ADVANCED BOTTLE CONDITIONING

Official NORTHERN BREWER Instructional Document

These instructions are to be used to finely tune your 'bottle conditioned' beers. Different beer styles from various countries all have differing techniques for carbonating beers to their collective 'tastes.' This document will discuss the concept of bottle conditioning and outline the differing methods and ways to achieve them. The use of the term 'bottle' refers to any container, not just bottles.

OVERVIEW

The concept is very simple. Put beer into bottles. Yeast in beer consume the sugar. The carbon dioxide produced carbonates your beer. Simple right? No, not really. Historically, beers all have their own requirements for grains and hops. What most people miss is that these beers also have a carbonation 'requirement.' Below are some techniques and info to help you out in customizing your own beers.

VERBIAGE

In the US, carbonation is described in terms of volumes of carbon dioxide, or CO_2 for short. There is a lot of argument about the actual meaning of this term but needless to say, the more volumes of gas the more carbonated the liquid will be. For example, English cask beer can be about 1.5 volumes whereas say champagne can be up towards 7.0 volumes. Other parts of the world use grams/Liter of which there are about 2.0g/L per volume of CO_2.

THEORY

Quite simply, CO_2 is soluble in a solution in an inverse relationship to the temperature of the solution. What this means is that the colder the liquid is the more CO_2 can be held in solution. This is very important when you get to calculating your volumes of CO_2 because the colder your finished beverage is the more residual CO_2 will be in solution. This is one of the main reasons that beers are over-carbonated.

CARBONATION RATE & PRIMING CALCULATION

Before considering anything else it must be ensured that the beer to be primed and carbonated has finished fermenting. Beers that are not finished fermenting will over-carbonate (and may burst). Assuming that our beer is completely fermented and ready for bottling we need to know/decide how much carbonation your individual beer needs (usually style based). There are many general charts available but we suggest you use this one we created. http://www.northernbrewer.com/priming You can either input your own volumes wanted into the text box or use the pull-down menu to find your style (or kit). The number next to the kit indicates the volume of carbonation for the style. You will then need to input the volume and temperature of your beer for the reasons mentioned above. The results are displayed in grams, ounces and cups. One has the option to use a wide range of sugars of which I will cover below. Some are more traditional than others but pretty much any natural sugar can be used for priming.

TYPES OF SUGARS

- **CORN SUGAR** - Dextrose. Most popular bottling sugar. Cheap and leaves no added flavor.
- **WHITE SUGAR** - Sucrose. aka table sugar, aka sugar sugar. See above.
- **BELGIAN CANDY SYRUP - ALL** - Invert sugar. Colored. More flavor as you increase in color. Not traditionally used but can be used to punch up the flavor on any Belgian beer.
- **BELGIAN SOFT CANDY SUGAR** - Invert sugar. Colored. More flavor as you increase in color. Some brewers use the syrup, some the soft sugar. The blonde version adds very little color or flavor. The brown version is on par with the dark version of the syrup.
- **BLACK TREACLE** - Type of molasses. Very dark. Leaves a lot of flavor. Treacle is a general English term for 'syrup'. Different from molasses in that this product is a boiled syrup of the finshed sugar rather than a by-product of raw sugar processing. More caramel flavors than molasses.
- **BROWN SUGAR** - partially refined sugar with molasses added (3% light & 6% dark). Flavor increase as light to dark. Muscovado is a type of brown sugar that is completely unrefined and possesses a much great depth of character.
- **CORN SYRUP (DARK AND LIGHT)** - Glucose syrup - No flavor. Traditionally used for all English cask beers. All store bought corn syrup in the US is high fructose variety and not traditional of which the light variety has vanilla in it and the dark is has caramel color added. Brewers syrup is a glucose syrup that is derived from corn.
- **DEMERARA** - unrefined sugar. pale gold. Very little flavor. The lightest unrefined sugar.
- **DME - ALL VARIETIES** - dry malt extract. More flavor as you get darker. Can be used in the place of traditional bulk kräusen priming.
- **DME - LAAGLANDER** - dextrinous malt extract. More flavor as you get darker. Laaglander is different in that it leaves a lot of residual sweetness and can be used to increase the body of beers that have finished low in gravity.
- **HONEY** - flavor depends on variety. Lighter honeys like clover will add no character but dark ones like buckwheat will add a lot. One can also use varietal honey, like orange blossom, to give a slight hint of its character to the finished beers. This works best in lighter styles of beer.
- **INVERT SUGAR SYRUP - ALL** - see Belgian candy syrup. An English version of the Belgian stuff. Highly popular over many styles. They rank in number from 1 to 3 (15-65SRM). Lyles Golden syrup is 50% invert:50% sucrose and about 15SRM.
- **MAPLE SYRUP** - More flavor as you get darker. Can dilute the beer quite a bit. The darker stuff is better for this purpose and the fancy stuff is regulated by its very high price.
- **MOLASSES** - see black treacle above
- **RICE SOLIDS** - sugar derived from rice. see corn sugar.
- **SORGHUM SYRUP** - used mainly for non-gluten beers. Corn sugar is cheaper, works better and has no gluten in it.
- **TURBINADO** - crystallized sugar cane pressings. aka 'Sugar in the raw.' Light brown. Darker with more flavor than demerara but not nearing light brown sugar.

BOTTLE TYPES AND PRESSURE

Most of the bottles you will use will be the standard 12oz bottle. These are suitable for the vast majority of styles but we don't suggest you use them for beers with over 3 volumes of CO_2. Below is a chart based on CO_2 volume and suggested bottle usage. These are approximate guidelines and demand that the bottles be free of cracks or chips.

BOTTLE:VOLUME CHART

Bottle type	Max. CO_2 Volume
12oz	3
33cl Belgian	3.5
500ml European	3.5
Swing top	4
Champagne	7
PET	10

Kegs can be used in the place of bottles and should be treated exactly like a large bottle. A lot of commercial brewers prime in bulk and then counter pressure fill at bottling.

ADVANCED BOTTLE CONDITIONING

GENERAL TECHNIQUES

Every commercial brewer knows that fresh and healthy yeast are of the utmost importance when it comes to bottle conditioning their beers. In comparison, most home brewers rely on the yeast they used to ferment their beers to also carbonate them. Most of the time this will work but one can never be sure of the variation from batch to batch. This is an unknown that doesn't need to be. The simple addition of fresh yeast at bottling will ensure your beers carbonate at the levels you specify.

CLEARING YOUR BEER

Most commercial breweries rely on some sort of filtering device to clear their beer before they prime and bottle it. This can be as simple as a high flocculant yeast strain to a complete filtration of the beer. Most of the Belgian brewers use a type of centrifuge that spins the yeast out. The most important thing for you as home brewers is to be aware that this happens. When you use fresh yeast you want as little of the old yeast into the priming solution as possible.

YEASTING RATES

As with carbonation rates, yeasting rates differ based on tradition. There are basically 3 camps. The Belgian, the English/American and the German. Belgian beers are usually carbonated to a higher level than the rest and also use more yeast at bottling. The English and Americans are only looking for enough yeast to prime their beers. Most of them are around 2-2.4 volumes of CO_2 which doesn't need a lot of extra yeast to do it. English and American ales are usually bottled at a rate of ~100,000 cells/ml. Traditional German beers are primed using 'speise' which we'll get to later and usually bottle at the same rates as the American and English beers. Belgian beers are much higher at a rate of 1-3,000,000 cells/ml.

YEAST NUMBERS

Style	Cells per ml	Total yeast/ 5gal needed
English & American	~100,000 cells/ml	~2.0 billion
German	~100,000 cells/ml	~2.0 billion
Belgian	1-3,000,000 cells/ml	~20 - 60 billion

We know the approximate amount of yeast per ml.

WHITE LABS - ~100 billion cells & 35ml total = 2.9 billion cells/ml

WYEAST - ~100 billion cells & 125ml total = 800 million cells/ml

DRY YEAST - ~230 billion cells & 11.5 grams = 20 billion cells/gram

***DRY YEAST** - ~14 billion cells/ 1/4tsp dry yeast. Add 1/4 dry yeast to 100ml of water and let bloom. Add 15ml of this slurry.

YEAST VOLUME

Style	Wyeast	White labs	Dry yeast
English & American	3-4 ml	2.5ml	~15ml*
German	3-4 ml	2.5ml	~15ml*
Belgian	7-20m	25-75ml	.33 tsp-1.0 tsp

EXAMPLES

Its assumed these beers have fermented completely. The priming calculator listed above was used as were the numbers for re-yeasting. Each beers variables are listed. All ingredients are mixed in bottling bucket and then bottled or kegged.

PRIMING EXAMPLES - 5 GALLONS

Style	Vessel	Vol CO_2 wanted	Temp	Amount sugar	Vol yeast
American lager	keg	2.6	65F	.66 cups Rice solids	2.5ml
Wyeast Brown Porter	12oz bottle	2.2	55F	3.25oz black treacle	.75 ml White labs
German Bock	500ml bottle	2.5	32F	3.25oz pils DME	15ml dry yeast slurry
Belgian Tripel	33cl bottle	3.3	60F	177g table sugar	1tsp dry yeast

SPECIAL TECHNIQUES

There are some very unique processes that go well beyond the advanced conditioning material. These include more historical methods rather that the exacting science we have covered thus far.

REAL ALE (NOT IMAGINARY)

Cask conditioned ales. These are the original English ales. The beer is added directly to a cask with priming sugar, yeast and a small amount of hops. They are served at cellar temperatures (~55F) from either gravity or pulled using a beer engine. The low volume of carbonation, the added hops and the warmer temperatures make these ales truly magnificent. Although not difficult to do, real ale does require some additional hardware.

OVERVIEW

Traditionally these beers were put into beer casks. More recently they are being served out of either firkins (~11gal) or pins (5.5gal). The smaller size allows them to be consumed quicker which ensures their freshness. During the 1980s brewers started switching to poly-pins, food-grade collapsible plastic pins, which requires no additional hardware for home consumption. Its quite difficult to find an actual poly-pin in the US but we do have plenty of equivalents. I prefer to use the collapsible water carrier used for camping as they are FDA approved for food storage. They come in 2.5 and 5.0 gallon sizes.

USE

All we need to do is treat the polypin as we would any other container. After you are sure your beer is completely fermented and has been cleared you can rack directly into your polypin. We really want quite a low level of carbonation so I like to shoot for about 1.8 volumes or so. Yeast at the above rates. One small change is the addition of a small quantity of hops to this pin. Just add .25 to .5 ounce of hops to a hop bag and insert that into your pin. Get it all mixed in your pin and allow a week or so for carbonation. After carbonation, it is of the utmost importance to introduce oxygen into this beer at this time. *****PLEASE NOTE - I KNOW THIS GOES AGAINST EVERYTHING YOU'VE BEEN TAUGHT BUT STAY WITH ME!** This limited oxygen exposure is mandatory to get the true cask flavors. A cask is basically open to the environment and every pull of the engine draws more air into it. Because we are using a poly-pin, as we draw pins off, they collapse ensuring there is no oxygen exposure. This is the benefit to using them but a hindrance in this instance. We need to get around this. Here is how you do it:

- Open spigot and bleed off the extra pressure
- Compress the poly-pin to push out as much of the CO_2 as possible
- Let the weight of the beer pull open the poly-pin and draw in as much air as possible
- Close the spigot when its full. It should feel bloated.
- Give the whole poly-pin a good shake to get the oxygen into the beer.
- Wait about a week and serve either by gravity or by beer engine.

Its best to store these beers on a downward angle towards the spigot as the yeast will settle out of solution and won't end up in your glass. If you are having real trouble getting yeast to fall out of solution you can use Isinglass at a rate of 1oz/ 5-6 gal (each poly-pin).

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KRÄUSENING (MIT SPEISE)

In Germany, the Reinheitsgebot allows only the use of malt, hops, yeast and water in brewing. This leaves the problem of carbonating the beer without the benefit of any regular sugars. What nearly all German brewers do is add a portion of fermenting beer to the finished beer. The process is called 'kräusening' in that you are taking part of an actively fermenting batch at high kräusen and adding it to a finished batch. This not only provides the sugar for carbonation but also the yeast. This technique can be used for bottles or done in bulk. The latter is practiced in German where the carbonated beer is then filtered before bottling.

For the home brewer there are basically two ways to accomplish this:

1) TRADITIONAL - ADD ACTIVELY FERMENTING WORT

Commercial brewers brew the same recipes over and over. Inasmuch, they always have an actively fermenting beer that is the same as the beer type as the one they want to carbonate. This isn't usually the case for home brewers. Lets just say for the sake of argument you are brewing the same beer you need to carbonate although any beer will work. If not, the closer the new beer to the one you will be carbonating the better. Each beer will be slightly different in that its fermentablility will vary from one recipe to the next. Keep in mind the higher the final gravity of the beer will change the amount of krausen that you add. The higher the FG the less krausen you will need.

PROCEDURE:

The amount of krausen to add is dependent on the amount of carbonation needed and the gravity of the krausen. Use this example as a reference:

Lets say we have 5 gallons of Oktoberfest sitting at 32F that we need carbonated. From the priming calculator we see that we need 2.5 volumes of CO_2. Our new batch of Oktoberfest is fermenting at high krausen and has an SG of 1.038. This means we will need approxiamtely .75qts (700ml) of krausen to carbonate our beer.

2) MODIFIED - MAKE A STARTER FROM SAVED WORT

As home brewers we don't brew all that regularly and usually like to do many different recipes. Doing the same beer twice in a row isn't appealing to most people. This puts a damper on a traditional kräusen to prime your beer. We, however, can do what I call a 'modified' kräusen. The procedure is basically the same as for the traditional method except that you save some of your wort after the boil. We can approximate how much kräusen we will need using the above methods. I then suggest you double it until you are comfortable with the process.

PROCEDURE:

We will use our Oktoberfest again as an example. After the boil we will save 2 quarts of wort in a sanitized container. Since this is a lager most people either choose to freeze this wort or to simply 'can' it in mason jars. When you are ready to prime your beer all you need to do is basically make a starter with this beer. Add the approximate amount of yeast as indicated in the 'yeast rate' section. At high kräusen, test the gravity and then do your final calculations on the amount to add (this is why we save extra).

Lets say we have the same 5 gallons of Schwarzbier sitting at 65F that we need carbonated. From the priming calculator we see that we need 2.3 volumes of CO_2. We canned 2qts of the original boiled wort and has an OG of 1.055. We add 100,000cells yeast/ml and let it start to ferment. At high krausen this 'starter' is at 1.029. When we plug this into our calculator we see that we need 1.5qts (~1400ml) of the 2qt starter.

KRAUSEN EXAMPLES - 5 GALLONS

Type	Yeast	Temp	Krausen S.G.	Krausen vol
Traditional	none	32F	1.038	.75qt (700ml)
Modified	2.5ml Wyeast	65F	1.029	1.5qt (~1400ml)

SPECIAL BUGS

There has been a lot of interest of late with the use of non-saccharomyces yeast and various 'bugs' in beer production. Traditionally most were contaminants that gave a specific character to the beers. The 'aged' flavor in English stock ales and stouts was found to come from Brettanomyces clausenii (aka B. anomalous). B. lambicus and B. bruxellensis provide the main 'funky' component to lambics. The bacteria Pediococcus cerevisiae and Lactobacillus delbrueckii respectively provided the acid to lambics and Berliner weiss. A very simple way to start using these bugs is to use them in your bottling process.

BUG CHARACTERISTICS

Style	Type of bug	Character	BU effect
B. bruxellensis	Yeast	barn yard	20bu
B. clausenii	Yeast	pineapple, aged tobacco	20bu
B. lambicus	Yeast	cherry pie	20bu
L. delbrueckii	Bacteria	lactic acid	10bu
P. cerevisiae	Bacteria	lactic acid	10bu

PITCHING CHART

Style	pitch rate per ml	Wyeast per package
Brett	3,000 to 1million	75 billion
Bacteria	1:4-5 vol of yeast used	10 billion

BRETTANOMYCES

You can substitute regular priming yeast with any of the brett stains and still do the same function. The only thing you need to remember is that brett can ferment some of the dextrins that saccharomyces can not so plan ahead for that depending on the body of your finished beer and the amount of priming sugar you will add. Brettanomyces can also eat the sugars (cellobiose) from the oak. Although the beer will carbonate quite quickly, it will take a while for any brett character to develop. It should also be noted that your choice of yeast you use to ferment the beer plays a role in the amount of brett character that will ultimately develop. Using a plain American ale yeast will give you a lot less character than one that is full of phenolics and higher alcohols like the Belgian strains. FWIW - Brett usually won't go below 1.006 FG but some strains have been known to go down to 1.002.

BACTERIA

Unlike yeast, these bacteria will not actually ferment sugar to produce carbonation. You will be using them, along with a bottling yeast strain, to give a unique character to your beer. The biggest hindrance to using these bacteria is the presence of hops. When deciding which beers to put these in it is imperative that the BUs are below 10. The farther you get over 10, the more likely these bacteria aren't going to work for you. Traditionally they are pitched at a ratio of 5 parts yeast to 1 part bacteria. It is also not a good idea to make a starter of these cultures but to add them directly from their packaging. Lactobaccilus can do its job aerobic and anaerobically but prefers the latter. Pediococcus is much more an anaerobe but can produce a good amount of diacetyl.

BUG EXAMPLES - 5 GALLONS (same pitching rates as above)

Style	Vol CO_2 wanted	Temp	Amount sugar	Vol yeast	Vol of bug*
Berliner weiss	3.5	65F	1.5 cups DME	2.5ml Wyeast	4.75ml L. delbreukii (1:4)
Brown porter	2.2	55F	3.0oz brown sugar	No yeast	12.5ml B. lambicus & 12.5ml B. bruxellensis
Belgian Tripel	3.3	60F	6.25oz table sugar	No yeast	25ml B. clausenii
Orval*	3.3	40F	125g Corn sugar	25ml Wyeast	~1ml B. bruxellensis

*1mill cells/ ml yeast and 3,000 cells/ml brett **WYEAST** Bacteria - ~10 billion cells & 100ml = 100 million cells/ ml. Brett - ~75 billion cells & 100 ml = 750 million cells/ ml