

Oxidative storage conditions influence the aroma & flavor of Hallertauer Mittelfrüh in dry-hopped lager beer

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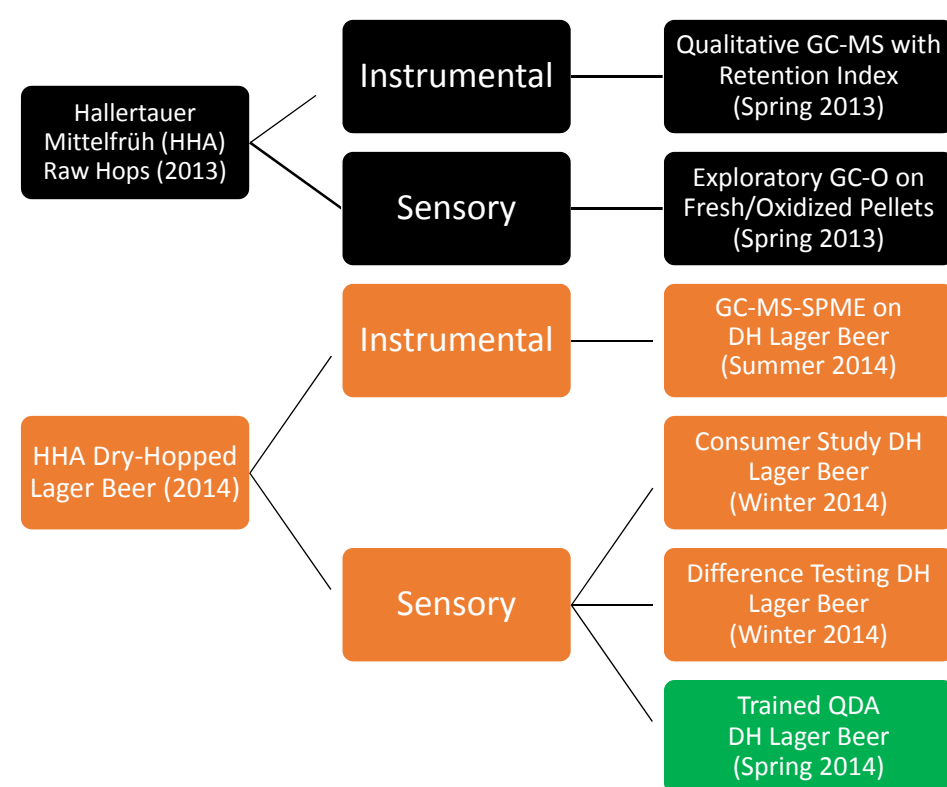
Background & Justification:

Previous work by Peacock et al. (1980) acknowledges the impact of oxidized hop compounds as they contribute to noble hop aroma. Our recent work in 2013 showed that the chemical & aroma profile of Hallertauer Mittelfrüh (HHA) hops changed upon storage under pro-oxidative conditions. This exposure to pro-oxidative conditions led to an increase in the oxygenated fraction of hop aroma compounds and a generalized decrease in the hydrocarbon fraction. This project investigated whether oxidized HHA hops used for dry hopping in a lager beer would impact the qualitative attributes of total hop aroma in the finished beer using sensory analysis techniques.

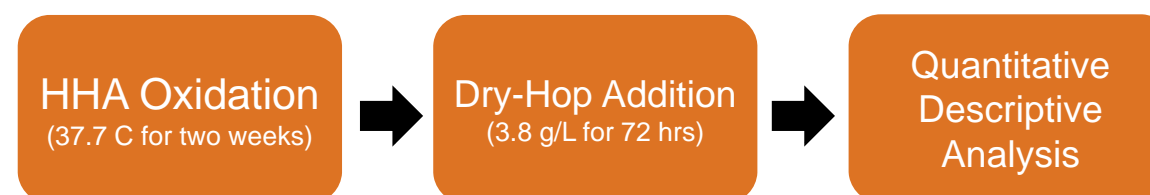
Study Objectives:

1. Establish if the beer aroma changes when oxidized HHA is used as a dry-hop
2. Characterize the qualitative changes that occur as a result of using oxidized dry-hops

Project Flow Chart:



Experimental Method:



HHA Oxidation:

- properly stored** HHA hops (stored in gas-flushed, high barrier bags at -20° C)
- oxidized** HHA hops (exposed to O_2 at for 2 weeks at 37.7° C - resealed)
- super-oxidized** HHA hops (container was opened, 30 grams were removed daily and the headspace was refreshed with pure O_2 daily, stored at 37.7° C for two weeks).

Dry-Hop Addition:

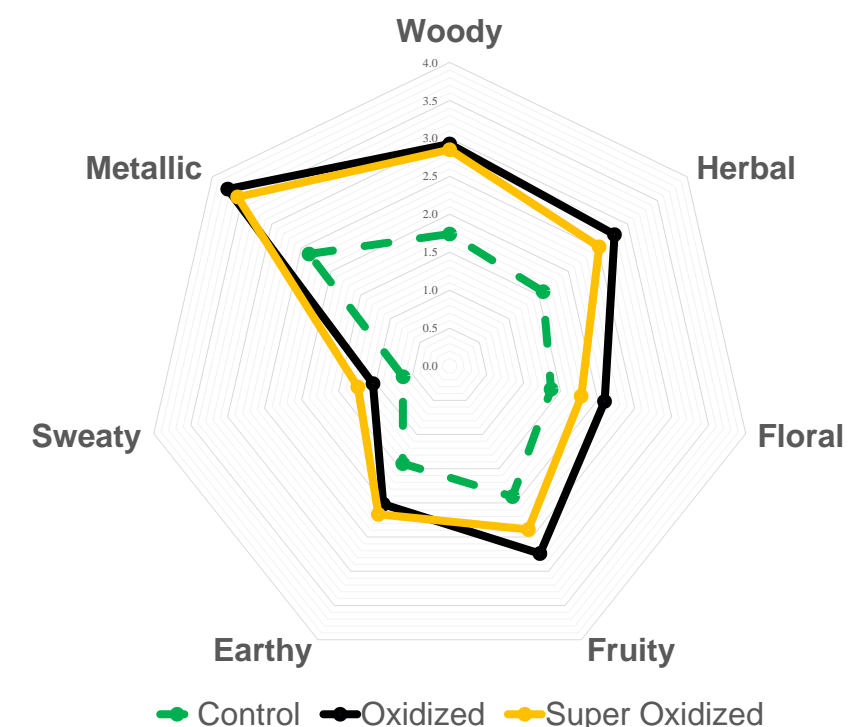
Unhopped lager was brewed in the Oregon State pilot brewery (66% GW 2-row, 32.5% Clearsweet-95, 1.5% Acidulated Malt) and fermented with lager yeast (Wyeast 2124). Lager beer was divided into 18 L portions where the differently treated dry-hops of the Hallertauer Mittelfrüh (HHA) variety were added. HHA Hops were placed in weighted, sealed synthetic cheesecloth bags. Cheesecloth bags with hops were placed into high barrier pouches, purged with N_2 and sealed until the dry hop addition. Hops were dosed into the unhopped lager at a rate of 3.8 g/L (1 lb/barrel) and were allowed to remain in the beer for 72 hours. After the exposure time, the beers were filtered using a plate and frame device with HS2000 filter pads (Pall Corp. Port Washington, NY) and were carbonated and served using draft dispense for sensory evaluation.

Quantitative Descriptive Analysis

Nine trained panelists who have extensive experience evaluating hop aroma and flavor were asked to evaluate the lager beers, dry-hopped with a range of different Hallertauer Mittelfrüh hops. Prior to data collection two intensive training sessions were conducted to develop a lexicon that best described the beer attributes. During evaluation, panelists were provided with 75 mL of dry-hopped beer during each of six sessions over three days. Presentation order was randomized across all panelists and samples were labeled with three-digit random codes. Within each session, all treatments were observed by all panelists. Using a 7-point categorical scale, panelists were asked to evaluate the following aroma attributes: *Woody*, *Herbal*, *Floral*, *Fruity*, *Earthy*, and *Sweaty* along with the flavor attributes: *Bitterness Intensity* and *Metallic*. Statistical analysis was completed using Minitab 16 (State College, PA) Quantitative Descriptive Analysis results were assessed using a three-way analysis of variance. Factors included in the analysis of variance were as follows: sample, panelist, replication, and all two-way interactions.

Results:

HHA Dry-Hopped Lager Beer



Spider graph illustrating the differences in mean attributes across the three treatments

Mean values of attributes across three different dry-hop preparations in lager beer. Standard Deviations are below in parentheses

Attribute	Control	Oxidized	Super Oxidized
Woody*	1.74 (1.47)	2.93 (1.64)	2.85 (1.63)
Herbal*	1.57 (1.38)	2.78 (1.97)	2.52 (1.87)
Floral ^{NS}	1.37 (1.26)	2.09 (1.40)	1.78 (1.31)
Fruity ^{NS}	1.91 (1.23)	2.74 (1.51)	2.39 (1.46)
Earthy ^{NS}	1.43 (1.28)	2.02 (1.27)	2.17 (1.54)
Sweaty ^{NS}	0.63 (1.10)	1.04 (1.35)	1.24 (1.30)
Metallic***	2.37 (1.34)	3.74 (1.23)	3.57 (1.41)
Bitterness Intensity*	1.22 (1.71)	1.87 (1.71)	2.06 (1.97)

*, **, *** Attributes are significant at $p < 0.05$, $p < 0.01$, and $p < 0.001$. NS attributes are not significant ($p > 0.05$).

Discussion:

Each sample was observed 54 independent times (6 reps x 9 panelists) during the quantitative descriptive analysis. Results indicate the beers prepared with oxidized HHA hops were significantly different than the control for the attributes: *Woody*, *Herbal*, *Metallic*, and *Bitterness Intensity*. The control sample was rated lower across all of the evaluated attributes compared to both oxidized treatments. Interestingly enough, the oxidized sample had higher mean ratings than super-oxidized sample in the attributes *woody*, *herbal*, *floral*, and *fruity*; showing that replenishing the headspace with O_2 on a daily basis resulted in no difference in those particular attributes. This relationship can be observed on the spider graph showing that the two treated samples (**oxidized** and **super-oxidized**) differed only slightly across almost all of the attributes.

Beers prepared with oxidized hops are qualitatively different than those made with hops that had been stored properly. This experiment illustrates the means to impart hop derived nuance into lager beer by manipulating the storage conditions of the hop material. Surprisingly the qualitative changes that occur as a result of exposing the hops to pro-oxidative conditions did not adversely impact the dry-hopped beer. As the craft beer industry flourishes both globally and in the United States, nuances contributed by raw ingredient handling can help brewers to diversify their product offerings.

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