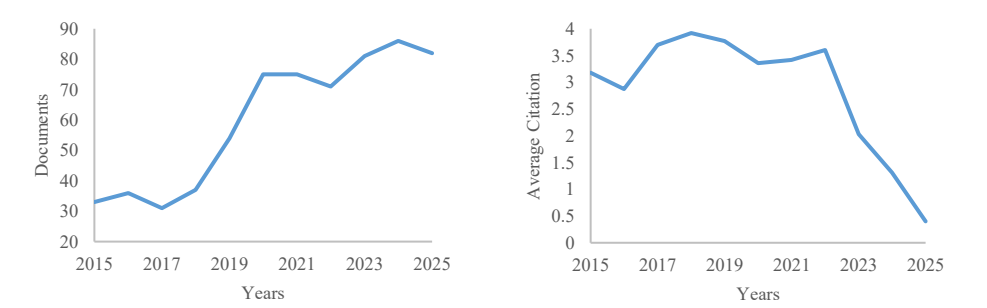


Fig. 1. Annual growth (Left) and average citation (Right) of publications in 2015-2025.

3.2 Core and influential works

3.2.1 Core and influential sources

The bibliometric analysis (Table 2) identifies that publications on herbal approaches to dairy cattle health are distributed across journals with multidisciplinary coverage, spanning animal science, veterinary medicine, food, and nutrition. This pattern indicates that issues of cattle health with herbal interventions are not solely the concern of veterinarians but are also closely linked to milk quality, food safety, and the sustainability of dairy production systems. Bihari et al. [6] highlight that citation growth is strongly influenced by journal credibility, open access status, and publication age. The data show that higher citation counts tend to occur in journals with stronger indices and earlier publication years.

Table 2. Core sources and impact metrics.

Sources	NP	H-index	G-index	M-index	TC	PY-start
Journal of Dairy Science	29	17	28	1.55	795	2015
Nutrients	23	16	23	1.45	615	2015
Food Chemistry	19	14	19	1.27	627	2015
Journal of Agricultural and Food Chemistry	13	11	13	1.00	507	2015
BMC Veterinary Research	12	10	12	0.91	329	2015
Food Research International	16	10	16	1.11	471	2017
Food And Function	11	9	11	0.82	241	2015
Veterinary Parasitology	15	9	15	0.90	250	2016
Animals	23	8	16	1.42	276	2019
Journal of Animal Science	10	8	10	0.73	175	2015
Frontiers in Veterinary Science	12	7	10	0.88	118	2018

Note: NP = number of publications; H-index = measures productivity and citation impact; G-index = emphasises highly-cited articles; M-index = ratio of H-index over publication years; TC = total citations; PY-start = publication year start.

Mainstream journals in this domain, such as the Journal of Dairy Science, Nutrients, and Food Chemistry, illustrate that the theme is growing productively and exerting a significant influence within the international literature. Publications in such high-index journals underscore the potential of herbal-based research to gain stronger scientific legitimacy and to serve as a reference point in shaping sustainable dairy farming practices. Meanwhile, although characterised by relatively lower index values, specialised outlets such as BMC Veterinary Research and Frontiers in Veterinary Science play a critical role as platforms for more applied and context-specific research in animal health. Together, these patterns suggest that herbal research in dairy cattle health will continue to evolve along two complementary trajectories. Strengthening its scientific foundations within high-impact international journals while simultaneously expanding its practical applications within the veterinary sciences

3.2.2 Core and influential authors

Core authors play a strategic role because their contributions reflect productivity and determine research development direction in specific themes. Several names stand out through their consistent contributions in the field of herbal approaches to dairy cattle health (Table 3). Casper DP and Da Silva AS are the authors with the most publications, indicating their active involvement in building the knowledge base in this field. Conversely, Zhang H, Walkenhorst M, and Sharma AK are more prominent regarding total citations. This condition indicates that although their productivity is comparable to that of other authors, their works have a broader appeal and influence in the scientific community.

Identifying core authors is crucial in researching herbal approaches to dairy cattle health. Figures such as Casper DP and Zhang H, with their high indices, serve as anchoring points

for identifying dominant trends and future directions, while authors with consistent M-index values indicate sustained productivity and long-term relevance. Beyond highlighting the most influential contributors, this mapping provides benchmarks for emerging scholars, opportunities for collaboration, and valuable lessons for professional growth, as metrics like the H-index and citation counts remain critical in academic recognition, promotion, and funding. At the institutional level, such insights support strategic planning by revealing strengths, gaps, and emerging talent. At the same time, bibliometric analysis contributes to mapping the intellectual structure of the field, tracing its evolution, and highlighting key contributors who drive the integration of herbal approaches into sustainable livestock practices [7].

Table 3. Core authors and impact metrics.

Authors	NP	TC	H_index	G_index	M_index	PY_start	AF
Casper DP	9	168	5	9	0.56	2017	2.09
Da Silva AS	9	75	3	8	0.33	2017	0.87
Fischer V	7	74	5	7	0.71	2019	0.87
Wagner R	7	187	3	7	0.42	2019	0.69
Liu T	6	89	4	6	0.66	2020	1.44
Liu Y	6	72	4	6	0.36	2015	0.80
Walkenhorst M	6	121	4	6	0.40	2016	0.98
Zhang H	6	124	4	6	0.57	2019	0.79
Li X	5	42	4	5	0.36	2015	0.82
Sharma AK	5	128	4	5	0.36	2015	0.59

Note: NP = number of publications; TC = total citations; H-index = measures productivity and citation impact; G-index = emphasises highly-cited articles; M-index = ratio of H-index over publication years; PY-start = publication year start; AF = articles fractionalised.

3.3 The most corresponding author's country and relevant affiliation

According to the data presented in Fig. 2, Brazil emerges as the leading country in publications on herbal approaches to livestock health, followed by China, Italy, and the USA. This distribution demonstrates that research on this theme is concentrated in Asia and strongly represented in South America and Europe, reflecting the global interest in integrating herbal medicine into livestock health management. China plays a central role as a research hub in this field. Meanwhile, Brazil’s prominence reflects its strong tradition in ethnoveterinary practices and biodiversity research, while India, Iran, and Egypt show steady contributions that reinforce Asia’s significant role in this domain.

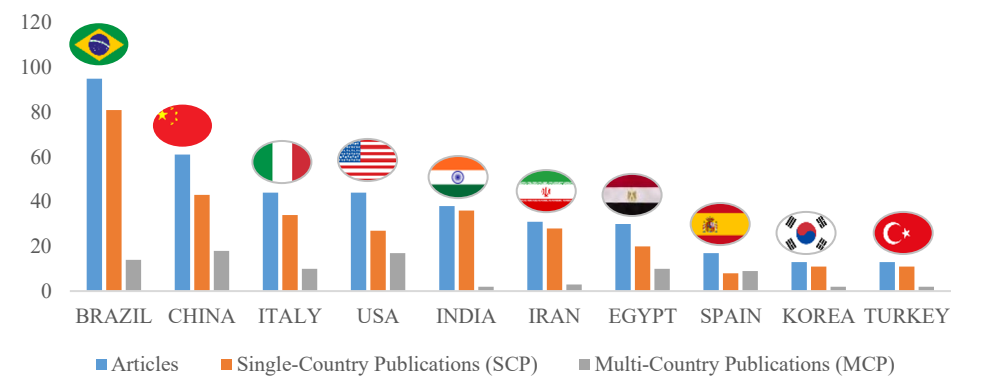


Fig. 2. The top 10 corresponding authors' countries.

The balance between single-country publications (SCP) and multi-country publications (MCP) among the top 10 countries reveals different collaboration strategies. Spain (52.9%), the USA (38.6%), and Egypt (33.3%) display relatively high proportions of MCP, underscoring their orientation toward international partnerships. In contrast, India’s output is overwhelmingly dominated by SCP (94.7%), which suggests a focus on local priorities with limited engagement in global networks. Brazil and China, while ranking first and second in overall article counts, show moderate MCP proportions (14.7% and 29.5%, respectively), indicating that their research is still largely domestically driven. Korea and Turkey also reveal similar patterns, with modest publication numbers and MCP shares of around 15%. This demonstrates that while Brazil and China dominate in volume, the USA and several European countries stand out for their collaborative orientation, highlighting complementary strengths that shape the global landscape of herbal dairy health research.

Fig. 3 highlights the leading institutions contributing to research on herbal approaches in dairy health. Universidade do Estado de Santa Catarina (UDESC) stands out as the dominant institution, followed by Gansu Agricultural University and Islamic Azad University. These institutions, alongside major European contributors like the University of Milan and the University of Naples Federico II, underscore the global interest in this topic.

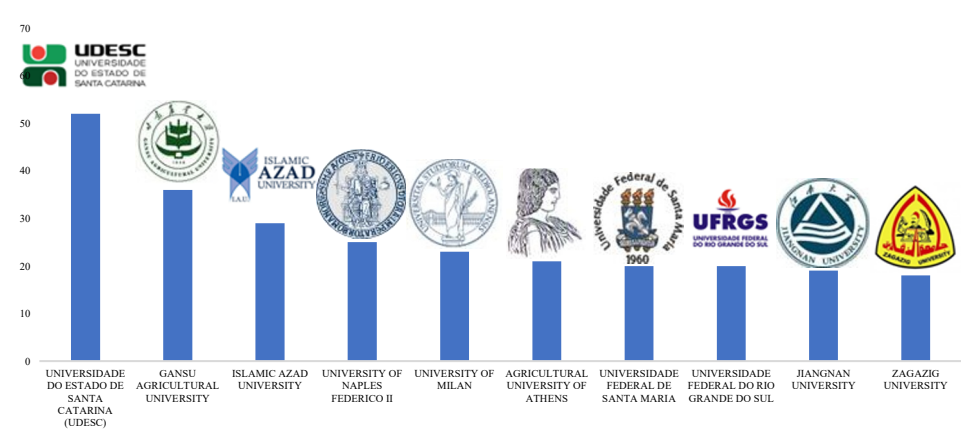


Fig. 3. The most relevant affiliation.

The varying levels of relevant affiliations across the other institutions likely reflect differences in research focus, size, international partnerships, and overall research activity and impact [8]. The distribution of publications across these institutions reflects their research capacity and regional focuses. Brazilian institutions, particularly UDESC, lead in this field, aligning with Brazil’s prominent position in Fig. 2. Meanwhile, China and Iran are making significant contributions, with Gansu Agricultural University and Islamic Azad University reinforcing Asia’s and the Middle East’s growing role in herbal dairy health. European institutions, like the University of Milan, continue to play a key role in interdisciplinary research linking veterinary and food science.

3.4 Keyword and popular topic analysis

The network map of author keywords (Fig. 4) visualises keywords that form several main clusters in herbal research for livestock health. The first and most prominent cluster centres on essential oils. Related keywords, such as antimicrobial, antibacterial activity, and mastitis, indicate that the primary research focus within this cluster is using essential oils as natural solutions to address infection and inflammation problems in livestock, particularly dairy cattle, frequently affected by mastitis. The second cluster focuses on antioxidants and

bioactive components in functional foods, with keywords such as oxidative stress, *Staphylococcus aureus*, and dairy cattle, highlighting the role of antioxidants in improving livestock health, especially in preventing oxidative damage that can compromise dairy cattle health.

The third cluster encompasses dairy products and functional foods, focusing on herbal-based products to support dairy cattle health, with keywords such as yoghurt and fatty acids. The fourth cluster centres on phytotherapy and medicinal plants, with keywords such as calf, growth performance, and antibacterial activity, demonstrating the use of medicinal plants as therapy for livestock diseases. Overall, the centre of these clusters reveals that the use of essential oils in natural medicine for livestock health, particularly in managing mastitis, represents the most dominant research theme. At the same time, other topics, such as nutrition and herbal therapy, also receive significant attention in sustainably improving dairy cattle performance and health.

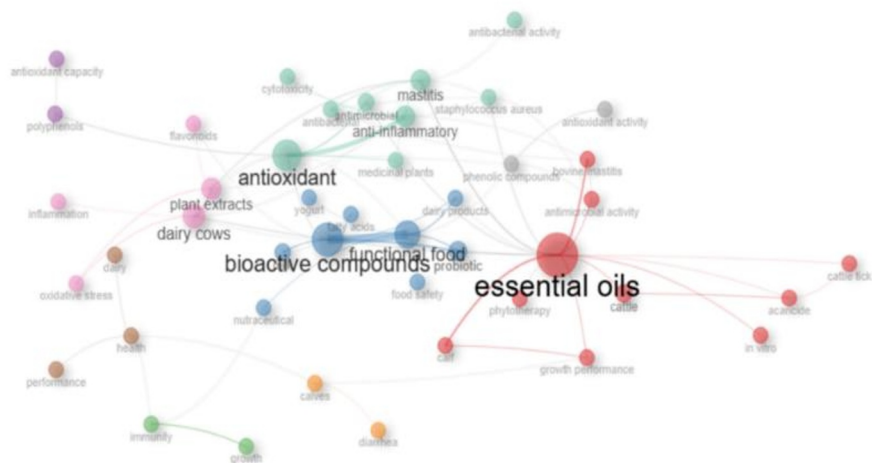


Fig. 4. Network map of author keyword research themes.

Thematic maps (Fig. 5) provide a more in-depth analysis, showing the distribution in four quadrants separated by two dimensions: Relevance Degree (Centrality) on the horizontal axis and Development Degree (Density) on the vertical axis. Motor themes, such as dairy cattle, essential oils, mastitis, and plant extracts, are located in the upper right quadrant, indicating that these themes are highly influential, relevant, and well-established in research. Meanwhile, niche themes such as bovine mastitis, encapsulation, and goat milk are positioned in the lower left quadrant, reflecting emerging topics with significant potential to become more dominant. On the other hand, declining themes such as *Saccharomyces cerevisiae* and ethnoveterinary show decreases in relevance and development. In contrast, basic themes, such as bioactive compounds and functional food, remain fundamental to many studies, with high significance and stable growth.

This thematic map demonstrates the importance of research focusing on motor themes such as dairy cattle, essential oils, and mastitis, which show significant relevance and development. Recommendations for future research include deepening the use of essential oils in addressing mastitis and other health problems in dairy cattle and integrating herbal-based functional foods in livestock care. Meanwhile, niche themes reveal potentially developing areas, such as encapsulation and bioactive peptides, which require greater attention.

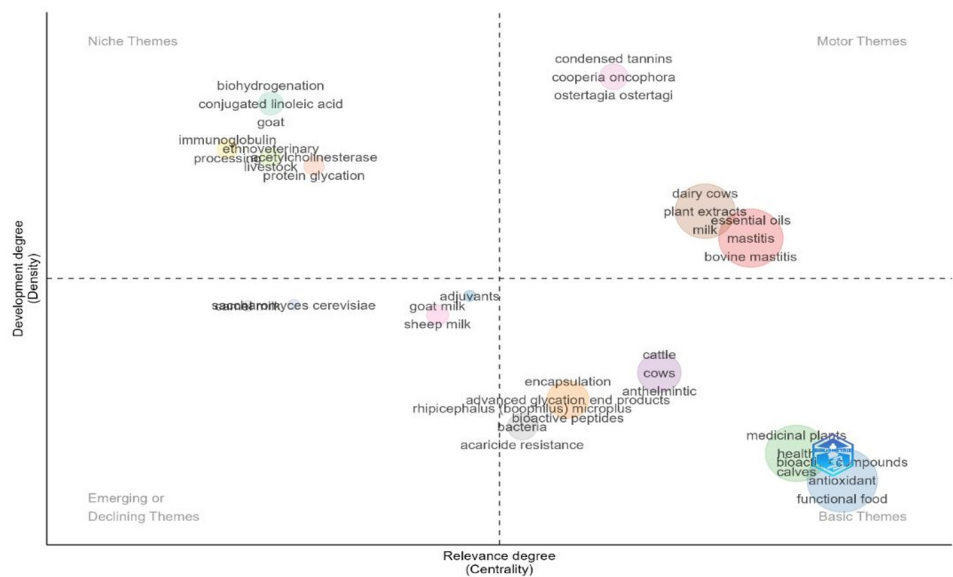


Fig. 5. Thematic maps from author keywords

Fig. 6 presents the Conceptual Structure Map based on Multiple Correspondence Analysis (MCA). This concept transforms categorical data into a two- or three-dimensional map, representing each keyword or category as a point. The distance between points reflects the level of association, where closer proximity indicates stronger relationships or similarities between keywords. This map divides research themes into three main areas, based on two dimensions: degree of relevance (Dim 1) on the horizontal axis and degree of development (Dim 2) on the vertical axis. The right map depicts highly relevant topics, featuring growth, health, and nutrition, focusing on livestock health management through herbal-based nutrition. These topics indicate that herbal-based livestock nutrition is receiving increasing attention and continuously developing relevance, particularly in improving livestock performance and addressing metabolic health problems. Meanwhile, the left map shows well-established topics focusing more on treating livestock diseases, such as mastitis, dairy cattle, and essential oils. This position indicates that research on mastitis and using essential oils for treating dairy cattle diseases is already well-established. However, further development is still required to optimise applications in herbal-based livestock treatment practices.

Future researchers can derive critical insights from the thematic maps and factorial analysis. Fig. 4, 5, and 6 comprehensively overview keyword relationships in herbal research for dairy cattle health. The network map (Fig. 4) reveals distinct thematic clusters, indicating that current primary research focuses on using essential oils to address dairy cattle diseases, particularly mastitis. Fig. 5 presents the thematic map, and Fig. 6 displays factorial analysis confirming that essential oils and mastitis demonstrate high relevance and significant development, associated with health and nutrition as the two main dimensions. Meanwhile, bioactive peptides and encapsulation are positioned within niche themes, suggesting that although these topics are important, they remain in earlier developmental stages. Collectively, these three figures interconnect themes including herbal treatment for mastitis, plant-based therapy, and livestock nutrition, revealing numerous opportunities for further research in areas such as alternative herbal products and combination therapies that could address future research gaps.

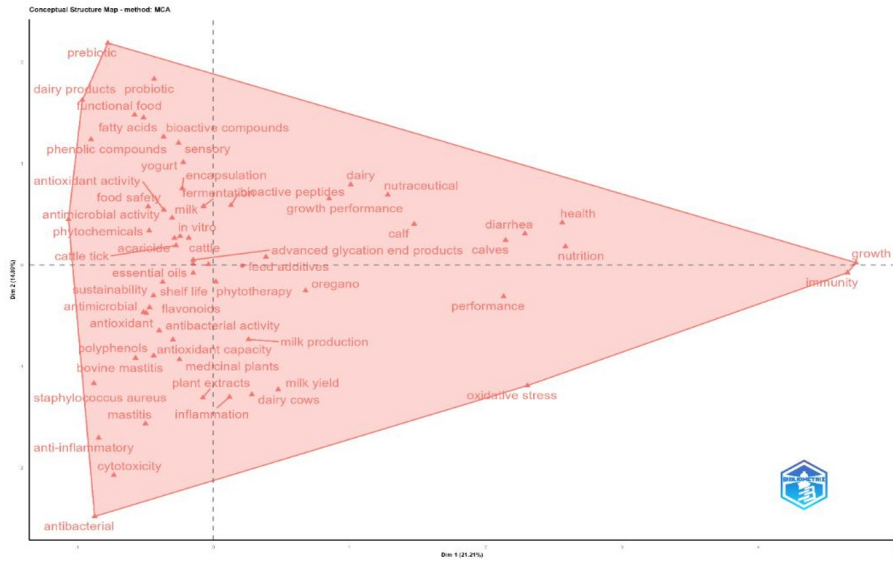


Fig. 6. Factorial analysis from the author's keywords.

3.5 Highly Cited Papers

Based on keyword analysis and thematic mapping, the most cited research on herbal applications in dairy cattle health (Table 4) strongly correlates with main themes such as using essential oils to treat mastitis and other health issues in dairy cattle. Research highlighting Agolin Ruminant, an essential oil blend containing eugenol, geranyl acetate, and geraniol, reflects the dominant focus on using essential oils as natural solutions for infection and inflammation problems, particularly mastitis. Key findings from this research show that Agolin Ruminant supplementation increased milk yield by 3.6%, improved feed efficiency (+4.4%), and reduced methane emissions, reflecting the significant potential of essential oils in enhancing milk productivity while reducing environmental impact. Although the mechanism of action of Agolin is not yet fully understood, long-term supplementation shows more consistent results compared to short-term studies that demonstrate more minor and less stable effects [9].

Additionally, research on carvacrol and thymol demonstrates that their combination has significant potential in microbial control, particularly against *Staphylococcus aureus*, which is commonly associated with mastitis in dairy cattle. Although this combination exhibits significant antimicrobial effects at low concentrations, the research reveals that both compounds show antagonistic effects at high concentrations. These findings reinforce the theme that while essential oil use is highly relevant in mastitis treatment, it requires greater attention to concentration and formulation to optimise effectiveness without compromising organoleptic quality [10].

The current literature dominates research on mastitis and essential oil applications in dairy cattle treatment. However, despite this well-established topic, significant potential remains for further investigation, particularly in dose optimisation and developing more effective formulations. Banumathi et al. [12] employed a nanotechnology approach, while Bonelli et al. [14] utilised encapsulation methods in herbal applications for dairy cattle health. This presents opportunities for advancing research in this field. Although essential oils dominate relevance and advancement, emerging research on nanotechnology and encapsulation shows great promise for comprehensive herbal therapy applications in mastitis and other diseases.

Such investigations could lead to developing superior alternative herbal products that address future research gaps in sustainable livestock disease treatment.

Table 4. The most cited papers about the application of herbs in dairy health.

Title	Key Finding	Author and Sources	TC	TCpY
A meta-analysis describing the effects of essential oils blend agolin ruminant on performance, rumen fermentation and methane emissions in dairy cattle	Supplementing dairy cattle with Agolin Ruminant (seed oil, eugenol, geranyl acetate, geraniol) increased milk yield (+3.6%), FPCM (+4.1%), and feed efficiency (+4.4%) while reducing methane emissions by up to 8.8%.	Belanche et al. [9] <i>Animals</i> (Q1)	107	17.83
Combination of Carvacrol and Thymol: Antimicrobial Activity Against <i>S. aureus</i> and Antioxidant Activity	The combination of carvacrol and thymol at lower concentrations (50–200 µg/mL) had an additive antioxidant effect, and effectively controlled <i>S. aureus</i> in food without affecting its quality.	Ru’a et al. [10] <i>Foodborne Pathogens and Disease</i> (Q2)	107	15.29
The effect of grape seed and grape marc meal extract on milk performance and the expression of genes of the endoplasmic reticulum Stress and inflammation in the liver of dairy cattle in early lactation	GSGME supplementation in dairy cattle increased milk yield and protein output without affecting dry matter intake or energy balance. It did not impact liver inflammation or ER stress but reduced FGF21 mRNA, indicating potential stress reduction. Plasma BHBA and retinol were higher in the GSGME group.	Gessner et al. [11] <i>Journal of Dairy Science</i> (Q1)	79	7.18
In vitro acaricidal activity of ethnoveterinary plants and green synthesis of zinc oxide nanoparticles against <i>Rhipicephalus (Boophilus) microplus</i>	<i>Lobelia leschenaultiana</i> leaf extract showed the highest acaricidal activity against R. (B.) microplus (93.33% mortality). Green-synthesised zinc oxide nanoparticles (LI-ZnO NPs) were more effective, with 100% mortality at 0.008 mg/ml and an LC50 of 0.0017 mg/ml.	Banumathi et al. [12] <i>Veterinary Parasitology</i> (Q1)	70	7
Identification of potential plant extracts for anti-tick activity against acaricide-resistant cattle ticks, <i>Rhipicephalus (Boophilus) microplus</i> (Acari: Ixodidae)	The 95% ethanolic extracts of <i>Datura metel</i> and <i>Argemone mexicana</i> showed significant acaricidal effects, with <i>D. metel</i> being more effective (65% mortality). Both extracts inhibited tick reproduction and were effective against acaricide-resistant tick lines.	Ghosh et al. [13] <i>Experimental and Applied Acarology</i> (Q2)	56	5.09
Oral administration of chestnut tannins to reduce the duration of the neonatal calf diarrhea	Chestnut tannins shortened the duration of neonatal calf diarrhea (6.6 days vs. 10.1 days in controls) and improved fecal scores. The treatment showed effective astringent properties without negative effects on health or milk intake, suggesting it as a low-impact alternative to antibiotics for treating neonatal diarrhea in calves.	Bonelli et al. [14] <i>BMC Veterinary Research</i> (Q1)	46	5.75

Note: Q: Quartile; TC: total citation; TCpY: total citation per year

3.6 Research collaboration and geographic distribution

The author collaboration network presented in Fig. 7 reveals a fragmented structure with several clusters, each representing distinct research groups or regions within herbal research for livestock health. Nodes in the network represent authors, with the size and connectivity

of the nodes reflecting their role in the network. Prominent authors, such as Li X (betweenness 25.5, PageRank 0.0443), Wang S (PageRank 0.0379), and Wang H (betweenness 6.47, PageRank 0.0408), form the central red cluster, which includes authors who connect multiple sub-clusters, indicating their pivotal role in the network. Li X's high betweenness and closeness values indicate that he is central in linking different sub-groups, making this red cluster the core of herbal research collaborations in livestock health.

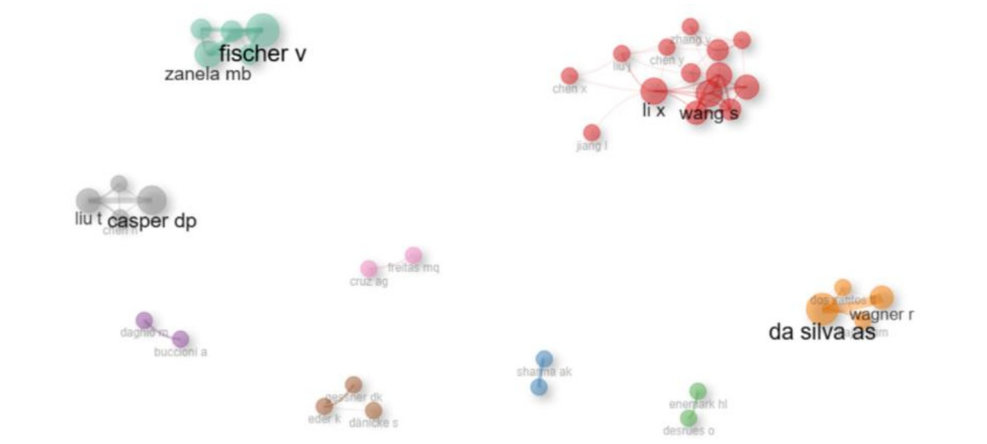


Fig. 7. Author collaboration network.

In addition to the dominant cluster, other authors form independent clusters. For example, Fischer V and Zanela MB (green cluster) have strong internal collaborations but fewer connections to the global network. Similarly, da Silva AS, Wagner R, and dos Santos TL (orange cluster) represent a regional research network in South America, though their collaborations are less connected globally. Other smaller clusters, such as Sharma AK and Kumar S (blue), Enemark HL and Desrués O (light green), and Buccioni A and Daghighi M (purple), show focused collaboration but are more isolated from the leading dominant network. Authors like Gessner DK and Eder K (brown cluster) have high closeness (0.5) and significant PageRank (0.0309), indicating their essential role in advancing dairy cattle nutrition and metabolism research. Meanwhile, authors like Liu T and Casper DP (grey cluster) have moderate PageRank values (0.0275–0.0331), showing that while they are not part of the primary red cluster, they still contribute significantly to cross-group knowledge sharing. The decentralised network structure observed in this study, characterised by multiple distinct clusters rather than a single dominant group, reflects the diverse and multifaceted nature of dairy cattle health research, consistent with network analysis patterns identified in similar scientific domains [15].

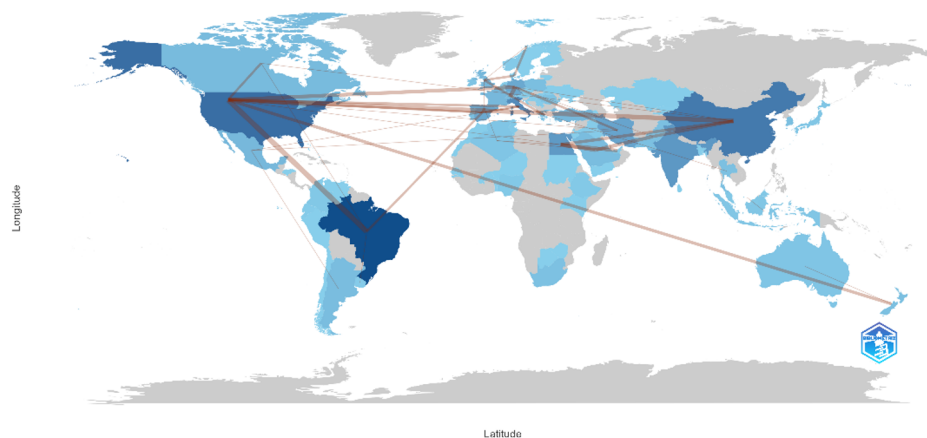


Fig. 8. The collaboration world map of the author.

The World Map Collaboration (Fig. 8) illustrates a complex network of connections spanning multiple continents, with robust links between the Americas, Europe, and Asia, indicating active international collaborations. These connections foster knowledge exchange and research synergy across borders. Insights from the Author Collaboration Network and the Collaboration World Map offer a holistic view of the authors' collaborative landscape, emphasising the significance of local and international partnerships in driving innovation and advancing research. The distinct clusters in the Author Collaboration Network and the global connections in the Collaboration World Map highlight opportunities for interdisciplinary and international collaborations. Authors can identify potential collaborators within existing clusters or reach out to those in other communities and regions with complementary expertise. Collaborating with central authors or those from diverse clusters and countries can enhance an author's visibility and impact within the global research community. Furthermore, analysing the evolution of the collaboration network and the world map over time enables authors to detect emerging trends, research frontiers, and potential gaps for further investigation, supporting the development of innovative and impactful research [15].

3.7 Research gaps and future research directions

The comprehensive bibliometric analysis reveals a research landscape focusing on specific therapeutic applications while leaving substantial gaps in holistic dairy health management approaches. Current research demonstrates heavy emphasis on treating established diseases, particularly mastitis, while preventive healthcare strategies, reproductive health interventions, and metabolic disorder management remain significantly underexplored. The field also suffers from methodological inconsistencies, with limited standardisation in extraction protocols, dosage formulations, and delivery systems across studies. Additionally, most research focuses on short-term efficacy assessments, creating critical knowledge gaps regarding long-term safety profiles, cumulative effects, and sustainable implementation in commercial dairy operations. The fragmented collaboration networks further limit knowledge integration and comprehensive approach development.

Future research directions should prioritise expanding beyond the current treatment-focused paradigm toward comprehensive, prevention-oriented strategies that address the full spectrum of dairy cattle health challenges. The emerging potential of nanotechnology and encapsulation systems presents opportunities for developing more effective delivery mechanisms that could revolutionise herbal therapeutic applications. Strengthening

international collaborations and establishing standardised research protocols will be essential for advancing the field from fragmented individual studies toward systematic, evidence-based practices. Moreover, integrating economic feasibility assessments and developing regulatory frameworks specifically for veterinary herbal medicine will be crucial for translating research findings into practical, sustainable solutions for the global dairy industry.

4 Conclusion

This bibliometric analysis successfully mapped the intellectual landscape of herbal approaches to dairy cattle health control over the past decade, revealing a field characterised by robust growth and evolving research priorities. The study demonstrated significant expansion in publication volume with a 9.53% annual growth rate, indicating sustained academic interest in natural alternatives for dairy cattle health management. The analysis identified essential oils and mastitis treatment as the most established research domains, while revealing the emergence of innovative approaches such as nanotechnology and encapsulation systems. Leading contributions came from authors such as Casper DP and Da Silva AS regarding productivity, and Zhang H, Walkenhorst M, and Sharma AK regarding citation impact, with Brazil, China, and Italy dominating publication output globally.

The bibliometric findings provide compelling evidence for the potential of herbal approaches to address contemporary challenges in dairy farming, including antimicrobial resistance and consumer demand for natural products. However, the fragmented collaboration networks and declining citation rates despite increasing publication volumes highlight the need for more strategic research coordination and international partnerships. This study's comprehensive mapping of research themes, author networks, and institutional collaborations offers valuable insights for researchers, funding agencies, and policymakers seeking to advance evidence-based herbal interventions in dairy cattle health management. These findings contribute to the broader understanding of how natural therapeutics can be integrated into sustainable livestock production systems, supporting animal welfare and food security objectives in the evolving global dairy industry.

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