UNIT 5
ROLE OF TECHNOLOGIES

FERMENTATION

Fermentation is a metabolic process that converts sugar to acids, gases, or alcohol using microorganisms such as bacteria and yeast. This ancient method of food preservation offers a range of benefits:

Enhanced Nutritional Value: Fermentation can increase the bioavailability of nutrients, making them easier for the body to absorb. For example, fermented dairy products like yogurt and kefir are rich in probiotics, calcium, and vitamins.

Improved Digestion: Fermented foods contain probiotics, beneficial bacteria that promote a healthy gut microbiome. This can improve digestion, alleviate symptoms of irritable bowel syndrome (IBS), and enhance overall gut health.

Increased Shelf Life: Fermentation naturally preserves food by creating an acidic environment that inhibits the growth of spoilage-causing bacteria. This allows foods to last longer without the need for artificial preservatives.

Enhanced Flavor and Texture: Fermentation develops complex flavors and textures in foods. For example, the tangy taste of sauerkraut, the umami of miso, and the effervescence of kombucha are all results of the fermentation process.

Detoxification: Certain fermenting bacteria can break down anti-nutrients and toxins present in food, such as phytic acid in grains and legumes, making the nutrients more accessible and reducing potential negative effects.

Boosted Immune System: The probiotics in fermented foods can enhance the immune system by improving gut health, which is closely linked to immune function. A healthy gut microbiome can help fend off infections and illnesses.

Reduced Food Waste: Fermentation allows for the preservation and utilization of surplus or imperfect produce that might otherwise go to waste, thus contributing to more sustainable food practices.

Economic Benefits: Fermentation can be a cost-effective way to preserve food and add value to raw ingredients, which can be particularly beneficial for small-scale producers and local economies.

Fermentors, also known as bioreactors, are sterilised and enclosed vessels that are used for the growth of microorganisms under optimal conditions. The microorganisms can be grown in large quantities to produce metabolites for commercial uses. Fermentors are equipped with special components for heating, mixing, and aeration. Its volume can be as big as 500,000 litres for an industrial scale, or as small as 1 litre for laboratory uses.

Different Types of Fermentors

Continuous Stirred-Tank Fermentor

The continuous stirred-tank reactor (CSTR) is composed of a vessel with pipes, pumps, valves, agitator, motor, shaft, and impeller(s). The shaft is situated at the bottom of the tank, and the number of impellers depends on the size of the bioreactor.

In this type of fermentor, a structure called sparger is found that keeps adding air to the culture medium. It is a ring-like structure with many holes. The sparger, along with the impellers, distribute gas in the entire vessel. The impellers break down the bubbles into smaller ones that are homogeneously distributed in the bioreactor.

Airlift Fermentor

The airlift bioreactors contain a baffle or a draft tube in the middle through which air is pumped into the vessel. There are two types of airlift fermentors:

- **Internal loop airlift bioreactor:** It has a single central draft tube that provides inner circulation channels.
- **External loop airlift bioreactor:** It contains external loops that separate the liquids flowing into independent channels.

Packed Bed Fermentor

In a packed bed fermentor, a hollow tube or pipe is packed with a biocatalyst. The bed is immobile in nature. The culture medium flows through the biocatalyst, which produces the metabolites continuously in the broth. These bioreactors are easy to operate but are often blocked due to poor oxygen circulation.

Fluidised Bed Fermentor

In this type of reactor, a solid granular bed that is usually made up of a biocatalyst is present. The fluid, that is, liquid or gas, is passed through the solid bed at high speeds, such that the suspended solid behaves like a fluid. This type of fermentor is used for microbial flocs, immobilised cells, and enzymes.

Membrane Fermentor

Membrane bioreactors work in conjugation with ultrafiltration and microfiltration. This type of fermentor is used for the biological treatment of wastewater. There are two types of membrane bioreactors:

- **Submerged membrane bioreactor:** In this type of fermentor, the membrane is found inside the vessel submerged in the wastewater.
- **Side-stream membrane bioreactor:** In this type of fermentor, the membrane is found outside the reactor and filtration by the membrane is an additional step in the whole process.

Bubble Column Fermentor

A bubble column fermentor is equipped with a cylindrical column that is filled with liquid, and gas is inserted into it from the bottom. It is vertically arranged, such that the introduction of gas from the bottom

creates a turbulent stream and allows optimum gas exchange. The sparger mixes the contents of the vessel. The liquid flows either in a parallel direction or in a counter-current direction.

CONTROL OF FERMENTATION IN FOOD

Controlling fermentation in food is crucial to ensuring the desired flavor, texture, and safety of the final product. Here are key factors and methods for controlling fermentation:

Temperature:

Optimal Range: Each microorganism has an optimal temperature range for fermentation.For example, lactic acid bacteria used in yogurt fermentation thrive at around 40-45°C (104-113°F), while yeast used in bread making works best at 25-30°C (77-86°F).

Monitoring and Regulation: Using thermostatically controlled environments like fermentation chambers or temperature-controlled incubators can help maintain the desired temperature.

pH Levels:

Initial pH: The starting pH of the food can influence the growth of microorganisms. Adjusting the pH can help favor beneficial microbes over spoilage organisms.

Monitoring: Regularly measuring pH levels during fermentation helps ensure that the process is proceeding as expected and can indicate when the fermentation is complete.

Oxygen Levels:

Aerobic vs. Anaerobic: Some fermentations require oxygen (aerobic), while others must be kept oxygen-free (anaerobic). For instance, vinegar production is aerobic, while sauerkraut fermentation is anaerobic.

Control: This can be managed by using airlocks, sealing containers, or fermenting in environments where oxygen can be controlled.

Microbial Inoculation:

Starter Cultures: Using specific starter cultures can ensure consistent fermentation results. These cultures contain known strains of microorganisms that produce the desired effects.

Hygiene and Sterilization: Maintaining a clean environment and sterilizing equipment can prevent contamination by unwanted microorganisms.

Substrate Composition:

Nutrient Availability: The composition of the food substrate (carbohydrates, proteins, vitamins, and minerals) can affect microbial activity. Adjusting these components can enhance fermentation.

Pre-treatment: Pre-treating food, such as soaking, cooking, or adding certain ingredients, can create a more favorable environment for fermentation.

Time:

Fermentation Duration: The length of fermentation affects the final product's characteristics. Monitoring and controlling fermentation time helps achieve the desired flavor, texture, and nutritional profile.

Stage Control: Some fermentations require different conditions at different stages. Adjusting factors like temperature and pH during specific phases can optimize the process.

Salt Concentration:

Brining: In many vegetable fermentations, such as pickles and sauerkraut, adding salt creates an environment that favors beneficial lactic acid bacteria while inhibiting spoilage organisms.

Monitoring: Controlling the salt concentration is essential to ensure proper microbial growth and fermentation progress.

Water Activity:

Moisture Control: The availability of water can influence microbial growth. Adjusting the moisture content through drying, adding salt, or using hygroscopic substances can help control fermentation.