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Mycotoxin Management in Animal Feed Research Trends: Scientometric Analysis

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ABSTRACT

Mycotoxins are hazardous secondary metabolites produced by fungus that contaminate animal feed and have the potential to seriously impair food safety, animal health, and the global food supply chain. Over the past ten years, there has been an increase in scientific interest in mycotoxin contamination in feed systems. In order to examine global shifts in research trends pertaining to mycotoxin control in animal feed, this study used a scientometric approach. Search on the bibliographic data in the PubMed database was performed and analyzed it using the Biblioshiny interface in the Bibliometrix R package to access collaboration networks, to identify the highly productive authors, to analyze publishing trends, and to assess new research areas. The studies show a rise in scientific publications in recent years, indicating the increasing interest in this type of research around the world. There was also significant international participation in some European countries, along with China and the US being some of the leading providers of research outputs. Based on the findings, aflatoxin contamination, food safety, toxicity evaluation, and methodologies for risk management were the key themes of research. All this together suggests that the research effort related to mycotoxins in animal feed is growing, and more scientific collaboration and interdisciplinary approaches are warranted for addressing the challenges associated with animal health and feed safety.

KEYWORDS: Animal Feed Safety, Contamination of Food, Fungal Feed Security, Mycotoxin Management, Scientometric Analysis

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INTRODUCTION

Mycotoxins that constitute animal feed contamination are not limited to any region, and the differences are subject to climatic conditions, modes of storage, and farming practices(Kos et al., 2023). One of the significant places where scientometric analysis has become an effective method is in measuring trends of the research and some of the major contributors, plus measuring the development of the science research on a certain basis(Gomis et al., 2023). Using the methods of bibliometrics, one can trace the development of research in the field of influences on Mycotoxins and identify leading authors, institutions, and nations that take the lead in the field. In addition, researchers and policymakers can adjust their strategies in the context of effective measures of Mycotoxin control by knowing the publication trend ('–'DallAsta et al., 2023). Also, differences between the regulations used in different countries create challenges for using common safety standards(López-García, 2022). Thus, the need for an in-depth scientometric review emerges to measure the development of the research on mitigating Mycotoxins and come up with trends in research. The purpose of the study is to evaluate the knowledge field of Mycotoxin control in animal feed with the help of scientometric tools. The results of the assessment of the trends in publications, author networks, and thematic regularities will give important answers to questions about the trend in the development of this vital area. By examining diverse research findings and publications on mycotoxin management in animal feed, this study requires a detailed analysis, utilizing scientometric and bibliometric comparisons to present a

comprehensive overview of the field. Through robust citation and productivity metrics, it honors great contributors and prominent authors, celebrating leading innovators. It elaborates to reveal thematic changes and emerging hotspots over the years based on keyword trends and vibrant author collaborations, as well as country-wise contributions to create a global picture of interrelated efforts. In doing so, it provides meaningful guidance from which practical suggestions, future directions, and policy recommendations arise; identifies key gaps in existing studies, and offers key insights relevant to the area; and provides innovative approaches to mycotoxin detection and mitigation for promoting the protection of animal health and food security.

Figure 1. Research Framework

MATERIALS AND METHODS

This bibliometric study seeks to survey the academic literature and resources about "Mycotoxin management in animal feed" between 1979 and March 2025 on growth, collaboration networks, diversity of search terms, and participation in international communities. Data was collected from databases including PubMed, using subject-specific keywords such as “Mycotoxin Prevention and control in Animal feed,” “mycotoxin/aflatoxin management,” and “Animal feed and Livestock food contamination.” Boolean operators and clarifiers were used to ensure that peer-reviewed articles, reviews, and conference papers would be included. The dataset (Fig 1) included 292 documents in 115 journals or sources published between 1979 and early 2025. Data was cleaned and prepared by deduplication, author name, institutional associations, and journal title standardization, and normalization according to keyword spelling and phrasing. The exported data were written in formats available for the analysis in bibliometric software. The bibliometric analysis was performed using the R programming language, with emphasis on the Bibliometrix and Biblioshiny packages (Aria & Cuccurullo, 2017). Main functions consisted of descriptive statistics, co-authorship, network analysis, keywords and co-occurrence mapping, Lotka's Law, and visualization tools such as collaboration, word clouds, and theme clusters. Key bibliometric features for interpretation Analysis of the dataset included the following bibliometric indicators: Annual Scientific Production, Authorship Patterns, Collaboration Index, Keyword Analysis, Average Document Age, and Citation Metrics. Network and thematic mapping were conducted to assess national and institutional collaborations, while keyword co-occurrence networks were examined through multidimensional scaling and Louvain clustering. Shortcomings are that there was no citation data, outdated affiliation data to date, more bias about English language journals, and no incorporation of patents and industry linkages. Ethical issues were addressed; the article considered only public sources of bibliographic data in this study.

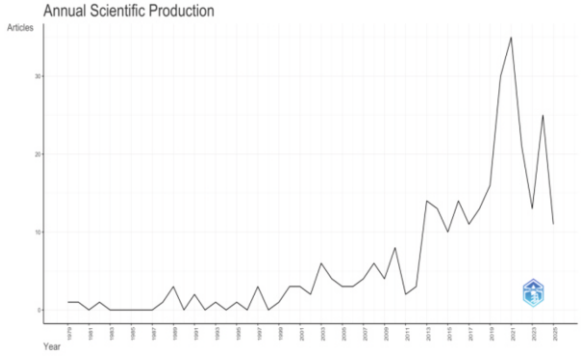

Figure 2. Annual Scientific Publication

RESULTS AND DISCUSSION Year-wise Publication

Figure 2 shows the frequency of publications from the previous years. Published articles appeared in the first few years (1970-1990), and only 0-2 of them were published. Annual growth in output to 3–6 publications from the latter part of the 1990s through the early 2000s further illustrates that the academic gaze on this area is growing. From 2010 onwards, this upward movement indicates a trend of increasing research output and academic engagement. A striking increase on the whole occurred between 2018 and 2021, when the number of publications sharply increased and reached the highest peak of more than 30 articles in a single year, indicating heightened research attention and productivity. After this peak, a slight decline and fluctuation are observed in the subsequent years,

though the output remains comparatively higher than earlier decades.

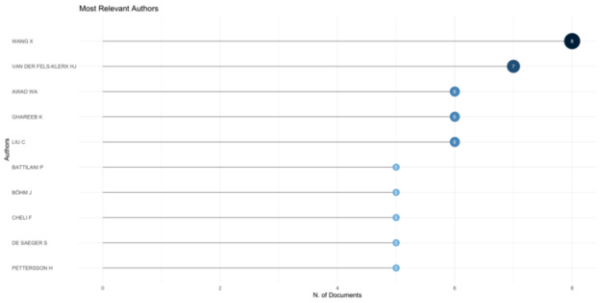

Figure 3. Productive Authors

Most Prolific Authors

It presents the most prolific authors over the paper number of Mycotoxin management research, through a visualization (Figure 3). The author's name of Wang X is reported multiple times in the dataset, but the author of each publication was found to be different researchers (Xiaodan Wang, Xichun Wang, and Xinxin Wang) on DOI verification. As articles were produced by different authors, these articles did not aggregate and thus were not considered as prolific authors (as is suggested for bibliometric data-cleaning procedures to remove ambiguity of author names) (Strotmann & Zhao, 2012). The most prolific author has been Van der Fels-Klerx HJ with seven publications, Awad WA, Ghareeb K, and LIU C have contributed six documents, all contributing positively to findings in this field. Other authors have contributed five documents each which include Battilani P, Böhm J, Cheli F, De Saeger S, and Pettersson H. The quite high number of publications by many authors indicates a vibrant and competitive area of research.

Table 1. List of Most Productive Authors

S.No	Author	Affiliation	No Publications	H-Index
1	Van Der Fels-Klerx HJ	Senior Scientist Wageningen Food Safety Research (WFSR), Wageningen, Netherlands https://orcid.org/0000-0002-7801-394X	7	55
2	Awad WA	Scientists University of Veterinary Medicine, Vienna Austria https://orcid.org/0000-0003-0843-2089	6	40
3	Ghareeb K	Professor and Head, Veterinary Medicine South Valley University, Egypt	6	29
4	Liu C	Researcher, Wageningen Food Safety Research, Wageningen University and Research Wageningen, Netherlands https://orcid.org/0000-0003-0513-9610	6	18
5	Battilani P	Professor Catholic University of the Sacred Heart, Piacenza and Cremona Campuses: Piacenza Italy https://orcid.org/0000-0003-1287-1711	5	63
6	Böhm J	Department of Animal Hygiene, Behaviour and Management, Faculty of Veterinary Medicine, South Valley University, Qena, Egypt	5	-
7	Cheli FProfessor	Department of Health, Animal Science and Food Safety, University of Milan, Milan, Italy https://orcid.org/0000-0003-2682-8685	5	-
8	De Saeger S	Professor Center of Excellence in Mycotoxicology & Public Health, Department of Bioanalysis, Ghent University, B-9000 Ghent, Belgium https://orcid.org/0000-0002-6151-5126	5	87
9	Pettersson H	Professor Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala, Sweden	5	-
10	István Pócsi	Professor, Department of Biotechnology and Microbiology, University of Debrecen, http://orcid.org/0000-0003-2692-6453	5	51

Table 1 shows the most productive authors for researching mycotoxin contamination in animal feed. Van der Fels-Klerx H.J. from Wageningen Food Safety Research, Netherlands, ranks first with seven publications, suggesting this area should be of a lot of interest to researchers on the topic. With six journals each, Awad W.A., Ghareeb K., and Liu C. attentively demonstrate steady scholarly contributions. With five publications individually, Battilani P., Böhm J., Cheli F., De Saeger S., Pettersson H. and Istě Pócsi come next. Since the key contributions are primarily associated with European research institutes, the connections have offered an intriguing reflection that supports their significance in advancing mycotoxin research related to animal feed safety and contamination management.

Author Productivity based on Lotka's Law

The idea that a small number of authors make important contributions to the structure of academic literature while the bulk continue to contribute seldom is supported by Lotka's Law, which is frequently employed in bibliometrics to explain scientific productivity. Pao (1986). The notion of a "core" group of productive writers has been supported by this trend, which has been seen in several scientific fields. The discrepancy between the actual and the expected distributions (as reflected in the gap between the solid and dashed lines) can indicate the existence of specific differences in the dataset, be it discipline specificity, institutional collaboration, or the changing publication habit. Nicholls (1989). Besides, reasons such as publishing trends and publishing online may influence the shape of productivity, thus violating the classic Lotka's paradigm. This distribution is crucial for policymakers, librarians, and academic institutions to appreciate and engage with influential researchers, allowing for suitable resource allocation.

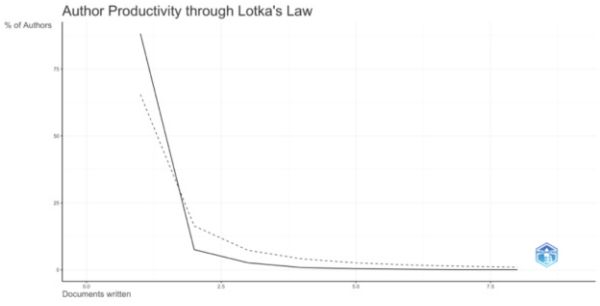

Figure 4. Distribution of Author Productivity Based on Lotka's Law

Geographic Distribution of Corresponding authors

The regional distribution of the main authors in Figure 5 shows the differences in cooperation and effort in research. China takes the lead with about 30 publications (20 SCP, 10 MCP), indicating there is a wider prevalence at home and some light international interest. The USA has an impressive 21 (16 MCP, 5 SCP), indicating strong international cooperation. There are about 10 publications in India (8 MCP, 2 SCP) and 14 in Italy (9 MCP, 5 SCP). It is three of the others: Poland, Austria, and Canada producing nine, of which Canada is a leading MCP supporter. But the Netherlands and Korea are donors that have similar trends.

Trending Topics in Mycotoxin Research

In earlier studies, food handling, ochratoxins, and regulatory standards were common themes (2006-2010). Between 2010 and 2014, however, the emphasis started moving toward consumer product safety and the impact of mycotoxins on health. The literature between the years 2014 and 2018 focused on toxicological processes and exposure of livestock. Toxicity of Aflatoxin B1, analysis of mycotoxin, and risk assessment are the main focus on recent literature (2019–2023), highlighting an emphasis on advanced analytical methods and food chain monitoring.

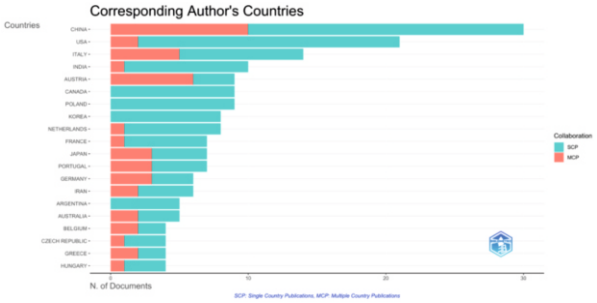

Figure 5. Country-wise distribution of Corresponding Authors

Sankey Visualization of Mycotoxin Research

Related to this, the Sankey graph in Figure 6 demonstrates the correlation between title terms (TI_TM), authors (AU), and authors' countries (AU_CO) in the field of mycotoxin studies. Authors related to title terms including mycotoxin, aflatoxin, zearalenone, contamination, risk, food, and deoxynivalenol appear in most literature associated with major mycotoxin toxicity and risk assessment studies, e.g., Pócsi I., Gyŏri Z., Mahato D.K. In fact, the authors (Wang X. & Liu C.) focus on some detection work conducted as a literature study in

aflatoxin and food contamination. Kumar P. and Kumar A. are published in the food safety risk management literature. Other countries—such as China, Italy, Hungary, and India—have made important contributions in research terms. Mahato D.K. is associated with India; Pócsi I. and Gyęri Z. with Hungary. Due to these countries—Germany, Korea, and the Netherlands—it has the international research component. These columns—author, titles, and nations—set the stage for research dynamics and focus on sectors including food safety risk assessment and mycotoxin contamination as areas of global collaboration.

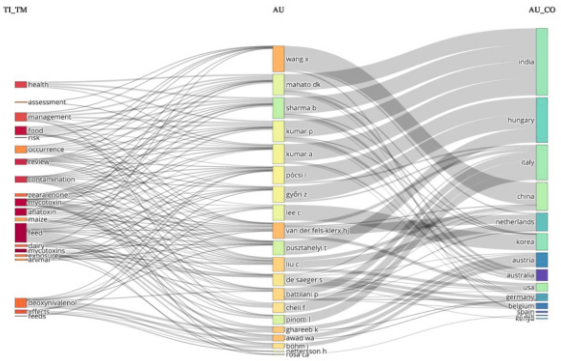

Figure 6. Sankey Visualization of Authors, Titles and Countries

Thematic Map of Mycotoxin Research

The thematic plot in figure 7 classifies research areas concurring to intensity (the level of development) and centrality (the relevance) and requires a basis for how the research data on food contamination, aflatoxins, and Risk Assessment development are organized. The quadrant Motor Themes (top-right) is dominated by highly developed and central topics such as animal feed/microbiology, fungi/metabolism, and food chains that tend to be at the center of interest in the fields of Food Safety, microbiology, and animal nutrition studies. The quadrant of Basic Themes (bottom-right) contains relatively less developed but important areas, like humans, Risk Assessment, food contamination/analysis, male, animal feed, and animals, suggesting that they are fundamentally important in their regard to toxicology and Food Safety. Niche Themes (top-left) possess specific and developed subjects with reduced overall functionality, such as aflatoxin M1/analysis, aflatoxin toxicity analysis, and food contamination prevention & control analysis, which allow highlighting their focused and partial embedding in other themes, e.g., research in China or infant health. The Emerging or Declining Themes quadrant (bottom-left) includes, for example, the topics of immunoassays and Aspergillus flavus, and these might be either new areas of investigation or fields in which the emphasis is diminishing, perhaps because of changes in methods. The thematic map will serve as a strategic tool to identify current research. significance, specialized niches, and future trends in food safety and toxicology, providing guidelines for researchers and policymakers.The scientometric analysis also needs an examination summarizing the status of field of mycotoxin infection in animal feed according to publications, country contribution, and corresponding keywords. This study also shows that there are several research areas and gaps in the literature, alongside a global trend in increasing research output, showing that there is concern about the worldwide impact of mycotoxin contamination of animal health and feed safety (Yilmaz et al., 2025 ; Luo et al., 2021 ; "Eskola et al., 2020). This increased publications reflects a rising awareness regarding economic losses and food safety issues from mycotoxins (Goda et al., 2025). However, in line with existing bibliometric studies focusing on this dominance of those nations, China and the US in general dominate scientific output, denoting heavy commitment to agricultural biotechnology and food-safety research –(Abdul & Pavoni, 2025 ; Altun et al., 2024 ; –Adeniji et al., 2025 ; Wang et al., 2024). The study also detected the presence of aflatoxin contamination levels, toxicity, and its use in food safety and risk assessment based on co-occurrence analysis. As mycotoxins found in the feed products, Aflatoxins are highlighted in highly toxic forms –(Yohannis et al., 2025 ; Okechukwu et al., 2024). This is consistent with previous studies indicating the importance of aflatoxin monitoring for feed and food safety '(Smaoui et al., 2023). Yet a scientometric analysis found only specific keywords associated with regulatory frameworks or policy building — with terms like "regulation" and "governance" appearing infrequently. This points to a lack of attention to coordinating internationally in mycotoxin regulatory and risk management (López-García, 2022 ; Chilenga et al., 2025). This study reflects that regulatory issues in toxin detection and mitigation studies have received less research than laboratory studies. Thematic analysis shows a key emphasis in the discussion of laboratory detection and contamination mechanisms, whereas the emphasis on broad implementation of these techniques and their field validation is diminishing. It also highlights the importance of field-based evaluations for application in agricultural practice. (Kahl et al., 2026 ; Reza et al., 2025). It shows there

are international research partnerships but concentrated in a few countries and institutions. Increased international collaboration could encourage knowledge transfer and the development of consolidated international mycotoxin contamination control efforts. '(Mafe & Büsselberg, 2024). Overall, the scientometric results have indicated a strong emphasis in mycotoxin research on analytical detection methods, toxicological evaluation, and contamination monitoring. Extenuation strategy validation, policy review, and regulatory harmonization are also underrepresented. Additional studies on these issues can improve scientific knowledge in facilitating secure feed application, possibly reducing the risk of mycotoxins(Yeassin et al., 2026).

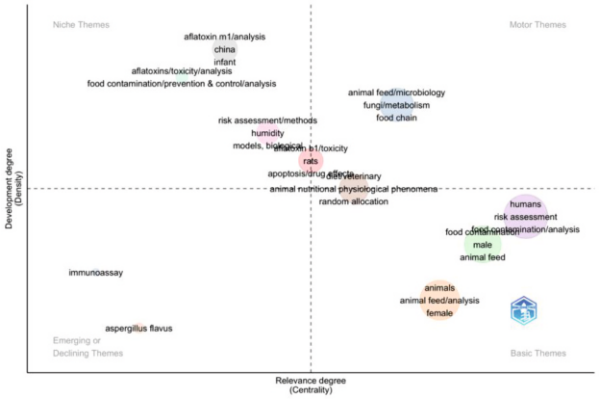

Figure 7. Thematic Mapping of Mycotoxin Research Areas

CONCLUSION

This scientometric study offers a general overview of advancements in the research area of mycotoxins, using a bibliometric and thematic approach. With one eye toward mycotoxin science, the analysis provides evidence of a steady rise in scientific papers throughout the study period, which illustrates how mycotoxin science has gained attention around the world. It has also reflected the authors, contributing countries, and forms of cooperation that have helped to spread this discipline. Based on co-occurring and trend analysis of the keywords, the main study themes are food safety, analytical detection techniques, and aflatoxin contamination and toxicity effects. These are the main issues in the dataset that require scientific exploration. The reviewed literature does not provide much coverage of topics like policy evaluation and regulatory frameworks. The scientometric results may give an organized understanding of the development, protagonists, and thematic trajectories of mycotoxin research and therefore, are a useful reference for further research in this field.

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