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VINEGAR PRODUCTION

Acetic acid was produced exclusively by fermentation from very early times until late in the nineteenth century, when the production by wood distillation was started. The decomposition of wood by heating to a temperature of 450°–550°C in the absence of air. The products of this process are gases (carbon dioxide, carbon monoxide, methane), liquids, and a solid residue - charcoal. The gaseous and liquid products separate out as a mixture of steam and gases, and when the mixture is cooled, a distillate is obtained. Manufacture by synthetic routes is economically convenient, because production rates are high: the acid is generated in the free-acid form and high concentrations (from 35 to 45%) are achieved. Now a days, microbiological production is directed to the food market in the form of vinegar, which is defined as an aqueous solution of acetic acid produced by fermentation. About 60% of the acetic acid produced is used in the manufacture of vinyl acetate monomer, which is a key raw material for plastics, adhesives, textile finishes and paints. Other major applications are found in the production of acetic anhydride for cellulose acetate, acetate esters for solvents, plasticizers, chloroacetic acid, acetate salts for heat transfer liquids, de-icers, and other uses, as well as in the pharmaceutical industry. Acetic acid fermentation is applied in the aerobic, two-step process for the production of vinegar. However, in the last decade a significant amount of research has been devoted to the anaerobic production from biomass and its potential to compete with chemical synthesis. Vinegar is a liquid condiment used as a food flavoring and as a preservative. It is produced by the action of aerobic bacteria of the genus *Acetobacter* on dilute solutions of ethanol such as cider, wine, or diluted distilled alcohol solutions. The ethanol solutions utilized are also produced microbiologically by the ethanol fermentation of sugars by *Saccharomyces cerevisiae*. When starch materials are used (as in malt or rice vinegar), the enzymatic saccharification of starch is required prior to the alcohol fermentation. Vinegar is the condiment made from various sugary and starchy materials by alcoholic and subsequent acetic acid fermentation. The bacteria responsible for the fermentation is the Acetic acid bacteria. Traditionally, vinegar was produced by using the cull fruit of apple (fruit with defects like mechanical damage/cuts etc) and waste products from apple processing. Modern production of vinegar is done using distilled grain alcohol, rice wine, sugar cane and others. Vinegar contains 5-20% acetic acid Types of vinegar The predominant type of vinegar in the United States is white or distilled vinegar. Vinegar is described in terms of grain

strength which is ten times the acid percentage. Vinegar varieties vary greatly from country to country. Some of the most popular vinegars and their characteristics are : Balsamic vinegar is brown in color with a sweet-sour flavor. It is made from the white Trebbiano grape (italian wine grape) and aged in barrels of various woods. Some Balsamic vinegars are over 100 years old. It has an Italian origin. Cane vinegar is made from fermented sugarcane and has a very mild, rich-sweet flavor. It is most commonly used in Philippine cooking. Champagne vinegar has no bubbles. It's made from a still, dry white wine made from Chardonnay or Pinot Noir grapes (both of which are used to make Champagne). Cider vinegar is made from apples and is the most popular vinegar used for cooking in the United States. Coconut vinegar (made from fermentable coconut sap) is low in acidity, with a musty flavor and a unique aftertaste. It is used in many Thai dishes. Distilled vinegar is harsh vinegar made from grains and is usually colorless. It is best used only for pickling. Malt vinegar is very popular in England. It's made from fermented barley and grain mash, and flavored with woods such as beech or birch. It has a hearty flavor and is often served with fish and chips Rice wine vinegar has been made by the Chinese for over 5,000 years. There are three kinds of rice wine vinegar: red (used as a dip for foods and as a condiment in soups), white (used mostly in sweet and sour dishes), and black (common in stir-fries and dressings). Sherry vinegar is caged under the full heat of the sun in wooden barrels and has a nutty-sweet taste. Wine vinegar can be made from white, red, or rose wine. These vinegars make the best salad dressings. The acetic acid bacteria have received the generic designation of Acetobacter which oxidizes ethyl alcohol to acetic acid in a highly aerobic environment. The oxidation involves two enzymes: an alcohol dehydrogenase that oxidizes ethanol to acetaldehyde, and an acetaldehyde dehydrogenase, which completes the oxidation to acetic acid. One gram of ethanol should yield 1.304g of acetic acid. Practical yields are usually above 85% of the theoretical value. The fermentation is carried out between 27 and 32°C, but the optimum temperature is dependent on the culture and the conditions in use. Some new thermotolerant strains of a few Acetobacter species that perform the fermentation between 38-40°C have been isolated. With these strains, higher production rates at similar acetic acid concentrations have been reported. Organisms of the genus Clostridium are able to convert glucose, xylose and some other hexoses and pentoses to acetic acid almost quantitatively under anaerobic conditions. The fermentation of sugars to acetate is a complex process. One mole of hexose is metabolized through the Embden–Meyerhof pathway to yield two moles of pyruvate, which are further metabolized to two moles of acetate and two moles of CO₂. This carbon dioxide serves as an electron acceptor; which then combines with the remaining CO₂ and coenzyme-A to form acetyl-CoA and finally the third mole of acetate. VINEGAR PRODUCTION Alcoholic fermentation: Sugar concentration is adjusted in the range of 8-20%. Some nutrients- nitrogen source, minerals – potassium or ammonium phosphates also added. SO₂ is added 50-100 mg/L. Two stages : Primary stage 3-7 days in open vats, secondary stage, several weeks in closed vats Acetic acid fermentation: 3 main processes • Orleans process : acetic acid bacteria grow slowly as a film over the surface of still medium • Quick process: Special type of fermenter : Frings generator • Deep fermentation process Orleans process: This method is also called the French method and it was developed in France in 1670. It is a slow method of acetifying wine. In this process, alcohol solutions less than 5% in wine cannot be acetified easily. Below this strength, phosphates and nitrogenous substances must be added to the mash and the products have to be sold under the name of “spirit vinegar”. The Orleans process was the only method to make pure wine vinegar, and was reported to be the best process to produce fine quality table vinegar. In this process, wood barrels are used and filled with alcohol

fermenting liquid to approximately $\frac{3}{4}$ full. Holes are drilled at the ends of the barrel a few inches above of the liquid surface. The holes are left open and covered with a fine screen. Approximately 20-25% of fresh vinegar is added into the barrel. The function of adding the fresh vinegar is acidifying the liquid to the point of optimum growth for the vinegar bacteria. Vinegar bacteria settle into the liquid from the air and form a gelatinous slime layer on top of the liquid. The liquid is fermented for about 1 to 3 months at 21°C to 29°C. After this time, 1/4 to 1/3 of the vinegar may then be drawn off for bottling purposes and an equivalent amount of alcoholic liquid added. Quick process: Air tight tank usually 14 feet in dia and 15ft high. Wooden grating near the bottom. A spraying arm fitted near the top. Air intakes around the tank near the level of wooden grate. Tubular cooling coils near the bottom, connected. Non compacting material is filled above a perforated wood grating floor in large upright wood tanks. Re circulated fermenting liquid trickles over the packing material toward the bottom while air moves from the bottom inlets toward the top. The recirculation process takes about 3 to 7 days after which 2/3 of the final vinegar product is withdrawn from the tank and new alcohol solution is added. Basically, the generator ferments the vinegar from diluted alcohol using beech wood chips packed loosely in a column. The column is arranged so that air can enter at the bottom and circulate up through the spaces between the beech wood chips. Prior to use, the chips are heated with 5% vinegar solution in a kettle at 100°C to permeate the chips and prepare them to receive the bacteria culture. After cooking, the wood chips are placed evenly on paper to dry. The heating process removes wild yeast and other bacteria from the surface of the chips. Generator is packed with wood shavings, coke, pumice, grape and other twigs, corn cobs. Medium consists of mix with following composition: glucose, 0.9%, amm phosphate, 0.4%, magnesium sulphate, 0.1%, potassium citrate, 0.1%, pantothenate, 0.00005%. Temperature: 27-32°C, O₂ level 12% Deep Fermentation Process In this process, air is forcefully supplied to alcohol liquid in a tank and the material is fermented at 30°C. At the end of every cycle, 1/3 of the liquid is discharged as final product and the submerged fermentor is refilled with 1/3 mash or fresh alcohol solution. Then, a new fermentation cycle begins