
# FACULTY OF ENGINEERING & TECHNOLOGY

# INTRODUCTION TO INDUSTRIAL BIOPROCESS

•Fermentation is the technique of biological conversion of complex substrates into simple compounds by various microorganisms such as bacteria and fungi.

• In the course of this metabolic breakdown, they also release several additional compounds apart from the usual products of fermentation, such as carbon dioxide and alcohol. These additional compounds are called secondary metabolites.

•Secondary metabolites range from several antibiotics to peptides, enzymes and growth factors. They are also called 'bioactive compounds' since they possess biological activity.

•The development of techniques such as Solid State Fermentation (SSF) and Submerged Fermentation (SmF) has lead to industrial-level production of bioactive compounds.

•These techniques have been further refined based on various parameters such as the substrates used, environmental parameters and the organisms used for fermentation. Based on research, certain bioactive compounds have found to be produced in higher quantities in SSF, whereas other compounds have been extracted using SmF.

**Solid-State Fermentation (SSF):**

▪SSF utilizes solid substrates, like bran, bagasse, and paper pulp. The main advantage of using these substrates is that nutrient-rich waste materials can be easily recycled as substrates. In this fermentation technique, the substrates are utilized very slowly and steadily, so the same substrate can be used for long fermentation periods. Hence, this technique supports controlled release of nutrients.

▪SSF is best suited for fermentation techniques involving fungi and microorganisms that require less moisture content. However, it cannot be used in fermentation processes involving organisms that require high aw (water activity), such as bacteria.

**Submerged Fermentation (SmF)/Liquid Fermentation (LF):**

▪SmF utilizes free flowing liquid substrates, such as molasses and broths. The bioactive compounds are secreted into the fermentation broth. The substrates are utilized quite rapidly; hence need to be constantly replaced/supplemented with nutrients.

▪This fermentation technique is best suited for microorganisms such as bacteria that require high moisture content. An additional advantage of this technique is that purification of products is easier. SmF is primarily used in the extraction of secondary metabolites that need to be used in liquid form.

**Substrates used for fermentation:**

▪The outcome of fermentation highly varies for each substrate; hence, it is extremely important to choose the right substrate. Fermentation techniques have to be optimized for each substrate. This is primarily due to the reason that an organism reacts differently to each substrate.

▪The rates of utilization of various nutrients differ in each substrate, and so does productivity. Some of the common substrates used in solid state fermentation are wheat bran, rice and rice straw, hay, fruit and vegetable waste, paper pulp, bagasse, coconut coir, and synthetic media. Some common substrates used in submerged fermentation are soluble sugars, molasses, liquid media, fruit and vegetable juices, and sewage/waste water.

**Primary Metabolites:**

▪The metabolites which are required for the growth, development, and reproduction of the organism are called **primary metabolites**.

▪The primary metabolite is typically a key component in maintaining normal physiological processes; thus, it is often referred to as a central metabolite.

▪Primary metabolites are typically formed during the growth phase as a result of energy metabolism, and are deemed essential for proper growth. Examples of primary metabolites include alcohols such as ethanol, lactic acid, and certain amino acids. Within the field of industrial microbiology, alcohol is one of the most common primary metabolites used for large-scale production.

▪Alcohol is used for processes involving fermentation which produce products like beer and wine. Additionally, primary metabolites such as amino acids– including L-glutamate and L-lysine, which are commonly used as supplements– are isolated via the mass production of a specific bacterial species,

- *Corynebacteria glutamicum.* Another example of a primary metabolite commonly used in industrial microbiology includes citric acid.

- Citric acid, produced by *Aspergillus niger*, is one of the most widely used ingredients in food production. It is commonly used in pharmaceutical and cosmetic industries as well.



## Importance of the primary metabolites

- Excessive production of the primary metabolites is very important and useful in the large scale purposes in industry.

- Even the enzymes find during the process have many uses in food production, textile finishing, and other industries too.

## Secondary Metabolites:

- Secondary metabolites are typically organic compounds produced through the modification of primary metabolite synthases.

- Secondary metabolites do not play a role in growth, development, and reproduction like primary metabolites do, and are typically formed during the end or near the stationary phase of growth.

- Many of the identified secondary metabolites have a role in ecological function, including defense mechanism(s), by serving as antibiotics and by producing pigments. Examples of secondary metabolites with importance in industrial microbiology include atropine and antibiotics such as erythromycin and bacitracin.

- Atropine, derived from various plants, is a secondary metabolite with important use in the clinic. Atropine is a competitive antagonist for acetycholine receptors, specifically those of the muscarinic type, which can be used in the treatment of bradycardia.

▪Antibiotics such as erythromcyin and bacitracin are also considered to be secondary metabolites.

▪Erythromycin, derived from *Saccharopolyspora erythraea*, is a commonly used antibiotic with a wide antimicrobial spectrum. It is mass produced and commonly administered orally.

▪ Another example of an antibiotic which is classified as a secondary metabolite is bacitracin.

▪Bacitracin, derived from organisms classified under *Bacillus subtilis*, is an antibiotic commonly used a topical drug.

▪ Bacitracin is synthesized in nature as a non ribosomal peptide synthetase that can synthesize peptides; however, it is used in the clinic as an antibiotic.

## Importance of the secondary metabolites

- Secondary metabolites are produced by very specific microorganisms only, mainly antibiotics and other products are used.
- Generally microorganisms synthesize numerous group of secondary metabolites compounds instead of one, for example, a strain of Streptomyces produces 35 anthracyclines at a time, instead of one.
- These are not required for the growth, reproduction, and development of the cell.
- The secondary metabolites do not directly benefit the cell growth and development, but they perform some unknown function which supports the cell survival.

| BASIS FOR COMPARISON | PRIMARY METABOLITES | SECONDARY METABOLITES |
|---|---|---|
| Meaning | The metabolism products that are produced during the growth phase of an organisms in order to perform the physiological functions and supports in overall development of the cell are called primary metabolites. | The end products of primary metabolism that are synthesized after the growth phase has been completed and are important in ecological and other activities of the cell are known as secondary metabolites. |
| Also known as | Trophophase. | Idiophase. |
| It occurs at the | Growth phase. | Stationary phase. |
| Production | These are produced in large quantities, and their extraction is easy. | These are produced in small quantities, and their extraction is difficult. |
| Occurrence | Same in every species, which means they produce the same products. | Varies in different species. |
| Importance | 1.These products are used in industries for various purpose.<br>2. Primary products play the significant role in the cell growth, reproduction and development. | 1.Secondary metabolites such as antibiotics, gibberellins are also important.<br>2. They also indirectly support the cell, in sustaining their life for long duration. |
| Examples | Vitamins, carbohydrates, proteins and lipids. | Phenolics, steroids, essential oils, alkaloids, steroids. |