Introduction

Industrial fermentation involves upstream and downstream processes

Upstream processes, include selection of a microbial strain characterized by the ability to synthesize a specific product having the desired commercial value. This strain then is subjected to improvement protocols to maximize the ability of the strain to synthesize economical amounts of the product. Included in the upstream phase is the fermentation process.

Downstream processing, the various stages that follow the fermentation process, involves suitable techniques and methods for recovery, purification, and characterization of the desired fermentation product. A vast array of methods for downstream processing, such as centrifugation, filtration, and chromatography, may be applied. These methods vary according to the chemical and physical nature, as well as the desired grade, of the final product.

Downstream processing encompasses all processes following the fermentation. It has the primary aim of efficiently, reproducibly and safely recovering the target product to the required specifications (biological activity, purity) while maximizing recovery yield and minimising costs.

Each stage in the overall recovery procedure is strongly dependent on the protocol of the preceding fermentation. Fermentation factors affecting downstream processing include the properties of microorganisms, particularly morphology, flocculation characteristics, size and cell wall rigidity. These factors have major influences on the filterability, sedimentation and homogenization efficiency. The presence of fermentation by-products, media impurities and fermentations additives such as antifoams may interfere with downstream processing steps and accompanying product analysis.

The products of fermentation are usually found in complex mixtures of dilute solutions and must be concentrated and purified.

The typical downstream operations involved in the processing of fermentation broth are:

1. Cell disruption (high pressure homogenization, wet milling, and lysis)
2. Clarification of extract (centrifugation, extraction, dead end filtration, and cross flow filtration)

3. Enrichment (precipitation, batch adsorption, ultrafiltration, and partition)
4. High resolution techniques (ion exchange, affinity, hydrophobic, gelfiltration, adsorption chromatography, and electrophoresis)
5. Concentration (sterile filtration, diafiltration, ultrafiltration, freeze drying, spray drying, and precipitation).

Various downstream processes

1) Filtration

Filtration is one of the most widely used and efficient processes for solid-liquid separation with different types of filtration systems. The process uses a porous medium that allows the flow of gas or liquids but not the solid material.

A simple filtration apparatus consists of a filtration cloth supported by a porous material. When the broth passes through the filter cloth, the solid material is deposited on it and a cake is formed. Due to the gradual deposition of solid on the cloth, the cake increases in thickness and a resistance in the flow gradually builds up. To make the rate of flow constant, an increasing pressure has to be applied on the cloth with the increase in thickness of the cake and resistance of flow. Sometimes the pores of the filtering cloth may be closed due to the clogging or the flow may be stopped due to the compression of the particles. In that case pressure can not be applied for filtration especially when the particles are compressible.

Following factors influence the choice of the most suitable equipment :
1. Viscosity and density of the filtrate
2. Nature of the solid particles: shape, size, distribution and packing characteristics
3. Solid: liquid ratio
4. Material required to be recovered i.e. solid or liquid or both
5. Mode of operation: continuous or batch
6. Need for additional attachment for vacuum suction or need for low temperature

2) Centrifugation

When solid separation is not satisfactory by filtration or a very high degree of separation is required, centrifugation is the method of separation. The main principle of centrifugation process is the sedimentation under centrifugation force.

Application

Centrifugation is one of the preferred methods of clarification of wine, removal of solids from the fermented broths etc. In this, high speed rotation impels suspended material out of

the wine. Speed of clarification is the primary advantages of centrifugation. It is especially useful when early bottling is desired. Centrifugation is also particularly valuable with very turbid wines. They frequently produce off-odours during spontaneous clarification and typically clog filter units. Centrifugation also increases the efficient use of polishing filtration by removing the most remaining suspended material.

3) Cell Disruption

Microbes are protected from the outside environment by rigid cell wall. The cell wall may be extremely hard and the recovery of the intracellular products requires the breakage of the cell wall. A number of cell disintegration methods are available (Fig. 4) but the choice of the method depends on its suitability for the particular substance. Though in some cases by the application of a particular method, a specific product can be recovered from inside the cells with greater yield and purity, most of the times these types of applications are not feasible. On the other hand, gross disruption of the cell releases a huge number of products and its down stream processing becomes difficult. Sometimes application of a particular process is only feasible in the laboratory scale and therefore, choice of suitable methods for the industrial application is a matter of investigation. In recent times, enzymes are the most important intercellular products of interest. But the disruption methods applied for the release of enzymes must keep them active and properly folded, at the same time release yield must be high.