

ASBC Annual Meeting

June 4–7 ■ Fort Myers, Florida

See what SCIENCE can brew for you

Impact of hop pellet processing in regard to the flavor contribution in beers late and dry hopped with US Cascade hops

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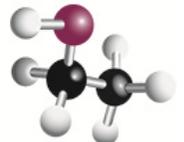
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Hop Product Advantages

- Easier handling:
Whole cone density: 100-150 kg/m³ (compared to 480-550 kg/m³ for pellets and 1,000 kg/m³ for CO₂ Extract)
- Better stability:
Whole cone undergo certain degradation reactions. Pellets are packaged in an inert gas atmosphere
- Increased homogeneity (e.g. alpha acid; oil content):
Prior to processing, hops are homogenized in the form of a powder
- Increased utilization:
Depending on the product and grade of enrichment, the utilization is improved

Background

- How does the grade of enrichment during processing affect known aroma compounds and sensory evaluations?
- Especially for dry hopped beers, linalool is not important
- Only very few and very expensive labs can analyse other aroma components other than the typical linalool, geraniol, citronellol, myrcene, caryophyllenoxide, etc.
- Nyseos is a french company specialising in wine aroma components, especially sulfur-containing aroma compounds



Why Type 90 and 45 and what does it mean?

What does Type 90 mean?

In old days of processing, it meant that 90% of the hop cone processed would end up in pellet form – the real names of today would be Type 93-97

What does Type 45 mean?

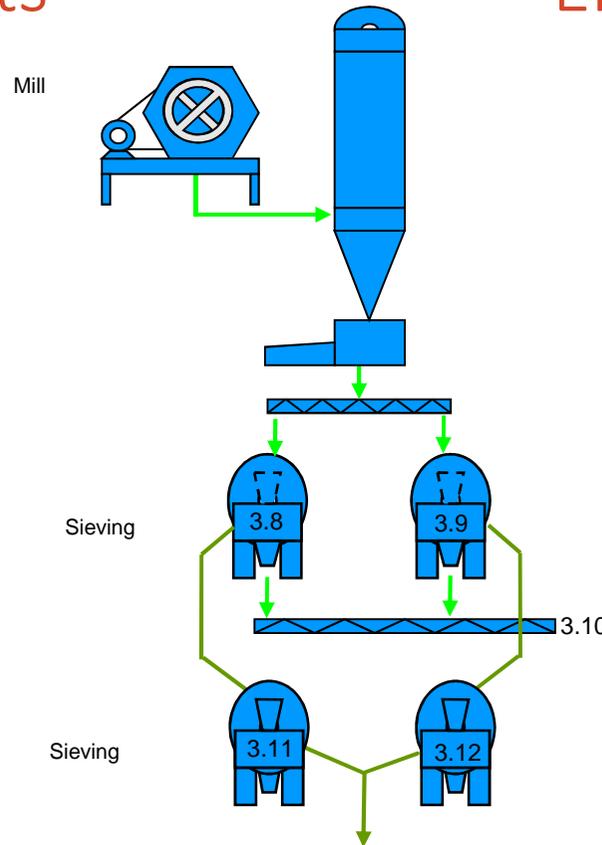
With the processing equipment located in a cold chamber and the possibility to enrich the alpha content, 45 refers to the double amount of alpha and oil in the pellet and the loss of vegetative material

This naming is **misleading** but in every brewers head!
There are simply hop pellets and enriched hop pellets.

The Pelletization Process

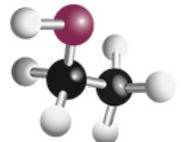
Normal Pellets

- Bale breaker
- Homogenization
- Magnet and gravity separator
- Drying
- Milling
- Powder Mixer
- Pelletisation
- Sieving
- Cooling
- Weighing
- Filling and Packaging



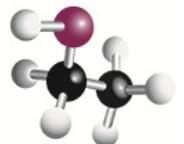
Enriched Pellets

- Milling and Sieving at $-35\text{ }^{\circ}\text{C}$ ($-31\text{ }^{\circ}\text{F}$)
- Separation of lupulin and spent hops by sieving
- Standardization to a certain α -acid/oil content by
- Removal of vegetative material



Background of trials

- Due to high level of hop dosage with normal pellets, we were expecting benefits to reduce vegetative material for better utilization and fewer beer losses
- We have seen with similar trials with Hallertau Mittelfrueh that aroma and flavor characteristics change significantly with the grade of enrichment
- Cascade is an important variety for the US craft brewers
- How does the enrichment in cascade pellets impact flavor and aroma in a dry hopped beer?



Hop Analysis

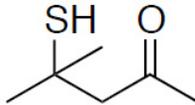
Details of the pellets used

Hop Product	Alpha %	Oil [ml/100g]
T90 Enriched	6.4	1.35
T90E Soft Pellet	6.4	1.35
T75	8.1	1.70
T55	11.1	2.45

Dosages	Dosage Bittering [g/hl]	Dosage Oil [ml/hl]	Dosage Dry/Whirlpool hopping [g/hl]	Total [g/hl]
T90 Enriched DH	104	8	593	647
T90 Soft DH	104	8	593	647
T70 DH	104	8	471	525
T45 DH	104	8	326	381
Control	54.8	0	0	54.8
T90 Soft WP	78.3	4	296	338
T70 WP	78.2	4	235	276
T45 WP	79.5	4	163	205

Varietal thiols: key aroma compounds of wine and beer

4MMP



4-mercapto-4-methylpentan-2-one

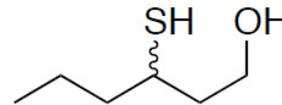
0,8 ng/L in wine / 1,5 ng/L in beer



Box tree, Blackcurrant bud

Du plessis et al., 1981; Darriet et al., 1991; Cosser et al., 1980

3MH



3-mercaptohexan-1-ol

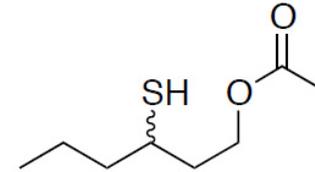
60 ng/L in wine / 55 ng/L in beer



'Exotic, Rhubarb' like, citrus

Tominaga et al., 1998; Kishimoto et al., 2006, Vermeulen et al., 2006

3MHA



3-mercaptohexyl acetate

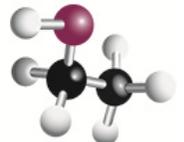
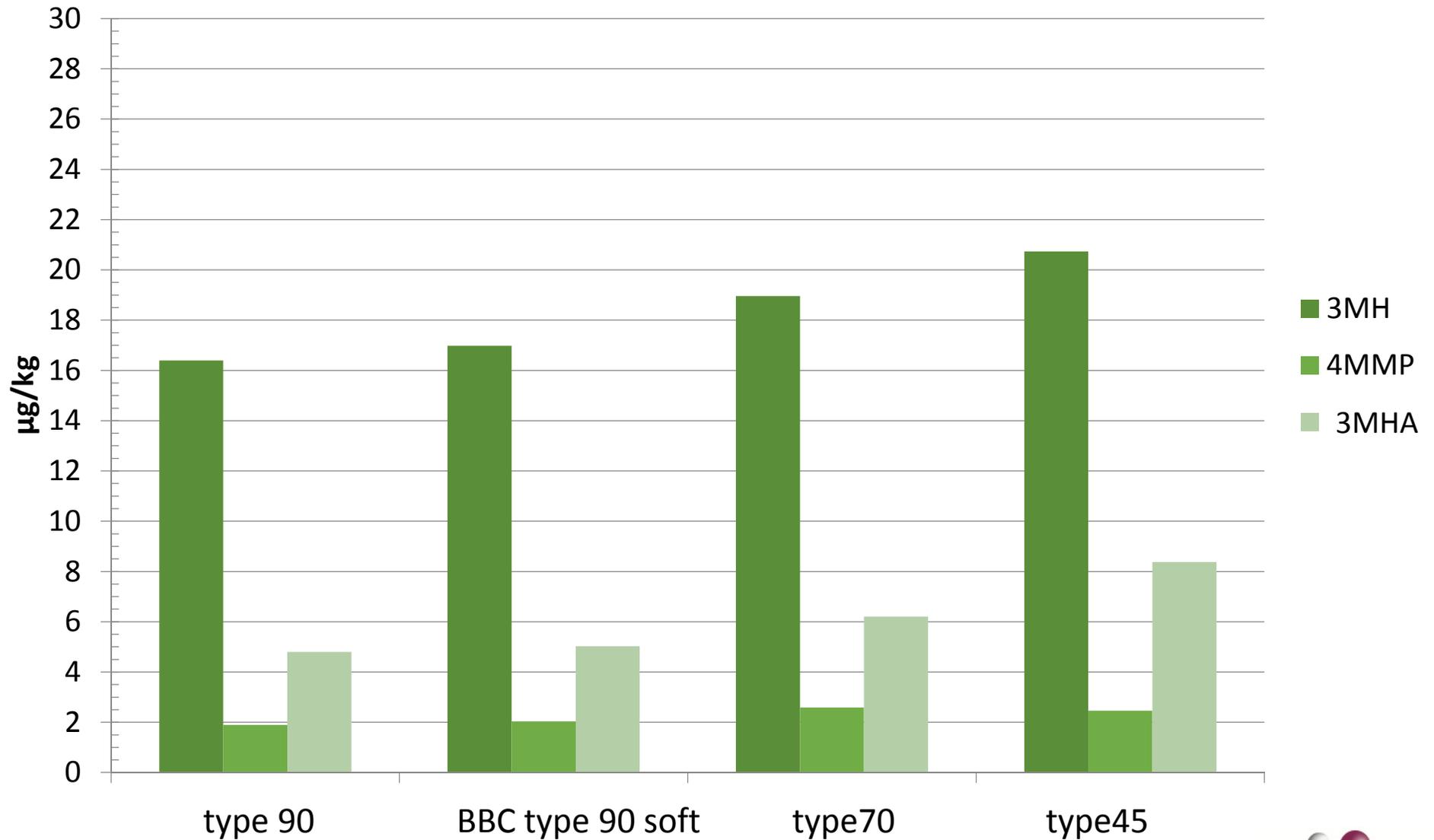
4 ng/L in wine/beer



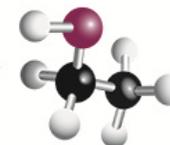
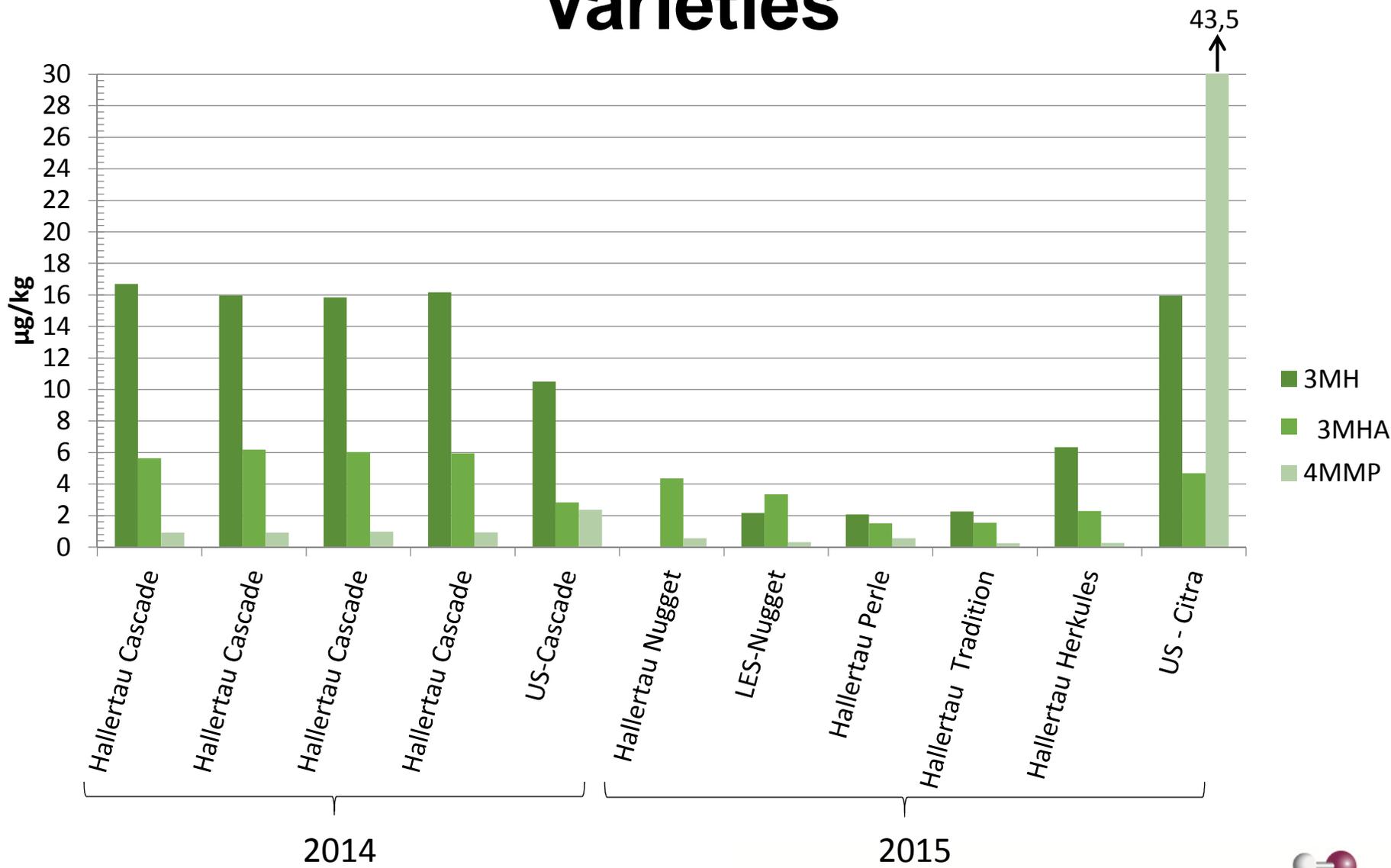
Goyava, Passion fruit



Analysis of different pellets



Sulfur Compounds in Different Hop Varieties



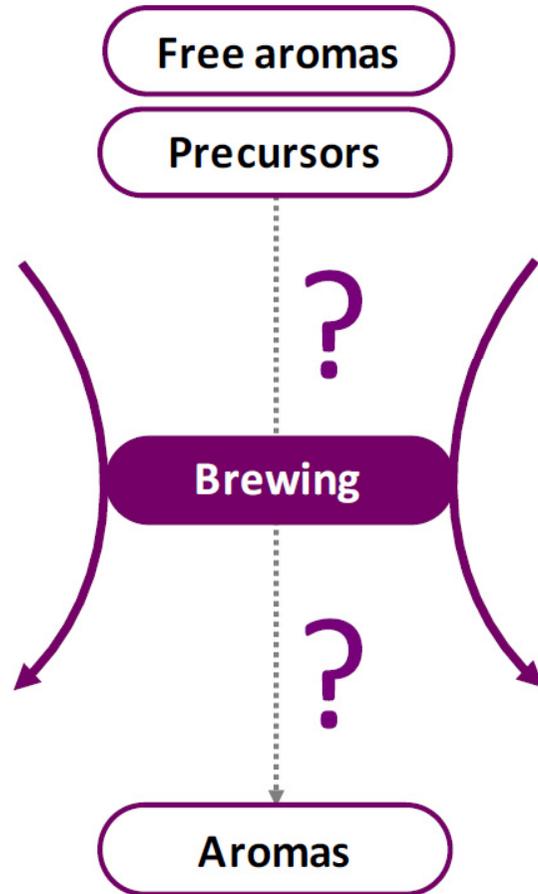
Beer Analysis

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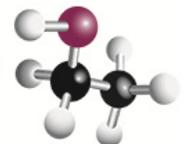
Beers Brewed

Trial Number		T90 Enriched DH	T90 Soft DH	T70 DH	T45 DH	Control	T90 Soft WP	T70 WP	T45 WP
Apparent attenuation	%	89.4	89.5	88.8	89.3	85.7	83.6	84.6	83.8
Alcohol (vol.)	%	5.35	5.22	5.29	5.26	5.05	5.05	5.09	4.93
Original Gravity	%	11.35	11.07	11.28	11.16	11.15	11.42	11.38	11.14
pH		4.61	4.64	4.66	4.64	4.64	4.67	4.73	4.68
Bitterness Units	EBC	34	34	35	35	21	25	24	25
Isohumulone	mg/L	17.6	17.8	18.8	19.3	21.4	16.5	16.7	17.5

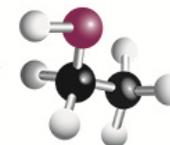
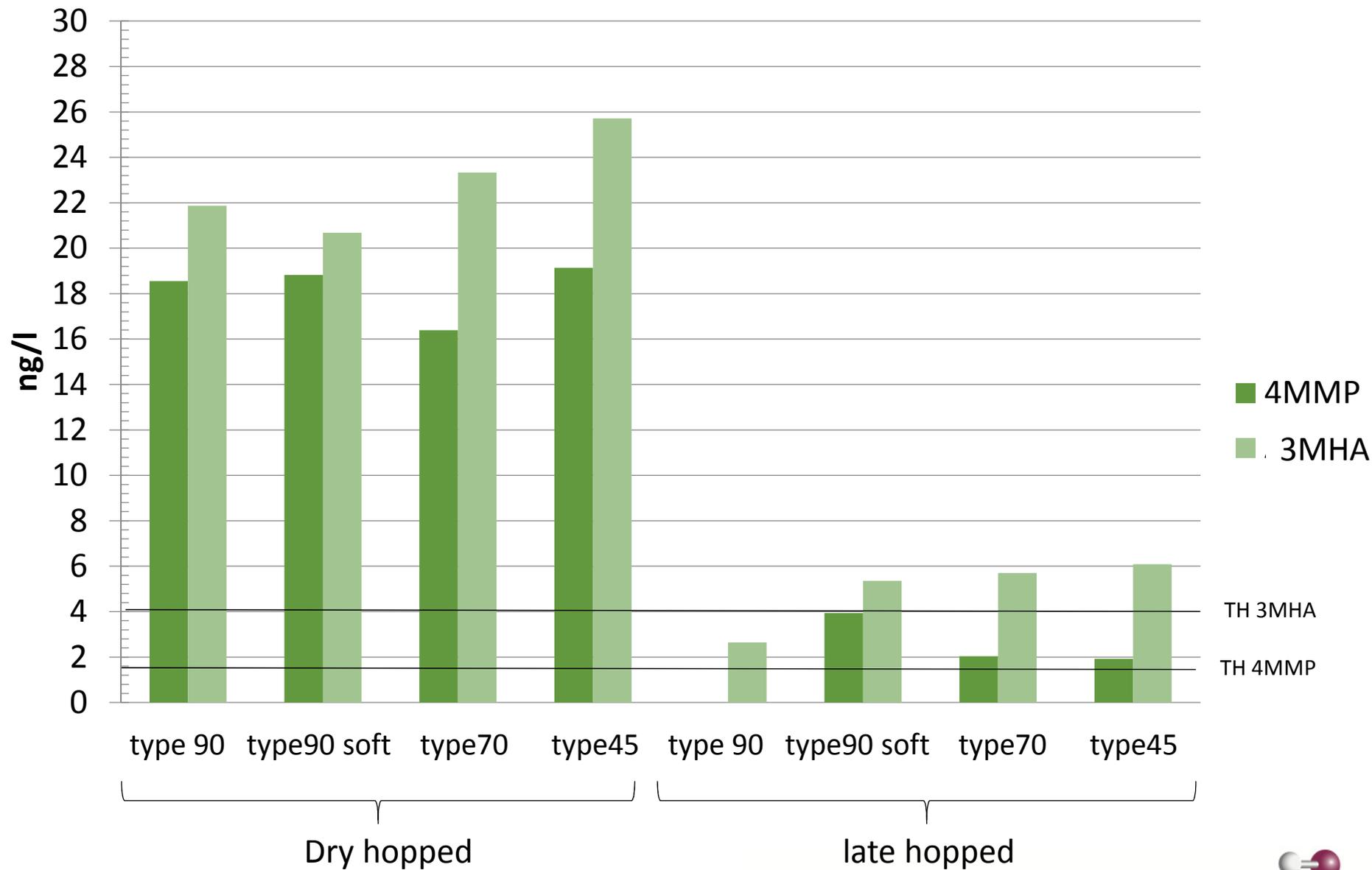
And for beer ?



- Identification of free thiols in hops
Kishimoto et al., 2008, Morimoto et al., 2009
- Hypothesis of other precursors in both malts and hops
Kishimoto et al., 2006; Gros et al., 2013
- S-cysteine conjugate
Gros et al., 2012
Cysteinylated precursor of 3MH formally identified in hops by HRMS
- Cleavage of S-cysteine conjugate into 3MH:
 1. During bottle refermentation *Nizet et al., 2013*
 2. Hypothetical dicarbonyl pathway *Hang Tran et al., 2015*



Aroma Analysis of the beers

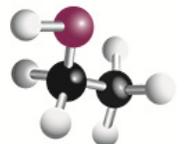
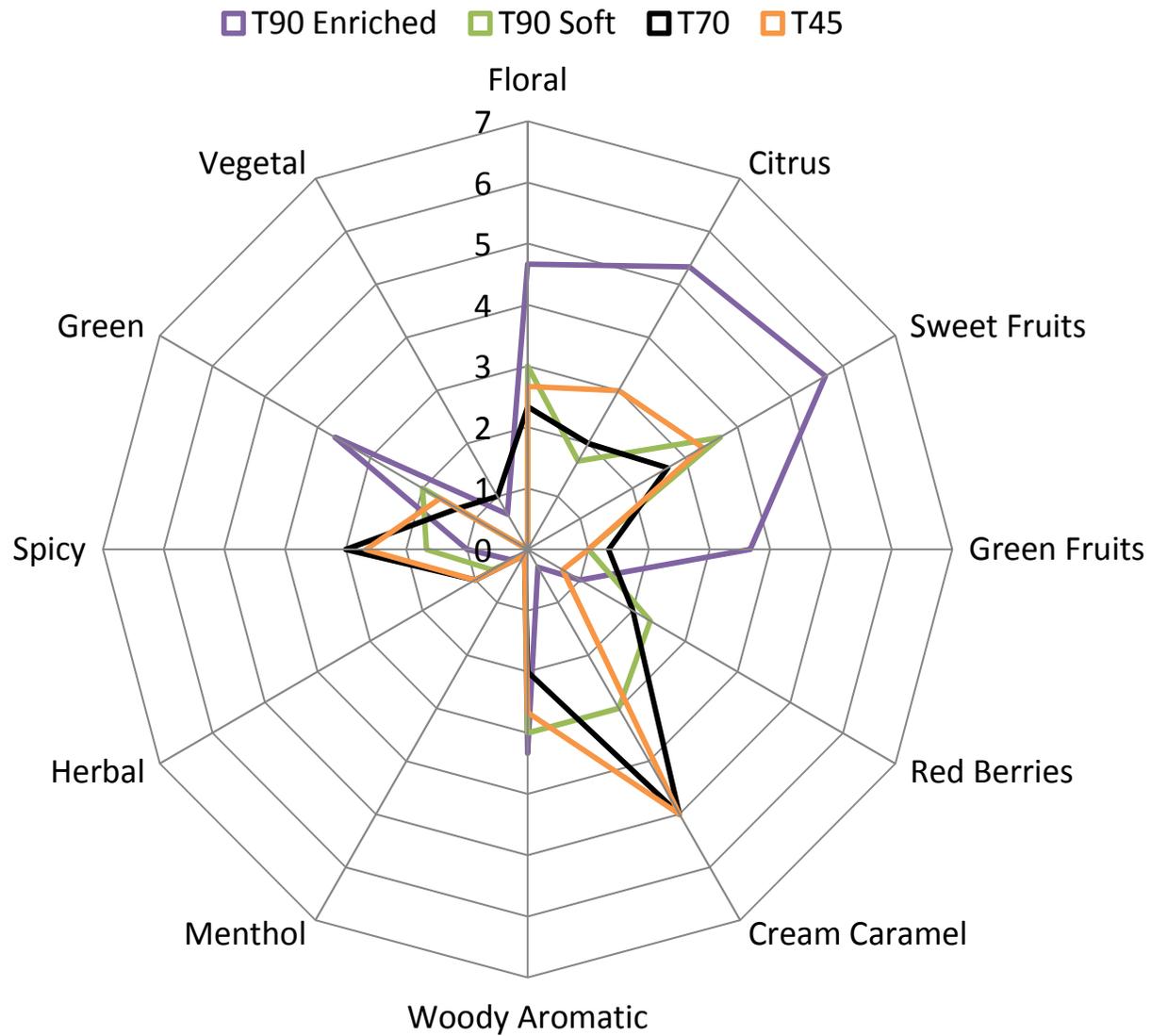


Barth Haas Group Tasting Scheme

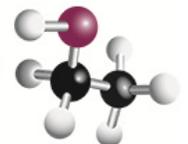
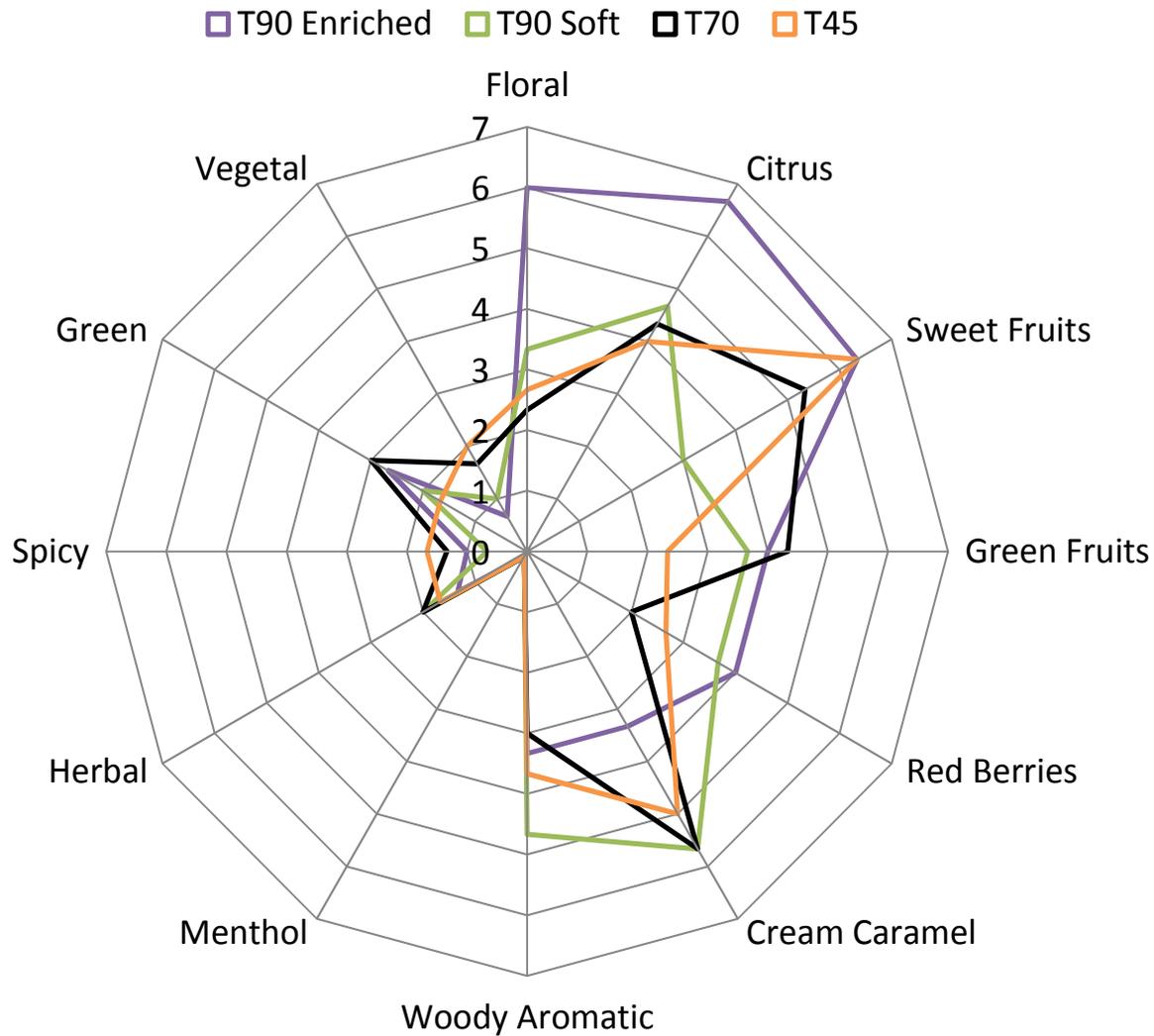
Descriptor	More detailed attributes
Floral	Elderflower, chamomile blossom, lily of the valley, jasmine, apple blossom, rose, geranium, carnation, lilac, lavender
Citrus	Grapefruit, orange, lime, lemon, bergamot, lemon grass, ginger, tangerine
Sweet Fruits	Banana, watermelon, honeydew melon, peach, apricot, passion fruit, lychee, dried fruit, plum, pineapple, cherry, kiwi, mango, guava
Green Fruits	Pear, quince, apple, gooseberry, white wine grapes
Red Berries	Cassis (black currant), red currant, blueberries, raspberries, blackberries, strawberries, wild strawberries, cranberries
Cream Caramel	Butter, chocolate, yoghurt, honey, cream, caramel, toffee, coffee, vanilla, tonka bean
Woody Aromatic	Tobacco, cognac, barrique, leather, woodruff, incense, myrrh, resin, earthy, cedar, pine
Menthol	Mint, lemon balm, sage, camphor, menthol, wine yeast
Herbal	Thuja, basil, parsley, tarragon, dill, fennel, thyme, rosemary, marjoram, green tea, black tea, mate tea
Spicy	Lovage, pepper, chili, curry, juniper, aniseed, nutmeg, liquorice, clove, ginger bread, fennel seeds, gingerbread
Grassy-Hay	Green-grassy, fresh cut grass, hay, tomato leaves, green peppers, nettle
Vegetal	Celery root, celery stalk, leek, onion, artichoke, garlic, wild garlic

Intensity Rating from 1-10

Whirlpool Hopped Beers



Dry Hopped



Terpenols

(ug/L)	a-terpineol	cis-rose oxide	citronellol	geraniol	linalool	nerol
T90 Enriched DH	19,20	0,70	47,49	398,86	270,24	9,17
T90 soft DH	24,52	0,71	63,37	494,52	265,31	12,08
T70 DH	21,36	0,69	40,36	473,42	274,08	10,45
T45 DH	22,30	0,68	42,19	571,39	264,54	11,11
Control	3,32	0,65	2,79	7,07	3,40	1,63
T90 soft WP	12,55	0,67	31,55	36,27	117,21	3,47
T70 WP	12,71	0,66	34,54	38,87	119,69	3,45
T45 WP	12,81	0,66	25,22	46,67	114,15	4,04

Coorelation?

(ug/L)	Sum of terpenols	Sum esters	Sum 4MMP,3 MH, MHA	4MMP	Floral	Citrus	Sweet Fruits	Green Fruits	Red Berries
T90 Enriched DH	745,645	3433,605	304	19	6,0	6,7	6,3	4,0	4,0
T90 soft DH	860,504	3475,065	341	19	3,3	4,7	3,0	3,7	3,7
T70 DH	820,364	3002,093	256	16	2,3	4,3	5,3	4,3	2,0
T45 DH	912,199	2718,792	261	19	2,7	4,0	6,3	2,3	2,7
Control	18,859	3035,848	37	0	1,3	1,0	0,1	0,1	0,1
T90 soft WP	201,704	3038,472	131	4	4,7	5,3	5,7	3,7	1,0
T70 WP	209,916	2678,426	114	2	3,0	1,7	3,7	1,0	2,3
T45 WP	203,551	2731,562	99	2	2,3	2,0	2,7	1,3	2,0

Woody

(ug/L)	ethyl vanillin	eugenol	furfural	guaiacol	maltol	o-cresol	syringol	trans-isoeugenol	vanillin	Sum	sensory
T90 Enriched DH	12,65	0,32	nd	1,44	66,99	1,08	19,84	nd	62,60	164,92	3,3
T90 soft DH	0,99	0,53	nd	1,67	221,11	1,01	7,78	0,40	21,50	254,98	4,7
T70 DH	0,07	0,27	nd	0,85	110,44	1,00	5,06	0,34	20,60	138,64	3,0
T45 DH	nd	0,17	nd	0,45	120,57	0,86	5,81	0,57	15,10	143,54	3,7
Control	nd	nd	nd	0,09	59,70	nd	3,51	0,30	15,30	78,89	1,0
T90 soft WP	nd	nd	nd	0,19	100,74	0,05	1,67	nd	5,70	108,35	3,3
T70 WP	nd	nd	nd	0,23	92,39	0,04	3,45	nd	18,70	114,81	3,0
T45 WP	nd	nd	nd	nd	100,07	0,07	2,11	nd	14,05	116,30	2,0

Summary

- Increased apparent degree of fermentation when dry hopping
- Increase in enrichment doesn't match with the same increase of sulfur compounds
- All beer tasted unique – T70 favorite
- Correlation of woody characteristics with analytical, as well as the fruity category with the esters, but not the terpenoids

Thanks for your attention!



Thanks to Dr. Christina Schönberger
and team!



Thanks to the Boston Beer team!



Thanks for the hop aroma
analysis!



Forschungsbrauerei
St. Johann

Thanks for brewing beers
and beer analysis!

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