



WORLD BREWING CONGRESS
August 13–17, 2016 • Denver, Colorado, U.S.A.

#ElevateBeer



Impact of hop pellet processing in regard to flavour contribution in dry hopped beers





Hop product advantages

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

Pressing of Bales

- Hop bales in rectangular bales

Press at the farm



Transportation and storage at
Hopfenveredlung, Hallertau, Germany





Why Type 90 and 45 and what does it mean ?

What means Type 90 ?

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

What means Type 45 ?

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

This naming is misleading but in every brewers head!

It is simply hop pellets and enriched hop pellets.

The upper limit of alpha enrichment is 20% (in final product) of alpha!



How special processing for dry hopping started

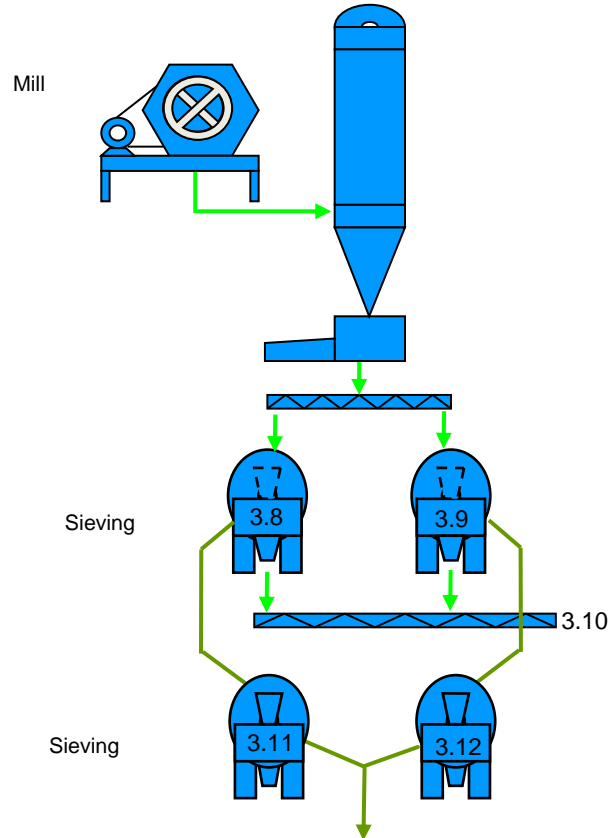
- Original use in kettle
- Pellet quality
- Dissolution of pellets
- Whole pellets in pumps and storage tank
- Issue in centrifugation
- Different plants, different pellets



The Pelletization Process

Normal Pellets

- Bale opener
- Homogenization
- Rotary 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
- Standardization to a certain α -acid/oil content by addition of spent hops (green matter)

The Pelletization Process

Pellet Type

Reg. Type 90

Purified Type 90 (BBC)

Enriched Type



Milling and Sieving

Ambient temp.

At -35°C

At -35°C with enrichment
of oil and alpha

Same as cone hops

Same as cone hops,
finer particles, coarse fraction removed

More oil, alpha, less polyphenols and
vegetative matter, finer particles,

Impact on Flavour in Brewing ?

96 % of original hops

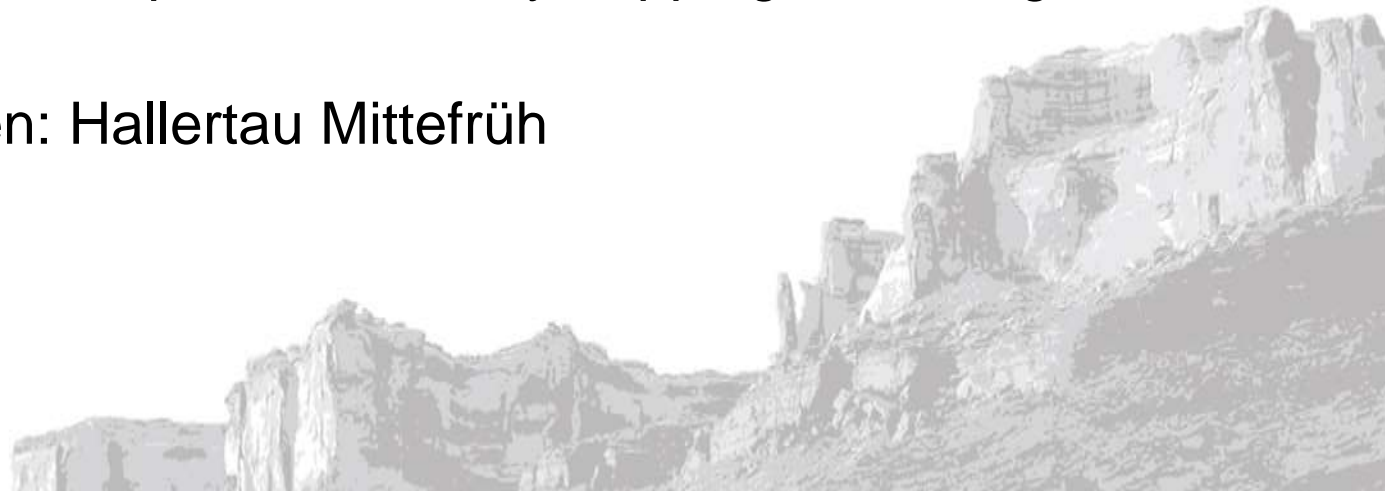
92% of original hops

30-92% of original hops



Background of trials

- The BBC pure hop pellet was developed a couple of years back, but the sensory impact was never investigated
- We investigated the flavour impact of pellet processing due to reduced vegetative matter with more enriched Type pellets.
- Beers were brewed according to a dry hopped lager type beer (all malt)
- Hop dosing in whirlpool and for dry hopping according to oil content
- Variety chosen: Hallertau Mittefrüh



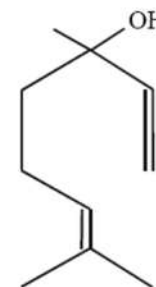
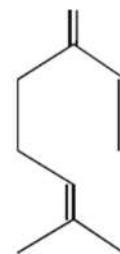


Substance Groups in Hop Oil

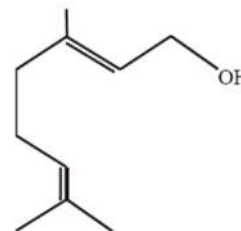
Compounds	Concentration
Monoterpenes	approx. 40 %
Sesquiterpenes	approx. 40 %
Carbonacid-esters	approx. 15 %
Carbonacids	approx. 1 %
Monoterpenoxides	approx. 1 %
Sesquiterpenoxides	approx. 1 %
Aldehydes, Ketones	approx. 1 %
Aliphatic hydrocarbons	< 1 %
Sulfur containing compounds	< 0.1 %
Glycosidically bound aroma compounds	?



Monoterpene



Linalool



Geraniol



Limonen
(monocyclisch)



β -Pinen
(bicyclisch)

www.hanscarl.com

Forster et al., Hopfen – Vom Anbau bis zum Bier, 2011

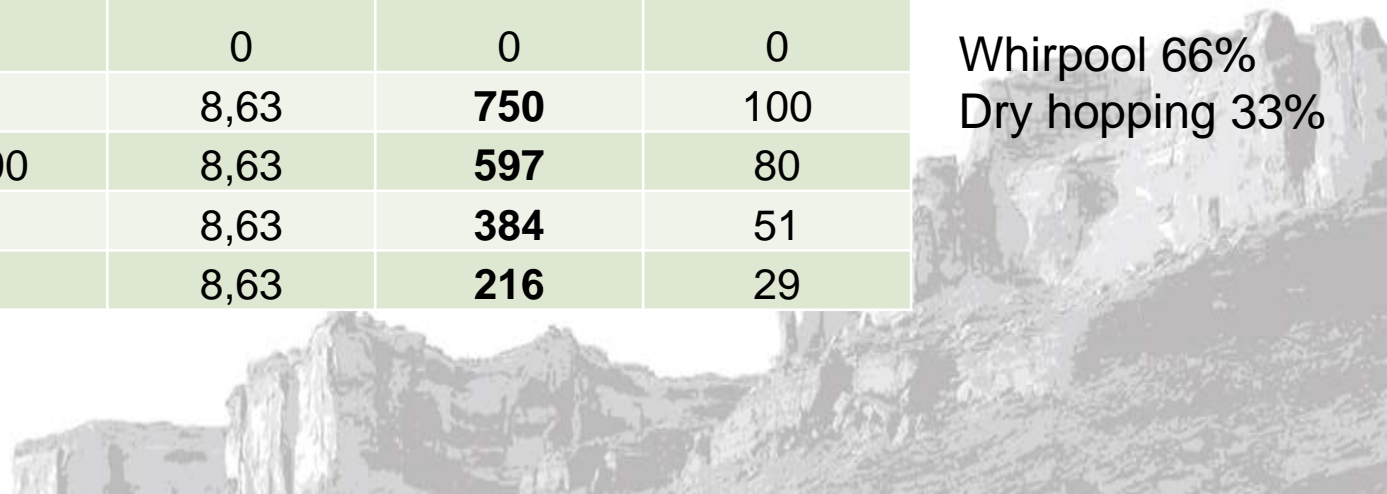


Details of the pellets used

Hop product	Alpha %	Beta %	HSI	Oil ml/100g
Regular Type 90	4,3	5,3	0,312	1,15
Purified Type 90	4,1	5,5	0,325	1,45
Type 67	6,2	8,2	0,329	1,85
Type 33	13	16,5	0,29	4,00
Purified Spent Hops (green matter)	0,55	0,94		0,15

	oil in ml/hl	hops in g/hl	%
Control	0	0	0
Type 90	8,63	750	100
Purified Type 90	8,63	597	80
Type 67	8,63	384	51
Type 33	8,63	216	29

Whirlpool 66%
Dry hopping 33%





Barth Haas Group Tasting Scheme

categories	descriptors
Menthol	Peppermint, melissa, sage, metallic, camphor
Tea	Green tea, camomile, black tea
Herbal	Tomato leaves, green peppers, nettle, thuja, basil, parsley, tarragon, dill, fennel, thyme, rosemary, marjoram
Citrus	Grapefruit, orange, lime, lemon, bergamot, lemongrass, ginger
Green	Green grass, tomato leaf, bell pepper
Vegetable	celery, leek, onion, artichoke, garlic
Cream/Caramel	Butter, chocolate, yoghurt, gingerbread, honey, cream, caramel, toffee, coffee
Woody/ Aromatic	Tobacco, cognac, woody barique, leather, tonka bean, sweet woodruff, resinous, incense, myrrh, resinous
Spicy	Maggie, black pepper, chillies, curry, juniper berry, anis, liquorice, fennel
Red Berries	Cassis, blueberry, raspberry, blackberry, strawberry
Sweet Fruits	Banana, water melon, honeydew melon, peach, apricot, passion fruit, leeches, dried fruits, plum, pineapple, white jelly baby, Pear, quince, apple, gooseberry, enteric, cognac oil
Floral	Elder, camomile flower, muguet, jasmine, apple blossom, rose, geranium

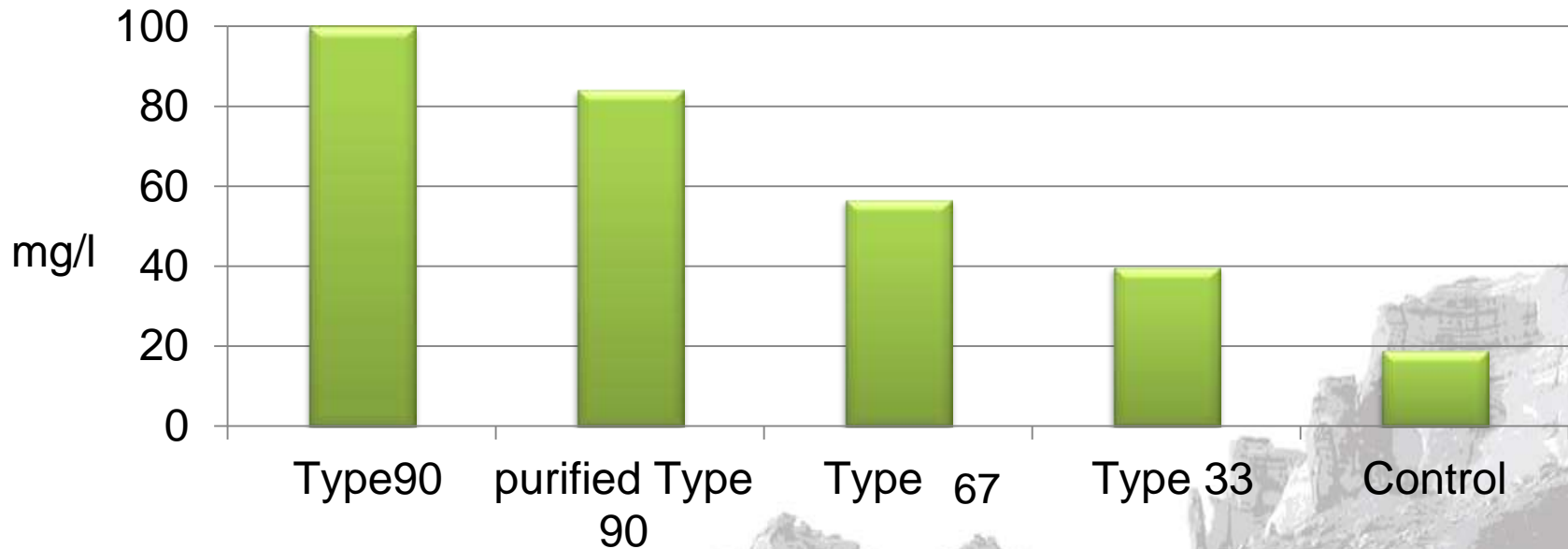
additionally
Bitterness Quality
Bitterness intensity
Overall harmony
Mouthfeel





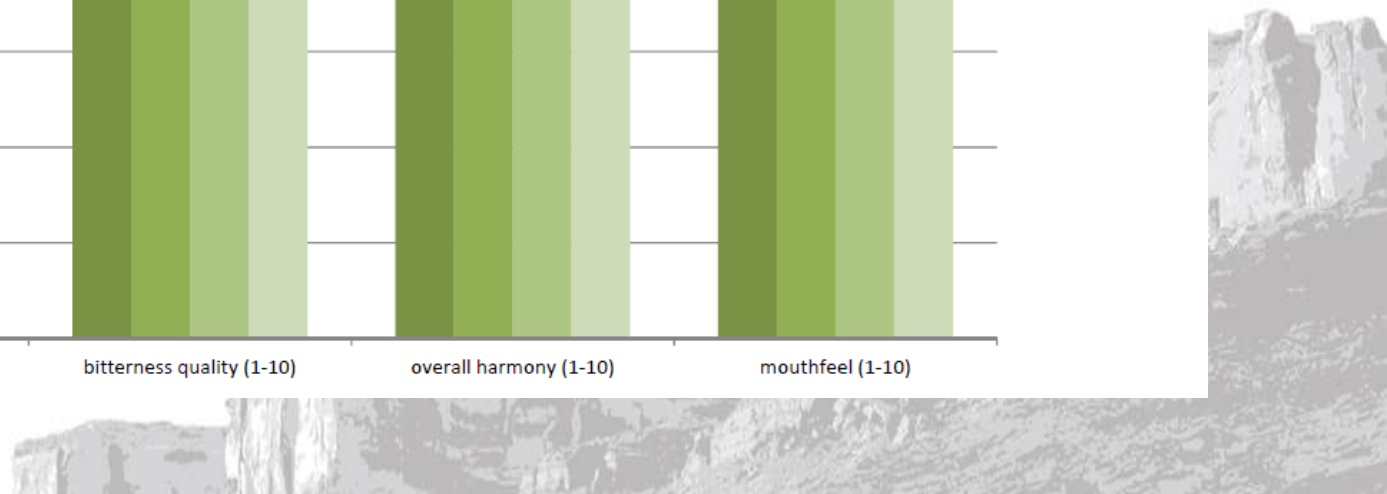
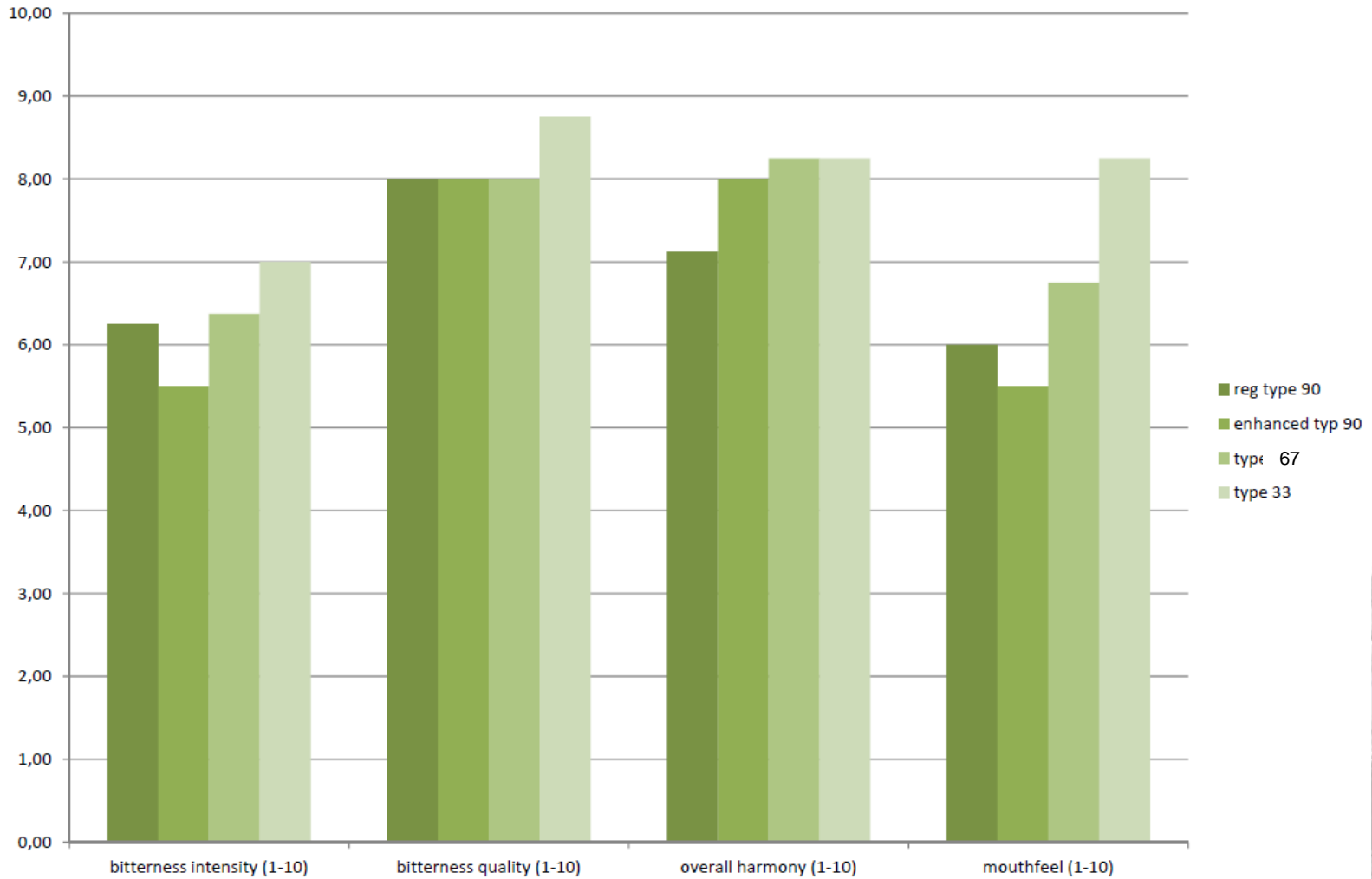
Beer Analysis

		normal T 90	Purified T 90	T 67	T 33	Control
pH		4,55	4,47	4,46	4,44	4,48
Iso-a-acids	mg/l	18,8	18,9	19,1	19,5	21,8
a-acids	mg/l	5,1	3,6	4,0	4,5	2,2
Bitterness	IBU	30	27	26	26	21
Total Polyphenols	mg/l	275	254	220	202	169



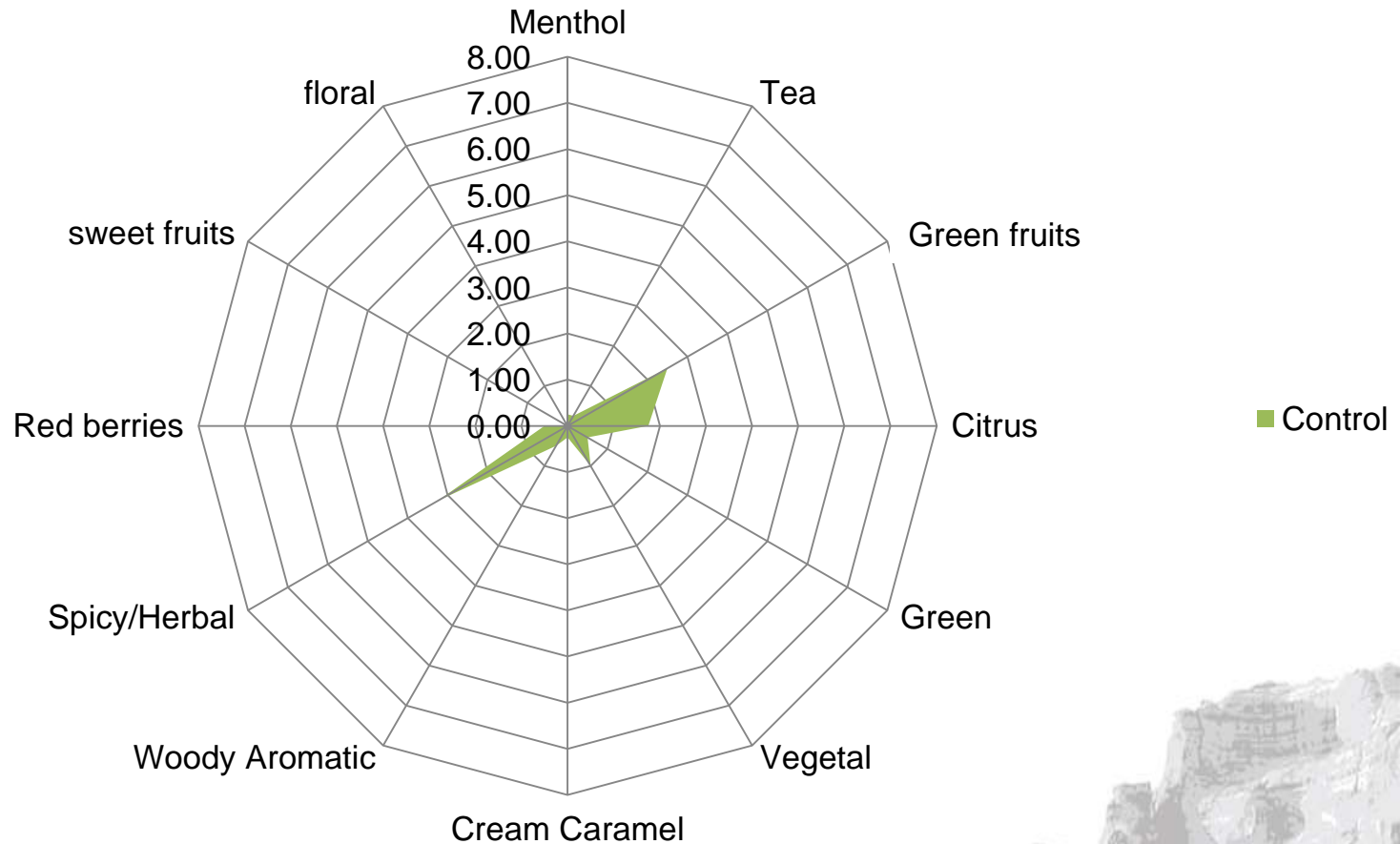


Tasting results (1)



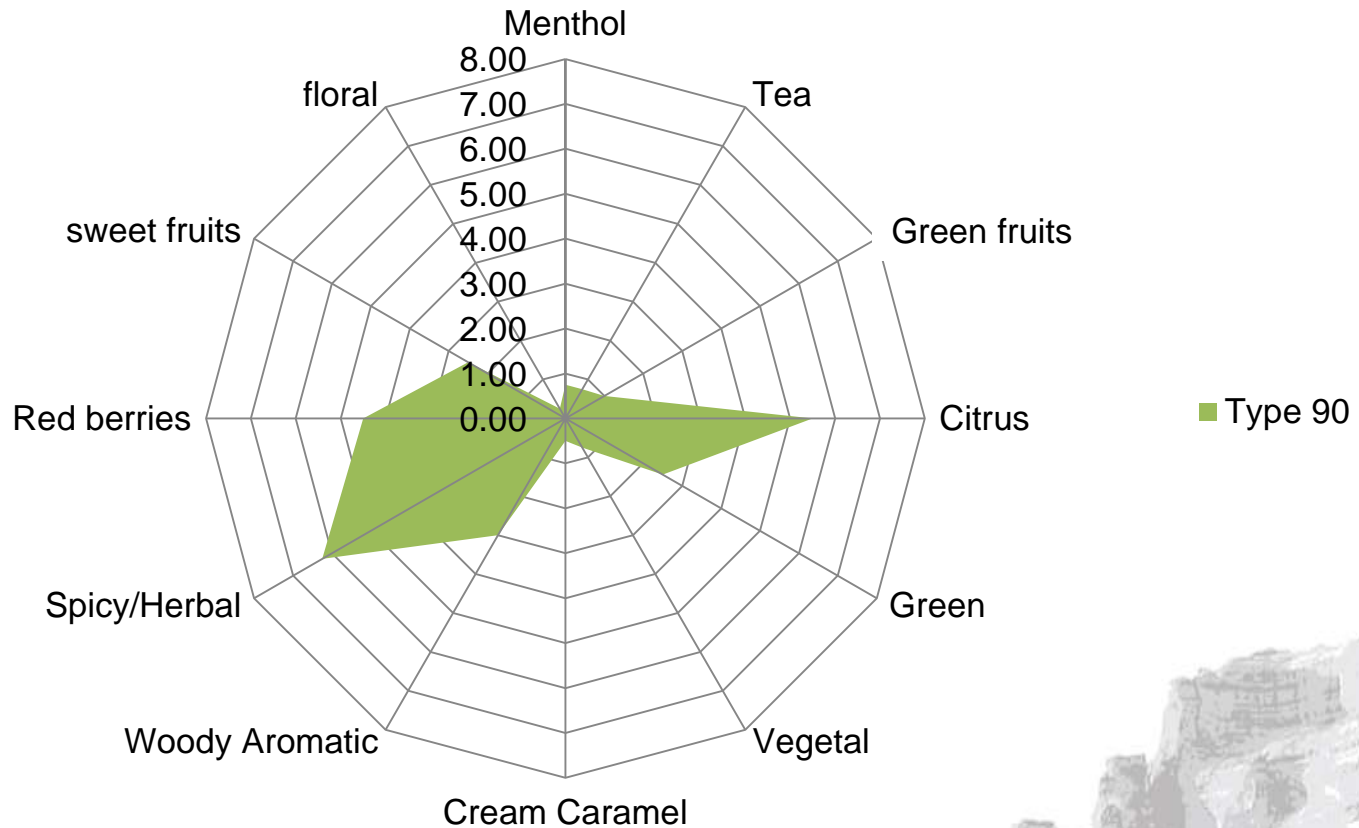


Sensory results of the Beers



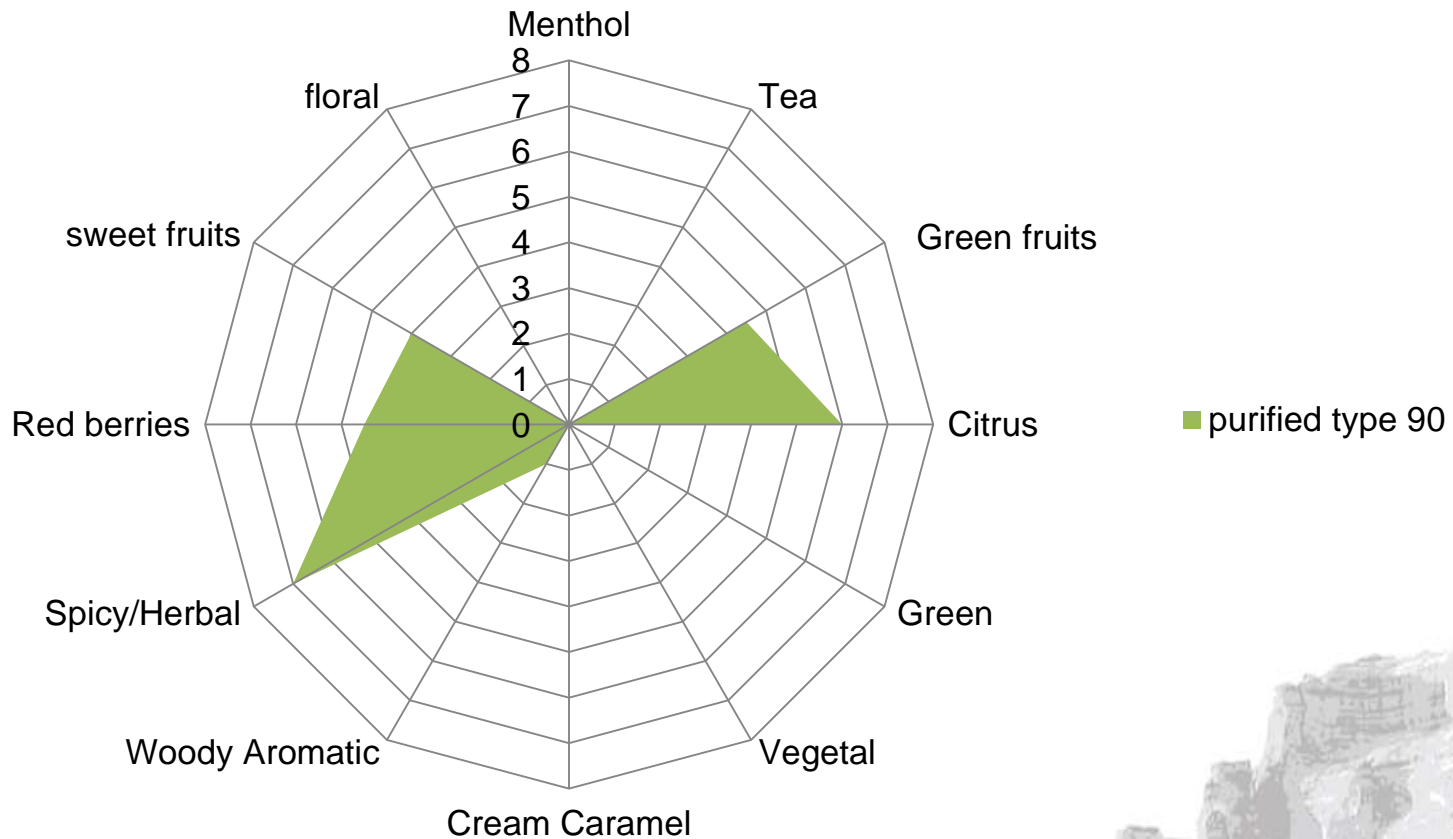


Beer whirlpool and dry hopped with reg. Type 90



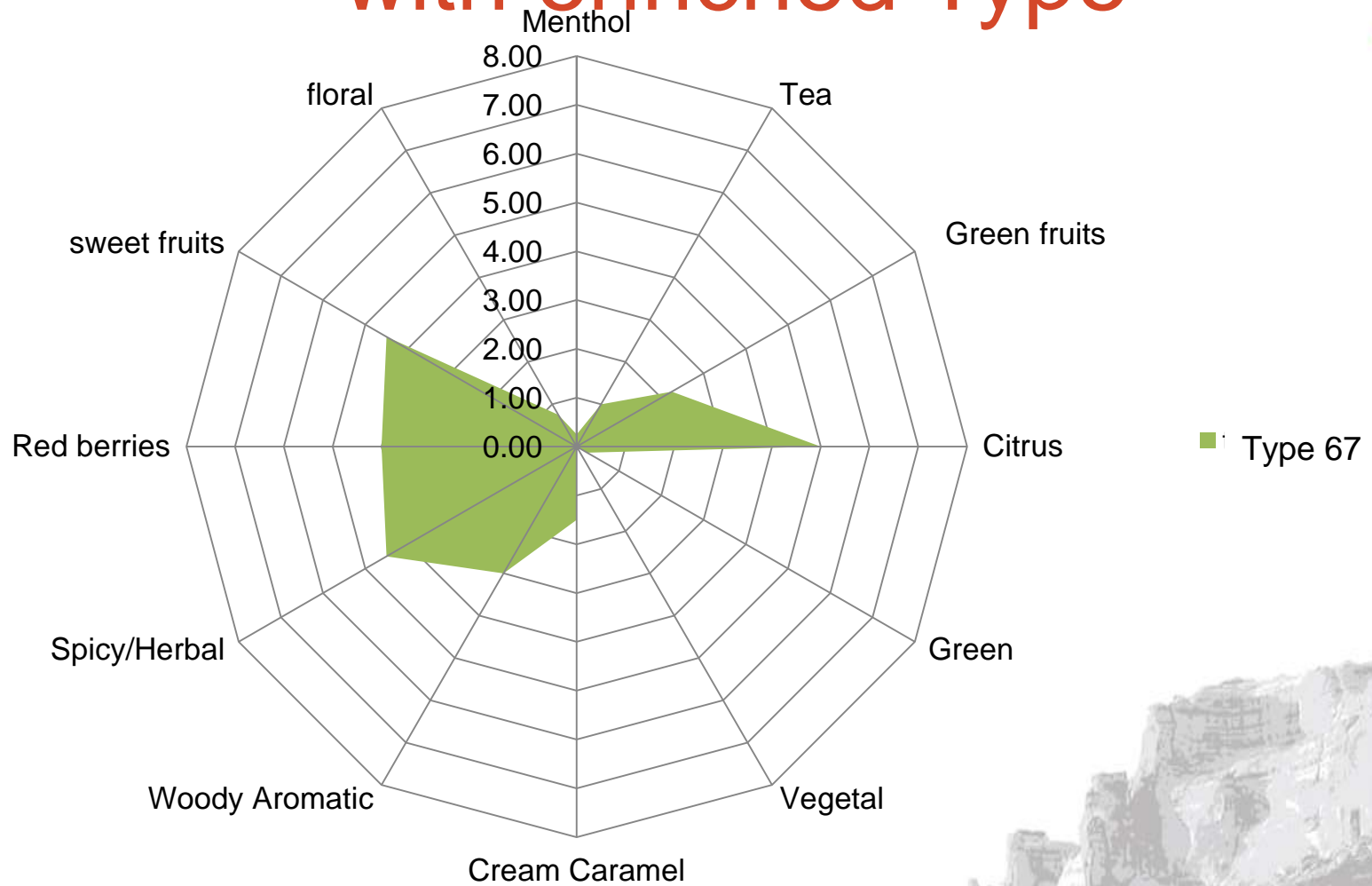


Beer whirlpool and dry hopped with purified Type 90



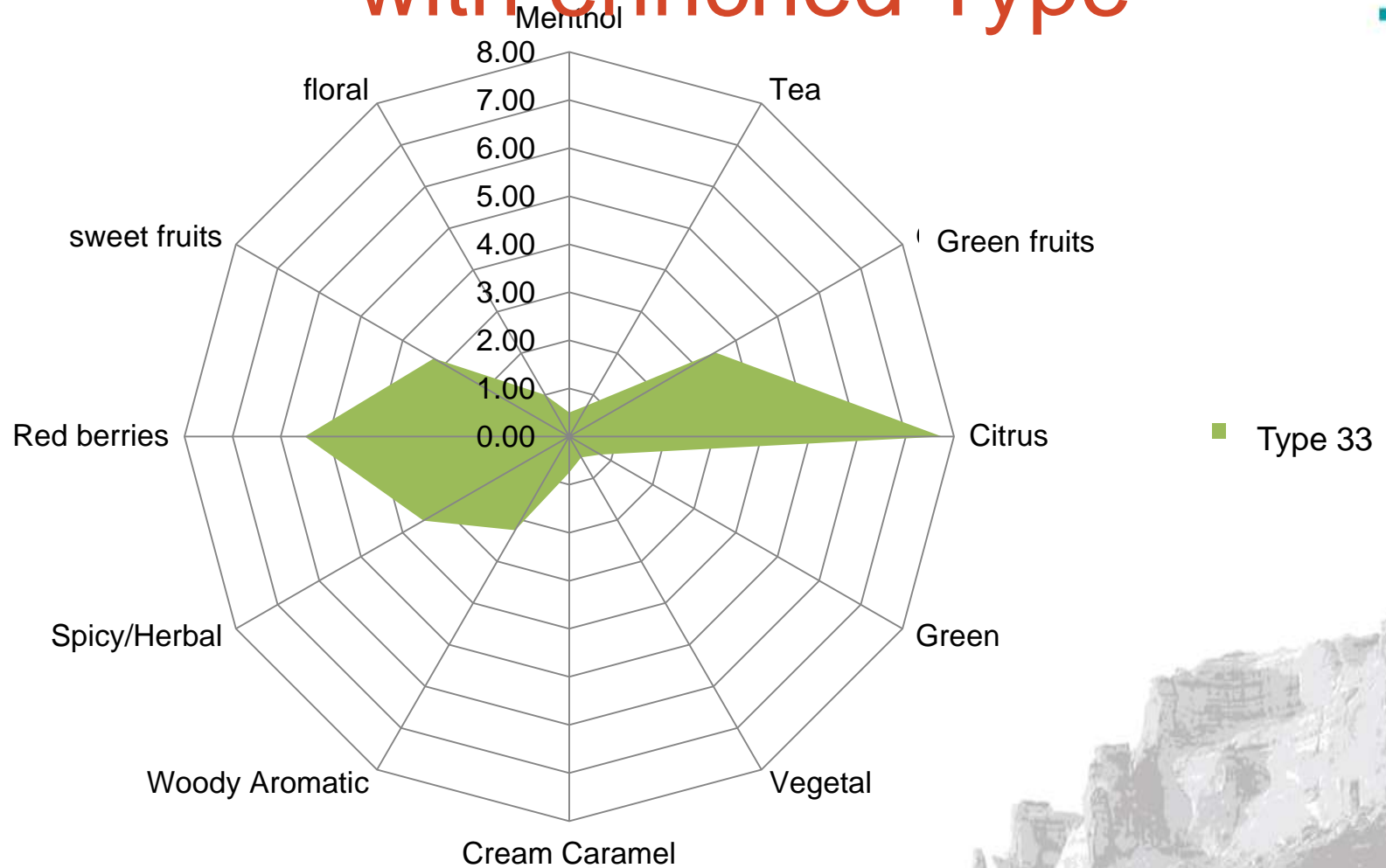


Beer whirlpool and dry hopped with enriched Type



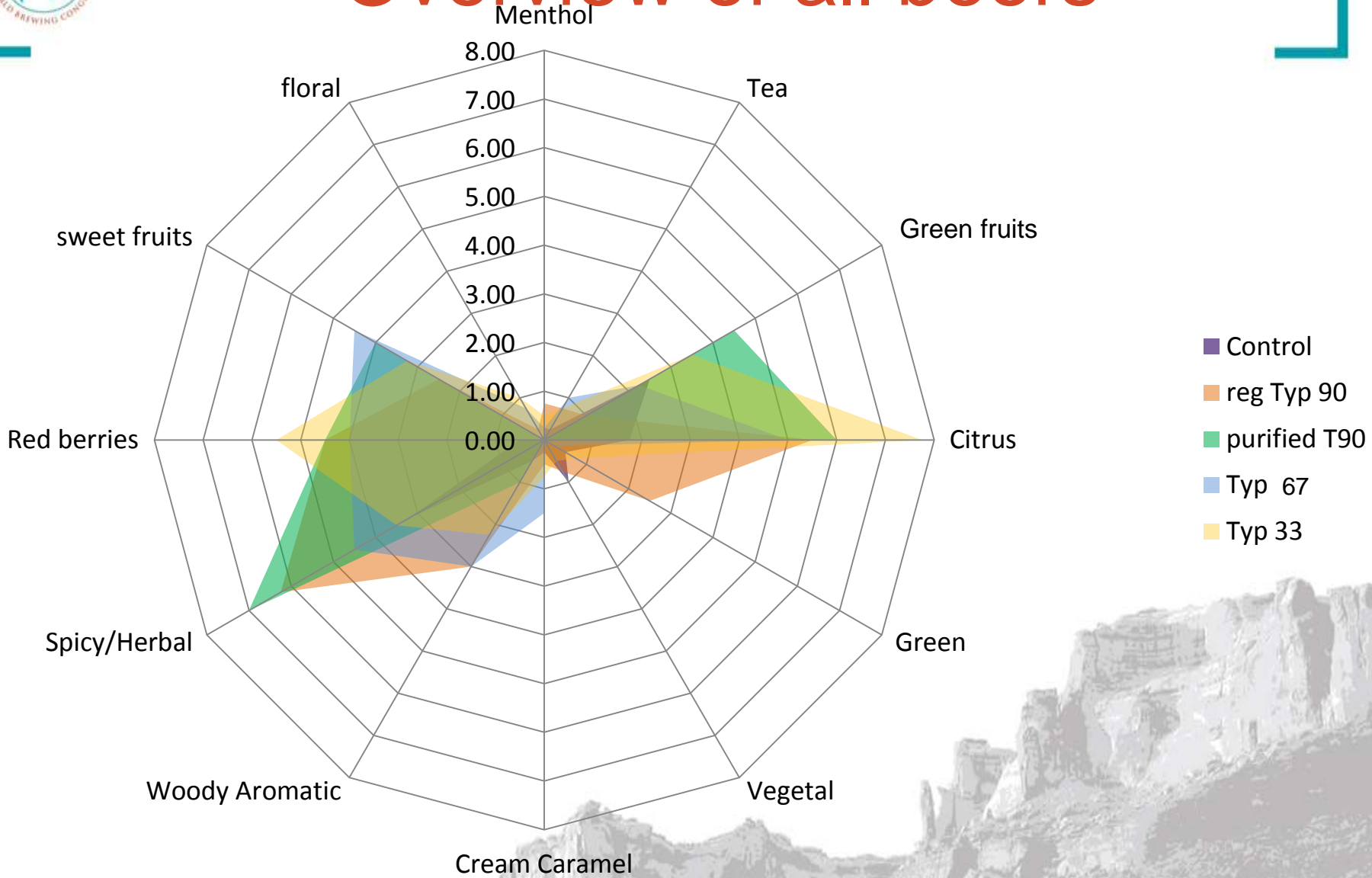


Beer whirlpool and dry hopped with enriched Type



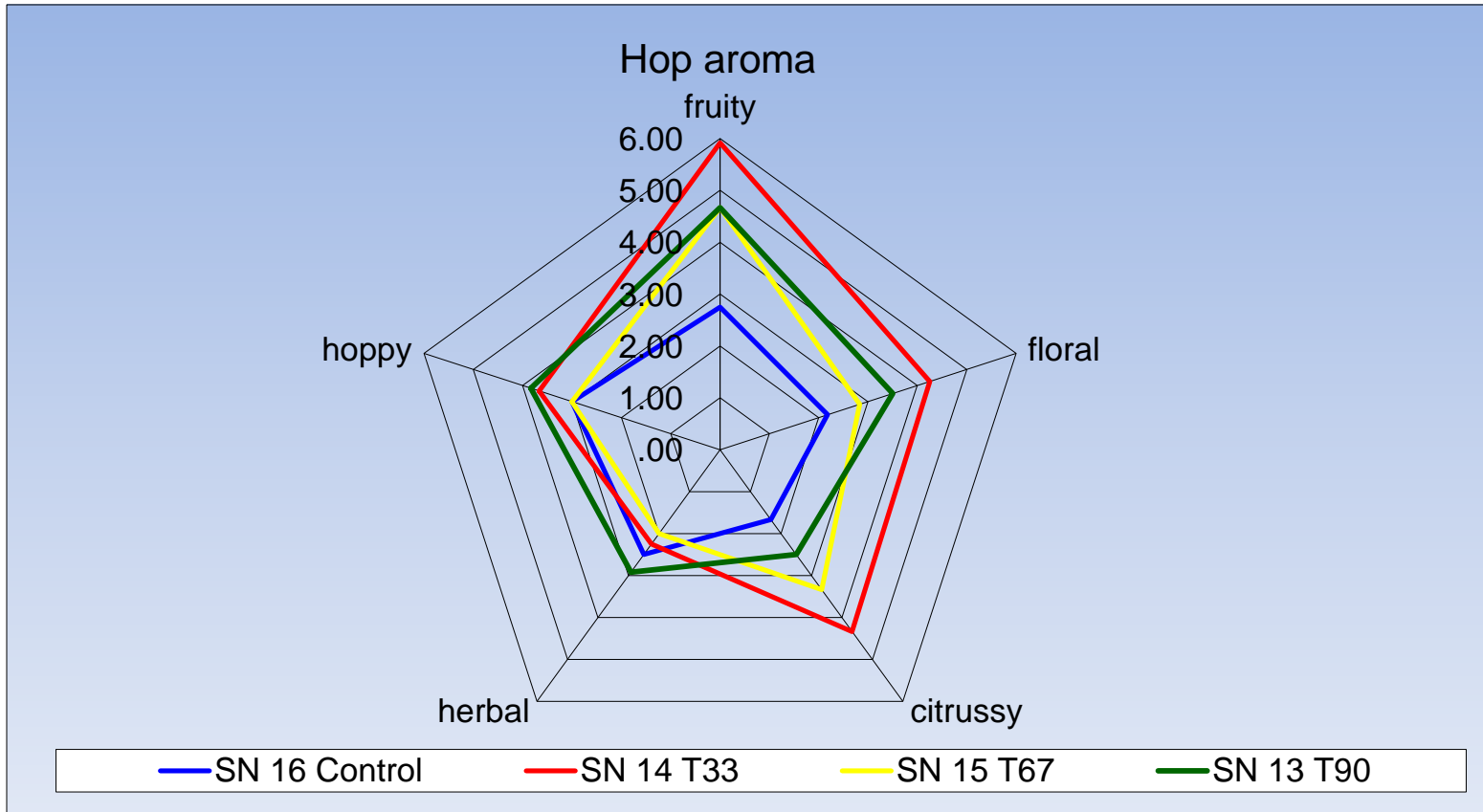


Overview of all beers





2nd Taste Panel Results

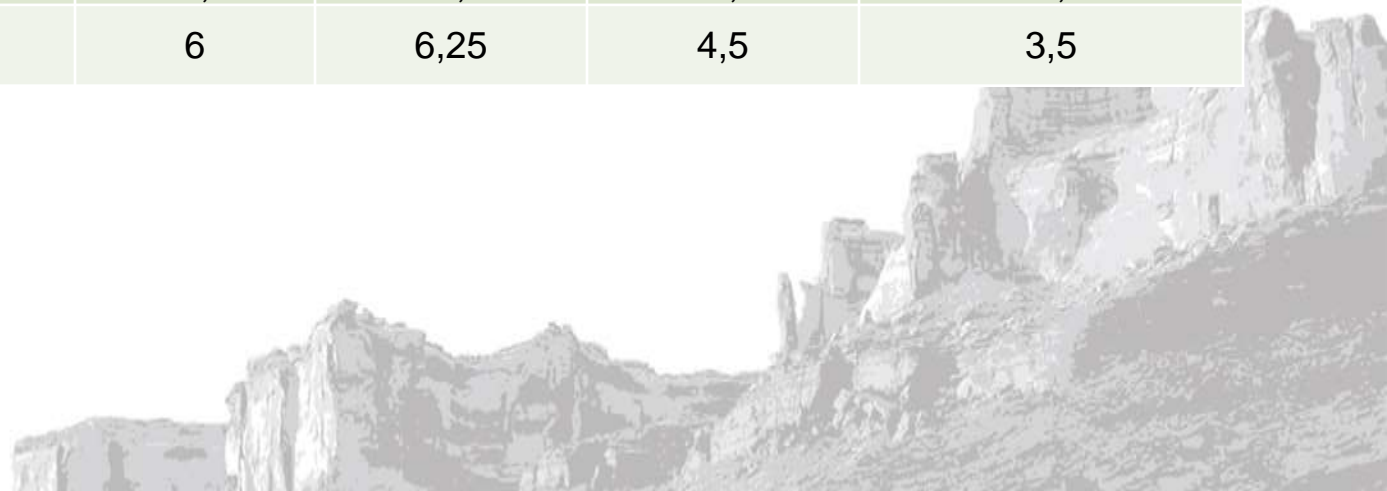




Sensory and analytical correlations?

% yield	Typ 33	Typ 67	Purified T90	T90
Linalool	15,4	8,9	5,5	5,6
Geraniol	32,7	15,6	8,7	11,2

compounds	p. Type 90	Type 90	Type 67	Type 33
caryophyllene oxide in ug/L	22,7	22,1	12,2	13,8
Spicy intensity	6	6,25	4,5	3,5





Sensory Analytical correlation ?

compounds	Control	purified Type 90	Type 90	Type 67	Type 33
α -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
β -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
myrcene	< 1,0	7,4	13,5	14,4	12,4
limonene	3,8	3,5	12,4	8,4	9,9
<i>cis</i> -linalool oxide	< 1,0	9,8	6,5	5,5	5,2
<i>trans</i> -linalool oxide	< 1,0	8,4	5,8	4,6	4,6
linalool	2,0	278,6	356,7	289,7	277,2
α -terpineol	< 1,0	9,5	13,3	11,6	12,7
citronellol	2,5	12,2	23,9	20,0	17,2
nerol	< 1,0	3,6	6,2	4,9	4,8
geraniol	1,1	26,2	41,7	29,9	35,3
geranyl acetate	4,5	< 1,0	3,1	3,0	2,3
Sensory rating					
citrus	1,7	6,0	5,5	5,0	7,8
fruitiness	3,7	14	9,25	12,45	15,55



Sensory Analytical correlation ?

compounds	Control	purified Type 90	Type 90	Type 67	Type 33
α -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
β -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
myrcene	< 1,0	7,4	13,5	14,4	12,4
limonene	3,8	3,5	12,4	8,4	9,9
<i>cis</i> -linalool oxide	< 1,0	9,8	6,5	5,5	5,2
<i>trans</i> -linalool oxide	< 1,0	8,4	5,8	4,6	4,6
linalool	2,0	278,6	356,7	289,7	277,2
α -terpineol	< 1,0	9,5	13,3	11,6	12,7
citronellol	2,5	12,2	23,9	20,0	17,2
nerol	< 1,0	3,6	6,2	4,9	4,8
geraniol	1,1	26,2	41,7	29,9	35,3
geranyl acetate	4,5	< 1,0	3,1	3,0	2,3
Sensory rating					
sweet fruits	0	4	2,5	4,5	3,25



Sensory Analytical correlation ?

compounds	Control	purified Type 90	Type 90	Type 67	Type 33
α -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
β -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
myrcene	< 1,0	7,4	13,5	14,4	12,4
limonene	3,8	3,5	12,4	8,4	9,9
<i>cis</i> -linalool oxide	< 1,0	9,8	6,5	5,5	5,2
<i>trans</i> -linalool oxide	< 1,0	8,4	5,8	4,6	4,6
linalool	2,0	278,6	356,7	289,7	277,2
α -terpineol	< 1,0	9,5	13,3	11,6	12,7
citronellol	2,5	12,2	23,9	20,0	17,2
nerol	< 1,0	3,6	6,2	4,9	4,8
geraniol	1,1	26,2	41,7	29,9	35,3
geranyl acetate	4,5	< 1,0	3,1	3,0	2,3
caryophyllene oxide	19,3	22,7	22,1	12,2	13,8
Sensory rating					
spicy	3	6	6,25	4,5	3,5



Sensory Analytical correlation ?

compounds	Control	purified Type 90	Type 90	Type 67	Type 33
α -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
β -pinene	< 1,0	< 1,0	< 1,0	< 1,0	< 1,0
myrcene	< 1,0	7,4	13,5	14,4	12,4
limonene	3,8	3,5	12,4	8,4	9,9
<i>cis</i> -linalool oxide	< 1,0	9,8	6,5	5,5	5,2
<i>trans</i> -linalool oxide	< 1,0	8,4	5,8	4,6	4,6
linalool	2,0	278,6	356,7	289,7	277,2
α -terpineol	< 1,0	9,5	13,3	11,6	12,7
citronellol	2,5	12,2	23,9	20,0	17,2
nerol	< 1,0	3,6	6,2	4,9	4,8
geraniol	1,1	26,2	41,7	29,9	35,3
geranyl acetate	4,5	< 1,0	3,1	3,0	2,3
caryophyllene oxide	19,3	22,7	22,1	12,2	13,8
Sensory rating					
green fruits	2	4	1	2,25	3,5
spicy	3	6	6,25	4,5	3,5
fruitiness	3,7	14	9,25	12,45	15,55



Conclusions

- Enrichment and way of processing of pellets has a big influence on flavour and aroma in beer
- For Hallertau Mittelfrüh the enrichment of oil and alpha resulted in more pronounced fruity notes in the final beer
- The yield (transfer rate) of certain aroma components is higher when using enriched pellets
- The concentration of Linalool, Citronellol and Geraniol does not correlate with floral, citrus or fruitiness
- Caryophellenoxide correlates with spicyness
- Interaction of aroma compounds still poorly understood (synergistic effect with sesquiterpenoxides ?)
- Correlation probably unique for every hop variety
- Enrichment in pelletization a huge playground for new flavours !
- Operational: enriched pellets decrease vegetative material, beer loss, sensory benefits, better yield of aroma components



Thank you for listening!

- Thanks to the Team of Boston Beer
- Thanks to the best Brewer ever Andi Gahr
- Thanks to the Sensory Panels
- Thanks to the VLB for Analysis
- Thanks to the colleagues at HV for sampling
- Thank to all passionate Brewers !

