Bioreaction regulation

Microorganisms cells have the ability to synthesize large number of enzymes ,these enzymes enter different pathways , and in order the microorganisms cell be an efficient unit these enzymes must be regulated quantitatively or qualitatively .

1- Enzymes used in anabolic biosynthesis
This is done through feedback repression. In this case final product or its derivatives block the enzyme synthesis through the linkage of final product derivatives with the genome in such a away in which it repress the gene replication.

2- Enzymes used in catabolic reactions
a- Induction
The enzyme is synthesized only when an induced compound is present in the media . The genome which is responsible for the synthesis of such enzyme will be inactive when the induced compound is absent ,such enzyme is termed inducible enzyme .

b-Feedback repression
Enzymes synthesis are repressed when concentration of their products reach the level required by the cell or when these products are added to the culture media (products and their analogus).
Products with low molecular weight acts as a corepressor and it combine with a protein (aporepressor) , this aporepressor is inactive , but when the products are formed at high concentration , these products which act as corepressor will linked with the aporepressor . This linkage make the aporepressor active in such a way in which aporepressor can link to the operator gene resulting in closing (blocking) it so the gene position after it will not replicate.

2- **Carbon source repression**

Enzyme synthesis (especially induced) are repressed when the microorganisms grow quickly in a culture media contain easily utilized carbon source .

The quick consumption of the carbon source result in deficiency of cAMP inside the cell ,and the absence of such compounds will result in blocking the gene responsible for the production of such enzymes .

Regulation of enzyme activity

1-Through decreasing of the substrate exposure to the enzyme. So the enzyme activity will be decreased through decreasing the membrane permeability.

2-Feedback inhibition

This is used in some pathways in amino acid synthesis in order to prevent the extra productivity of such products.

When the concentration of final products reaches a certain level ,these products inhibit the enzyme activity through the linkage of the final product with the enzyme in such a way it prevent the adsorption of the enzyme on the substrate.

3-Modification of the enzyme structure

In such a way the permeable substrate linked to , resulting in changing the enzyme form so its activity will be reduced.

4-Enzyme dissociation

Sometimes enzymes are dissociated after its action on the substrate is ended , (cells do not need it since its function is finished) , so the digestive enzymes will lyses it , so other enzymes can synthesize and act .

5-Through concentration of some substrates related with energy such as ADP, ATP, AMP, NADH and others which control catabolic processes and anabolic processes.

Alcohol fermentation (Ethanol production)

Industrial alcohol production

Ethyl alcohol, $CH_3 CH_2 OH$ (synonyms: ethanol, methyl carbinol, grain alcohol, molasses alcohol, grain neutral spirits, cologne spirit, wine spirit), is a colorless, neutral, flammable liquid with a molecular weight of 46.47, a boiling point of 78.3° C and a sharp burning taste.

Uses of Ethanol

(1) Use as a chemical feed stock: In the chemical industry, ethanol is an intermediate in many chemical processes because of its great reactivity as shown above. It is thus a very important chemical feed stock.
(2) Solvent use: Ethanol is widely used in industry as a solvent for dyes, oils, waxes, explosives, cosmetics etc.
(3) General utility: Alcohol is used as a disinfectant in hospitals, for cleaning and lighting in the home, and in the laboratory second only to water as a solvent.
(4) Fuel: Ethanol is mixed with petrol or gasoline up to 10% and known as gasohol and used in automobiles.

Raw materials (Substrates) Raw materials used in ethanol production:-
1-Saccharine materials.
Sugar cane, sugar beet, molass, whey, fruit juices.
2-Starchy materials
Cereals (whey , corn , barley, rice)
3-Cellulosic materials
Wastes from paper manufacturing from wood such as sulfite liquor.
The ethanol was produced by fermentation of sucrose, derived from sugar cane, using *Saccharomyces cerevisiae*.
Apart from sucrose, other conventional fermentation substrates for ethanol fermentations include simple sugars derived from plants and dairy wastes. These require relatively little processing.

Direct sugar sources (cane, beet, whey, etc.) require less energy consuming processing and are readily fermented

saccharification

starches ⟶ readily fermented products (glucose, maltose)

delignification *saccharification*

lignocellulose ⟶ cellulose and hemicellulose ⟶ hexoses & pentoses*

Fig. 10.2 Substrates for ethanol production (*much less readily fermented products).

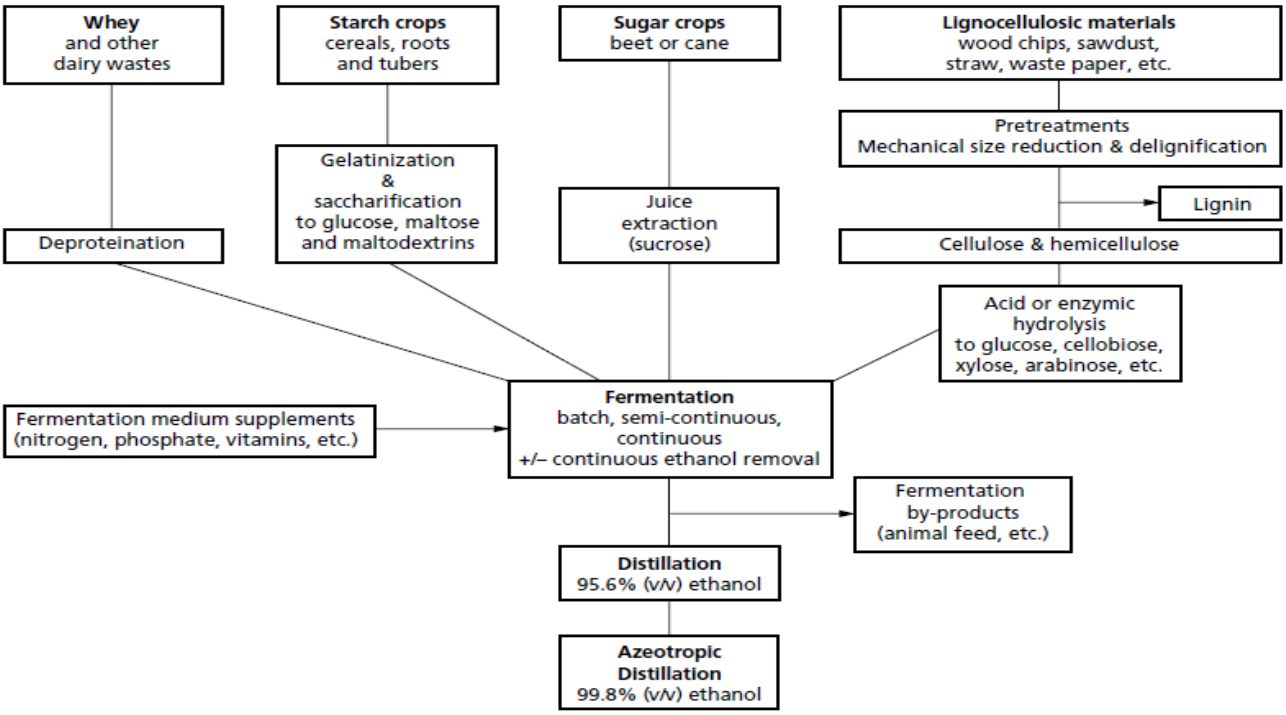

Fig. 10.3 Industrial ethanol production from various substrates.

Production of ethanol from molass

The substrate is molass (a secondary product in sugar production from sugar cane or sugar beet).

Production could be summarized as follows:-

1-Dilution of molass with water

(molass is diluted with water to contain a sugar concentration (14-25%).

2-Addition of the starter. a-the microorganism used is (Saccharomyces cerevisiae var. ellipsoideus)

b-Characteristics of the strain used.

1- Has the ability to tolerate high concentration of sugar.
2- Has the ability to tolerate high concentration of ethanol.
3- Has the ability to tolerate high temperature.

c-Using other microorganisms depending upon the raw material which is used in general :-

For Hexose sugars :Saccharomyces cerevisiae var. ellipsoideus) is used
For pentose sugars : Candida utilis is used
For whey : Kluyveromyces fragilis is used
For cellulosic materials: Clostridium thermocellum is used

3-Fermentation conditions.

Temperature (25-27° C) PH (4.5)

Anaerobic conditions (aeration is used at first to promote rapid growth but anaerobiosis is soon established to promote fermentation and alcohol accumulation and to prevent it oxidation to carbon dioxide and water)

4-Distillation

The fermented mash contains crude alcohol with a concentration of 6-9% and termed beer. The fermented mash or beer is pushed into large tanks for storage and then distillation .

Distillation is made in order to reach the concentration of ethanol to 60-90% , more distillation may reach the concentration to 95%.

By products in ethanol production

Small amounts of glycerol with fusel oils , the last contain amyl, isoamyl alcohol, propyl, butyl and other alcohol with acetic, butyric and other acids as well as various esters.

Ethanol yield

Theoretical yield (51.1%)and practical yield (not exceed 48%)
(so the efficiency of fermentation reaches about 90%).

(During the aerobic phase for yeast about 1-2% of the sugar is oxidized to carbon dioxide and water)

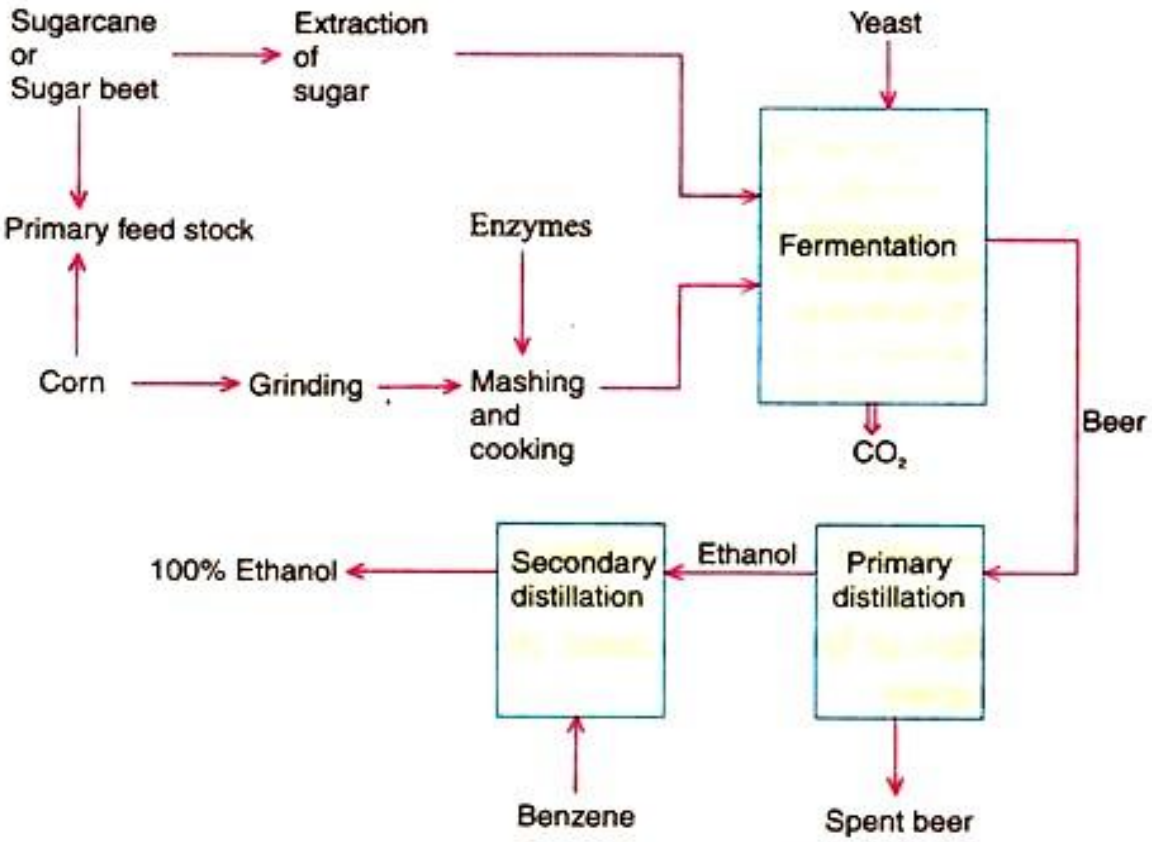

Fig. 20.6: Ethanol production from molasses.

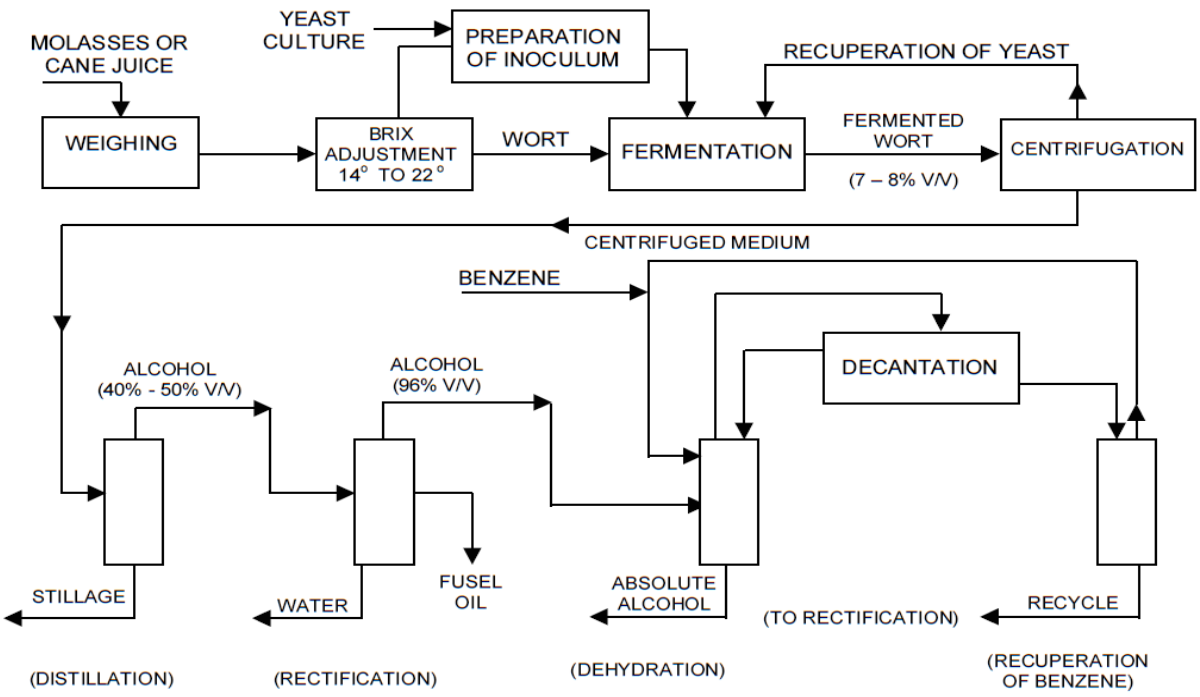

Fig. 20.4 Flow Diagram of Conventional Alcohol Production

Mechanism of ethanol production from glucose

Glucose $C_6H_{12}O_6$

↓ Through EMP Pathway

$2ADP \longrightarrow 2ATP$

2 Pyruvic acid $CH_3COCOOH$

↓ Pyruvic decarboxylase

TPP + Mg

2 Acetaldyde $CH_3CHO + 2\ CO_2$

↓ Alcohol dehydrogenase

$NADH2 \longrightarrow NAD$

2 Ethanol C_2H_5OH