Alcohol (Ethyl Alcohol) Production:

Alcohols are important industrial materials and solvents. These include Methanol, Ethanol, Isopropanol and Ethylene Glycol.

Ethanol or **(Ethyl Alcohol)** production industry is considered one of the important commercial activities for many countries.

A primary industrial alcohol is ethanol, or ethyl alcohol (C_2H_5OH). Alcoholic fermentation is one of the oldest, best known and most important of industrial fermentations. In this process, ethyl alcohol is produced from carbohydrate materials (such as sugars) by yeasts. The reaction is catalyzed by yeast enzymes called zymases. A balanced chemical reaction for this process, assuming the sugar is Table Sugar or Sucrose, is:

$$\underset{\text{Sugar}}{C_6H_{12}O_6} \xrightarrow[\text{(Zymase Complex)}]{\text{Enzymes}} \underset{\text{(Ethyl alcohol)}}{2C_2H_5OH} + 2CO_2 + \text{energy}$$

Ethanol is made from a variety of agricultural products &wastes such as grain, molasses, fruit, whey and sulfite waste liquor.

Uses of alcohol:

- **Fuels:** Some alcohols, mainly ethanol and methanol can be used as an alcohol fuel
- **Preservative**
- **Solvents:** Alcohols have applications in industry and science as reagents or solvents ethanol can be used as a solvent in medical drugs, perfumes and vegetable essences such as vanilla
- **Alcoholic beverages**
- **Antifreeze**
- **Antiseptics:** Ethanol can be used as an antiseptic to disinfect the skin.

Manufacture of ethyl alcohol

1. **Organisms used:** Several microorganisms have been considered as ethanologenic or alcoholgenic microbes as follow**:**

Bacteria:

- *Zymomonas mobilis*
- *Clostridium acetobutylicum*
- *Klebsiella pneumonia*

➢ **Yeast**

- *Saccharomyces cerevisiae*
- *Saccharomyces carlsbergenesiae*
- *Saccharomyces saki*
- *Saccharomyces oviformis*
- *Candida utilis*
- *Mucur sp.*

2. **Raw materials used (Fermentable Substrate)**

The many and varied raw materials used in the manufacture of ethanol via fermentation are conveniently classified under three types of agricultural raw materials:

- Sugary materials
- Starchy material
- Cellulosic materials

SUGARY MATERIALS:

Sugars can be converted to ethanol directly like

- Molasses
- Sugar cane
- Sugar beet
- Sweet potato
- Sulfide waste
- Wheat sorghum
- Whey
- glucose
- Sucrose
- Lactose

STARCHY MATERIALS

Starches must first be hydrolyzed to fermentable sugars by the action of enzymes from malt or molds like

cereals: wheat, maize, barley, sorghum, corn, rice

Roots: potato, tropica

Mild products: wheat flour, corn feed

CELLULOSIC MATERIALS

Cellulose must likewise be converted to sugars generally by the action of mineral acids. Once simple sugars are formed, enzymes from yeast can readily ferment them to ethanol like: Wood**,** Paper waste**,** Agricultural waste

Notes:

- Molasses are one of the commonest raw materials used in the manufacture of alcohol. Due to they are cheap and readily available in large quantities. Molasses contains about 50% Total Sugar, of which 30 to 33% are cane sugars and the rest are reducing sugars.
- Selected strains of the yeast *Saccharomyces cerevisiae are* commonly employed for fermentation. Because (a) they grow vigorously, (b) they have high tolerance for alcohol and (c) they have a high capacity for producing a large yield of alcohol.

3. CONDITIONS FOR FERMENTATION

- Carbon sources: pure sugar or crude sugars/molasses (10-18%).
- Nitrogen sources: Mostly available in the form of ammonium sulphate.
- Growth factors: can be provided in the form of molasses.
- pH: 4.8-5.0.
- Temperature: 70-80°F. Temp. can be controlled by cooling jacket.

- Time: Depends on yeast strain. Usual time is between 30 to 72hrs.
- Yield: 0.4 gallon of ethyl alcohol per one gallon of molasses. 90% carbohydrates can be converted in to alcohol.

4. <u>Steps involved in the process</u>

It is a large scale biotechnological process requiring large scale tubular tower fermenters (bio-reactors) and involves the following steps.

a. Preparation of the medium: Water is added to the molasses to bring down the sugar concentration to the desired level (usually 30 to 40 percent). A measured quantity of acid is then added so as to adjust the pH on the acidic side.

b.Addition of yeast: After adjusting the desired temperature, a yeast 'starter' is allowed to be mixed thoroughly with the molasses 'mash' in the fermentation tank.

c.Fermentation: Fermentation by the yeast process starts and soon becomes vigorous. A large quantity of carbon dioxide is evolved during the process. The gas (by-product of the alcohol industry) is collected, purified and used in various other industries.

d. Separation of ethyl alcohol: Alcoholic fermentation is completed in about 48 hours. The fermented medium contains alcohol as well as other volatile constituents and unused constituents of the molasses. Therefore, separation of ethyl alcohol from other impurities is necessary. This is done by distillation (Distillation is a kind of separation technique of two or more volatile liquid compounds by using the difference in boiling points and relative volatility. The process takes place in a column, and two heat exchangers).

e. Purification: Finally, alcohol is purified with the help of rectifying columns and stored in bonded warehouses.