

What is fermentation

- Conversion of sugar to alcohol using yeast.
- Chemical conversion of carbohydrates into alcohols or acids.
- The process is often used to produce wine and beer
- Also employed in preservation to create lactic acid in sour foods such as pickled cucumbers, kimchi and yogurt.
- The science of fermentation is known as zymology.
- With the goal of producing a specific chemical product.



CONDITIONS FOR FERMENTATION

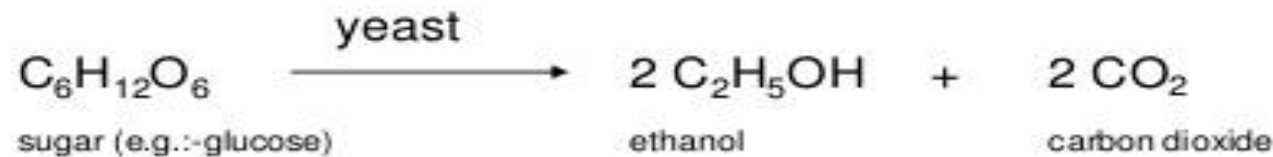
- ✚ **Carbon sources:** pure sugar or crude sugars/molasses (10-18%).
- ✚ **Nitrogen sources:** Mostly available in the form of ammonium sulphate.
- ✚ **Growth factors:** can be provided in the form of molasses.
- ✚ **pH:** 4.8-5.0.
- ✚ **Temperature:** 70-80 F. Temp. can be controlled by cooling jacket.

Direct conversion of sugar to ethanol



- This is usually done using molasses.
- **Molasses** is a thick dark syrup produced by boiling down juice from sugarcane; specially during sugar refining.
- As molasses is a by product, ethanol production from molasses is not done in a large scale around the world.

The main reaction involved is fermentation



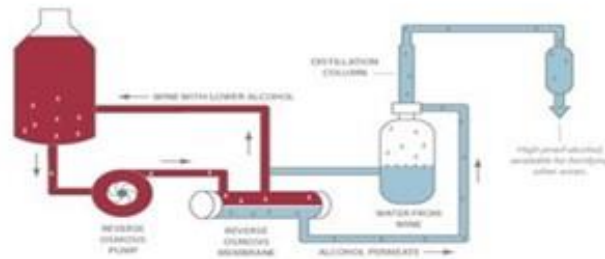
Characteristics of Enzymes?

Enzymes

- 1) speed up chemical reactions
- 2) are required in minute amounts
- 3) are highly specific in their action
- 4) are affected by temperature
- 5) are affected by pH
- 6) Some catalyse reversible reactions
- 7) Some require co-enzymes
- 8) Are inhibited by inhibitors



Ethanol Fermentation is a form of anaerobic respiration which is primarily used by yeast when oxygen is not present. Ethanol Fermentation is also referred to as **Alcohol Fermentation**.



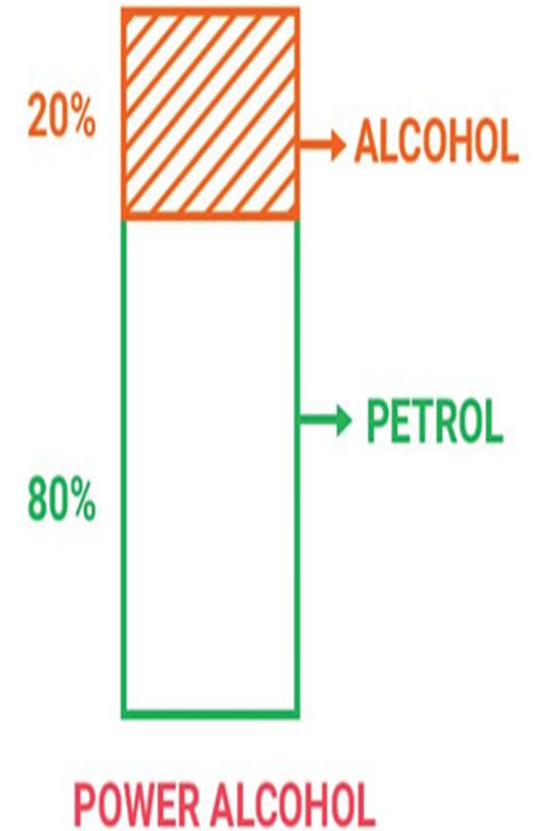
Ethanol is produced during the process of **fermentation**. Yeast is added to a sugar solution and left in the absence of air for several days. This is an **anaerobic** exercise.

Fermentation

Power Alcohol

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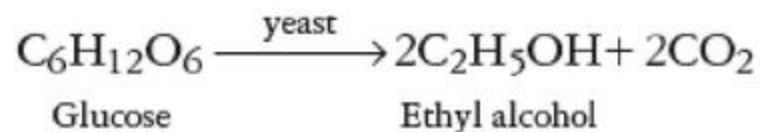
Power Alcohol and Synthetic Petrol

Power Alcohol

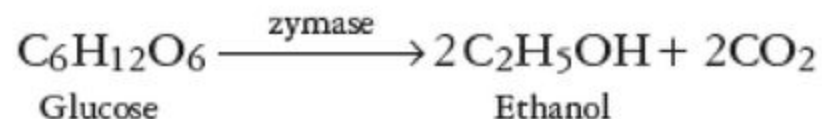
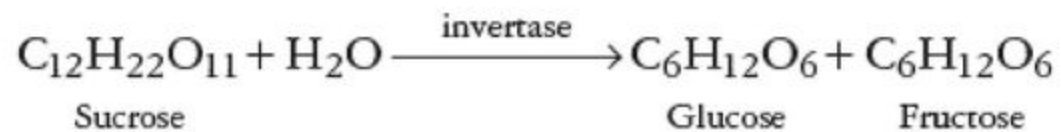
Ethyl alcohol is used as additive to motor fuels. When blended with petrol at concentrations of 5–10%, it is called power alcohol. The addition of alcohol to petrol increases its octane number.

Manufacture of Ethanol

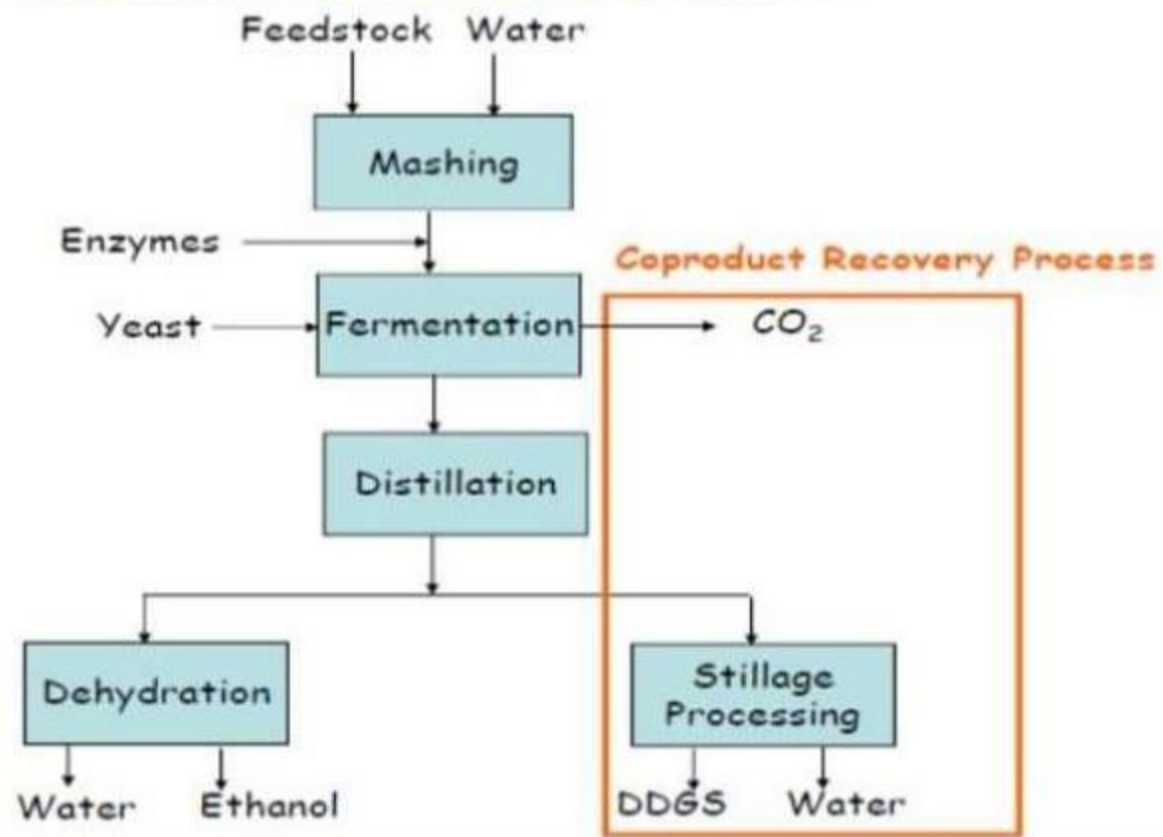
1. By fermentation



2. Using Molasses as raw material



Ethanol Production Process



Bioethanol Production



- Wheat/Grains/Corn/Sugar-cane can be used to produce ethanol. (Basically, any plants that composed largely of sugars)
- Bioethanol is mainly produced in three ways.

• **Sugar** → ethanol

• **starch** → **sugar** → ethanol

• **cellulose and hemicellulose** → ethanol



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❖ Power Alcohol from Sugarcane (Molasses)

- ✓ Molasses is a dark colored viscous liquid left after the crystallization of cane sugar from sugar cane.
- ✓ It contains 50-55% total sugar, of which 35-40% is the Sucrose ($C_{12}H_{22}O_{11}$).

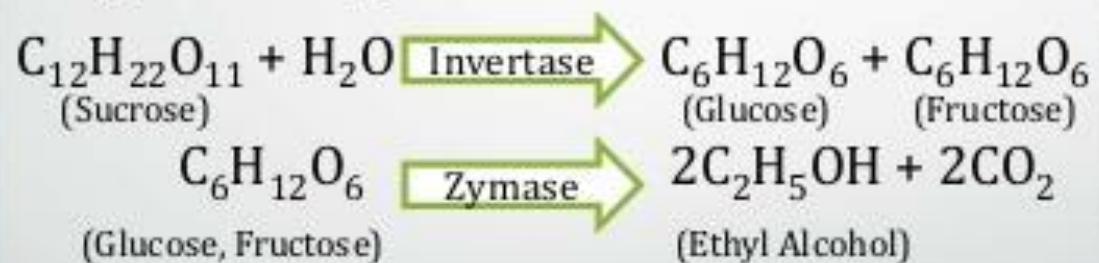
❖ **Process**

- ✓ Molasses is first diluted with water in 1:5(molasses: water) ratio by volume.
- ✓ If the nitrogen content of molasses is small, it is now fortified with ammonium sulphate to provide adequate supply of nitrogen to yeast.



✓ Fortified solution is then acidified with small quantity of sulphuric acid. Addition of acid favours the growth of yeast but unfavours the growth of useless bacteria.

✓ **FERMENTATION** : The resulting solution is received in a large tank and yeast is added to it at 30° C and kept for 2 to 3 days. During this period, enzymes sucrose and zymase which are present in yeast, convert sugar into ethyl alcohol.



✓ **FRACTIONAL DISTILLATION**: Alcohol obtained by the fermentation is called WASH, which is about 15% to 18% pure. By using fractional distillation technique, it is converted into 92% pure alcohol which is known as rectified spirit or commercial alcohol.

❖ Advantages

- ✓ Power Alcohol has high octane number which possess better anti- knock properties
- ✓ There is no starting difficulties with Power Alcohol.
- ✓ Air required for complete combustion is less.
- ✓ It has the ability to absorb trace of moisture
- ✓ Ability to burn completely.



❖ Disadvantages

- ✓ Power Alcohol may cause corrosion.
- ✓ It lowers the calorific value of petrol.
- ✓ It has the ability to easily get oxidized to acid.
- ✓ Air entering the cylinder need to be regulated by modifying air inlet as less air is required for combustion.



❖ Ethyl Alcohol form Corn

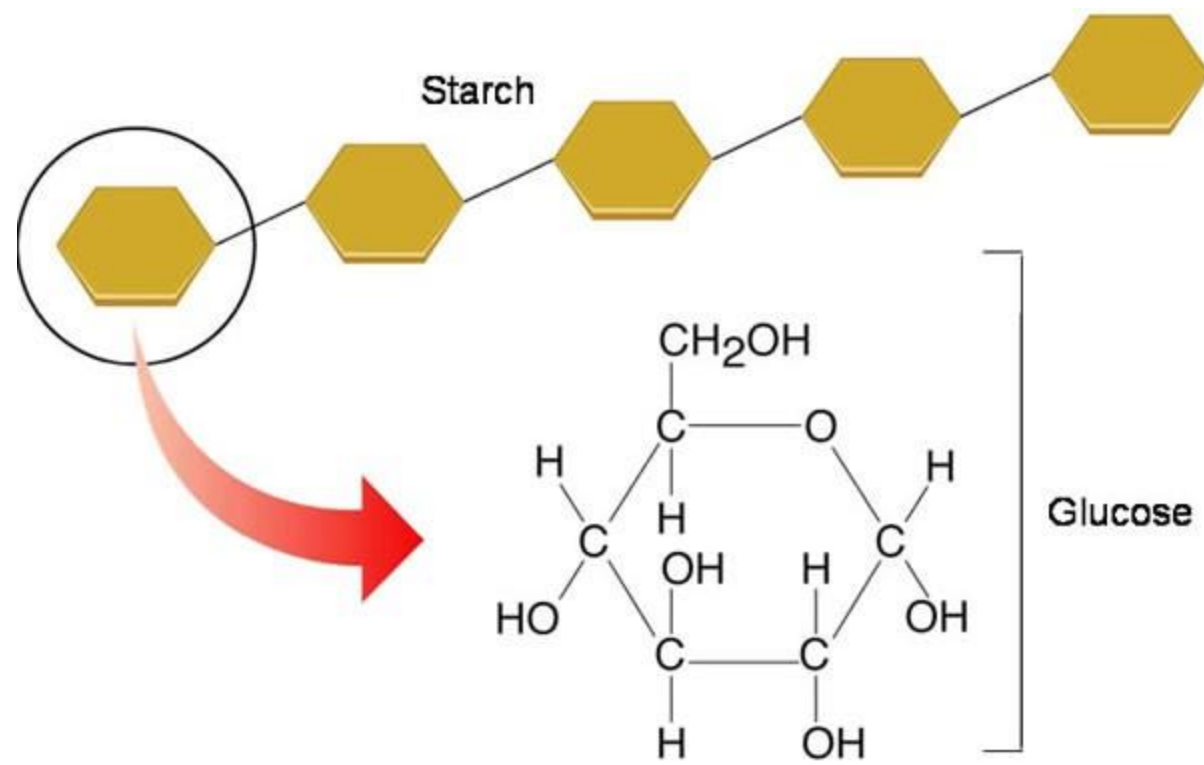
✓ Ethyl Alcohol is produced from corn by fermentation, chemical processing and distillation.

✓ The processes are of two types:

1. Dry Milling process (82%) : In this the entire corn kernel is ground into flour mill.
2. Wet Milling process (18%) : In this the corn grain is steeped into the dilute combination of sulphuric acid and water in order to separate the grain.

✓ Fermentation Condition = ph 5-7 , temperature 30-37 °C. Rest of the fermentation and distillation process is same as that of Molasses.





What is starch?

SOURCES OF STARCH

- Starch or amyllum is a carbohydrate consisting of a large number of glucose units joined together by glycosidic bonds;
- It is the most important carbohydrate in human diet;
- It is produced by all vegetables as an energy store: it is contained in cereals such as wheat, corn and rice or in tubers such as potatoes and cassava.

STARCH PRODUCTS

- Pure starch is a white, tasteless and odourless powder that is insoluble in cold water or alcohol. It can be used as such in processed foods or in the paper industry;
- Glucose syrups are liquids which are used in the food industry for their sweetening power and for other numerous functionalities or as a fermentescible substrate.
- Starch and glucose can be transformed into modified starches or different kinds of sweetening products which are used in the food industry.

Bioethanol Production



- **Wet milling process**

- corn kernel is soaked in warm water
- proteins broken down
- starch present in the corn is released (thus, softening the kernel for the milling process)
- microorganisms, fibre and starch products are produced.
- In the distillation process, ethanol is produced.



Bioethanol Production



- **Dry milling process**

- Clean and break down the corn kernel into fine particles
- Sugar solution is produced when the powder mixture (corn germ/starch and fibre) is broken down into sucrose by dilute acid or enzymes.
- Yeast is added to ferment the cooled mixture into ethanol.



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Bioethanol Production



- **Sugar fermentation**

- Hydrolysis process breaks down the biomass cellulosic portion into sugar solutions which will then be fermented into ethanol.
- Yeast is added and heated to the solution.
- Invertase acts as a catalyst and convert the sucrose sugars into glucose and fructose. (both $C_6H_{12}O_6$).

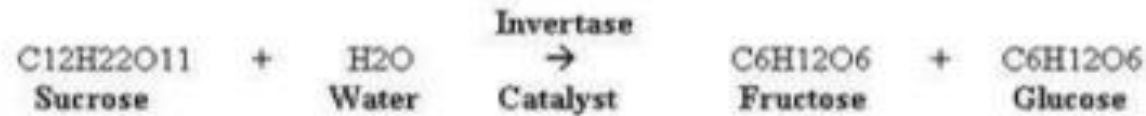


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Bioethanol Production

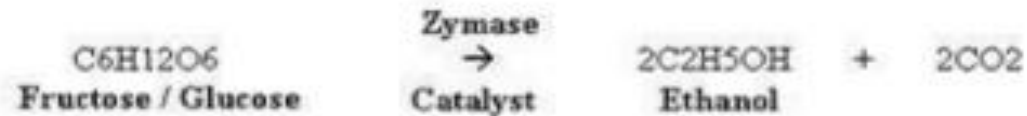


Chemical reaction 1



- The fructose and glucose sugars react with zymase to produce ethanol and carbon dioxide.

Chemical reaction 2



- Fermentation process requires 3 days to complete and is carried out at a temperature of between 250°C and 300°C.

Bioethanol Production



- **Fractional Distillation Process**

- After the sugar fermentation process, the ethanol still does contain a significant quantity of water which have to be removed.
- In the distillation process, both the water and ethanol mixture are boiled.
- Ethanol has a lower boiling point than water, therefore ethanol will be converted into the vapour state first → condensed and separated from water.

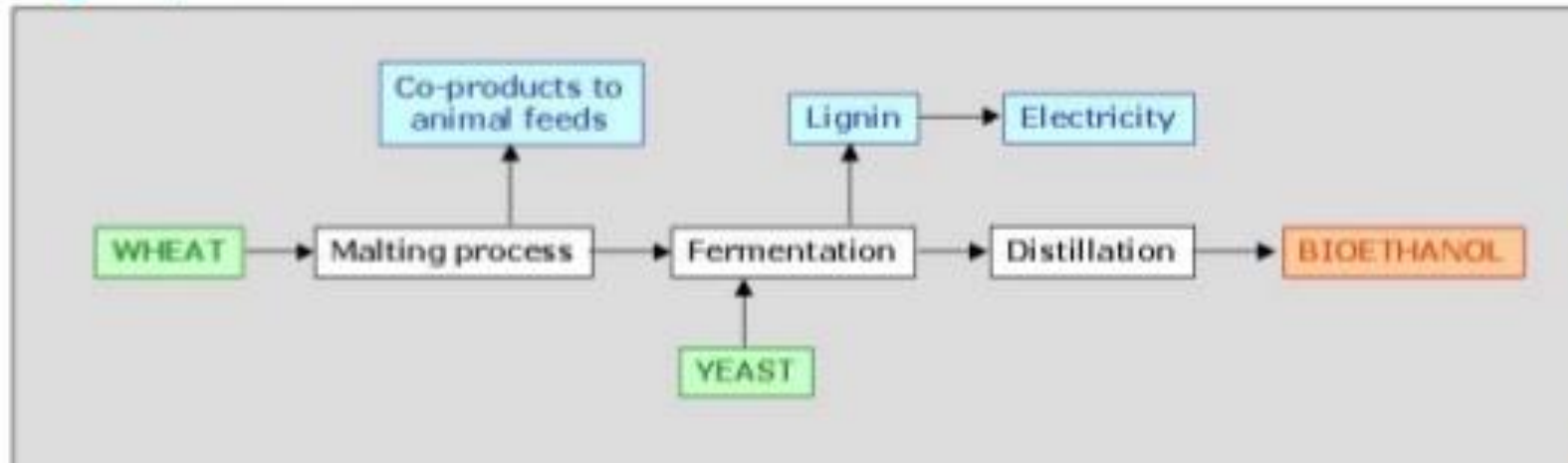


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Conversion of starch to sugar and then sugar to ethanol



Eg:-1) wheat



Fermentation conditions

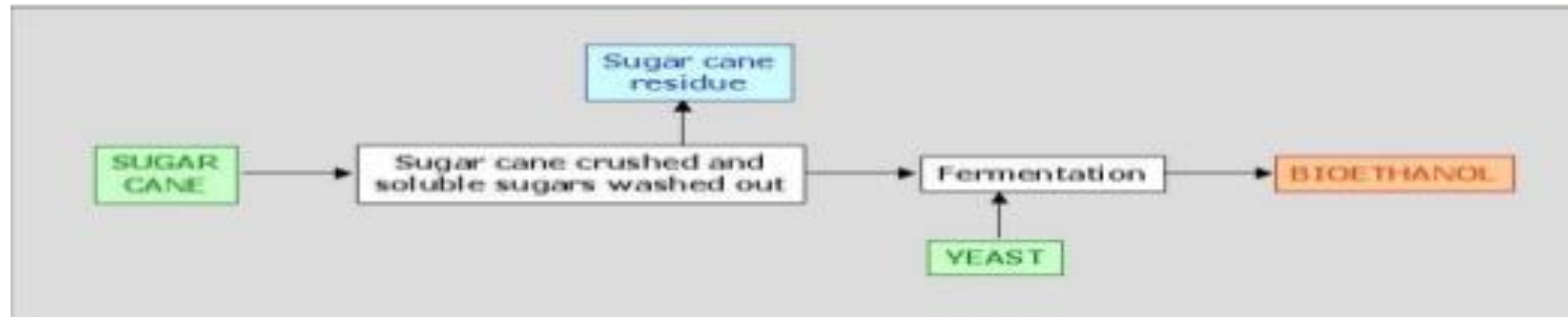
Temperature - 32°C and 35°C
pH - 5.2.

- Ethanol is produced at 10-15% concentration and the solution is distilled to produce ethanol at higher concentrations



Eg:- 2) sugar cane

Simplest of all the processes



- Fermentation conditions are similar to the above process

Definition

- Beer is defined as a fermented, alcoholic beverage made from barley, wheat, rice etc. & flavoured with hops.





Production Process Of Beer :

- **Milling:** In order for the malt components to be rapidly extracted and converted, the malt is milled to obtain coarse flour.
- **Mashing:** The flour from the cereals (malt and other unmalted cereals) is mixed with water and subjected to certain processes to obtain a wort of a suitable composition for the kind of beer being produced (varying times, temperatures and PH). Mashing lasts 2 to 4 hours and finishes with a temperature of approximately 75 °C.
- **Filtration of the wort:** After mashing, the whole volume is filtered in order to separate the spent grains (which is an excellent animal feed) from the wort itself. This is done by passing water through the mash at the right temperature in a filter press or lauter tun, which lasts around 2-3 hours, conducted at a temperature of 75-80 °C.

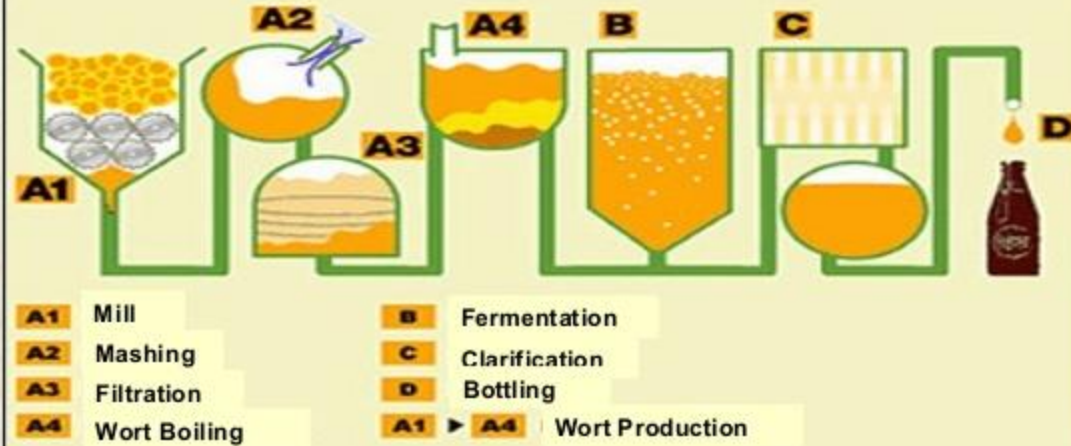


Production Process Of Beer Contd.:

- **Boiling the wort:** The diluted and filtered wort is boiled for around 2 hours. Hops are added at this stage. The purpose of boiling is to:
 - Transform and make soluble the bitter substances in the hops
 - Eliminate undesirable volatile substances.
 - Sterilise the wort
 - Provoke the precipitation of proteins of high molecular weight
 - Establish the final concentration of wort.



Flow Chart Of Beer Production:



Basic components or step to making wine

- ▮ *Harvesting.*
- ▮ *Crushing and Pressing.*
- ▮ *Fermentation.*
- ▮ *Clarification.*
- ▮ *Aging and bottling.*

6 Steps of Wine Making

For several years wine making has been practiced through the process called as vinification, this is a very simple method as compared to the other methods of making alcoholic beverages. The process of wine making involves six basic steps:

- Viticulture
- Harvesting
- Crushing
- Fermentation
- Clarifying the solution
- Bottling

Viticulture: As a known fact the flavor of the wine is dependent on the kind of grapes which are used. The variety of grapes depends on the place where they are grown, the climate of the place where they are grown, the drainage system around the winery, the quality of the soil, humidity content of the region and even the exposure levels to the sun. Other than these factors, one of the most important which is an important determinant in the making of wine is the techniques used to make the wine. In fact the different wineries formulate a customized wine making procedure according to the needs of their winery, so that they can bring out the best flavors of their grapes.

Harvesting: The next step in the winemaking process is the harvesting of the finely cultivated grapes. When the grapes are ripped and harvested it is very important that the timing of ripping the grapes is apt and the exact timing can be ascertained through experience. The timing of the ripping the grapes should be such that the grapes have the apt combination of sugar, acid and moisture. The harvesting of the grapes can be either done manually or mechanically, however majority of the grape wineries rip it manually.

Crushing: The next step after the grapes have been harvested is to crush and press so as to have their inherent flavors in the form of liquid. As the fruits are crushed the grapes withdraw their moisture content and the sugars. Many wineries make the usage of specialized machines for the process of crushing and pressing the grapes. The resultant liquid which is formed after crushing and pressing the wines is referred to as must, at this stage the wine will either turn into red color or white color depending on the preference of the winemaker. The wines become red when they are simply left after they are crushed because in this stage juices from the skin and the flavors are ripped off, thus when you

leave the must for a certain period of time, the wine become red wine, and in case you immediately crush the wine after pressing and segregate the skin then the wine becomes white wine.

Fermentation: After the grapes are being crushed and pressed, the fermentation takes place since the grapes have good quantity of sugar and moisture they easily get fermented with the reaction of wild yeast. Fermentation takes almost 10 to 30 days, however this depends on the quality of grapes and the climate.

Clarifying the solution: This is also referred to as stabilization.

Bottling: The final stage is to transfer the clarified solution in the wooden barrels or bottles.

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Reference:

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