ISSN 2303-4521
Periodicals of Engineering and Natural Sciences *Original Research*
Vol. 11, No. 6, December 2023, pp.27-35

Lactic acid production a bibliometric study

C. G. Cárdenas-Arias[1,2], E. Zuza-Hernández[2], J. E. Quiroga-Méndez[3], O. Lengerke-Perez[1], O. A. Acosta-Cárdenas[1]

[1] 1 Design and materials research group (DIMAT), Automation and Control Energy Systems Research Group (GISEAC), Electromechanical engineering, Faculty of Natural Sciences and Engineering, Unidades Tecnológicas de Santander UTS, Calle de los estudiantes No 9-82, 680005, Bucaramanga, Colombia

[2]Doctoral program in Sustainable Materials and Process Engineering, Department of Sustainable Materials and Process Engineering, University of the Basque Country, UPV/EHU, Engineer Torres Quevedo Plaza, 1, 48013, Bilbao, Spain

[3]Energy and materials research group, Mechanical engineering school, Universidad Industrial de Santander, Calle 9 Carrera 27, Bucaramanga, Colombia

ABSTRACT

Bibliometrics is a documentary analysis tool that is positioning itself as a support to know and understand the study status of a specific topic. In this case, the VOSviewer software was used to determine the evolution of lactic acid production, carried out through a programmed search with the VOSviewer application, which allowed a clear and reliable bibliographic review for the topic development under study, which made possible to obtain enough material to know who, where and in what year have published about the latest advances in the production of lactic acid. The database used was Scopus, with the search equation "lactic acid" and production and "natural sources".

Keywords: Bibliometrics, lactic acid, evolution, production

Corresponding Author:

Carlos Gerardo Cárdenas Arias,
Electromechanical engineering,
Unidades Tecnológicas de Santander,
Calle de los estudiantes No 9-82, 680005, Bucaramanga, Colombia.
E-mail: ccardenas@correo.uts.edu.co

1. Introduction

This document presents the results obtained from an evolution lactic acid production bibliometric analysis through the VOSviewer software, which made it possible to determine the latest advances in lactic acid production. Bibliometric studies are a form of evaluation that was created in order to offer an estimate about the research or scientific products established within a respective journal or institution. In this way, the applications that contain this investigative and documentary analysis practice have had greater strength today, taking into account that they allow the publishers of magazines or institutions certified for scientific production to rate their quality for the realization of adjustments or requests about any changes that are identified [1]

Currently, the biotechnological and industrial production of lactic acid is of interest due to its possible applications [2] and its low cost due to the minimization of this variant in the substrates, along with the use of low production temperatures. and decrease in energy use. For this reason, research is focused on finding new and real nutritional sources and fermentation techniques that allow these new inputs to generate high substrate conversions and better yields in the production of lactic acid [3]. Currently, alternatives such as biotechnology are being explored, through the fermentation of substrates rich in carbohydrates such as glucose, lactose, starch and cellulose, by bacteria or fungi, which is achieved quickly with low generation of byproducts, being a characteristic that industrial lactic acid microorganisms possess [4].

2. Method

For the work development, a quantitative and qualitative bibliographic review is carried out, due to the results obtained through the statistical method use [5]. In this way, the sources were constituted by texts related to the search equation in Scopus, organizing and classifying according to their geographical location, researchers involved and research categories Figure 1.

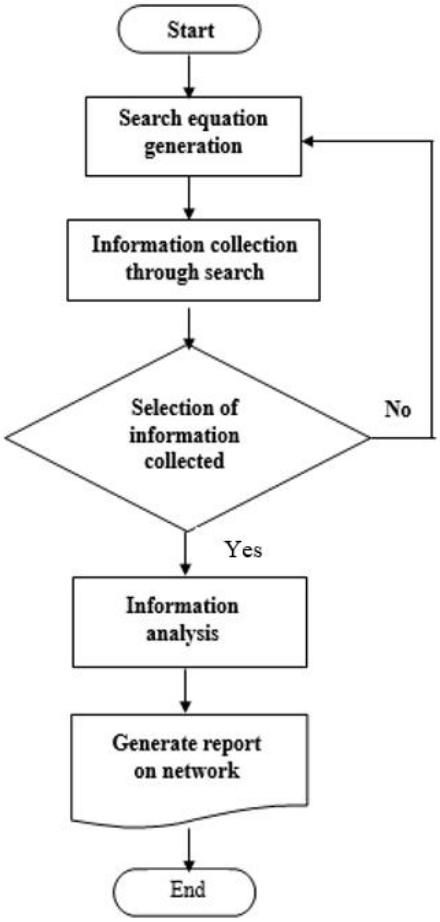

Figure 1. Research flow diagram

2.1. Inclusion criteria

• Documentation that comes from scientific databases corresponding to Scopus.
• Updated articles that meet the established time parameters (5 years old).
• Studies linked to the description of lactic acid production

2.2. Exclusion criteria

Seminars, congresses, conferences, opinions, manuscripts that lack a scientific structure and content, as well as those texts that are not closely related to the research topic, will not be taken into account.

3. Results and discussion

To achieve the work objectives, bibliometric indicators of scientific importance were selected, such as the number and distribution of publications, cooperation and, as an impact indicator, the citation of publications.Figure 1 presents the co-occurrence network map developed from Scopus, where the search equation “lactic acid” and production and “natural source” was used. Keyword co-occurrence shows the appearance of a term within the keywords of two or more scientific documents [6]. To build the network deployment, 76 Scopus document records were processed in CSV format. Figure 2 was generated using the word co-occurrence analysis type and the selected analysis unit is keyword plus.

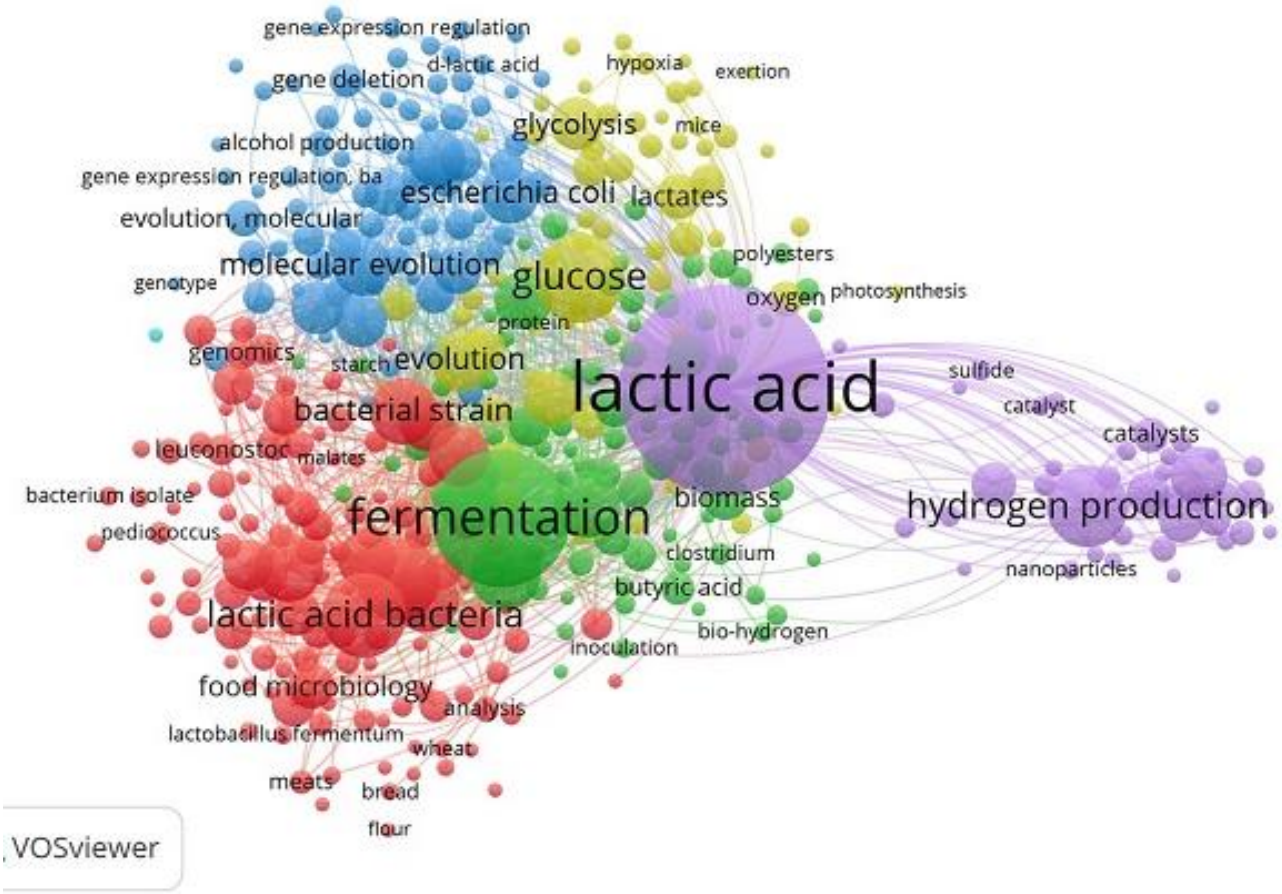

Figure 2. Co-occurrence network map "lactic acid" and production and "natural source" (Scopus co-occurrence base)

The network has a co-occurrence size of 489 elements. It was originally 609, of which 120 words were considered non-specific. The clustering parameters were resolution 1.0 and minimum cluster 1, with which five clusters were identified. A co-occurrence analysis was performed, the unit of analysis is the keywords and the counting method is the total count. This co-occurrence network has 398 nodes, 5 clusters or representative groups and 18727 links between the nodes. Clustering, or most representative clusters identification, is carried out with an association method, with an attraction - repulsion relationship of 2 to 0, with a cluster resolution of 1.00 and a minimum cluster size of 20. As a study of Clustering resulted in the delimitation of five groups of related words, Cluster 1 (purple); lactic acid; Cluster 2 (green); fermentation; Cluster 3 (yellow); glucose; Cluster 4 (red); lactic acid bacteria; Cluster 5 (blue); molecular evolution.
Within this graph, a node represents a keyword plus (standardized term provided by editors or databases) and the elements size is a number's function of times a term appears within the analyzed documents. The most prominent frequent words are specified in Table 1.

Table 1. Word co-occurrence

Prominent words	Occurrence
Lactic acid	372
Fermentation	183
Glucose	89
Lactic acid bacteria	83
Molecular evolution	45

The map shows regions with a higher concentration of nodes. The smaller the distance between two nodes, the greater the relationship between the words. Therefore, in this map a high relationship is observed between research related to lactic acid, fermentation and glucose. Additionally, a co-authorship analysis was carried out, Figure 3, which represents the collaboration between different entities and people, to carry out a work and make

it known to the community. Within the research of lactic acid production, the main study according to Scopus is evidenced by the article by Xincheng Wang (2017) [7], which has been cited 596 times, with the title "An Assessment of the Lactic Acid-Producing Potential of Bacterial Strains Isolated from Food Waste."

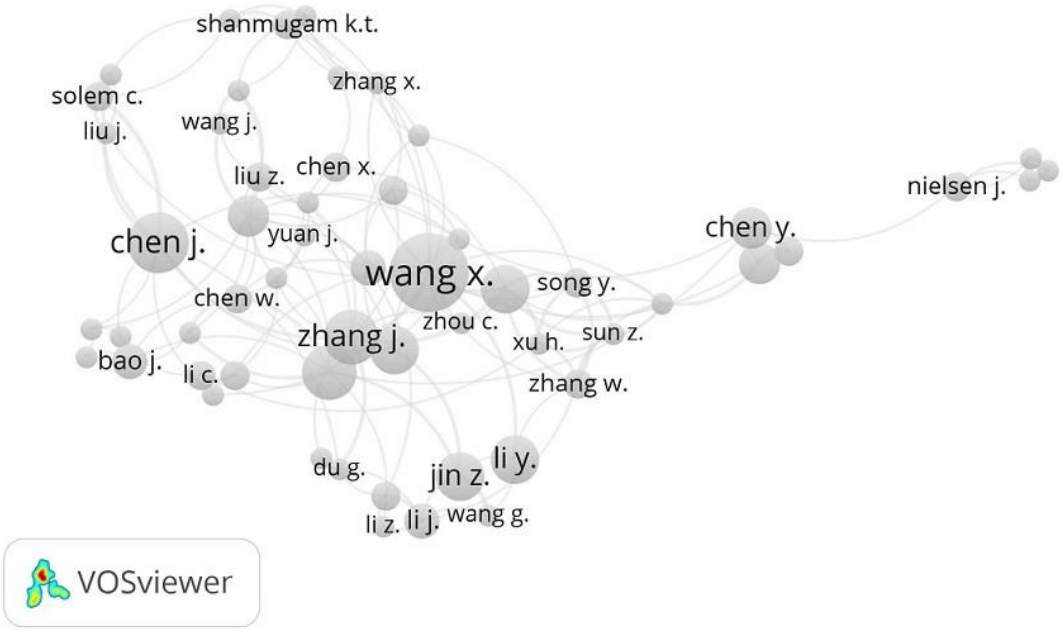

Figure 3. Co-authorship network map "lactic acid" and production and "natural source" (Scopus co-authorship database)

This article describes the use of imidazole and epichlorohydrin polymers ([IMEP]Cl) as catalysts to convert glucose to lactic acid in water. In this research, a possible reaction mechanism is proposed assuming that the coordination between the polymer weak Lewis acid centers with the electronegative oxygens in the intermediates efficiently facilitates the rate-determining step during the reaction. This route allows easy recovery and catalyst recycling while providing a new strategy for carbohydrate conversion.

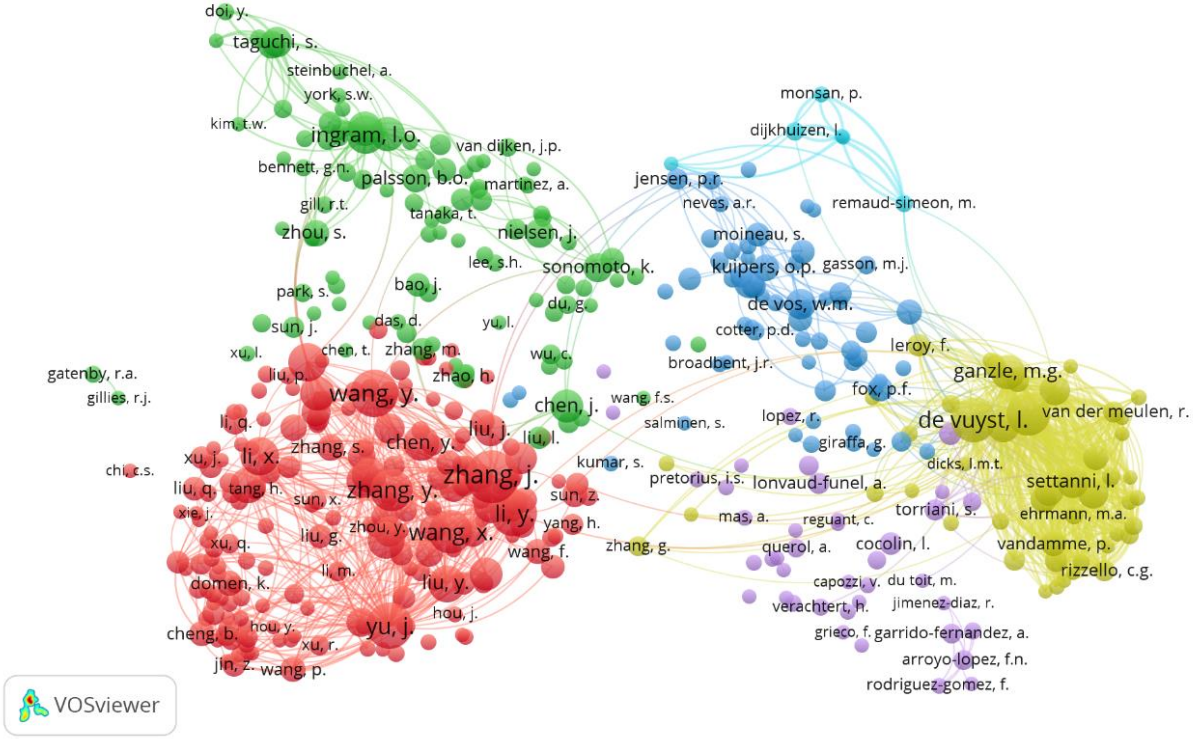

Figure 4. Cocitation network map authors "lactic acid" and production and "natural source" (Scopus cocitation database)

In this item, which citation of author's consists who have cited the first author who wrote about a study carried out, a network is presented with seven clusters, which have 447 nodes and 52,584 links between the nodes. Jinwen Zhang presents 269 citations with 22320 total bond strength, studying the field of lactic acid and nanoparticles, but Marco Gobbetti, who has studied fermentation processes, with 181 citations presents a total bond strength of 46013.

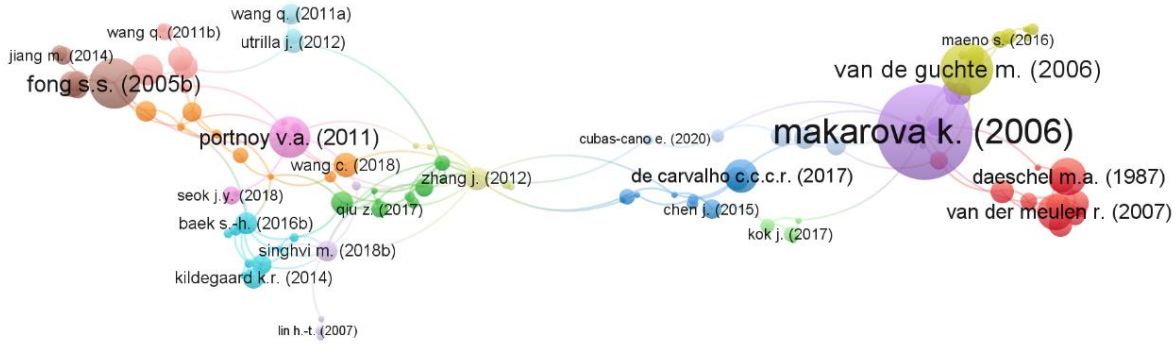

Figure 5. Citation network map for documents "lactic acid" and production and "natural source" (Scopus citation database)

Kira Makarova is one most cited author in the area of knowledge, with the article "Comparative genomics of the lactic acid bacteria", which has more than 1600 citations. In this document she presented nine genomic sequences, where the monitoring carried out on the genomes showed losses and acquisition of genes during the coevolution of lactic acid-producing bacteria. [8]

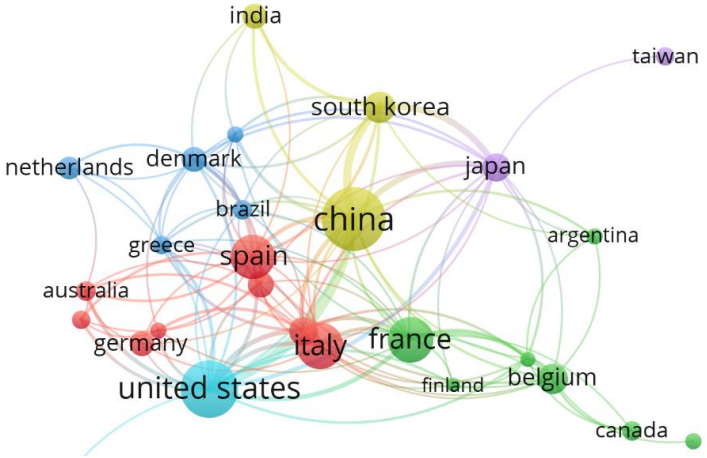

Figure 6. Citation network map by country "lactic acid" and production and "natural source" (Scopus citation by country database)

In this citation network by country, it is observed that the United States, followed by China, are the countries with the most citations in the documents obtained with this search equation. Although they seem distant, they have a strong link, which involves mutual citation between documents published in these countries.

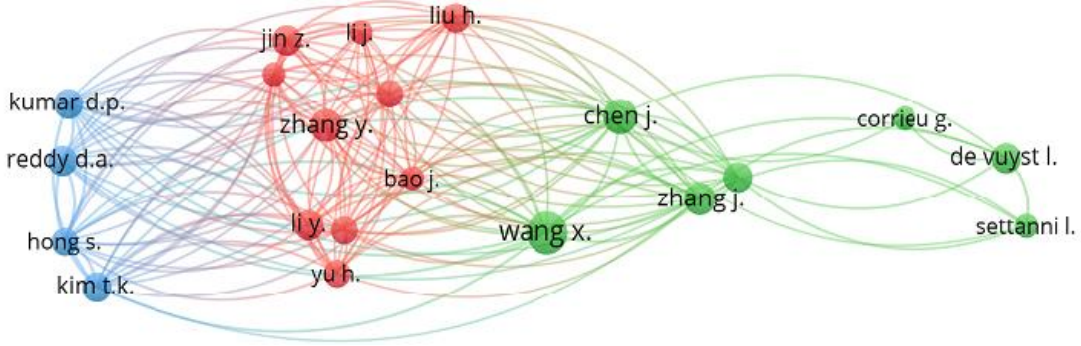

Figure 7. Bibliographic coupling network map by authors "lactic acid" and production and "natural source" (Scopus Bibliographic coupling by authors database)

This item analyzes the citation or common references that occur in the documents presented by each author. Three clusters are presented, with 21 nodes and 158 links between the nodes, with an attraction of 4.0, a repulsion of 1, a resolution of 1.0 and a minimum cluster size of 1.

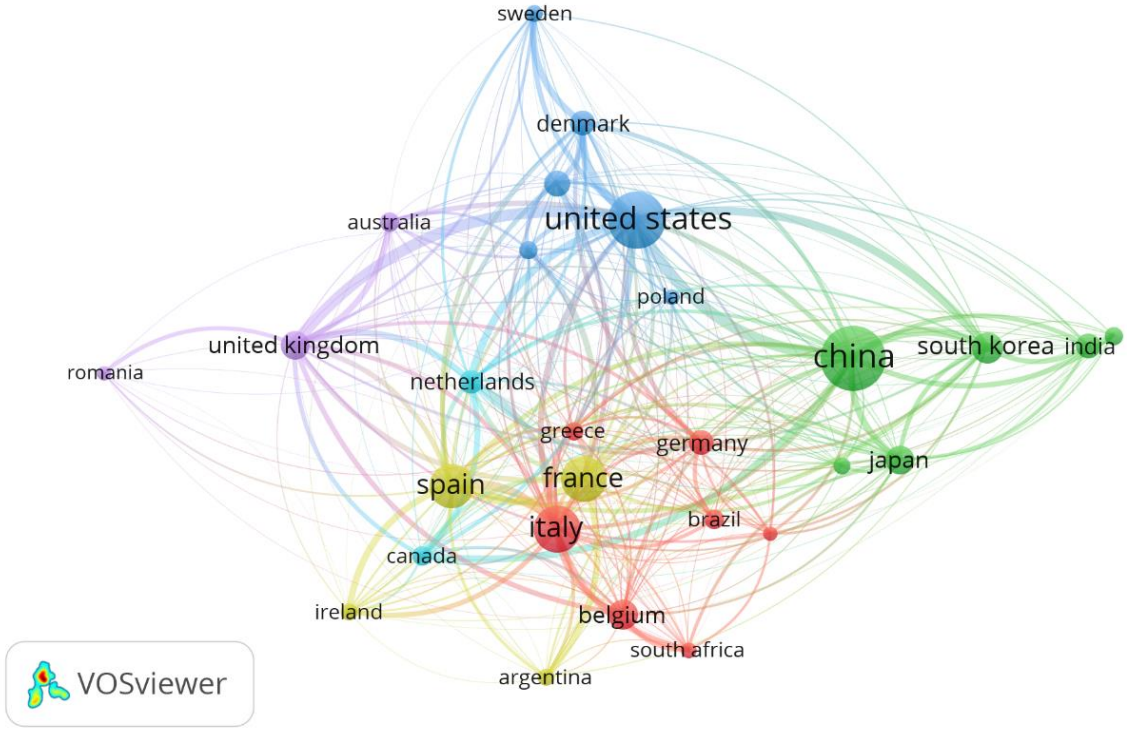

Figure 8. Bibliographic coupling network map by countries “lactic acid” and production and “natural source”. Scopus Bibliographic coupling by countries database

Corresponding to Figure 6, it is observed that the greatest coupling occurs between the United States and China. On the other hand, China is the country where the most has been published on these topics, followed by India and the United States, as seen in Figure 9.

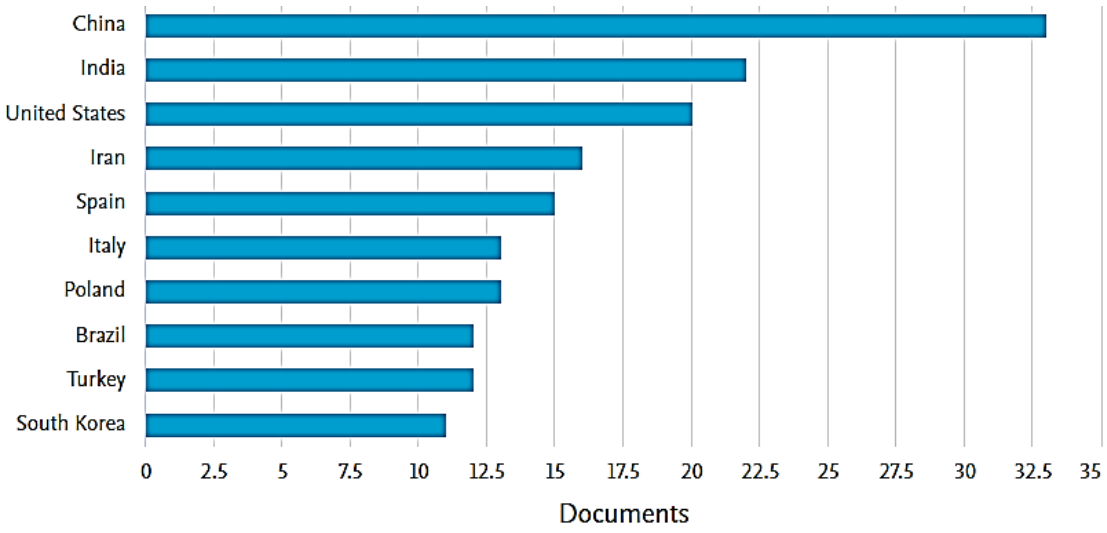

Figure 9. Documents by country

It can also be seen in Figure 10, that the area of knowledge that most relates these topics is Agriculture and biological sciences, with 18.3% of the publications, while, in the area of Materials Sciences, there have only been published 3.3%, which can be inferred that in this area there is greater interest in the application of this product than in its achievement.

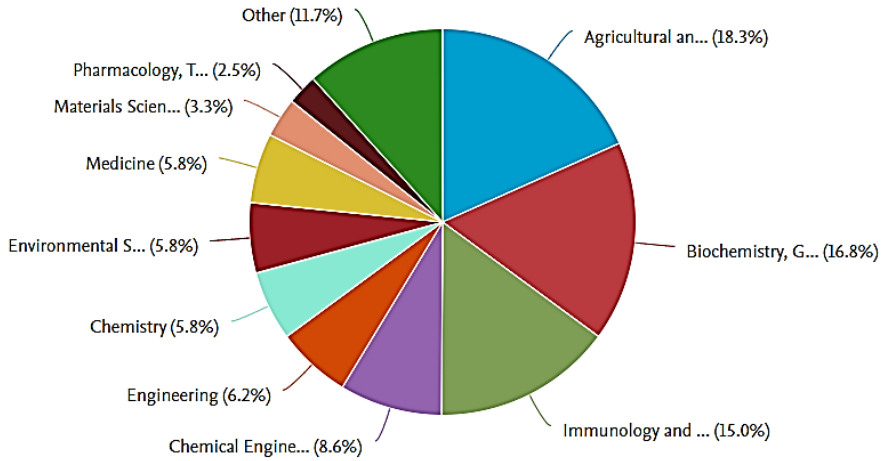

Figure 10. Documents by knowledge area

As for the authors, Hazleen Anuar and Maizirwan Mel from the International Islamic University of Malaysia, José Manuel Domínguez from the University of Vigo, Spain and Anderson Sant'Ana from the Universidade Estadual de Campinas, Brazil as seen in Figure 11.

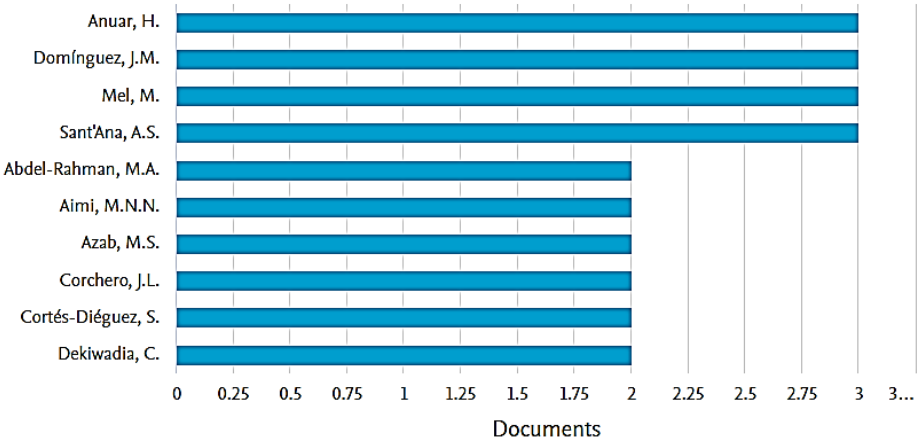

Figure 11. Documents by author

Hazleen and Maizirwan wrote in 2012 how to obtain lactic acid from potatoes and corn [9]. José Manuel Dominguez, in 2013, compiled a technologies compilation to produce lactic acid, such as commercial production, chemical synthesis and fermentation [10]. In 2018, Anderson Sant'Ana generated a review on the different ways of producing lactic acid such as co-culture, genetic and metabolic engineering, different types of bioreactors and some types of fermentation [11].

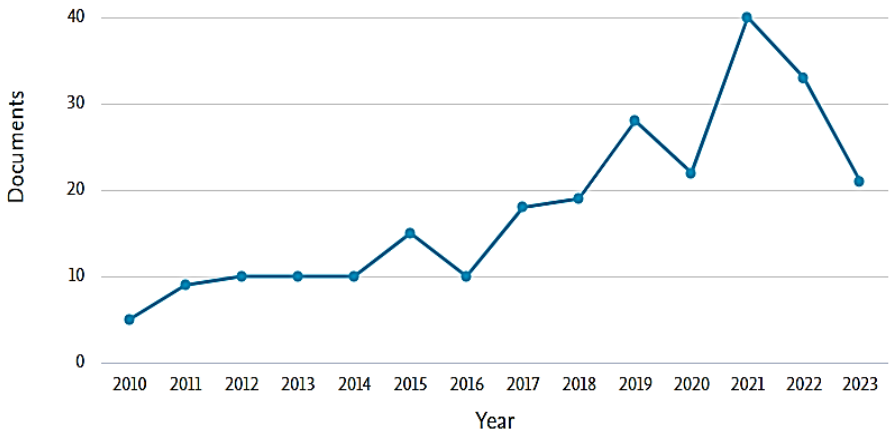

Figure 12. Documents per year

Regarding production over time, the upward trend of writings on the topic of lactic acid is seen. Figure 12

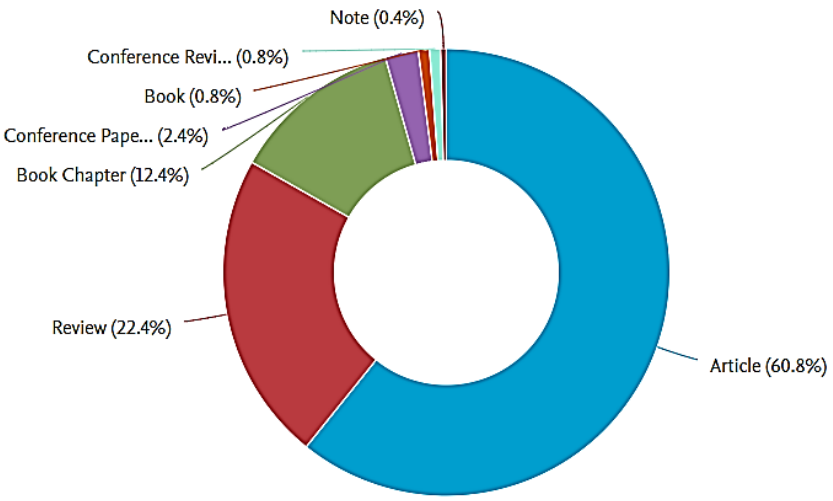

Figure 13. Documents by publication type

In Figure 13, it is observed that the works dissemination is through articles with 60.8%, topic reviews with 22.4% and through book chapters with12.4%.

4. Conclusion

From the bibliometric analysis, the co-occurrence shows that the topic of non-human lactic acid has had a significant study, where fermentation is also highlighted, probably because it is the most common way to obtain the acid, as well as in a smaller quantity, glucose and lactic acid bacteria are mentioned, which are means to produce it.

Regarding co-authorship, it is observed that the United States and China lead in number of publications, with Xincheng Wang being the most referenced on the subject. On the other hand, the study of lactic acid grew at the beginning of the second decade of the 2000s and currently its research has focused mainly on the development of reinforced polylactic acids. Finally, the main dissemination channel is articles, followed by book chapters.

Declaration of competing interest

The authors declare that they have no any known financial or non-financial competing interests in any material discussed in this paper.

Funding information

The financing of this research was carried out by Unidades Tecnológicas de Santander – UTS, led by the Rector Ph D. Omar Lengerke Pérez.

Acknowledgements

Special thanks to the UTS Research and Extension Directorate, led by Javier Mauricio Mendoza Paredes.

Reference

[1] A. Vitón, “About the article: "Custom made science. Bibliometric and scientometric studies in a new section,” *Rev. haban cienc. médi.*, vol. 17, no. 5, pp. 847–848, 2018, [Online]. Available: http://scielo.sld.cu/scielo.php?pid=S1729-519X2008000300003&script=sci_arttext

[2] T. Anh Ngoc Le, J. Jie Lin Lee, and W. Ning Chen, “Stimulation of lactic acid production and Lactobacillus plantarum growth in the coculture with Bacillus subtilis using jackfruit seed starch,” *J. Funct. Foods*, vol. 104, no. November 2022, p. 105535, 2023, doi: 10.1016/j.jff.2023.105535.

[3] G. Arrazola, “BIOTECHNOLOGICAL PRODUCTION OF LACTIC ACID,” no. March 2015.

[4] J. Delgado and P. Realpe, “Production of lactic acid by fermentation of the bacteria lactobacillus casei using cocoa shell (theobroma cacao),” pp. 1–103, 2019, [Online]. Available: http://repositorio.ug.edu.ec/handle/redug/40005

[5] C. A. Monje Álvarez, “Methodology of the quantitative and qualitative investigation. Didactic guide,” *Univ. Surcolombiana*, pp. 1–216, 2011, [Online]. Available: http://carmonje.wikispaces.com/file/view/Monje+Carlos+Arturo+-+Guía+didáctica+Metodología+de+la+investigación.pdf

[6] Minciencias, “Glossary Minciencias.” 2020.

[7] H. P. Uwamahoro, F. Li, A. Timilsina, B. Liu, X. Wang, and Y. Tian, “An Assessment of the Lactic Acid-Producing Potential of Bacterial Strains Isolated from Food Waste,” *Microbiol. Res. (Pavia).*, vol. 13, no. 2, pp. 278–291, 2022, doi: 10.3390/microbiolres13020022.

[8] K. Makarova *et al.*, “Comparative genomics of the lactic acid bacteria.,” *Proc. Natl. Acad. Sci. U. S. A.*, vol. 103, no. 42, pp. 15611–15616, Oct. 2006, doi: 10.1073/pnas.0607117103.

[9] S. M. Nurhafizah, H. Anuar, M. Mel, R. Othman, M. N. Nur Aisyah, and M. N. Nur Aimi, “Production of lactic acid from kenaf core hydrolysate by Rhizopus oryzae FTCC 5215,” *Adv. Mater. Res.*, vol. 576, no. July 2014, pp. 248–251, 2012, doi: 10.4028/www.scientific.net/AMR.576.248.

[10] F. A. Castillo Martinez, E. M. Balciunas, J. M. Salgado, J. M. Domínguez González, A. Converti, and R. P. de S. Oliveira, “Lactic acid properties, applications and production: A review,” *Trends Food Sci. Technol.*, vol. 30, no. 1, pp. 70–83, 2013, doi: https://doi.org/10.1016/j.tifs.2012.11.007.

[11] F. B. Campagnollo *et al.*, “Selection of indigenous lactic acid bacteria presenting anti-listerial activity, and their role in reducing the maturation period and assuring the safety of traditional Brazilian cheeses,” *Food Microbiol.*, vol. 73, pp. 288–297, 2018, doi: https://doi.org/10.1016/j.fm.2018.02.006.