Bottle fermentation – revival of an old technique

INCREASINGLY POPULAR | When looking at craft beers on shop shelves, the term "bottle fermentation" appears on the labels with increasing frequency. Shoppers interested in buying beer wonder what this actually means. And many brewers also ask themselves the same question. So let's have a closer look at bottle fermentation technique and also at the associated pros and cons.

BOTTLE FERMENTATION IS CERTAINLY NOT a new invention of the craft beer movement, it is rather a procedure practiced over centuries, still used exactly as heretofore for some beer types. One of the best examples is Bavarian Hefeweizen or Hefeweissbier.

Let's get back to basics: the term bottle fermentation is a bit misleading. It is in actual fact a secondary fermentation in the bottle as main fermentation commonly takes place in a tank or tub. Then, after having bottled the beer, it is fermented further by yeast already in the beer or other yeasts or microorganisms are added to promote further fermentation. So-called food is also commonly added i.e. fermentable sugars in the form of pure sugar or wort.

Which beers are suitable for bottle fermentation?

Principally: all.

But there are exceptions to the rule. Beers that are typically filtered are, naturally, not suitable as subsequent filtration would no longer be possible. Beers processed in a different way also pose some difficulties, or the process has to be altered. A barrel of aged beer can of course be enhanced by bottle fermentation after barrel storage. However, barrel storage always has to precede bottle fermentation.

Top-fermented beers tend to be somewhat more suitable for bottle fermentation due to the fact that top-fermenting yeast is somewhat more resistant to autolysis.

Still, excellent results can be achieved when bottom-fermented beers undergo bottle fermentation.

What do I have to do to produce top-class beers?

First of all, one has to be clear about the beer type to be produced as this is important for deciding how secondary fermentation in the bottle should be carried out. On the one hand, it is possible to use the same yeast as was used for main fermentation also for secondary fermentation. On the other hand, another yeast or even other microorganisms or possibly also a mix of various microorganisms can be added.

Let's take a Weizenbier/Weissbier as an example: top-fermenting Weissbier yeast is initially used for main fermentation. As soon as main fermentation is completed and final attenuation has been attained, the beer is mixed with food. Unfermented cast wort is mostly used as food. It is of particular importance to select the right amount of food. I'll come to the calculation later.

This is followed by bottling. In this instance, the top-fermenting yeast used for main fermentation also takes on bottle fermentation. Bottles thus have to be stored at temperatures above 15 °C. A period of one week is usually sufficient before the beer can be drunk. There is some controversy about whether this should be followed by cold storage. But this is not generally necessary. However, cold storage has a positive effect on CO_2 bonding in beer and is carried out relatively more frequently.

Another option is to add bottom-fermenting yeast before bottling. In this case, the largest amount of top-fermenting beer possible should be removed from the green beer. This can be done by cooling and sedimentation, but much more effectively by centrifuging or filtration. After having been filled, bottles should be stored at 8 to 10 °C. At these temperatures, the bottom-fermenting yeast ferments available sugars whereas top-fermenting yeast becomes inactive at such low temperatures. It goes without saying that, applying this method, the resulting beer will have a totally different character compared to the exclusive use of top-fermenting yeast.

Care should always be taken to select the correct temperature for secondary fermentation. It depends largely on the micro-

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organism used. When combining microorganisms, even more care should be taken. It does not make a lot of sense using bottom-fermenting yeast for main fermentation and, without complete removal of this bottom-fermenting yeast, adding top-fermenting yeast for secondary fermentation in the bottle. At the elevated temperatures required for top-fermenting yeasts, bottom-fermenting yeast would also ferment vigorously, resulting in undesirable fermentation by-products.

Apart from classical cultured brewers' yeasts, yeasts of the *Brettanomyces* or *Saccharomyces diastaticus* strains or also *Lactobacillus* strains are useful for production of excellent sour beers. It is important to be familiar with the fermentation spectra of these microorganisms i.e. to know exactly which sugars they ferment. That brings us to one of the most important points of secondary fermentation.

How much food must I add?

Whole generations of brewers have been faced with this question. There is a simple rule of thumb, i.e. just adding 10% of the overall volume in the form of wort. But this should be taken with a pinch of salt. Though this rule of thumb works in most instances, nobody is immune from a nasty surprise every now and then. But back to basics.

Once final attenuation has been attained, main fermentation is followed by bottling. In other words, the green beer no longer contains any fermentable sugars. But exactly these are needed for bottle fermentation so that the microorganism selected is able to ferment and, in particular, supply the required CO_2 for bottle fermentation. And this CO_2 is the cornerstone for calculating the food. To start with, we should not lose sight of the fact that 0.5 g of alcohol and 0.5 g of CO_2 are formed from one gram of sugar during fermentation.

In the next step, the CO_2 content of the beer produced has to be decided on. Assuming e.g. lager, the level is about 5 g/l, it is considerably higher at 6 to 7 g/l for Weissbier whereas barley wine can make do with 2 to 3 g/l of CO_2.

Then final attenuation of the food used has to be determined. The microorganism used for bottle fermentation should also be used for this. As soon as this has been determined, it is possible to calculate the amount of fermentable sugars that have to be contained in the food.

And, finally, CO_2 content of the green beer after main fermentation has to be known. Unfortunately, this is often neglected because some protagonists believe that green beer – having undergone pressureless fermentation – no longer contains any CO_2 worth mentioning. But this is simply not the case. CO_2 content can be measured with a measuring instrument or read out of a table. Several different CO_2 calculators are already available on the Internet. Simply input atmospheric pressure, i.e. about 1 bar, and also the temperature of the green beer. For a green beer e.g. at 10 °C, a CO_2 content of tidy 2.27 g/l is calculated. It is thus obvious that the beer would be over-carbonated, should the existing CO_2 content be ignored.

Now the difference between the CO_2 content desired and the CO_2 already in the green beer is calculated. Let's take a target CO_2 content of 5 g/l by way of example. We still need 5 g/l – 2.27 g/l = 2.73 g/l of CO_2. As mentioned above, we'll get 0.5 g of CO_2 from one gram of sugar. In our example, we would still need 2.73 g/l divided by 0.5 g/g sugar equals 5.46 g of sugar/l.

Let's assume further that the food that we want to use contains 85 g/l of fermentable sugars (determined on the basis of final attenuation measurement). We would need to add a sufficient amount of sugar in order to adequately carbonate the green beer and that the feed added also has enough sugar for CO_2 formation.

All that can be shown in a simple summation equation:

(1 litre of green beer x O g/fermentable sugars) + (food volume x 85 g/l of fermentable sugars) = (1 litre of beer x 5.46 g/l + food volume x 10 g/l)

It is initially assumed on the left-hand side that green beer no longer contains any fermentable sugars. 85 g/l were contained in the food. Thus, the left-hand side of the equation shows the sugar quantity that has to be contained in the mix. The right-hand side shows the amount of sugar needed for one litre of green beer to be carbonated to the desired CO_2 content. As the food initially contains no CO_2 though the finished beer should be carbonated, 10 g/l of sugars have to be factored in for 5 g/l of CO_2.

By solving the above equation for food volume, one obtains the result below:

Food volume = (1 litre of beer x 5.46 g/l)/(85 g/l – 10 g/l)

This results in a food volume of 0.0728 l/l of beer or 7.28 l for each hectolitre of beer.

Our example demonstrates quite impressively that the figure is indeed not 10% as mentioned earlier.

For how long should the beer be stored?

It always boils down to the beer type. Weissbier should be consumed as fresh as possible so one or two weeks are sufficient. Strong beers like longer storage periods every now and then, even for several months in some instances. Really good sour beers also require several months, even years, in order to develop their complex body to the fullest.

To take the easiest route, simply taste a bottle during storage at fixed intervals. It's thus very easy to determine the right point in time for sale and to have, in addition, a lot of fun during tasting. ■