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BIBLIOMETRIC STUDY ON PRESERVATION METHODS IN TILAPIA SHELF LIFE

ESTUDO BIBLIOMÉTRICO SOBRE MÉTODOS DE CONSERVAÇÃO NA VIDA ÚTIL DA TILÁPIA

ESTUDIO BIBLIOMÉTRICO SOBRE MÉTODOS DE CONSERVACIÓN EN LA VIDA ÚTIL DE LA TILAPIA

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ABSTRACT:
Tilapia is one of the most widely produced fish species worldwide and plays an important role in global aquaculture. However, its chemical composition makes it highly susceptible to spoilage, requiring effective preservation strategies to maintain product quality and extend shelf life. This study aimed to conduct a bibliometric analysis of scientific publications related to tilapia shelf life, focusing on preservation methods and research trends. The bibliographic search was performed in the Web of Science Core Collection database using the terms “Tilapia” AND “shelf life”. After applying inclusion criteria and screening titles and abstracts, 170 research articles published between 1983 and 2025 were selected for analysis. Bibliometric indicators, including publication trends, leading countries and institutions, collaboration networks, most cited articles, and keyword co-occurrence patterns, were analyzed using VOSviewer software. The results showed a significant increase in publications after 2010, with China, Brazil, and India standing out as the most productive countries. However, the co-authorship analysis revealed limited international collaboration among research groups. In addition, keyword analysis indicated a technological evolution in preservation methods, with increasing emphasis on natural preservatives, edible coatings, and emerging technologies such as cold plasma. These findings provide a comprehensive overview of global research trends and highlight opportunities to strengthen international collaboration and technological innovation in tilapia preservation studies.

KEYWORDS: Tilapia conservation, emerging technologies, storage stability.

RESUMO:
A tilápia é uma das espécies de peixe mais produzidas no mundo e desempenha um papel importante na aquicultura global. No entanto, sua composição química a torna altamente suscetível à deterioração, exigindo estratégias eficazes de conservação para manter a qualidade do produto e prolongar sua vida útil. Este estudo teve como objetivo realizar uma análise bibliométrica de publicações científicas relacionadas à vida útil da tilápia, com foco em métodos de conservação e tendências de pesquisa. A busca bibliográfica foi realizada na base de dados Web of Science Core Collection utilizando os termos “Tilápia” E “vida útil”. Após a aplicação dos critérios de inclusão e a triagem de títulos e resumos, 170 artigos científicos publicados entre 1983 e 2025 foram selecionados para análise. Os indicadores bibliométricos, incluindo tendências de publicação, principais países e instituições, redes de colaboração, artigos mais citados e padrões de coocorrência de palavras-chave, foram analisados utilizando o software VOSviewer. Os resultados mostraram um aumento significativo nas publicações após 2010, com China, Brasil e Índia se destacando como os países mais produtivos. No entanto, a análise de coautoria revelou uma colaboração internacional limitada entre os grupos de pesquisa. Além disso, a análise de palavras-chave indicou uma evolução tecnológica nos métodos de conservação, com ênfase crescente em conservantes naturais, revestimentos comestíveis e tecnologias emergentes, como o plasma frio. Esses resultados fornecem uma visão abrangente das tendências globais de pesquisa e destacam oportunidades para fortalecer a colaboração internacional e a inovação tecnológica em estudos de conservação de tilápia.

PALAVRAS-CHAVE: Conservação de tilápia, tecnologias emergentes, estabilidade de armazenamento.

RESUMEN:
La tilapia es una de las especies de peces más producidas a nivel mundial y desempeña un papel importante en la acuicultura global. Sin embargo, su composición química la hace altamente susceptible al deterioro, lo que requiere estrategias de conservación efectivas para mantener la calidad del producto y prolongar su vida útil. Este estudio tuvo como objetivo realizar un análisis bibliométrico de publicaciones científicas relacionadas con la vida útil de la tilapia, centrándose en los métodos de conservación y las tendencias de investigación. La búsqueda bibliográfica se realizó en la base de datos de la Colección Principal de Web of Science utilizando los términos "Tilapia" y "vida útil". Tras aplicar los criterios de inclusión y filtrar títulos y resúmenes, se seleccionaron para su análisis 170 artículos de investigación publicados entre 1983 y 2025. Se analizaron indicadores bibliométricos, incluyendo tendencias de publicación, países e instituciones líderes, redes de colaboración, artículos más citados y patrones de coocurrencia de palabras clave, mediante el software VOSviewer. Los resultados mostraron un aumento significativo en las publicaciones después de 2010, destacando China, Brasil e India como los países más productivos. Sin embargo, el análisis de coautoría reveló una limitada colaboración internacional entre los grupos de investigación. Además, el análisis de palabras clave indicó una evolución tecnológica en los métodos de conservación, con un énfasis creciente en conservantes naturales, recubrimientos comestibles y tecnologías emergentes como el plasma frío. Estos hallazgos ofrecen un panorama completo de las tendencias globales de investigación y destacan oportunidades para fortalecer la colaboración internacional y la innovación tecnológica en los estudios de conservación de tilapia.

PALABRAS CLAVE: Conservación de tilapia, tecnologías emergentes, estabilidad de almacenamiento.

INTRODUCTION

Global aquaculture has grown in recent years, surpassing capture fishery production and contributing 57% of fish production for human consumption (FAO, 2024). The increased fish supply has led to higher consumption due to falling prices (Ali et al., 2018). However, other factors also affect the demand for fish, such as consumers, the market, and the important nutritional and functional properties of this group of animal proteins (Chikowi et al., 2021).

Among the main aquaculture species, tilapia stands out as the second most produced group of fish worldwide, after carp, and Brazil's most produced fish (FAO, 2024; Peixe BR, 2024). The consumption of tilapia meat can guarantee food and nutritional security due to its composition, which provides consumers with a high-quality source of proteins and essential lipids (Hossain et al., 2022; Chikowi et al., 2021).

However, tilapia has a compromised shelf life due to the presence of accompanying microbiota and enzymatic reactions, which makes the fish susceptible to spoilage due to its large percentage of moisture and high-water activity, pH close to neutrality, presence of polyunsaturated fatty acids, and muscle enzymes contained in its chemical composition (Kilincceker et al., 2009; Shao et al., 2023; Gonçalves, 2021). To extend tilapia shelf life, several preservation methods can reduce or even prevent deterioration reactions, such as active packaging, modified atmosphere, the application antimicrobials and antioxidants, or maintaining

the cold chain when storing the product (Sharma et al., 2024; Yudhistira et al., 2024; Liu et al., 2024; Shahrier et al., 2023).

Traditional preservation methods, such as heat, cold, salting, and smoking, are also widely used to combat the microbial and oxidative deterioration of tilapia (Al Banna et al., 2022; Jiang et al., 2023; Basak et al., 2023; Ruiz-Alonso et al., 2021). However, the preservation mechanism used may affect the product's sensory characteristics, which may influence consumer preferences and choices (Andoh-Odoom et al., 2024).

Therefore, it is important to evaluate the application of preservation methods, the resulting sensory changes, and their effects on tilapia shelf life in order to identify technological trends and better understand the evolution of research and market demands related to tilapia products. Thus, the objective of this study was to carry out a bibliometric review of tilapia and its shelf life, with a focus on preservation methods.

METHODOLOGY

The bibliographic search was conducted in the Web of Science Core Collection database in April 2026. The search strategy used the keywords and Boolean operator: “Tilapia” AND “shelf life”, applied to titles, abstracts, and keywords. This search initially retrieved 311 documents.

To ensure the consistency and relevance of the dataset, a screening process was carried out based on previously defined inclusion and exclusion criteria. Initially, documents published after 2025 were excluded, since data collection took place in April 2026 and publications for 2026 were not yet fully indexed in the database. Therefore, 3 documents were excluded, resulting in 308 records.

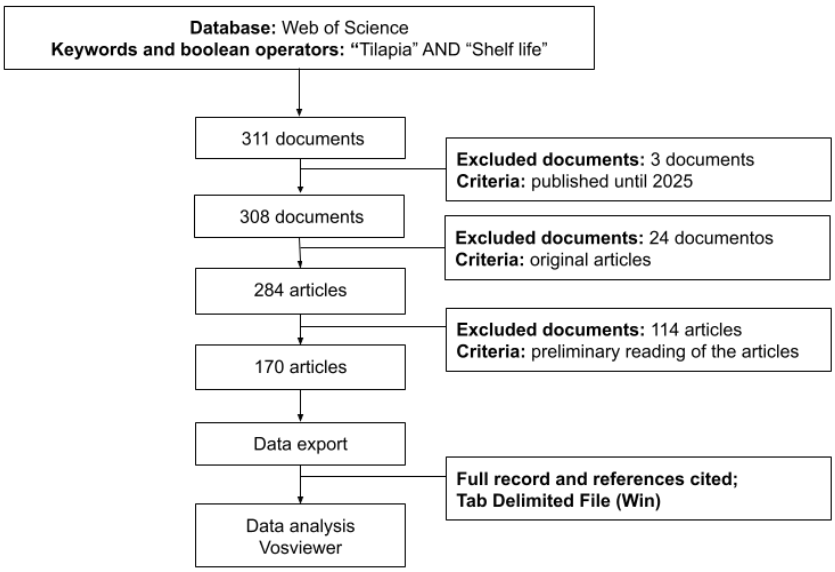
Next, only original research articles were considered, excluding other types of documents such as reviews, conference papers, book chapters, and editorial notes. After this step, the dataset was reduced to 284 articles.

A preliminary screening of titles and abstracts was then conducted to identify studies specifically related to preservation methods, shelf-life evaluation, and sensory or nutritional quality of tilapia products. Articles that did not specifically address preservation methods or shelf-life extension of tilapia were excluded. Studies focused on other fish species were also removed, even when the term “tilapia” appeared in the title, abstract, or keywords, but was not the main subject of the research. After this filtering process, a final dataset of 170 articles published between 1983 and 2025 was obtained.

After defining the dataset, the bibliometric analysis was conducted to evaluate publication trends over time, leading countries and institutions, collaboration networks, most cited articles, and keyword co-occurrence patterns. The bibliographic data were exported from Web of Science in full record and cited references format (tab-delimited file) and analyzed using VOSviewer software (version 1.6.20).

The methodological steps adopted in the selection and analysis of articles are summarized in Figure 1.

Figure 1 - Methodological steps for conducting the bibliometric analysis.



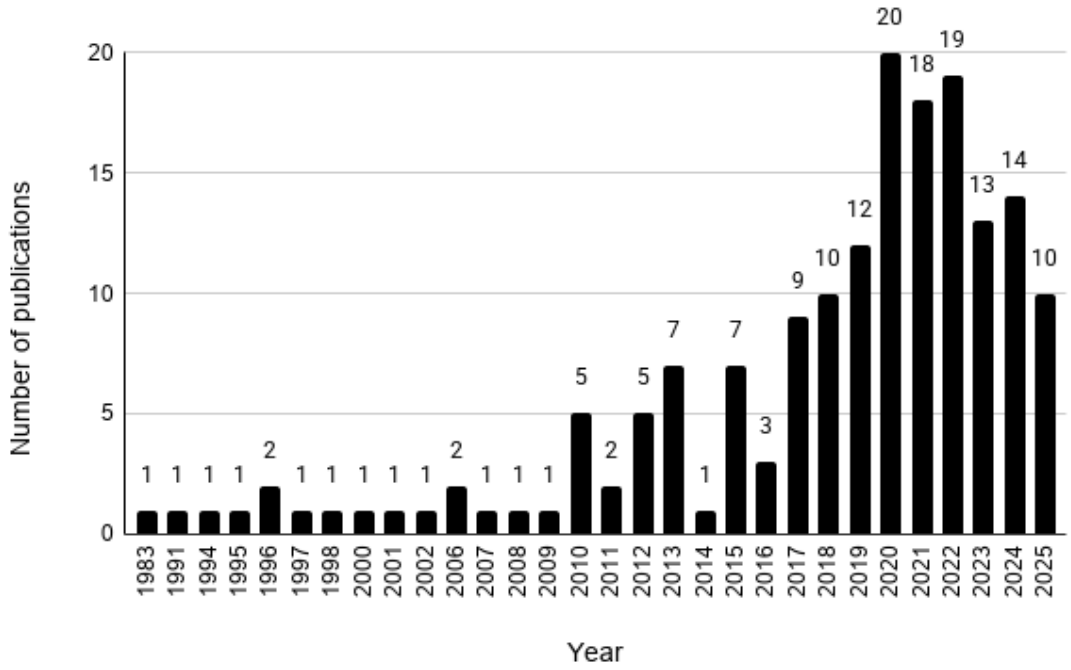
Source: Authors, 2026.

RESULTS AND DISCUSSION

Distribution of publications by year

Figure 2 shows the annual distribution of publications related to tilapia shelf life. The first study addressing preservation methods for tilapia was published in 1983. During the following years, scientific production remained low, oscillating between one and two publications per year, totaling 18 publications between 1983 and 2009.

Figure 2 – Total number of publications involving research on tilapia shelf life by year of publication in the Web of Science database from 1983 to 2025.



Source: Web of Science, 2026.

From 2010 onwards, however, the number of publications increased considerably, reflecting a growing scientific interest in technologies aimed at extending the shelf life of tilapia products. The peak of annual publications was observed in 2020, with 20 studies, followed by 19 publications in 2022 and 18 publications in 2021 (Figure 2).

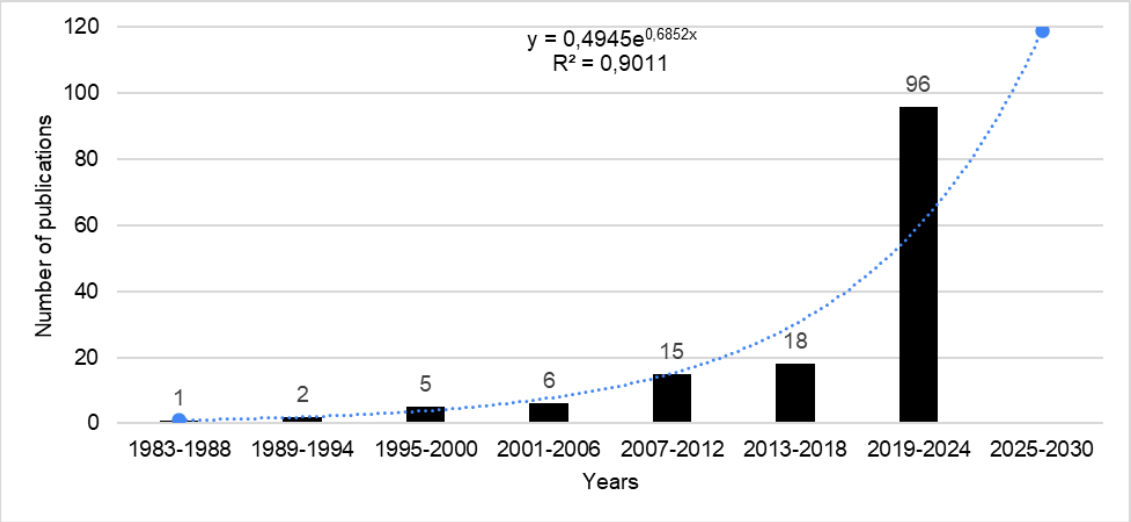
The increase in studies on tilapia shelf life may be associated with the expansion of global aquaculture production. According to FAO (2024), aquaculture production expanded by approximately 204% between 1990 and 2022, with an average annual growth rate of 5.2%. The growing availability of tilapia in global markets increases the demand for technologies capable of preserving product quality during storage and distribution.

In addition, consumers have become increasingly concerned about food quality and freshness, which stimulates research aimed at extending shelf life without compromising nutritional and sensory characteristics (Domínguez-Aragón et al., 2018). Another factor contributing to the growth of research in this area is the increase in global fish consumption, which reached approximately 20 kg per capita in 2022 and is projected to reach 21.3 kg per capita by 2032 (FAO, 2024). Furthermore, fish farming is often considered a more environmentally sustainable source of animal protein when compared to the production of other animal protein sources (Amorim & Tosta, 2020; Poore & Nemecek, 2018).

Although annual publication data provide a detailed view of research activity over time, short-term variations may occur due to normal fluctuations in scientific production or delays in

database indexing. Therefore, to better visualize long-term trends in scientific output, publications were grouped into five-year intervals (Figure 3).

Figure 3 - Temporal distribution of publications on tilapia shelf life grouped into five-year periods (1983–2023).



Source: Web of Science, 2024.

The analysis based on these five-year intervals reveals a clear exponential growth in the number of studies related to tilapia shelf life over the past decades. While early periods between 1983 and 2006 show small publication numbers, a significant increase is observed from 2007 onwards. The most recent period (2019–2023) accounts for the highest number of publications, indicating a consolidation and expansion of research in this field.

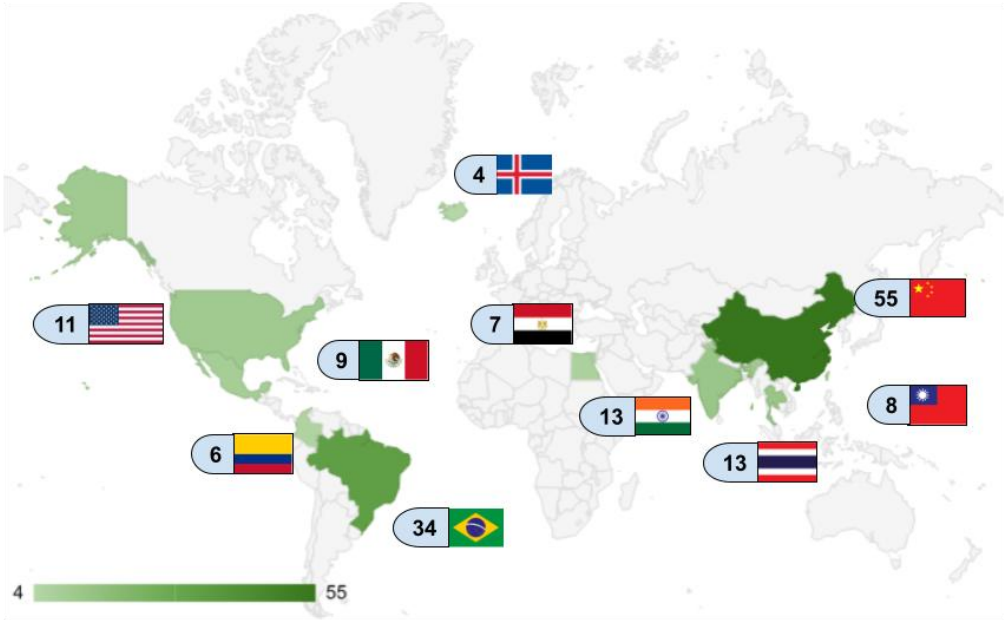
This growth reflects the increasing economic importance of tilapia in global aquaculture and the growing need for technological solutions that improve product quality, storage stability, and distribution efficiency. During the COVID-19 pandemic, tilapia remained an accessible source of animal protein in several regions due to its relatively lower market price (Hasan *et al*., 2021; Mitra *et al*., 2022), which may have contributed to maintaining scientific interest in technologies related to tilapia preservation and processing.

Although the exponential trend model indicated a projection of a more pronounced increase in the number of publications only for the 2025–2030 period, the observed data show that this growth occurred earlier than expected, with a significant rise already evident during the 2019–2024 period. This acceleration can be attributed to the significant increase in scientific and industrial interest in the topic, driven by the expansion of aquaculture and the demand for safe foods with a longer shelf life. Thus, the intensification of research occurred earlier than expected, highlighting an acceleration in scientific development in the field.

Distribution of publications by countries

Figure 4 shows the distribution of articles based on the ten most influential countries in research associated with tilapia shelf life.

Figure 4 - Countries that have produced the most research related to the study of tilapia shelf life in the Web of Science database through 2025.



Source: Web of Science, 2026.

China has a large industrial complex for processing tilapia, mainly in Guangdong province, producing around 220,000 tons/year. It is currently the largest exporter of tilapia worldwide and, as one of the main producers of the species, leads the ranking of world publications (Figure 4). The tilapia processing industry in China is versatile and adaptable to the international market, as it produces a variety of processed and value-added products (FAO, 2024).

Although Brazil is one of the four largest producers of tilapia globally, it has the second largest number of studies on extending the shelf life of this fish. The great interest of institutions in the subject may be related to the increased consumption of tilapia by Brazilians, who previously preferred imported fish to domestic production. This was related to reports of an earthy taste (off-flavor) or uncertainty about its origin (Peixe BR, 2024).

By conducting scientific research on tilapia, institutions can provide information on the nutritional and microbiological quality of the products supplied by domestic and global fish farming, consequently increasing the consumption of this species and the export rate (Wang et al., 2022a; Liu et al., 2022; Tayebi et al., 2020; Sary et al., 2020).

India and Thailand rank third in the scientific production of tilapia. Studies in this country are advancing not only to extend shelf-life, but also to make use of by-products, since the options for adding value to the species in the country are limited, leading to environmental, financial, and food security challenges (Relekar et al., 2021; Pati et al., 2022).

The United States is the leading global importer of aquatic animals and the largest importer of Brazilian tilapia (FAO, 2024; Peixe BR, 2024). Scientific institutions in the USA have the fourth-largest production of scientific articles aimed at extending the shelf life of tilapia (Figure 4).

Globally, total aquaculture production has increased significantly on all continents in recent decades, except Europe, which has gradually declined since the late 1980s, with some inter-annual fluctuations until 2022 (FAO, 2024). This has a major impact on the quantity of studies on the European continent, which is not among the top 10 in terms of scientific research on tilapia (Figure 4).

A major problem in aquaculture has been the insufficient growth in production compared to the high rate of human population growth, and it is up to researchers to promote technological resources to guarantee consumers nutritionally qualified products consistent with social responsibility and the principles of sustainable development. As stated by the UN Millennium Goals, scientific knowledge and ensuring the transfer of viable and safe technologies aimed at increasing the contribution of aquatic biodiversity, including providing essential food reserves, help limit the extreme volatility of food prices (ONU, 2020).

Distribution of publications by countries

The organizations responsible for publishing articles related to tilapia shelf life are shown in Table 1, by clusters, number of documents, number of citations, and total link strength.

Table 1 - Number of documents and citations about tilapia shelf life by international institutions grouped into clusters.

Cluster 1 (red)	**Documents**	**Citations**	**Total link strength**
Hainan Univ.	10	392	12
Chinese Acad. Trop. Agr. Sci.	4	224	8
Hezhou Univ.	3	195	5
Nanjing Agr. Univ.	3	56	5
Guangdong Ocean Univ.	4	81	3
Cluster 2 (green)	**Documents**	**Citations**	**Total link strength**
South China Univ. Technol.	5	123	3
Kunming Univ Sci & Technol	7	113	3

Jiangnan Univ	3	56	2
Cluster 3 (yellowgreen)	**Documents**	**Citations**	**Total link strength**
Guangxi Univ.	54	85	5
Qinghai Normal Univ.	3	37	3
Cluster 4 (blue)	**Documents**	**Citations**	**Total link strength**
Chinese acad. Fishery Sci.	5	130	1
Dalian Polytech Univ.	4	237	8

The total link strength represents the strength of the connection between the institutions. As such, Hainan University in China has the strongest collaborative links with other institutions distributed in the network (Table 1). The international collaboration network is important for boosting research with more complex approaches, such as spatialization of fisheries production, research capacity development at an interpersonal level, and promoting sustainability and reducing costs (Huang, 2014).

However, a limitation was identified in the collaboration by country for articles related to tilapia shelf life. China is the predominant country in all the clusters, and the collaborative links are only national (Table 1).

Table 2 shows the top 10 most productive institutions, which are from countries other than China and are on the same continent, potentially connected by the collaborative network. Countries with the same documents were ranked based on the number of citations.

Table 2 - The ten most productive institutions in tilapia shelf-life research.

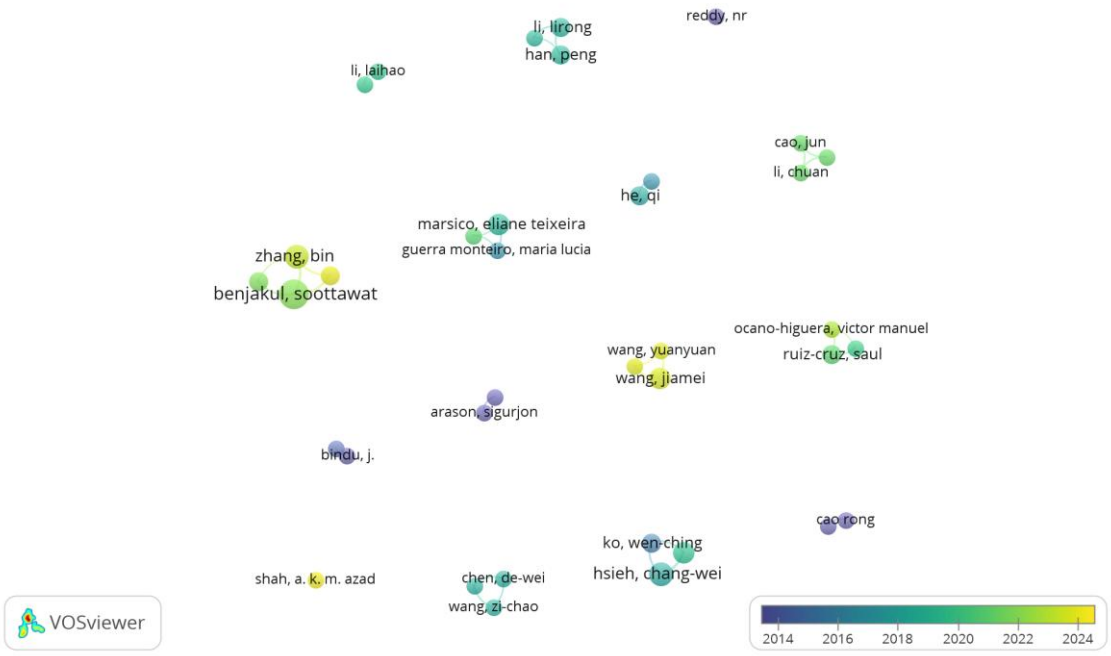
Ranking	Organization	Country	Documents	Citations
1	Hainan Univ.	China	10	392
2	Prince Songkla Univ.	Thailand	9	158
3	Kunming Univ. Sci. & Technol.	China	7	113
4	Zhejiang Ocean Univ	China	6	73
5	China Agr. Univ.	China	5	151

6	Univ Fed Fluminense	Brazil	5	134
7	Chinese Acad. Fishery Sci.	China	5	130
8	South China Univ Technol	China	5	123
9	Guangxi Univ	China	5	85
10	Guangdong Ocean Univ	China	5	81

In terms of country of origin, 8 of the 10 organizations in the ranking are located in China, with Hainan University standing out with 10 published articles, along with a significant number of citations (392) compared to the other organizations, which demonstrates its influence and high recognition for studies on tilapia shelf-life analysis.

A total of 770 authors were found and only 37 met the minimum threshold of 3 published articles. Among these, Brazilian researcher Eliane Teixeira Mársico, a lecturer and researcher at the Universidade Federal Fluminense/Brazil, accounted for the largest number of articles available in the database on tilapia shelf life, followed by Soottawat Benjakul (Faculty of Agro-Industry, Prince of Songkla University) from Thailand and Chang-Wei Hsieh (Da-Yeh University) from Taiwan, both with 6 articles each.

Figure 5 - Co-authorship network between researchers of publications on tilapia shelf life over the years in the Web of Science database.



Source: Web of Science, 2026.

Figure 5 shows the distribution network of researchers publishing on tilapia shelf life over the years, where it is possible to see several distinct and isolated research groups. This reinforces the limited international collaboration found in the institutions.

The limited international collaboration observed in this study may influence both the scientific impact and the technological development of research related to tilapia preservation. International research networks often facilitate knowledge exchange, access to specialized infrastructure, and the integration of complementary expertise from different institutions (Ajiferuke et al., 2021). Such collaborations are important in aquaculture research, where technological solutions frequently require multidisciplinary approaches involving food science, microbiology, engineering, and supply chain management. Therefore, the predominance of nationally concentrated research groups identified in this study may limit methodological diversity and slow the development of innovative preservation strategies for tilapia products.

The research groups were divided into 15 clusters, which, in addition to showing limited international contributions, also reveal weaknesses in scientific collaboration at the national level. This limitation is particularly evident among Chinese authors, whose collaborations are fragmented across different regions of the country. For example, one cluster consists of De-Wei Chen and Zi-Chao Wang, from Guangxi University and Northwest Polytechnic University, respectively, while another brings together Yuanyuan Wang and Jiamei Wang, both from Hainan University, with no connection between them. This pattern suggests low integration among research groups located in different regions of the same country, indicating possible institutional, geographical, or structural barriers.

In contrast, an international connection is observed in a cluster that includes author Bin Zhang, from the Guangxi Academy of Fishery Sciences in China, who co-authors with Soottawat Benjakul, from Prince of Songkla University in Thailand. This contrast reinforces the need to strengthen internal research networks in order to promote greater scientific cohesion and enhance knowledge production on a national and international scale.

Distribution of publications by journals and the most cited articles

The analysis identified 77 journals that had published research articles on tilapia shelf life in the last 41 years, of which only 14 had a minimum of 3 documents. Table 3 shows the top 10 journals in this category, accounting for approximately 45% of all articles. Journals with the same publications were ranked based on the highest number of citations.

Table 3 - Main journals with at least 3 publications involving techniques to extend tilapia shelf life.

Ranking	Journal	Documents	Number of citations	Impact factor
1	Journal of Food Processing and Preservation	16	187	2.6
2	Journal of Food Science	11	226	3.9
3	Journal of Aquatic Food Product Technology	11	89	1.6
4	LWT- Food Science and Technology	9	198	6.0
5	Food Chemistry	6	409	8.8
6	Foods	6	8	5.2
7	International Journal of Food Science and Technology	5	118	3.3
8	Food Science and Nutrition	5	93	3.7
9	Journal of the Science of Food and Agriculture	5	92	4.1
10	Journal of Food Science and Technology- Mysore	4	43	3.1

The Journal of Food Processing and Preservation accounted for the largest amount of research on the subject (18 articles), followed by the Journal of Food Science with 9 articles (both indexed on the Wiley Online Library platform) and the Journal of Aquatic Food Product Technology, also with 9 documents indexed on the Taylor and Francis platform.

The journals in 4th and 5th place are both indexed on the Elsevier platform and have the highest number of citations and impact factors of 6 and 8.8, respectively when compared to the others in the Top 10. Citation counts can be considered a good indicator of the reach and influence of journals, demonstrating the quality of publications and knowledge production (George et al., 2021).

The articles involving studies on tilapia shelf life with the highest number of citations are shown in Table 4. Four of the top 10 most cited articles were published in the journal Food Chemistry, demonstrating the quality of the journal and the papers, as well as the importance of this research on the topic in question.

Table 4 - Top 10 most cited articles involving studies on the shelf life of tilapia over the last 41 years (1983–2025).

Ranking	Authors	Title	Journal	Year	NC
1º	Alsaggaf, M. S.; Moussa, S. H.; Tayel, A. A.	Application of fungal chitosan incorporated with pomegranate peel extract as edible coating for microbiological, chemical, and sensorial quality enhancement of Nile tilapia fillets	International Journal of Macromolecules	2017	127
2ª	Wei, P.; Zhu, K.; Cao, J.; Dong, Y.; Li, M.; Shen, X.; Duan, Z.; Li, C.	The inhibition mechanism of the texture deterioration of tilapia fillets during partial freezing after treatment with polyphenols	Food Chemistry	2021	98
3º	Cao, J.; Wang, Q.; Ma, T.; Bao, K.; Yu, X.; Duan, Z.; Shen, X.; Li, C.	Effect of EGCG-gelatin biofilm on the quality and microbial composition of tilapia fillets during chilled storage	Food Chemistry	2020	92
4º	Reesha, K. V.; Panda, S. K.; Bindu, J.; Varghese, T. O.	Development and characterization of an LDPE/chitosan composite antimicrobial film for chilled fish storage	International Journal of Macromolecules	2015	85

5º	Ko, W.-C.; Yang, S.-Y.; Chang, C.-K.; Hsieh, C.-W.	Effects of adjustable parallel high voltage electrostatic field on the freshness of tilapia (*Orechromis niloticus*) during refrigeration	LWT- Food Science and Technology	2016	84
6º	Yanar; Y.; Çelik, M., Akamca, E.	Effects of brine concentration on shelf-life of hot-smoked tilapia (*Oreochromis niloticus*) stored at 4 °C	Food Chemistry	2006	83
7º	Ebrahimi, M.; Daeman, N. H.; Chong, C. M.; Karami, A.; Kumar, V.; Hoseinifar, S. H.; Romano, N.	Comparing the effects of different dietary organic acids on the growth, intestinal short-chain fatty acids, and liver histopathology of red hybrid tilapia (*Oreochromis sp*.) and potential use of these as preservatives	Fish Physiology and Biochemistry	2017	73
8º	Wong, L.-W.; Loke, X.-J.; Chang, C.-K.; Ko, W.-C.; Hou, C.-Y.; Hsieh, C.-W,	Use of the plasma-treated and chitosan/gallic acid-coated polyethylene film for the preservation of tilapia (*Orechromis niloticus*) fillets	Food Chemistry	2020	64
9º	Liu, S.; Fan, W.; Zhong, S.; Ma, C.; Li, P.; Zhou, K.; Peng, Z.; Zhu, M.	Quality evaluation of tray-packed tilapia fillets stored at 0°C based on sensory, microbiological,	African Journal of Biotechnology	2010	60

		biochemical, and physical attributes			
10ª	Shi, Y.; Wei, P.; Shi, Q.; Cao, J.; Zhu, K.; Li, Z.; Zhou, D.; Shen, X.; Li, C.	Quality changes and deterioration mechanisms in three parts (belly, dorsal and tail muscle) of tilapia fillets during partial freezing storage	Food Chemistry	2022	58

NC: number of citations

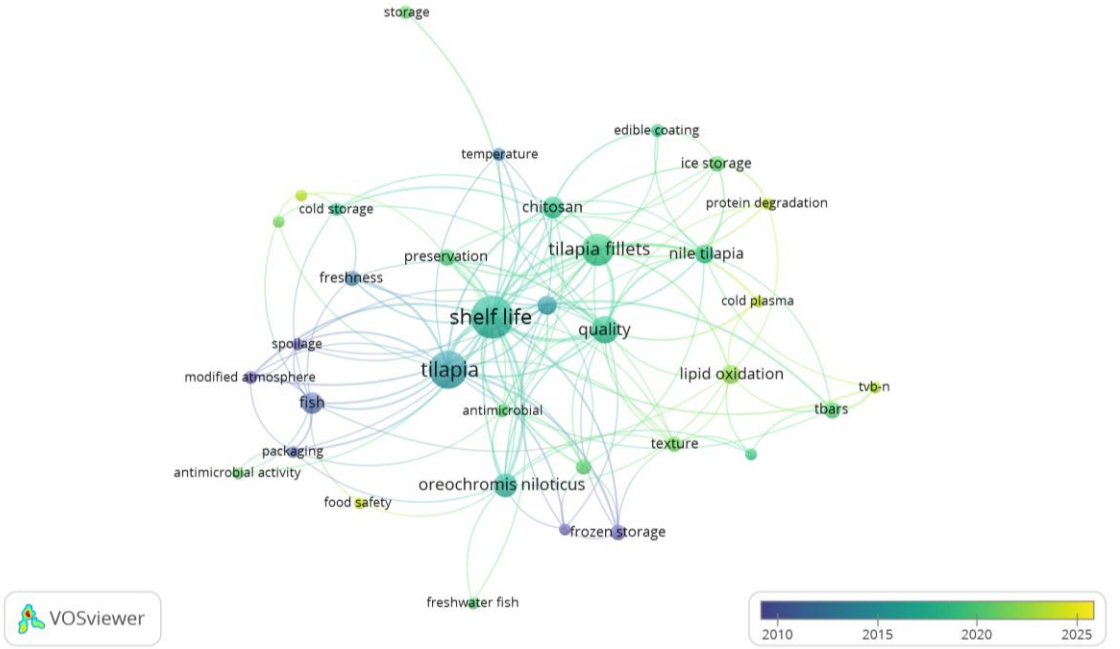
The most cited article evaluated the use of natural derivatives, such as fungal chitosan and pomegranate peel extract, in coating films to preserve Nile tilapia fillets and maintain their quality (microbiological, chemical, and sensory) during refrigerated storage. This coating successfully resulted in a marked decrease in microbial counts and managed to delay chemical deterioration parameters. Furthermore, sensory evaluation showed that the coated samples were preferred for odor, texture, color, and general acceptability (Alsaggaf et al., 2017).

The second most cited article evaluated the mechanism by which polyphenol treatment inhibits texture deterioration in tilapia fillets during partial freezing over 49 days. The study demonstrated that polyphenol treatments were effective in delaying protein degradation, lipid oxidation, and the growth of spoilage microorganisms (Wei et al., 2021).

Analysis of the co-occurrence of keywords

The network of co-occurrences of the main terms used in the articles is shown in Figure 6. From this, it is possible to visualize the main terms used by authors and thus indicate the possible directions used within the research. As expected, the size of the circles indicates that the “shelf-life” and “tilapia” keywords have the highest number of article occurrences.

Figure 6 – Keyword co-occurrence network along the 1983–2025 time dimension of research related to tilapia shelf life in the Web of Science database.



Source: Web of Science, 2026.

Analysis of the co-occurrence map keywords reveals the main methods used to increase tilapia shelf life: essential oils, modified atmosphere, edible packaging, chitosan, and cold plasma. Additionally, the highlighted terms (sensory analysis, texture, and color) indicate potential research directions and underscore the critical importance of preserving the fish's sensory characteristics during preservation.

The temporal dimension of the keywords displayed, based on the color variation gradient (Figure 6), reveals a progression of research topics over time. Among current preservation methods for tilapia is cold plasma, a non-thermal treatment technology. However, this technique has been associated with lipid and protein oxidation in food. To mitigate this, combining cold plasma with mango extract can improve fillets quality, thereby contributing to an extended shelf life (Liu et al., 2024). Research has also focused on analyzing tilapia texture (Wei et al., 2024), as preservation techniques must maintain sensory characteristics to extend shelf life.

Time evolution of conservation methods applied to tilapia

Keyword analysis revealed the evolution of tilapia preservation methods. Before 2012, the most common techniques included temperature variation (Surendran et al., 1989; Waliszewski et al., 2001), tray packaging (Liu et al., 2010), and modified atmosphere (Reddy et al., 1994). Other preservation methods, including salting (Yanar et al., 2006), liquid smoking (Chen et al., 2011), and irradiation (Monteiro et al., 2012), have also been used.

The evolution of preservation methods identified in the literature also reflects broader technological and market trends in the food industry. In recent years, consumers have increasingly

demanded minimally processed foods with fewer synthetic additives, which has stimulated research on natural preservation strategies such as essential oils, plant extracts, and edible coatings (Shahrier et al., 2023; Sharma et al., 2024). In parallel, advances in food processing technologies have encouraged the development of non-thermal methods, including cold plasma, which can reduce microbial contamination while preserving sensory and nutritional properties (Wang et al., 2022b). These innovations are relevant for aquaculture products, as they may help reduce post-harvest losses and extend market distribution.

Entering 2014, the highlights were still the use of temperature, this time as the cold chain influenced the microstructure of tilapia (He et al., 2015), and rigor mortis (Viegas et al., 2013). Since 2016, chitosan and essential oils have been more relevant in tilapia conservation, although these methods have been used since 2012 (Cao et al., 2012; Albarracín et al., 2012). The growing interest in natural preservatives such as chitosan, essential oils, and plant extracts reflects a broader global trend toward clean-label food technologies. Consumers increasingly demand products with fewer synthetic additives, which has stimulated research into natural antimicrobial and antioxidant compounds. In addition, these preservation strategies may add value to aquaculture products and contribute to more sustainable food systems by reducing chemical preservatives and food waste.

In 2018, researchers employed edible coatings to prolong the freshness of tilapia, using a combination of chitosan and starch (Li et al., 2018). This development follows the first study in 2002, which used a gelatin base (Ou et al., 2002).

In 2020, antioxidant potential, phenolic compounds, and polyphenols were widely used to reduce the deterioration of tilapia, with the potential to minimize the oxidative rancidity of tilapia fillets (Alves et al., 2020). More recently, cold plasma technology has been explored (Wang et al., 2022b).

The development of new preservation technologies for tilapia is also closely linked to the expansion of global aquaculture production. As tilapia production continues to increase worldwide, maintaining product quality during storage and distribution becomes a critical challenge for producers and exporters (FAO, 2024). Consequently, research on shelf-life extension plays an important role not only in ensuring food safety but also in reducing economic losses and improving the competitiveness of aquaculture products in international markets.

FINAL CONSIDERATIONS

This bibliometric study provides a comprehensive overview of the global scientific landscape related to tilapia shelf life and preservation technologies. The results demonstrate a significant increase in scientific production over the last two decades, reflecting the growing importance of tilapia in global aquaculture and the need for effective preservation strategies to maintain product quality during storage and distribution.

The analysis also revealed that research activity is concentrated in a limited number of countries and institutions, particularly in China and Brazil. Although these countries play an important role in advancing scientific knowledge in this field, the limited international

collaboration observed in the co-authorship networks suggests that greater global integration among research groups could enhance knowledge exchange, methodological diversity, and technological innovation. Strengthening collaborative networks may therefore contribute to the development of more efficient preservation technologies and to the expansion of research capacity in emerging aquaculture regions.

In addition, the evolution of preservation techniques indicates a clear shift from conventional methods toward emerging and more sustainable approaches, such as natural antioxidants, edible coatings, and non-thermal technologies like cold plasma. These strategies are aligned with current consumer demand for minimally processed foods and may contribute to reducing post-harvest losses and improving the competitiveness of tilapia products in international markets.

Finally, this study highlights research gaps and future opportunities, particularly in strengthening international collaboration and advancing innovative preservation technologies capable of ensuring both shelf-life extension and maintenance of sensory and nutritional quality in tilapia products.

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