75

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INVESTIGATIONS INTO THE BITTERNESS OF DRY-HOPPED BEER

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JUSTIFICATION AND BACKGROUND

The increasing popularity of dry-hopping in the brewing industry has more and more brewers using this technique to impart additional hop aroma in beer. Most brewers use bitterness measurement as a tool to gauge hopping efficiency and, in some cases, dry-hopping contributions to the bitterness of beer. This study investigated the different hop components that contribute bitterness to beer during dry-hopping. ASBC Methods of Analyses Beer-23 and Beer-35 for measuring bitterness and polyphenols combined with a trained sensory panel were used to gather instrumental and sensory data on beer bitterness. Our goal was to learn which hop components contribute to bitterness increases in dry-hopped beer in order to better control the dry-hopping process.

EXPERIMENTAL METHODS

An unhopped ale was brewed with 98.5% pale ale and 1.5% acidulated malt in the OSU pilot plant resulting in a beer with the following specifications:

- 13˚P original gravity, 2.53˚P final gravity, 5.1 pH

For each experiment, a sanitized keg, pressurized with CO_2, was filled with the following:

- 10L unhopped ale
- Dry-hopped with 4g/L or 16g/L of Chinook hops (13% alpha, 0.293 HSI)
- Over the course of 6, 24, or 72 hours

The beer was then filtered through a cartridge filter filled with Plyban synthetic cheesecloth.

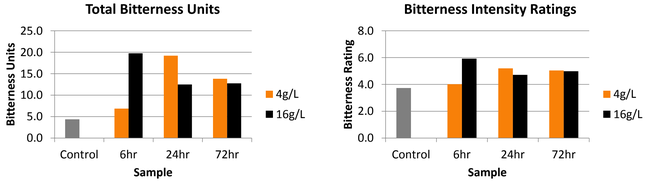
A sensory panel of 11 trained panelists rated the samples separately for bitterness intensity and aroma intensity on a category scale of 0 to 9.

Samples were quantitatively analyzed for the following:

- BU
- Polyphenols
- Alpha and beta acids
- Iso-alpha-acids
- Oxidized alpha and beta acids

RESULTS

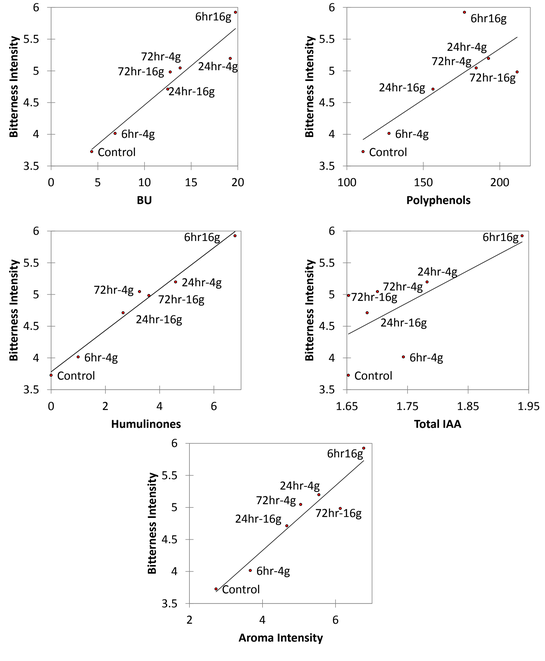
A graphical representation of the instrumental and sensory bitterness data



Averaged Instrumental and Sensory Data for the Dry-Hopped Samples

Beer	BU	PP	Total IAA	Alphas	Betas	Humulinones	Hulupones	Bitterness Intensity	Aroma Intensity
Control	4.4	111	1.65	0.0	0.0	0.0	0.0	3.7	2.7
6hr-4g/L	6.9	128	1.74	0.0	0.0	1.0	0.0	4.0	3.7
6hr16g/L	19.8	177	1.94	0.0	0.0	6.8	0.0	5.9	6.8
24hr-4g/L	19.2	193	1.78	0.0	0.0	4.6	0.0	5.2	5.5
24hr-16g/L	12.5	156	1.68	0.0	0.0	2.7	0.0	4.7	4.7
72hr-4g/L	13.8	185	1.70	0.0	0.0	3.3	0.0	5.0	5.0
72hr-16g/L	12.8	211	1.65	0.0	0.0	3.6	0.0	5.0	6.1

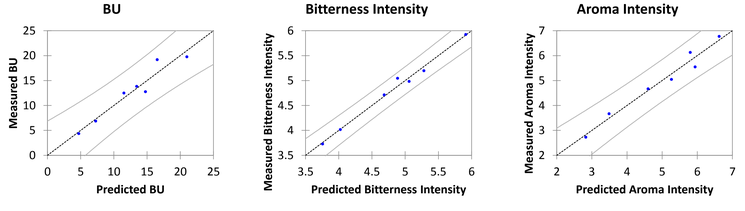
Graphical data depicting the relationship of Bitterness Intensity to instrumental measurements and Aroma Intensity



Multiple linear regression predicts the relationships between the attributes and measured values

Attribute	Intercept	Polyphenols	Iso-Alpha-Acids	Humulinones	R2
Bitterness Units	= 2.372	+ 0.021 * PP		+ 2.195 * Humulinones	0.929
Bitterness Intensity	= 5.458		- 1.029 * Total IAA	+ 0.362 * Humulinones	0.988
Aroma Intensity	= 1.213	+ 0.015 * PP		+ 0.417 * Humulinones	0.968

Multiple Linear Regression Predicted vs Calculated Values



CONCLUSION

- A range of bitterness can be detected in the dry-hopped samples.
- A strong correlation was found between bitterness intensity and aroma intensity.
- Bitterness contributed by dry-hopping can be described as a combination of the levels of polyphenols and humulinones found in the final beer.

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