Research Trends and Applications of Spray Drying Technology in Probiotics: Bibliometric Analysis

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ABSTRACT

Spray drying is a key method for producing stable and viable probiotic powders for food and pharmaceutical applications. This study optimized spray drying parameters to maintain probiotic viability, including inlet temperature, feed rate, and protective agents. The findings revealed that microencapsulation with biopolymers, such as alginate and proteins, significantly enhances probiotic stability during spray drying. Recent innovations in encapsulating materials and combining spray drying with other preservation methods further improve probiotic efficacy. This research underscores the importance of refining spray drying techniques to enhance the effectiveness of probiotics. Future studies should optimize these methods and explore their applications in various food matrices to develop more effective functional foods and therapeutic formulations. Advancements in spray drying and encapsulation technologies offer promising opportunities for improving probiotic delivery in the food and pharmaceutical industries.

Keywords: Spray drying, Probiotics, Microencapsulation, Encapsulation materials.

INTRODUCTION

Probiotics have long been recognized for their significant health benefits, especially in maintaining the balance of the gut microbiota and strengthening the immune system. These live microorganisms, generally bacteria or yeast, are often added to foods and supplements to provide beneficial health effects. However, the main challenge in applying probiotics is ensuring their stability and viability during storage and consumption. Spray drying technology has emerged as a superior method to overcome this challenge, as it can produce probiotic products with high viability and good stability.

Spray drying is an efficient drying method in which particles are created by spraying a solution or suspension of material into a gas stream (Seveline, 2018). In addition to being economical and useful for increasing shelf life, this method offers great potential for application in the food industry. The use of this technique in production has sparked the interest of researchers and professionals, resulting in a large body of scientific literature discussing the technical aspects, benefits, and challenges involved.

Researchers used bibliometric analysis to understand the development and trends in using this technology (Saraswati et al., 2023). This analysis allows us to identify the research areas that have been explored, the leading researchers and institutions, and the relationships between research topics. Research clusters can be identified through visualization, and correlations between different themes can be found. Therefore, bibliometric analysis provides valuable insights into the evolution of spray drying technology in probiotic research.

This study conducted a bibliometric analysis that focused on preserving probiotics through spray drying technology, including the impact of microencapsulation on the gut microbiota and probiotic viability. Key terms frequently found in these studies were “probiotics,” “microencapsulation,” “spray drying,” and “lactic

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acid bacteria." The connection between these terms suggests the need for cross-disciplinary collaboration in the study of spray drying and probiotics.

This study has evolved and focused on several important areas, such as increasing probiotic viability during storage, developing new formulations, and applying this technology to various food products. This analysis has also identified areas requiring further research and current trends in the field. For example, topics such as the application of new carriers and the influence of process parameters on the final quality of probiotic products are of major interest.

This study is important because spray drying technology offers a solution to the major challenges in the stability and viability of probiotics during storage. Although many studies have addressed the technical aspects of this technology, a deeper understanding of research trends and its specific applications in probiotic product development is still needed. This study aims to identify the main trends in research on spray drying technology for probiotics through a bibliometric analysis and to provide recommendations for future research.

MATERIAL AND METHODS

A. Research Design

This study was conducted using bibliometric analysis methods to identify trends and developments in spray drying technology in probiotics. Data were collected from leading research databases and analyzed to determine key research topics, contributing researchers and institutions, and relationships between different issues.

B. Database and Research Trend

Data for this study were obtained from the Scopus, Web of Science, and Google Scholar databases. A literature search was conducted for studies published between 2000 and 2023. The language of the studies accessed was English to ensure broad coverage and relevance in a global research context.

C. Inclusion and Exclusion Criteria

The studies included in this analysis met the following criteria: (1) original research focusing on spray drying technology in probiotic development; (2) articles published in peer-reviewed journals; and (3) studies providing quantitative or qualitative data regarding the effectiveness of spray drying in maintaining probiotic viability. Studies that did not focus on probiotics or did not use spray drying technology, as well as review articles without empirical data, were excluded from the analysis.

D. Research Procedures

A literature search was conducted using keywords such as "spray drying," "probiotics," "microencapsulation," and "lactic acid bacteria." After the initial search, the results were screened based on the title and abstract to exclude irrelevant articles. The remaining articles were then fully evaluated to ensure they met the inclusion criteria.

E. Data Processing and Analysis

Data from the included studies were analyzed using bibliometric software such as VOSviewer and Biblioshiny. This analysis identified research clusters, the most productive researchers and institutions, and the most frequently discussed topics. A flowchart was created to illustrate the number of studies found at each stage (initial search, after application of inclusion criteria, and after application of exclusion criteria).

F. Visualization and Interpretation

The results of the bibliometric analysis were visualized in the form of network maps and temporal graphs to

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show research trends and relationships between topics. Interpretation of the results was done to identify key trends, gaps in research, and recommendations for future research.

RESULT AND DISCUSSIONS

A. Keyword Network Visualization

The network visualization generated through bibliometric analysis shows a map of the relationships between keywords in research on spray drying technology for probiotics. In this visualization, nodes (dots) represent keywords, while connecting lines between nodes indicate the relationship or association between the keywords. The size and colour of the nodes indicate the frequency and strength of the relationship of each keyword.

The most dominant keywords in this visualization are "probiotics", "microencapsulation", and "lactic acid bacteria". The large size of these keywords indicates that they often appear in related literature. Probiotics and lactic acid bacteria are the main focus of this study. At the same time, microencapsulation techniques are frequently used to improve the stability and viability of probiotics during the spray drying process (Gharsallaoui et al., 2007).

B. Visualization Data Source

This visualization is derived from Scopus, Web of Science, and Google Scholar databases. The analysis includes articles published between 2000 and 2023, focusing on probiotic spray drying technology.

C. Main Cluster Classification

This visualization reveals several key clusters:

1) Probiotics and Microencapsulation This cluster includes research on using microencapsulation technology to enhance probiotic viability. Keywords such as "sodium alginate," "pectin," and "alginate" are often associated with the use of carriers in microencapsulation.

2) Spray Drying Techniques

   This cluster includes research that focuses on the spray drying process itself, including keywords such as “spray-drying,” “spray dryer,” and “optimization.” Research in this cluster often discusses optimal process parameters to maintain probiotic viability.

3) Health and Functional Benefits This cluster includes keywords related to the health benefits of probiotics, such as “intestinal microbiota,” “intestinal health,” “immunity,” and “survival.” The study explores the effects of probiotics on gut health and the immune system.

4) Food Applications

   This cluster includes the application of probiotics in food products, with keywords such as “food preservation,” “fermented foods,” “functional products,” and “bioactive." The study focuses on integrating probiotics in various food and beverage products to enhance their functional value.

D. Emerging Trends in Research

Furthermore, the analysis shows the following growing trends in research on spray drying and probiotics:

1) Edible Coatings and Films

   Research using edible coatings and films to encapsulate probiotics shows great potential in food

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applications. Keywords such as "edible coating" and "films" indicate the growing interest in this method.

2) Synbiotics

Research on the use of probiotics in drug delivery and therapeutic applications, as seen from the keywords "drug delivery" and "biotherapeutics," indicates the expansion of probiotic applications beyond the food sector.

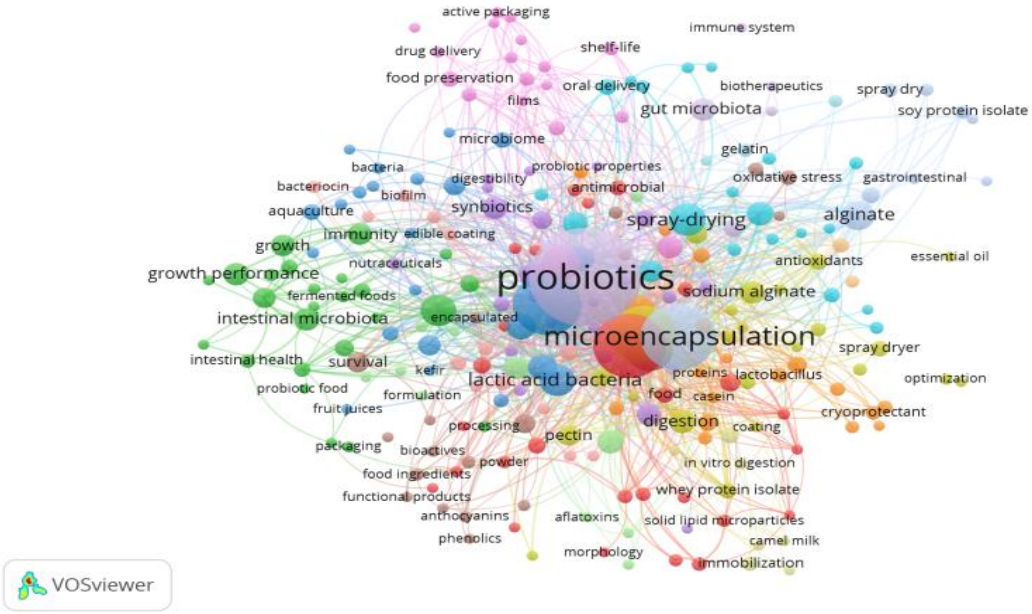

Fig 1. Network of the appearance of keywords in spray drying technology for probiotics

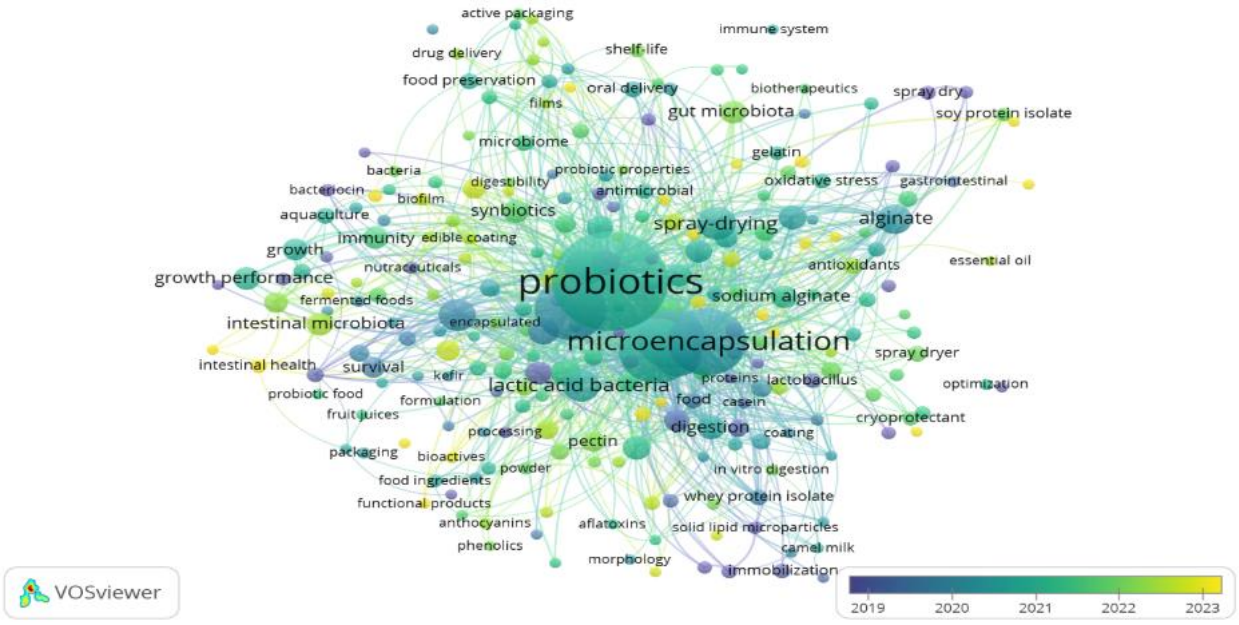

Fig 2. Overlay Visualization of Spray Drying for Probiotics

E. Temporal Trends in Spray Drying Research for Probiotics

The presented overlay visualization shows the evolution of research in spray-drying technology for probiotics from 2019 to 2023. The colour of the nodes indicates the year of publication, with dark blue representing older

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studies (2019) and yellow indicating more recent studies (2023). From this visualization, it is apparent that key topics such as "probiotics," "microencapsulation," and "spray-drying" have remained a consistent research focus over the past few years, with many recent studies related to these keywords. This suggests that interest in spray drying technology to improve probiotic viability and stability remains high and continues to grow.

CONCLUSION

This bibliometric analysis provides a comprehensive insight into research trends in probiotic spray-drying technology. By understanding the patterns and relationships between these studies, researchers can identify promising areas for further exploration and develop more effective strategies for probiotic applications.

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