Wheat Beer Yeast and Fermentation

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WHEAT BEER YEAST AND FERMENTATION

- Flavors and Aromas
- Brewing Techniques

TASTE AND AROMA

Wheat beers are characterized specifically by:

‘spicy’

‘clove’

‘phenolic’

And generally as with other beers by different levels of:

‘fruity’

‘banana’

‘floral’

‘sulfury’

& others

The unique flavor of Wheat Beers comes from alcohols, esters, phenols as well as other compounds.

PRIMARY, SECONDARY AND TERTIARY FLAVORS

$$FU = \frac{\text{concentration in beer in mg/l}}{\text{threshold in mg/l}}$$

2 FU =	Primary Flavor
0.5–2.0 FU =	Secondary Flavor
< 0.5 FU =	Tertiary Flavor

HIGHER ALCOHOL PRODUCTION
FROM THE LITERATURE

- Mainly produced during Primary fermentation
- Fusel alcohols are produced through the metabolism of amino acids
- Fusel alcohols are those other than ethanol
- Common examples are isoamyl alcohol and phenyl ethyl alcohol
- Increase complexity and fullness of beer at low level; harsh at high levels

HIGHER ALCOHOLS IN WHEAT BEERS
FROM THE LITERATURE

Higher alcohols: :	Avg value(ppm)	Characteristic Flavor or Aroma	Threshold
1-propanol	18.80	fusel, solvent-like	?
2-methyl-1-propanol	36.50	alcohol, solvent-like	10-200 ppm
2-methyl-1-butanol (amyl alcohol)	20.10	alcohol, solvent-like	10-65
3-methyl-1-butanol (isoamyl alcohol)	58.00	alcohol, banana	30-70
phenyl ethyl alcohol	33.0	rose or rose oil	28-135

ESTER PRODUCTION
FROM THE LITERATURE

- Acetate ester excretion is rapid and complete after yeast growth complete
- Fatty acid ethyl esters take longer to produce
- Formed as a by-product of acetyl CoA and alcohols
- Most ale yeast produce lower levels of esters compared to lager yeasts under similar fermentation conditions
- Common examples are ethyl acetate, isoamyl acetate and ethyl hexanoate

ESTERS IN WHEAT BEER
FROM THE LITERATURE

Ester:	Avg value(ppm)	Characteristic Flavor or Aroma	Threshold value
Ethyl acetate	32.0	solvent-like (acetone),	25-30
Isoamyl acetate	3.00-4.00	very fruity, banana	1.0-1.6
Hexanoic acid ethyl ester (ethyl caproate)	0.12	fruity, apple	
Octanoic acid ethyl ester (ethyl caprylate)	0.25	fruity, winy	
Decanoic acid ethyl ester (ethyl caprate)	0.05	fruity, winy	
Phenyl ethyl acetate	0.98	rose	

OTHER ESTERS

Ester:	Characteristic Flavor or Aroma	Threshold value (ppm)
Ethyl heptanoate	fruity, pineapple	
Ethyl butyrate	grape, apple	0.4
Isobutyl acetate	fruity, banana	0.4-1.6

PHENOL PRODUCTION
FROM THE LITERATURE

- Increase in phenols follows the main and secondary fermentations
- Phenol-carbon acids are decarboxylated into phenols by yeast
- Weizen beer yeast can decarboxylate ferulic acid into 4-vinyl guaiacol
- Ferulic acid production occurs most successfully in mashing at 44 C and pH 5.7

PHENOLICS IN WHEAT BEERS
FROM THE LITERATURE

Phenolic substances:	Avg value(ppb)	Characteristic Flavor or Aroma (threshold)
4-vinyl guiacol	1500	clove-like(~1000ppb)
4-vinyl phenol	970	phenolic
4-hydroxy benzaldehyde	125	phenolically bitter
phenol	40	phenolic, cresol-like
4-vinyl syringol	310	smoky aroma and flavor
guaiacol	120	phenolic, medicinal, smoky
vanillin/acetovanillon	153	vanilla
eugenol	70	phenolic
isoeugenol	38	clove-like, nutmeg-like
styrene		resiny, plastic-like, harsh

OTHER FLAVOR COMPONENTS
FROM THE LITERATURE

Flavor component:	Avg value(ppm)	Characteristic Flavor or Aroma	Threshold value
Beta-damascenone		dried fruit, rose	
Maltol		sweet	
DMS	42.0 ppb	cooked vegetable	50.0-80.0 ppb
Diacetyl	0.04	butterscotch	0.10-0.15
Acetaldehyde	0.40	acidic, pungent, sharp	10

Ester Production is supported through

- Increasing the wort concentration above 13%
- Increasing the ADF
- Decreasing wort aeration
- Increasing fermentation temperatures
- Decreasing hydrostatic pressure during fermentation (shallow fermenters)

Dr. Narziss

16th Technological Seminar at Weihenstephan 1983

Fermentation

- Pitching Rate 12-18 million cells/ml
- Starting Temperature 12-15 C (lower starting temps more common when starting tank is used to settle cold trub and then transfer to fermenter before start of fermentation where free rise occurs)
- Max temperature 18-22 C
- Main fermentation is 2-4 days
- Maximum Cell count is 60-80 million

Bottle Conditioning

- Lager yeast is less likely to autolyze and settles better
- If top-fermenting yeast is used, shelf life should be limited to 4-6 weeks

Fermenter Shape

- Cylindrical tanks produce only 2/3 the esters of shallow open fermenters
- Horizontal tanks perform like open fermenters

H. Kieninger et al

Monatsschrift fuer Brauwissenschaft, Vol 37, January 1984

- Selection of yeast strain exercises a large influence on phenol production
- Small test fermentations at 15, 20 and 25 C indicated that both 4VG and 4VP reached a maximum at 20 C. Levels of both showed declines after main fermentation through bottle conditioning and lagering

<u>From observations at 5 different weizen production breweries:</u>

- Cylindrical fermenters - CO2 evolving through deeper tanks comparatively to open fermenters scrubs more flavor compounds
- Flotation without yeast – Flotation with the yeast produces more phenols than without
- DE filtration reduces 4VG and 4VP, presumably the low molecular phenols are attached to the larger protein and phenol compounds removed by filtration
- The use of wort(speise) to prime the beer for secondary fermentation increase the phenol content

F. Nitzsche
Investigations into Optimizing Wheat Beer Quality
Brauwelt, Vol 32, 8 Aug 1991

- The taste and smell threshold is 0.8 mg of 4VG/L
- 4VG levels over 2 mg/L bring a strong/severe character to the beer
- The fact that the levels of ferulic acid can fluctuate widely in malt can effect the levels of 4VG in beer
- As a rule, wheat malt has less ferulic than barley malt
- The highest levels of 4VG occur after the final limit of attenuation is reached
- More 4VG is present when the final limit of attenuation is reached in 4 days as opposed to 2 days
- The levels of 4VG don't decrease significantly with the age of the beer, although other staling by-products may cover up the taste of 4VG

Pitching Rate and Aeration

- Under pitching may increase esters

- Many breweries pitch 5-10 million cells/ml
- Pitch 15-20 million cells/ml for Weizenbocks

  - Yeast cells double more times at warm temps
  - Yeast growth promotes higher ester production

- Under aeration may increase esters (some aerate only 50% of knockout)

OBSERVATIONS BY HANS PETER DREXLER (SCHNEIDER) ON WEISSBIER

- Longer the rest at 44˚C, the higher the 4-V-G (clove phenol)
- Low Kolbach index (≤ 38%) for wheat and barley needed for estery beer
- Removal of cold break creates neutral taste and is not necessary
- Open fermenters increase esters
- Bottle conditioning increases phenols
- O_2 reduction at bottling important

Open fermentation

•Some Bavarian brewers have switched to cylindroconical fermenters

•Many of these brewers pitch fresh yeast every batch

•Pitching fresh yeast every batch common; many smaller breweries borrow culture from larger breweries

•Open fermenters still common for Weissbier, brewpubs, and traditional Bavarian lager breweries

•Open fermenters allow the brewer to remove/skim the hop resins carried by yeast to the surfice from 12-24 hours after pitching

•Then the yeast crop is harvested by skimming at high krausen 24-36 hours after pitching

SCHNEIDER YEAST PROPAGATION PLANT

WEISSBIER FERMENTER
SCHNEIDER

FERMENTATION AND CONDITIONING

- After 2-4 days fermenting, the green beer is cooled and conditioned 1-4 weeks
- Cooling temperature depends on if weizen yeast or lager yeast will be used for bottle conditioning
- Conditioning is normally done in horizontal tanks
- Some beers are filtered before being bottle conditioned with fresh yeast
- New yeast, speise and new yeast is sometimes mixed in a mixing tank before bottling

OPEN BREWPUB FERMENTERS FLIEGERBRAEU, MUNICH

SCHONRAM OPEN FERMENTERS

BOTTLE CONDITIONING

BOTTLE CONDITIONING

- Speise is added to raise the specific gravity by 1.004-1.006 depending on the final desired CO2 levels
- Timing can be difficult to collect wort for speise
- Krausen beer can be used for priming either from another batch of weissbeer or from a lager fermentation
- Bavarian brewers with local distribution tend to use weizen yeast for bottle conditioning
- Weizen yeast need warm conditioning (20-25 C) for 2-5 days then transferred to a cold box

FREILASSING

SMALL OPEN WEISSEBIER FERMENTER

HACKER-PSCHORR BREWPUB

PAULANER BREWPUB

SCHNEIDER WEISSE ORIGINAL

KELHEIM

Malt:	60% wheat malt, 40% pale barley malt (color comes from <1% carafa)
Water: Grist	Ratio: 5.5 to 1 (very liquid)
Mash (2 decoctions)	35°C, mash in
	44°C, 10-15 min (ferulic acid → 4VG)
	52°C, protein rest
	62°C, gelatinize
	72°C, saccharification
	Mash off
Lautering	3.5 hr
Boil	58 min @ ??°C with external calandria
Hops	12 IBU
Whirlpool	
Knockout	12.8°P @ 16°C
Aeration	5 mg of O_2 in-line
Yeast	proprietary yeast @ 4-7MM cells/ml (don't reuse yeast – top crop)
Primary	? Days @ 16-24°C in open fermenters – fully attenuated
Bottle Conditioning	centrifuge to drop yeast count to 0.3 to 0.5MM cells/ml
	cool beer to 2.5g CO_2/L (8˚C)
	Mix Speise in tank for 6.5g CO_2/L (3.2 CO_2 v/v)
	Fob bottles after filling
	1 week @ 20˚C, then 2 week @ 10˚C

HEFEWEIZEN BEER
DOEMENS AKADEMIE

OG	12 to 13˚P
BU	≈ 13
ADF ≈ 80%	
C02	≥ 6g/L
Malt	60% Wheat, 38% Pale barley, 2% Sauermalz
Water: Grist 3.75:1	

Temperature (˚C)	Rest (min)	Comment
45	20	Precursor ferulic acid for 4VG formed
50	10	by direct heat to mash tun
62	10	After 10 min. pull 1st decoction
decoction	in 10 min	raise to 72˚C, hold 15 min, then boiling for 15 min
72	15	Add decoction to raise main mash to 72˚C
78	--	Transfer to lauter tun

Hops	Hallertau Perle pellets, one addition 10 min after start of boil
Ferment	at ≈ 20˚C until fully attenuated,
Bottling	add Speise held back from brew day, and condition at room temperature

HEFEWEIZEN
(SMALL BAVARIAN BREWER)

OG	12.4%
BU	na
H_2O treatment	none
Malt	56% wheat, 28% pale barley, 12% Munich, 4% Caradunkel; Farbebier equal to 1.5% added to kettle
Mashing	(1 decoction)

Temperature (˚C)	Rest (min)	Comment
45	15	Mash in
52	5	Optional, may begin heating immediately to next rest
62	20	Pull decoction, boil 20 min, add back for next rest
72	72	Optional, add decoction to raise main mash to 72˚C
75	--	Transfer to lauter tun

Lautering	2:20 hr total; 1:00 first runnings, 1:20 for 2 sparge additions
Boil	1:45 hr
Hops	1 addition of Hallertau Perle 10 min after boil start
Ferment	Cool to 16-17˚C in 65 min.

YEAST SELECTION

- **Weihenstephan 68** balanced ester/phenol profile **WL300**

- **Weihenstephan 175** moderately high, spicy, phenolic overtones reminiscent of cloves **WL351, W3638**

- **Weihenstephan 66** Subtle flavor profile for wheat yeast with unique sharp tart crispness, fruity, sherry-like palate **W3333**

  Large clove and phenolic aroma and flavor, with minimal banana. Refreshing citrus and apricot notes **WL380**

TIME TO ENJOY

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