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# ADVANCED HOP PRODUCTS: USAGE AND OPTIMIZATION

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**Hop Innovation** ›

There was a time when hopping a brew wasn't terribly complicated. Using whole hops, a brewer only had to contend with what varieties to use, and through experience and art, dosed the whole hops into the brew kettle at specified times to produce the bitterness and aroma that was desired for the beer. No science was used, until of course, the brewing chemists became involved. They were on the cusp of making significant strides in identifying the brewing-valued compounds in hops and developing methods to measure them in the hops and in beer. It was for the better – the promise of better control and consistency in the final brew.

For all the essential benefits hops bring to beer, it's been long known that traditional hopping is terribly inefficient with significant losses in bitterness and aroma components occurring through the long and punishing brewing process. The alpha acids isomerization reaction in the brew kettle is slow and ultimately incomplete in a standard boiling regime. To make matters worse, even though the isomerized alpha acids (isoalpha acids) are more beer-friendly in terms of solubility than the original alpha acids, they still have an adversity to wort and beer. When given the chance, they will attach themselves to most surfaces, including vessel walls, wort suspended solids, and yeast. As a result, only about 25 to 30 percent of the alpha acids that are initially dosed into the brew kettle end up as isoalpha acids, and bitterness (IBU), in the final beer. Brewers, especially large brewers, face the cost of hop bittering losses in the traditional hopping process. It was long considered to be an inevitable cost in traditional brewing.

Although beer bitterness is the primary role of iso-alpha acids, they are important in providing microbiological stability in the wort and beer. It's this anti-bacterial property that helped give rise to hops' popularity as early as the 15th century, greatly enhancing the shelf-life stability of beers (India Pale Ale is a prime example in the exploitation of that effect). As an additional cosmetic benefit, hops interact with malt proteins to produce an attractive foam and lacing of the beer glass. It is a shame that most of the alpha acids are essentially wasted in the brewing process.

So why not add hops later in the brewing process instead of the boil? The traditional method of hopping requires that the cones or pellets be added to a vigorously boiling brew kettle in order to extract the resins from the hops' lupulin glands and suspend the alpha acids and the essential oil compounds in the hot liquid medium. Then, to provide hop bitterness in the beer, it is required that the alpha acids be boiled in order for an isomerization chemical reaction occur, producing the isoalpha acids. In addition to its effect on isomerization, it is the boil that provides the dissolution of the various volatile hop aroma components, with some useful oxidation reactions.

So give the hops chemists their due…technology is continually advancing to help provide greater efficiency and flexibility in the production of beer through the development of what are now termed “advanced hop products”, formulated to allow a much more efficient post-fermentation dosing. We also now also developed of methods to fractionate the various components and provide hop products with greater functional specificity, with emphasis in enhancing bitter, foam, and light-protection…inhibiting the dreaded skunky, light-struck phenomenon in clear or green bottled beers.

Advanced hop products have been part of the brewing scene since the 1970s, but further efforts have refined the products to a high level of purity, solubility and effectiveness. Early on, researchers found that minor modifications in the structure of the isoalpha acids molecule, accomplished through processes known as reduction and hydrogenation (common in the food processing industry), could provide a basis for the development of the highly specialized bitter products rho-isoalpha acids, tetrahydro-isoalpha acids, and hexahydro-isoalpha acids. In summary, their benefits are:

- RHO: This product is used primarily to give protection from light-struck flavor when used as a sole source of hop-derived bittering or in conjunction with other reduced hop products such as tetra and hexa. It will act as an antimicrobial agent, and is often described as having a pleasant, smooth bitterness.

- TETRA: Its most popular feature is in the enhancement of beer foam and contributes as a post-fermentation replacement for part of the normal bittering. In the absence of alpha acids and isoalpha acids, tetra will give protection from the formation of light-struck flavor. The product can produce nearly double the bitterness of isoalpha acids at the same dosing levels. However this bitterness is often described as harsh, and therefore it’s recommended that tetra be used sparingly and in conjunction with other hop bitter products to achieve maximum benefit. As with all the isoalpha acids products, it acts as an antimicrobial agent.

- HEXA: It is similar to tetra in its functionality, but because it is not as bitter, it is effective when used in low IBU beers. Hexa has a more pleasant bitterness than tetra. It is often sold as a tetra/hexa blend, often about 50:50, but variations exist. Hexa is not nearly as popular as tetra and rho, primarily because it is similar to tetra in function, but expensive to produce. However, some brewers use it as an important component in their beer formulations.

The more recent research efforts for advanced hop products has been in the area of hop aroma. The bitter products, though having challenges of their own in their development and refinement, pale in comparison to the complexities in understanding and formulating post-fermentation aroma products as a suitable and efficient substitute for traditional hopping. This goal has been further complicated by the emphasis on flavor impact from hops in beer, brought to the forefront with the popularity of hop-forward craft beer styles. No longer is hop aroma a subtlety in beer, but it is now a defining feature. The increased hopping rates utilized (including a reliance on dry-hopping for effect) has exacerbated hop usage inefficiencies, and has led to significant production losses in wort and beer through liquid absorption by the hop solids. This makes the proposition of post-fermentation liquid hop products even more attractive.

Hops are amazing in the flavor diversity they can contribute to beer, with more than 400 essential oils identified including a multitude of different floral, fruity, citrus, herbal and spicy characters. Specific aromas derived from hops include the unlikely descriptors of coconut, kiwi, lavender, cream caramel and “barrel-aged”. The interactions and variations of hop aroma compounds are exceedingly complex, and their impact at high dosing rates make a wide range of flavors even more evident. The diverse impacts and volatilities of the different classes of hydrocarbons, terpenes, sesquiterpenes and thiols brought about in the brew kettle, as well as oxidation effects on solubility and flavor, have proven difficult to replicate in a product designed for post-fermentation addition. Further flavor effects can occur due to the bio-transformation of aroma compounds through interactions with yeast metabolism during fermentation. It is certainly complicated, and researchers in the fields of hop aroma and sensory can be assured that their jobs are secure for decades to come.

However, despite these challenges, advanced aroma products have shown promise and are continually improving. Fractionation of the hop essential oils allow them to be isolated into their basic aroma categories of floral, citrus, spicy, herbal and fruity, as well as more specific flavors.

Recombining various components can mimic the effects of late-hopping versus dry-hopping. One important drawback of these products, however, is the influence on beer aroma by various contributors other than essential oils, such as many of the more water-soluble components, e.g. glycosides. The more extreme hopping rates in many craft beer styles draws out a great deal of these additional components above a sensory detection level not apparent with milder hopped styles such as lager beer. It’s for this reason that many of the essential oil-based advanced aroma products work well in the lighter beers, but fall short in their effect with more robust craft formulations.

So, what should brewers consider in the choices that can be made in the hop products available, whether they be traditional products or the more advanced? The challenges with the advanced products are numerous along with a steep learning curve, and with the complexities involved there often comes a reluctance to delve into the use of the more specialized hop products. This is understandable, but there is a great deal of help available in brewing literature, brewing organizations, and certainly from the hop product suppliers who are more than willing to help. And when considering the use advanced products, either bitter or aroma, it can be an incremental process…just a little at a time. The greatest success in many cases is to take advantage of many of the benefits through only a minor replacement or addition in a standard traditional hopping regime. Just a little tetra, perhaps as low as 2 ppm in beer can have a significant effect on beer foam and lacing enhancement in light lagers. Many of the advanced aroma products supplementing a standard hopping bill can provide more flexibility and impact on a beer's flavor profile. The gains in efficiencies and consistency can be substantial, along with a flavor impact that can set a beer apart from the norm.

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