**Alcoholic Beverages: Whisky**

In whisky production, grains are mashed and fermented to produce an alcohol/water solution, that is distilled to concentrate the alcohol and finally the distilled product is aged to provide flavor, color, and aroma. The steps involved in whisky production are as follows:

* **Grain Handling And Preparation** - Distilleries utilize premium cereal grains, such as hybrid corn, rye, barley, and wheat, to produce the various types of whisky and other distilled spirits. Grain is received at a distillery from a grain handling facility and is prepared for fermentation by milling or by malting (soaking the grains to induce germination).
* **Grain Mashing** - Mashing consists of cooking the grain to solubilize the starch from the kernels and to convert the soluble starch to grain sugars with barley malt and/or enzymes. Small quantities of malted barley are sometimes added prior to grain cooking. The mash then passes through a noncontact cooler to cool the converted mash prior to entering the fermenter.
* **Fermentation** -The converted mash enters the fermenter and is inoculated with yeast. The fermentation process, which usually lasts 3 to 5 days for whisky, uses yeast to convert the grain sugars into ethanol and carbon dioxide. Congeners are flavor compounds which are produced during fermentation as well as during the barrel aging process. The final fermented grain alcohol mixture, called "beer", is transferred to a "beer well" for holding. From the beer well, the beer passes through a pre heater, where it is warmed by the alcohol vapors leaving the still, and then to the distillation unit. The beer still vapors condensed in the pre heater generally are returned to the beer still as reflux.
* **Distillation** - The distillation process separates and concentrates the alcohol from the fermented grain mash. Whisky stills are usually made of copper, especially in the rectifying section, although stainless steel may be used in some stills. Following distillation, the distilled alcohol spirits are pumped to stainless steel tanks and diluted with demineralized water to the desired alcohol concentration prior to filling into oak barrels and aging.
* **Grain And Liquid Stillage** (“Dryer House Operations”) - In most distilleries, after the removal of alcohol, still bottoms (called whole stillage), are pumped from the distillation column to a dryer house. Whole stillage may be sold, land applied (with permitting), sold as liquid feed, or processed and dried to produce distillers dried grains (DDG) and other secondary products. Solids in the whole stillage are separated using centrifuges or screens; the liquid portion (thin stillage) may be concentrated by vacuum evaporation and the concentrated liquid is recombined with the solids or dried. Drying is typically accomplished using either steam-heated or flash dryers.
* **Warehousing/Aging** - Aging practices differ from distiller to distiller, and even for the same distiller. Variations in the aging process are integral to producing the characteristic taste of a particular brand of distilled spirit. The aging process, which typically ranges from 4 to 8 years or more, consists of storing the new whisky distillate in oak barrels to encourage chemical reactions and extractions between the whisky and the wood. The constituents of the barrel produce the whisky's characteristic color and distinctive flavor and aroma. White oak is used because it is one of the few woods that holds liquids while allowing breathing (gas exchange) through the wood. The oak barrels and the barrel environment are key to producing distilled spirits of desired quality. The new whisky distillate undergoes many types of physical and chemical changes during the aging process that removes the harshness of the new distillate. As whisky ages, it extracts and reacts with constituents in the wood of the barrel, producing certain trace substances, called congeners, which give whisky its distinctive color, taste, and aroma.
* **Blending/Bottling** - Once the whisky has completed its desired aging period, it is transferred from the barrels into tanks and reduced in proof to the desired final alcohol concentration by adding demineralized water.

**Emissions and Controls:** The principal emissions from whisky production are volatile organic compounds (VOCs), principally ethanol, and occur primarily during the aging/warehousing stage. In addition to ethanol, other volatile compounds, including acetaldehyde (a HAP), ethyl acetate, glycerol, fusel oil, and furfural, may be produced in trace amounts during aging. Smaller quantities of ethyl acetate, isobutyl alcohol, and isoamyl alcohol are generated as well; carbon dioxide is also produced during fermentation. Other emissions, including SO , CO , CO2, and PM (particulate matter) may be generated by fuel combustion from power production facilities located at most distilled spirits plant. However, distillers ensure that barrel construction is of high quality to minimize leakage, thus reducing ethanol emissions. Ethanol recovery would require the use of a collection system to capture gaseous emissions in the warehouse and to process the gases through a recovery system prior to venting them to the atmosphere.



**Fig: Major steps involved in whiskey production**