WORLD BREWING CONGRESS
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#ElevateBeer

Symposia BCOJ

Selective removal of myrcene and improved isomerization of α-acids by pre-incubation of aroma hops

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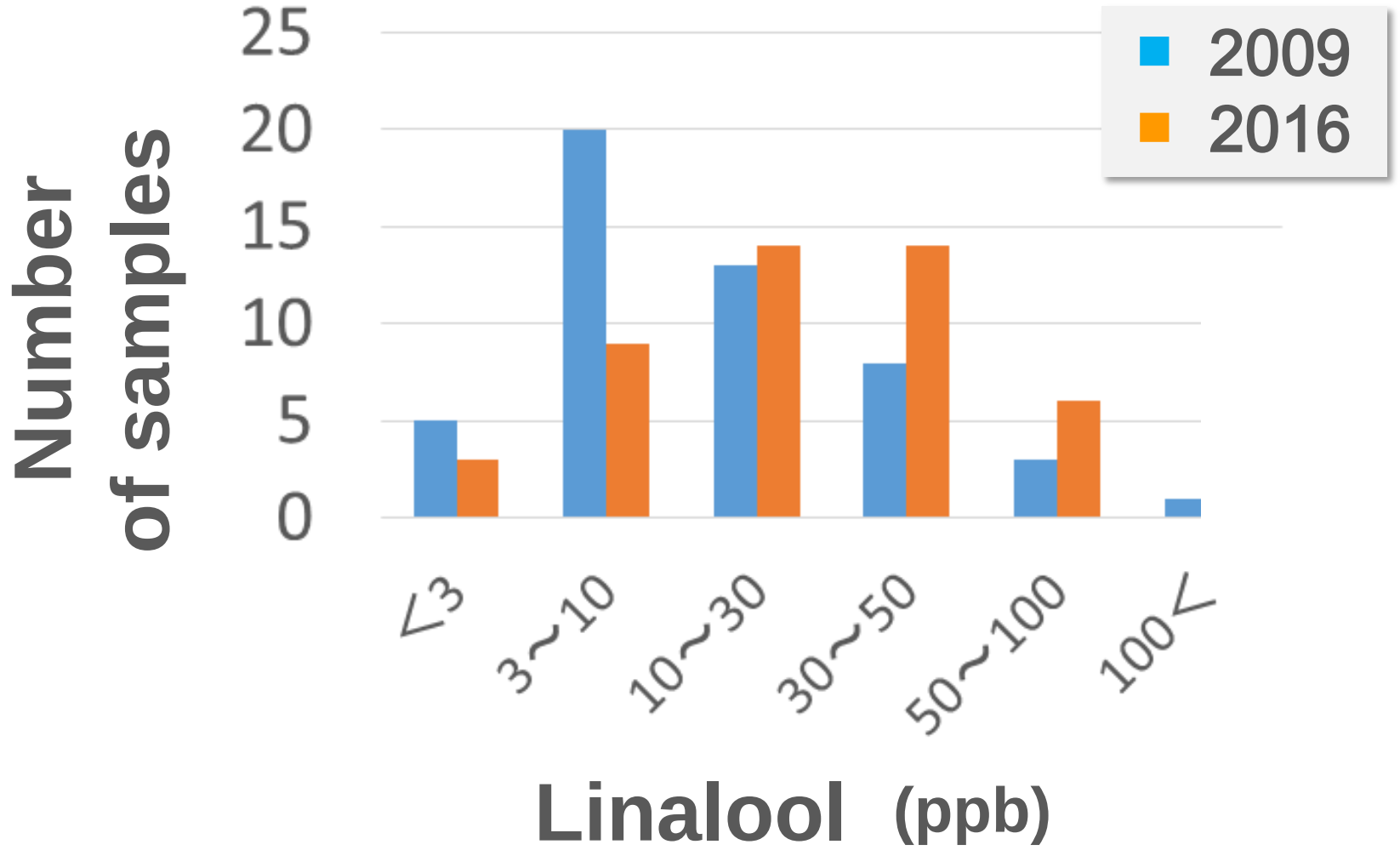
Sunday, August 14, 2016

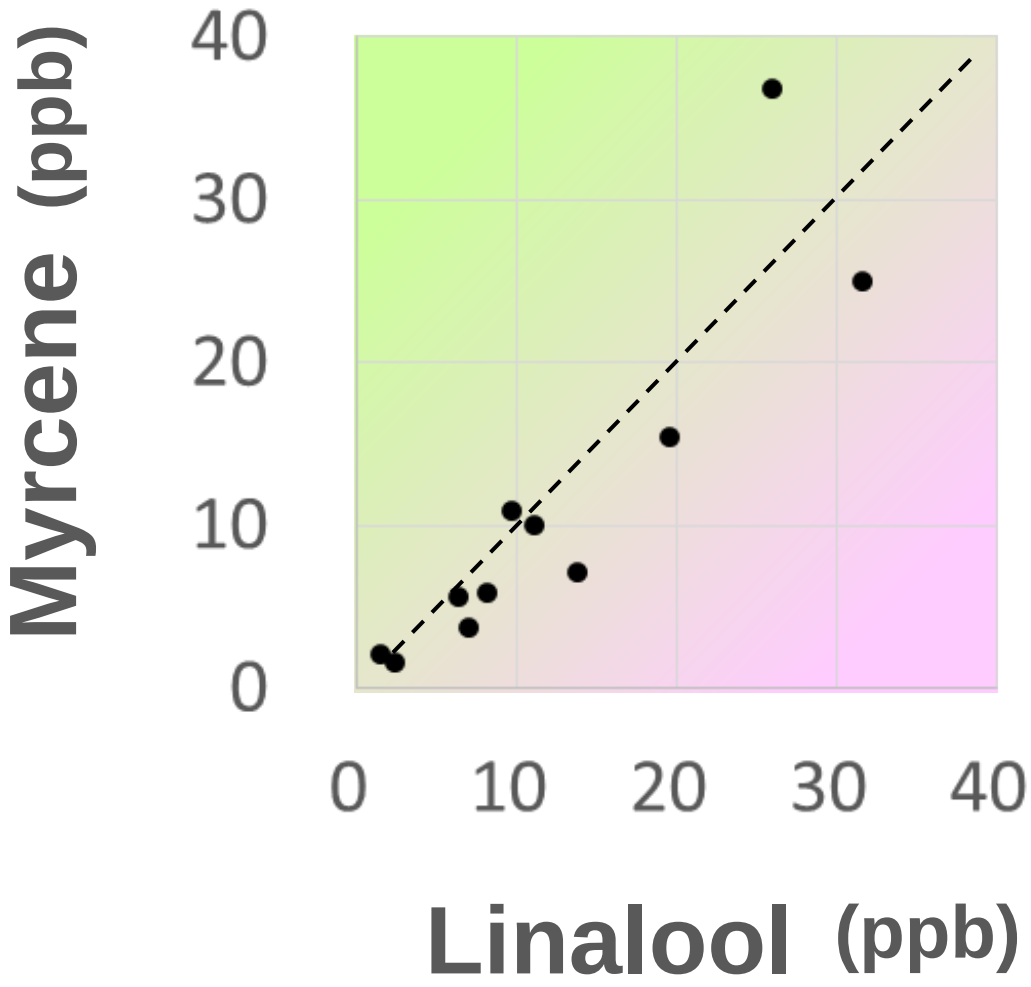
Linalool in 50 brands of Japanese beer



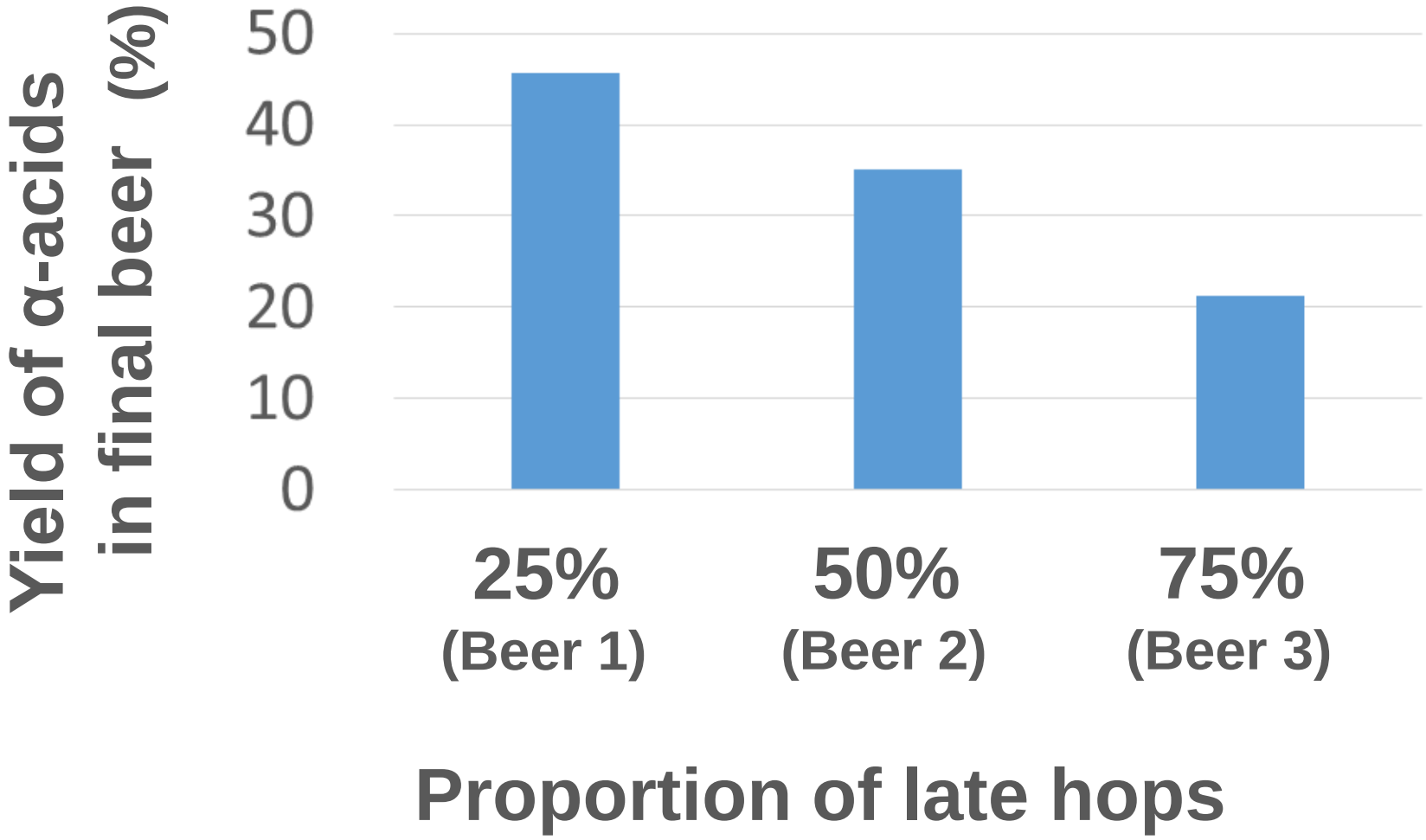
Disadvantages in late hopping

- Higher level of myrcene
- Lower utilization of α- acids

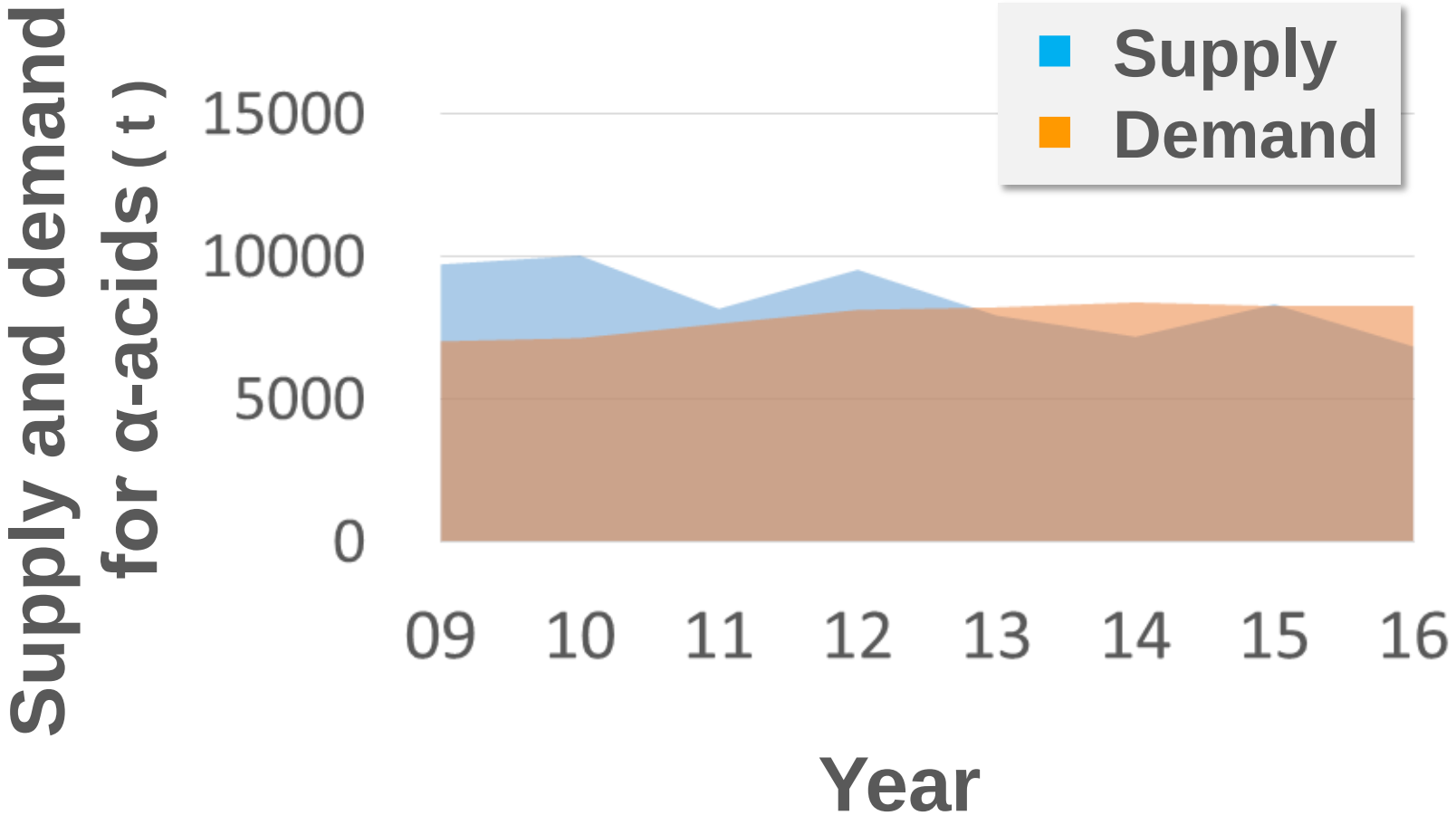
Myrcene and Linalool in various brands



Yield of α-acids in various ratio of late hops



Global supply and demand for α-acids



Hopsteiner ; 2016

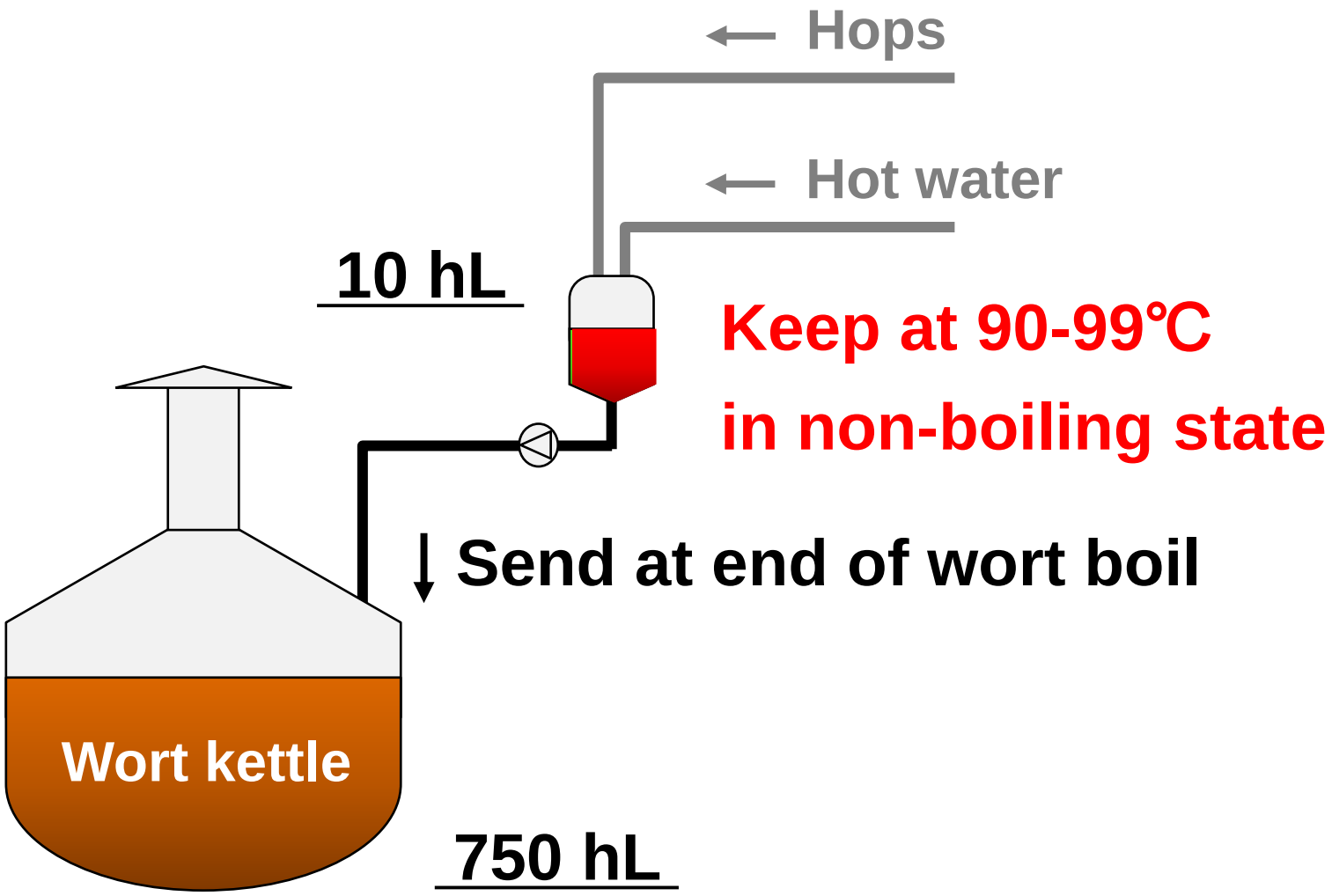
Our previous research

2008 WBC (O-52)
PIE (Pre- Isomeriser & Evaporator)

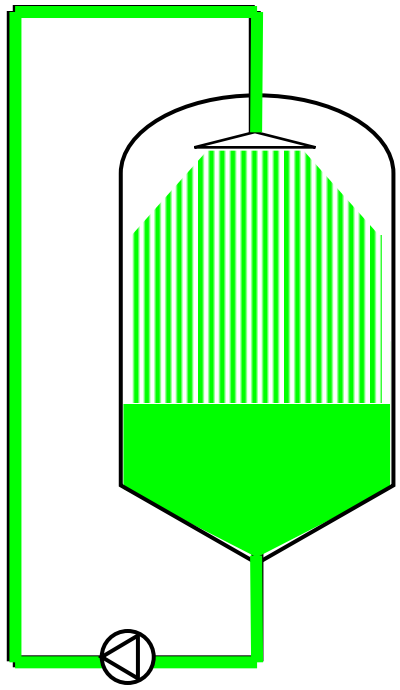
2011 ASBC (O-32)
Effect of PIE on a commercial scale

2014 ASBC (A-88)
Pre-incubation of hops

Hop Incubation



Hop Incubator

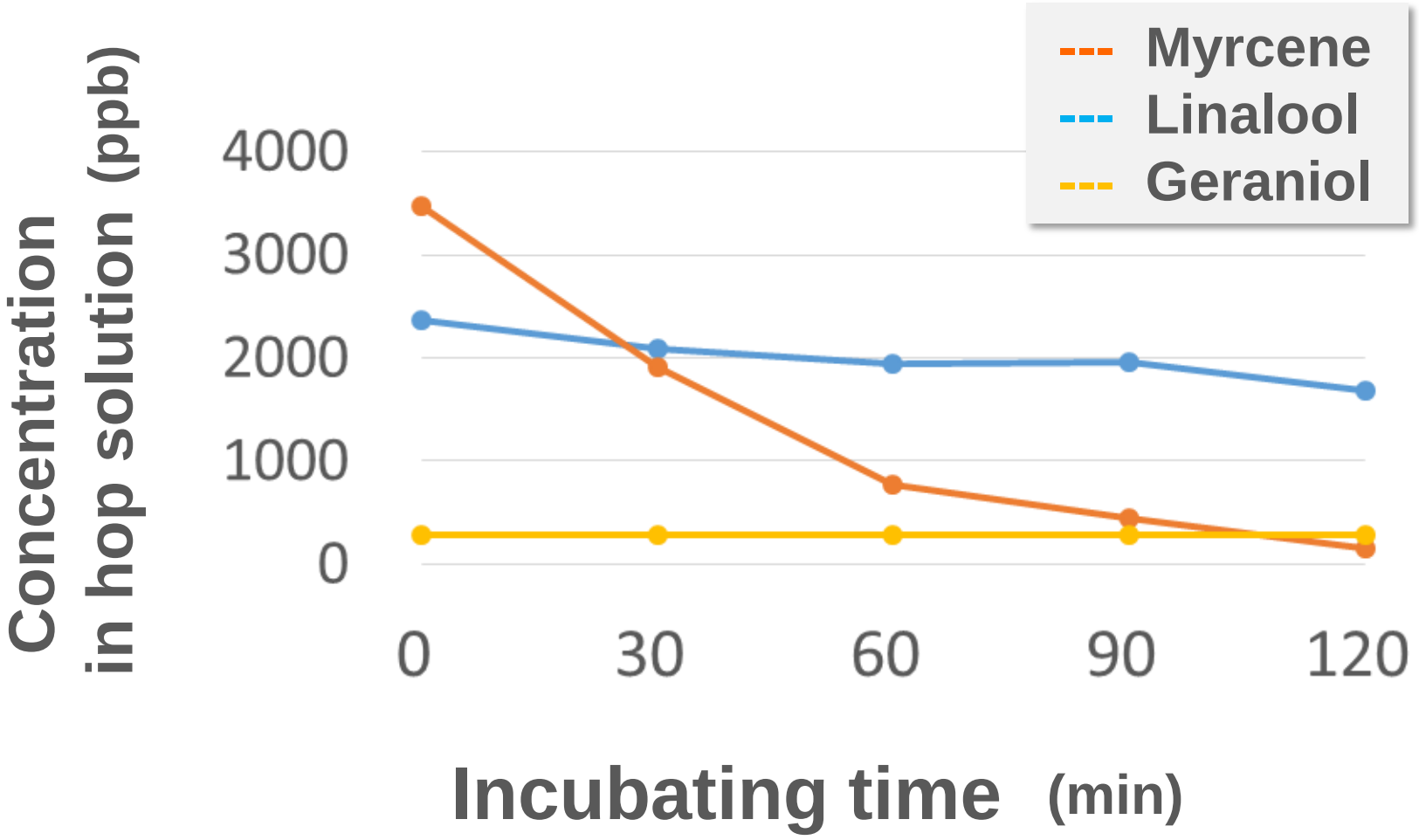


Circulate & spread

Advantages of hop incubation

- Selective removal of myrcene
- Improved utilization of α-acids

Aroma substances during hop incubation



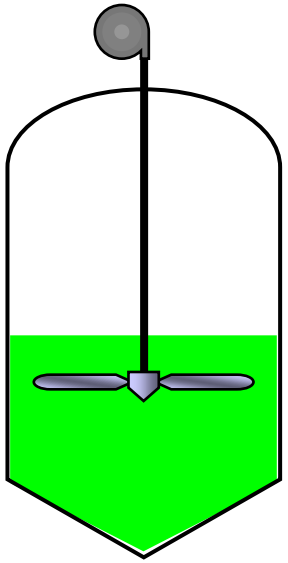
Equilibrium vapor pressure of hop aromas

	Equilibrium vapor pressure* [kPa]	Aroma character
β-Ionone	0.4	Violet
Geraniol	0.8	Rose
Citronellol	0.9	Citrus
Nerol	1.1	Apricot
Terpineol	1.7	Pine
Linalool	3.3	Floral
Myrcene	10.2	Green, Resin

* at 100℃

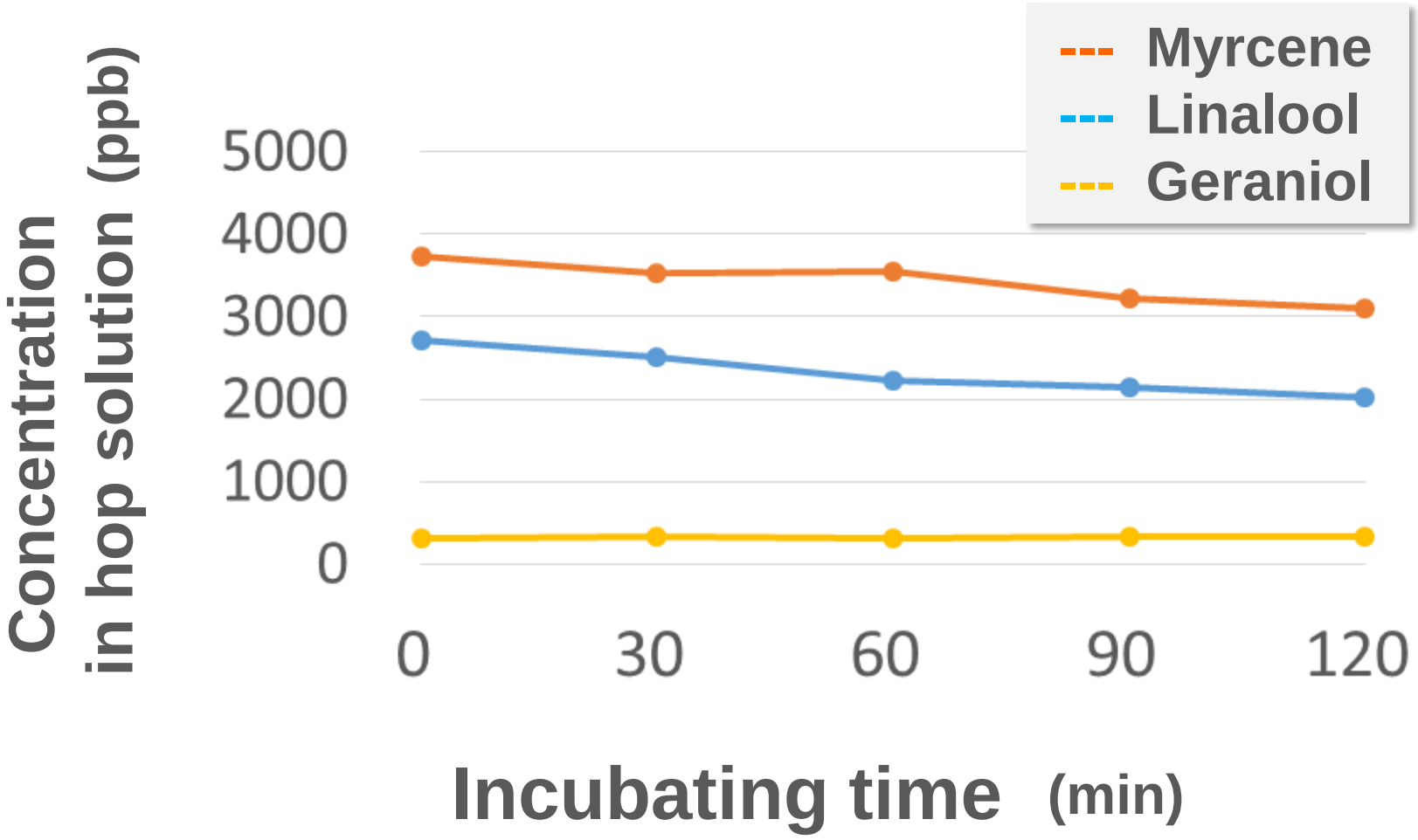
Choji Kashima; 2014

Another type of hop incubator

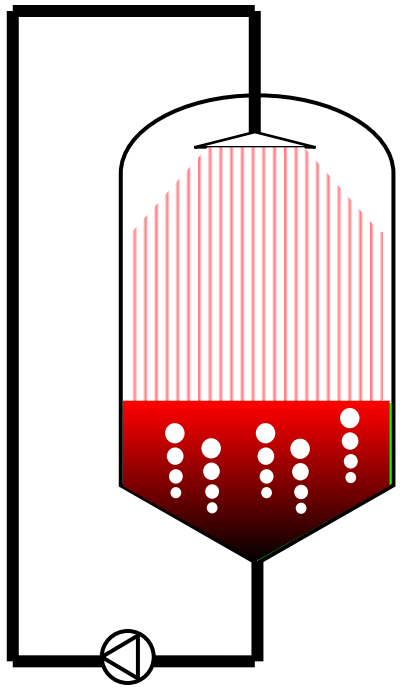


Agitate

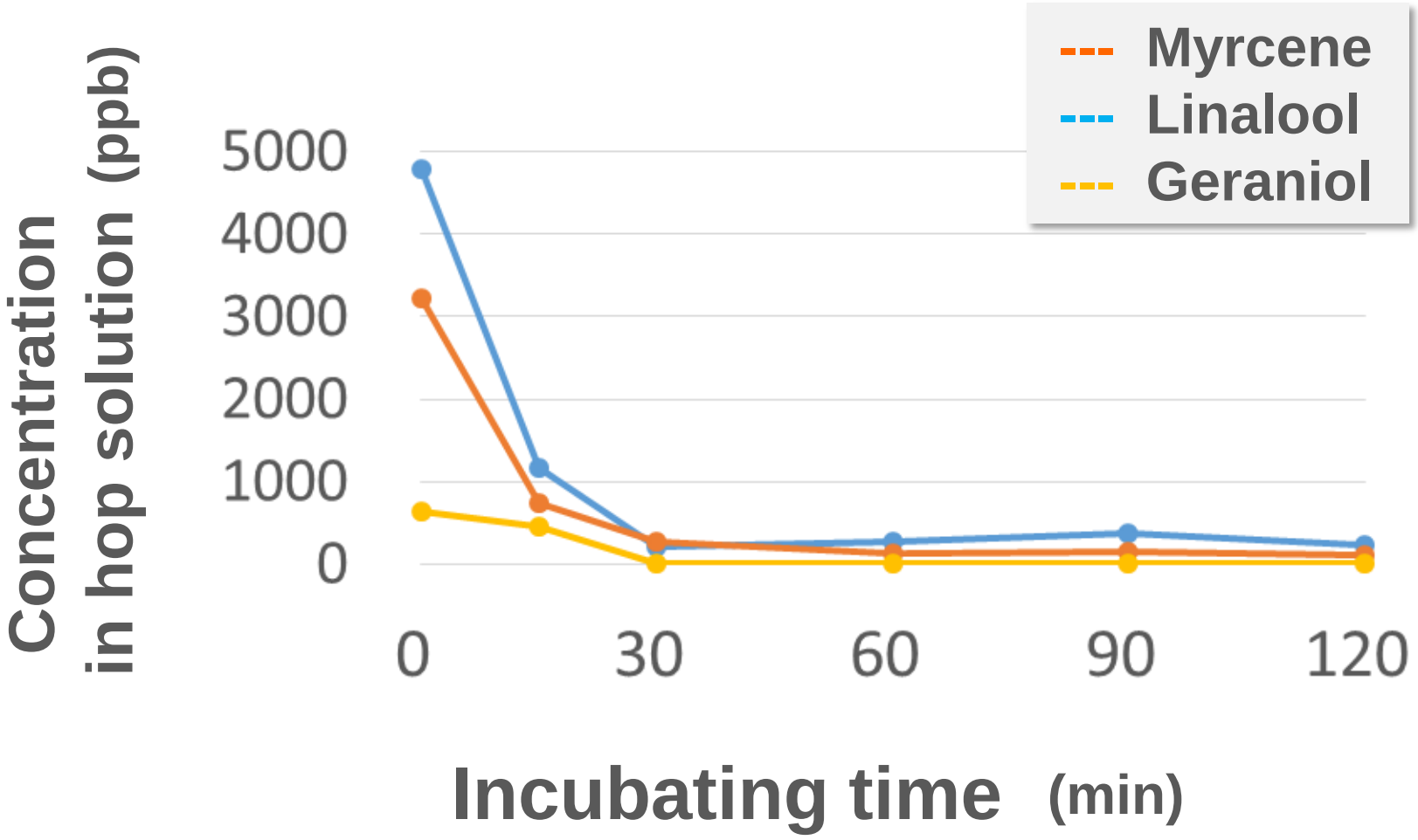
Aroma substances during hop agitation



Hop Boiling



Aroma substances during hop boiling



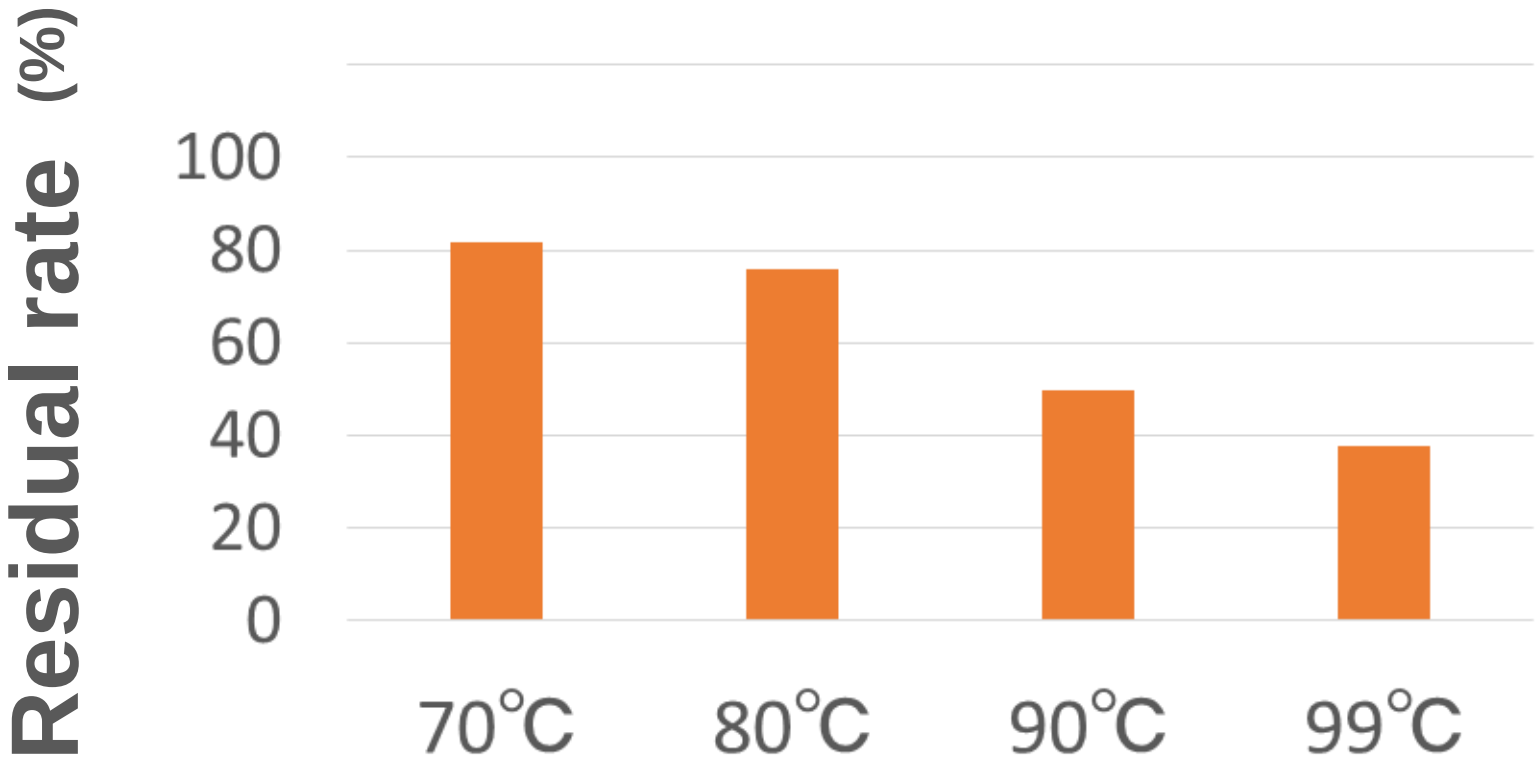
Hop incubation ≠ Boil

(Equilibrium shift) (Steam distillation)

Parameters in hop incubation

- Time
- Circulation times
- **Temperature**
- Hop concentration in the solution
- Inner pressure

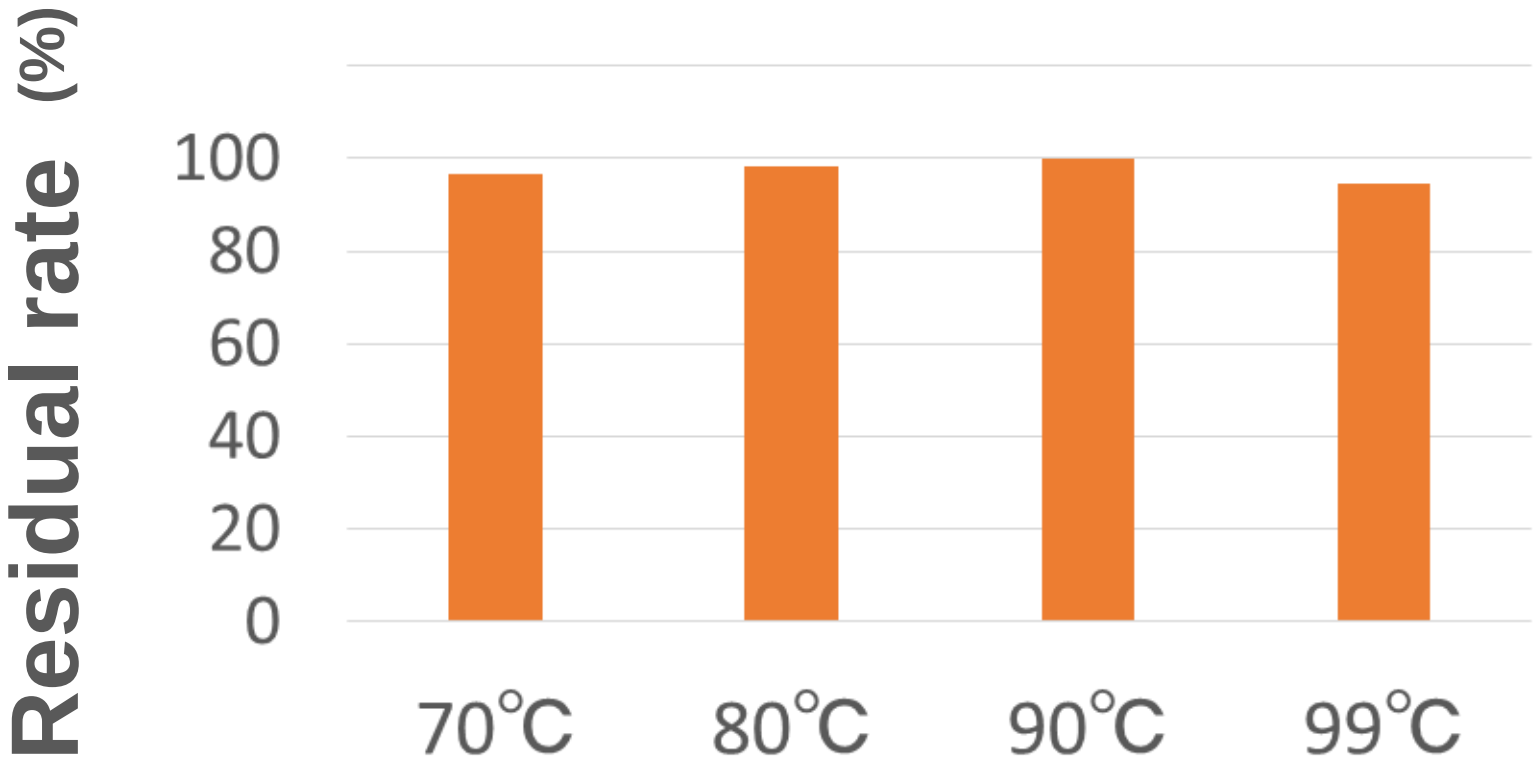
Myrcene incubated at 70-99℃



Volume of solution : 150 L

Incubating time : 30 min

Linalool incubated at 70-99℃



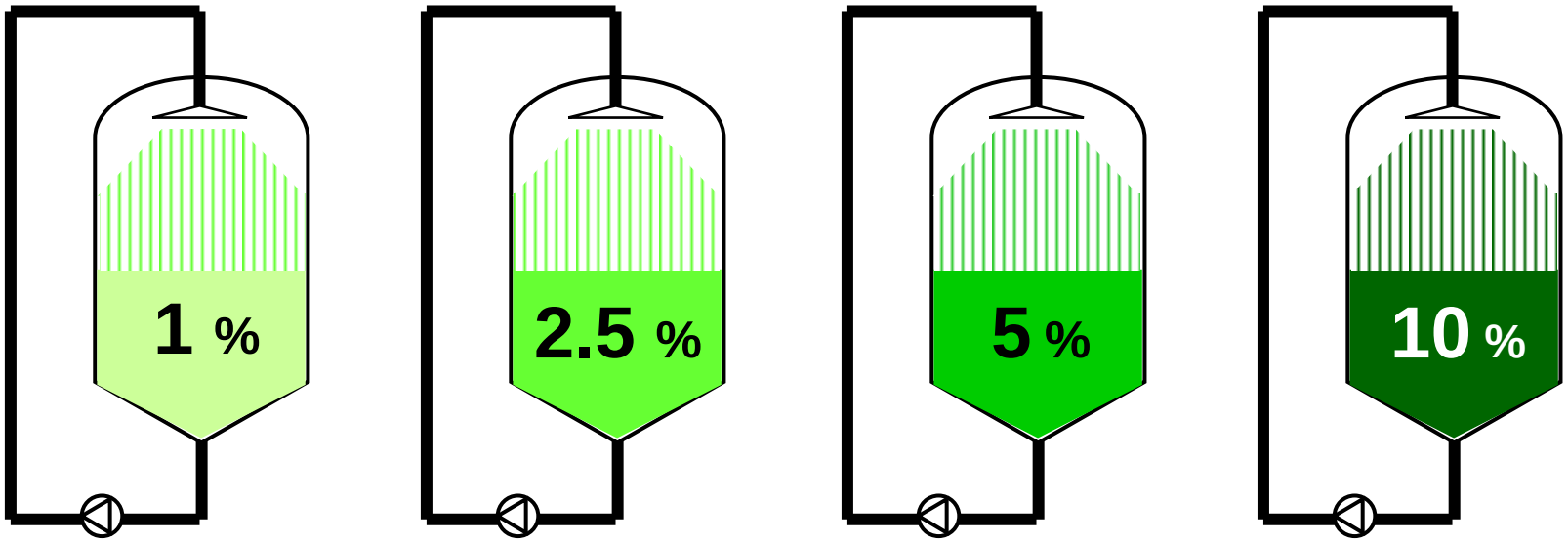
Volume of solution : 150 L

Incubating time : 30 min

Parameters in hop incubation

- Time
- Circulation times
- Temperature
- **Hop concentration in the solution**
- Inner pressure

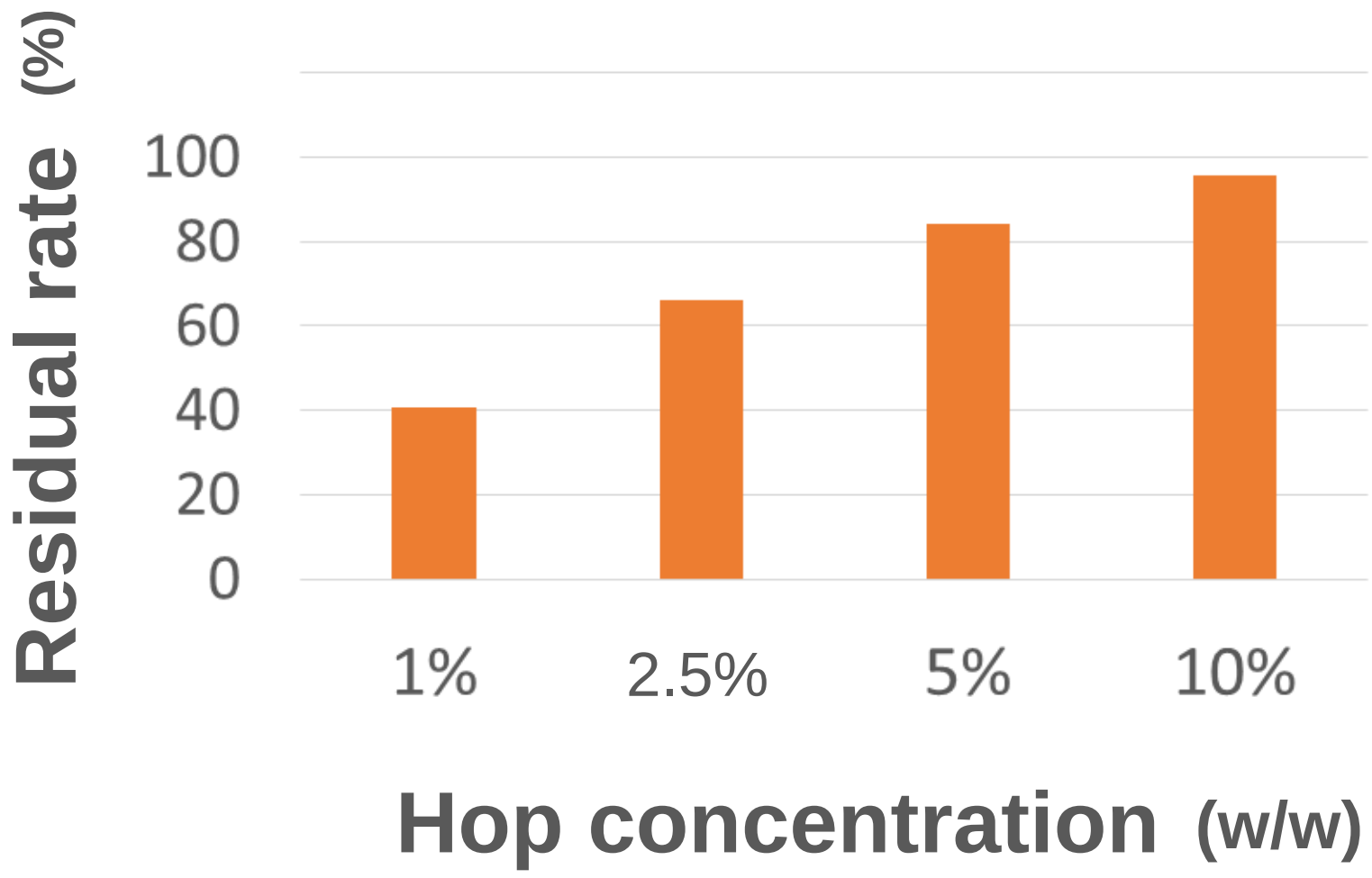
Hop concentration in the solution



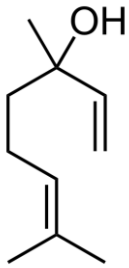
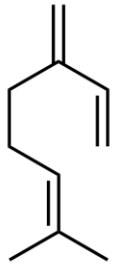
Volume of solution : 150 L

Incubating time : 30 min

Myrcene incubated at various concentrations

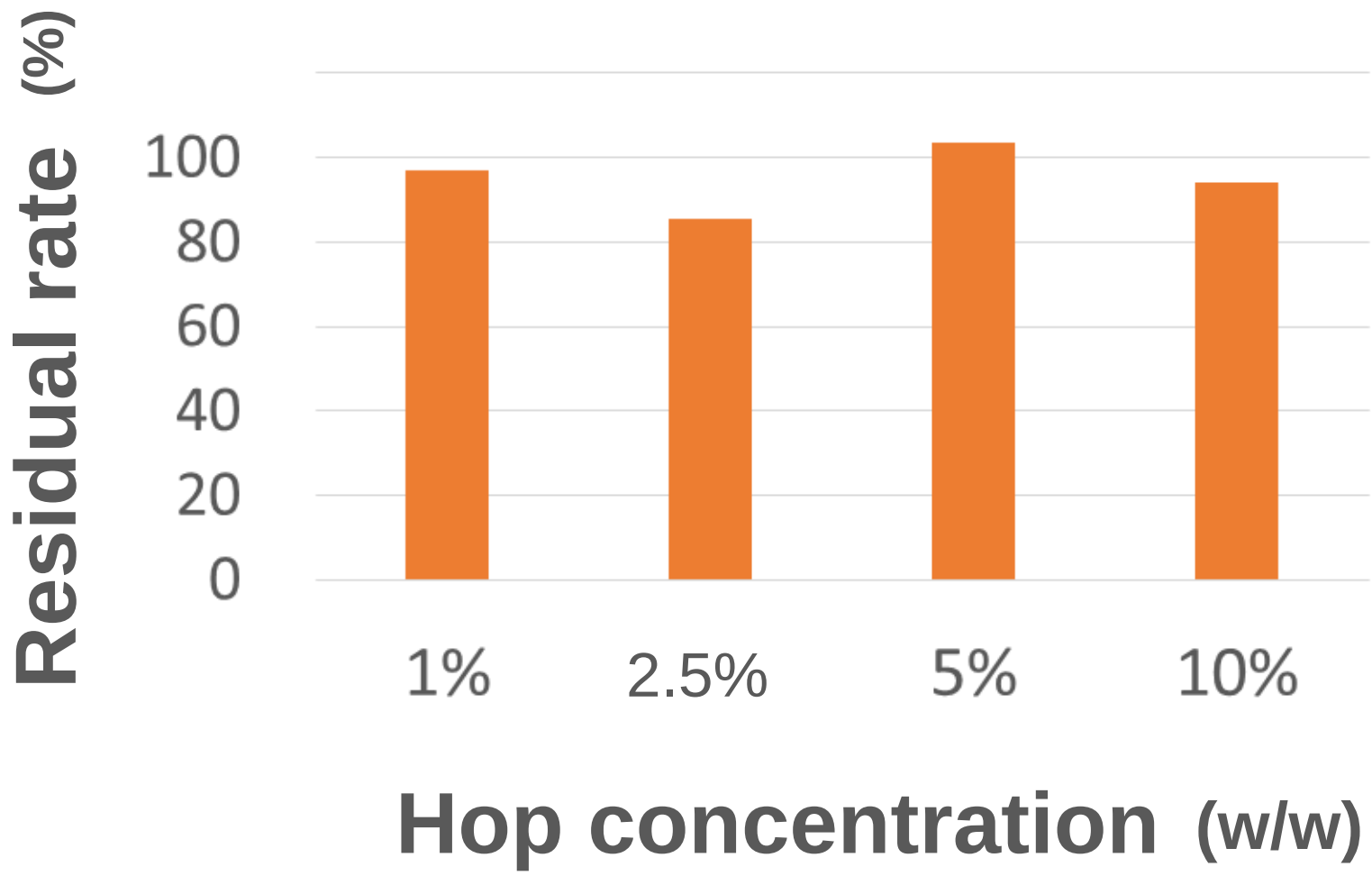


Solubility of hop aroma substances

	Linalool	Myrcene
Formula		
Type	Alcohol	Hydrocarbon
Solubility*	1450 mg/L	Practically insoluble

* at 25℃

Linalool incubated at various concentrations

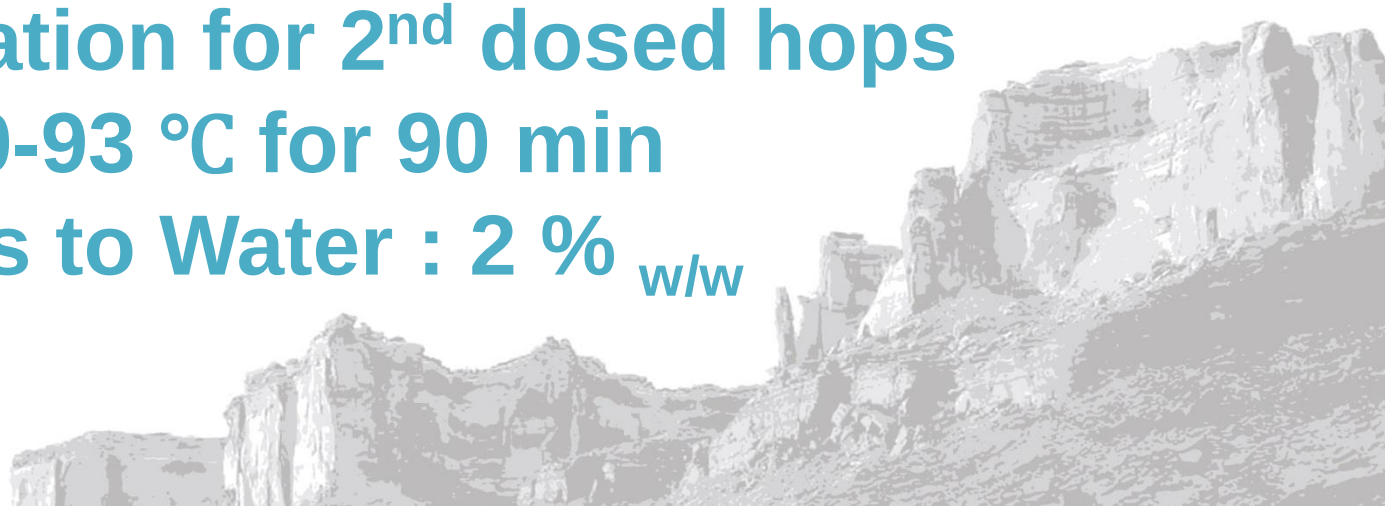


Brewing Trial

- 750hL / Brew
- Wort boil for 60 min

- Hop dosing
  - 65 % at start of wort boil
  - 35 % at end of wort boil

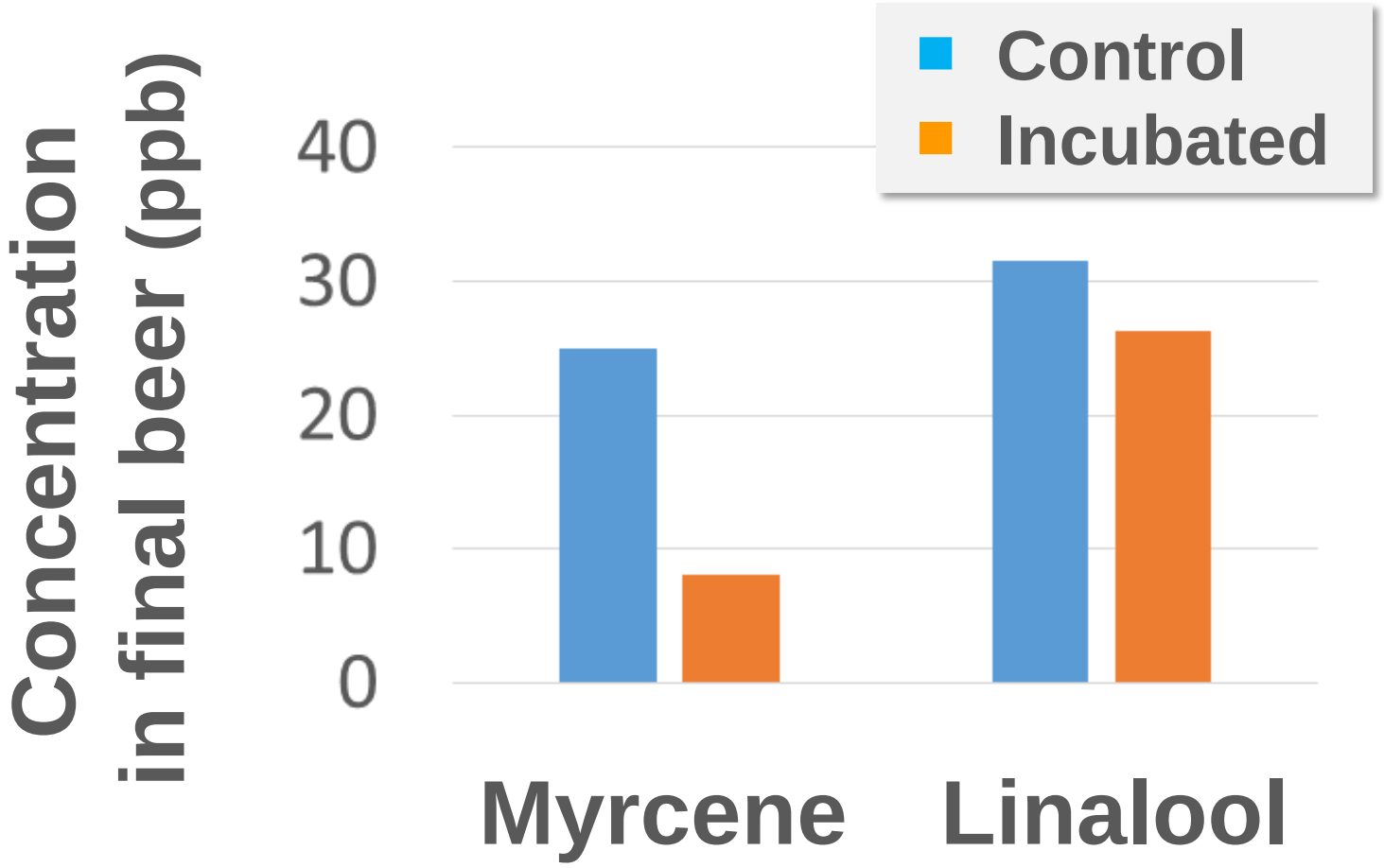
- Incubation for 2nd dosed hops
  - at 90-93 ℃ for 90 min
  - Hops to Water : 2 % w/w



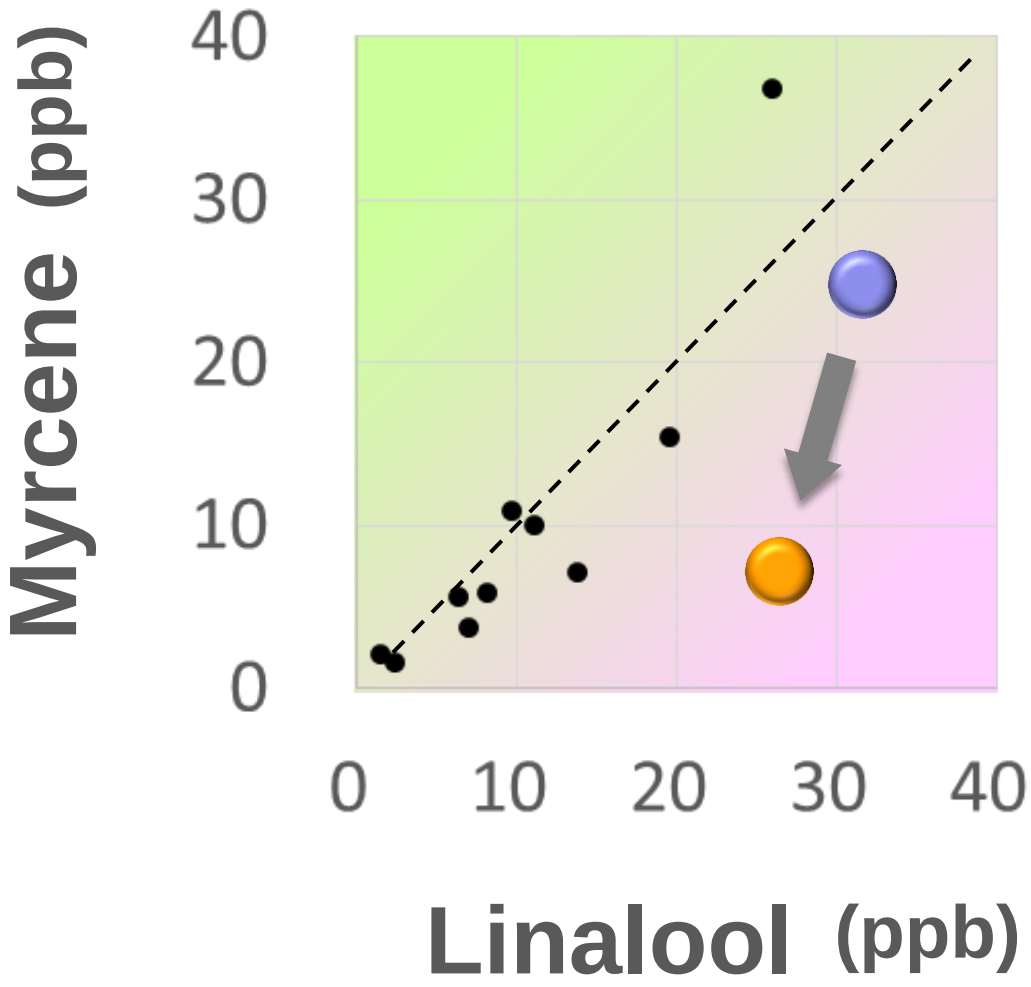
Results

- Myrcene and linalool
- Sensory evaluation

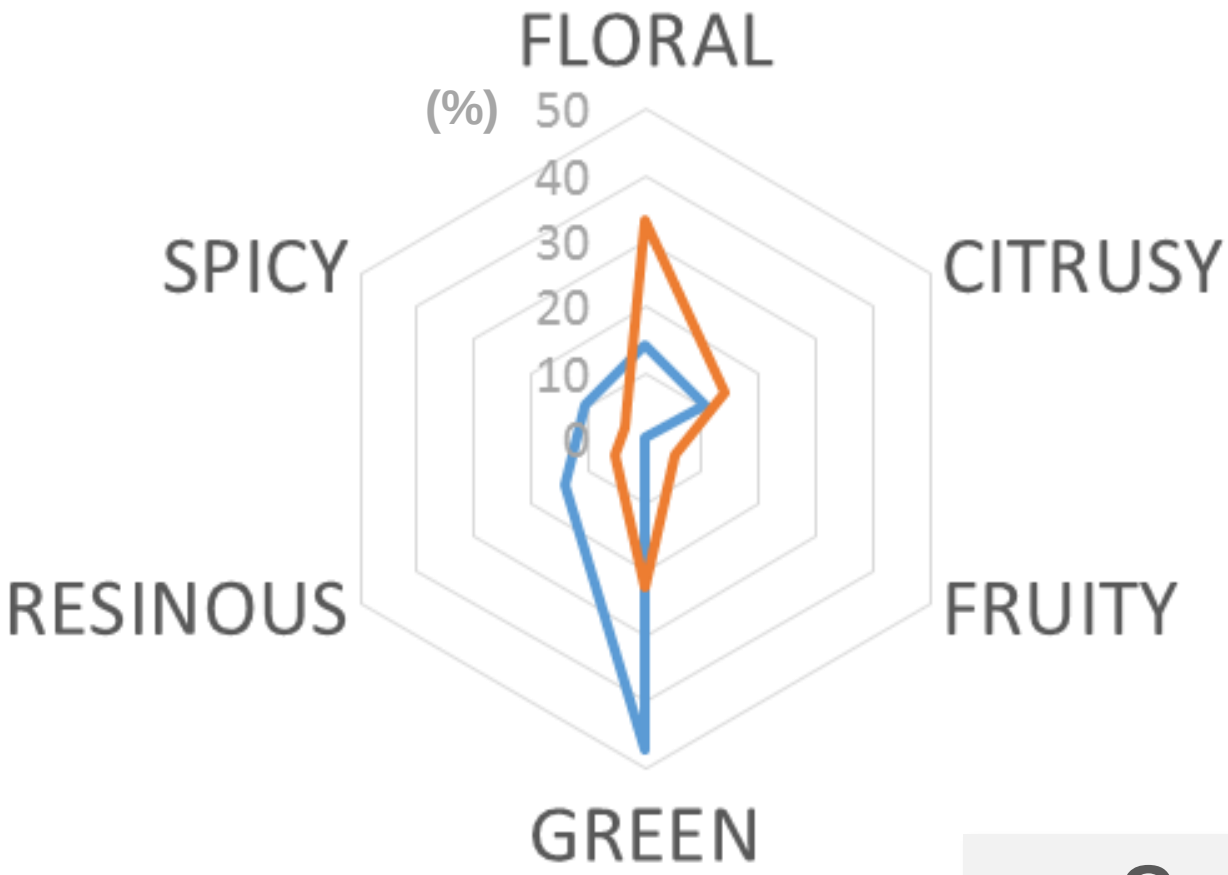
Myrcene and linalool in the final beer



Myrcene and linalool in the final beer



Sensory evaluation



Paired comparison

Panel : n = 67

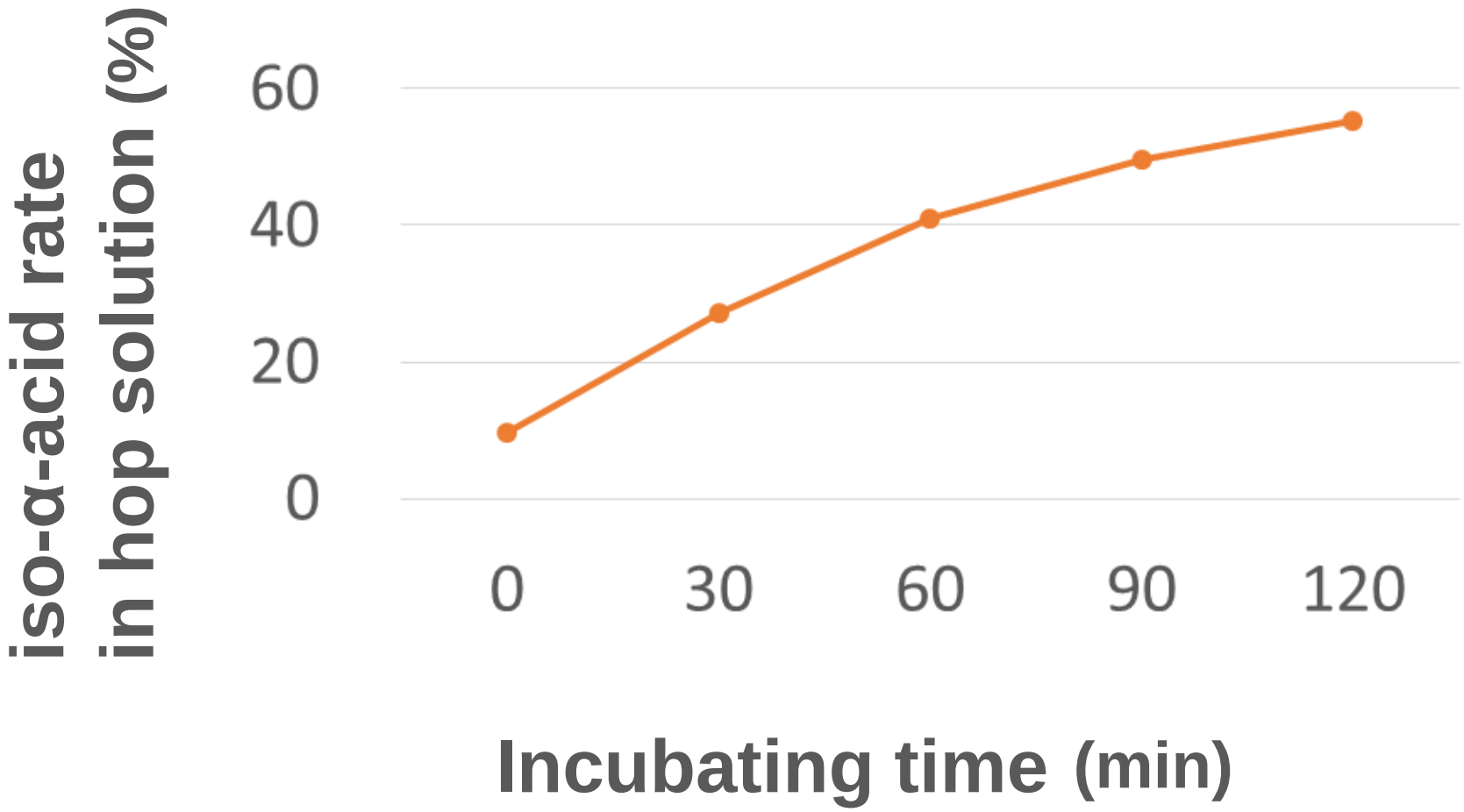
--- Control

--- Incubated

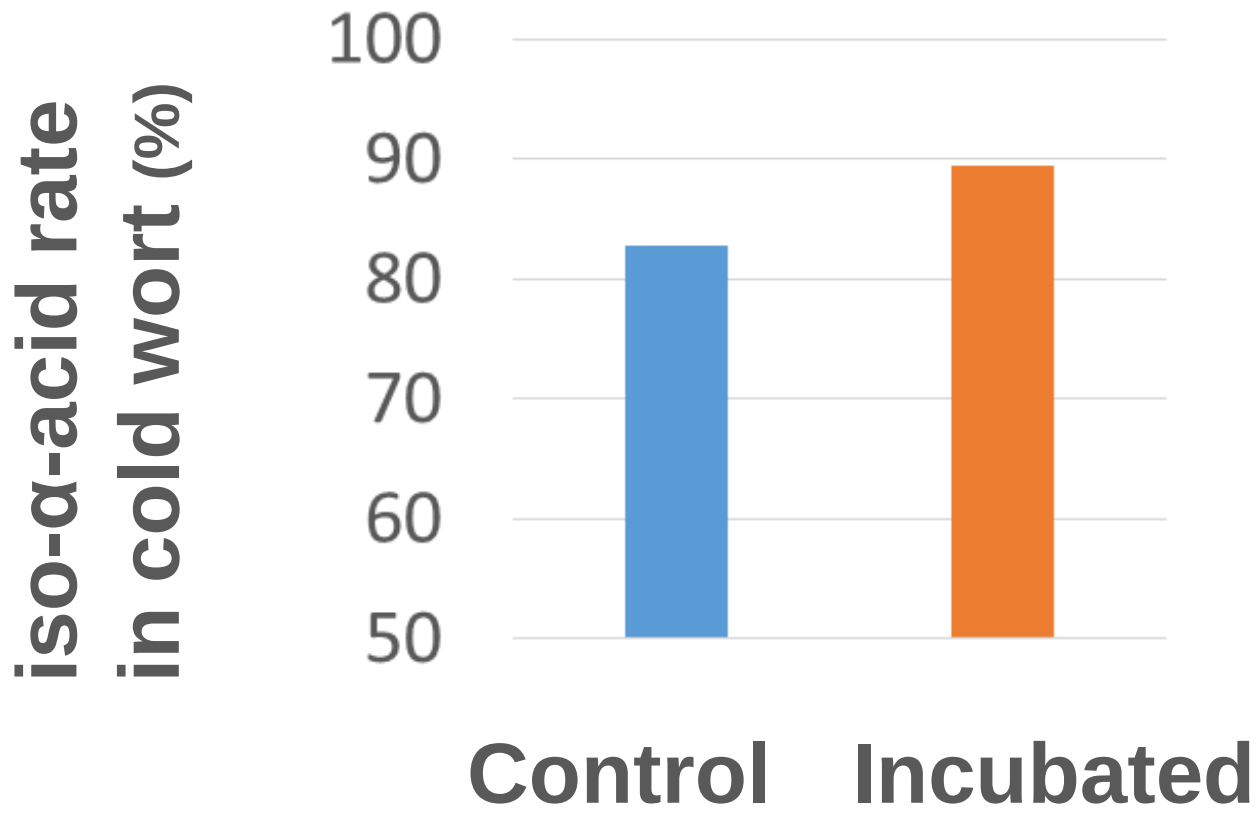
Advantages in hop incubation

- Selective removal of myrcene
- Improved utilization of α-acids

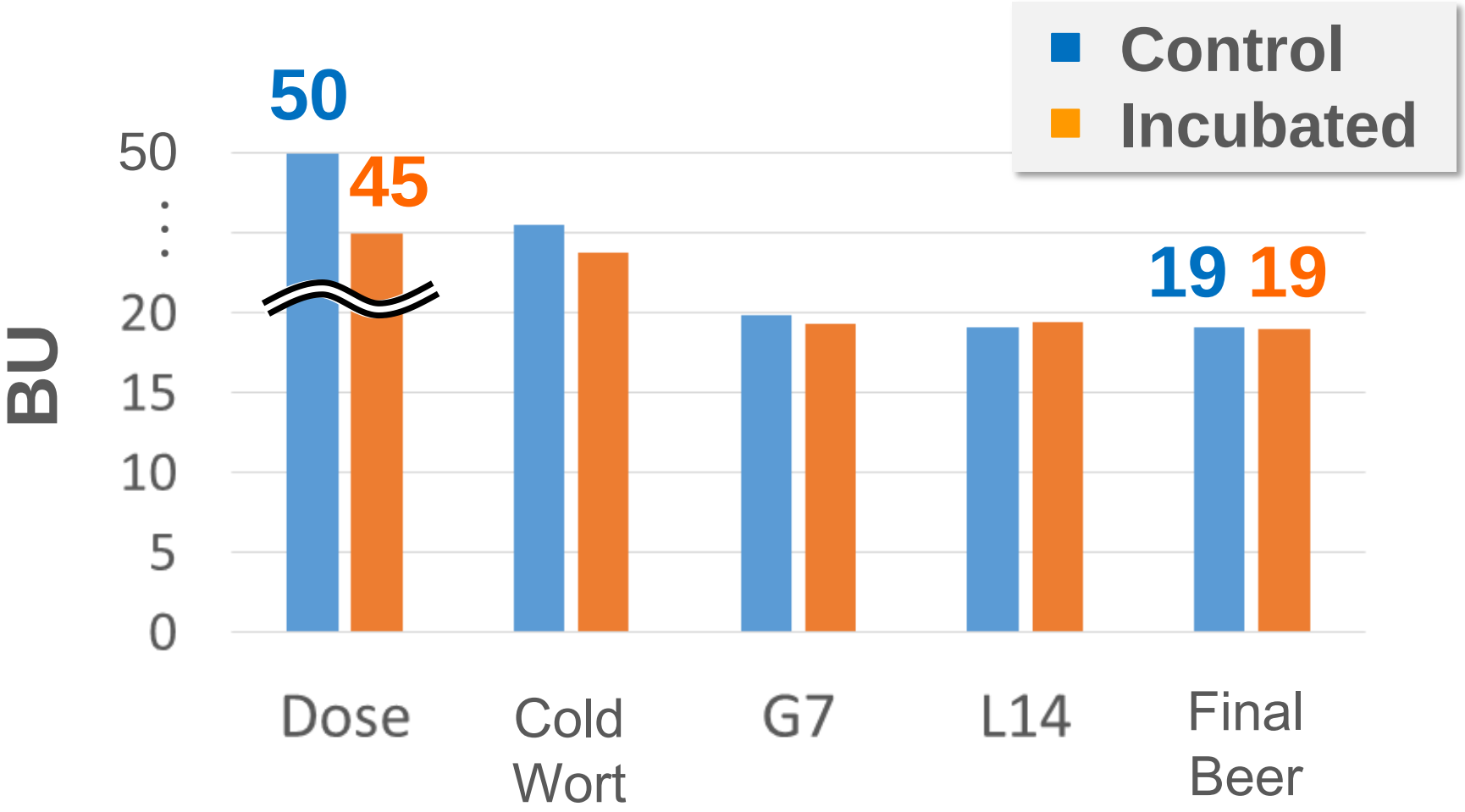
Isomerization of α-acids during hop incubation



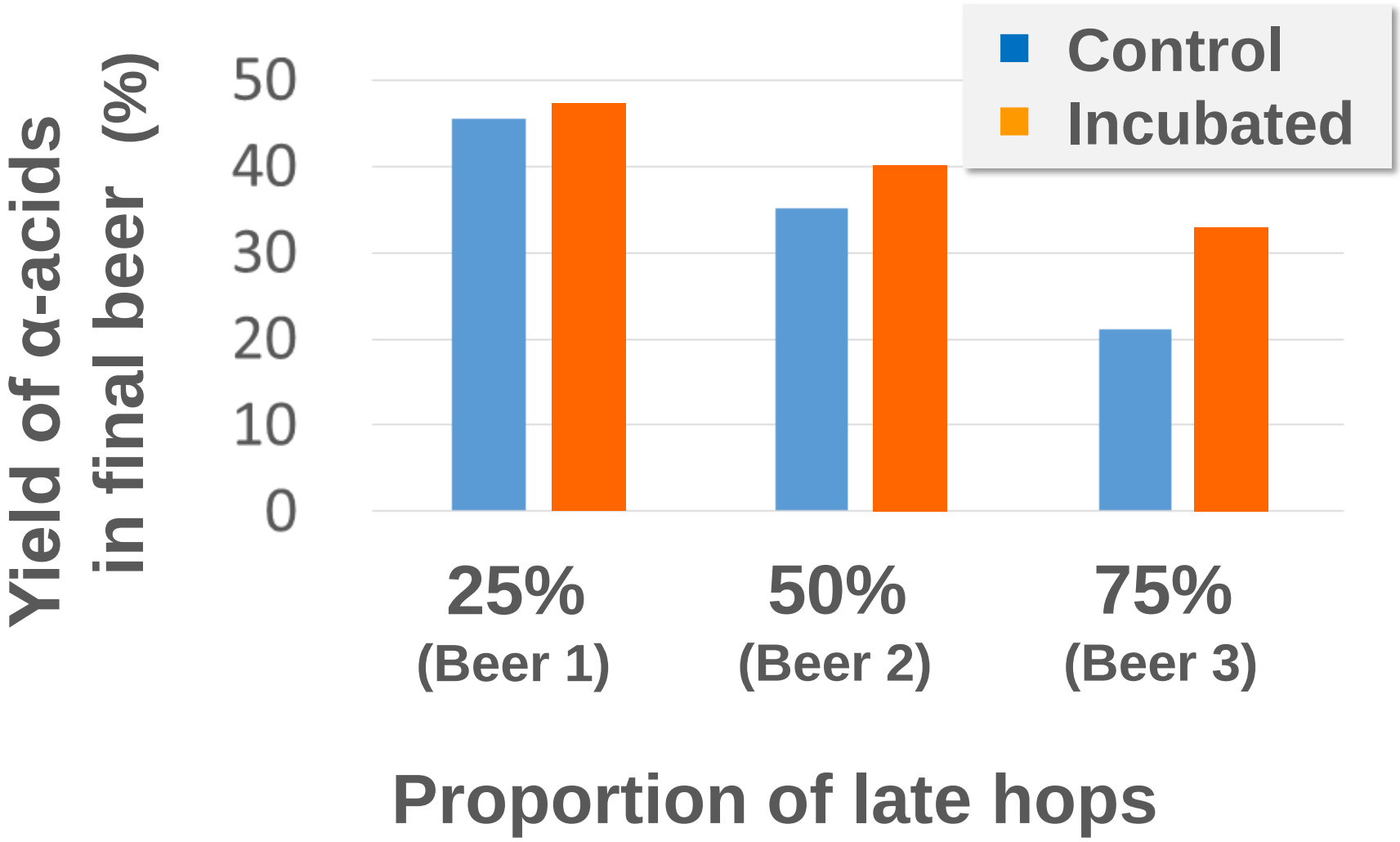
iso- α-acid rate in cold wort



BU during brewing process



Improved yield of α-acids



Conclusion

- Hop incubation at 90-99℃
  - Myrcene ~ ▲ 95 %
  - α-acid yield ~ + 50 %
- Regulated by
  - Time, Temperature,
    Hop concentration

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