

CHARACTERISTIC FLAVORS FROM YEAST

(And Their Relationship to World Beer Styles)

Jim Graham

INTRODUCTION

Yeast is, by far, the single most important contributor to the flavor of most beers. (The only real exception to that rule is, perhaps, the various Belgian beer styles, which rely as much on bacterial fermentation.) You can spend as much time and money as you want to on a batch of beer, and still not end up with the beer you were trying to brew if you use the wrong yeast. Likewise, if you mis-handle your yeast, you can miss your target even with the right yeast. This is an introduction to the various characteristic flavors produced by yeast and their impact on the flavor of beer.

Rule Number One: Brewers don't make beer. Yeast makes beer.

DIACETYL AND ESTERS

During the respiration phase, where yeast reproduce until they reach an optimal population for fermenting wort,[†] two key flavor contributors are produced: diacetyl and esters.

Esters

Esters are compounds produced by yeast which are generally characterized as having various fruity flavors or aromas, including strawberry, apple, banana, grapefruit, pear, and raspberry.[1] These flavors are often well pronounced in British and American pale ales and IPAs, and in Belgian Lambics. They are also present, to some degree, in English bitters, old ales, brown ales, porters, German wheat beers, and some Belgian beers. Esters are also found in very low quantities in most, but not all, other beers. Notable exceptions include most lagers.[2][3] For more information, refer to the BJCP Style Guidelines.

[†] Roughly 50 million cells per milliliter of wort[1]

The formation of esters varies with both the type of yeast and the fermentation temperature. Some strains of yeast, particularly ale yeast (*Saccharomyces cerevisiae*), such as Brewtek's CL-150 ("British Real Ale") and CL-170 ("Classic British Ale"), produce a very pronounced array of esters. Other strains, primarily lager yeast (*Saccharomyces uvarum*), such as CL-660 ("Northern German Lager") and CL-600 ("Original Pilsener"), produce little to no esters.[4]

Diacetyl

Diacetyl is a compound responsible for a buttery or butterscotch flavor in beer. Diacetyl can be produced by bacterial fermentation, but is always produced by yeast. It is also removed by yeast later in the fermentation process. How much diacetyl is produced, and how much is later removed, is highly dependent on the type of yeast used and how it is handled.[5]

Highly flocculant yeast strains, such as those used by the Samuel Smith Brewery in County York, England, must be roused on a regular basis, and thus are unable to reduce the diacetyl levels. This, however, has become a standard characteristic of such beers.[1][3]

Diacetyl production and reduction are also dependent on temperature. At higher temperatures, more diacetyl is produced by the yeast than at lower temperatures. Likewise, the reduction of diacetyl is greater at higher temperatures. This is, in fact, the reason for the diacetyl rest when fermenting lager beers. Near the end of fermentation, the temperature is raised to 58–68° F for a few days to allow the yeast to reduce diacetyl levels.[5]

For a detailed analysis of diacetyl and its impact on beer, see [5].

OFF-FLAVORS

Yeast produces many flavor characteristics which, depending on the style of beer, are considered desirable. Yeast can also produce flavors which are rarely, if ever considered desirable. These are generally the result of improper yeast handling, such as under-pitching or over-pitching, lack of proper control of fermentation temperature, and so on.

Fusel Alcohols

Alcohol is another flavor component of beer produced by yeast. Ethanol is the primary alcohol produced, but there are other higher forms of alcohol, called fusel alcohols, that are produced. Higher alcohols tend to add a rather harsh, solvent-like character to the beer. They also produce a warming sensation. These are normally present only in very small amounts, and are below the flavor threshold. Excessive yeast growth, however, will **always** result in excessive quantities of higher alcohols.[6][7] Causes of excessive yeast growth include under-pitching, fermenting at high temperatures, and introducing oxygen after pitching the yeast.

Dimethyl Sulfide (DMS)

Dimethyl sulfide is a compound that produces a vegetal flavor in beer, often described as a cooked corn or cabbage-like flavor. The majority of DMS found in beer is from malted barley, with lager malts being particularly high in DMS precursors (up to 40 times higher than some ale malts). Excessive DMS is normally the result of inadequate boiling of the wort, or boiling with the brew kettle completely covered, thus preventing the DMS from being boiled off. DMS can also be produced by bacterial activity in the wort if the yeast fails to take off quickly enough. This is one of many reasons relating to bacterial activity to pitch the proper amount of good, healthy yeast.[6][8]

Another source of DMS is the reduction of DMSO by yeast, particularly at lager fermentation temperatures. The amount of DMS produced by yeast varies with the yeast strain, fermentation temperature, amount of oxygen in the wort, and the amount of yeast pitched.[8]

Yeast Autolysis

Yeast autolysis is a process which occurs when the yeast is stressed. Potential sources of yeast autolysis include over-pitching, very high temperatures, sudden environmental changes (e.g., “shocking” the yeast), and long-term storage, such as leaving the yeast in the beer too long after fermentation is complete. The yeast’s digestive enzymes are released, destroying the yeast cell. The yeast is then consumed by other yeast.

Flavors resulting from yeast autolysis include astringency and “yeast bite.” [6][7][8]

Other Problems Resulting from Improper Pitching Rates

Pitching too little or too much yeast can damage or destroy the flavor of beer. Problems can range from simple off-flavors to bacterial infection. [6][7][10]

Under-pitching will cause excessive yeast growth, resulting in increased levels of diacetyl, esters, and higher alcohols. Under-pitching also provides a longer lag time, providing an opportunity for bacterial fermentation.† Normally, yeast will use all of the oxygen in wort, preventing aerobic bacteria from surviving long enough to infect beer. Yeast also lowers the pH in the wort during fermentation, making it difficult for anaerobic bacteria to survive. Inadequate pitching rates, however, can prevent or reduce this effect, leading to bacterial infection. [10]

Over-pitching, on the other hand, will result in an increase in the “green beer” flavor from acetaldehyde, and may result in excessive yeast autolysis. [7] Over-pitching can also result in a degradation of the yeast’s health over time due to low yeast growth. Instead of a new population of yeast being produced, the same yeast is pitched repeatedly.

WILD YEAST

The two yeasts used in brewing most beer styles are the various strains of ale yeast (*Saccharomyces cerevisiae*) and lager yeast (*Saccharomyces uvarum*). There are, however, quite a few other types of wild yeasts which produce less desirable characteristics. These include *Brettanomyces*, *Candida*, *Hansenula*, *Kloeckera*, *Pichia*, *Rhodotorula*, species in the *Saccharomyces* genus other than *cerevisiae* and *uvarum*, and *Torulopsis*. Characteristics of these yeast strains include haze, excessive attenuation, phenolic flavors, acetic acid formation, and flavors described as “horse sweat” (*Brettanomyces*). [11]

† The most troublesome bacteria being acetic acid bacteria, *Acetomonas*, *Lactobacillus delbruckii*, *Lactobacillus pastorianus*, *Obesumbacterium proteus*, *Pediococcus*, and *Zymomonas* spp. Of these, *Lactobacillus* and *Pediococcus* are the most common. [9]

BACTERIAL AND WILD YEAST FERMENTATION AND BELGIAN BEERS

Mention bacterial fermentation or wild yeast, and you will normally get a most unpleasant reaction from a brewer. There are, however, exceptions to this rule, most notably, Belgian Lambics.[12]

The characteristic flavor of a Belgian Lambic is primarily due to fermentation from *Brettanomyces lambicus* and *Pediococcus damnosus*. *Brettanomyces lambicus* is a wild yeast which produces a “horsy” or “old leather” character. *Pediococcus damnosus* is a bacteria which produces, among other things, acidity and large amounts of diacetyl.[4]

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