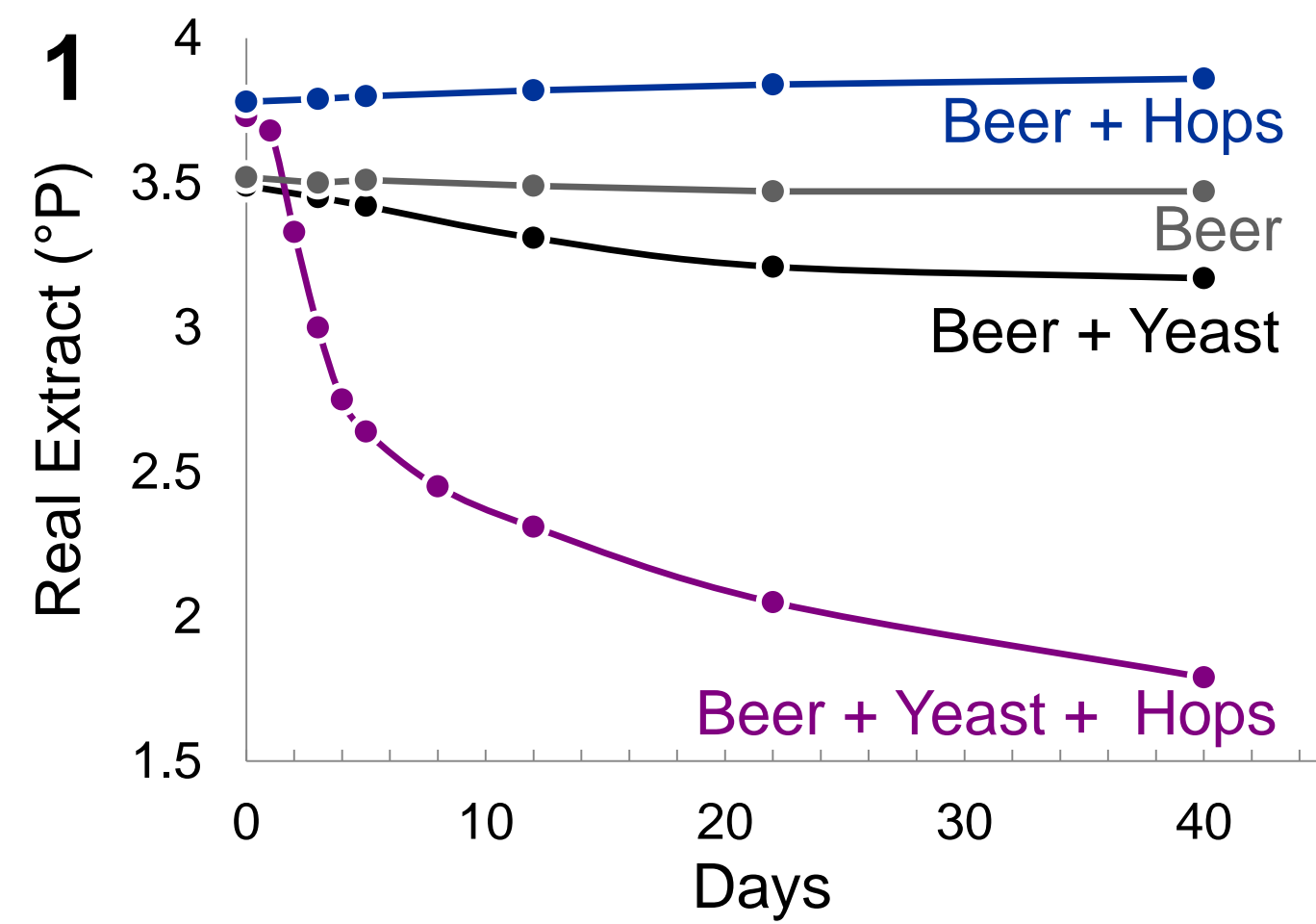


Background: After-fermentation of dry-hopped beer in the presence of yeast is referred to by the brewing community as **“hop creep.”** Since this phenomenon is not well understood, we sought to investigate the cause and underlying mechanisms. To our knowledge, this phenomenon has not been described in literature since 1941 where maltase activity was evidenced in dry-hopped cask ales.*

Hypothesis: Hop material contains dextrin hydrolyzing enzymes that can break down unfermentable carbohydrates remaining in finished beer to fermentable carbohydrates such as maltose and glucose.

Janicki, J., W. V. Kotasthane, A. Parker, and T. K. Walker. "THE DIASTATIC ACTIVITY OF HOPS, TOGETHER WITH A NOTE ON MALTASE IN HOPS." *Journal of the Institute of Brewing* 47, no. 1 (1941): 24-36.

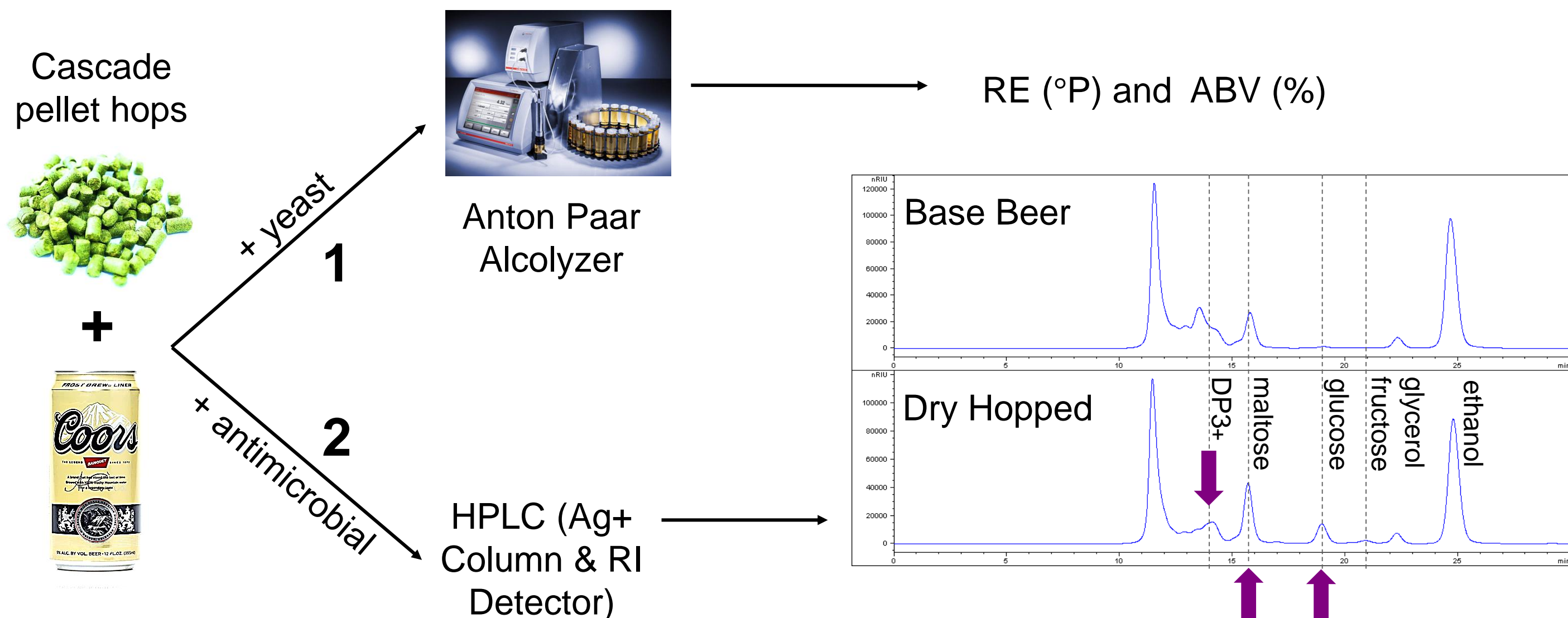
What does “hop creep” look like over time?



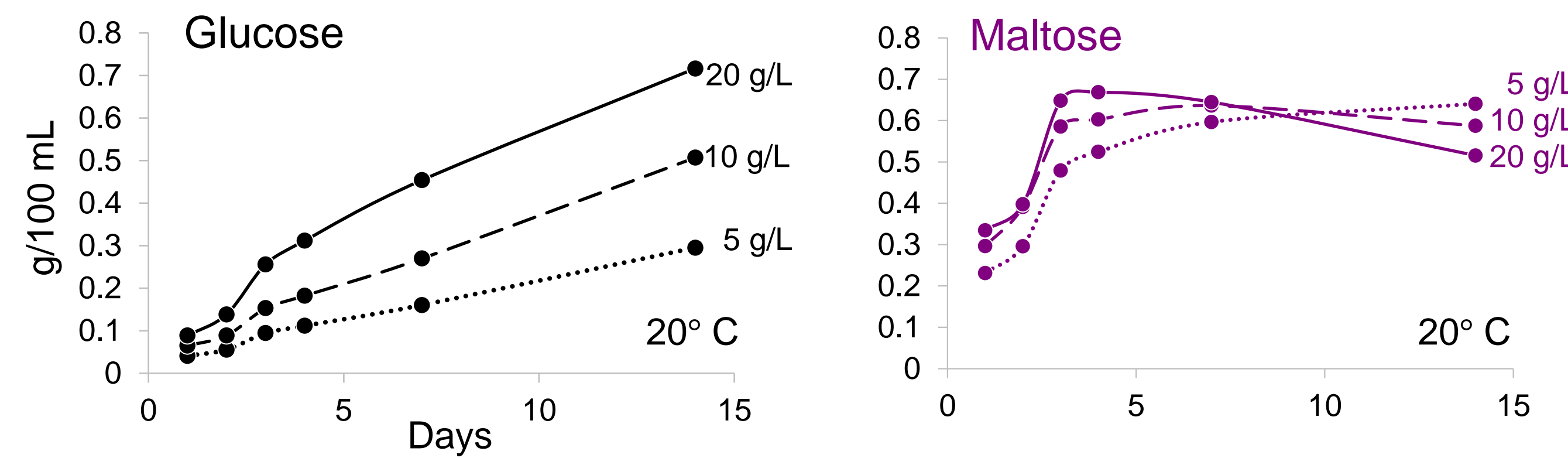
Measurement	Δ 5 days	Δ 40 days
RE (°P)	-1.1	-1.9
ABV (%)	+0.7	+1.3
CO ₂ (v/v)	+2.75	+4.75

Finished beer was dry-hopped with 10 g/L Cascade pellet hops and held at 20°C for up to 40 days. A significant reduction in RE can be observed over time when beer, yeast, and hops are combined compared to controls.

Profiling changes in beer fermentability using two methods

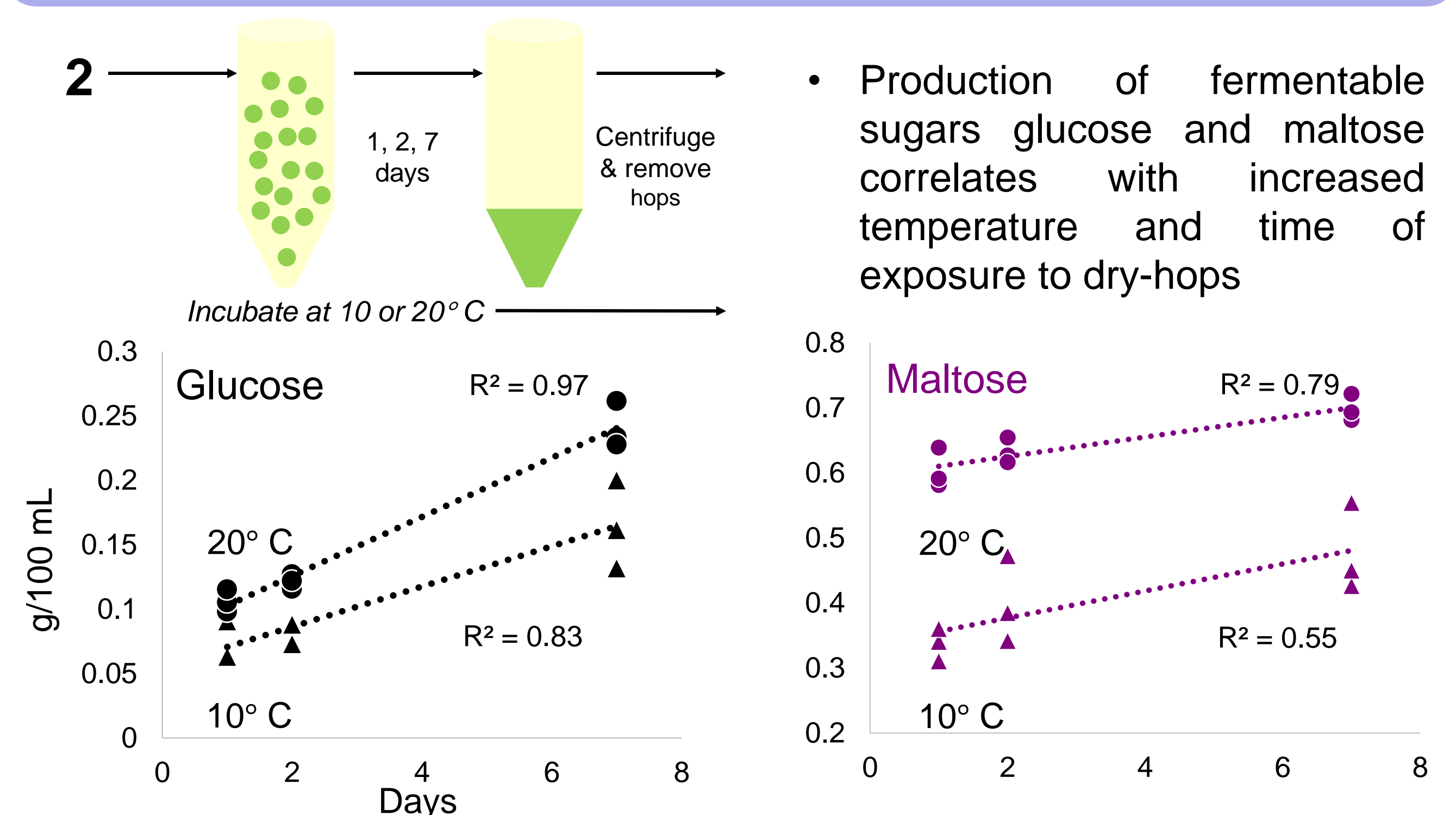


What is the effect of dry-hop concentration on formation of fermentable sugars?



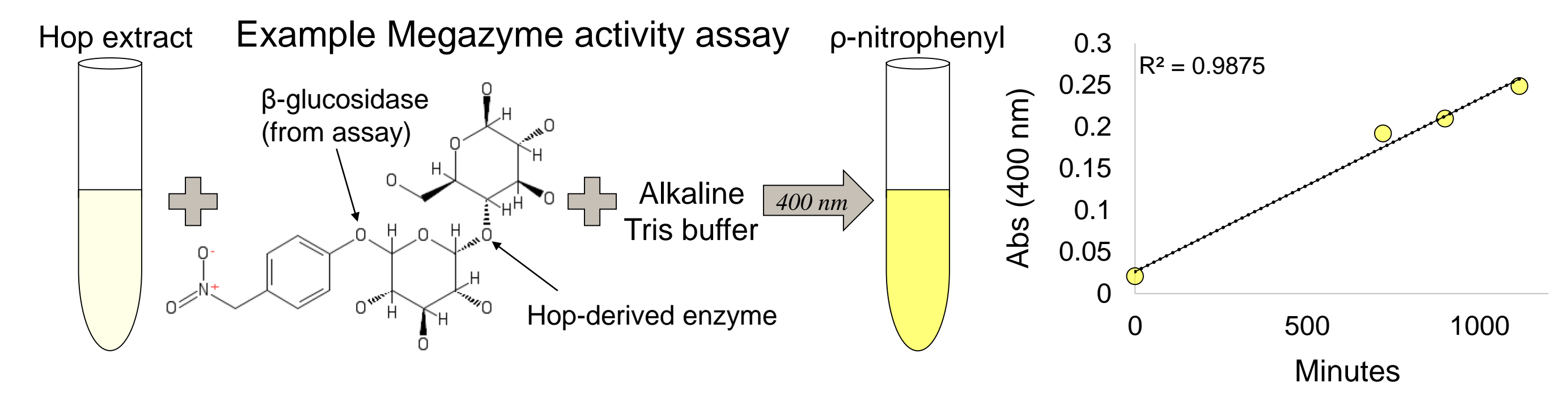
- Correlates with increasing concentrations of glucose
- Correlates with increasing concentrations of maltose (up until ~ day 5)
- Maltose concentration declines in highly hopped beers (after day 5)

What is the effect of dry-hop temperature & time of exposure on formation of fermentable sugars?



- Production of fermentable sugars glucose and maltose correlates with increased temperature and time of exposure to dry-hops

Probing hop enzyme activity



Enzyme activities in Units / g material

Enzyme	Hops (Cascade)	Malt (130 dp)
Amyloglucosidase	0.02	NA
α-amylase	0.35	198
β-amylase	0.41	13
Limit dextrinase	<0.01	NA

Conclusions & Future Directions

- Conclusions**
- Cascade hops can degrade residual dextrans to fermentable sugars glucose and maltose in beer
 - Dextrin reduction is hypothesized to be due to hop-derived amyloglucosidase in combination with low levels of α-amylase and β-amylase activity
 - Dry hop parameters can mediate enzyme activity of Cascade hops in finished beer
 - Despite low levels of enzyme activity in Cascade hops, there is sufficient activity to cause significant changes in beer RE (°P), ABV (%), and CO₂ (v/v)
 - Excessive production of CO₂ (v/v) poses a consumer safety risk due to potential package overpressurization
- Future Directions**
- Measure enzymatic power of different hop varieties
 - Investigate commercial dry-hopped beer fermentable carbohydrates over time

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