Alcohol Fermentation

Introduction

- **Alcoholic fermentation** is a complex biochemical process during which yeasts convert sugars to **ethanol**, carbon dioxide, and other metabolic byproducts that contribute to the chemical composition and sensorial properties of the **fermented** foodstuffs.
- Alcoholic beverages are produced from sugar containing liquids by alcoholic fermentation. Sugars, fermentable by yeasts, are either present as such or are generated from the raw material by processing, i. e. by hydrolytic cleavage of starches and dextrins, yielding simple sugars.
- **Alcoholic beverages** are **produced** by fermentation of grapes, grains, barley, fruits, sugarcane, and rice type of feed stock by treating them with yeast in controlled environment. Fermentation is a biological reaction, in which sugar reacts with yeast at different temperatures.

Introduction

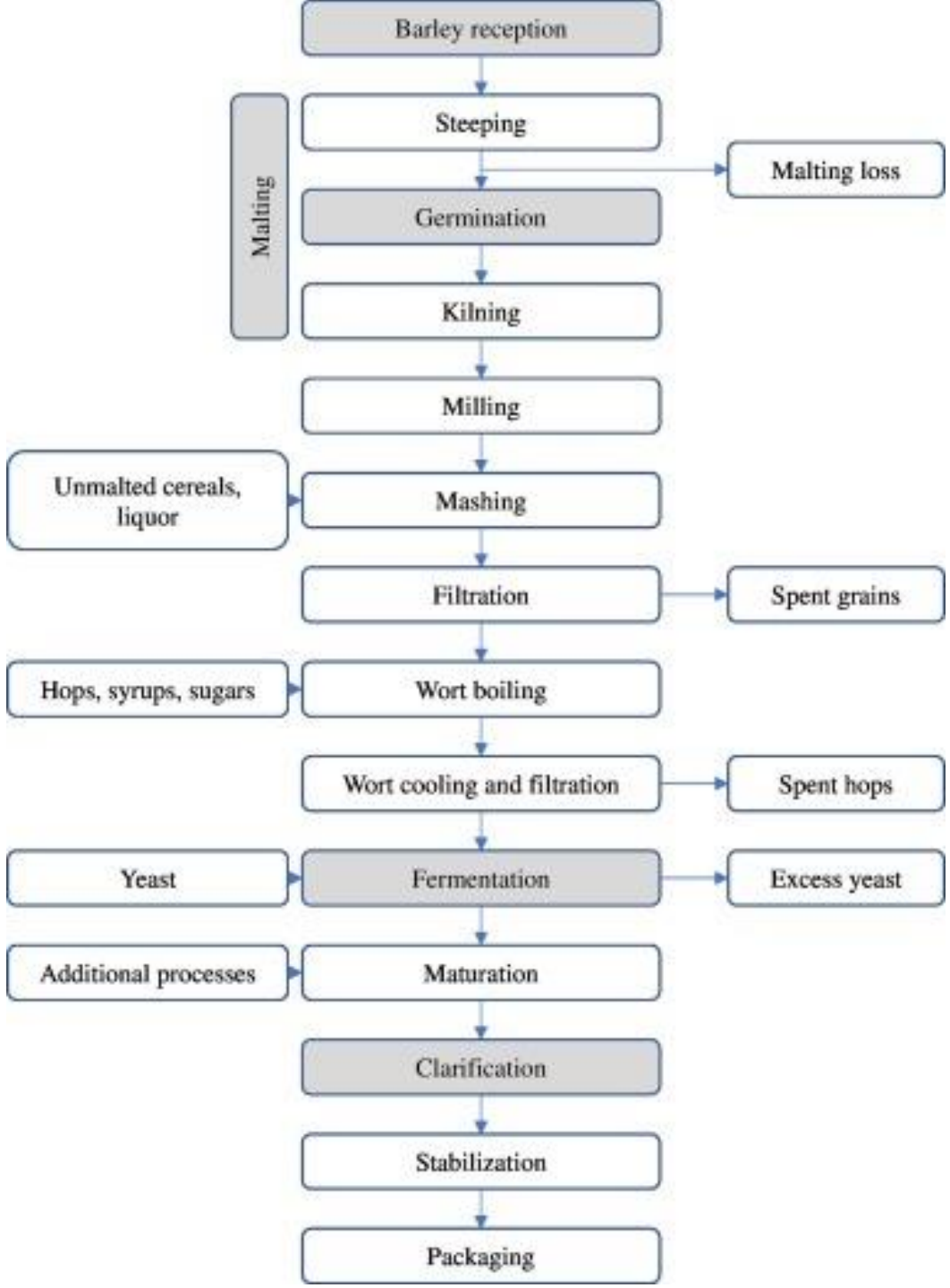
- What is the main component in an alcoholic beverage?
- **Ethanol** and **water** are the main components of most alcoholic beverages, although in some very sweet liquors the sugar content can be higher than the **ethanol** content.
- **Ethanol** (CAS Reg. No. 64–17–5) is present in alcoholic beverages as a consequence of the fermentation of **carbohydrates** with yeast.

Beer Production

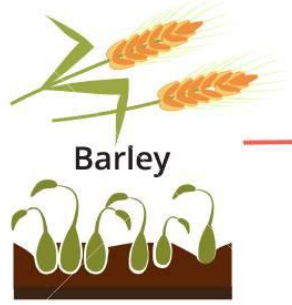
- **Beer production** involves malting, milling, mashing, extract separation, hop addition and boiling, removal of hops and precipitates, cooling and aeration, fermentation, separation of yeast from young **beer**, aging, maturing, and packaging.
- The **first step** is malting- partial germination of cereal grains
- The **second step** in the **beer-making** process is mashing and wort preparation, in which the grist, or milled malt, is transferred to the mash tank. Mashing is the process of combining the grist and water, also known as liquor, and heating it to temperatures usually between 100 -170 degrees Fahrenheit. Hops area added to impart their bitter flavor and aroma (wort preparation)
- The **third step** is Yeast Fermentation
- **Last step** is Post fermentation – aging, maturation and carbonation.

Steps involved in beer production are:

1. Malting: **Beer** is produced from barley grains. ...
2. Kilning: The germinated seed are then killed by slow heating at 80° This **process** is called kilning. ...
3. Mailing: ...
4. Mashing: ...
5. Boiling of wort: ...
6. Hops: ...
7. Fermentation: ...
8. Finishing, Ageing, Maturation and Carbonation:


Barley reception
Steeping
Malting
Malting loss
Germination
Kilning
Milling
Unmalted cereals, liquor
Mashing
Filtration
Spent grains
Hops, syrups, sugars
Wort boiling
Wort cooling and filtration
Spent hops
Yeast
Fermentation
Excess yeast
Additional processes
Maturation
Clarification
Stabilization
Packaging

Beer BREWING SCHEME

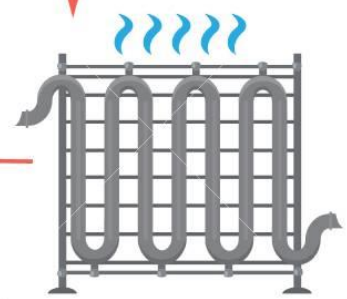


Malt

Crushing

Filtration

Boiling With Hop



Cooling

Fermentation, Ripening

Filtration

Bottling

1. Malting

- The grains are soaked in water tanks for 2-3 days at 10-15°C (steeping)
- They are allowed to germinate for 6-15 days(humidity: 45%, temperature: 12-21°C).
- Enzyme cystase converts insoluble starch to soluble one.
- Enzyme diastase converts the soluble starch into sugars.
- Conversion of starch into sugars (maltose) is known as malting.

Figure 14: The malting process in barley.

2. Milling

- After drying and heating, the rootlets from the malt is removed.
- These malt culms are then sold to provide feed for cattle.
- The grains are then grinded coarsely in roller mills; forming grists.

Figure 16.1: The roller mill.

Figure 16.2: Different varieties of grinded malted grains.

3. Mashing

- The grist is mixed with hot water
- The mash is cooked for up to 6 hours at low temperature.
- Enzymes in the malt convert starch into sugars producing wort.
- The wort is then boiled for about an hour and a half.
- Factors like: temperature, time and pH are adjusted.

Figure 17: The mash tun.

4. Lautering

- Refers to the separation of wort(sugar solution) from the undissolved part of the grain.
- Water is sparged through the grains.
- Sparging must be done very gradually.
- This process is done in tanks known as lauter tun which contains a giant sieve.
- The spent grains are sold as feed for cattle.
- The malt mixture might also be sprayed with hot water.

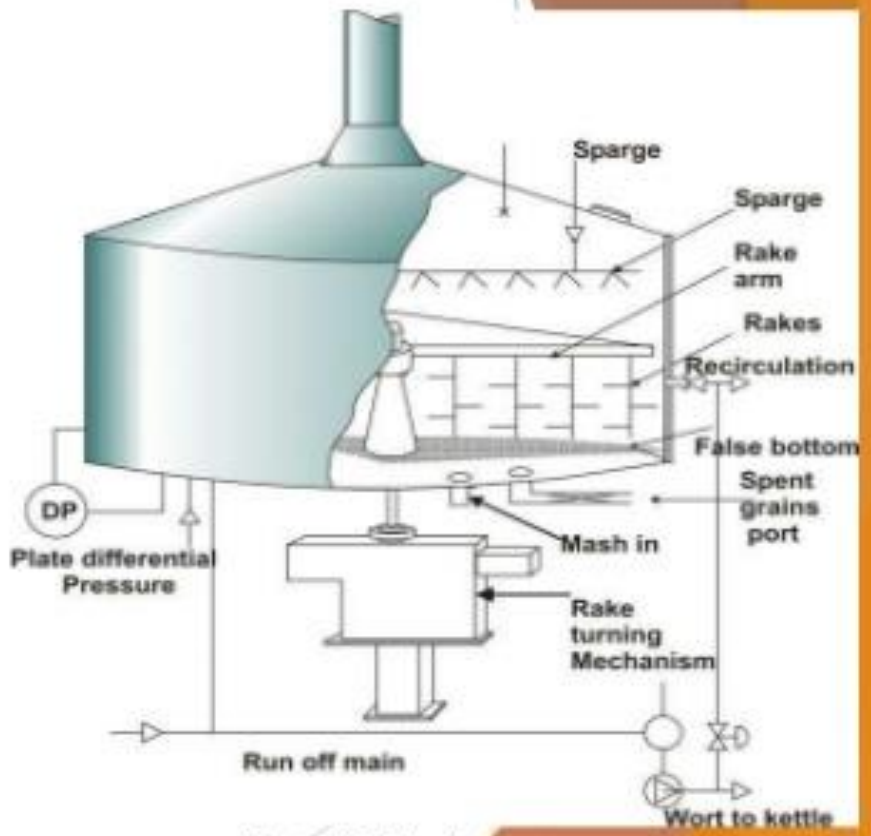


Figure 18: The lauter tun.

5. Boiling

- The wort is then transferred into boiling tanks (kettle)
- Hops are added at this stage.
- Boiling :sterilizes the wort, inactivates enzymes, coagulates proteins present and forms flavour compounds from added hops.
- Hops and precipitated proteins are separated from wort after boiling is done.
- Resulting liquid is cooled in a plate heat exchanger to the fermenting temperature.

Figure 19: The copper kettle.

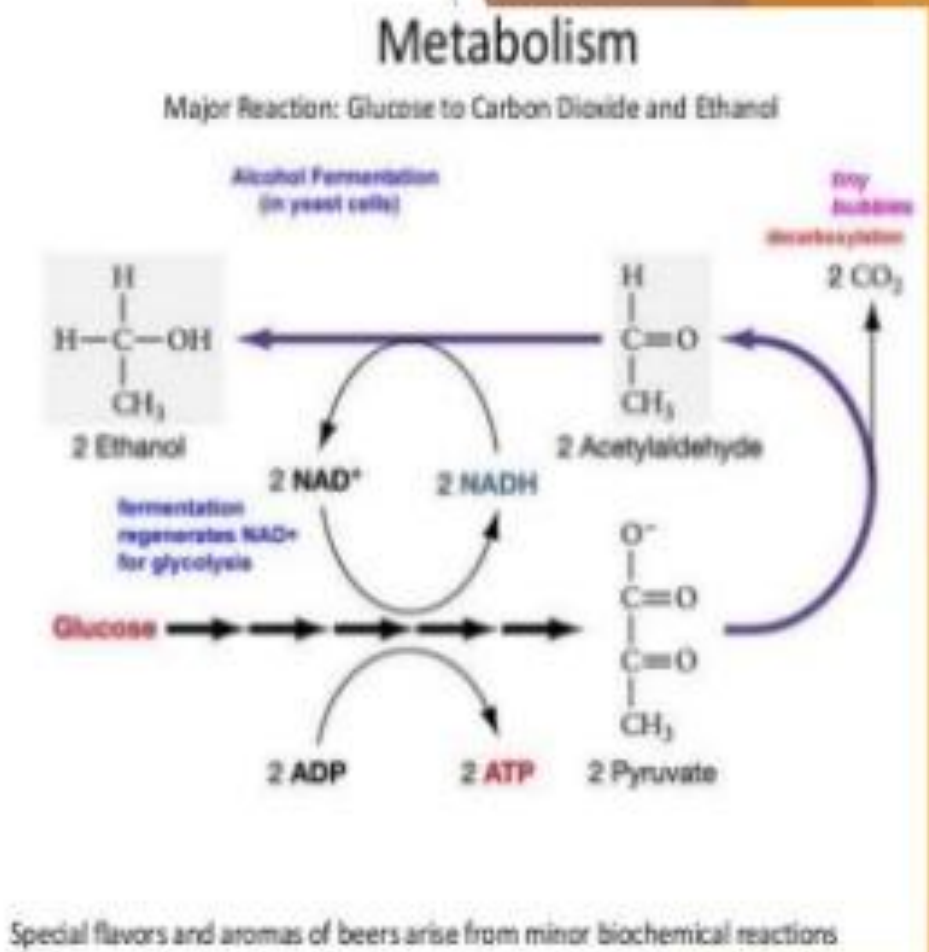
6. Hop Separation and Cooling

- Proteins and hops are then removed from the wort.
- The wort is oxygenated during cooling.
- The wort then goes to the hot wort tank.
- It is then cooled in a plate cooler where the coolant flow in opposite direction to the wort.
- The wort's temperature drops from boiling to about 10-20°C in a few seconds.

Figure 20: The plate cooler.

7. Fermentation

- The cooled oxygenated wort is placed into fermenting vessels and yeasts are added.
- Vessels used: square open or conical(mostly used).
- Fermentation last for about 7 to 10 days or more.
- The function of the fermenter is:
  - To contain a maximum amount of wort.
  - To allow evacuation or collection of carbon dioxide.
  - To have a proper cooling system.
  - To monitor pH and pressure inside vessel.



Fermentation

- Fermenting temperature depends on yeasts being used.
- Antifoam agents used when foam production is high.
- At the end of the fermentation, the yeast is removed and saved for reuse in the next batch.

- Four main factors affecting the rate and quality of beer fermentation:

1. Fermentation temperature.
2. Volume of yeast used at the start of fermentation.
3. Volume of oxygen in the wort at the start and during fermentation.
4. Level of nutrients in wort.

Summary of the processes that occur during fermentation.

I. Yeasts use up O_2 producing sterol promoting its growth.

II. The pH is reduced and ethanol and CO_2 are formed.

III. When most of the wort sugars are used up, fermentation rate decreases.

IV. An increase in alcohol level causes flocculation and settling of yeasts.

V. Beer is removed and subjected to further treatment.

Types of Beer fermentation

1. Top fermentation

- Use ale or 'top-fermenting' yeast *Saccharomyces cerevisiae*
- Warmer temp: 65 - 75°F
- Yeast and foam found at the top of the medium is removed
- Second crop that is produced by the end of fermentation is harvested since the yeast is pure.
- Types of beer produced: Ale, porter, stout…

2. Bottom fermentation

- Use lager or 'bottom-fermenting' yeast *Saccharomyces uvarum*
- Cooler temp: 45 - 55°F
- Settled yeast is decanted from the unconditioned beer.
- It is manually collected from middle layer of the sediment due to its purity.
- Types of beer produced: Lager, pilsner…

8. Lagering

- Lagering- storing and conditioning stage of beer.
- Beer is kept at about 0°C in stainless steel tanks after fermentation has occurred.
- Beer is stabilised and matured to produce desired flavour.
- It is either pasteurised or filtered once or twice before bottling.
- This process takes 1-3 weeks or months depending on the type of beer being produced.

Figure 23: The lager tank.

9. Bottling and preservation

- Packaging done in: bottles, cans and barrels.
- The container is kept free of oxygen.
- The beer is then pasteurized.
- This kill the remaining yeasts.
- Beer can also be preserved using special micro-filters.
- When bottling, the beer is also subjected to carbonization process.

Figure 24: The bottling process.

Differences between ale and lager beers

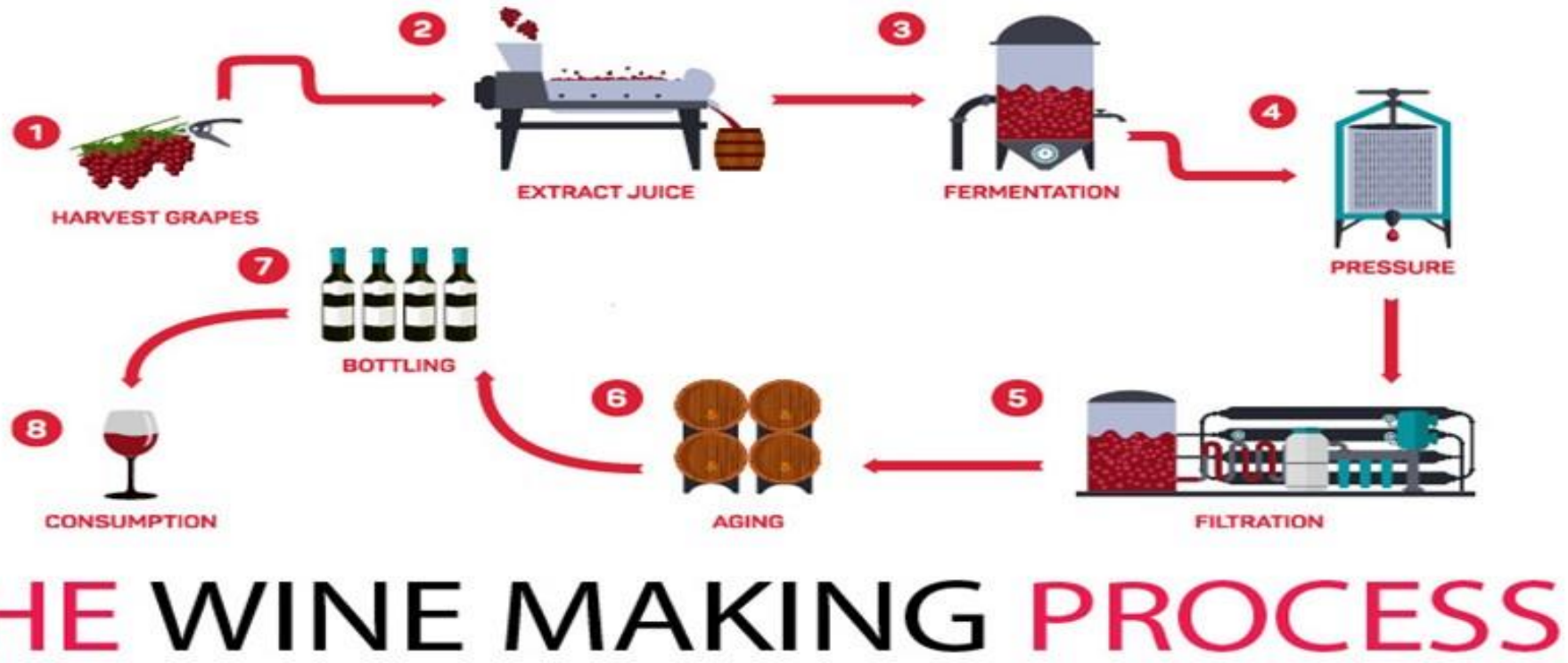
Ale beer	Lager beer
Antique type of beer	Relatively new concept
Top fermentation	Bottom fermentation
Saccharomyces cerevisiae is used	*Saccharomyces uvarum* is used
Brewing occurs at 65-75°F	Brewing occurs at 45-55°F
Quick brew cycle (7 days)	Longer brew cycle (several months)
Served cool at 10-14°C	Served cold at 4-7°C
Has a relatively shorter storage period	Has a longer storage period
Darker brown colour	Bright gold to yellow in colour
Strong taste	Subtle taste
Higher alcohol content	Lower alcohol content
Lower carbonation	Has high carbonation
Styles: pale ale, porter, amber ale, stout, brown ale, strong ale, wheat beers, speciality ale	Styles: pale lager, dark lager, bock beer, amber lager, speciality lager, malt liquor, steam beer

Factors Affecting Beer Quality

- Activity of yeast cell during fermentation influence character of beer.
- Factors affecting quality of beer produced:
  - Non-fermentable components - have an impact on the medium.
  - Fermentable sugar - converted also to some.
  - Inner yeast cell released components - released from the yeast cell when it is inactive.
  - Surface active components - adsorbed into the yeast cell wall.
  - Contamination – has huge impact on fermentation.

Wine

- There are five basic **stages** or **steps** to **making wine**: harvesting, crushing and pressing, fermentation, clarification, and then aging and bottling. Undoubtedly, one can find endless deviations and variations along the way.



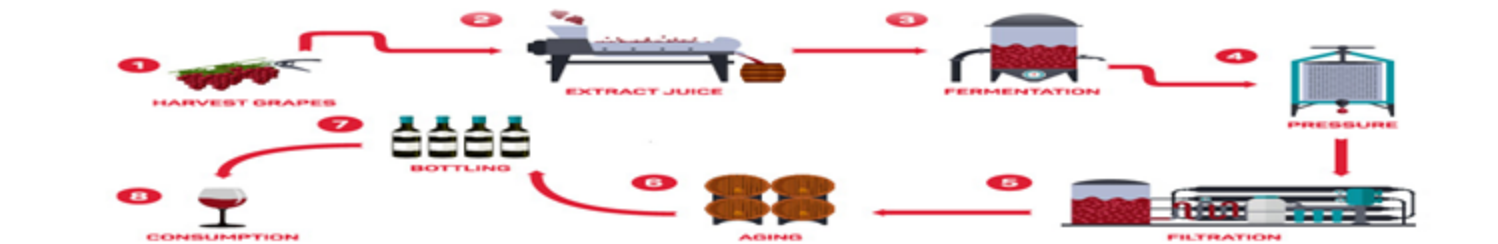
FERMENTATION PROCESS OF WINE PRODUCTION

HARVESTING

first step in wine making process. Grapes are the only fruit that contain the necessary acids, tannins, esters which are required to make a natural wine

SQUASHING

After the grapes are sorted they are then de-stemmed and squashed. Mechanical stomping is done as it has improved the sanitation of the wine as it avoids contamination and thus has increased the quality of the wine



THE WINE MAKING PROCESS

Source: oceania.ohaus.com

FERMENTATION

Fermentation begins naturally within 6-12 hours when aided with yeast in the air. 4 The fermentation continues until all the sugar is completely converted into alcohol and dry wine is produced.

CLARIFICATION

Wine is transferred into a different stainless steel tank. Wine is then clarified by filtration. Filtration occurs by using a filter to capture the larger particles in the wine. The clarified wine is then transferred into another vessel & prepared for bottling or for future aging.

BOTTLING

Bottling is the final stage of wine making process.

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HOW RED WINE IS MADE

WINE FOLLY

This is just the tip of the iceberg, keep exploring!
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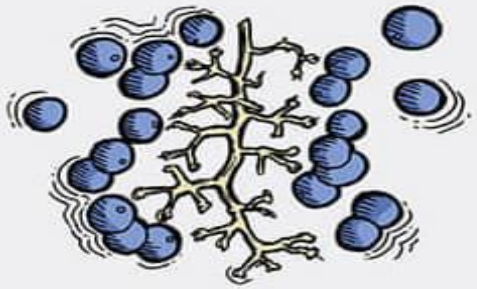
Harvest grapes

The vintner chooses when to harvest and if it's done by hand or machine. Generally speaking, red wine grapes ripen later in the season than white wine grapes.

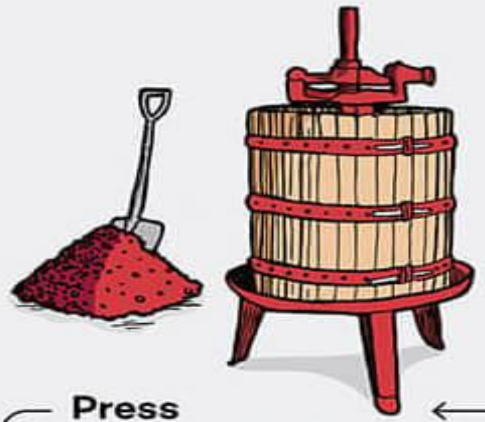


Prepare grapes

Grape bunches get destemmed. Some vintners ferment whole clusters to add tannin. The must is analyzed while grapes cold soak. Most winemakers add sulfur dioxide during this step to stop microbial growth.

Clarification

Clarifying or "fining" agents (such as egg whites or vegan bentonite clay) remove proteins. Then, wine passes through a filter for sanitation. Some wines are left unfined and unfiltered.



Press

After the fermentation, vintners drain the freely-running wine from the tank and press the skins and seeds for any remaining "press" wine.

Fermentation

Grape skins give red wine its color and flavor. So, during the fermentation, vintners punch down grapes or pump-over the must so the skins stay submerged.

Add yeast

Yeasts (wild or commercial) eat grape sugars and make alcohol, CO_2, and heat. Red wines ferment for an average of 5–21 days at 68–86 °F (20–30 °C) and often get left to macerate on the grape skins for 7–28 days after the fermentation completes.

Bottling

Bottling occurs with minimal exposure to oxygen. Sometimes sulfur dioxide is added during this stage to help preserve the wine.

Malolactic

As wine settles in tanks or barrels, a second "fermentation" happens. Malolactic fermentation (MLF) is when bacteria converts sharp malic acid into smoother, more chocolatey-tasting lactic acid.

Aging

Red wine ages in barrels or tanks for several months to several years. Oak barrels enhance red wines with aromatic compounds (such as vanillin) and subtle oxidation.

Blending

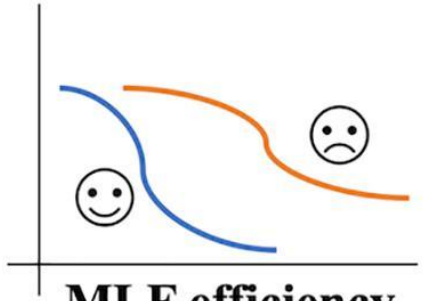
The winemaker blends grape varieties or barrels together to create the final wine. Winemakers often rely on texture as the aromas haven't finished evolving.

Bottle aging

Some wines continue to age in bottles for years until release.

Red & White Wine Production

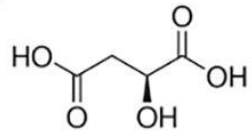
One of the first things they realized was that red wine production required that the grapes be fermented in contact with their skins. This gives the wine color and body. In contrast, most white wine production does not occur in contact with the grape skins. Whites are valued for their fresh fruit characteristics, and skin contact would impart unwanted bitter tannins.



MLF efficiency

Wine colour
Acetaldehyde metabolism
Glycosidase activity

Main role of LAB

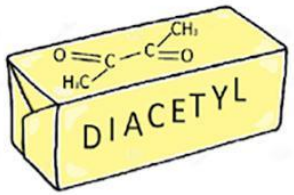


Malic acid → **Lactic acid** + CO_2

Oenococcus

Lactiplantibacillus

*Pediococcus**

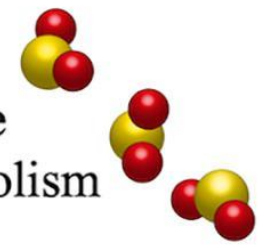


Enzymatic activities
Contribute to wine aroma & flavour (buttery, floral and fruity aromas)

Wine stabilisation
Proteolytic activity

Wine filterability
Pectinolytic activity

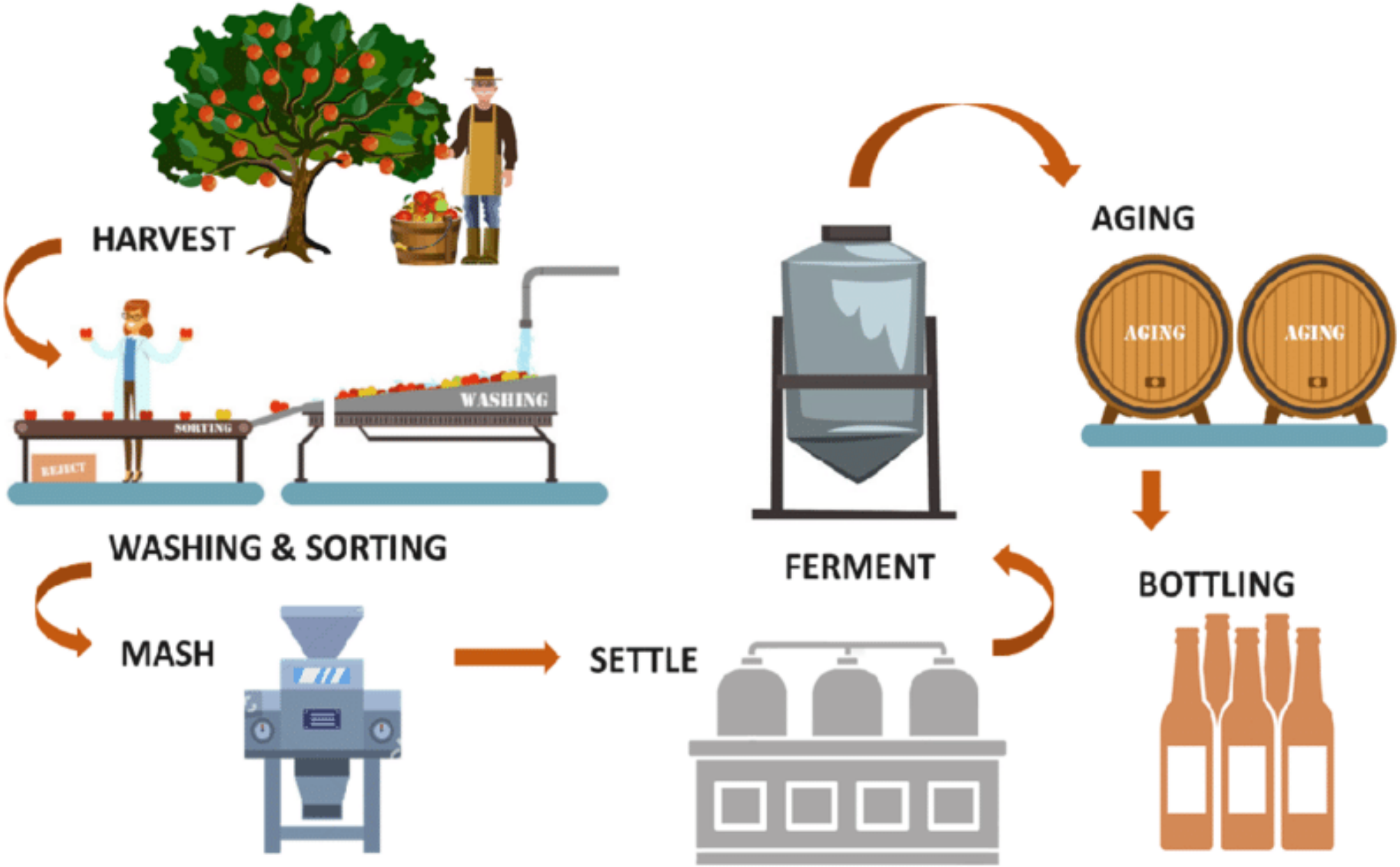
Minimize-eliminate
Biogenic amines
Ethyl carbamate
Volatile phenols

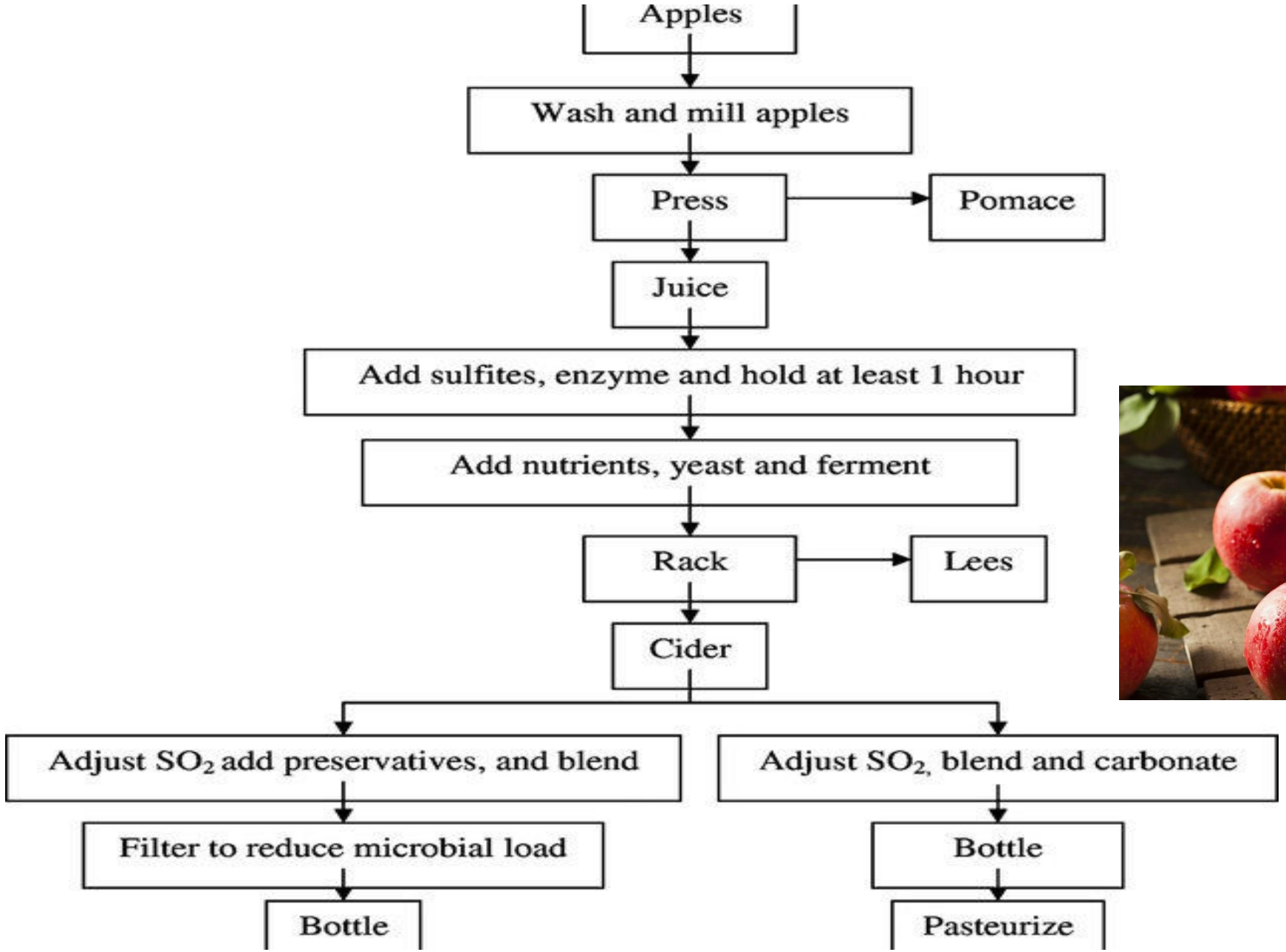


Reduce SO_2 use
Acetaldehyde metabolism

Cider

- Cider is an alcoholic beverage made from the fermented juice of apples. Cider is widely available in the United Kingdom and the Republic of Ireland.
- The UK has the world's highest per capita consumption, as well as its largest cider-producing companies. Ciders from the South West of England are generally stronger.
- Fermentation of apple cider is the process by which yeast converts the apple sugars into ethyl alcohol and carbon dioxide. ... First, yeast converts the sugar to alcohol and then lactic acid bacteria convert the natural malic acid into carbon dioxide. This hard cider contains 2-3% solids and 2-8% alcohol.


HARVEST
WASHING & SORTING
SORTING
REJECT
WASHING
MASH
SETTLE
FERMENT
AGING
AGING
AGING
BOTTLING


Apples
Wash and mill apples
Press
Pomace
Juice
Add sulfites, enzyme and hold at least 1 hour
Add nutrients, yeast and ferment
Rack
Lees
Cider
Adjust SO_2 add preservatives, and blend
Filter to reduce microbial load
Bottle
Adjust SO_2, blend and carbonate
Bottle
Pasteurize

INDIGENOUS MICROORGANISMS

- Various indigenous yeast species in apple are responsible for the initial fermentation for enhanced flavour. Ripe apples have less than 500 yeast-like organisms per gram of sound fruit.
- Main organisms are *Aureobasidium pullulans, Rhodotorula spp., Torulopsis, Candida, Metschnikowia,* and *Kloeckera apiculata*
- The malo-lactic fermentation is carried out by non-slime forming strains of *Leuconostoc mesenteroides*, *Lactobacillus collinoides* and very rarely *Pediococcus cerevisiae*.
- Nitrogenous compounds released at the end of the yeast fermentation are: Pantothenic acid, riboflavin along with some phosphorus compounds (necessary for the malo-lactic fermentation) (**Beech *et al.*, 1972**).

Vinegar

- **Vinegar** is essentially a dilute solution of acetic (ethanoic) acid in water. Acetic acid is produced by the oxidation of ethanol by acetic acid bacteria, and, in most countries, commercial production **involves** a double **fermentation** where the ethanol is produced by the **fermentation** of sugars by yeast.
- The term "**vinegar**" actually refers to the two-step **process** of **fermentation** from a carbohydrate to an alcohol to an acetic acid. Sugar is converted into alcohol, which is then **fermented** into **vinegar**.
- White vinegar consists of **4–7% acetic acid and 93–96% water**. It is a great ingredient to use for cooking, baking, and cleaning. It may aid weight loss and lower blood sugar and cholesterol. White vinegar adds an extra zing of flavor to marinades and sauces.

The biochemical processes for vinegar production

$$CH_3CH_2OH + (O) \longrightarrow CH_3CHO + H_2O$$

Ethyl alcohol oxygen — Acetaldedyde Water

$$CH_3CHO + H_2O \longrightarrow CH_3CH + (OH)_2$$

Hydrated acetaldehyde

$$CH_3CH(OH)_2 + (O) \xrightarrow{\text{(Aldehyde)}} CH_3COOH + H_2O$$

Dehydrogenase — Acetic acid

Principles of vinegar production

- 2 processes
  1. Ethanolic fermentation
     - Sugar (glucose, fructose…) $\xrightarrow[\text{(anaerobic)}]{\text{yeast}}$ ethanol
  2. Acetogenic fermentation
     - Ethanol $\xrightarrow[\text{(aerobic)}]{\text{acetic acid bacteria}}$ acetic acid (vinegar)

Vinegar is the product of a two-stage fermentation. In the first stage, yeast convert sugars into ethanol anaerobically, while in the second ethanol is oxidized to acetic (ethanoic) acid aerobically by bacteria of the genera *Acetobacter* and *Gluconobacter.*


Holland House.
MAKE IT BOLD!
MALT VINEGAR
A distinct flavored, rich, golden brown malt vinegar
12 FL OZ (355 mL)
NAPA VALLEY NATURALS
OAK AGED
Organic
RED WINE VINEGAR
12.7 FL. OZ (375ML)
SODIUM FREE • SUGAR FREE
Marukan
SINCE 1649
GENUINE BREWED
Rice Vinegar
マルカン米酢
12 FL OZ (355 mL)
HEINZ
EST'D 1869
All Natural
DISTILLED WHITE
VINEGAR
5% ACIDITY
32 FL OZ (946mL)
PATRICIA BRAGG
N.D., Ph.D.
Pioneer Health Crusader
Health Educator, Author
PAUL C. BRAGG
N.D., Ph.D.
Originator Health Stores
Life Extension Specialist
BRAGG
Originator Health Stores
Established 1912
ORGANIC
RAW ~ UNFILTERED
APPLE CIDER VINEGAR
With The 'Mother'
UNPASTEURIZED
Naturally Gluten Free
16 FL OZ ~ 473 mL
Health Crusaders Since 1912
COLAVITA
Aged
WHITE WINE
VINEGAR
PRODUCT OF ITALY
17 Fl. Oz. (500 ml)

Apple cider vinegar, or cider vinegar, is a vinegar made from fermented apple juice, and used in salad dressings, marinades, vinaigrettes, food preservatives, and chutneys.

It is made by crushing apples, then squeezing out the juice. Bacteria and yeast are added to the liquid to start the alcoholic fermentation process, which converts the sugars to alcohol. In a second fermentation step, the alcohol is converted into vinegar by acetic acid-forming bacteria (Acetobacter species).

Apple Cider Vinegar Health Benefits

- Prevents flu and stomach illness
- Lowers glucose levels in diabetics
- Regulates pH balance in the body
- Helps relieve allergies
- Helps relieve nausea
- Breaks down fat
- Reduces inflammation
- Relieves migraines
- Kills cancer cells
- Dissolves kidney stones

Natural News

Distilled Beverages

- Distillation is the process of converting a liquid into gas or vapor by heating it and then condensing it back into liquid form.
- Distilled spirits are all alcoholic beverages in which the concentration of ethyl alcohol has been increased above that of the original fermented mixture by a method called distillation.
- Brandy, Gin, Rum, Tequila, Vodka, and Whiskey.
- Brandy is a spirit distilled from fermented wine and is aged for varying periods in oak barrels. Whisky is a spirit distilled from fermented malted cereals such as barley, wheat, rye and corn and, like Brandy, is aged for varying periods in oak barrels.
- Rum is a liquor made by fermenting then distilling sugarcane molasses or sugarcane juice. The distillate, a clear liquid, is usually aged in oak barrels.
- vodka is a spirit with a neutral taste, colour and smell. ... Gin can technically be described as a flavoured vodka. It too begins its life as a grain and is distilled into a neutral spirit; however, it's then redistilled with juniper berries, which are the key ingredient in classifying a spirit as gin.