



Effects in Beers Hopped with German Perle and Czech Saaz Pellet Hops with Three Different HSI Values

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World Brewing Congress
August 13-17, 2016
Sheraton Downtown Denver
Denver, CO 80202, U.S.A.

Introduction

Hop Storage Index (HSI) is an important quality parameter for hop farmers, hop suppliers and breweries that defines the oxidation of hops. These interested groups are looking to achieve/purchase hops with a low HSI value to keep the amount of oxidized compounds at a minimum. The HSI value is measured by ASBC 6A/12 by a non-specific spectrophotometric method at wavelengths of 275 nm, which is the maximum UV absorbance of alpha and beta decomposition products, and 325 nm, the UV absorbance of alpha and beta acids. This method requires highly trained laboratory staff to ensure accurate measurements. In Table 1 you can find a categorization of quality ranking for different HSI values.

$$HSI \text{ (hop storage index)} = A_{275}/A_{325}$$

The goal of this study was to look at the claim that the lowest HSI values produces beers of best quality. The study concentrated on bitterness (IBU) values, total polyphenols in beer, as well as a comprehensive sensory analysis of hop aroma based on different pellet hops at different HSI values.

Table 1: HSI quality ranking

<0.25	very fresh hops
<0.31	freshly picked
0.31-0.40	hops of normal storage and processing
0.40-0.50	slightly aged hops
0.50-0.60	aged hops
>0.60	oxidized hops

Trial Setup

German Perle (PE) and Czech Saaz (SA) hop pellets were used in this study and were placed in **pro-oxidative** conditions until three different HSI values for each variety were reached (Table 2). They were arbitrarily labeled as low, medium, and high. The hops were held at 20°C in the presence of air, which only simulates an oxidation of hops and not real conditions in a brewery. Pellet hops normally packaged with inert gas will also increase in HSI, but will undergo different reactions, i.e. produce iso-alpha-acids.

12 beers were brewed on a 50 L brewhouse at the Research Brewery in Weihenstephan. All beers were brewed to 12 °P original gravity with a final apparent gravity of 2.3 °P. Fermentations were completed with lager yeast 34/70 at 12 °C. Alcohol was 5.1% vol. and final pH values averaged 4.6.

Table 2: Brewing Data – HSI, Alpha Acids, and Dosages

Hops and Dosage	HSI		Alpha Acids (ASBC) [%]	Dosage Whirlpool [g/l]	Dosage Dry Hopping [g/l]
	Value	Category			
PE WP	0.271	low	8.5%	5.28	0.00
PE DH	0.271	low	8.5%	5.28	2.00
PE WP	0.327	medium	7.4%	6.05	0.00
PE DH	0.327	medium	7.4%	6.05	2.00
PE WP	0.466	high	5.8%	7.65	0.00
PE DH	0.466	high	5.8%	7.65	2.00
SA WP	0.310	low	2.7%	13.05	0.00
SA DH	0.310	low	2.7%	13.05	2.00
SA WP	0.397	medium	2.3%	15.30	0.00
SA DH	0.397	medium	2.3%	15.30	1.50
SA WP	0.493	high	1.9%	18.50	0.00
SA DH	0.493	high	1.9%	18.50	2.00

Results and Discussion

All beers were single-hopped. For each HSI value, one beer was whirlpool-hopped (WH) and one beer was whirlpool- and dry-hopped (DH). Each beer had a target of 20 mg/l iso-alpha acids and a dry-hop dosage of 2 g/l. Dry-hopping was completed in cellulose mesh sacks. See Table 2 for total hop dosages.

Bitterness was calculated based on the dosage at the beginning of the boil and the whirlpool addition. Hop aroma dosages occurred at the whirlpool- and dry-hopping dosages. The loss of alpha-acids during storage necessitated an increased hop dosage for the middle and high HSI values. See table 2 for alpha-acid losses (ASBC 6A).

Polyphenol content correlated with the higher dosage of hops. The higher the dosage of pellets, the higher the amount of polyphenols were found in the final beer (Table 3).

Table 3: Total polyphenol content

Total Poly-phenols	mg/l	Hops		PE WP		PE DH		SA WP		SA DH		SA WP		SA DH	
		HSI	0.271	0.271	0.327	0.327	0.466	0.466	0.31	0.31	0.397	0.397	0.493	0.493	
		141	155	148	163	143	156	217	256	268	296	306	333		

Looking closer at the bitterness units, there was a wide variation between isohumulone values and bitterness (EBC) in beer (Figure 1). Further investigations into oxidized alpha- and beta-acids was not undertaken.

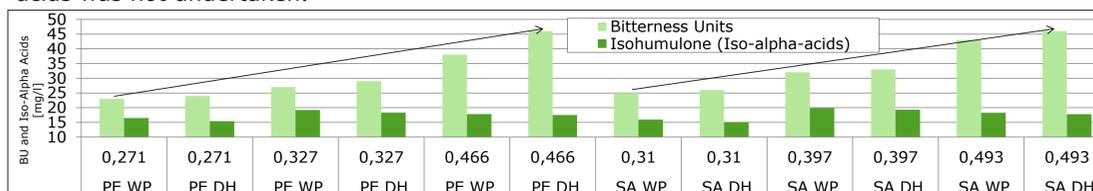


Figure 1: Bitterness Units vs. Iso-alpha acids [mg/l]

Table 4: Bitterness compounds with thresholds

EBC-Bitterness Units	HSI	PE WP		PE DH		SA WP		SA DH		Average	Threshold	
		0.271	0.271	0.327	0.327	0.466	0.466	0.31	0.31			
Isohumulone	mg/l	16.49	15.42	19.19	18.30	17.81	17.53	15.96	15.08	19.84	17.73	5.0
Cis-Iso-Cohumulone	mg/l	3.92	3.73	4.96	4.78	4.81	4.77	3.95	3.86	4.95	4.44	2.7
Trans-Iso-Cohumulone	mg/l	2.22	2.11	2.70	2.61	2.62	2.54	3.02	1.97	2.43	2.41	6.5
Cis-Iso-(n)-Humulone	mg/l	5.34	4.93	5.91	5.58	5.28	5.16	5.29	4.91	6.49	5.64	3.2
Trans-Iso-(n)-Humulone	mg/l	2.78	2.59	3.05	2.88	2.75	2.72	2.55	2.36	3.06	2.84	6.1
Cis-Iso-Adhumulone	mg/l	1.62	1.49	1.90	1.83	1.80	1.77	1.58	1.47	2.17	1.84	2.4
Trans-Iso-Adhumulone	mg/l	0.60	0.57	0.67	0.63	0.56	0.57	0.56	0.52	0.74	0.63	4.4
Alpha acids	mg/l	5.37	6.10	3.97	5.21	4.01	4.59	3.27	3.40	2.94	4.16	8-10
Cohumulone	mg/l	2.93	3.24	2.22	2.77	2.15	2.39	1.39	1.47	1.40	2.04	5.5
n-Humulone	mg/l	2.05	2.40	1.45	2.02	1.55	1.84	1.60	1.63	1.28	1.77	7.0
Adhumulone	mg/l	0.39	0.46	0.31	0.42	0.30	0.36	0.28	0.30	0.26	0.35	7.6
Xanthohumol	mg/l	0.10	0.14	0.14	0.14	0.13	0.13	0.11	0.12	0.08	0.12	4.7
Isoxanthohumol	mg/l	0.72	0.67	0.91	0.86	0.86	0.81	0.94	0.90	1.05	0.94	2.9

Results and Discussion

Isohumulone, cis-iso-cohumulone, and cis-iso-humulone were all found to be above published thresholds. Despite the high hop dosages in the medium and high HSI beers, the low HSI beer contained the highest amount of alpha acids. All of the non-isomerized compounds were at higher concentrations in the dry-hopped beers (Table 4).

Sensory Analysis

There was no significant difference in triangle tests between the low and middle HSI values in beer, although there was a significant difference between beers with low and high HSI values. Further tastings were completed to analyze the aroma and taste of each beer. Beers that were whirlpool hopped showed similar or even better hop aroma and taste intensity and quality with a medium HSI value. The tastings of the dry-hopped beers demonstrated that a low HSI value provides a better hop aroma and taste intensity and quality (Figure 3-6).

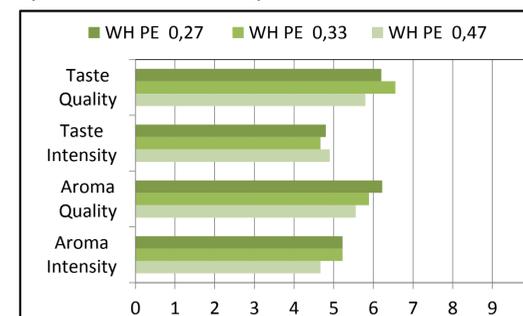


Figure 3: PE whirlpool-hopped

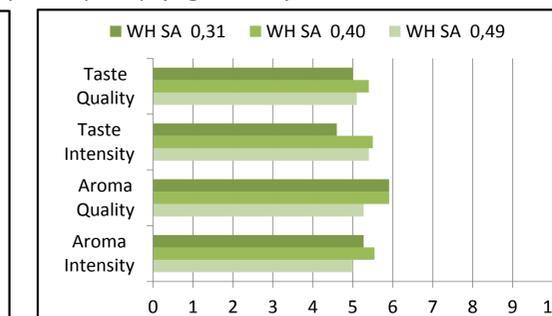


Figure 4: SA whirlpool-hopped

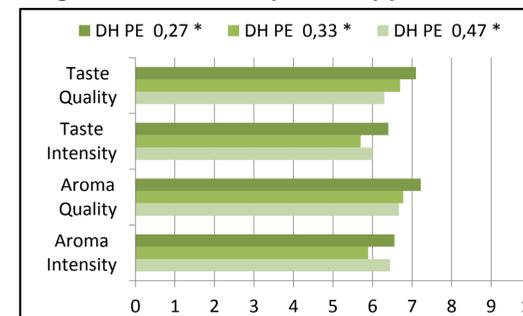


Figure 5: PE dry-hopped

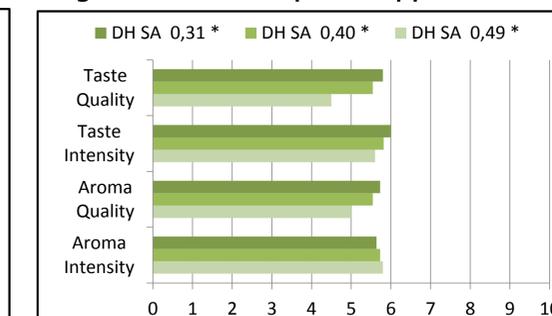


Figure 6: SA dry-hopped

Conclusion

The HSI value is an important quality parameter for many people in the brewing industry. Many hop purchasing and brewing decisions are based on HSI values. Medium HSI values could have a positive influence on hop aroma when dosed on the hot side of brewing. When dry-hopping on the cold side, a hop with a low HSI value will have a positive influence on hop aroma quality and intensity. When using hops with high HSI values, careful calculations of hop dosages is necessary.

Many thanks to Weihenstephan Research Brewery for brewing the beers, good advice from my colleagues and to Barth Innovations, Ltd. for letting me publish this work.