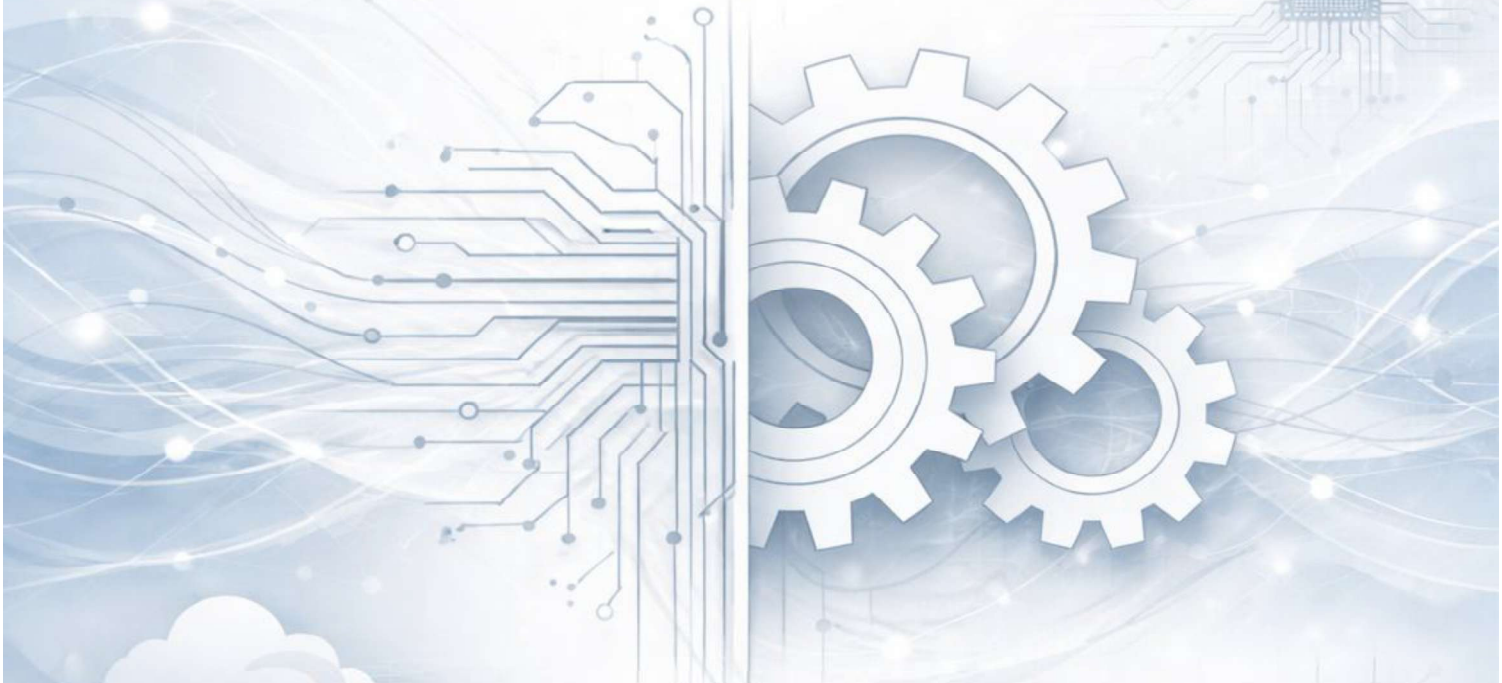
Interdisciplinary Engineering and Technology Management



Dr. DIANA AGNES
Mrs. DIMPLE JUNEJA
MD MOYEED ABRAR
Dr. K. MANIKANDAN

SRR
Publicizing Research

ISBN 978-819992068-2

Interdisciplinary Engineering and Technology Management

March 2026

Dr. DIANA AGNES
Researcher, Department of English
School of Social Sciences and Languages
Vellore Institute of Technology, Vellore
Tamil Nadu, India.

Mrs. DIMPLE JUNEJA
Research Scholar, Department of Education
Mohanlal Sukhadia University
Udaipur, Rajasthan, India.

MD MOYEED ABRAR
Assistant Professor
Department of Computer Science and Engineering
Khaja Bandanawaz University, Kalaburagi
Karnataka, India.

Dr. K. MANIKANDAN
Assistant Professor
Department of Electrical and Electronics Engineering
Academy of Maritime Education and Training (AMET),
Deemed to be University
Kanathur, Tamil Nadu, India.

March 2026

ISBN: 978-81-999206-8-2

Published By

SRR
Publicizing Research

SCIENTIFIC RESEARCH REPORTS
(A Book Publisher, approved by Govt. of India)

I Floor, S S Nagar, Chennai - 600 087,
Tamil Nadu, India.

editors@srrbooks.in, contact@srrbooks.in
www.srrbooks.in

PREFACE

The rapid convergence of engineering, technology, and management disciplines has redefined the landscape of modern research and practice. *Interdisciplinary Engineering and Technology Management* emerges as a timely scholarly contribution that captures this dynamic integration, offering a comprehensive exploration of contemporary issues, innovations, and applications across diverse domains.

This volume brings together a rich collection of research chapters that reflect the evolving role of technology in addressing complex societal, industrial, and economic challenges. The contributions span a wide spectrum—from machine learning and artificial intelligence to consumer behavior, sustainable supply chains, and human resource management—demonstrating the power of interdisciplinary approaches in generating impactful solutions.

A significant focus of this book lies in the application of advanced computational techniques such as machine learning and artificial intelligence. Chapters on predictive analytics in engineering, smart agriculture, human activity recognition, and autonomous robotic inspection highlight how intelligent systems are transforming industries by enhancing efficiency, safety, and decision-making processes. These studies not only underscore technological advancement but also emphasize sustainability and human-centric development.

Equally important are the insights into socio-economic and behavioral dimensions of technology. Research on social media influence, online marketplaces, consumer preferences, and

emerging e-commerce trends provides a nuanced understanding of how digital transformation is reshaping consumer behavior and business strategies. These chapters are particularly relevant in today's data-driven economy, where understanding user engagement and perception is critical for organizational success.

The book also addresses pressing global concerns such as sustainability and energy transition. Discussions on electric vehicles and sustainable supply chain management reflect the urgent need for environmentally responsible practices in engineering and commerce. These contributions offer valuable perspectives on balancing innovation with ecological and economic considerations.

Furthermore, the inclusion of studies on employee engagement, remote work strategies, and service quality in various sectors highlights the growing importance of human resource management in a technologically evolving workplace. The integration of human factors with technological systems remains a cornerstone for achieving long-term organizational effectiveness.

Notably, the volume also embraces interdisciplinary connections beyond engineering and management, as seen in the exploration of literature and social identity, demonstrating the breadth and inclusivity of the work.

This book is intended for academicians, researchers, industry professionals, and students who seek to understand and contribute to the interdisciplinary nexus of engineering and management. It is our hope that this compilation will inspire further research, foster innovation, and encourage collaborative problem-solving in addressing the challenges of the future.

The editors extend their sincere gratitude to all contributors for their valuable research and dedication in making this volume a meaningful academic resource. We extend our sincere thanks to our publisher, Scientific Research Reports, Chennai, India, for their dedicated efforts in preparing this book and for ensuring the inclusion of enriched and high-quality technical content.

Wishes and Regards,

Dr. DIANA AGNES
Researcher, Department of English
School of Social Sciences and Languages
Vellore Institute of Technology, Vellore
Tamil Nadu, India.

Mrs. DIMPLE JUNEJA
Research Scholar, Department of Education
Mohanlal Sukhadia University
Udaipur, Rajasthan – 313002, India

MD MOYEED ABRAR
Assistant Professor
Department of Computer Science and Engineering
Khaja Bandanawaz University, Kalaburagi
Karnataka, India.

Dr. K. MANIKANDAN
Assistant Professor
Department of Electrical and Electronics Engineering
Academy of Maritime Education and Training (AMET),
Deemed to be University
Kanathur, Tamil Nadu, India

CONTENTS

Chapter 17

Microbial Production of Cosmetic Ingredients Production of Hyaluronic Acid, Collagen, and Enzymes using Microorganisms

Kameshwaran S[a], Sai Ramesh A[a*]

[a]*Department of Bio-Engineering, School of Engineering, Vels Institute of Science, Technology & Advanced Studies (VISTAS), Chennai*

**Corresponding Author Mail id: drsairamesh@gmail.com*

Abstract

Cosmetic biotechnology is an emerging field that uses biological systems to develop safe, effective, and sustainable cosmetic ingredients. In recent years, the demand for natural and eco-friendly skincare products has increased rapidly, which has encouraged the use of microorganisms in cosmetic production. Microorganisms such as bacteria, yeast, and fungi can act as biological factories and produce many useful bioactive compounds through microbial fermentation. This technology allows the large-scale production of important cosmetic ingredients like hyaluronic acid, collagen, and various enzymes that support skin health. Hyaluronic acid is widely used in skincare products because of its strong ability to retain moisture and maintain skin hydration. It is commonly produced by microorganisms like *Streptococcus zooepidemicus* through fermentation processes. Collagen is another important protein responsible for maintaining skin elasticity and firmness, and it can be produced using recombinant microorganisms such as Saccharomyces cerevisiae and Escherichia coli. In addition, microbial enzymes such as proteases and lipases play important roles in exfoliation, cleansing, and improving skin texture. Microbial

fermentation technology provides several advantages including high purity, consistent quality, and reduced dependence on animal-derived materials. It is also considered more sustainable and environmentally friendly compared to traditional extraction methods. With the help of modern biotechnology techniques like genetic engineering and metabolic engineering, the efficiency of microbial production can be further improved. Overall, cosmetic biotechnology offers a promising approach for the development of advanced cosmetic ingredients. The use of microbial systems not only improves product safety and effectiveness but also supports sustainable manufacturing in the cosmetic industry.

Keywords: Streptococcus, zooepidemicus, fermentation processes, microorganisms.

1. Introduction

The cosmetic industry has grown very fast in recent years because people are more interested in skincare and beauty products. Nowadays consumers are not only looking for beauty products, but they also want products that are safe, natural, and environmentally friendly. Because of this reason, biotechnology has become very important in the cosmetic field. Biotechnology mainly uses living organisms such as microorganisms to produce useful substances. Microorganisms like bacteria, yeast and fungi can act like small biological factories. Through a process called microbial fermentation, these microorganisms can produce many bioactive compounds that are useful in skincare products. Important cosmetic ingredients such as hyaluronic acid, collagen and certain enzymes are now produced using microbial systems. These ingredients help to maintain skin hydration, improve elasticity and support overall skin health.

ISBN 978-819992068-2

Another advantage of using microorganisms is that the production process can be controlled very well in laboratories or industries. It also reduces the need for animal derived materials which were used earlier. Therefore, microbial biotechnology is becoming an important method for producing cosmetic ingredients in a safe and sustainable way.

2. Role of Microorganisms in Cosmetic Biotechnology

Microorganisms play a major role in cosmetic biotechnology because they are capable of producing many useful biomolecules. Different types of microorganisms such as bacteria, yeast and fungi are commonly used in biotechnology industries. Certain bacteria like *Streptococcus zooepidemicus* and *Bacillus subtilis* are widely used for the production of hyaluronic acid and different industrial enzymes. These bacteria grow fast and can produce large amounts of useful compounds during fermentation. Yeast organisms such as Saccharomyces cerevisiae are also important because they are often used for recombinant protein production. Scientists can insert specific genes into yeast cells so that they produce proteins like collagen.

Fungi such as *Aspergillus niger* are also used in biotechnology for enzyme production. These enzymes are later used in cosmetic formulations for different skincare benefits. Microorganisms are very useful because they grow quickly, need simple nutrients and can be easily modified using genetic engineering techniques. Because of these advantages they are widely used as biological factories in cosmetic biotechnology.

3. Microbial Fermentation Technology in Cosmetic Ingredient Production

Fermentation technology is an important process used for producing many cosmetic ingredients. In this process microorganisms are grown in controlled conditions where they produce useful biomolecules. First a suitable culture medium is prepared which contains nutrients required for microbial growth. Then the microorganisms are added to the fermentation vessel. During fermentation different factors like temperature, pH and oxygen supply must be carefully controlled so that the microorganisms grow properly and produce the desired compound. After the fermentation process is completed, the product is separated and purified through different downstream processing methods. These methods may include filtration, precipitation and chromatography techniques. Through this process high quality cosmetic ingredients can be obtained. Microbial fermentation allows industries to produce cosmetic ingredients in large quantities with consistent quality. Because of this reason it is widely used in the cosmetic and pharmaceutical industries.

4. Microbial Production of Hyaluronic Acid

Hyaluronic acid is a very important compound naturally present in the skin and connective tissues. It is a polysaccharide that helps to retain water and maintain skin moisture. Because of this property it is widely used in moisturizers, serums and anti-aging cosmetic products.

Earlier hyaluronic acid was mainly extracted from animal tissues like rooster combs. But this method had some limitations such as safety concerns and difficulty in purification. Nowadays microbial

ISBN 978-819992068-2

fermentation is commonly used for the production of hyaluronic acid. The bacterium *Streptococcus zooepidemicus* is most commonly used for industrial production of hyaluronic acid. During fermentation this bacterium synthesizes hyaluronic acid which can later be purified and used in cosmetic formulations. With the help of modern biotechnology and recombinant DNA technology scientists have also developed other microbial systems such as Escherichia coli for producing hyaluronic acid. Microbial production provides better purity, improved safety and more sustainable manufacturing process compared to traditional extraction methods.

5. Microbial Production of Collagen

Collagen is an important structural protein present in skin, bones and connective tissues. It plays a very important role in maintaining skin strength, elasticity and firmness. In the cosmetic industry collagen is widely used in anti-aging creams, moisturizers and dermal fillers. Traditionally collagen was obtained from animal sources such as bovine tissues or marine organisms. However, there are certain risks associated with animal derived collagen including disease transmission and allergic reactions. Because of this reason scientists have started producing collagen using microbial biotechnology.

Using recombinant DNA technology microorganisms like *Saccharomyces cerevisiae* and Escherichia coli can be genetically engineered to produce collagen or collagen like proteins. These recombinant systems allow controlled production of collagen in large quantities. Microbial collagen production is considered safer and more reliable. It also reduces dependence on animal sources and provides better quality control during production.

6. Microbial Production of Cosmetic Enzymes

Microorganisms are also used for producing various enzymes that are important in cosmetic formulations. Enzymes such as proteases, lipases and antioxidant enzymes play different roles in skincare products.

Protease enzymes help in removing dead skin cells by breaking down proteins present on the skin surface. This process helps in exfoliation and improves skin texture. Lipase enzymes are useful in cleansing formulations because they help in breaking down oils and impurities from the skin. Microorganisms like *Aspergillus niger* and *Bacillus subtilis* are commonly used for enzyme production because they can secrete large amounts of enzymes during fermentation. These enzymes are later purified and used in different cosmetic products. The use of microbial enzymes improves the effectiveness of skincare products and helps in maintaining healthy skin.

7. Applications of Microbial Cosmetic Ingredients in Skincare

Microbially produced ingredients are widely used in modern skincare products. These ingredients are commonly found in moisturizers, anti-aging creams, facial serums and skin repair formulations. Hyaluronic acid helps to maintain skin hydration by holding water molecules in the skin. Collagen improves skin elasticity and helps in reducing the appearance of wrinkles. Enzymes produced by microorganisms help in gentle exfoliation and support skin renewal process. Because of these benefits microbial ingredients have become very important in advanced cosmetic formulations. Many cosmetic companies are now using biotechnology-based ingredients to develop more effective skincare products.

ISBN 978-819992068-2

8. Advantages of Microbial Production in the Cosmetic Industry

Microbial production offers several advantages for the cosmetic industry. One of the major advantages is sustainability. Microbial fermentation reduces the need for animal derived materials and helps in protecting natural resources. Another advantage is that microbial production can be carried out in controlled industrial conditions which ensures consistent product quality. Large scale production is also possible using fermentation technology. Genetic engineering techniques also allow scientists to improve microbial strains so that they can produce higher yields of desired compounds. Because of these benefits microbial biotechnology has become an important part of the modern cosmetic industry.

9. Future Perspectives in Cosmetic Biotechnology

The future of cosmetic biotechnology looks very promising. Scientists are continuously working on improving microbial production methods using advanced technologies such as metabolic engineering and synthetic biology.

Researchers are also exploring new microorganisms that can produce novel bioactive compounds with better cosmetic benefits. These compounds may help in developing more effective skincare and anti-aging products.

In addition, the combination of biotechnology with nanotechnology and green chemistry may further improve the efficiency and sustainability of cosmetic ingredient production. These advancements may bring many innovations in the cosmetic industry in the coming years.

10. Conclusion

Microbial biotechnology has become an important approach for producing cosmetic ingredients in a safe and sustainable way. Microorganisms can be used as biological factories to produce important compounds such as hyaluronic acid, collagen and enzymes. Compared to traditional extraction methods microbial production provides better purity, improved safety and environmentally friendly manufacturing process. As biotechnology continues to develop, microbial systems will play an even bigger role in the production of modern cosmetic ingredients. Therefore, microbial biotechnology is expected to contribute significantly to the development of advanced and high-performance cosmetic products in the future.

References

[1] Marwan-Abdelbaset, E., Samy-Kamal, M., Tan, D., & Lu, X. (2025). Microbial production of hyaluronic acid: The current advances, engineering strategies and trends. Journal of Biotechnology, 403, 52–72.

[2] Espah Borujeni, N., Armagan, H. S., & Demirci, A. (2026). Microbial hyaluronic acid production by integrating molecular structure, biological function, purification, and application. International Journal of Biological Macromolecules, 339, 149963.

[3] Serra, M., Casas, A., Toubarro, D., Novo Barros, A., & Teixeira, J. A. (2023). Microbial hyaluronic acid production: A review. Molecules, 28(5), 2084.

[4] Ahmed, R. M., Enan, G., Saed, S., et al. (2023). Hyaluronic acid production by Klebsiella pneumoniae strain H15 (OP354286) under different fermentation conditions. BMC Microbiology, 23, 295.

[5] Wei, M., Huang, Y., Zhu, J., Qiao, Y., Xiao, N., Jin, M., Gao, H., Huang, Y., Hu, X., & Li, O. (2024). Advances in hyaluronic acid production: Biosynthesis and genetic engineering strategies based on

ISBN 978-819992068-2

Streptococcus — A review. International Journal of Biological Macromolecules, 270, 132334.

[6] Silva, S., Bautista-Hérnandez, I., Gomez-García, R., Costa, E. M., & Machado, M. (2025). Precision fermentation as a tool for sustainable cosmetic ingredient production. Applied Sciences, 15(17), 9246.

[7] De Moura Campos, S., Dos Santos Costa, G., Karp, S. G., & Thomaz-Soccol, V. R. (2025). Innovations and challenges in collagen and gelatin production through precision fermentation. World Journal of Microbiology and Biotechnology, 41(2), 63.

[8] Gao, B., Tan, C., Roshani, D., Yang, R., Lv, Z., Li, P., & Shang, N. (2025). Microbial collagenases: Characterization, degradation mechanisms, and applications. Critical Reviews in Food Science and Nutrition, 65(29), 6269–6293.

[9] Zhang, K., & Han, Y. (2024). Thermostable bacterial collagenolytic proteases: A review. Journal of Microbiology and Biotechnology, 34(7), 1385–1394. ht

[10] Xu, L., Li, J., Zhang, H., Zhang, M., Qi, C., & Wang, C. (2025). Biological modification and industrial applications of microbial lipases: A general review. International Journal of Biological Macromolecules, 302, 140486.