**Lec. : 2**

**Fermentation Technology**

**1.Lactic acid fermentation :**

Is example of lactic acid bacteria that convert sugars into lactic acid , is one of the most common methods of home preservation like vegetable and dairy products , and today is also utilized in industrial fermentation like yogurt production ., lactic acid bacteria are widely used for production of various fermented food throughout the world such as yogurt .

There are two types of Lactic acid fermentation :

**A: Homolactic fermentation** : is the production of Lactic acid exclusively

**B: Heterolactic fermentation** : is the production of lactic acid as well as other acids such as acetic acid and alcohols .

**A: Homo- fermentative :** in this type of fermentation , lactic acid is the sole product by reduction of pyruvic acid with the help of the enzyme lactic acid dehydrogenase ., the reaction regenerates NAD from NADH2 which is reused for oxidation of GAP to DPGA in the glycolysis pathway ., as one molecule of lactic acid is formed from one molecule of pyruvic acid ., two molecules of lactic acid are produced from each molecule of glucose , when it is dissimilated through EMP .

Some representative species of homo- fermentative lactic acid bacteria are : *Lactococcus lactis* , *Lactococcus cremoris* , *Lactobacillus lactis* , *Lactobacillus bulgaricus* and *Lactobacillus acidophilus* .,etc .

Homolactic fermentation is the simplest of all fermentations , involving only a single step in which pyruvic acid is reduced to lactic acid .

**B:** **Heterofermentative** : in this type the products are lactic acid and ethanol or aceic acid and co2 , lactic acid produced from one half of the glucose molecule , and ethanol or acetic acid and co2 from the other half ., representative of heterofermentative type include *Leuconostoc mesenteroides* and *Bifidobacterium bifidum* etc.

The heterofermentative lactic acid bacteria lack two vital enzymes of the glycolysis pathway , aldolase and isomerase ., hense , they are unable to use EMP ., they employ the pentose phosphate pathway , it is cleave xylose 5 – phosphate into glycerin aldehyde phosphate (GAP) and acetyle phosphate ., GAP is then converted to pyruvic acid by the usual EMP enzymes , while acetyle phosphate is reduced either to acetic acid or to ethanol ., briefly , from pyruvic acid , lactic acid is formed by the lactate dehydrogenase activity .

Pyruvic acid lactate dehydrogenase lactic acid

**2: Alcoholic fermentation** :

In this type of fermentation one glucose molecule is broken down into two pyruvate molecules by glycolysis ( Embden – Meyerhof – Paranse ) pathway (EMP) ., yeast and some kinds of bacteria can convert sugars into ethyl alcohol and carbon dioxide .

Alcoholic fermentation generally means production of ethanol ., commonly yeasts , particularly *Saccharomyces cerevisiae* are used for production of various alcoholic beverages , as well as industrial alcohol .

Conversion of pyruvic acid to ethanol proceeds in two steps : pyruvic acid to acetaldehyde and acetaldehyde to ethanol ., the first step is catalysed by pyruvic acid decarboxylase and the second step by alcohol dehydrogenase which requires NADH2 as coenzyme . NADH2 is thereby oxidized to NAD which can be reused for reduction of GAP to DPGA in the EMP .

**3: Propionic acid fermentation :**

Is carried out by several bacteria belong to *Propionibacterium* ( which are the coryneform ) and *clostridium* , etc ., that convert lactate into propionic acid by dissimilate glucose via EMP and produce pyruvic acid which is converted to oxalasetic acid , then reduced in two steps to succinic acid through reversal of TCA cycle reactions , in the final step yields propionic acid ., the propionic acid bacteria are used for production of swiss cheese that add nutty flavor of swiss – type cheese during production process. Propionic acid contributes to the special flavor of swiss cheese together with lactic acid bacteria .

**4: Butyric acid fermentation :**

The bacteria carrying out butyric acid fermentation are all obligatory anaerobic spore forming bacteria belonging to the genus Clostridium , this type of bacteria can produce butyric acid during fermentation by oxidizing sugar , besides butyric acid and n –butanol, several other products of this fermentation are acetic acid , ethanol , isopropanol and acetone depending on species ., Clostridia dissimilate glucose by EMP to form pyruvic acid which by decaboxylation produces acetyle co- A.

Butyric acid has many important application chemical industry , plastic material and pharmaceutical industries .

**5: Acetic acid fermentation :**

This type can convert 2 – 4 % lactate into acetate , Acetic acid bacteria have a role in this fermentation like *Acetobacter* etc., acetic acid bacteria have multiple applications in food industry like vinegar , Kombucha , ascorbic acid and tartaric acid .

**6: Mixed acids fermentation :**

This type of fermentation occurs characteristically in bacteria belonging to the family enterobacteriaceae , these bacteria can grow both aerobically carrying out oxygen respiration or anaerobically carrying out fermentation ., the type of fermentation is called mixed – acid because as products several different organic acids and neutral compounds are produced ., depending on species . , number of different substances are formed , like acetic acid , succinct acid , lactic acid , ethanol acetoin , butandiol , co2 and molecular hydrogen ., Mixed acid fermentation is sometimes called formic acid fermentation under anaerobic condition , *E. coli* cleaves pyruvic acid to acetyl- CO A and formic acid , the reaction is catalyzed by the enzyme pyruvate – formic acid lyase .