Improving Beer Freshness by Augmenting Sensory Panels with MicroESR Instrumentation

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ASBC
THE SCIENCE OF BEER

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Outline

- Why Beer Freshness?
- Instrument Analysis of Beer Freshness – MicroESR
- Correlating MicroESR to Human Sensory Panels
- Using MicroESR to Improve Beer Freshness in the Brewing Process
- Summary and Future Work

Beer Freshness

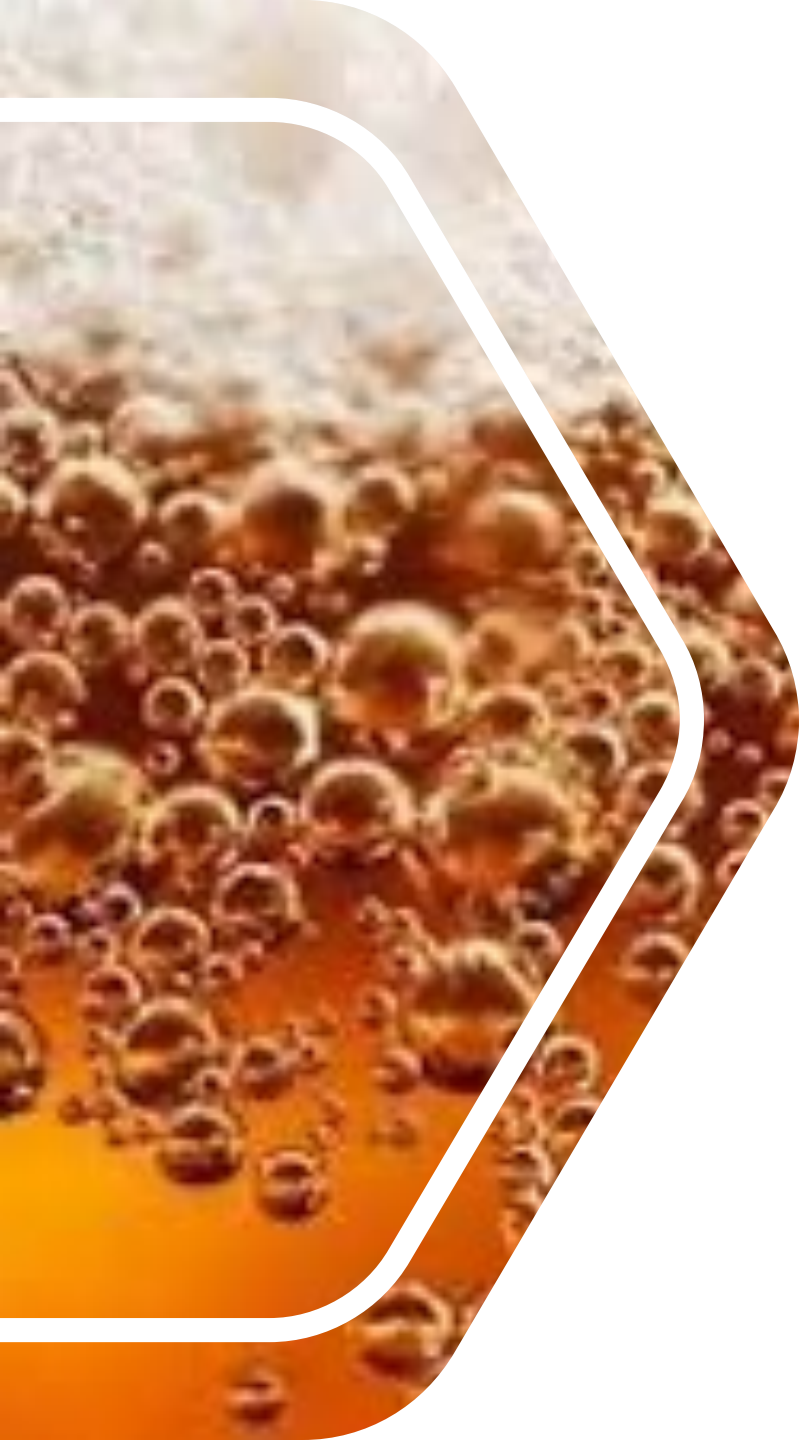
Today we see an ever-changing landscape for businesses regarding travel, logistics and operations. For beer, the disruption to the supply chain can have a cascade effect down the line to consumer enjoyment. Whilst many beverages remain flavour stable for up to a year, we know that beer loses freshness due to oxidisation and flavour change within a few weeks of packaging.

We've seen first-hand how issues with beer freshness can impact global brands, potentially damaging brand reputation and value.

Beer Freshness

Although the technology of electron spin resonance (ESR) is well established, its application to deliver increased shelf-life, in-line with expert sensory panels is novel. By analysing a direct correlation between free radicals and sensory values, a concise approach to extending shelf-life can be observed.

Since we are measuring free radicals and not the end products associated with oxidation of beer, we are able to use this technology to examine the whole brewing process and also, raw materials to eliminate or refine those processes or materials that either increase the quantity of free radicals or decrease the amount of antioxidant materials



Instrument Analytical – Micro ESR

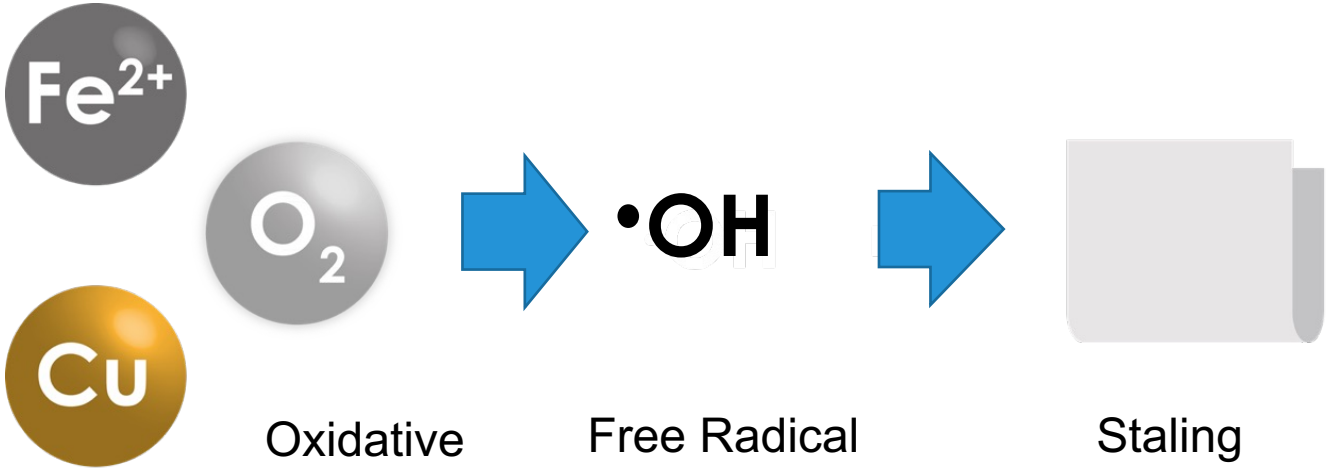
What is ESR?

- ESR / EPR = Electron Spin Resonance / Electron Paramagnetic Resonance (Spectroscopy, Spectrophotometry)
- **It's a technology that measures free radicals (biological reactions have free radicals)**

All free radicals have an unpaired electron

- Using this technology we can determine qualitatively and quantitatively the nature of each sample

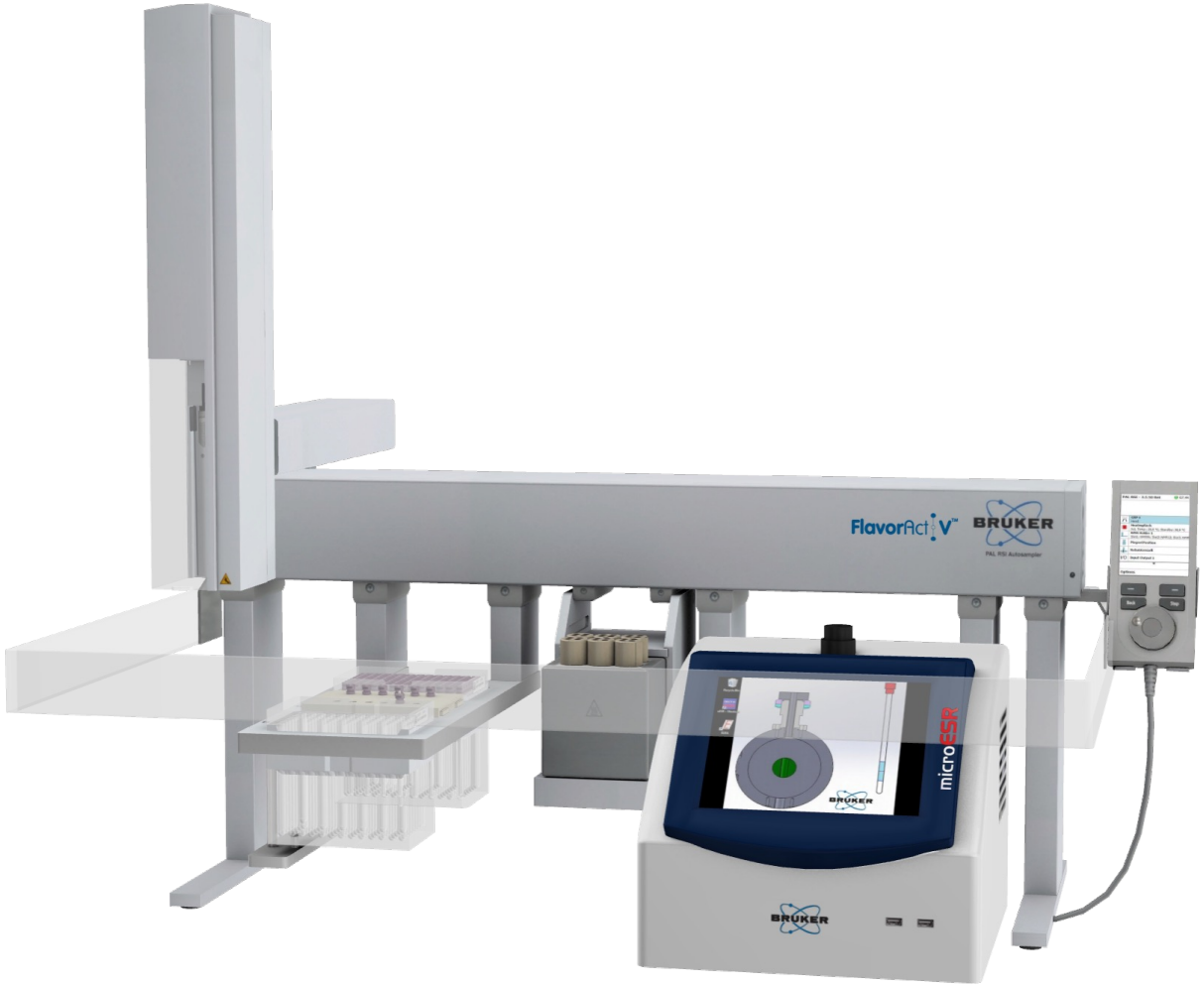
What is Measured by ESR?



Oxidative precursors interact to form free radicals – the most common in beer is the hydroxyl radical.

The hydroxyl radical interacts chemically with beer components to produce staling flavours and reduce the shelf life of the beer.

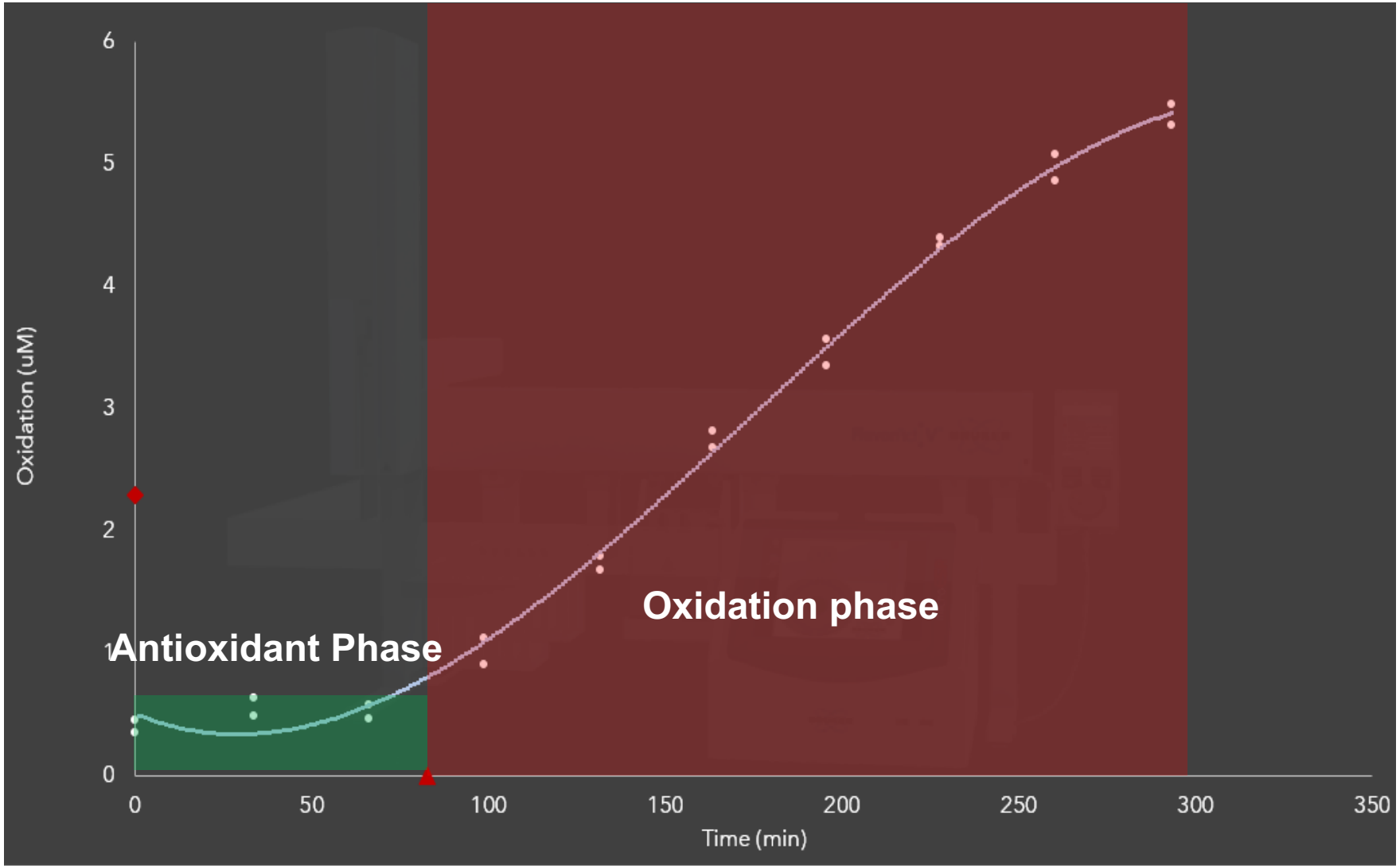
Application of ESR in Beer

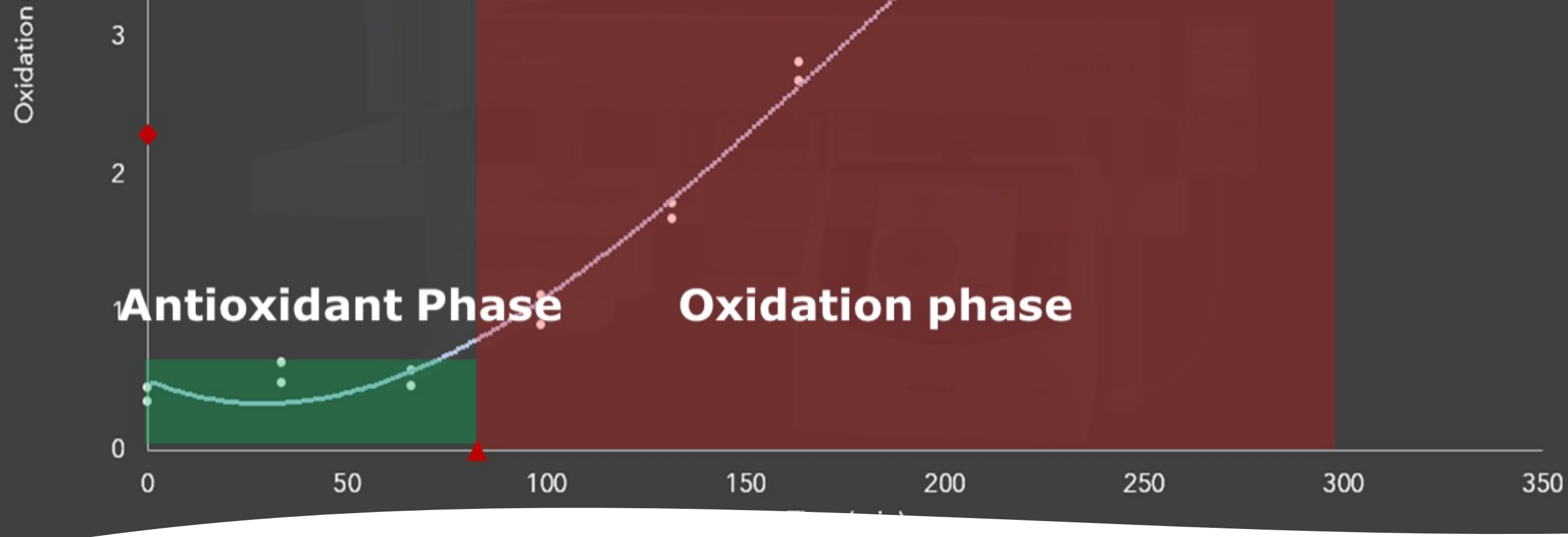


- Measuring the Hydroxyl radical (most reactive ROS species) production offers an opportunity to estimate the potential for ageing in beer

- Mapping the production of the Hydroxyl radical throughout the brewing process is the key focus of Beer Freshness.

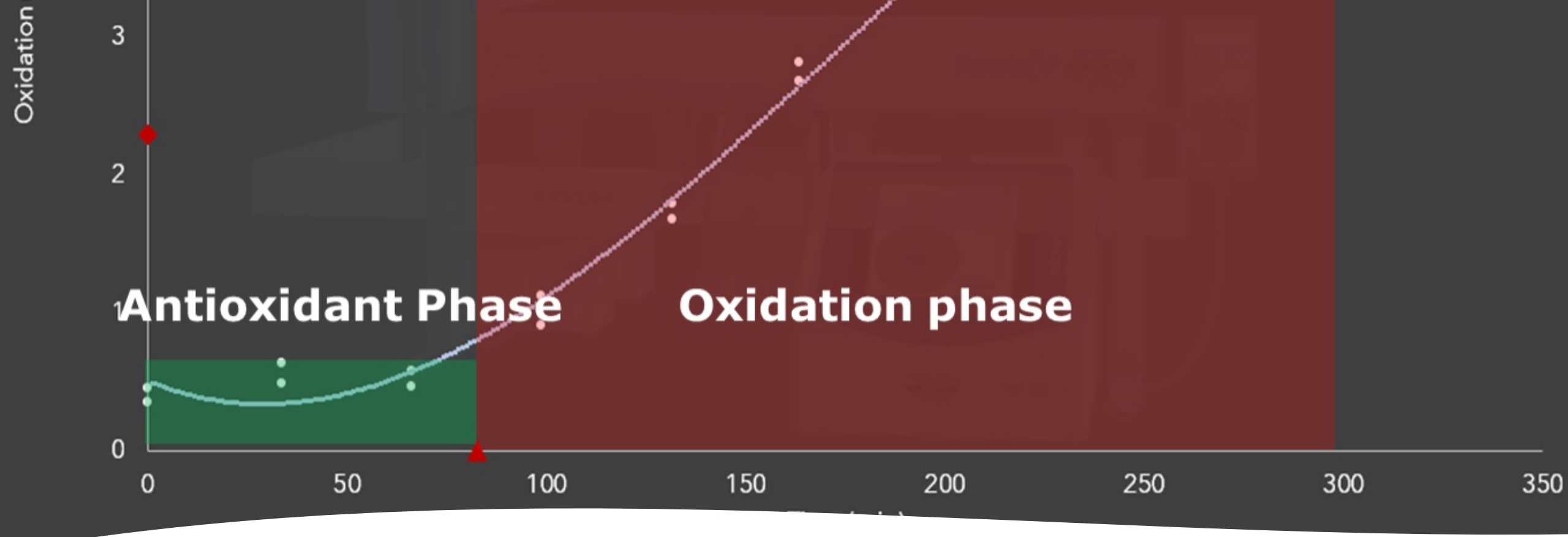
How we measure – The Oxidative Forcing Test





Antioxidant Phase

- Antioxidant activity phase (protection)
- Beer protection against oxidation
- Little or no signal
- Measured using Freshness Index (Lagtime) as minutes



Oxidation Phase

- Oxidation phase (damage)
- Free radical production
- No protection
- Linear production of free radicals
- Clear signal

*Measured using signal at 150min

- Oxidation Index (T150)

Indicators and Targets for Beer Freshness

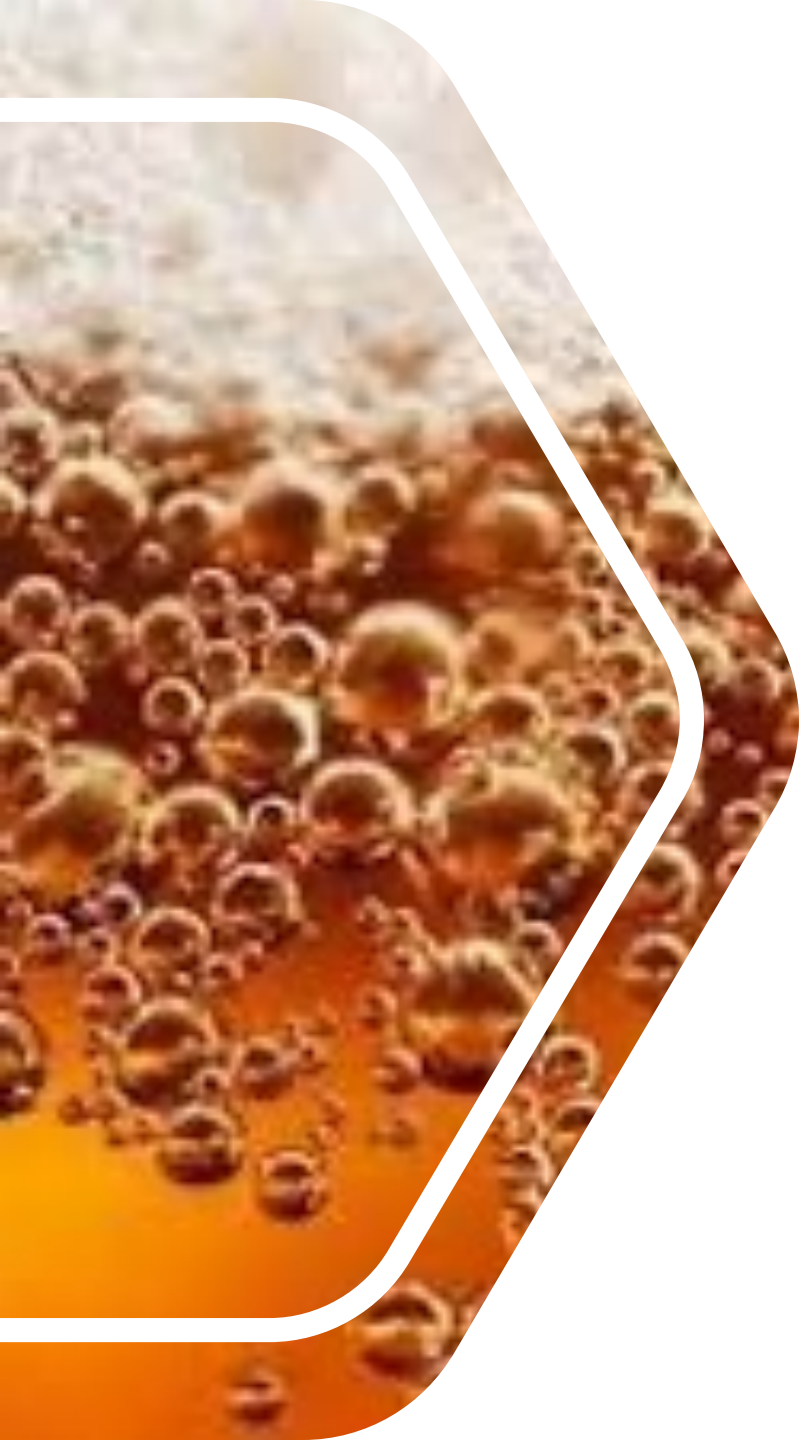
Indicator	Target	Description
Freshness Index	>90 min	Measurement of the amount of antioxidants naturally within the beer. This number should best be higher than the target for better freshness. **Indicates the amount of antioxidants that are still present in the beer at the time of testing**
Oxidation Index	< 1uM	Measurement of the amount of free radicals present in the beer that will cause oxidation. This number should be lower than the target for best freshness. **Indicates the potential for the formation of staling compounds after the antioxidants have been depleted.**
Oxidation Rate	< 15 uM/min	This is the measurement of the capacity to oxidize which considers the amount of antioxidants present in the beer versus the free radicals present. This number should be lower than the target to obtain better beer freshness.

How is the Data Generated Used?

- All results are generated using the ActiV Freshness Application developed by FlavorActiV to generate more accurate and reliable Freshness indicators.
- Raw data from the instrument is used in the ActiV Freshness Application to generate Freshness KPIs
- Only Freshness Index and Oxidation Index is used for data analysis on reports

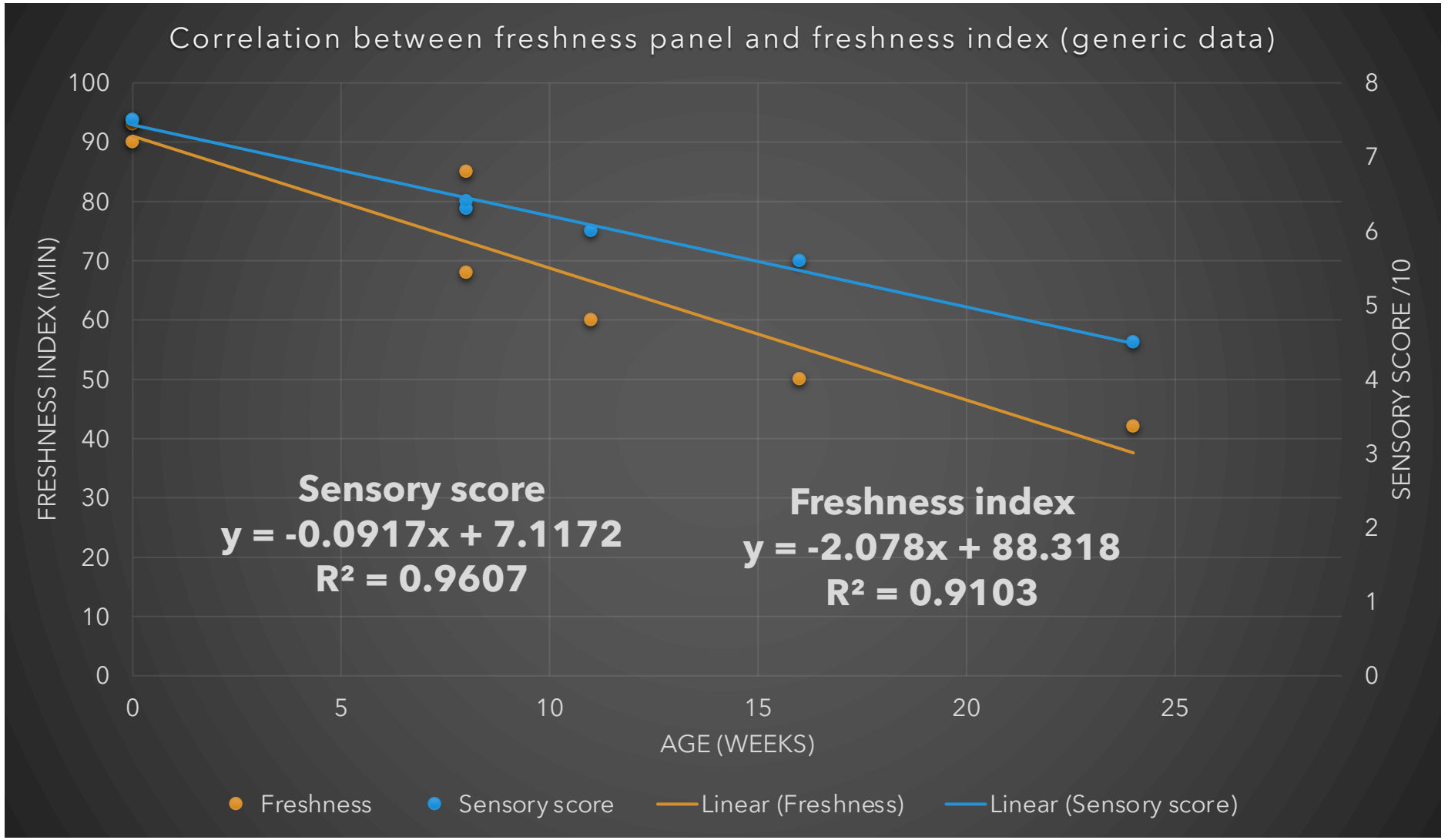
Beer Freshness KPIs and Targets

		Freshness Index	Oxidation Index
Target	The beer has a high antioxidant capacity	90+	<1uM
Acceptable	Optimization of beer freshness is required	40-90	1-2.5 uM
Poor	Urgent attention is required to improve beer freshness	<40	>2.5 uM



Correlation of Micro ESR to Human Sensory

Correlation of Analytical to Human Sensory



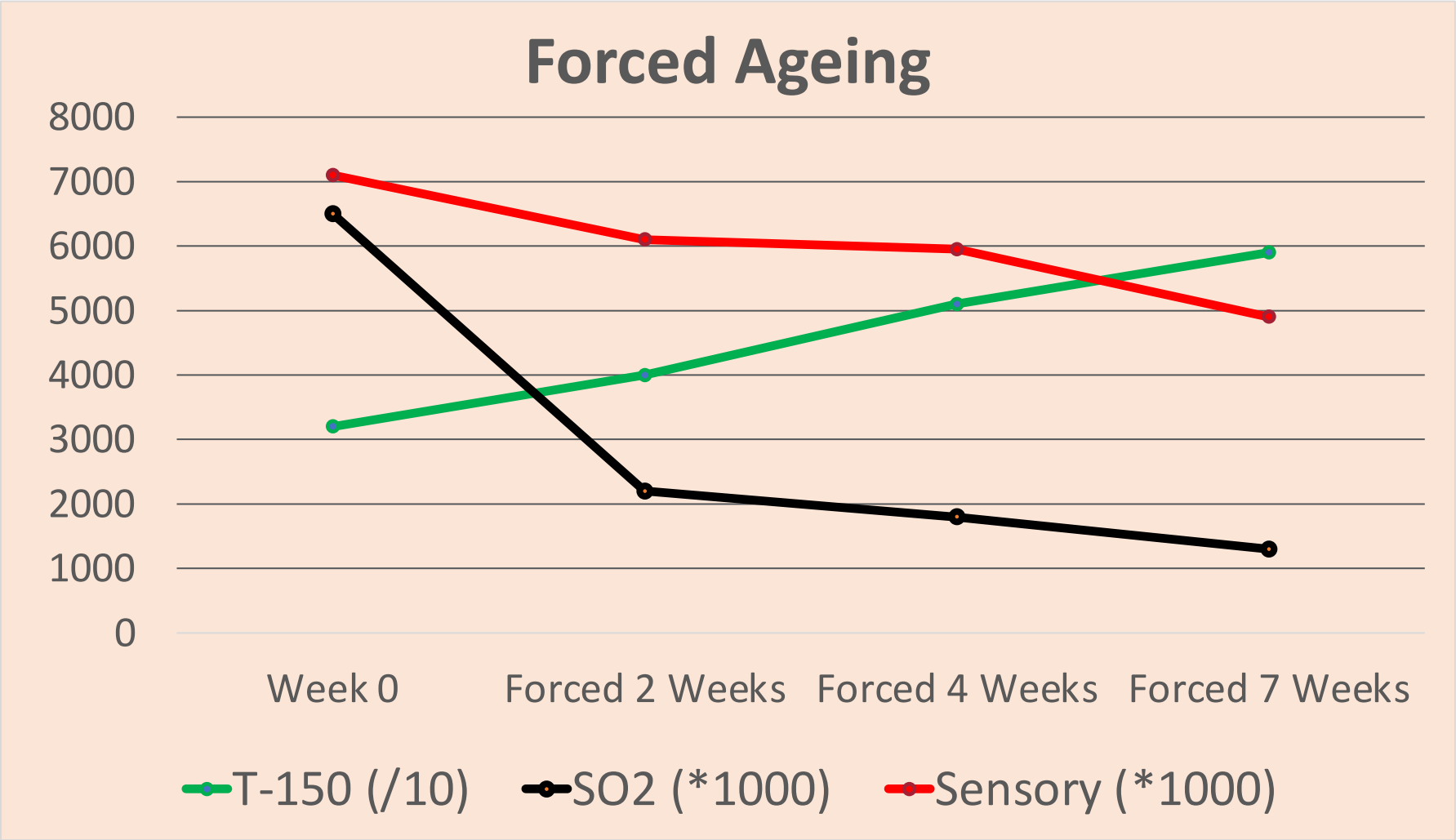
Shelf Life Studies

Study showing correlation of mESR KPIs and Sensory score with age for an optimised beer sample

Acceptable level of sensory score > 5

This was reached after 20 weeks indicating an acceptable shelf life of 20 weeks

Beer Freshness: Instrument versus Sensory Panel



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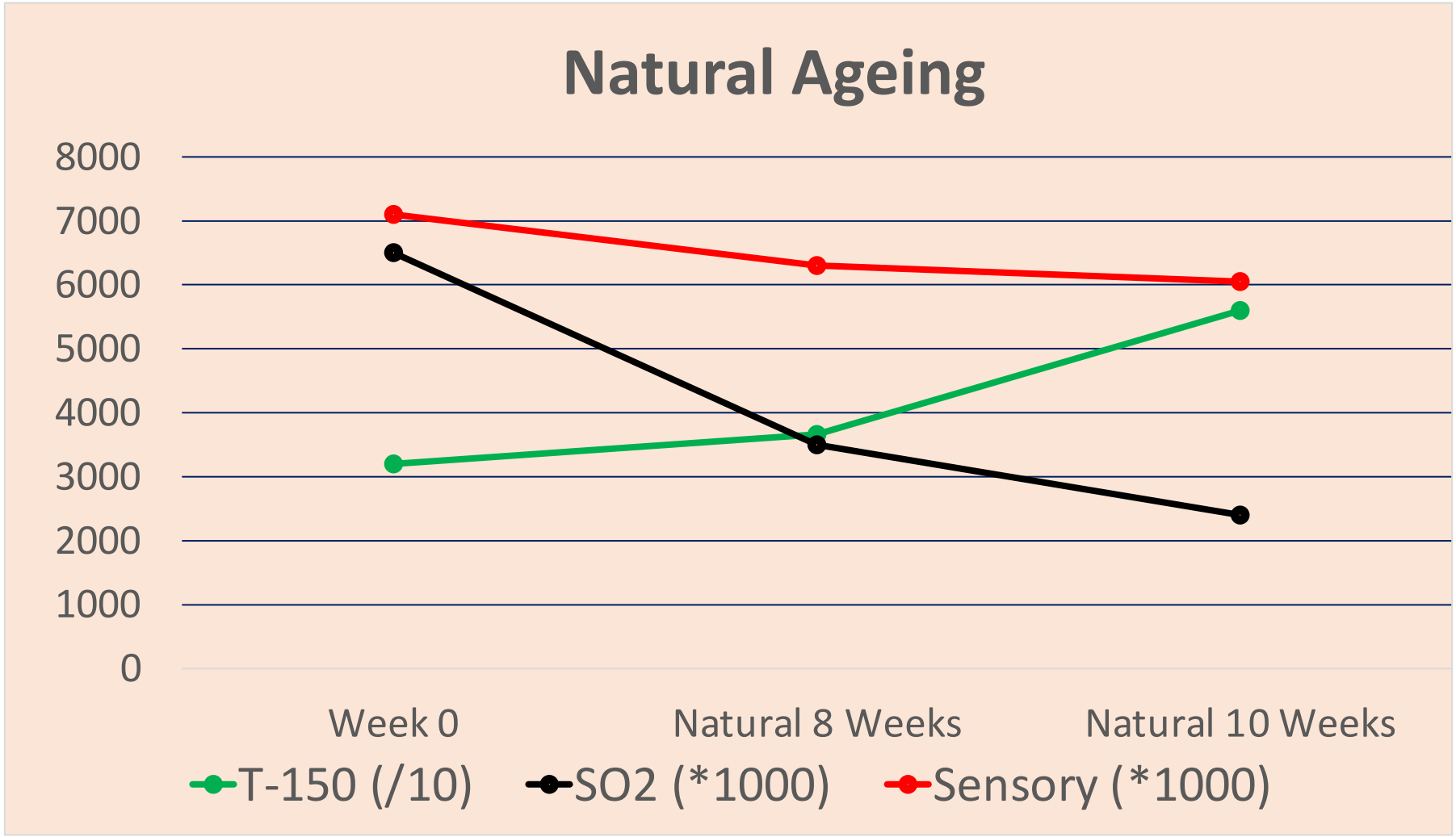

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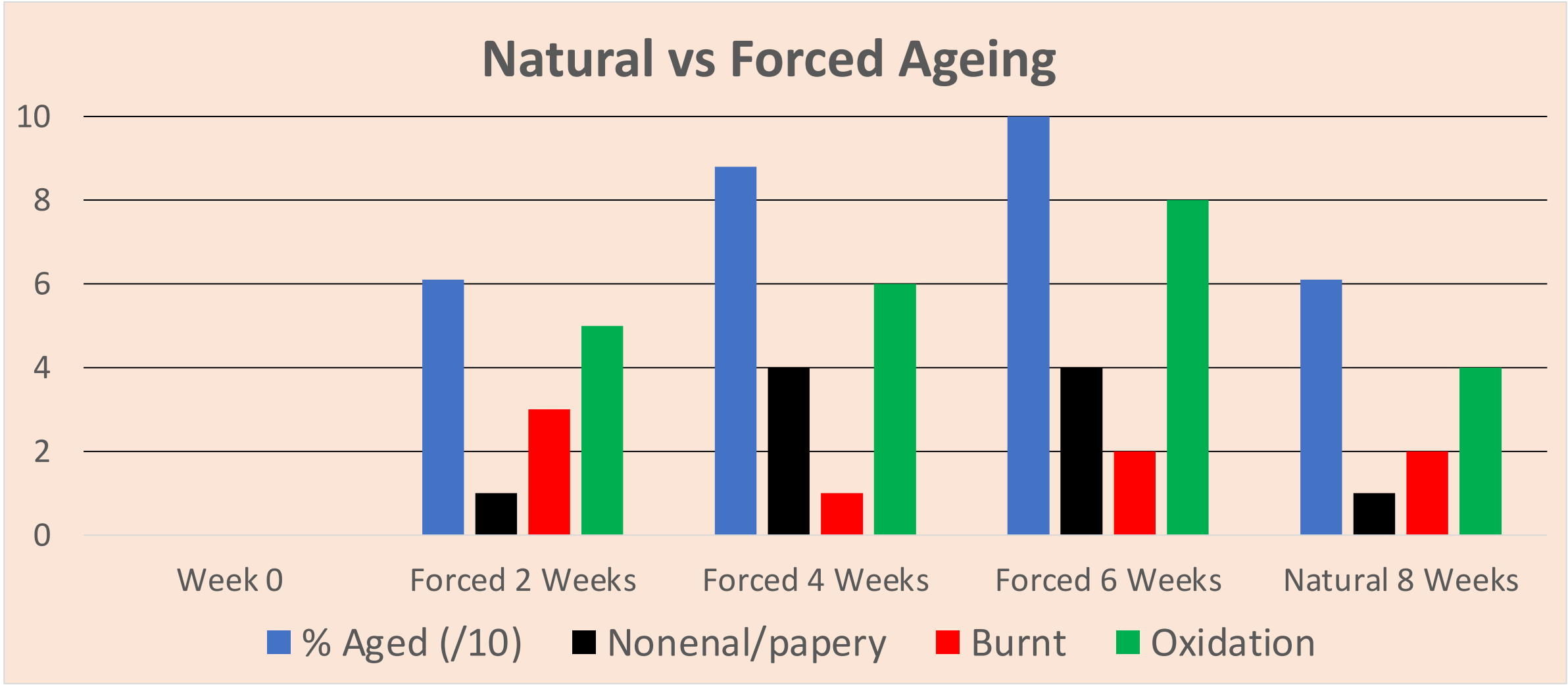
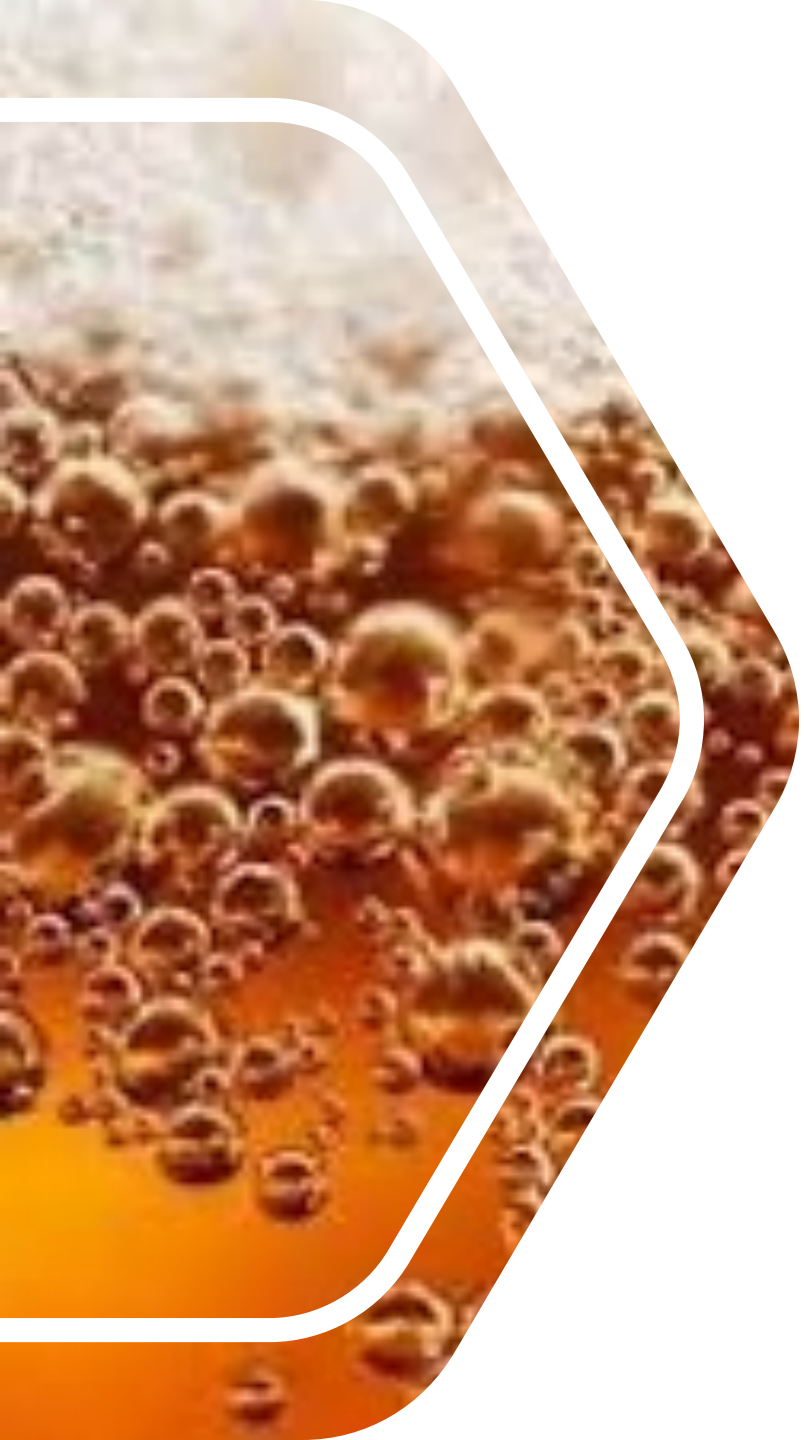


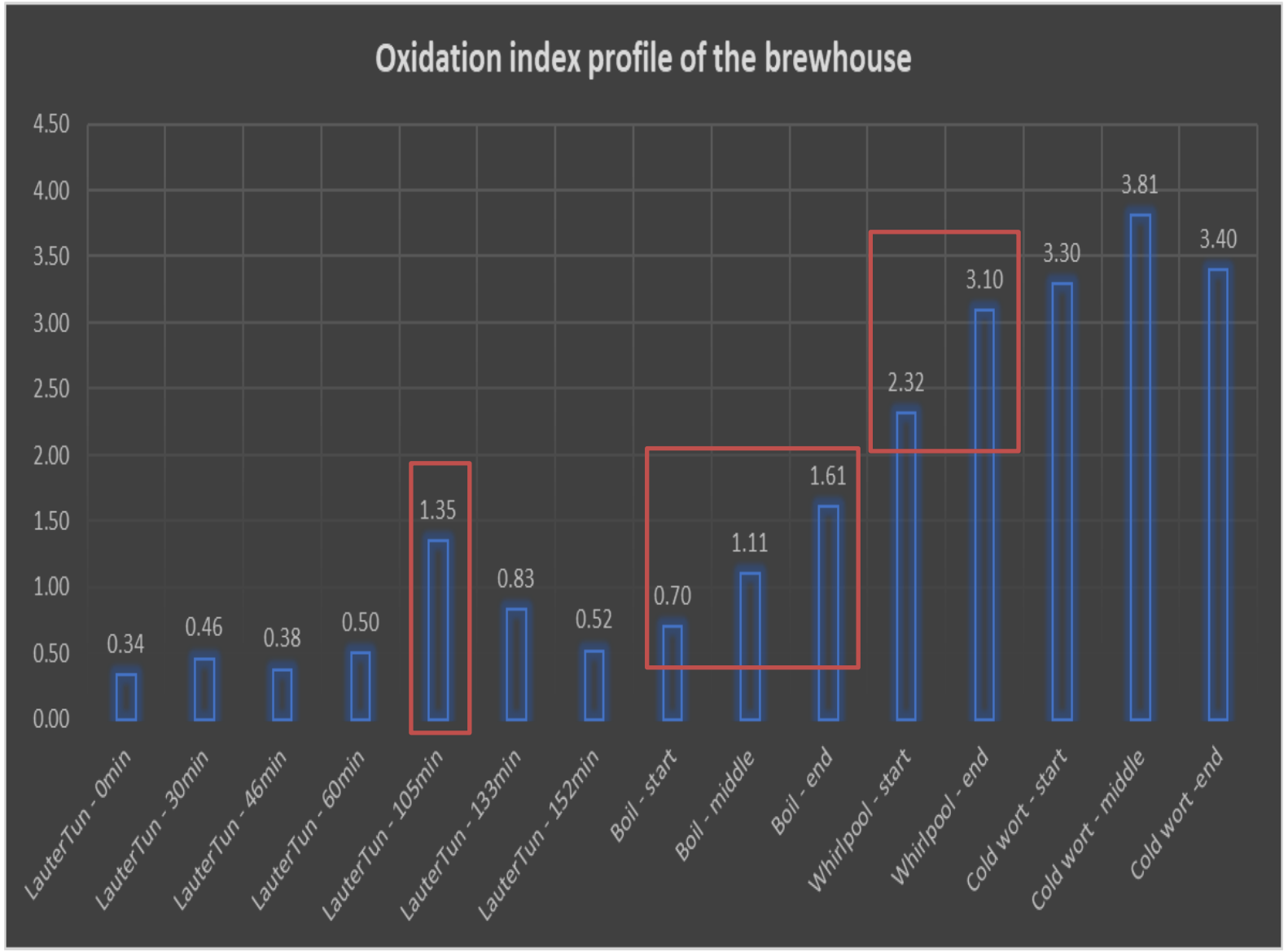
Beer Freshness: Instrument versus Sensory Panel

- Instrument correlated very well with sensory performance
- Also, analytical correlated with other known metrics of freshness, for example SO_2
- Sharp decrease in SO_2 noted during forced ageing attributed to the high temperatures used during forced aging



Using MicroESR to Improve Beer Freshness in a Brewery

Brewhouse Deep Dive



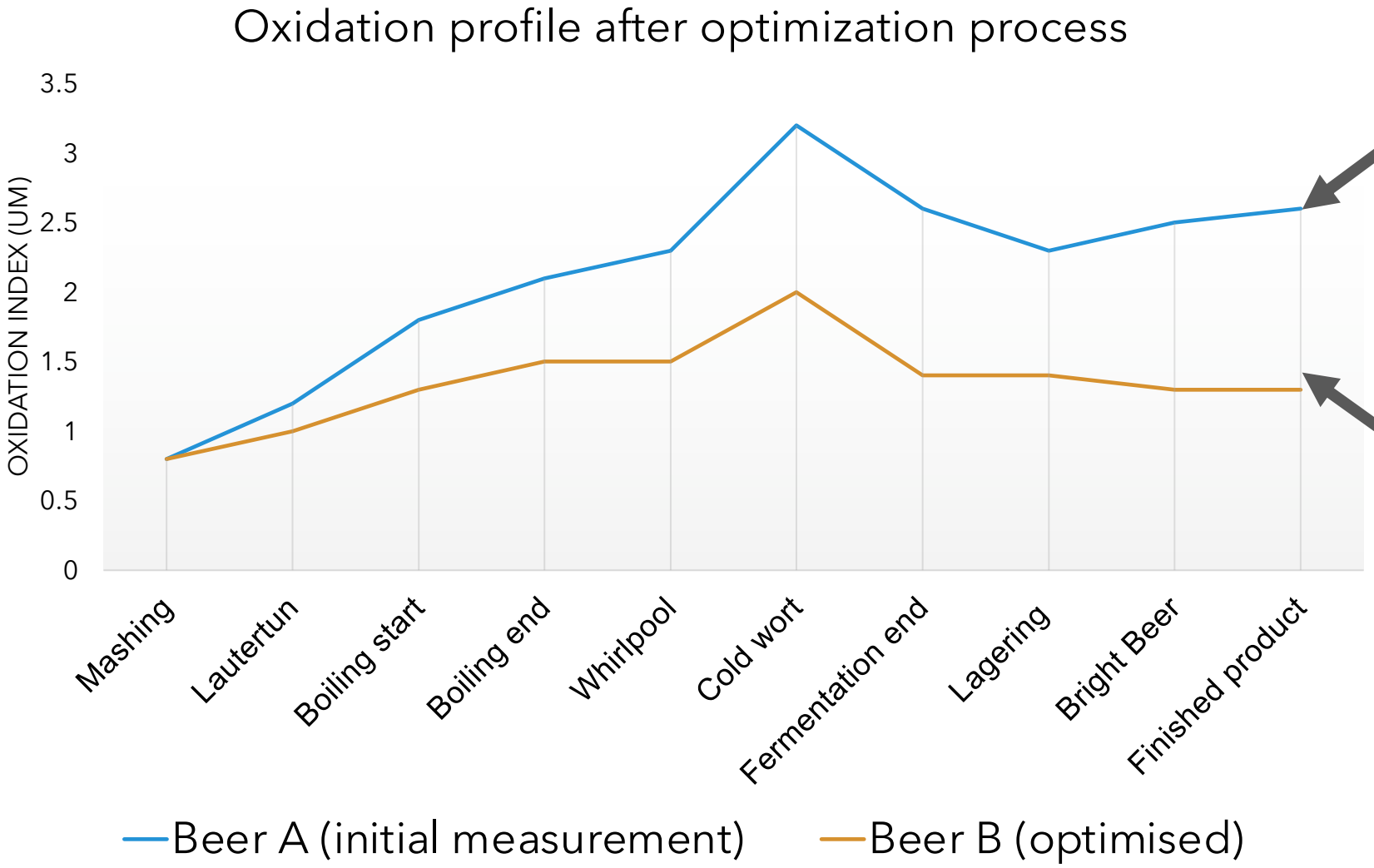
→ Lautertun at 105 mins – huge spike in oxidation index will affect freshness negatively. This spike (negative contribution) is carried on to the following processes.

→ Boiling process – oxidation index increased by more than double

→ Whirlpool stand – has a negative effect to the overall freshness of the product

→ Improve management of the Lautertun

Optimization



Before Optimization

Freshness index - 40
Oxidation index – 3,1
Sensory score - 6
Shelf life < 2 weeks

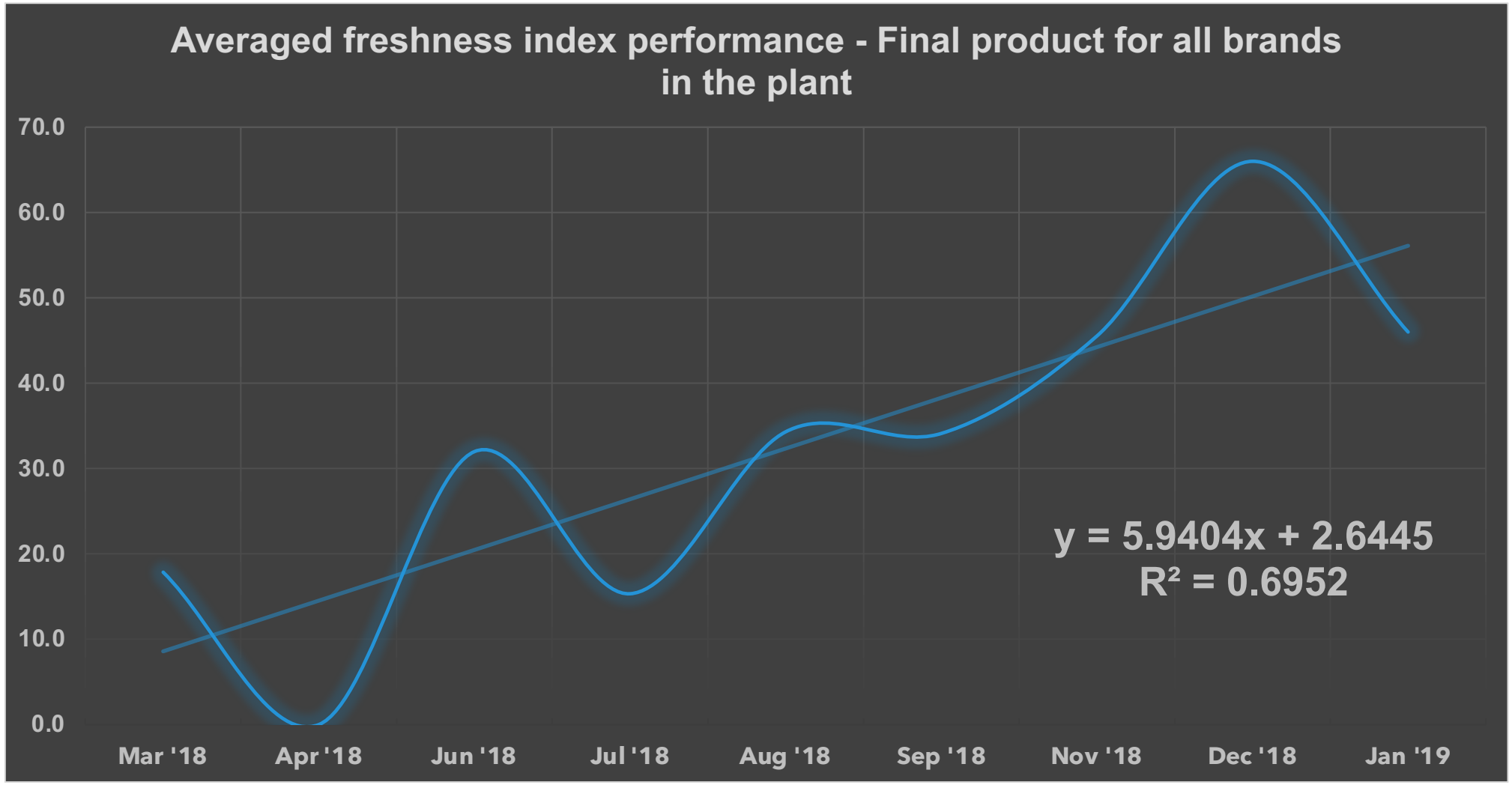
Optimization focus

Kettle, Fermentation, Filtration

After Optimization

Freshness index - 120
Oxidation index – 1,3
Sensory score – 7,5
Shelf life >8 weeks

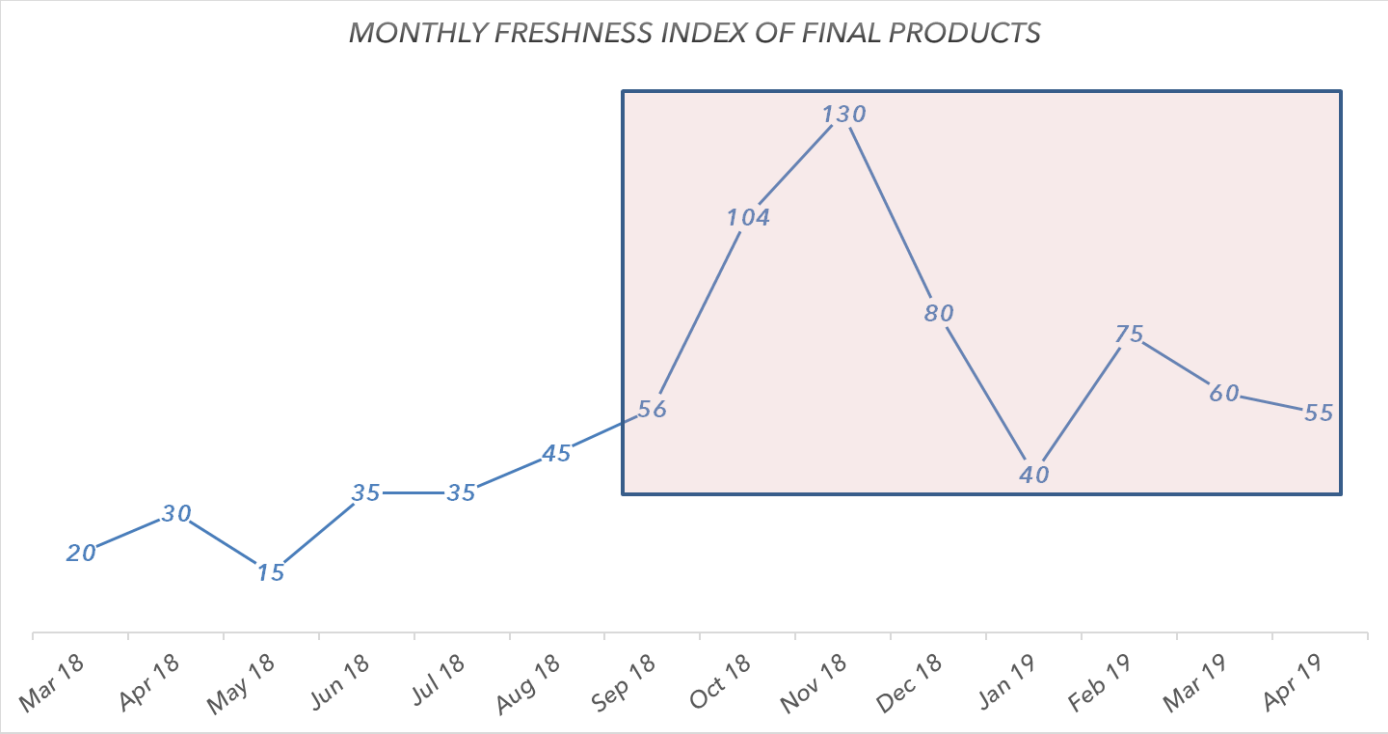
Post Optimization – Monitor and Control Beer Freshness



Improvement of the Freshness index over time as a result of the optimization actions

Post Optimization – Monitor and Control Beer Freshness

- Quality control tool to manage consistency.
- Drop in freshness performance was due to a non conformance of the brewery operators not following an updated SOP in the Fermentation process.

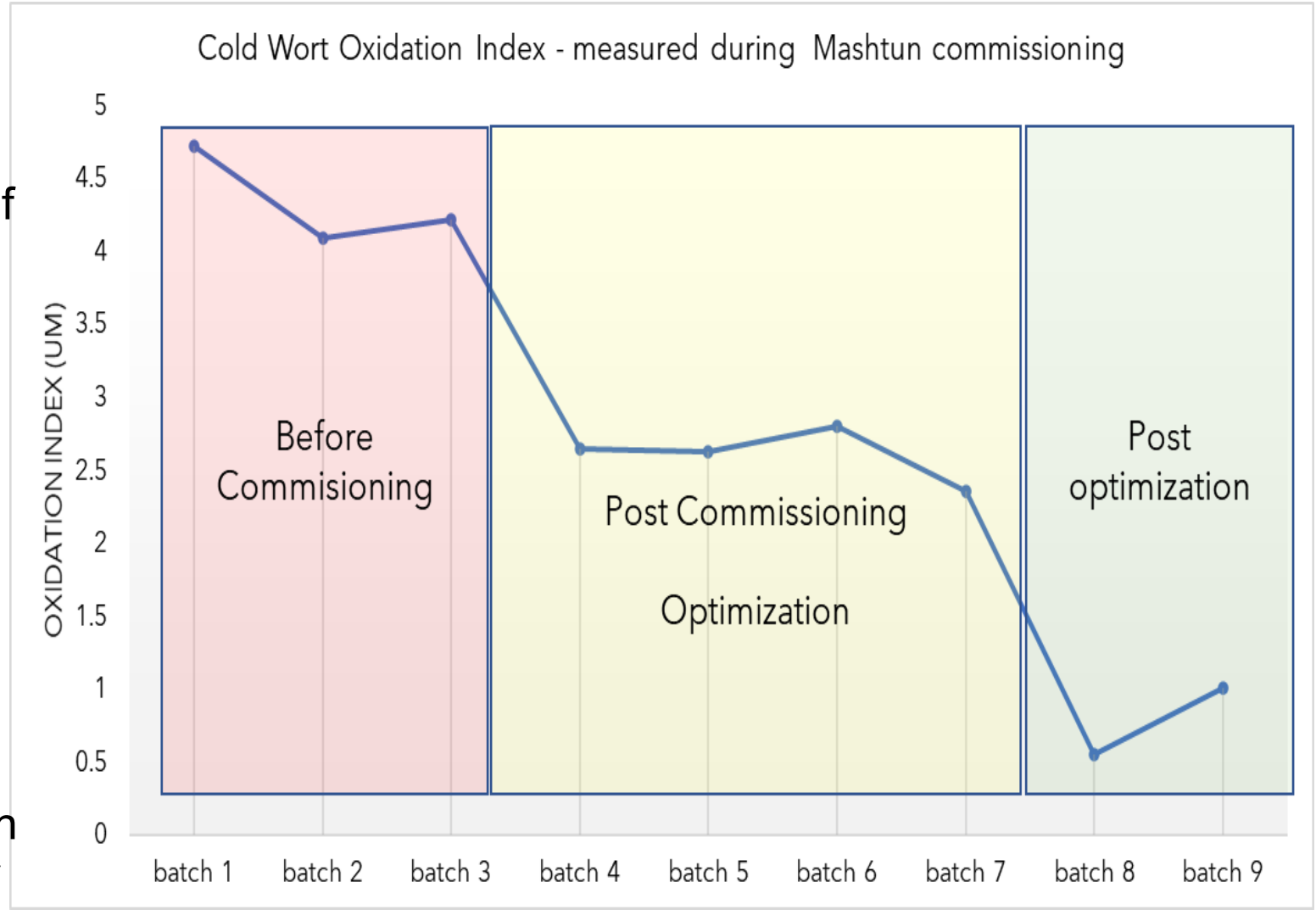


Percentage change and inconsistency impacting beer freshness negatively.

During monitoring and control process these differences can be identified and managed properly.

Plant Upgrade- Beer Freshness Optimization

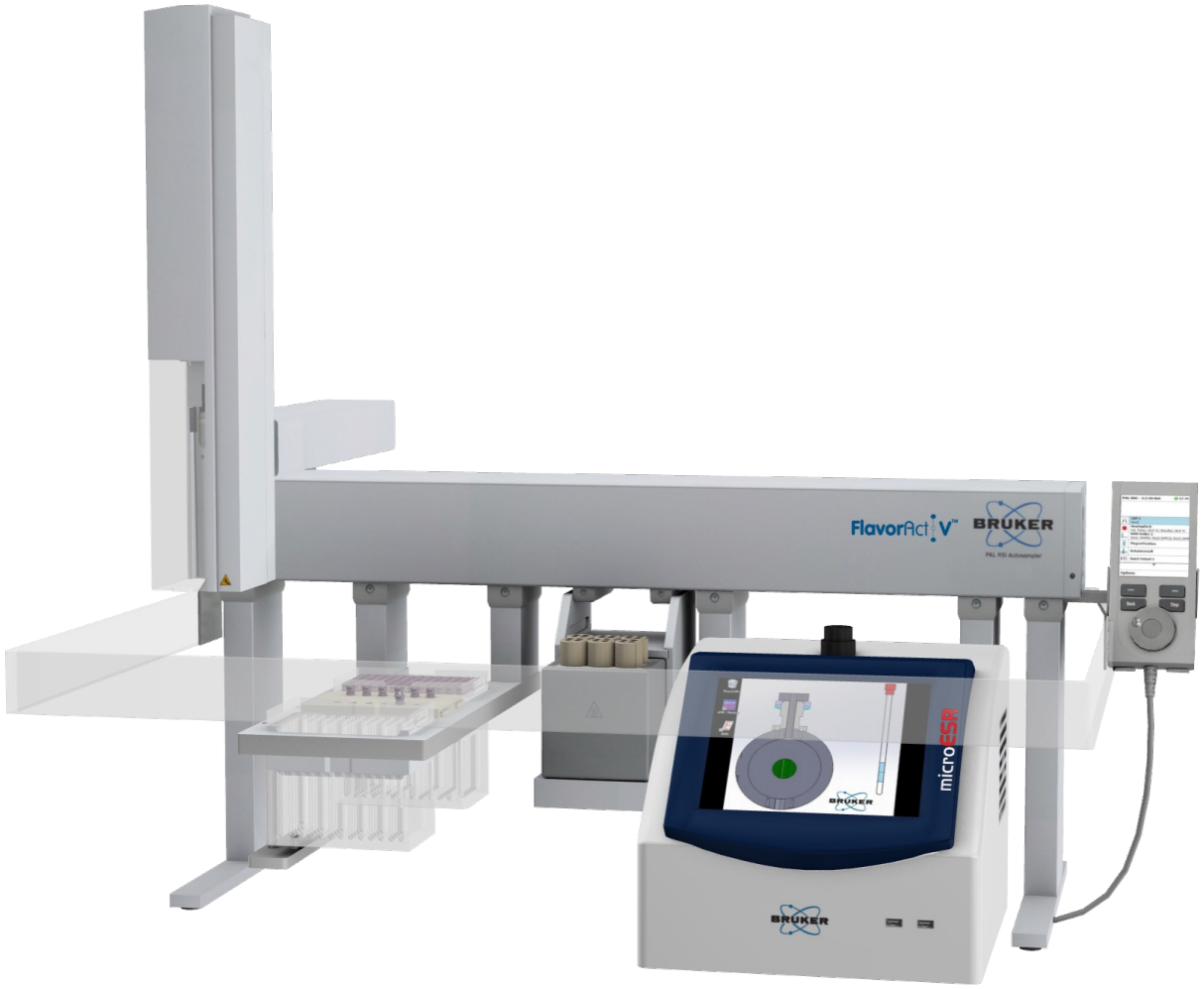
- Actions taken in the brewing process to optimize for beer freshness (sensory performance of the final product)
- Plant upgrade may take up to 3 months to align with product freshness
  - Samples must be tasted
- Plant was optimised within a 2 week period (from a possible 3 months)
  - Cost saving – cost of a 3month trial, man hours, panel, further monitoring



Summary

In summary, we have shown how freshness can be improved using a MicroESR instrument and human sensory panel. With that we have developed the **FlavorActiV Beer Freshness Package.**

The FlavorActiv Beer Freshness Package?



- Integrate the use of the ESR technology with Human Sensory Panel.
- Utilize the obtained ESR data as a KPI inhouse to optimize production and shelf life.
- Utilize the data to investigate raw materials and process to reduce number of free radicals generated or to increased amounts of antioxidants produced
- Correlate ESR with trained human sensory panel specifically tuned to oxidation

Future Work in Progress

Continue to build database of information on beer freshness from the Micro ESR.

Further training of human sensory panel to identify all possible oxidation flavours in beer.

Work with the E-Nose Instrument to positively identify all oxidation compounds, as well as in-process oxidation precursors.