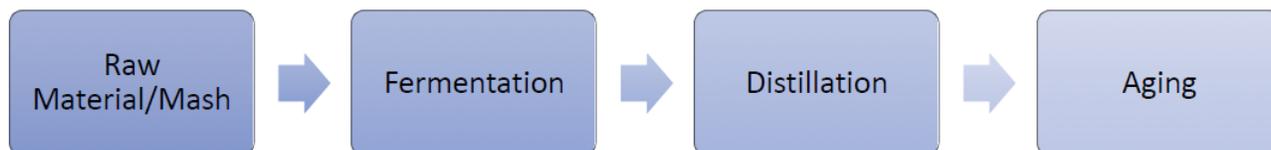


## 1.16: Distilled Spirits

### Distilled Alcoholic Beverages

Distilled spirits are all alcoholic beverages in which the concentration of ethanol has been increased above that of the original fermented mixture by a method called distillation. More Information about Distilling: [Artisanal Distilling](#), A Guide for Small Distilleries, Kris Berglund

Distilled Spirits Production Steps:



### Raw Materials

Any sugar containing fruit or syrup can be used for fermentation and then distilled to prepare spirits. Similarly, grains and potatoes are fermentable and can be used for whiskey or vodka production. Like wine and cider production, the fruits are harvested and mashed to release enzymes and simple mono- and di-saccharides.

#### ? Exercise 1.16.1

Review: Describe the steps and any necessary additives (like pectinases and sulfite)

For grain spirits, the process involves malting of the grain, milling, boiling a mash to release the complex carbohydrates.

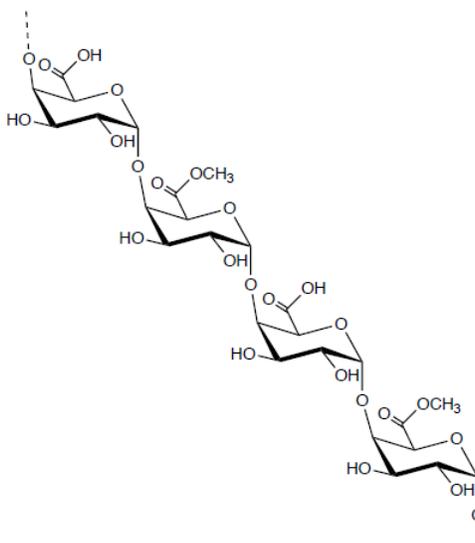
#### ? Exercise 1.16.2

Review: Describe the steps and any necessary additives (like amylases)

### Preparation of the Mash

#### Fruit Spirits: Minimize Methanol Production

As you remember from the 'Cider' unit, many fruits contain a large amount of pectin. Pectin is a polymer of the sugar galacturonic acid.



### ? Exercise 1.16.3

- Draw the monomer unit.
- What type of linkages are used in this polysaccharide? Circle the correct designations.
  - $\alpha$  or  $\beta$
  - 1-2 1-3 1-4 1-5 1-6 2-4

This pectin can form a gel that is undesirable in ciders or fruit beverages, so it is necessary to allow native pectolytic enzymes to hydrolyze this polysaccharide. In addition, some producers add extra pectolytic enzymes. Pectin methylesterase is an enzyme found in cherries, pears, and apples that hydrolyzes the esters that are on the side chains of pectin.

### ? Exercise 1.16.3

Show the product of this reaction.

In cider or wines, the small amounts of methanol formed in this process are not a concern. However, when the wine is distilled the methanol is also concentrated and can have toxic impacts on consumers. One way to limit the formation of methanol is by heating of the mash to a temperature of 80- 85 °C.

### ? Exercise 1.16.4

What will this do to the enzyme?

## Fermentation

Fermentation is the same process as seen in the previous discussions of Bread, Beer, Cider, and Wine.

### ? Exercise 1.16.5

- In grains, the amylose is converted to the disaccharide \_\_\_\_\_ with the \_\_\_\_\_ enzyme presented in the grain.
- Mannose is converted to glucose with the yeast enzyme \_\_\_\_\_.
- Sucrose (and other di- and tri-saccharides) can be converted to glucose and fructose with the yeast enzyme \_\_\_\_\_.
- The primary fermenting organism is \_\_\_\_\_.
- This alcoholic fermentation is [ **aerobic or anaerobic** ].
- Define the Crabtree effect.
- During fermentation, glucose and/or fructose are converted to \_\_\_\_\_ and \_\_\_\_\_.
- Sulfur dioxide is often added to these fermentation mashes to prevent \_\_\_\_\_.
- The higher the sugar content of the mash or must or pomace, then the final alcohol content will be [ **higher / lower** ].
- Due to the toxicity of ethanol, the maximum alcohol content for a fermentation is:  
5% 10% 15% 20% 25% 30% 35% 45% 50% 60% 75%
- Fusel alcohols are yeast fermentation side-products derived from:
- Esters are yeast fermentation side-products formed from

## Distillation

### Theory

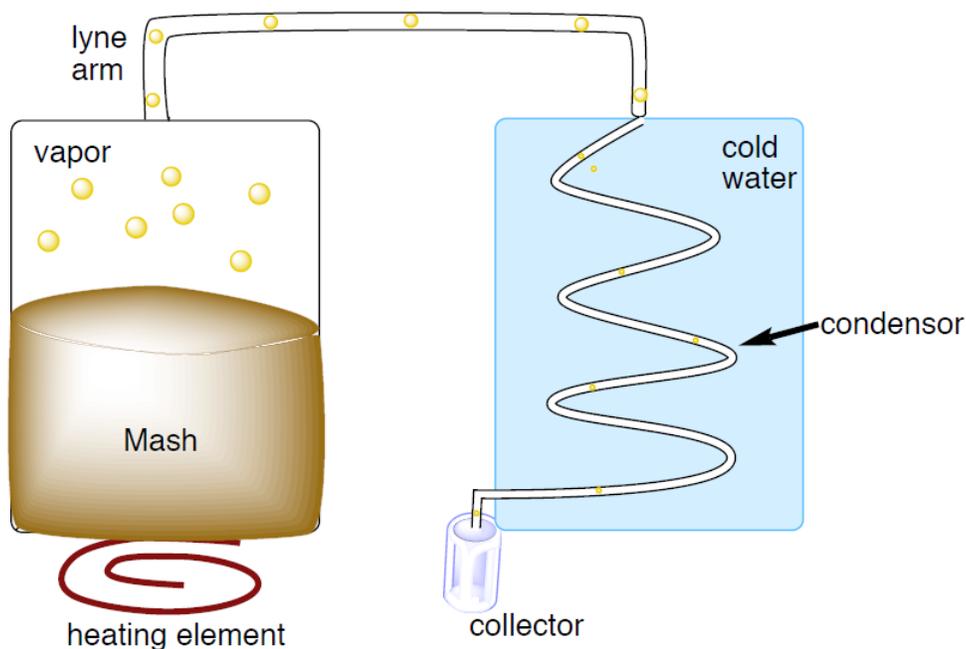
Distillation in the concentration of ethanol content in an alcoholic beverage through boiling. Ethanol boils at a lower temperature ( 78.4 °C or 173.12 °F) than water ( 100 °C or 212 °F). When the fermentation mixture is heated, the ethanol is evaporated in a higher concentration in the steam. This is condensed and collected resulting in a product that is approximately 25- 35% alcohol.

? Exercise 1.16.6

If a distillery desires a higher concentration of alcohol, then what will they need to do?

Still: The pot still

The still vessel is filled with mash, wine, or beer up to 50-75 % full and then closed. More viscous mashes are diluted with 20 % water. Pomaces which yield a low alcohol content are mixed preferentially with 20 % coarse spirit.



? Exercise 1.16.7

1. As the mash is boiled, the ethanol and water are \_\_\_\_\_.
2. As the vapors move through the condenser tube which is cooled by water, the ethanol and water will \_\_\_\_\_.

Most distilleries use copper stills as they produce cleaner and aromatic because copper reacts with the sulfur side-products found in mashes to form non-volatile compounds.

? Exercise 1.16.8

What is the problem with sulfur side-products in mash (and then the final product)?

Boiling points of different alcohols present in mashes:

Alcohol	Boiling Point (°C)
Ethanol	78
Methanol	65
Small Aldehydes, Esters	30-60
Fusel Alcohols, (amyl alcohol, isoamyl, etc)	115-140

Most distillers will collect three fractions from the distillation process: fore-run (head), middlerun (heart), and after-run (tail).

### ? Exercise 1.16.9

What is the primary component(s) in each fraction?

- Fore-run:
- Middle-run:
- After-run:

Which fraction will be sold as a distilled spirit?

With direct heating of the fermentation product in the pot stills, the highly viscous mashes/fruit pulps can lead to burning.

### ? Exercise 1.16.10

The decomposition products of sugar leads to \_\_\_\_\_. The products formed in this process can lend a bitter or burnt flavor to the final distilled spirits.

#### Direct heat or not?

Wood fires directly below the pot are problematic due to leads to concerns about burning the mash and possible explosions.

### ? Exercise 1.16.11

Why is distillation prone to fires? Hint: consider flammability of the product.

Some whisky distillers choose to use the wood fired heating because they like the flavors. To keep the mash from burning, they use a 'rummager' to continuously stir the mash. The fire also requires careful tending, making sure it's not burning too hot or too cold. To prevent burning the mash, other distillers have moved to steam, hot water baths around the pot, or electrical heating.

#### Still: The column still

With column distillation, the mash enters near the top of the still and begins flowing downward. This brings it closer to the heating source, and once it's heated enough to evaporate, the vapor rises up through a series of partitions known as plates or stripping plates. At each plate along the way, the vapor ends up leaving behind some of the higher boiling compounds. It is important to note that pot stills operate on a batch by batch basis, while column stills may be operated continuously allowing higher throughput.

### ? Exercise 1.16.12

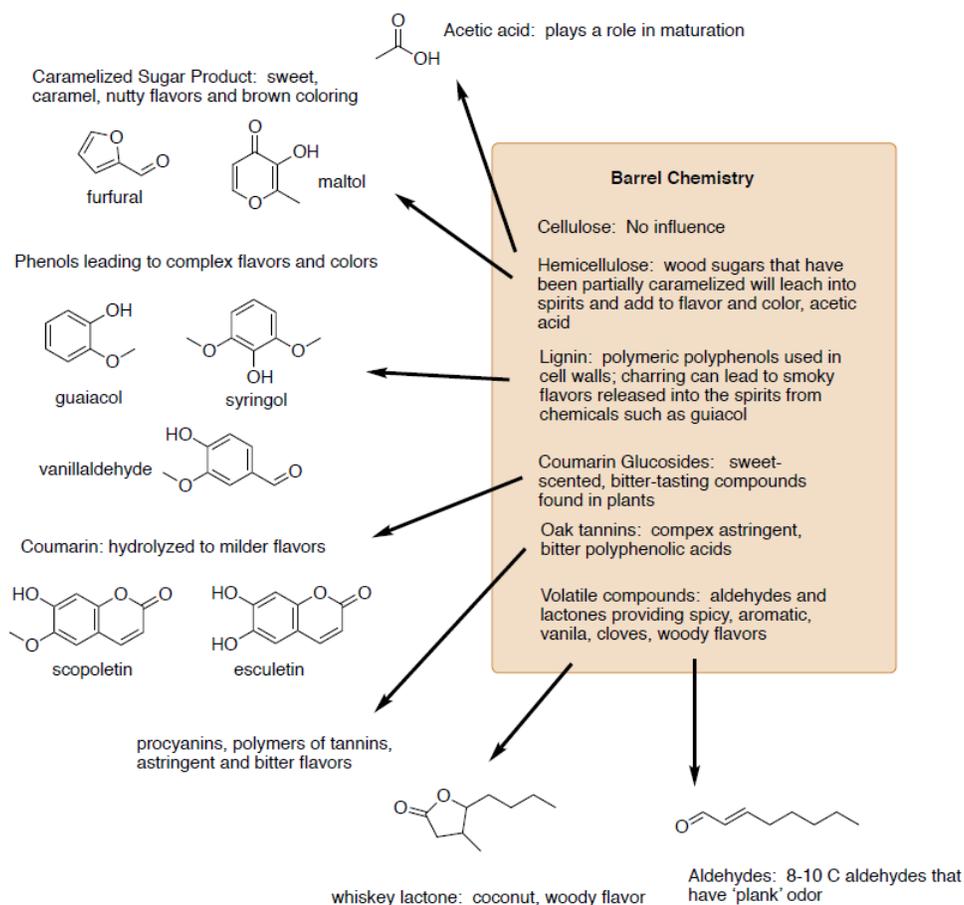
- Draw a picture of column still.

Is scorching a problem with this method?

## Aging

### Chemistry of Aging in Barrels

The aging process is similar to wines. The aging process allows tannins, terpenes, lignins, polyphenols, and minerals from the wood of the barrel to dissolve into the spirits. Many of the barrels have been charred so there are oxidized lignin and wood sugars also available. As these compounds are dissolved into the spirits, new condensation and oxidation reactions can occur during this process.



Some barrels have been previously used for wines so they will also release flavors from the polyphenols of wines that were absorbed into the wood.

### Process

Each of the distilled spirits have a slightly different aging process.

- Apple spirits, cherry spirits, and brandies a short storage in oak barrels (or steel tanks) proved to be best.
- Kirsch (cherry) and plum distillates are aged in closed glass carboys or tanks in a warm environment for aging.
- Single malt scotch and Irish whiskeys must all be aged for a minimum of 3 years.
- Bourbon can only be aged in a new barrel while whiskeys are usually aged in barrels that previously contained sherry or other wines.
- Not all distilled spirits are aged. Tequila, rum, vodkas, moonshine, and gins are can be unaged.

You will notice that the more northern the climate in which the distilled spirit is produced, the longer it is aged.

#### ? Exercise 1.16.13

- Suggest a reason for the differences in aging times in different climates.

### Choosing to Age or Not

#### ? Exercise 1.16.14

- A pot distilled spirit will have [ **more / less** ] flavor and aroma compounds.
- A [ **column or pot** ] distilled spirit will benefit from aging.

## Processing

### Blending with Water

Most distillates have greater than 40-45 % alcohol content. In order to be drinkable, they have to be watered down.

### Cool Storage

The distilled spirits still contain a variety of flavor and aroma compounds from the original mash, the fermentation process, the Maillard reaction in the still, or from the wood barrels in the aging process. Some of these compounds can cause a cloudy or hazy appearance to the distilled spirits.

Distillers will often cool the spirits to between 0 and -10 °C.

#### ? Exercise 1.16.15

- A compound with low solubility will \_\_\_\_\_ at these temperatures.

### Filtration

After cold storage, the distilled spirits are filtered to remove any precipitates.

### Bottling

The bottling of the distilled spirits is straightforward.

#### ? Exercise 1.16.16

- Unlike beer, cider, and wine, there is usually not a problem with contamination from microorganisms. Why?

## Flavors and Aromas

There are many flavors in distilled spirits. It is highly dependent upon the original raw materials, yeast fermentation process, presence of any microbial contaminants, aging, etc.

However, distillation can intensify flavors that are found in the middle-run, but many other flavors do not get transferred from the pot to the distillate.

It is important to note that the addition of flavorings, sugars or other sweetening products after distillation is forbidden for distilled beverages such as rum, whiskey, fruit distillates or wine brandy. The addition of caramel in fruit distillates is not allowed, while whiskey is allowed plain caramel coloring only.

#### ? Exercise 1.16.17

- The flavors of the original grains or fruits would be expected to be [ **strong / light** ].
- The color of most distilled spirits is \_\_\_\_\_.
- Distilled spirits are [ **sweet / not sweet** ].
- The primary components of distilled spirits are water and \_\_\_\_\_.

## Types of Distilled Spirits

The most common spirits are those derived from grains (whiskey, vodkas), grapes (cognac, brandy), molasses (rum), and agave (tequila).

### Whiskey

Whisky is a distilled beverage from cereal grains and matured in barrels. There are different regional variations on this drink. The malt from corn, barley, rye, or wheat is mashed in a process similar to beer. The wort is then directly distilled.

### ? Exercise 1.16.18

- Look up the differences in the grains, malting, distillation, and aging process for these whiskies:
  - Scotch Whisky:
  - Irish Whiskey:
  - American Bourbon:
  - Rye Whiskey (Canadian Whiskey):

### Brandy

Brandy is a distilled wine beverage.

### ? Exercise 1.16.19

- Describe the process for the production of brandy. Comment on the variations such as Armagnac, Cognac, and Pisco.

### Rum

Rum is a distilled beverage from sugar cane.

### ? Exercise 1.16.20

- Describe the process for the production of rum.

### Tequila

Tequila is a distilled beverage from agave.

### ? Exercise 1.16.21

- Describe the process for the production of tequila.

### Eau de vie

An eau de vie is a clear fruit brandy that is produced by means of fermentation and double distillation. For example, Framboise is a double distilled raspberry brandy. Unlike liqueurs, *eau de vie* are not sweetened. Although *eau de vie* is a French term, similar beverages are produced in other countries (e.g. German Schnapps, German Kirschwasser, Turkish rakı, Hungarian pálinka, and Sri Lankan coconut arrack).

### ? Exercise 1.16.22

- The fruit flavor in eau de vie is typically [ **strong / light** ].

### Liqueurs

Liqueurs are drinks made by adding fruit, herbs or nuts to neutral distilled spirits. Usually a distilled beverage like vodka is used as it is mostly alcohol and little flavoring. They are often also heavily sweetened. They are often served with dessert. You might drink it straight, with coffee, used in cocktails, or in cooking.

Typical Liqueurs

Liqueur	Flavor
Absinthe	Brandy with anise, fennel, wormwood
Amaretto	Apricot and almond flavors
Bailey's	Irish Whiskey and chocolate
Benedictine	Brandy with 27 herbs and spices
Cherry Brandy	Brandy with cherries

Liqueur	Flavor
Cointreau	Distillates from bitter and sweet orange peels
Drambuie	Scotch Whisky with herbs and honey
Grand Marnier	Cognac blended with bitter orange and sugar
Kahlua	Rum with coffee, sugar, vanilla
Malibu	Rum with coconut
Sambuca	Anis, sugar

### ? Exercise 1.16.23

- The flavors in liqueurs are typically [ **strong / light** ] compared to a brandy or eau de vie.
- The flavors are added [ **before / after** ] distillation.
- Unlike spirits, liqueurs have added \_\_\_\_\_.

### Sources

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