

specific application requirements. The scalability of enzyme production in recombinant host systems further facilitates the commercialization of enzyme-based biocatalysts, paving the way for widespread adoption in industrial settings [5].

Recent Advancements in Enzyme Discovery and Engineering: Recent advancements in genomics, metagenomics, and protein engineering have revolutionized the field of enzyme discovery and engineering, leading to the identification and optimization of novel enzymes with tailored properties. Metagenomic approaches allow for the exploration of diverse microbial ecosystems, uncovering enzymes with unique functionalities and catalytic capabilities. Protein engineering techniques, such as rational design and directed evolution, enable the modification of enzyme structures and active sites to enhance substrate specificity, catalytic activity, and stability. Furthermore, advances in high-throughput screening and computational modeling facilitate the rapid screening and characterization of enzyme variants, accelerating the development of enzyme-based biocatalysts for industrial applications. These innovations have expanded the toolbox of industrial enzymes, enabling the development of tailored solutions for specific manufacturing processes and applications [6].

Industrial Enzymes and Their Applications: Industrial enzymes find diverse applications across various sectors, including food and beverage production, textiles, biofuels, and waste management. In the food and beverage industry, enzymes are used for starch hydrolysis, protein modification, flavor enhancement, and clarification processes. Enzymes such as amylases, proteases, lipases, and cellulases play key roles in optimizing product quality, reducing processing times, and minimizing waste generation. In the textiles industry, enzymes are employed for desizing, scouring, bleaching, and biofinishing processes, offering eco-friendly alternatives to harsh chemical treatments [7]. Enzymatic processes enable efficient removal of impurities, enhancement of fabric properties, and reduction of water and energy consumption. Moreover, in the biofuels sector, enzymes catalyze the conversion of biomass feedstocks, such as lignocellulose, into biofuels, such as ethanol and