Hop Creep – Technical Brief

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EXECUTIVE SUMMARY

There is evidence that hops have amylolytic enzymes in or on them that biochemically modify beer during dry-hopping, leading to degradation of long-chain, unfermentable dextrins into fermentable sugars. This increase in fermentable sugars can, in the presence of yeast, give rise to a slow secondary fermentation, which is referred to as 'hop creep.' Hop creep requires three conditions for it to appear: (1) some amount of unfermentable real extract in the wort or beer prior to dry-hopping; (2) live yeast in suspension; and (3) the addition of hops to fermenting or fermented beer. The main consequences of hop creep result in beer being out of specification in terms of alcohol, diacetyl and CO_2 (Table 1). It is particularly concerning when it occurs post-packaging because of the consumer safety risk related to package over-pressurization. Methods for controlling hop creep, to either accentuate or reduce it, involve manipulating wort composition, yeast strain selection and suspended cell concentration during dry-hopping, and dry-hop form, timing, contact time and temperature.

WORT FERMENTABILITY AND BIOCHEMISTRY

The mashing process combines malted barley and warm water to create wort, which is made up of fermentable sugars (principally, maltose), unfermentable dextrins, proteins, minerals and ash. Taken together, these components are termed 'total extract.' Yeast use the fermentable sugars during fermentation to produce alcohol, CO_2, more yeast, and various other secondary metabolites, some of which contribute to fermentation-derived beer flavor. The wort components consumed by yeast are referred to as the 'fermentable extract.' In beer, the longer-chain dextrins are not fermented, and once fermentation is complete these dextrins carry through into the final beer. This fraction of the extract along with the untouched protein, minerals and ash is referred to as 'real extract.' The amount and type of unfermentable dextrins remaining in the final beer depends on the enzymic properties of the mash grist and the mashing temperature/time profile. The malt-derived enzymes are inactivated during wort boiling, and after the boil, the wort is enzymatically inactive until the yeast is added after cooling and aeration. Some brewers choose to add hops near the end of fermentation or after fermentation is complete to accentuate hop-derived flavors and aromas, in a process known as dry-hopping.

HOW HOP CREEP IS TIED TO DRY-HOPPING

During dry-hopping, enzymes associated with the hops are carried into the beer and begin breaking down unfermentable dextrins left behind from mashing into fermentable sugars. The action of these enzymes appears to be more active when hop material is suspended in beer, but a portion of these enzymes may migrate into beer and remain active even after the hops have been removed from the fermenter/dry-hopping vessel. Any amount of yeast remaining in finished beer can metabolize the sugars liberated by amylolytic enzymes, producing alcohol and CO_2. When this occurs within the brewery cellar, a brewer will notice a slow decline in the apparent gravity of the dry-hopped beer beyond the anticipated terminal gravity. This slow reduction in the final gravity is referred to by brewers as hop creep.

TABLE 1: An example of hop creep in a beer that was dry-hopped near the end of active fermentation when the apparent extract reached 3.5°P (O.G. 14.3°P)

Beer property	Unit	Without dry-hopping*	9 days after dry-hopping	Absolute Difference
Real extract	%w/w (°P)	5.03	4.70	-0.27
Apparent extract	%w/w (°P)	2.75	2.25	-0.50
Real degree of fermentation (RDF)	%	67.36	70.44	+3.08
Apparent degree of fermentation (ADF)	%	81.20	85.02	+3.82
Alcohol	%v/v	6.42	6.92	+0.50
CO_2	volumes			+2.02

*beer chemistry performed on a forced fermentation of the beer without dry-hopping

ISSUES CAUSED BY HOP CREEP

Fermenter hop creep leads to extended cellaring time, as the refermentation caused by the spike in fermentable extract can take a long or indeterminate time to finish. Extended cellar time can tie up fermentation or dry-hopping tank space, thereby delaying production of

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subsequent batches. The resultant beer will have a higher than expected alcohol concentration. Some brewers also observe a dry-hop-induced reappearance of diacetyl followed by long reduction times. In non-dry-hopped beer, diacetyl production at the end of fermentation and its subsequent reduction is part of normal fermentation. The reappearance of diacetyl post-dry-hopping and the often very slow reduction of this secondary diacetyl spike is a potentially greater process flow headache for the brewer than the out-of-specification alcohol content. This secondary diacetyl spike can be sporadic from batch to batch making the task of predicting its appearance even more frustrating.

A potentially dangerous result from hop creep can be package over-pressurization, which is a consumer safety risk. If a brewery is dry-hopping a beer shortly before packaging and does not sterile filter or pasteurize, the beer may contain active yeast and hop enzymes. If hop creep has not occurred in the cellar, it may occur in the package which can lead to package over-pressurization and/or gushing or even out-of-specification alcohol due to refermentation. This may be particularly problematic for hazy/juicy styles of beer where yeast counts and hopping rates are both high. In-package, hop creep can be dangerous for the consumer should the container fail. It also leads to expensive and potentially brand-damaging product recalls.

TABLE 2: How Dry-Hopping Practice is Tied to Hop Creep: Factors that promote/reduce hop creep

Factor	Promote Hop Creep	Reduce Hop Creep
Hop Form	Whole Cone, T90	CO_2 extracts, Cryo pellets, T45
Dry-Hop Duration	Long duration	Short duration
Dry-Hop Temperature	Warm (50-65+°F)	Cold (<50°F)
Dry-Hop Hop Load	High hop load (>2lb/bbl)	Low hop load (<2lb/bbl)
Fermenter Yeast Load	High yeast load	Low yeast load
Package Yeast Presence	Yeast present	Yeast absent
Filtration	No filtration	Filtration
Pasteurization	No pasteurization	Pasteurization

APPROACHES TO MITIGATING OR WORKING WITH HOP CREEP

There are different philosophies around dealing with hop creep. Some involve slowing hop creep down or stopping it outright, while others involve speeding it up so that it occurs in the brewery or cellar and not in the packaged beer. Example brewhouse controls include modifying beer recipes to create a more fermentable wort that is less susceptible to hop creep. Dry-hopping at lower temperatures and after a total or partial centrifugation will reduce the extent of hop creep and potentially limit the secondary diacetyl spike, but it will not eliminate it completely. Hop creep still has the potential to occur once the beer warms in package. Replacing T90 with more concentrated T45 or cryo-hop pellets in the dry-hop bill will also reduce hop creep, as the enzymes appear to be associated more with the hop's green matter. For these approaches, hop creep can be slowed down but not stopped completely. Thus, package over-pressurization is still a possibility even if a small amount of yeast is present at the time of packaging. Dry-hop-induced diacetyl spikes can be reduced, but not eliminated, by using alpha acetolactate decarboxylase enzymes. Depending on the yeast strain, suspended cell concentration and brand, allowing the terminal diacetyl levels to drop below sensory threshold before adding dry-hops can keep diacetyl levels low even if there is a slight increase from hop creep; however this approach may take considerable time. And finally, pasteurization will stop hop creep outright and guarantee the shelf stability of the beer, as any hop enzymes or yeast will be denatured or inactivated, respectively.

Conversely, if a brewer is interested in speeding hop creep in the cellar in order to minimize the risk of it occurring in the package, dry-hopping can be carried out when fermentation is still active, warm and there is a higher yeast concentration in suspension. This approach, depending on yeast selection, can also reduce the magnitude of a dry-hop-induced diacetyl spike and its subsequent reduction. The "solution" in this case is to live with hop creep and to try to speed it along thereby shortening the duration of its effects. This approach may be appropriate for some breweries but not for others. Regardless of the approach, each brewery will have its own idiosyncrasies associated with how they carry out dry-hopping. Some basic studies carried out within your brewery can provide insight into the challenges dry-hop creep may present to you.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions and edits to this article made by a subset of the Brewers Association Quality Subcommittee and Hop Quality Group representatives who include Jason Perkins (Allagash Brewing Company), Lauren Torres (Bell's Brewery), Daniel Sharp (Ninkasi Brewing Company), Tom Nielsen (Sierra Nevada Brewing Company), Max Kravitz (pFriem Family Brewers) and Kaylyn Kirkpatrick (Brewers Association). The authors express their appreciation for edits, comments and input from the Brewers Association Quality Subcommittee.

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