JAFOST
Journal of Agri-Food Science and Technology

P-ISSN 2686-0716 | E-ISSN 2746-5519

Journal homepage http://journal2.uad.ac.id/index.php/jafost
Journal email jafost@tp.uad.ac.id

Trends in Indonesian Fermented Fish Research (1967–2024): A Bibliometric Analysis Based on Scopus Database

Mutiara Ulfah[a*], Athiefah Fauziyyah[a], Anis Khairunnisa[b], Dini Nur Hakiki[c]

[a]Food Technology Study Program, Faculty of Science and Technology, Universitas Terbuka, Banten, Indonesia
[b]Marine Product Processing Program, Marine and Fisheries Polytechnic of Jembrana, Bali, Indonesia
[c]Agricultural Engineering Program, Graduate School of Agricultural Science, Kobe University, Kobe, Japan

[*]Corresponding author, Email: mutiaraulfah@ecampus.ut.ac.id

Received 27/09/2025 Revised 04/11/2025 Accepted 05/12/2025

ABSTRACT

Indonesia has a variety of fermented fish products. These products are frequently the subject of academic studies, which result in related research publications. This research contributes to identifying research trends in fermented fish products, particularly in Indonesia using bibliometric analysis. The data sources used are scientific documents published in Scopus. The data were processed in Excel and VOSviewer for data mapping. A total of 83 relevant publications on Indonesian fermented fish were obtained, with the largest output from Indonesia, namely 73 publications. The collected publications published from 1967 to 2024 include 53 articles, 21 conference papers, 4 book chapters, 3 reviews, and 2 books. Data were retrieved in August 2024 using four search strings, i.e, "Fermented Fish AND Indonesia", "Indonesian Fermented AND Fish", "Fish Fermentation AND Indonesia", and "Fermented Seafood AND Indonesia". The main fermented fish products discussed are terasi (13 publications), bakasang (8 publications), budu (8 publications), peda (6 publications), bekasam (11 publications), jambal (3 publications), rusip (4 publications), chao (4 publications), wadi (3 publications), and inasua (5 publications). The current trend in Indonesian fermented fish focuses on three main areas: microbial diversity and the role of lactic acid bacteria; chemical characteristics and nutritional value; and food safety of fermented fish products. Further research has the potential to develop starter cultures, identify the bioactive compounds, assess food safety, and standardize the fermentation process to maintain product quality.

KEYWORDS

Bibliometric; Fermented fish; Lactic acid bacteria; Traditional; VOSviewer

1. INTRODUCTION

Indonesia is an archipelagic nation with a vast ocean area and abundant marine resources, including diverse fish species [1]. This maritime wealth is further complemented by enormous water bodies, such as lakes, rivers, and ponds, which collectively contribute to this country's high potential for fish production [2]. This potential is reflected in data from the Ministry of Maritime and Fisheries Affairs [3], which show production figures for key fish species. In 2023, Indonesia's capture fisheries yielded 761,340 tons of skipjack tuna, 458,899 tons of skipjack, 379,030 tons of mackerel, and 355,966 tons of tuna capture fisheries [3]. Furthermore, aquaculture is crucial in Indonesia's fisheries sector and contributes significantly to production volume. In the same year, aquaculture yielded an estimated 1,368,542 tons of tilapia, 1,136,619 tons of catfish, 772,709 tons of milkfish, and 304,852 tons of various other fish species [3]. While national production data illustrate the importance of fisheries, only essential statistics are highlighted here to maintain focus on the research context.

Fish have a high protein content, which makes them perishable and susceptible to rapid microbial growth and spoilage. Therefore, appropriate processing methods are essential to extend their shelf life and maintain their quality [4]. Among these methods, fermentation emerges as a traditional technology that can

help prolong the shelf life of fishery products [5], [6]. Fermentation has been a long-standing method for preserving fish, dating back to ancient times, and remains a vital practice today [7].

The fermentation process often relies on traditional knowledge and practices passed down through generations, contributing to the diversity of fermented fish products found across different regions [8]. Indonesia, with its rich culinary heritage, offers a diverse range of fermented fish products, such as *bekasam* from Kalimantan [6], *peda* from Java [9], *inasua* from Maluku, *jambal roti* and *terasi* from West Java, *naniura* from North Sumatra, *cincalok* from West Kalimantan, and *rusip* from Bangka Belitung [10]. This diversity plays a crucial role in food security and is central to the nation's cultural and culinary identity.

Research on fermented fish in Indonesia has been gaining attention. It has included studies on microbial characteristics, potential probiotic properties, nutritional and chemical characteristics, and cultural, health, and safety concerns. While these individual studies offer valuable data, comprehensive reviews are crucial for synthesizing existing research findings and identifying research gaps [11], [12]. One method is bibliometric analysis. Bibliometric analysis provides quantitative indicators that help in assessing the influence of research outputs [13], [14]. It enables precise assessment and identification of the research trends, which can guide future research [15].

Previous studies have reviewed specific aspects of fermented fish in Indonesia. Examples of studies include research that explored particular products, such as *bekasam* [6], and the scientific aspects of *inasua* [16]. Other studies have conducted comprehensive literature reviews of the characteristics of lactic acid bacteria (LAB) in Indonesian fermented fish [10] and have analyzed bibliometric data on the traditional food topic [17].

However, despite the previous research's contributions, a research gap remains. There is no literature that presents a quantitative analysis of fermented fish research in Indonesia, especially in the context of bibliometric analysis. Therefore, this study was conducted to provide a comprehensive bibliometric analysis of the developmental trends in Indonesian fermented fish studies over the past decades. The results are expected to offer insights into research trends and future directions for Indonesian fermented fish studies.

2. MATERIALS AND METHODS

2.1. Documents Collection

Data collection involved retrieving articles indexed in the Scopus database. Scopus was selected as the primary database because it provides a broader coverage of content compared to other databases, with a significant number of journals [18], [19]. We acknowledge the limitation of single-database bias inherent in this approach [20].

The exact search query was constructed using four specific keyword combinations using Boolean operators, such as "Fermented Fish AND Indonesia", "Indonesian Fermented AND Fish", "Fish Fermentation AND Indonesia", and "Fermented Seafood AND Indonesia". The final data retrieval was performed in August 2024, yielding 183 articles.

To ensure the dataset's relevance, a rigorous data filtering process was performed [21], [22]. This process, detailed in Figure 1, involved a sequential exclusion based on some criteria. The data cleaning process began with removing duplicate entries to ensure each record was counted only once. Following duplication, the remaining records were screened against several criteria to define the final dataset. The initial inclusion criteria were all types of sources, including journal articles, book chapters, conference papers, reviews, and books published between 1967 and 2024, which were initially considered, provided they represented final, published documents. Furthermore, only English-language articles were included in the analysis. The refinement steps excluded data by subject for the paper, focusing on non-food applications of fermented fish or on non-fermented fish products. This ensured that the entire dataset was relevant to the core topic of fermented fish in food applications. The final step is to ensure that the keyword is consistent to manage synonyms, plural, and singular forms, thereby maintaining consistency across the dataset's terminology. This resulted in a refined dataset of 83 articles suitable for subsequent bibliometric analyses.

2.2. Data Analysis

The dataset was subjected to a thorough data cleaning and completion process in Microsoft Excel [23]. The data was then manually standardized for keywords, ensuring consistency by identifying singular and plural forms and similar words. Subsequently, the clean and complete dataset was processed into VOSviewer (version 1.6.19) for bibliometric analysis [18], [20], [24].

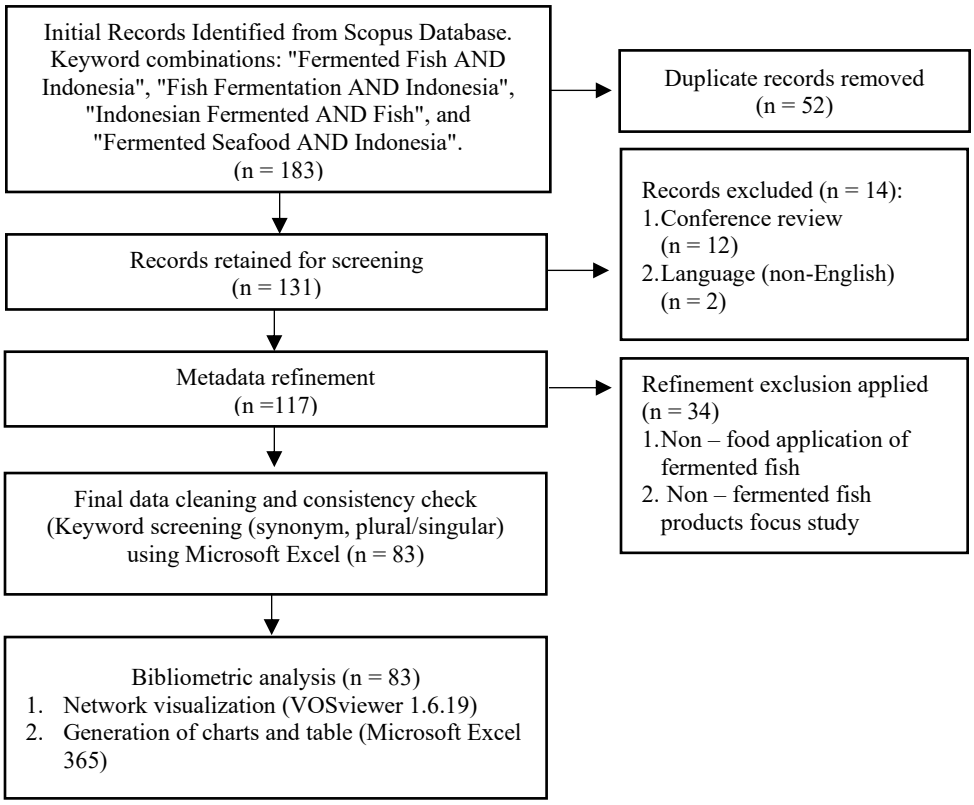

Figure 1. Flow chart of data collection and Bibliometric analysis process.

3. RESULTS AND DISCUSSION

3.1. Trends and Annual Publications in Indonesian Fermented Fish Research

There are several types of research publications on Indonesian fermented fish, including articles, book chapters, conference papers, reviews, and books, published from 1967 to 2024. The number of publications is presented in Figure 2. The first known publication on Indonesian fermented fish appeared in 1967. From 1967 to 2017, the number of publications was low and fluctuated, suggesting little growth in research output on Indonesian fermented fish. After this period, in 2018, the number of publications began to increase, consisting of articles, book chapters, and conference papers, indicating a growing academic interest in the field. This increase peaked in 2020, with 14 research publications, including articles, conference papers, book chapters, and reviews. This number then fluctuated until 2024, but showed an increasing trend compared to the period before 2018. Looking specifically at publications from 1967 to 2024 on Indonesian fermented fish, the most common types were articles (53), followed by conference papers (21), book chapters (4), reviews (3), and books (2). This number will continue to grow as research on Indonesian fermented fish develops.

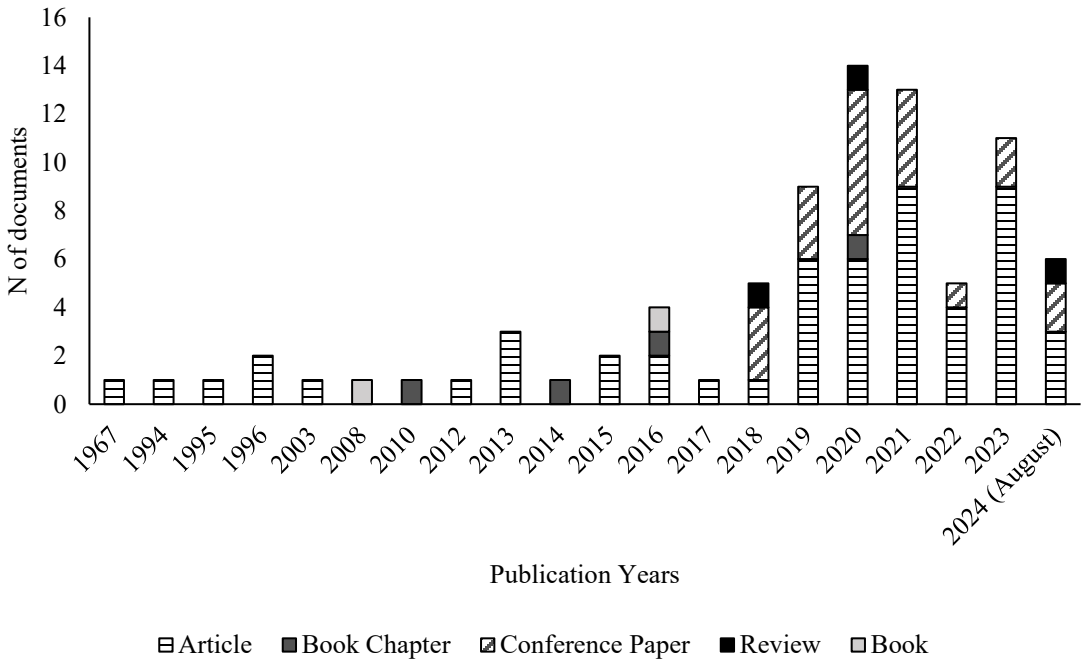

Figure 2. The publication trend of Indonesian fermented fish research in Scopus.

3.2. Most Cited Country in Indonesian Fermented Fish Research

Indonesia demonstrates the highest research focus on fermented fish, as indicated by the data in Table 1, with 75 documents and 518 citations. While Japan has 7 papers on this research topic, fewer than Indonesia, it boasts a high number of citations (225). This suggests that research on Indonesian fermented fish significantly influences the scientific community. Malaysia and Ghana also contribute to this field of study. This data emphasizes the prominent role of Indonesian researchers and the potential for international collaborations to advance knowledge in this field.

Table 1. The 10 leading countries in research output and cited in Indonesian fermented fish.

Country	Documents	Citations
Indonesia	75	518
Japan	7	225
Malaysia	6	52
Ghana	3	37
Thailand	2	2
United States	2	77
Australia	1	28
Belgium	1	6
India	1	28
Canada	1	50

3.3. Most Frequent Keywords Used by Researchers in Indonesian Fermented Fish Studies

Based on data from all types of publications on Indonesian fermented fish, 219 keywords are regularly used by authors. Of these keywords, 31 keywords meet the specified requirements that have at least 3 co-occurrences and were subsequently divided into five distinct clusters. The detailed keywords were presented in Figure 3. Based on the data in Figure 3, the most frequently appearing keyword is "fermented fish." The finding is expected, as the main topic revolves around fermented fish products. The second most common keyword is "lactic acid bacteria", which aligns with Figure 4 from the VOSviewer

results, indicating that many studies on fermented fish products are related to lactic acid bacteria (LAB). Other keywords, such as "fermentation," "traditional," and "fermented process," are associated with the fermentation process of traditional fermented fish products. Additionally, several types of fermented fish products, such as *terasi*, *bekasam*, and *bekasang*, are mentioned, as they are among the most extensively studied product types.

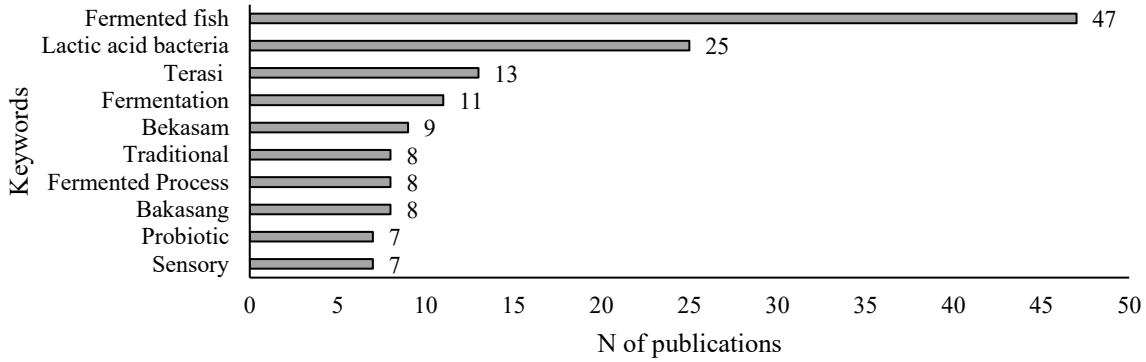

Figure 3. Most frequent keywords used by researchers in Indonesian fermented fish studies.

3.4. Co-occurrence of Keywords Analysis

A VOSviewer network visualization of the relationships among keywords used in research on Indonesian fermented fish is shown in Figure 4(a). In this network, each node represents a keyword, and its size typically reflects the keyword's frequency in the dataset. The connecting lines indicate the co-occurrence relationships between keywords [25]. Based on the visualization's color, five clusters delineate the main intellectual structure of the studies.

One prominent cluster of keywords includes research keywords such as “fermented fish”, “fermentation process”, “flavor”, “amino acid”, “fish sauce”, and “tuna”. This cluster likely represents research focused on the fermentation process and its role in enhancing the flavor of amino acids in fermented fish products. Several studies in this cluster, particularly those on fermented fish products such as fish sauce, used raw materials like tuna.

The second cluster emphasizes keywords such as “lactic acid bacteria”, “antimicrobial”, “16S rRNA”, “*Lactobacillus plantarum*”, “*bekasam*”, and “*chao*”. This cluster likely represents research focused on the role of lactic acid bacteria, particularly *Lactobacillus plantarum*, in producing antimicrobial compounds during fermentation. This research also appears to use 16S rRNA sequencing to identify the beneficial bacteria in Indonesian fermented fish products, such as *bekasam* and *chao*.

The third cluster emphasizes keywords such as “traditional”, “fermentation”, “characteristic”, “*terasi*”, “shrimp”, “shrimp paste”, and “Indonesia”. The connection between these keywords indicates that the research focuses on traditional methods, fermentation processes, distinctive characteristics, and the culture of *terasi* (fermented shrimp paste).

The fourth cluster includes keywords such as “chemical”, “microbiological”, “quality”, “sensory”, “*bakasang*”, “*peda*”, and “sardine”. The connection between these keywords in the context of fermented fish products highlights the intricate relationships among chemical and microbiological processes, quality, and sensory attributes, particularly as applied to products such as *bakasang* and *peda*, which are often made from sardines.

The last (fifth) cluster has the keywords “probiotic”, “characterization”, “*budu*”, “*jambal*”, and “*rusip*”. This cluster likely represents research focused on the exploration and characterization of the probiotic potential of Indonesian fermented fish products, such as *jambal*, *budu*, and *rusip*. This research highlights their potential health benefits and uses scientific methods to identify and validate probiotic properties.

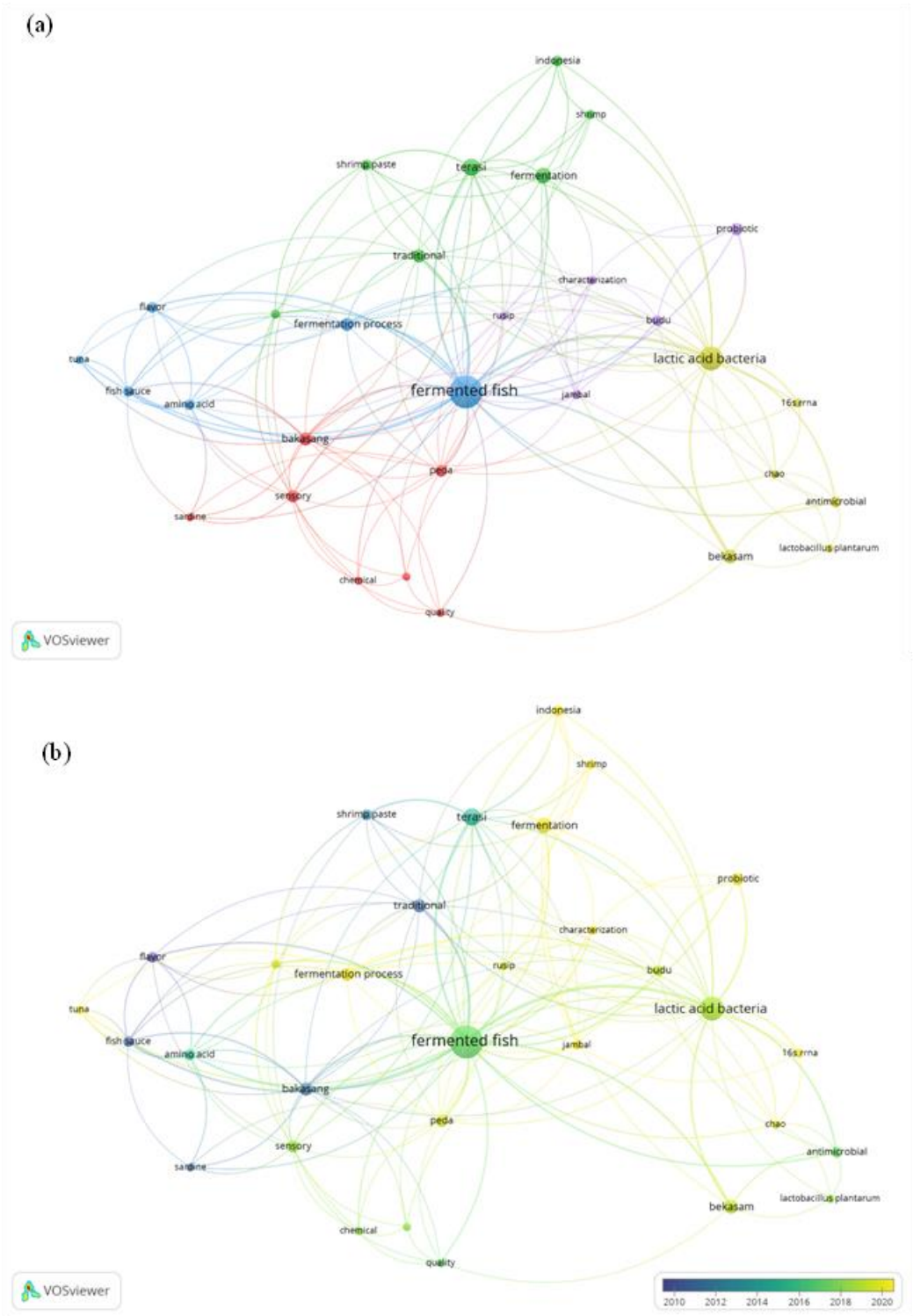

Figure 4. Co-occurrence of all keywords in Indonesian fermented fish research. (a) Illustrates the keyword clustering, (b) annual trends in keywords used for Indonesian fermented fish research.

3.5. Research Trend

The analysis of research trends on Indonesian fermented fish is presented in Figure 4(b). The data reveal that three primary thematic areas have emerged as dominant research focuses over the recent period

(2010–2020). The first primary focus is on microbial diversity and the role of lactic acid bacteria (LAB) in the fish fermentation process. Many studies have been dedicated to identifying and characterizing microbial communities, particularly LAB, from various Indonesian fermented fish products, including *wadi* [26], [27], *bekasam* [28], [29], *jambal* [30], *pado* [31], and *budu* [32], [33]. Several of those studies have also employed 16S rRNA gene sequencing for molecular identification [26], [31], [34], [35], [36]. It also includes studies on the antimicrobial effects of LAB against pathogens such as *Salmonella sp*., *Staphylococcus aureus*, and *E. coli* [33], [35], [37]. Research on LAB also includes the health potential of bioactive compounds produced during fermentation, such as gamma-aminobutyric acid (GABA) [38] and bacteriocins [39].

The second research trend topic focuses on the chemical characteristics and nutritional composition of fish products during fermentation. Some studies show that fermentation can significantly alter the chemical composition, thereby improving the product's taste. For example, during the fermentation of fish sauce, *chao*, and shrimp paste, protein hydrolysis occurs, producing free amino acids that play an essential role in forming the umami taste [40], [41], [42]. Several studies have examined the factors influencing these changes, including fermentation conditions and raw materials. There are studies comparing the effects of different fermentation conditions on the amino acid and fatty acid profiles of *inasua* fish products [43]. Other research examines the chemical characteristics of various types of fish sauce based on the raw materials used [41]. Some studies observe the effect of adding sucrose on the sensory quality of shrimp paste [44].

The third topic trend is research on food safety in Indonesian fermented fish products. During the fish fermentation process, compounds such as histamine, acrylamide, and other biogenic amines can form, which potentially affect food safety [45], [46]. The addition of fish to the production of *terasi*, for example, can increase levels of histamine and acrylamide, thereby requiring greater attention to food safety [45].

Based on current trends, research on Indonesian fermented fish products is expected to continue to grow. This research can explore various aspects, including the role of microbes—particularly lactic acid bacteria (LAB) in the fermentation process. Understanding LAB's contribution could lead to the development of starter cultures, ensuring consistent quality in fermented fish products. Furthermore, studies can focus on identifying bioactive compounds with health benefits, assessing food safety to mitigate potential risks, and standardizing production processes to maintain quality and product characteristics. The development of research in this field is expected to provide significant knowledge and enhance its cultural heritage and commercial potential.

This trend in fermented fish studies in Indonesia can provide an overview as a basis for further research. However, this study has methodological limitations, namely the use of a single primary data source (the Scopus database) and the range of data obtained based on the time of data collection [47]. Using a single Scopus database led to the exclusion of relevant articles from other databases that could have provided additional data. To address this limitation, future research should expand data sources by incorporating multiple databases and updating data collection periodically to capture ongoing developments. These steps will ensure the results remain up to date with the evolving landscape of fermented fish research in Indonesia.

4. CONCLUSION

A bibliometric analysis of Indonesian fermented fish indicates a growing research trend, with 83 publications across various document types, including articles, book chapters, conference papers, reviews, and books published between 1967 and 2024. In this study, several keywords were frequently used, including fermented fish, lactic acid bacteria, fermentation process, and Indonesian fermented fish products such as *terasi*, *bekasam*, and *bekasang*. These keywords highlight the study's core research focus. Specifically, the analysis reveals three main thematic focuses: (1) the identification and functional role of microbial diversity, specifically lactic acid bacteria, during the fermentation process; (2) the analysis of chemical characteristics and the resulting nutritional enhancement of the products; and (3) the assessment of food safety protocols within fermented fish processing. Future research in this field holds significant potential, encompassing the development of starter cultures for fish product fermentation, the identification

of bioactive compounds, food safety assessment, the standardization of fermentation processes to maintain product quality, and the strengthening of the commercial potential of these Indonesian fermented fish products.

AUTHOR CONTRIBUTION

Mutiara Ulfah: Writing (original draft), formal analysis, methodology, and conceptualization. **Athiefah Fauziyyah**: Writing (original draft), resources, conceptualization, and investigation. **Anis Khairunnisa**: Investigation, data curation, visualization, writing (review and editing), and supervision. **Dini Nur Hakiki:** writing, supervision, writing (review), and conceptualization.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this article.

ACKNOWLEDGMENT

This study was supported by a grant from LPPM (Institute of Research and Community Service) Universitas Terbuka. The authors are very grateful for their invaluable support in completing this article.

REFERENCES

[1] R. S. Pontoh, S. Mulyani, S. Zhahira, O. A. Wiratama, M. N. Farras, and R. Arisanti, "Mapping Indonesian potential fishing zone using hierarchical and non-hierarchical clustering," *Commun. Math. Biol. Neurosci.*, vol. 23, pp. 1–18, 2023, https://doi.org/10.28919/cmbn/8088.

[2] N. M. S. Iswari, Wella, and Ranny, "Fish freshness classification method based on fish image using k-Nearest Neighbor," in *4th International Conference on New Media Studies (CONMEDIA)*, IEEE, pp. 87–91, 2017, https://doi.org/10.1109/CONMEDIA.2017.8266036.

[3] Ministry of Maritime and Fisheries Affairs, "Data and statistics of fisheries production in Indonesia." [Online]. Available: https://portaldata.kkp.go.id/portals/data-statistik/layer1.

[4] X. Nie, R. Zhang, L. Cheng, W. Zhu, S. Li, and X. Chen, "Mechanisms underlying the deterioration of fish quality after harvest and methods of preservation," *Food Control*, vol. 135, p. 108805, 2022, https://doi.org/10.1016/j.foodcont.2021.108805.

[5] R. Azara, I. A. Saidi, Omega, and L. Hudi, "Quality of snakehead fish (*Channa striata*) bekasam fermented in various media and salt concentration," *J. Phys. Conf. Ser.*, vol. 1232, no. 1, p. 012044, 2019, https://doi.org/10.1088/1742-6596/1232/1/012044.

[6] R. H. B. Setiarto and V. T. Herlina, "Exploring bekasam, an indigenous fermented fish product of Indonesia: Original South Sumatra region," *J. Ethn. Foods*, vol. 11, no. 1, p. 18, 2024, https://doi.org/10.1186/s42779-024-00230-w.

[7] A. A. Ayeloja and W. A. Jimoh, "Fermented fish products in Sub-Saharan Africa," in *African Fermented Food Products- New Trends*, Cham: Springer International Publishing, pp. 251–263, 2022, https://doi.org/10.1007/978-3-030-82902-5_17.

[8] N. S. Antara, I. B. W. Gunam, P. K. D. Kencana, and I. M. S. Utama, "The role of lactic acid bacteria on safety and quality of fermented foods," in *AIP Conference Proceedings*, p. 020005, 2019, https://doi.org/10.1063/1.5125509.

[9] M. Intania, N. Arpi, and Hasanuddin, "Effect of salt pretreatment, chitosan, and storage period on the sensory acceptability of peda, fermented sardine (*Sardinella* sp.)," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 425, no. 1, p. 012082, 2020, https://doi.org/10.1088/1755-1315/425/1/012082.

[10] A. A. Prihanto, N. I. Umam, and J. D. G. Bangun, "Unveiling the secrets of Indonesian fermented fish: Characteristics of lactic acid bacteria, roles, and potential in product development," *Food Biosci.*, vol. 61, p. 104629, 2024, https://doi.org/10.1016/j.fbio.2024.104629.

[11] C. Leenaars, K. Tsaioun, F. Stafleu, K. Rooney, F. Meijboom, M. Ritskes-Hoitinga, and A. Bleich, "Reviewing the animal literature: How to describe and choose between different types of literature reviews," *Lab. Anim.*, vol. 55, no. 2, pp. 129–141, 2021, https://doi.org/10.1177/0023677220968599.

[12] C. L. Russell, "An overview of the integrative research review," *Prog. Transplant.*, vol. 15, no. 1,

pp. 8–13, 2005, https://doi.org/10.1177/152692480501500102.
[13] G. Haddow, "Bibliometric research," in *Research Methods*, Elsevier, pp. 241–266, 2018, https://doi.org/10.1016/B978-0-08-102220-7.00010-8.
[14] T. Brown, S. A. Gutman, and Y. Ho, "Occupational therapy publications by Australian authors: A bibliometric analysis," *Aust. Occup. Ther. J.*, vol. 65, no. 4, pp. 249–258, 2018, https://doi.org/10.1111/1440-1630.12453.
[15] M. S. Patel, D. Franceschelli, A. Grossbach, J. K. Zhang, P. A. Mercier, and T. A. Mattei, "Top 50 spine surgery publications most cited by patents: A bibliometric analysis focused on research driving innovation," *World Neurosurg.*, vol. 191, pp. 234–244, 2024, https://doi.org/10.1016/j.wneu.2024.08.079.
[16] C. B. Persulessy, E. Kusdiyantini, R. S. Ferniah, T. W. Agustini, and A. Budiharjo, "Ina sua: The traditional food fermentation from Teon Nila Serua, Central of Maluku, Indonesia," *J. Ethn. Foods*, vol. 7, no. 1, p. 24, 2020, https://doi.org/10.1186/s42779-020-00055-3.
[17] M. Djalal, J. Tashi Wangdi, A. Dirpan, F. Bastian, R. Latief, A. F. Ainani, and D. S. Yolanda, "Traditional Indonesian food: A bibliometric review from 2013-2022," *Canrea J. Food Technol. Nutr. Culin. J.*, pp. 172–182, 2022, https://doi.org/10.20956/canrea.v5i2.736.
[18] F. I. Maulana, D. Lestari, V. P. Widartha, N. Haidar, and W. Dirgantara, "Digital technology in health education trend mapping through bibliometrics analysis," in *International Conference on Informatics, Multimedia, Cyber and Information System (ICIMCIS)*, IEEE, pp. 523–528, 2022, https://doi.org/10.1109/ICIMCIS56303.2022.10017990.
[19] A. Fitriani, H. Onyeaka, and F. C. Agustia, "Mapping the worldwide knowledge of jack bean by a bibliometric approach," *J. Agri-Food Sci. Technol.*, vol. 5, no. 1, pp. 1–17, 2024, https://doi.org/10.12928/jafost.v5i1.10235.
[20] O. D. W. Ardhi, T. R. Soeprobowati, K. Adi, E. Prakasa, and A. Rachman, "Deep learning methods for plankton identification: A bibliometric analysis and general review," in *1st International Conference on Smart Technology, Applied Informatics, and Engineering (APICS)*, IEEE, pp. 96–101, 2022, https://doi.org/10.1109/APICS56469.2022.9918707.
[21] S. C. J. Lim and I. S. Ghazali, "Research evolution in design engineering education: A visual approach using thematic network," in *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, IEEE, pp. 504–508, 2017, https://doi.org/10.1109/IEEM.2017.8289942.
[22] J. Han, H.-J. Kang, M. Kim, and G. H. Kwon, "Mapping the intellectual structure of research on surgery with mixed reality: Bibliometric network analysis (2000–2019)," *J. Biomed. Inform.*, vol. 109, p. 103516, 2020, https://doi.org/10.1016/j.jbi.2020.103516.
[23] S. Janzen, "Advancing the advanced search: Improving the web of science user experience with a spreadsheet search query tool," *HCI International 2022 Posters*, pp. 292–299, 2022, https://doi.org/10.1007/978-3-031-06417-3_40.
[24] J. Li, C. Deacon, and M. R. Keezer, "The performance of bibliometric analyses in the health sciences," *Curr. Med. Res. Opin.*, vol. 40, no. 1, pp. 97–101, 2024, https://doi.org/10.1080/03007995.2023.2281503.
[25] Z. Yin, Y. Chen, J. Gu, S. Ying, and Y. Guo, "A knowledge graph construction method based on co-occurrence for traffic entity prediction," *Int. J. Appl. Earth Obs. Geoinf.*, vol. 142, p. 104717, 2025, https://doi.org/10.1016/j.jag.2025.104717.
[26] Y. B. Soemarie, T. Milanda, and M. I. Barliana, "Isolation, characterization, and identification candidate of probiotic bacteria isolated from Wadi Papuyu (*Anabas testudineus* Bloch.) a fermented fish product from central Kalimantan, Indonesia," *Int. J. Food Sci.*, vol. 22, pp. 1–9, 2022, https://doi.org/10.1155/2022/4241531.
[27] H. Cai, L. Tao, X. Zhou, Y. Liu, D. Sun, Q. Ma, Z. Yu, and W. Jiang, "Lactic acid bacteria in fermented fish: Enhancing flavor and ensuring safety," *J. Agric. Food Res.*, vol. 16, p. 101206, 2024, https://doi.org/10.1016/j.jafr.2024.101206.
[28] S. Sukmawati, R. Ratna, S. Sipriyadi, and M. Yunita, "Characterization and molecular identification

of bacteria from mackerel *bekasam* in Sorong City, Southwest Papua Province, Indonesia," *Biodiversitas J. Biol. Divers.*, vol. 24, no. 9, 2023, https://doi.org/10.13057/biodiv/d240940.

[29] A. Miftachurrochmah, K. Fibrianto, and W. Bekti Sunarharum, "*Bekasam*, an Indonesian unique traditional fermented fish as umami sources," *Adv. Food Sci. Sustain. Agric. Agroindustrial Eng.*, vol. 7, no. 2, pp. 158–168, 2024, https://doi.org/10.21776/ub.afssaae.2024.007.02.5.

[30] M. Karyantina, S. Anggrahini, T. Utami, and E. S. Rahayu, "Moderate halophilic lactic acid bacteria from jambal roti: A traditional fermented fish of Central Java, Indonesia," *J. Aquat. Food Prod. Technol.*, vol. 29, no. 10, pp. 990–1000, 2020, https://doi.org/10.1080/10498850.2020.1827112.

[31] Y. Syafitri, H. D. Kusumaningrum, and R. Dewanti-Hariyadi, "Identification of microflora and lactic acid bacteria in pado, a fermented fish product prepared with dried *Pangium edule* seed and grated coconut," *Food Sci. Technol.*, vol. 42, 2022, https://doi.org/10.1590/fst.19921.

[32] Y. Marlida, M. Susalam, H. Harnentis, J. Jamsari, N. Huda, W. Noordin, L. Anggraini, and L. Ardani, "Metagenomic analysis and biodiversity of bacteria in traditional fermented fish or *Budu* from West Sumatera, Indonesia," *J. Adv. Vet. Anim. Res.*, p. 1, 2024, https://doi.org/10.5455/javar.2023.j736.

[33] H. Harnentis, Y. Marlida, Y. S. Nur, W. Wizna, M. A. Santi, N. Septiani, F. Adzitey, and N. Huda, "Novel probiotic lactic acid bacteria isolated from indigenous fermented foods from West Sumatera, Indonesia," *Vet. World*, vol. 13, no. 9, pp. 1922–1927, 2020, https://doi.org/10.14202/vetworld.2020.1922-1927.

[34] M. Karyantina, S. Anggrahini, T. Utami, and E. S. Rahayu, "Jambal roti characteristics: A traditional fermented fish from Rembang, Central Java," *Food Res.*, vol. 5, no. S2, pp. 128–134, 2021, https://doi.org/10.26656/fr.2017.5(S2).011.

[35] L. Anggriani, S. Budiarti, and N. R. Mubarik, "Lipase-producing ability of bacteria from *inasua* (fish fermented product) from Central Moluccas, Indonesia," *Biodiversitas J. Biol. Divers.*, vol. 21, no. 2, 2020, https://doi.org/10.13057/biodiv/d210226.

[36] J. Kanklai, T. C. Somwong, P. Rungsirivanich, and N. Thongwai, "Screening of GABA-producing lactic acid bacteria from Thai fermented foods and probiotic potential of Levilactobacillus brevis F064A for GABA-fermented mulberry juice production," *Microorganisms*, vol. 9, no. 1, p. 33, 2020, https://doi.org/10.3390/microorganisms9010033.

[37] H.-Y. Lin, P.-Y. Chen, F.-Y. Shen, H.-W. Chang, and T.-T. Chou, "Improving antagonistic effect of Lactobacillus gasseri MS-72 with herbal medicine extracts against pathogenic bacteria," *The Microbe*, vol. 9, p. 100583, 2025, https://doi.org/10.1016/j.microb.2025.100583.

[38] A. L. O. Putri, E. Kusdiyantini, and S. Pujiyanto, "The growth and potential of gamma-aminobutyric acid (GABA) by lactic acid bacteria isolated from fish fermented food from Maluku, Indonesia," *J. Phys. Conf. Ser.*, vol. 1524, no. 1, p. 012133, 2020, https://doi.org/10.1088/1742-6596/1524/1/012133.

[39] I. Desniar, A. Rusmana, Suwanto, and N. R. Mubarik, "Organic acid produced by lactic acid bacteria from bekasam as food biopreservatives," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 414, no. 1 (Jan), p. 012003, 2020, https://doi.org/10.1088/1755-1315/414/1/012003.

[40] U. Syahriati, M. N. Fitriani, R. Yusuf, Saleh, Luthfiah, and Sumarni, "Chao teri: The traditional fish fermentation from South Sulawesi, Indonesia," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1097, no. 1 (Oct), p. 012070, 2022, https://doi.org/10.1088/1755-1315/1097/1/012070.

[41] J. Leiwakabessy, R. B. D. Sormin, and M. N. Mailoa, "Amino acid profile of tuna (*Thunnus albacores*) fish sauce fermented by salt and papain enzyme," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 777, no. 1, p. 012027, 2021, https://doi.org/10.1088/1755-1315/777/1/012027.

[42] A. A. Prihanto, R. Nurdiani, Y. D. Jatmiko, M. Firdaus, and T. S. Kusuma, "Physicochemical and sensory properties of *terasi* (an Indonesian fermented shrimp paste) produced using *Lactobacillus plantarum* and *Bacillus amyloliquefaciens*," *Microbiol. Res.*, vol. 242, p. 126619, 2021, https://doi.org/10.1016/j.micres.2020.126619.

[43] F. Mahulette, "Microbiological and chemical characteristics of porkfish *inasua*, traditional fish fermented from Maluku, Indonesia," *Biodiversitas J. Biol. Divers.*, vol. 25, no. 1, 2024, https://doi.org/10.13057/biodiv/d250101.

[44] L. Rianingsih, Sumardianto, Romadhon, M. B. Rusdi, and P. H. Riyadi, "The effect of sucrose addition on the sensory quality of 'terasi' an Indonesian shrimp paste," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 890, no. 1, p. 012048, 2021, https://doi.org/10.1088/1755-1315/890/1/012048.

[45] R. Surya, D. Nugroho, N. Kamal, and K. Petsong, "Characteristics of Indonesian traditional fermented seafood paste (*terasi*) made from shrimp and anchovy," *J. Ethn. Foods*, vol. 11, no. 1, p. 2, 2024, https://doi.org/10.1186/s42779-023-00218-y.

[46] M. T. D. Ambarita, K. Raes, and B. De Meulenaer, "Identification of key sensory attributes of sambal-terasi, impact of different type of terasi, chemical characteristics and salt addition," *Sains Malaysiana*, vol. 49, no. 3, pp. 561–571, 2020, https://doi.org/10.17576/jsm-2020-4903-11.

[47] A. Dirpan, M. Djalal, K. I. Prahesti, N. A. Bahmid, and S. Asab, "A bibliometric analysis of understanding absorbent food for the development of sustainable packaging," in *IOP Conference Series: Earth and Environmental Science*, p. 012183, 2023, https://doi.org/10.1088/1755-1315/1230/1/012183.