

BIOREACTOR ENGINEERING

Chapter 1

Introduction of Bioprocess Engineering

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Introduction of Bioprocess Engineering by Chew Few Ne

Chapter Description

- Topic Outcome
 - Discuss types of fermentation process
- References
 - Doran, P.M. (2013) Bioprocess Engineering Principles. Elsevier.
 - Liu, S. (2013) Bioprocess Engineering: Kinetics, Biosystem, Sustainability and Reactor Design. Elsevier.
 - Rao, D.G. (2010) Introduction to Biochemical Engineering. McGraw Hill.



Topic Outline

- Introduction to Bioprocess Engineering
- Introduction to Fermentation



Introduction to Bioprocess Engineering

- Chemical engineer vs Bioprocess engineer
 - Chemical Engineering: The branch of engineering that deals with the **design, construction, and operation** of plants and machinery for making products by adapting the chemical reactions to **large-scale production**.
 - Bioprocess Engineering: Applies the **same principles as Chemical Engineering**, by changing the power of biological system (microorganism) to produce better products.



Introduction to Bioprocess Engineering

- The bioprocessing steps include:
 - Prepare the biochemicals and animal tissue
 - Identify the part of animal chromosome
 - Gene cut from chromosome
 - Prepare the microorganism (e.g., *E. coli*)
 - Identify the microorganism plasmid
 - Cut the plasmid
 - Recombinant the plasmid with the animal chromosome
 - Insert the recombinant plasmid into microorganism



Introduction to Bioprocess Engineering

- The bioprocessing steps include:
 - Plasmid multiplication and gene expression
 - Cell division
 - Small-scale culture
 - Bench-top bioreactor
 - Pilot-scale bioreactor
 - Industrial-scale operation
 - Product recovery
 - Packaging and marketing



Introduction to Bioprocess Engineering

- Examples of bioprocess engineering
 - Chemical industry: Fermentation of sugar to alcohol
 - Food industry: Conversion of milk to cheese; Production of flavours and colouring agents; Brewing and wine making
 - Medicine: Production of Hepatitis B vaccine; Production of insulin for use by diabetics; Production of artificial skin for burn therapy
 - Agriculture: Bio-insecticide development; Modification of plants to improve nutritional and processing characteristics
 - Environment: Sewage and other organic waste treatment



Introduction to Fermentation

- Fermentation can be used to describe any process which involved the production of product by mass culture of microorganism (e.g., bacteria, yeast, and fungi)
- The product can either be:
 - The cell itself: Production of microbial cell
 - Microorganism enzymes (e.g., lipases and proteases)
 - Microorganism own metabolites (e.g., amino acid, lipids, steroids, and vitamin)
 - Microorganism foreign products: Products from recombinant DNA technology or genetically engineered strain. (e.g., recombinant proteins, insulin, vaccines, and human therapeutics)



Introduction to Fermentation

- Fermentation can be classified into:
 - Submerged fermentation (SmF)
 - The microorganism grows inside a liquid medium
 - Suitable for microorganism (e.g., bacteria, yeast) that requires high moisture content (> 95%)
 - Utilizes free flowing liquid substrates (broth, soluble sugars, fruit and vegetable juices, sewage/waste water)
 - Solid-state fermentation (SSF)
 - The microorganism grows on the surface of a solid medium
 - Suitable for microorganism (e.g., fungi) that requires less moisture content (40% - 80%)
 - Utilizes solid substrates (wheat bran, paper pulp, rice husk, fruit and vegetable waste)



Introduction to Fermentation

- Advantages & disadvantages of SSF over SmF

ADVANTAGES	DISADVANTAGES
Lower capital and operating costs.	Control problem due to heterogeneous nature of the media (e.g., control of pH, DO, temperature, and moisture level)
Lower chance of contamination	
Lower costs of downstream processing	
Low waste water output	
Lower of foam formation	
May use wet and dry fermented solids directly.	
Low energy requirements (No agitation)	



Introduction to Fermentation

- Modes of fermentation process
 - Batch fermentation
 - Continuous fermentation
 - Fed-batch fermentation
 - Cell recycle fermentation
 - Multistage continuous fermentation



CREDITS

Special thanks to

- Prof. Dr. Tey Beng Ti
- Prof. Madya Dr. Rosfarizan binti Mohamad
- Dr. Farhan binti Mohd Said

Thanks to Dr. Rozaimi bin Abu Samah for proofreading the learning contents.

