CSIR NET Life Science Unit 12

Microbial Fermentation

Fermentation has always been an important part of our lives: foods can be spoiled by microbial fermentation, foods can be made by microbial fermentation, and muscle cells use fermentation to provide us with quick responses. Fermentation could be called the staff of life because it gives us the basic food, bread. But how fermentation actually works was not understood until the work of Louis Pasteur in the latter part of the nineteenth century and the research which followed. Fermentation is the process that produces alcoholic beverages or acidic dairy products. For a cell, fermentation is a way of getting energy without using oxygen. In general, fermentation involves the breaking down of complex organic substances into simpler ones. The microbial or animal cell obtains energy through glycolysis, splitting a sugar molecule and removing electrons from the molecule. The electrons are then passed to an organic molecule such as pyruvic acid. This results in the formation of a waste product that is excreted from the cell. Waste products formed in this way include ethyl alcohol, butyl alcohol, lactic acid, and acetone-the substances vital to our utilization of fermentation

Role of Fermentation in Industry

In industry, as well as other areas, the uses of fermentation progressed rapidly after Pasteur's discoveries. Between 1900 and 1930, ethyl alcohol and butyl alcohol were the most important industrial fermentations in the world. But by the 1960s, chemical synthesis of alcohols and other solvents was less expensive and interest in fermentations diminished. Questions can be raised about chemical synthesis, however. The chemical manufacture of organic molecules such as alcohols and acetone relies on starting materials made from petroleum. Petroleum is a non-renewable resource; dependence on such resources could be considered short-sighted. Additionally, the use of petroleum has associated environmental and political problems. The worldwide interest in microbial fermentation is once again growing especially with reference to renewable resources and microbial biocatalysts. Plant starch, cellulose from agricultural waste, and whey from cheese manufacture are abundant and renewable sources of fermentable carbohydrates. Additionally, these materials, not utilized, represent solid waste that must be buried in dumps or treated with wastewater.

Other Benefits Microbial Fermentations

Microbial fermentations have several other benefits. For one, they don't use toxic reagents or require the addition of intermediate reagents. Microbiologists are now looking for naturally occurring microbes that produce desired chemicals. In addition, they are now capable of engineering microbes to enhance the production of these chemicals. In recent years, microbial fermentation has been revolutionized by the application of genetically-engineered organisms. Many fermentations use bacteria but a growing number involve culturing mammalian cells. Some examples of products currently produced by fermentation are listed in Tables 1 and 2

Table 1. Fermentations by naturally-occurring organisms

PRODUCT	APPLICATION	ORGANISM
Bacitracin	Antiobiotic	Bacillus subtilis (bacterium)
Chloramphenicol	Antiobiotic	Streptomyces venezuelae (bacterium)
Citric acid	Food flavoring	Aspergillus niger (fungus)
Erythromycin	Antibiotic	Streptomyces erythaeus (bacterium)
Invertase	Candy	Saccharomyces cerevisiae (fungi)
Lactase	Digestive aid	Escherichia coli (bacterium)
Neomycin	Antibiotic	Streptomyces fradiae (bacterium)
Pectinase	Fruit juice	Aspergillus niger (fungus)
Penicillin	Antibiotic	Penicillium notatum (fungus)
Riboflavin	Vitamin	Ashbya gossypii (fungus)
Streptomycin	Antibiotic	Streptomyces griseus (bacterium)
Subtilisins	Laundry detergent	Bacillus subtilis (bacterium)
Tetracycline	Antibiotic	Streptomyces aureofaciens (bacterium)

Table 2. Fermentation by genetically engineered organisms

PRODUCT	APPLICATION	ORGANISM
B. growth hormone	Milk production(cows)	*Escherichia coli* (E. coli)
Cellulase	Cellulose	*E. coli*
H. growth hormone	Growth deficiencies	*E.coli*
Human insulin	Diabetics	*E. coli*
Monoclonal antibodies	Therapeutics	Mammalian cell culture
Ice-minus	Prevents ice on plants	*Pseudomonas syringae*
Sno-max	Makes snow	*Pseudomonas syringae*
t-PA	Blood clots	Mammalian cell culture
Tumor necrosis factor	Dissolves tumor cells	*E.coli*

Fermentation Work in Biotechnology

In the pharmaceutical and biotechnology industries, fermentation is any large-scale cultivation of microbes or other single cells, occurring with or without air. In the teaching lab or on the research bench, fermentation is often demonstrated in a test tube, flask, or bottle-in volumes from a few millilitres to two litres. At the production and manufacturing level, large vessels called fermenters or bioreactors are used. A bioreactor may hold several litres to several thousand litres. Bioreactors are equipped with aeration devices as well as nutrients, stirrers, and pH and temperature controls.

Role of Microorganisms in Enhancement of the Nutritional Quality in Fermented Foods

Fermented foods are more nutritious compared to their unfermented counterparts. Fermented foods are having high nutritional value because of the presence of fermenting microorganisms in them. Microorganisms break down the complex substances into the simpler substance and produce complex vitamins and other growth factors. A different mechanism is used to increase plant material's nutritional properties through enzymatic degradation of polymers that cannot be digested by humans into simple sugars and their derivatives like cellulose, hemicelluloses, and a similar form of polymers. The cellulose-containing substrates in fermented foods can be improved for human consumption by the use of microbial enzymes. Many cereal foods are low in their nutritional content value. However, L.A.B. and yeast fermentation was noticed to increase the nutritional content and food digestibility.

Advantages of Fermented Foods over Conventional Food items

1. **Vitamins Bio-Enrichment -** According to a public health measure, nutrients, mainly vitamins, are fortified in some selected, manufactured foods: for example, vitamin D is added to milk and riboflavin during bread production, whereas ascorbic acid can be fortified in fruit juices. However, this fortification process can only be used in the Western world due to its high cost. Due to its high cost, most countries do not use this type of food fermentation for the biological enrichment of foods. There is a deficiency of thiamine caused by using highly polished white rice. This type of rice can cause beriberi which can lead to strokes and paralysis. Infants who are breastfed by thiamine-deficient mothers can also suffer from sudden death at three months due to their heart failure. Thiamine is produced by the microorganisms which are involved in the tape Ketan fermentation. These are also responsible for the re-establishment of the thiamine level in the unpolished rice. It can be a great help to rice-eating individuals.

2. **Antioxidant Activity -** Antioxidant activities in fermented foods can consist of the reducing power assay, 20-azino-bis (3-ethylbenzo-thiazoline-6-sulfonic acid; A.B.T.S.) and 1,1-diphenyl-2-picryl hydrazyl (D.P.P.H.) radical scavenging activity and total phenol content (TPC) estimation. It was remarkably enhanced by the microbes, which leads to the whole improvement in the sensory attributes and the food safety.

3. **Enzymes Production through Microorganisms -** Such enzymes like amylase, proteinase, mannose, catalase, cellulase, etc. generally originated from fermenting microorganisms. Stable, dry, and cake-like amylolytic starter cultures are used to produce alcohol in the Himalayan region. These starter cultures have mixed yeast strains like *Saccharomycopsis capsularis, S. fibuligera*, and *Pichia burtonii*, that increase the quantity of amylase in the end product.

4. **Anti-Nutritive Compounds Degradation -** Anti-nutritive substances are found in most food substrates. They are toxic to human beings and are responsible for decreasing the food's nutritive value. These compounds can be degraded by microbes inhabited in fermented foods, making inconsumable products consumable. Grating, dewatering, washing, peeling, fermentation, and roasting are a few ways except fermentation used to lower the cyanide content in the finished products.