

## Comparison of characteristics of taste and polyphenols in beer using different hop varieties

Takamasa Hasegawa, Tomoyuki Nakahama, and Takako Inui / Suntory Beer Ltd., Osaka, Japan

### Objective

Hops are essential components that contribute to the hoppy aroma and taste-related characteristics such as fullness, sweetness, bitterness and astringency of beer. Among the different hop-derived compounds, polyphenols are specifically considered to play an important role in imparting taste, and their profiles are thought to vary between hop varieties, resulting in different characteristics with regard to taste as well as aroma in beer.

This study investigated the polyphenol profiles of 6 hop varieties, and the polyphenol profiles and taste characteristics of beer prepared using each hop variety.

### Materials and methods

#### Hop raw materials

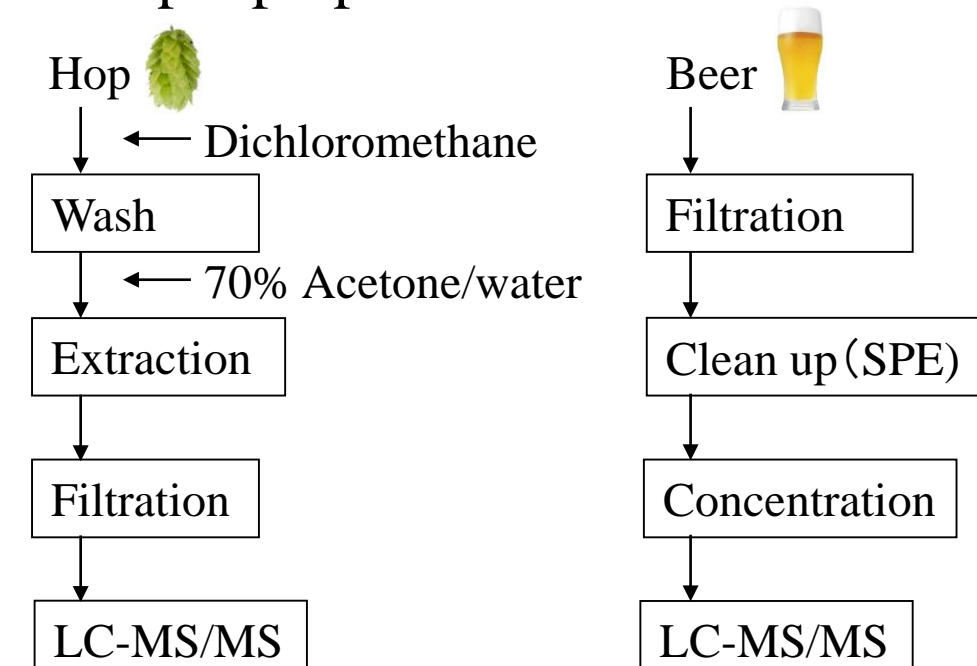
Varieties	Parentage	Origin
Hallertauer Mittelfrüh	landrace	Germany
Saazer	landrace	Czech Republic
Tettnanger	landrace	Germany
Hallertauer Tradition	Hallertauer Gold × 75/15/106M <sup>a</sup>	Germany
Perle	Northern Brewer × 63/5/27M <sup>b</sup>	Germany
Cascade	(Fuggle × [Serebriana × Fuggle - seedling]) × open-pollinated	USA

<sup>a</sup>47% Hallertauer, 15% Saazer, 9% Spalter, 28% wild hops, 1% Northern Brewer  
<sup>b</sup>Hallertauer Mfr., Spalter, Saazer. The percentage of mixed breed are not known.

Cf. "Genetic diversity and phylogenetic relationships among accessions of hop, *Humulus lupulus*, as determined by amplified fragment length polymorphism fingerprinting compared with pedigree data" Seefelder S, et al. *Plant Breeding*. **119**: 257-263 (2000)

#### Extraction and quantification of hop polyphenols

##### Sample preparation



##### LC-MS/MS conditions

LC-MS/MS : SHIMADZU LCMS-8040  
Column : Luna® 5 µm C18(2) 100 Å,  
LC Column 150 x 4.6 mm  
Mobile phase : A: water containing 0.1% formic acid  
B: acetonitrile containing 0.1% formic acid  
Flow rate : 0.7 mL/min  
Gradient (min/%B) : 0/5, 5/5, 35/98, 40/98, 40/5, 50/5  
Injection : 10 µL

#### Brewing trial

- Brewing size: 100 L
- Malt ratio: 100%
- Conditions of hop addition:  
145 g of each variety of hop was added at the start of boiling.  
Bitterness was adjusted using CO<sub>2</sub> extract.
- Fermentation conditions: Lager yeast, 10°C

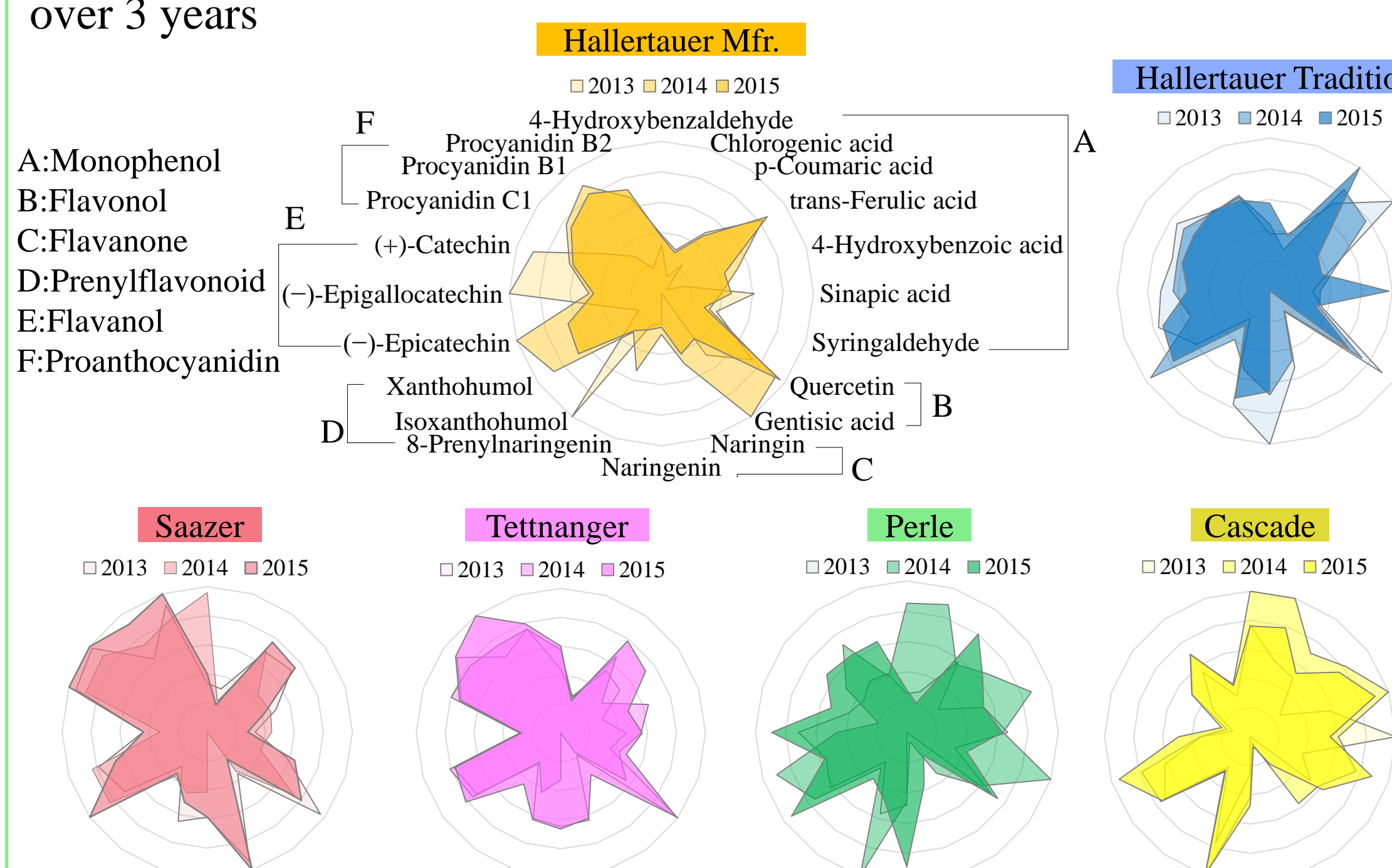
#### Sensory evaluation

- Seven trained panelists
- Four sensory descriptors:  
**Sweetness, Bitterness, Fullness, Astringency**
- Scoring:  
Scored from 0 to 3 and normalized

### Results

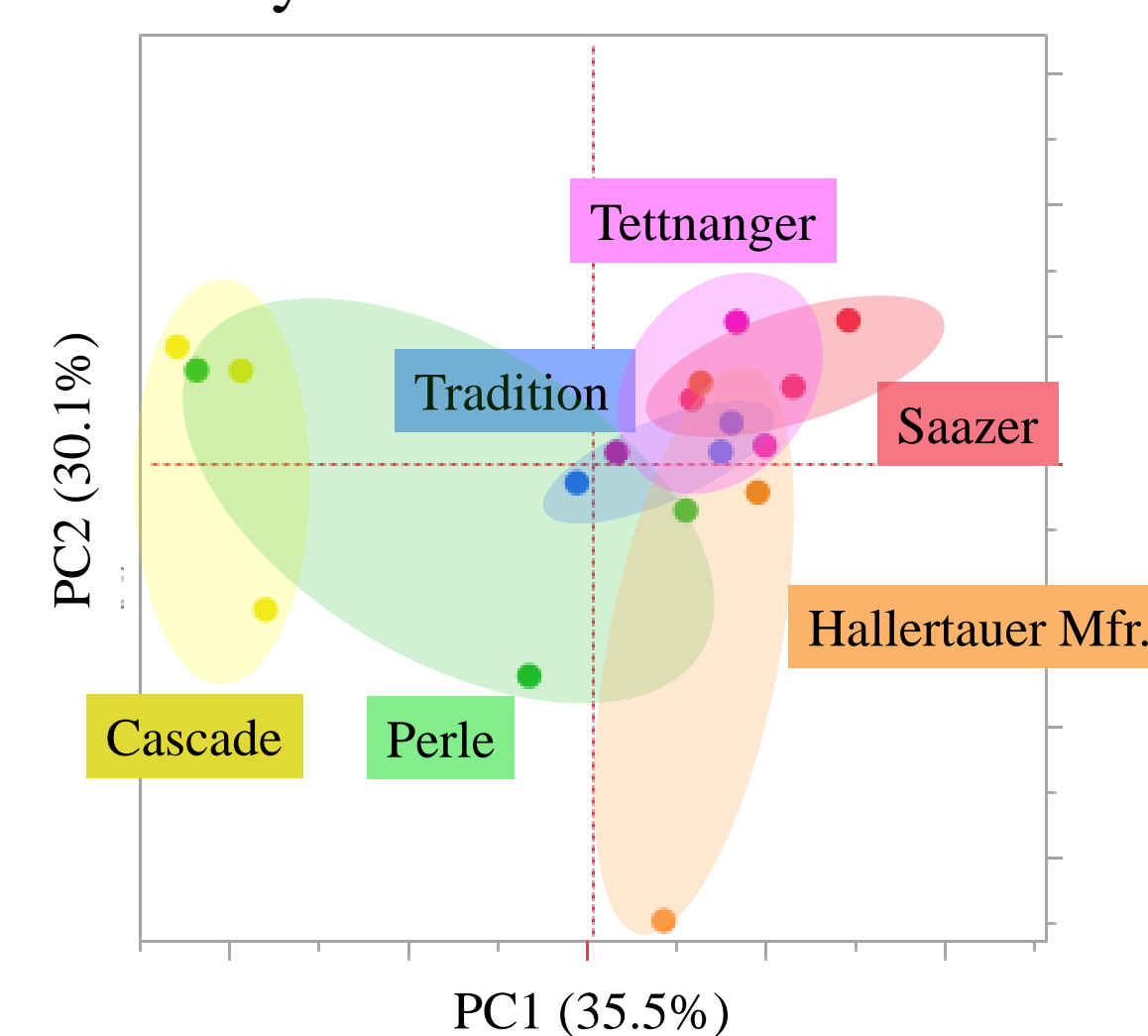
#### Results of hops

Fig 1. Comparison of polyphenol profile in each hop variety harvested over 3 years



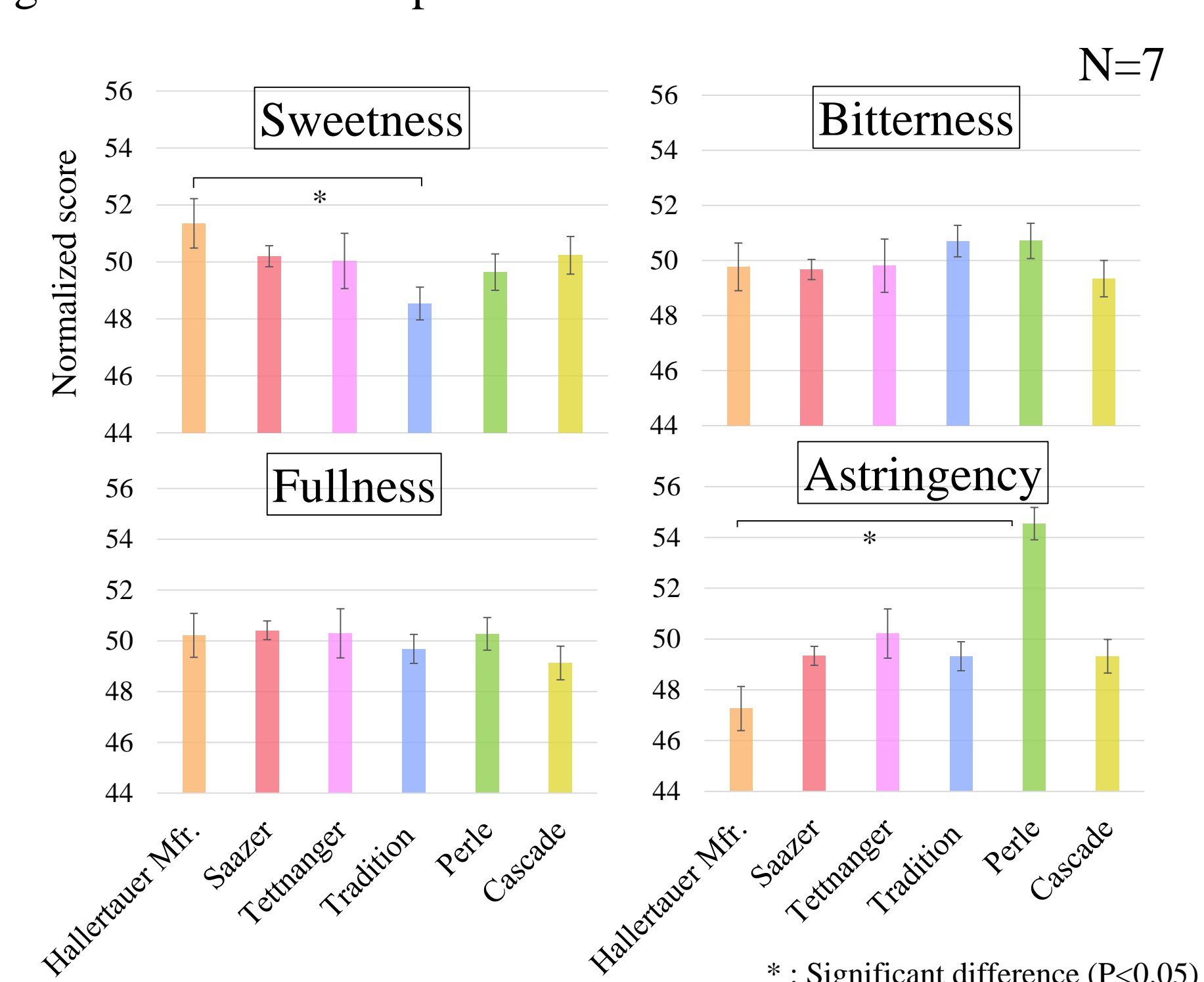
Hallertauer Mfr., Saazer, and Tettnanger have more proanthocyanidin (F).  
Perle, Cascade, and Tradition have more flavanone (C) and prenylflavonoid (D).

Fig 2. Principal component analysis of polyphenol profiles in each hop variety harvested over 3 years



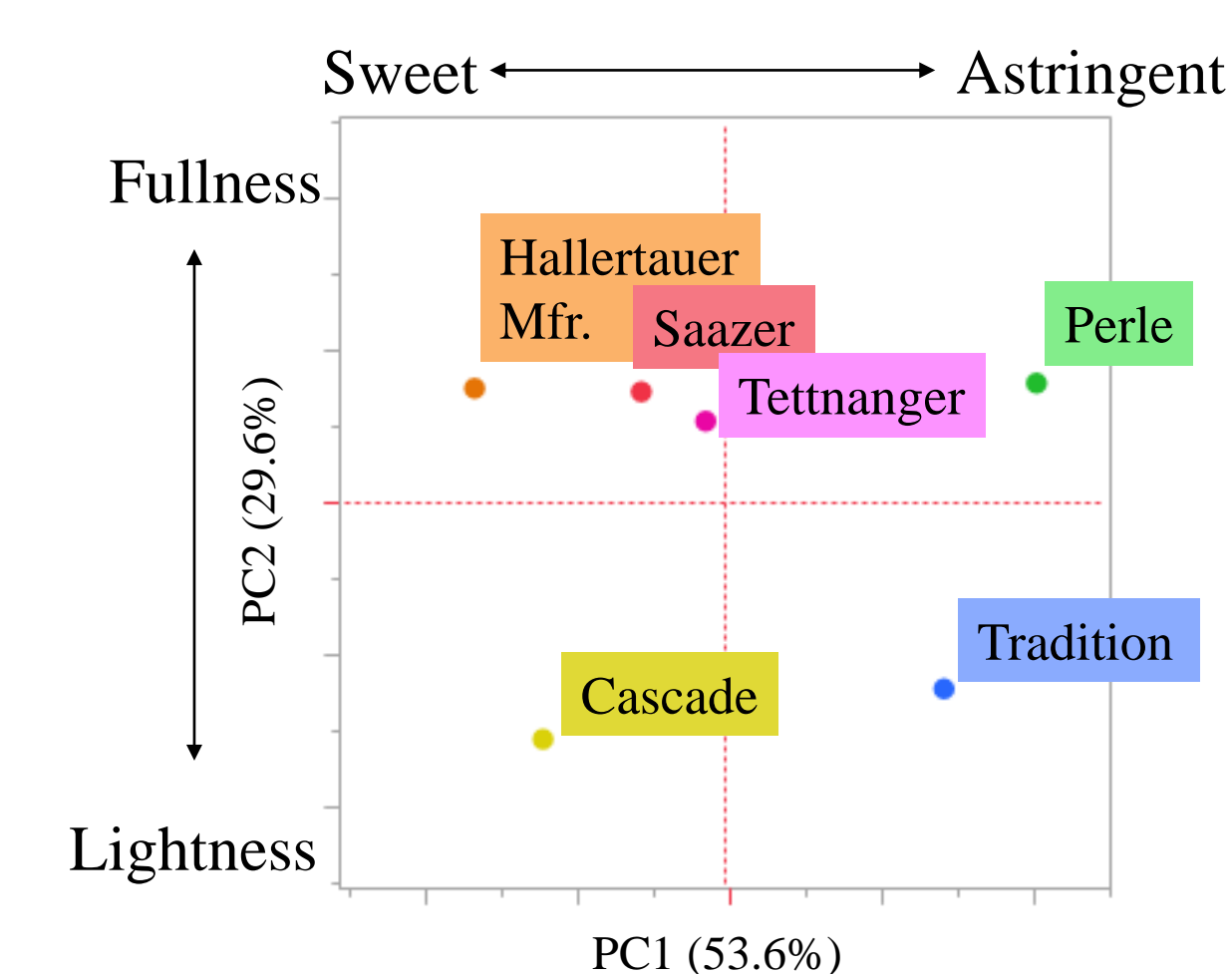
#### Results of beer

Fig 3. Influence of hop varieties on taste characteristics of beer



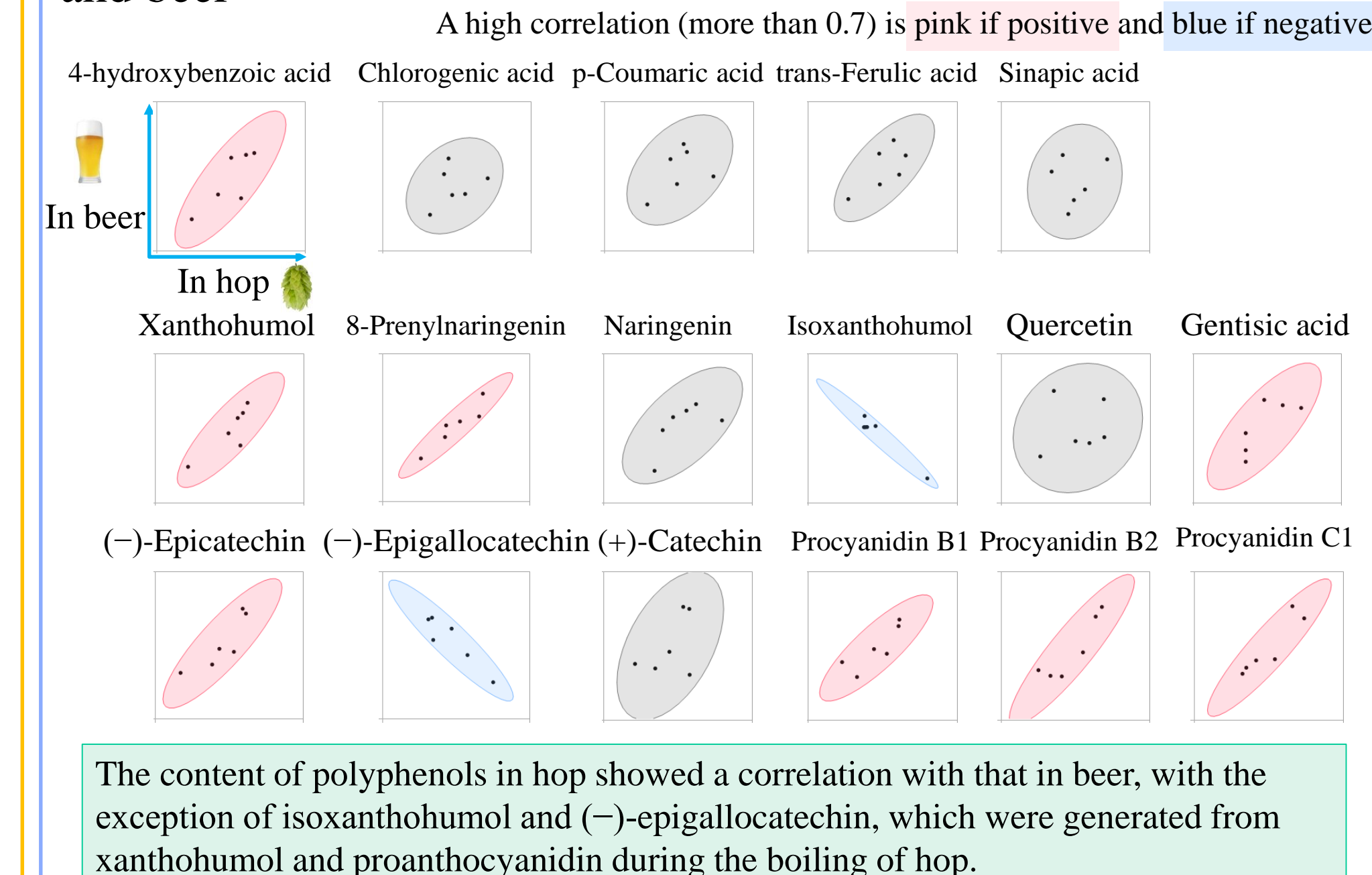
\* : Significant difference (P<0.05)

Fig 4. Principal component analysis of taste score of beer



#### Results of hop vs beer

Fig 5. Correlation between content of each polyphenol in hop and beer



The content of polyphenols in hop showed a correlation with that in beer, with the exception of isoxanthohumol and (-)-epigallocatechin, which were generated from xanthohumol and proanthocyanidin during the boiling of hop.

### Conclusion

- Each hop variety exhibited a different polyphenol profile.
- Fresh beer samples using 6 hop varieties showed different taste characteristics, especially in sweetness and astringency.
- It was observed that the differences in polyphenol profiles as well as taste characteristics between hop varieties were strongly linked to the genetic similarities.
- It was suggested that the contents of proanthocyanidin were correlated with the intensity of fullness while the contents of flavanone and prenylflavonoid were correlated with the intensity of astringency.
- The content of each polyphenol in beer was similar to that in hop.

### Futurework

- To verify how much each polyphenol in hop contributed to the taste in beer, by the addition of extracted polyphenols from hop or hopped beer or by the addition of individual chemicals to beer
- To elucidate factors other than hop varieties that affected polyphenol profile in hop, such as cultivation and brewing conditions