Study of Yeast POF Character Impact on Hop Flavor Expressions in Hoppy Beers

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ABSTRACT

Yeasts may play a unique role in heavily hopped beers from different perspectives. To evaluate the impact of different yeast strains, two types of trials at pilot scale were performed: one with a New England IPA type beer and another with a brut IPA type beer. In both trials, POF+ yeast strains produced higher amounts of phenolic flavors, which were

perceived by the trained assessors. Along with it, a reduced overall intensity perception of the entire hop expression was noticed. The high dosage of fruity hops added in later stages in these IPA beer types is not enough to cover the perception of phenolic flavors, even when below the threshold level.

In the 150 years since Louis Pasteur published *Études sur la Bière*, brewers have acquired a much greater understanding of the diversity of brewer's yeasts, but little has been explored with regard to the interaction of yeast and raw materials such as hops. By thoughtfully choosing yeast strains, brewers can accentuate the fruity flavor profile found in heavily hopped beers with tropical and citrus aromas.

New and heavily hopped beer styles have emerged recently, such as the new members of the India pale ale (IPA) beer family. Examples of hazy IPAs (or New England IPAs) and brut IPAs have been quickly spread on beer shelves—and, although there is plenty of information about hop variety recommendations, little is known about the most appropriate yeast type to produce these kinds of beers. Yeasts may play a unique role in heavily hopped beers from different perspectives: (1) transforming and releasing bound hop components by biotransformation; (2) producing fermentative fruity aromas that support or act synergistically with the perception of hop fruity flavors; and (3) producing fermentative compounds that negatively affect the overall perception of hop flavors. In the midst of several yeast-derived flavor-active compounds, fruity acetate and ethyl esters may be crucial, but so too are other powerful flavor compounds with low flavor thresholds, such as sulfur and phenolic compounds.

An important aspect of beer yeast strains is their difference in phenolic off-flavor (POF) gene expression. Some yeast strains have a specific enzyme that decarboxylates phenolic acids present in beer wort, such as ferulic acid and cinnamic acid, producing flavor-active compounds such as 4-vinyl-guaiacol and 4-vinyl-phenol, respectively. These components produce clovey, spicy, woody, or medicinal-like flavors and, depending on the concentration, may add complexity in some ales but also can impact the perception of other flavors. Thus, this work aims mainly to eluci-

date the impact of POF+ yeast strains on the hop flavor expression in hoppy beers.

Methodology

To evaluate the impact of different yeast strains, two types of trials at pilot scale were performed: one with a New England IPA type beer and another with a brut IPA type beer (Table 1). In both trials, 4 hL of each single batch of wort was divided into 50 L sterile cylindroconical tanks, and the only parameter changed was the yeast strain. All beers were pitched with active dry yeasts at 50 g/hL and fermented at 23°C. Fermentation performance (attenuation by Anton Paar), volatiles (GC-MS), and sensory analysis (by quantitative descriptive analysis with the average of 18 trained panelists) were performed.

Discussion and Conclusion

Fermentation performances and volatile profiles for all studied conditions are shown in Table 2.

As expected, the yeasts produced different ratios of important flavor components, which differed for each yeast strain as well as for the same yeast strain in the two beer matrices studied (New England and brut IPA: cases of SafAle S33, K97, Be256, S04, and US05).

In both trials, POF+ yeast strains (HA-18, BE-134, and T58) produced higher amounts of phenolic flavors, which were perceived by the trained assessors (Figs. 1 and 2). Along with it, a “reduced” overall intensity perception of the entire hop expression was noticed.

In conclusion, the high dosage of fruity hops added in later stages in New England IPA and brut IPA beer types is not enough to cover the perception of phenolic flavors, even when below the threshold level (0.3 ppm). In addition, it was perceived that fruity POF– yeasts such as SafAle S33, S04, and K97 played a bigger role in the overall fruity perception of hopped beers.

The next steps of this work are to investigate which of the evaluated fermentation components are the most important for the overall fruity-hop flavor perception, as well as to evaluate

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the possible activity of the yeast to metabolize hop components by biotransformation and lastly to better understand the masking effects of phenolic flavors.

In addition, the fermentation flavoring components produced by the yeasts must not be underestimated in heavily hopped beers. Phenolic flavors may act as a masking effect in a hopped beer in

Table 1. Pilot-scale trials conducted

Trial	Original gravity	Wort composition	Hops and hop regimes	Yeasts
NE IPA	16°P	Pils malt (80%), wheat malt (10%), and oats (10%)	Hop varieties: Simcoe, Mosaic, and Citra Hop additions: whirlpool, fermentation days 2 and 4, and maturation Total amount: 1 kg/hL	SafAle S33 SafAle S04 SafAle US05 SafAle K97 SafAle BE256 SafAle BE134* SafAle T58* SafLager S189 SafLager S23
Brut IPA	13°P	Pils malt (85%), saccharose (15%), and amyloglucosidase (50 g/hL)	Hop varieties: Cascade, Mosaic, and Citra Hop additions: whirlpool Total amount: 700 g/hL	SafAle BE256 SafBrew HA18* SafAle K97 SafAle S04 SafAle S33 SafAle US05

^a Asterisk (*) indicates POF+ yeasts. NE = New England.

Table 2. Fermentation and volatile profiles of New England (NE) IPA and brut IPA beers with different beer yeast strains

Yeast	TFT	Alc	ADF	Dia	4-VG	n-P	EA	IB	2-MB	3-MB	IBA	EB	IAA	EH	PAIc	EO	PAc	ED	S_Alc	S_Est
Brut IPA																				
BE256	48	8.8	106.4	2.62	0	10.4	37.2	25.7	14.99	108.9	0.224	0.1272	3.678	0.31	22.6	0.3818	1.022	0.11161	182.6	43.1
*HA18	48	8.9	106.2	5.37	0.177	8.7	36.3	23.9	9.37	153.6	0.237	0.2047	2.31	0.685	19.6	0.4449	0.913	0.07971	215.2	41.2
K97	48	8.7	106.1	3.33	0	9.8	38.6	15.3	11.24	106.2	0.157	0.1458	2.782	0.314	21	0.4342	0.839	0.05519	163.5	43.3
S04	48	8.8	107.0	6.07	0	9.5	26.7	31.3	13.1	109.7	0.324	0.1394	3.682	0.302	21.2	0.4221	1.423	0.14801	184.8	33.1
S33	48	8.7	105.2	3.08	0	11.2	51.7	19.2	10.58	129.2	0.265	0.2579	3.791	0.797	21	0.6616	1.237	0.18596	191.2	58.9
US05	96	8.7	106.1	10.28	0	9.1	22.9	15.6	10.21	77.3	0.068	0.1864	0.886	0.388	19.5	0.6886	0.309	0.12234	131.7	25.5
NE IPA																				
S33	144	5.9	75.0	8.52	0.169	39.8	48.9	31.5	13.17	107.5	0.176	0.149	2.42	0.962	56.4	0.213	0.569	0.047	248.4	53.4
S04	144	6.6	84.6	85.7	0.165	37.1	57.5	43.6	16.21	132.7	0.191	0.156	2.52	1.159	61.1	0.296	0.584	0.065	290.7	62.5
US05	144	7.5	89.1	98.49	0.112	30.8	46.4	35.2	12.03	94.8	0.099	0.32	1.37	0.586	25.8	0.304	0.205	0.024	198.6	49.3
K97	144	7.4	89.6	14.57	0.147	28.7	59.1	30.9	17.14	130.9	0.081	0.192	2.32	1.327	56.1	0.304	0.442	0.049	263.7	63.8
BE256	144	7.6	90.0	13.39	0.131	24.6	56.1	53.4	20.13	143.4	0.227	0.158	3.41	0.638	65.1	0.262	0.807	0.071	306.6	61.7
*BE134	144	8.0	93.7	7.98	0.262	32.7	74.8	35.6	11.77	126.8	0.229	0.402	3.21	0.733	45.9	0.378	0.64	0.072	252.8	80.5
*T58	144	6.9	80.9	19.93	0.201	32.1	62.9	38.8	16.21	152.2	0.226	0.247	3.46	0.828	47.6	0.313	0.497	0.061	286.9	68.5
S189	144	7.6	88.2	15.3	0.118	13.8	49.9	18.0	10.4	113.2	0.073	0.135	1.48	0.566	35.8	0.246	0.367	0.028	191.2	52.8
S23	144	7.6	87.6	13.97	0.114	12.9	47.9	14.6	9.23	117	0.063	0.153	1.47	0.588	35.6	0.266	0.375	0.034	189.3	50.8

^a Asterisk (*) indicates POF+ strain. Column headings: TFT = total fermentation time (h); Alc = alcohol (v/v%); ADF = apparent degree of fermentation (%); Dia = diacetyl (ppb); 4-VG = 4-vinyl guaiacol (ppm); n-P = n-propanol (ppm); EA = ethyl acetate (ppm); IB = iso-butanol (ppm); 2-MB = 2-methyl-butanol (ppm); 3-MB = 3-methyl-butanol (ppm); IBA = isobutyl acetate (ppm); EB = ethyl butanoate (ppm); IAA = isoamyl acetate (ppm); EH = ethyl hexanoate (ppm); PAIc = phenylethyl alcohol (ppm); EO = ethyl octanoate (ppm); PAc = phenylethyl acetate (ppm); ED = ethyl decanoate (ppm); S_Alc = sum of alcohols (ppm); and S_Est = sum of esters (ppm).

Figure 1. Sensory analysis of New England IPA.

Figure 2. Sensory analysis of brut IPA.

which intense fruity flavors are expected, and in this scenario not necessarily neutral yeast strains must be the most appropriate choice for hoppy beer styles. The amount and/or variety of fruity

compounds derived from fermentation as a consequence of the metabolism of a given yeast strain must be considered as an elementary factor for overall fruity flavors in hopped beer.