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Fermentation

Introduction

Fermentation is a microbial process in which microbes utilizes substrates like carbohydrates, sugar, hydrocarbons, cellulose and convert into value added products like alcohol, amino acids, organic acids, antibiotics, biopolymers etc. In most of the cases substrates are catabolized anaerobically and appearance of carbon dioxide in the form of gas bubbles confirm the fermentation process.

The term ‘fermentation’ is originated from the Latin word ‘*fervere*’ which means boiling, that described by the appearance of gas bubble that was produced by the action of yeast on fruit juice or malted grains. However, fermentation may have different meanings defined by biochemists or microbiologists. In biochemical term it is considered as the catabolism to generate energy, where as microbiologist define it as a process where useful product obtained by action of microbes.

History

The use of fermentation in beverage production has existed since Neolithic era and has been documented. In India use of alcohol is mentioned in many Ayurveda medications. In 1837, first independent paper was published by Charles Cagniard dela Tour, Theodor Schwann and Friedrich Traugott Kützing concluded the presence of microbe; yeast that reproduced by budding.

This investigation was supported by Louis Pasteur (1822-1895), who conducted an experiment and showed that souring of milk is caused by lactic acid which is produced by fermentation in presence of living organism.

Although the experiment showed the fermentation results by the presence of living organism but it was not experimentally proved. The major breakthrough came in year 1897, when a German scientist Eduard Buechner ferments the sugar solution by the use of ‘juice extracted’ from yeast. Later, this juice extract is term as ‘enzyme’ and it was considered that fermentation is caused by the action of enzyme on food stuffs or fruit juices. For this remarkable achievement Eduard Buechner was awarded by Nobel prize (1907) in chemistry.

Modes of Fermentation process

Fermentation processes are mostly operated in fed batch or batch condition, although continuous process is also used but the major challenge to maintained sterility.

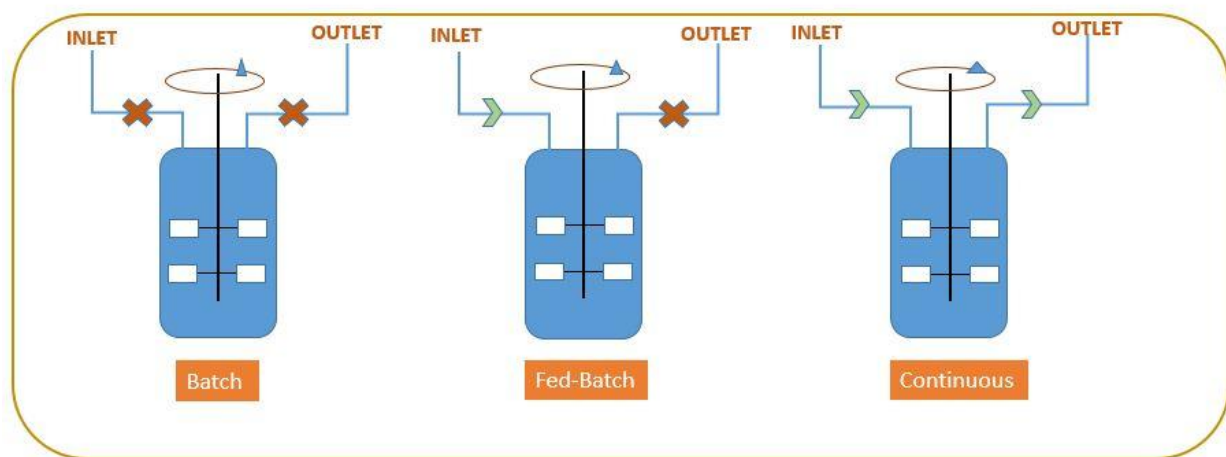


Figure 1 Different modes of fermentation process

Batch Process

Batch process also known as ‘Closed system’ is the process in which all ingredients are combined and fermentation proceeds without any further input. It is commonly used in bread and alcoholic beverages, enzymes and organic acid production.

Fed Batch Process

Fed-batch process is also known as ‘semi-open system’, some of the ingredients are added in the medium during the fermentation. This process is widely used in production of secondary metabolites and allows good control over the stages of the process.

Continuous Process

Continuous fermentation is also known as ‘open system’, it is identified by continuous adding of substrates and removal of final products. Continuous fermentation operated at three different conditions.

Chemistats, in which nutrient level is constant.

Turbidostats, in which cell mass is constant.

Plug Flow Reactors in which the culture medium flows steadily through a tube while the cells are recycled from the outlet to the inlet.

Development of Fermentation Industries

The chronological development of fermentation industries from alcohol production to monoclonal antibiotics may be represented by five stages (Table 1).

Stage I of the fermentation growth was confined to alcohol and vinegar production. **Stage II** considered between 1900-1940s of the growth, the main products were yeast biomass, citric acid, lactic acid, acetone and butanol. **Stage III** (1964 onwards) was arose as a result of penicillin production.

The application of Genetic engineering, enabled the expression of human and mammalian genes into micro-organisms, resulted in fifth stage of growth **Stage V** (1969 onwards) with high-value, low-volume products formation such as Monoclonal antibodies.

Table 1: The stages in the chronological development of the fermentation industry

Stage	Main product	Culture methods	Strain selection
I (Pre-1900)	Alcohol	Batch	Pure Yeast Culture
	Vinegar	Batch	Inoculated with ‘good’ vinegar
II (1900-1940)	Baker’s Yeast	Batch & Fed batch	Pure Culture

	Citric acid Lactic acid Acetone/butanol		
III (1940-date)	Penicillin Streptomycin Amino acids Nucleotides Enzymes	Batch, Fed-Batch Continuous	Mutation and selection programmes essential
IV (1964-date)	Single Cell Protein	Continuous culture	Genetic engineering of producer strains
V (1979-date)	Monoclonal antibodies	Batch, Fed- Batch or Continuous	<i>In vitro</i> recombinant DNA Techniques

Range of Fermentation

Production of alcohol by yeast has been considered the first industrial product and produced in large scale for many years, recent development in fermentation industries reported varieties of products. On the basis of these products the range of fermentation may be defined into five major groups.

1. Microbial Biomass production- Baker's Yeast
2. Microbial enzyme production
3. Microbial metabolites production
4. Recombinant products
5. Biotransformation

Application of fermentation in Industrially important product formation

In 1910 bacterium *Clostridium acetobutyricum* was discovered by Chaim Weizmann that ferments starch to butanol and acetone. This discovery opened a breakthrough in the field of commercialization of fermentation products. In this process some readily available raw material rich in carbohydrate such as corn starch or molasses is supplied to a pure culture of a specific microorganism, which utilized these materials and produces a product of greater value.

Microbial fermentation also plays an important role in production of ‘methanol’ used to make “gasohol”, other industrially important products such as formic, acetic acid, propionic, butyric, and succinic acids, and glycerol, ethanol, isopropanol, butanol, butanediol and biopolymers are also produced by fermentation.

These fermentations are generally carried out in huge closed vats in which temperature and access to air are adjusted to favor the multiplication of the desired microorganism and to exclude contaminating organisms.

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