Vinegar Production

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Vinegar may be defined as a condiment made from various sugary & starchy materials by alcoholic and subsequent acetic fermentation .It must contain 4g acetic acid per 100ml (4%). Pickling vinegar has 18% acetic acid. Vinegar is a French word “Vin agre” that means sour wine. Weak hard liquors can become bitter on exposure to the air. This can be because of the conversion of the alcohol in ethanoic acid. ethanoic acid is created by chemical change numerous substrates (starchy answer, sugar solutions or alcoholic foodstuffs like wine or cider) with *Acetobacter* bacterium.

Vinegar History

Vinegar use can be traced back over 10,000 years ago. In the 6th century BC, the Babylonians were making & selling vinegar flavoured with fruit, honey, malt etc. Egyptians records dates back to 300 BC.

Vinegar Bacteria

The 2nd edition of Bergey's Manual of Systematic Bacteriology classifies the Acetic acid bacteria in the order Acetobacterales & family Acetobacteraceae.

Acetic acid bacteria also called as vinegar bacteria are Gram-negative, ellipsoidal to rod-shaped that have a required aerobic metabolism with oxygen as terminal electron acceptor.

Gluconoacetobacter is differentiated from *Acetobacter* by their inability to oxidize acetic acid or lactic acid to CO_2.

In 1998, two strains of *Acetobacter* isolated from red wine and cider vinegar were named *Acetobacter oboediens* and *Acetobacter pomorum.*

In 2000, *Acetobacter oboediens* and *Acetobacter intermedius* were transferred to Gluconacetobacter on the basis of 16S rRNA sequencing.

In 2002, *Acetobacter cerevisiae* and *Acetobacter malorum* were identified by 16S rRNA sequence analysis of Acetobacter strains.

In 2006, a strain of *Acetobacter* isolated from spoiled red wine was named *Acetobacter oeni*.

Classification

Bacteria

α- Proteobacteria

Rhodospirillales

Acetobacteraceae

Acetobacter aceti, A. xylinum, A europaeus, Gluconobacter oxydans, G.hansenii

Types of Vinegar

Type of Vinegar	Raw material
Balsamic Vinegar	Trebbiano Grape
Cane Vinegar	Sugarcane
Champagne Vinegar	Pinot Noir Grapes
Cider Vinegar	Apples
Coconut Vinegar	Coconut
Distilled Vinegar	Grains
Malt Vinegar	Barley & Grained Mash
Rice Vinegar	Rice
Wine Vinegar	White, Red or Rose Wine

Color and aroma of vinegar greatly depends on the material from which it is made.

Principles of Vinegar Production

It is a 2 step process

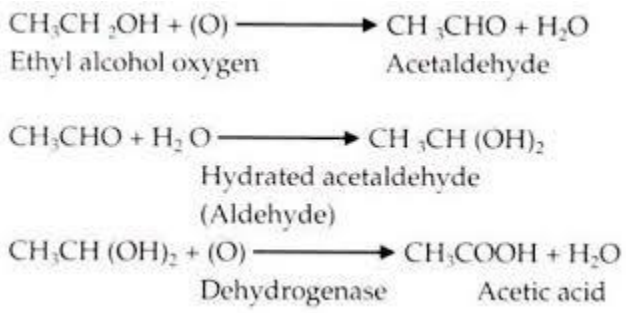
Step I: Alcoholic fermentation, which occurs in anaerobic conditions in presence of yeast at temp 30-32°C

Sugar (Glucose, Fructose) $\xrightarrow{\text{Yeast}}$ $2C_2H_5OH$ (Ethanol) + $2CO_2$

By products like Glycerol, Succinic acid and amyl alcohol may be formed when substrate other than sugar is used.

Step II: Acetogenic fermentation, which occurs in aerobic conditions in presence of *Acetobacter aceti* at temp 27-37°C

Ethanol $\xrightarrow{\text{Acetic acid bacteria}}$ CH_3COOH (Acetic acid) + H_2O



By products formed are esters, acetoin.

Processing steps in vinegar production

Cleaning of raw material

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Juice extraction

↓

Filtration

↓

Pasteurization

↓

Cooling of raw material (Starch)

↓ Amylases

Sugar

↓ Mixing of Yeast (Yeast Fermentation/Alcoholic Fermentation under anaerobic condition)

Ethanol (Check the end fermentation product)

↓ Addition of mother liquor (Containing Acetic acid bacteria)

Hydrated acetaldehyde/acetic Fermentation under aerobic condition

↓ Dehydrogenation by aldehyde dehydrogenase

Acetic Acid (Check the end fermentation product)

↓

Filtering

↓

Distillation

↓

Pasteurization at 74 ^{o}C

↓

Bottled

There are 3 methods of vinegar production as described below.

Orleans Process/ Batch Culture/Slow Method

This was the only method earlier to make pure wine vinegar & fine quality table vinegar.

In this process wood barrels were used & filled with alcoholic fermenting liquid to ¾ full.

Holes were drilled at the end of barrels few inches above the liquid surface and covered with fine screen/mesh.

App. 20 to 25 % fresh vinegar was added into the gallon. The function of adding of fresh vinegar was to acidify the liquid to the point of optimum growth of vinegar bacteria.

Vinegar bacteria settle into the liquid & form a gelatinous slime layer on top of liquid.

This liquid is fermented for 1-3 months at 70-85^{o}F.

After this time ¼ to ¾ of vinegar may be drawn for bottling & equal amount of alcoholic liquid was added.

This method is not very efficient as the bacteria come with contact with air and substrate only at the surface & secondly alcoholic liquid is not moved during acidification.

Generator Fermentation/ Trickle Method/ Quick Method

In this method Bacteria is grown to form a thick slime coat around a non-compacting material like wood shaving charcoal or coke.

Recirculated fermenting liquid trickles over the packing material towards the bottom while air moves from bottom to the top through inlets (Refer to Figures below).

Rate of acidification is dependent upon oxygen concentration.

Limited air means limited acetic acid production and lower generator temperature.

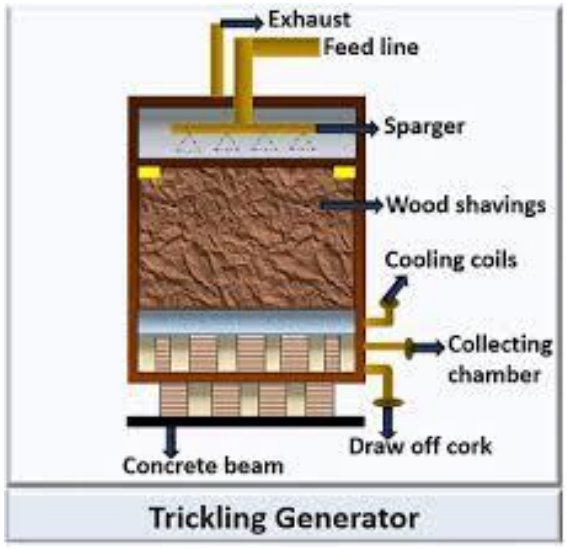
High air creates over production and high generator temperature so generator must be closely monitored to prevent over oxidation and high temperature. Optimum required temperature is 30 to 32^{o}C . So temperature cooling and control system is required.

The process takes 3 to 7 days.

2/3 of final vinegar product must be withdrawn and fresh mash should be added.

Process is operated in a continuous fashion that is why recalculated fermenting liquid term is used.

In starting a new generator, the slime of vinegar bacteria must be established before vinegar can be made. Middle section of tank is filled with raw vinegar that contains active vinegar bacteria to inoculate the shaving with desired bacteria. This material is circulated through generator. Then alcoholic liquid is acidified with vinegar through slow tickling. The vinegar at bottom may be re-circulated if insufficient acid is produced.



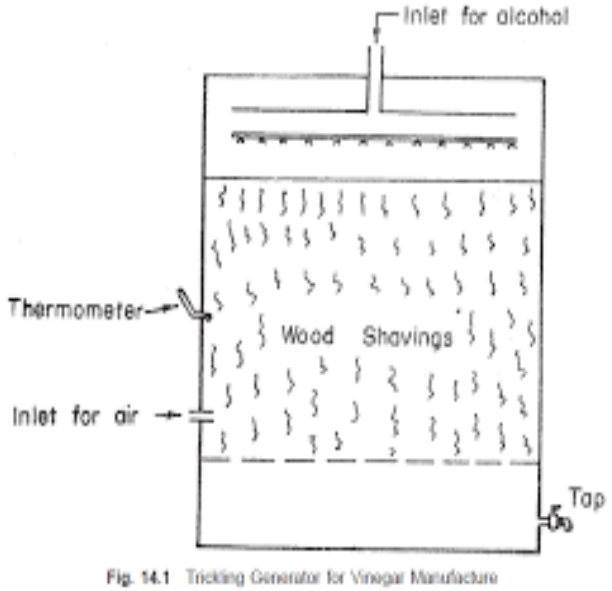
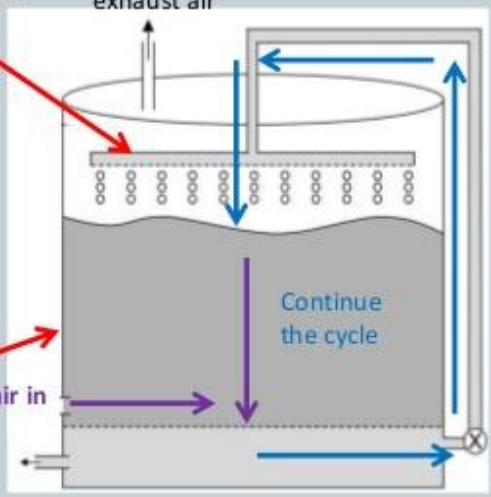


Fig. 14.1 Trickling Generator for Vinegar Manufacture

Trickling generator process

Sparing arm break liquid into small droplet

- Produce vinegar faster
  - Oxidation reaction is accelerated by increase surface area expose to O_2



Material of vessel (wood shaving, corn cob…) contribute to flavor

Trickle Method

Submerged Fermentation/Bubble method/Acetator method

Most common production method used at Industrial scale in which tank filled with alcohol is pumped with oxygen and maintained temperature.

This improves the general fermentation conditions like aeration, stirring, heating etc.

The vinegar bacteria float in liquid and so do not make a vinegar mother (Bacterial Slime layer) and hence comparatively cleaner vinegar is obtained.

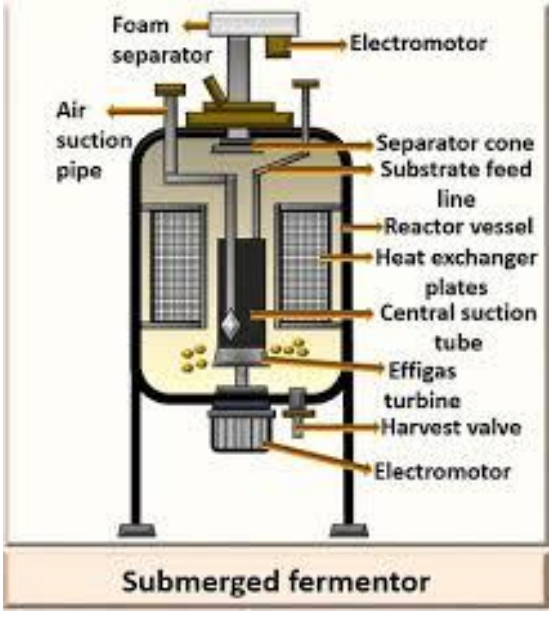
The fermenters are fitted with a heat exchanger for maintenance of optimum temperature during the process.

<u>The operation mode is semi-continuous form.</u>

Due to proper aeration 90-98% of alcohol is converted to acetic acid.

A stirred medium containing 8-12% alcohol is inoculated with *Acetobacter* and held at 24-29^{o}C with controlled aeration. Bacteria grow in a suspension of fine air bubbles and fermenting liquid.

If not monitored properly acetic acid formed may oxidize further to CO_2 and H_2O (Over-oxidation).



Submerged fermentor

Related journals for Acetic Acid Fermentation

Fermentation Technology, Journal of Biotechnology & Biomaterials, Journal of Bioprocessing & Biotechniques, Journal of Bioterrorism & Biodefense, Molecular Biology, Journal of Phylogenetics & Evolutionary Biology, Journal of Molecular and Genetic Medicine, Chemical Sciences Journal, Biology and Medicine, Journal of Advanced Chemical Engineering

Thank You