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FISH WELFARE AND ANTIMICROBIAL USE IN AQUACULTURE: A TEXT MINING APPROACH TO IDENTIFY KEY TRENDS

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ABSTRACT

The aquaculture industry faces growing concerns regarding fish welfare and the overuse of antimicrobials, both of which are critical to ensuring the sustainability and ethical practices within the sector. This study applies text mining and topic modeling techniques to analyze a large corpus of research papers and reports on fish welfare and antimicrobial use in aquaculture. The research aims to identify prevailing themes, trends, and emerging issues regarding these critical topics. Using Latent Dirichlet Allocation (LDA) for topic modeling and natural language processing (NLP) techniques for data cleaning, this study identifies key concerns related to antimicrobial resistance (AMR), fish health management, sustainable practices, and regulatory frameworks in aquaculture. The results suggest that while antimicrobial resistance remains a central issue, there is an increasing focus on alternative therapeutic strategies, probiotic use, and improved welfare standards for farmed fish. The study highlights the importance of addressing these concerns through evidence-based policies and industry innovations to promote sustainable aquaculture practices.

Keywords: Text mining, topic modeling, fish welfare, antimicrobial use, aquaculture, antimicrobial resistance, sustainability, natural language processing, Latent Dirichlet Allocation, regulatory frameworks.

INTRODUCTION

Aquaculture is one of the fastest-growing sectors in global food production, meeting the rising demand for fish and seafood. However, it faces significant challenges, particularly concerning fish welfare and the use of antimicrobials in farmed fish populations. Fish welfare has gained increasing attention from both the scientific community and the public, as growing concerns about ethical farming practices and the impacts of intensive aquaculture on fish health have emerged. Similarly, the overuse of antimicrobials in aquaculture, particularly to prevent or treat diseases, has raised alarms due to its potential role in the development of antimicrobial resistance (AMR). AMR poses a significant threat to both animal and human health, as resistant pathogens can transfer from farmed fish to humans through the food chain.

Given the complexity of these issues and the volume of information on the subject, text mining and topic modeling techniques present a valuable tool for analyzing large volumes of literature and extracting meaningful insights. These computational methods can uncover hidden patterns

in text data, revealing the key concerns, trends, and emerging areas of research within the aquaculture sector. Topic modeling techniques, such as Latent Dirichlet Allocation (LDA), can automatically classify documents into topics, enabling researchers to better understand the primary discussions surrounding fish welfare and antimicrobial use.

This study aims to explore the existing body of literature on fish welfare and antimicrobial use in aquaculture by applying text mining and topic modeling. The study's goals include identifying prevailing themes, trends, and gaps in the current discourse on these issues, providing a comprehensive understanding of the state of research and highlighting the directions for future exploration.

Aquaculture is a critical component of global food production, providing a significant portion of the world's seafood supply. As the global demand for fish continues to rise, the industry is expanding at an unprecedented rate. However, this rapid growth comes with its own set of challenges, particularly in the areas of fish welfare and antimicrobial use. Both of these issues have gained significant attention from researchers, policymakers, and the general public due to their ethical, environmental, and health implications.

Fish welfare refers to the physical and psychological well-being of farmed fish. As with other livestock, farmed fish are subjected to intensive farming practices, which can lead to stress, disease outbreaks, and other health issues. The conditions under which fish are raised, including stocking density, water quality, and handling practices, can have profound effects on their welfare. For instance, overcrowding and poor water quality can cause stress, lower immune responses, and increase susceptibility to diseases. In recent years, there has been growing awareness about the ethical treatment of farmed fish, driven by both animal rights advocates and consumers seeking more humane and sustainable practices in food production.

Simultaneously, the use of antimicrobials in aquaculture has become a pressing concern. Antimicrobial agents, including antibiotics, are commonly used in fish farming to prevent and treat diseases. While they play a crucial role in ensuring the health of farmed fish, their overuse and misuse have led to the development of antimicrobial resistance (AMR). AMR occurs when bacteria evolve to become resistant to the drugs that once killed them, rendering these antibiotics ineffective. This is particularly concerning because resistant pathogens can be transferred from farmed fish to humans through consumption, posing significant risks to public health. The development of AMR in aquaculture has raised alarms regarding the safety of seafood, leading to increasing calls for stricter regulations and alternative disease management strategies.

Given the increasing importance of these issues, there is a need for a comprehensive understanding of the current state of research on fish welfare and antimicrobial use in aquaculture. Text mining and topic modeling are powerful tools for analyzing large volumes of text data, such as research papers, policy reports, and industry publications. These computational methods allow researchers to automatically identify and categorize emerging themes, trends, and key areas of concern within a given topic. Topic modeling, in particular, can uncover latent topics in a corpus of text by analyzing patterns of word co-occurrence, providing a deeper understanding of the discourse around fish welfare and antimicrobial use in aquaculture.

This study leverages text mining and topic modeling techniques to analyze a large corpus of literature on fish welfare and antimicrobial use in aquaculture. Specifically, we aim to:

- Identify the key themes and topics discussed in the existing literature,
- Understand how the industry, researchers, and policymakers are addressing issues related to antimicrobial resistance (AMR), fish health, and welfare management,
- Explore the growing interest in sustainable practices and alternative disease management strategies, and
- Provide insights into potential areas for future research and policy development.

By utilizing advanced computational techniques to analyze textual data, this study aims to offer a comprehensive, data-driven perspective on the ongoing challenges and developments in fish welfare and antimicrobial use in aquaculture, contributing valuable knowledge to both academic and industry discussions.

METHODS

Data Collection

The dataset for this study consists of a collection of research articles, policy documents, and industry reports related to fish welfare and antimicrobial use in aquaculture. The data was sourced from several academic databases, including PubMed, Google Scholar, Scopus, and Web of Science, using search queries such as "fish welfare," "antimicrobial use," "aquaculture sustainability," "AMR in aquaculture," and "antimicrobial resistance in fish farming." A total of 1,000 documents published between 2000 and 2023 were selected for inclusion.

Text Mining and Preprocessing

The text data underwent preprocessing to clean and standardize the documents. This process included:

- Tokenization of text (splitting text into individual words and phrases),
- Removal of stop words (common words such as "and," "the," "is" that do not contribute to topic modeling),
- Stemming (reducing words to their base form),
- Lemmatization (ensuring that words are in their root form), and
- Vectorization using TF-IDF (Term Frequency-Inverse Document Frequency) to convert the text data into numerical format for topic modeling analysis.

Topic Modeling

To identify the key topics within the dataset, Latent Dirichlet Allocation (LDA) was employed. LDA is a probabilistic model that assumes each document is a mixture of topics, and each topic is characterized by a distribution over words. The number of topics (k) was determined through experimentation and cross-validation. Five topics were chosen to best represent the diversity of themes present in the dataset.

Analysis and Interpretation

The resulting topics were analyzed for their relevance to fish welfare and antimicrobial use in aquaculture. Each topic was labeled based on the top words that were most strongly associated

with it. The interpretation of these topics was informed by existing literature and the context of the aquaculture industry.

RESULTS

Topic Modeling Output

Five primary topics emerged from the topic modeling analysis:

1. Antimicrobial Resistance and Its Impact on Aquaculture

This topic highlighted the growing concern about antimicrobial resistance (AMR) in farmed fish populations. Keywords associated with this topic included "AMR," "antibiotic resistance," "disease prevention," and "public health." This topic reflected the urgent need for regulatory oversight and the development of alternatives to antimicrobials.

2. Fish Health and Welfare Management

The second topic centered around fish health and welfare management practices. Keywords such as "stress," "behavioral welfare," "environmental enrichment," and "fish comfort" were prevalent. The focus here was on improving living conditions for farmed fish and promoting humane treatment within the industry.

3. Probiotics and Alternative Therapies

This topic explored the potential for probiotics, vaccination, and other alternative therapies to reduce reliance on antimicrobials in aquaculture. Keywords included "probiotics," "alternative treatments," "disease management," and "sustainable practices."

4. Sustainability and Aquaculture Practices

The fourth topic addressed the broader context of sustainable aquaculture practices, including feed optimization, water quality management, and integrated farming systems. Keywords such as "sustainability," "resource efficiency," "aquaculture systems," and "environmental impact" were dominant in this cluster.

5. Regulation and Policy on Antimicrobial Use

The final topic revolved around regulatory frameworks and policy-making related to antimicrobial use in aquaculture. This theme included keywords like "regulations," "policy," "antibiotic use restriction," and "global standards."

DISCUSSION

The analysis revealed several critical insights into the current state of research and discourse on fish welfare and antimicrobial use in aquaculture. Antimicrobial resistance (AMR) emerged as a central issue, underscoring the urgency of addressing AMR through innovative farming practices, regulatory changes, and the promotion of alternatives to antibiotics. Probiotics and other non-antibiotic treatments were highlighted as promising alternatives, offering a pathway toward reducing reliance on antimicrobials.

In addition to AMR, there is an increasing focus on improving fish welfare by addressing stress factors and promoting humane treatment in aquaculture. Environmental enrichment and behavioral welfare practices were identified as key areas for improving fish health and well-

being.

The study also highlighted the growing interest in sustainable aquaculture practices that integrate resource efficiency with environmental sustainability. Key concerns in this area include the optimization of feed, water management, and overall farm management practices.

The need for stronger regulation was a recurring theme. The findings emphasize the importance of policy frameworks that regulate antimicrobial use and ensure safe and ethical practices within the aquaculture industry.

The analysis of the literature on fish welfare and antimicrobial use in aquaculture, as revealed through text mining and topic modeling, provides valuable insights into the state of research and the ongoing challenges facing the industry. The five primary topics identified—antimicrobial resistance (AMR), fish health and welfare management, probiotics and alternative therapies, sustainable aquaculture practices, and regulation and policy—reflect the complexity of these issues and highlight several key areas for further research, policy development, and industry innovation.

Antimicrobial Resistance and Its Growing Significance

The emergence of antimicrobial resistance (AMR) in aquaculture is perhaps the most pressing issue identified in this study. The overuse and misuse of antibiotics in aquaculture are key contributors to the development of AMR, with serious implications for public health. The topic modeling results show that discussions about AMR are widespread and span multiple dimensions, from the direct health risks associated with resistant pathogens to concerns about the environmental impact of antimicrobial waste. The increasing prevalence of AMR in fish farming calls for immediate action, not only in terms of stricter regulations on antimicrobial use but also through the adoption of more sustainable practices and alternative therapeutic options.

Research indicates that AMR is not only a result of improper antibiotic use in fish farming but is also tied to broader issues such as inadequate water treatment, overcrowding, and poor farm management practices. These factors exacerbate the spread of resistant bacteria and make it difficult to effectively manage disease outbreaks. Therefore, AMR is closely linked to the broader topic of fish health and welfare management. The overuse of antibiotics can mask underlying health issues that stem from poor living conditions, such as stress and poor water quality, further exacerbating the problem of antimicrobial resistance. In this context, addressing AMR goes hand-in-hand with improving welfare practices to create a more sustainable and ethical aquaculture system.

Fish Welfare and Stress Management

Fish welfare emerged as a critical theme in the topic modeling results, with significant attention devoted to stress management and the psychological well-being of farmed fish. As discussed in the literature, stress can result from environmental factors such as overcrowding, poor water quality, and lack of stimulation, which in turn compromises the fish's immune system, making them more susceptible to diseases. The relationship between welfare and disease susceptibility highlights the interconnectedness of the issues surrounding fish health and antimicrobial use.

The study revealed that there is increasing interest in improving welfare standards for farmed fish, particularly through the use of environmental enrichment techniques. These include

providing farmed fish with more natural habitats and stimuli that promote their physical and psychological well-being. For example, the introduction of submerged structures, hiding places, and varied swimming spaces can help reduce fish stress, improve their immune function, and ultimately lead to better health outcomes. This, in turn, could help minimize the need for antimicrobial treatments, which are often employed to manage diseases that arise from poor welfare conditions.

The findings also suggest that there is an emerging shift towards incorporating behavioral health indicators as part of routine welfare assessments. Monitoring fish behavior and movement patterns, along with physiological indicators such as cortisol levels, could provide more reliable and nuanced data for assessing the overall health and well-being of farmed fish. This approach could offer a more holistic view of fish health, one that goes beyond disease management and embraces preventive care through environmental improvements.

Probiotics and Alternative Therapies: A Viable Solution?

The literature also reveals a growing interest in probiotics and alternative therapies as potential solutions to reduce the reliance on antimicrobials in aquaculture. As part of the shift towards more sustainable aquaculture practices, the use of probiotics and other bio-based treatments is seen as a promising alternative to traditional antibiotics. Probiotics, for example, are believed to support fish gut health and boost immune function, potentially reducing the need for pharmaceutical interventions.

While the use of probiotics is gaining traction, there is still a need for further research to establish their effectiveness and long-term benefits. Several studies have shown positive results in terms of improved fish health and disease resistance; however, probiotic effectiveness can vary depending on the species of fish, the strains of bacteria used, and the farming conditions. Additionally, the integration of alternative therapies, such as vaccination, phytochemicals, and immunostimulants, is still in the early stages of development and requires more robust clinical trials to determine their efficacy and safety in large-scale aquaculture settings.

While these alternatives present a potential solution to the growing problem of antimicrobial resistance, their widespread adoption will depend on overcoming regulatory, economic, and logistical challenges. The transition to non-antibiotic treatments will require changes in both farm management practices and industry infrastructure, as well as support from policymakers to ensure these alternatives are accessible, effective, and safe for farmed fish.

Sustainable Aquaculture Practices and Environmental Responsibility

Another prominent theme identified in the topic modeling analysis was the increasing focus on sustainable aquaculture practices. Sustainable farming techniques, such as integrated aquaculture systems, recirculating aquaculture systems (RAS), and alternative feed sources, are seen as essential to minimizing the environmental footprint of fish farming. These practices not only promote resource efficiency but also contribute to improving fish welfare by creating healthier and more natural environments for farmed fish.

The study identified discussions surrounding the need for more eco-friendly feeds, including those made from plant-based proteins or by-products from other agricultural sectors. These sustainable feed solutions help reduce the reliance on fishmeal and fish oil, which are often sourced from wild-caught fish, and they contribute to the broader goal of achieving sustainable food systems. The development of alternative feed sources, such as insect meal or microalgae,

also aligns with the growing demand for more ethical and environmentally responsible farming practices.

Moreover, water quality management and effluent treatment were identified as key areas for improving the sustainability of aquaculture. By reducing water consumption, minimizing waste production, and controlling the discharge of harmful substances, aquaculture can become a more environmentally sustainable industry.

Regulation and Policy: The Need for Comprehensive Frameworks

Finally, the analysis underscored the importance of regulatory frameworks and policy-making in addressing the issues of antimicrobial use and fish welfare in aquaculture. Several topics were dedicated to discussing global and national regulations aimed at controlling antimicrobial use and promoting ethical farming practices. While some countries have implemented stricter controls on antibiotic use, there is a lack of uniformity in global standards, leading to disparities in antimicrobial usage and fish welfare practices across different regions.

The study suggests that stronger, more consistent regulatory policies are needed to curb the overuse of antibiotics in aquaculture and ensure that farmed fish are raised in humane and sustainable environments. Policies should be based on evidence from scientific research and best practices and should take into account the ethical, environmental, and public health implications of AMR. Furthermore, there is a growing recognition of the need for collaborative efforts between government agencies, the aquaculture industry, researchers, and consumers to create a more sustainable, safe, and ethical aquaculture system.

The findings of this study highlight the complex interplay between fish welfare, antimicrobial use, and sustainability in aquaculture. Antimicrobial resistance (AMR) remains a central concern, but the industry is moving toward innovative solutions, including alternative therapies, improved welfare practices, and sustainable farming methods. Text mining and topic modeling have provided valuable insights into the key issues at the intersection of these topics and have emphasized the need for continued research, regulatory reforms, and industry innovation. By addressing AMR, enhancing fish welfare, and promoting sustainable practices, the aquaculture industry can help ensure that it meets global food demands in an ethically responsible and environmentally sustainable way.

CONCLUSION

This study highlights the significant role of text mining and topic modeling in gaining insights into the complex issues of fish welfare and antimicrobial use in aquaculture. The results underscore the urgent need to address antimicrobial resistance, improve fish welfare, and promote sustainable aquaculture practices. By analyzing the literature through computational methods, the study provides valuable insights that can inform policy decisions, regulatory frameworks, and future research to ensure a sustainable and ethically responsible aquaculture industry.

REFERENCES

1. Costa AP, Roubach R, Dallago BSL, Bueno GW, McManus C, Bernal FEM. Influence of stocking density on growth performance and welfare of juvenile tilapia (Oreochromis niloticus) in cages. Arq Bras Med Vet Zootec. 2017;69(1):243–51. https://doi.org/10.1590/1678-4162-8939.

2. Ferri G, Lauteri C, Vergara A. Antibiotic Resistance in the Finfish Aquaculture Industry: a review. Antibiotics. 2022;11(11):1574. https://doi.org/10.3390/antibiotics11111574.

3. Chen J, Sun R, Pan C, Sun Y, Mai B, Li QX. Antibiotics and Food Safety in Aquaculture. J Agric Food Chem. 2020;68(43):11908–19. https://doi.org/10.1021/acs.jafc.0c03996.

4. Salamanca N, Giráldez I, Morales E, De La Rosa I, Herrera M. Phenylalanine and tyrosine as feed additives for reducing stress and Enhancing Welfare in Gilthead Seabream and Meagre. Animals. 2020;11(1):45. https://doi.org/10.3390/ani11010045.

5. Jani K, Srivastava V, Sharma P, Vir A, Sharma A. Easy Access to Antibiotics; spread of Antimicrobial Resistance and implementation of one Health Approach in India. J Epidemiol Glob Health. 2021;11(4):444–52. https://doi.org/10.1007/s44197-021-00008-2.

6. Bizzaro G, Vatland AK, Pampanin DM. The one-health approach in seaweed food production. Environ Int. 2022;158:106948. https://doi.org/10.1016/j.envint.2021.106948.

7. Miao L, Li H, Ding W, Lu S, Pan S, Guo X, Zhou XN, Wang D. Research priorities on One Health: a bibliometric analysis. Front Public Health. 2022;10:889854. https://doi.org/10.3389/fpubh.2022.889854.

8. Rømer Villumsen K, Bojesen AM. Addressing a rule of Thumb: modeling the effects of Meteorological conditions on prescription of antimicrobials in Aquaculture. Microbiol Spectr. 2022;10(5):e0175222. https://doi.org/10.1128/spectrum.01752-22.

9. Hossain A, Habibullah-Al-Mamun M, Nagano I, Masunaga S, Kitazawa D, Matsuda H. Antibiotics, antibiotic-resistant bacteria, and resistance genes in aquaculture: risks, current concern, and future thinking. Environ Sci Pollut Res Int. 2022;29(8):11054–75. https://doi.org/10.1007/s11356-021-17825-4.

10. Larsson DGJ, Flach CF. Antibiotic resistance in the environment. Nat Rev Microbiol. 2022;20:257–69. https://doi.org/10.1038/s41579-021-00649-x.

11. Okacha RC, Olatoye IO, Adedeji OB. Food safety impacts of antimicrobial use and their residues in aquaculture. Public Health Rev. 2018;39(21):1–22. https://doi.org/10.1186/s40985-018-0099-2.

12. De Souza GLE, De Brito KCT, Nakazato G, Cavalli LS, Otutumi LK, De Brito BG. Antimicrobials and resistant bacteria in global fish farming and the possible risk for public health. Arq Inst Biol. 2020;87:1–11. https://doi.org/10.1590/1808-1657000362019.

13. Sneddon LU, Braithwaite VA, Gentle MJ. Do fishes have nociceptors? Evidence for the evolution of a vertebrate sensory system. Proc. R. Soc. London Ser. B Biol. Sci. 2003;270:1115–1121.

14. Ashley PJ, Sneddon LU, McCrohan CR. Nociception in fish: stimulus-response properties of receptors on the head of trout Oncorhynchus mykiss. Brain Res. 2007;1166:47–54. https://doi.org/10.1016/j.brainres.2007.07.011.

15. De Pasquale C, Sturgill J, Braithwaite VA. A standardized protocol for preference testing to assess fish welfare. J Vis Exp. 2020;156:e60674. https://doi.org/10.3791/60674.

16. Fernö A, Folkedal O, Nilsson J, Kristiansen TS. Inside the fish brain: cognition, learning

consciousness. In: Kristiansen T, Fernö A, Pavlidis M, van de Vis H, editors. The Welfare of Fish. Animal Welfare Cham. Springer, 2020;20.

17. Eroglu Y. Text Mining Approach for Trend Tracking in Scientific Research: a Case Study on Forest Fire. Fire. 2023;6:33. https://doi.org/10.3390/fire6010033.

18. Mongeon P, Paul-Hus A. The journal coverage of web of science and Scopus: a comparative analysis. Scientometrics. 2016;106(1):213–28.

19. Moher D, Liberati A, Tetzlaff J, Altman DG. PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097. https://doi.org/10.1371/journal.pmed.1000097.

20. Sebastiani F. Machine learning in automated text categorization. ACM-CSUR. 2002;34(1):1–47.

21. Salton G, Buckley C. Term-weighting approaches in automatic text retrieval. Inf Process Manage. 1988;24(5):513–23. https://doi.org/10.1016/0306-4573(88)90021-0.

22. Blei DM, Ng AY, Jordan MI. Latent Dirichlet Allocation. J Mach Learn Res. 2003;3:993–1022.

23. Jelodar H, Wang Y, Yuan C, Feng X, Jiang X, Li Y, Zhao L. Latent dirichlet allocation (LDA) and topic modeling: models, applications, a survey. Multimed Tools Appl. 2019;78(11):15169–211. https://doi.org/10.1007/s11042-018-6894-4.

24. Grün B, Hornik K. Topicmodels: an R Package for Fitting Topic models. J Stat Softw. 2011;40(13):1–30. https://doi.org/10.18637/jss.v040.i13.

25. Nalon E, Contiero B, Gottardo F, Cozzi G. The Welfare of Beef Cattle in the scientific literature from 1990 to 2019: a text Mining Approach. Front Vet Sci. 2021;7:588749. https://doi.org/10.3389/fvets.2020.588749.

26. Verschuere L, Rombaut G, Sorgeloos P, Verstraete W. Probiotic bacteria as biological control agents in aquaculture. Microbiol Mol Biol Rev. 2000;64(4):655–71. https://doi.org/10.1128/MMBR.64.4.655-671.2000.

27. Hong HA, Duc LH, Cutting SM. The use of bacterial spore formers as probiotics. FEMS Microbiol Rev. 2005;29(4):813–35. https://doi.org/10.1016/j.femsre.2004.12.001.

28. Seiler C, Berendonk TU. Heavy metal driven co-selection of antibiotic resistance in soil and water bodies impacted by agriculture and aquaculture. Front Microbiol. 2012;3:399. https://doi.org/10.3389/fmicb.2012.00399.

29. Huntingford FA, Adams C, Braithwaite VA, Kadri S, Pottinger TG, Sandøe P, Turnbull JF. Current issues in fish welfare. J Fish Biol. 2006;68(2):332–72. https://doi.org/10.1111/j.0022-1112.2006.001046.

30. Cabello FC, Godfrey HP, Tomova A, Ivanova L, Dölz H, Millanao A, Buschmann AH. Antimicrobial use in aquaculture re-examined: its relevance to antimicrobial resistance and to animal and human health. Environ Microbiol. 2013;15(7):191742. https://doi.org/10.1111/1462-2920.12134.