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### Microbial Enzymes in Industry: An Overview

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#### Abstract

Recently, more attention has been given to finding alternative approaches that support sustainability and help minimize the harmful effects of chemical substances by using safer and more eco-friendly replacements. Hence, Microorganisms are important because they are producing many useful substances, among which microbial enzymes are especially significant due to their wide applications in industry, biotechnology chemical, pharmaceuticals, fermentation and food production. Enzymes are natural substances that work to catalyze the reactions in living organisms. Therefore, Enzymes are an essential factor for all biological reactions due to their role in catalyzing components. This article discusses the diversity of microbial enzymes in industry and their environmental significance.

**Keywords:** Bacteria, Fungi, Enzymes, Applications

### 1. Introduction

Enzymes are natural substances that catalyze the reactions in living organisms, enabling the substitution of various hazardous chemical reactions with environmentally friendly and sustainable biological methods (Patel et al., 2023). Thus, enzymes that are obtained from microbial sources are considered as a great source of enzymes because of their features as pH stability, thermostability, lower cost, high production rate, and availability (Banerjee and Ray, 2017; Thapa et al., 2019). Therefore, microbial enzymes play a crucial role because of their application. They have been widely utilized across various industries such as pulp and paper, leather processing, detergents, textiles, pharmaceuticals, food and beverages, chemical, animal feed and biofuels **Figure 1** (Adrio and Demain, 2014). Their applications also include extending the self-life of food and

beverage products. Microbial enzymes are highly valuable in industrial applications due to several advantages. These enzymes are used in large-scale industrial fermenters, independent of seasonal or climatic variations. Additionally, they offer consistent quality across production batches, and advances in protein expression technologies have enabled high yields of active enzymes (Guerrand, 2018). The use of enzymes for such purpose dates to ancient times, but recent advancements have significantly enhanced their industrial relevance and efficiency (Singh et al., 2016; Kumar et al., 2024). In addition, microbial enzymes play an important role in antimicrobial resistance. As a result of the excessive and improper utilization of antibiotics, a menace of resistance has increased in pathogenic microbes (Aggarwal et al., 2024). Currently, the interest of using biological strategies gets attention to use rather than using chemical materials. Egorov et al., 2018 reported that microbial enzymes have an important effect in antibiotic resistance by inactivating antibiotics, modifying drug targets, transforming antibiotic molecules, or enabling metabolic bypasses. "Microbial enzymes represent approximately 90% of the global enzymes market, with their producers primarily concentrated located in Europe and Asia (Guerrand, 2018)". Thus, due to the global importance of microbial enzymes, extensive research has been carried out globally.



**Figure 1** summary of Microbial Enzymes Application (Adrio & Demain, 2014).

## 2. Microbial Enzymes: Sources and Environmental significance

Previous studies have reported that a bunch of microbial enzymes were discovered, for example, cellulase, laccase, amylase, lipase, and protease enzymes (Nigam, 2013). Moreover, these enzymes were obtained from various types of bacteria such as *Bacillus subtilis* (Sun et al., 2023), *Pseudomonas*, *Clostridium*, and *Bacillus* (Nigam, 2013). Besides, microbial enzymes are also isolated from fungi like *Pleurotus* (Devi et al., 2020), *Trametes* (Liu et al., 2014), *Aspergillus oryzae* (sun et al., 2024), *Rhizopus oryzae* (López-Fernández et al., 2020), *Acremonium sclerotigenum* and *Candida* (Safdar et al., 2023). Clearly, microorganisms tend to thrive in

environments that are rich in essential nutrients such as protein, lipid, and carbohydrates. To utilize these macromolecules, microbes secrete specific enzymes that break them down into smaller, absorbable units (Conlon and Bird, 2014; Banerjee and Ray, 2017). Several studies have pointed out that microbial enzymes have received global recognition due to their extensive applications across diverse industries, including food, agriculture, chemicals, medicine, and energy (Singh et al., 2016). Microbial enzymes are considered one of the most important tools in the industry field, which is their capability to synthesize biodegradable polymers. Additionally, this method will be safe for the environment because of synthesizing "from renewable carbon sources via biological processes, degrade biologically after use and then return to the natural environment as renewable resources, such as carbon dioxide (CO<sub>2</sub>) and biomass" (Singh et al., 2016). This eco-friendly process has significant implications for biofuel production and waste management, and sustainable industrial applications. According to Singh et al. (2016) there are several studies reported that there are a group of enzymes that are used for waste treatment as amidases, amylases, amyl glucosidases, cellulases, glucoamylases, lipases, nitrile hydratases, pectinases and proteases. Microbial enzymes are considered as a great source of biodegradation of poisonous natural toxic compounds. Moreover, fungal enzymes are deemed as one of the significant enzymes in environmental sustainability due to their application in agricultural, medicinal requests, and industrial processing (El-Gendi et al., 2022). "El-Gendi et al. (2022), reported that fungi contribute to the production of over 50% of the required enzymes, due to species like *Aspergillus*, *Trichoderma*, *Rhizopus*, and *penicillium*." Additionally, Gonzalo et al. (2016) reported that the role of bacterial enzymes in breaking down lignin, a major component of plant biomass. Bacterial species such as *Pseudomonas*, *Bacillus*, and *Rhodococcus* produce key oxidative enzymes like laccases and peroxidases, enabling the conversion of lignin into simpler aromatic compounds (Lee et al., 2019). Also, there is a lactic acid bacterium, this type of bacteria used to degrade complex compounds polysaccharides into simpler compounds monosaccharides (Ludfiani et al., 2024). Numerous study research were isolated bacteria from waste and soil for detection of protease enzyme (Boominadhan et al., 2009; Das and Prasad, 2010). According to Contesini et al. (2018) *Bacillus* species is considered as one of the most important sources of protease enzymes. Moreover, *Bacillus* species can produce high yields of neutral and alkaline proteolytic enzymes with remarkable properties (Contesini et al. 2018). There is some species of *bacillus* strains are listed on the Food and Drug Administration's GRAS as safe (Schallmey et al., 2004). Hence, these gram-positive bacteria can produce various types of industrial enzymes such as amylases, xylanases, lipases, cellulases, phytases, laccases, and proteases. Furthermore, *Bacillus* genomes are considered as a powerful tool of the development of new biotechnologies due to the characteristics of *bacillus* strains including high stability across a broad range of temperatures and pH, high specificity, substrate specificity and the ability to biodegrade various complex compounds and the high potential of sequenced (Danilova and Sharipova, 2020). Boominadhan et al., (2009) reported that several isolates of Bacteria such as *Bacillus subtilis*, *Bacillus amyloliquefaciens*, *Bacillus megaterium* and *Bacillus licheniformi* produced protease enzyme. According to Das and Prasad, (2010), *Bacillus* species are specific producers of extracellular proteases.

### 3. Key Enzymes and Their Industrial Applications

### 3.1 Cellulases

Microbial celluloses are linear polysaccharides that are synthesized and secreted by microorganisms such as bacteria, fungi and algae (Shahaban et al., 2024). Bacteria are considered an excellent source of microbial cellulose (Sarvananda, and Premarathna, 2022). However, **cellulases** are one of the most popular microbial enzymes that have several applications in various commercials including "agriculture, food industry, brewing, laundry, pulp and paper and textile industry" (Ejaz et al., 2021).

### 3.2 laccases

Besides cellulase applications, **laccases** have numerous applications such as textiles, pulp and paper, and the food industry (Singh& Gupta, 2020). Additionally, laccase has been applied in biosensors designing, biofuel cells, also; it used as a medical diagnostics tool and bioremediation agent to clean up herbicides, and pesticides (Shraddha et al., 2011).

### 3.3 $\alpha$ - Amylases

**$\alpha$ -Amylases enzymes** are obtained from a wide range of microorganisms such as bacteria, fungi, and yeast (Sahu et al., 2024). Subsequently, the  $\alpha$ -Amylases enzymes are used in various fields of industries such as food, fermentation, textile, paper, detergent, and pharmaceutical industries (de Souza and de Oliveira Magalhães, 2010). Furthermore, Gopinath et al. (2017) reported that the level of amylase production varies from one microbe to another-even within the same genus, species, or strain. Between diverse microorganisms, bacteria are considered the most efficient producers because of their rapid enzyme synthesis and cost-effectiveness. Moreover, bacteria are commonly used in genetic engineering due to their simplicity and compatibility, which makes them perfect for producing recombinant enzymes.

### 3.4 Proteases

**Protease enzymes** are used as a wide range of applications such as leather industry, food processing and food industry and pharmaceuticals (Jabalia et al., 2014). According to Ojo-Omoniyi et al. (2024), proteases make up about 60% of the global industrial enzyme market. There is a gap in understanding the biological role of most protease's enzymes, also, the limitation of conventional protease is rendered by chemical and thermostable protease (Jabalia et al., 2014). Multiple previous studies have reported that bacteria and fungi are a great source of different types of proteases such "as alkaline protease, cysteine protease, aspartate protease, and metallo protease" (Banerjee and Ray, 2017).

### 3.5 Lipases

**Lipases** are hydrolase enzymes that are utilized in several applications such as food industry, industrial cleaners, leather processing, polymers, biomedical applications and pesticides. (Godoy et al., 2022). lipases are considered among the preferred enzymes in industrial applications because they work without the expensive and hard to replace cofactors required by some other enzymes, such as dehydrogenases or ligases (Javed et al., 2018; Godoy

et al., 2022). Several studies have reported that lipases enzymes have been extracted from numerous microbial sources such as fungi, bacteria and yeast. The microbes that were isolated from sources that have environmental conditions such as contaminated soils, hot springs, and glaciers are sources of lipases that are characterized to have a unique characteristic (Ali et al., 2023).

#### **4. Challenges and Future Prospects**

Microbial enzymes offer great potential for industrial use; their widespread application is still limited. This is mainly due to the high cost of procedures required for their extraction and purification (Khan, 2025). There are also other challenges in the application of microbial enzymes industry. For example, alkaline proteases are widely used enzymes due to their ability to break down collagen and proteins found in hair follicles. However, as noted by Niu et al. (2025), their use in the leather industry—particularly during the hair removal stage—can sometimes damage the surface of the hide, which limits their effectiveness in this application. As a result, the use of alkaline proteases for leather dehairing remains somewhat restricted. According to Ejaz et al., (2021) cellulases have challenge which is the cost production impedes their exploitation, particularly for cellulosic ethanol. one of the major environmental challenges is plastic pollution. Microbial enzymes have shown great potential in addressing this issue. Despite this potential, their efficiency remains limited, especially with tough polymers such as PE (Polyethylene), PET (Polyethylene terephthalate), and PS (Polystyrene) (Choi et al., 2024). In addition, Chow et al. (2023) points out that a major challenge in applying microbial enzymes lies in identifying enzymes that can actively degrade fossil-fuel-based polymers. This limitation continues to hinder broader industrial adoption of enzymatic plastic degradation methods. According to Abdelaziz et al., (2025). In addition, lipase enzymes have force obstacles to understand the molecular mechanisms influencing lipase stability. Focusing on the use of advanced techniques, especially genetic engineering, can help improve the production of highly efficient microbial enzymes. Future research should focus on microbial enzyme mechanisms to improve advance their biotechnology applications. Moreover, focusing on the discovery of new microbial species can lead to the identification of novel enzyme types that may be even more effective.

#### **5. Conclusion**

Overall, microbial enzymes are considered as eco- friendly catalysts enzymes. They have the ability of remediation of several toxic compounds. They play a critical role in solving and helping to reduce the toxic pollutants in the environment. Previous methods such as physical and chemical have a lot of challenges, consequently researchers focused on finding alternative methods such as bioremediation (Ayilara and Babalola, 2023). Moreover, microbes are one of the best sources that are used to solve this challenge by using their enzymes because of their rapid growth and ability to be easily manipulated (Ayilara and Babalola, 2023). They have many features for instance their easier to produce in large amounts, at low cost, within short time, and exhibit stability under various extreme conditions( Gopinath et al., 2017). To increase enzymes production and reduce their costs, various methods have been used such as microbial cultures and industrial waste and statistical methods (Abdella

and Ahmed., 2025). Additionally, microbial enzymes have a long shelf life, allowing these enzymes to be stored for extended periods after isolation while maintaining their activity and stability (Abdella and Ahmed., 2025). Consequently, many enzymes with optimal features have been developed (Zheng et al., 2024). Lastly, microbial enzymes, such as Cellulases, laccases,  $\alpha$ - Amylases, Proteases, and Lipases have demonstrated significant importance in various industrial and environmental applications.

## References

- Abdelaziz , A. A., Abo-Kamar, A. M., Elkotb, E. S., & Al-Madboly, L. A. (2025). Microbial lipases: advances in production, purification, biochemical characterization, and multifaceted applications in industry and medicine. *Microbial Cell Factories*, 24(1), 40.
- Abdella, M. A., & Ahmed, S. A. (2025). Stable protease from *Bacillus licheniformis*-MA1 strain: statistical production optimization, kinetic and thermodynamic characterization, and application in silver recovery from used X-ray films. *Microbial Cell Factories*, 24(1), 98.
- Adrio, J. L., & Demain, A. L. (2014). Microbial enzymes: tools for biotechnological processes. *Biomolecules*, 4(1), 117-139.
- Aggarwal, R., Mahajan, P., Pandiya, S., Bajaj, A., Verma, S. K., Yadav, P., ... & Johri, A. K. (2024). Antibiotic resistance: a global crisis, problems and solutions. *Critical Reviews in Microbiology*, 50(5), 896-921.
- Contesini, F. J., Melo, R. R. D., & Sato, H. H. (2018). An overview of *Bacillus* proteases: from production to application. *Critical reviews in biotechnology*, 38(3), 321-334.
- Ayilara, M. S., & Babalola, O. O. (2023). Bioremediation of environmental wastes: the role of microorganisms. *Frontiers in Agronomy*, 5, 1183691.
- Banerjee, G., & Ray, A. K. (2017). Impact of microbial proteases on biotechnological industries. *Biotechnology and Genetic Engineering Reviews*, 33(2), 119-143.
- Boominadhan, U., Rajakumar, R., Sivakumaar, P. K. V., & Joe, M. M. (2009). Optimization of protease enzyme production using *Bacillus* sp. isolated from different wastes. *Bot. Res. Int*, 2(2), 83-87.
- Chow, J., Perez-Garcia, P., Dierkes, R., & Streit, W. R. (2023). Microbial enzymes will offer limited solutions to the global plastic pollution crisis. *Microbial Biotechnology*, 16(2), 195-217.
- Conlon, M. A., & Bird, A. R. (2014). The impact of diet and lifestyle on gut microbiota and human health. *Nutrients*, 7(1), 17-44.
- Danilova, I., & Sharipova, M. (2020). The practical potential of bacilli and their enzymes for industrial production. *Frontiers in microbiology*, 11, 1782.
- Ali, S., Khan, S. A., Hamayun, M., & Lee, I. J. (2023). The recent advances in the utility of microbial lipases: A review. *Microorganisms*, 11(2), 510.

- Choi, J., Kim, H., Ahn, Y. R., Kim, M., Yu, S., Kim, N., ... & Kim, H. O. (2024). Recent advances in microbial and enzymatic engineering for the biodegradation of micro-and nanoplastics. *RSC advances*, 14(14), 9943-9966.
- Das, G., & Prasad, M. P. (2010). Isolation, purification & mass production of protease enzyme from *Bacillus subtilis*. *Int. Res. J. Microbiol*, 1(2), 26-31.
- de Souza PM, de Oliveira Magalhães P. Application of microbial  $\alpha$ -amylase in industry - A review. *Braz J Microbiol*. 2010 Oct;41(4):850-61.
- Devi, S. K., Prabhu, N., Monika, S., Swapna, N. M., Vaishali, S., & Gajendran, T. (2020). Sequestration and purification of essential enzyme from *Pleurotus florida* compost waste and its application studies. *Journal of Applied Biology & Biotechnology*, 8(1), 64-68.
- Egorov AM, Ulyashova MM, Rubtsova MY. Bacterial Enzymes and Antibiotic Resistance. *Acta Naturae*. 2018 Oct-Dec;10(4):33-48. PMID: 30713760; PMCID: PMC6351036.
- Ejaz, U., Sohail, M., & Ghanemi, A. (2021). Cellulases: from bioactivity to a variety of industrial applications. *Biomimetics*, 6(3), 44.
- El-Gendi, H., Saleh, A. K., Badierah, R., Redwan, E. M., El-Maradny, Y. A., & El-Fakharany, E. M. (2022). A Comprehensive Insight into Fungal Enzymes: Structure, Classification, and Their Role in Mankind's Challenges. *Journal of Fungi*, 8(1), 23.
- Godoy, C. A., Pardo-Tamayo, J. S., & Barbosa, O. (2022). Microbial lipases and their potential in the production of pharmaceutical building blocks. *International Journal of Molecular Sciences*, 23(17), 9933.
- Gopinath, S. C., Anbu, P., Arshad, M. M., Lakshmipriya, T., Voon, C. H., Hashim, U., & Chinni, S. V. (2017). Biotechnological processes in microbial amylase production. *BioMed research international*, 2017(1), 1272193.
- Guerrand, D. (2018). Economics of food and feed enzymes: Status and perspectives. In *Enzymes in human and animal nutrition* (pp. 487-514). Academic Press.
- Jabalia, N., Mishra, P. C., & Chaudhary, N. (2014). Applications, challenges and future prospects of proteases: An overview. *Journal of Agroecology and Natural Resource Management*, 1(3), 179-183.
- Javed, S., Azeem, F., Hussain, S., Rasul, I., Siddique, M. H., Riaz, M., ... & Nadeem, H. (2018). Bacterial lipases: a review on purification and characterization. *Progress in biophysics and molecular biology*, 132, 23-34.

- Khan, M. F. (2025)Khan, M. F. (2025). Recent advances in microbial enzyme applications for sustainable textile processing and waste management. *Sci*, 7(2), 46.
- Kumar, A., Dhiman, S., Krishan, B., Samtiya, M., Kumari, A., Pathak, N., ... & Dhewa, T. (2024). Microbial enzymes and major applications in the food industry: a concise review. *Food Production, Processing and Nutrition*, 6(1), 85.
- Lee, S., Kang, M., Bae, J. H., Sohn, J. H., & Sung, B. H. (2019). Bacterial valorization of lignin: strains, enzymes, conversion pathways, biosensors, and perspectives. *Frontiers in bioengineering and biotechnology*, 7, 209.
- Liu, J., Liu, W., Cai, Y., Liao, X., Huang, Q., & Liang, X. (2014). Laccase production by *Trametes hirsuta*, characterization, and its capability of decoloring chlorophyll. *Polish Journal of Microbiology*, 63(3), 323.
- López-Fernández, J., Benaiges, M. D., & Valero, F. (2020). *Rhizopus oryzae* lipase, a promising industrial enzyme: Biochemical characteristics, production and biocatalytic applications. *Catalysts*, 10(11), 1277.
- Ludfiani, D. D., Asmara, W., & Arianti, F. D. (2024). Enzyme characterization of lactic acid bacteria isolated from duck excreta. *Veterinary World*, 17(1), 143.
- Nigam, P. S. (2013). Microbial enzymes with special characteristics for biotechnological applications. *Biomolecules*, 3(3), 597-611.
- Niu, C., Liu, C., & Li, Q. (2025). Significant alleviation of water pollution in leather dehairing through an eco-friendly compound enzyme system. *Journal of Environmental Chemical Engineering*, 115520.
- Ojo-Omoniyi, O. A., Moro, D. D., & Afolab, O. B. (2024). Microbial Proteases: Sources, Significance and Industrial Applications. *Int J Curr Microbiol App Sci*, 13, 1-23.
- Patel, A. K., Dong, C. D., Chen, C. W., Pandey, A., & Singhania, R. R. (2023). Production, purification, and application of microbial enzymes. In *Biotechnology of microbial enzymes* (pp. 25-57). Academic Press.
- Safdar, A., Ismail, F., & Imran, M. (2023). Characterization of detergent-compatible lipases from *Candida albicans* and *Acremonium sclerotigenum* under solid-state fermentation. *ACS omega*, 8(36), 32740-32751.
- Sahu, P. K., Singh, R., Shrivastava, M., Darjee, S., Mageshwaran, V., Phurailtpam, L., & Rohatgi, B. (2024). Microbial production of  $\alpha$ -amylase from agro-waste: An approach towards biorefinery and bio-economy. *Energy Nexus*, 14, 100293.
- Schallmeyer, M., Singh, A., & Ward, O. P. (2004). Developments in the use of *Bacillus* species for industrial production. *Canadian journal of microbiology*, 50(1), 1-17.

- Shahaban, O. S., Khasherao, B. Y., Shams, R., Dar, A. H., & Dash, K. K. (2024). Recent advancements in development and application of microbial cellulose in food and non-food systems. *Food Science and Biotechnology*, 33(7), 1529-1540.
- Shraddha, N., Shekher, R., Sehgal, S., Kamthania, M., & Kumar, A. (2011). Laccase: microbial sources, production, purification, and potential biotechnological applications. *Enzyme research*, 2011(1), 217861.
- Sarvananda, L., & Premarathna, A. D. (2022). Microbial cellulose: an alternate source for plant cellulose. *Silva Balcanica*, 23(2).
- Singh, D., & Gupta, N. (2020). Microbial Laccase: a robust enzyme and its industrial applications. *Biologia*, 75(8), 1183-1193.
- Singh, R., Kumar, M., Mittal, A., & Mehta, P. K. (2016). Microbial enzymes: industrial progress in 21st century. *3 Biotech*, 6, 1-15.
- Sun, B., Zou, K., Zhao, Y., Tang, Y., Zhang, F., Chen, W., ... & Zheng, Y. (2023). The fermentation optimization for alkaline protease production by *Bacillus subtilis* BS-QR-052. *Frontiers in Microbiology*, 14, 1301065.
- Sun, Z., Wu, Y., Long, S., Feng, S., Jia, X., Hu, Y., ... & Zeng, B. (2024). *Aspergillus oryzae* as a cell factory: research and applications in Industrial Production. *Journal of Fungi*, 10(4), 248.
- Thapa, S., Li, H., OHair, J., Bhatti, S., Chen, F. C., Nasr, K. A., ... & Zhou, S. (2019). Biochemical characteristics of microbial enzymes and their significance from industrial perspectives. *Molecular biotechnology*, 61, 579-601.
- Zheng, C. C., Gao, L., Sun, H., Zhao, X. Y., Gao, Z. Q., Liu, J., & Guo, W. (2024). Advancements in enzymatic reaction-mediated microbial transformation. *Heliyon*, 10(19).