

Assessing Variability in Product Quality

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Introduction

- Every manufacturing process is associated with variability in production.
- Product variability may impact consumer perception and satisfaction.
- Repeated measurement of product performance is needed to assess degree of variability and its impact.
- Two applicable research contexts:
 - Process Troubleshooting: Sampling of a production process to identify sources of variability and opportunities for process optimization
 - Process Monitoring: Assess production variability to establish control limits and rules of what constitute meaningful changes in consumer acceptance

Process Troubleshooting

- In order to troubleshoot a production process, samples of a carbonated beverage* were collected at different time points and evaluated by consumers (N=150) using measures of Overall Liking and attribute intensity scales.

- Results summarized by means of:

- **Profile Plot:** to visualize differences across samples in liking and attribute intensity
- **Biplot:** to identify underlying drivers of consumer liking
- **Trend Chart:** to show the impact of a single attribute on Overall Liking

- Key Finding:

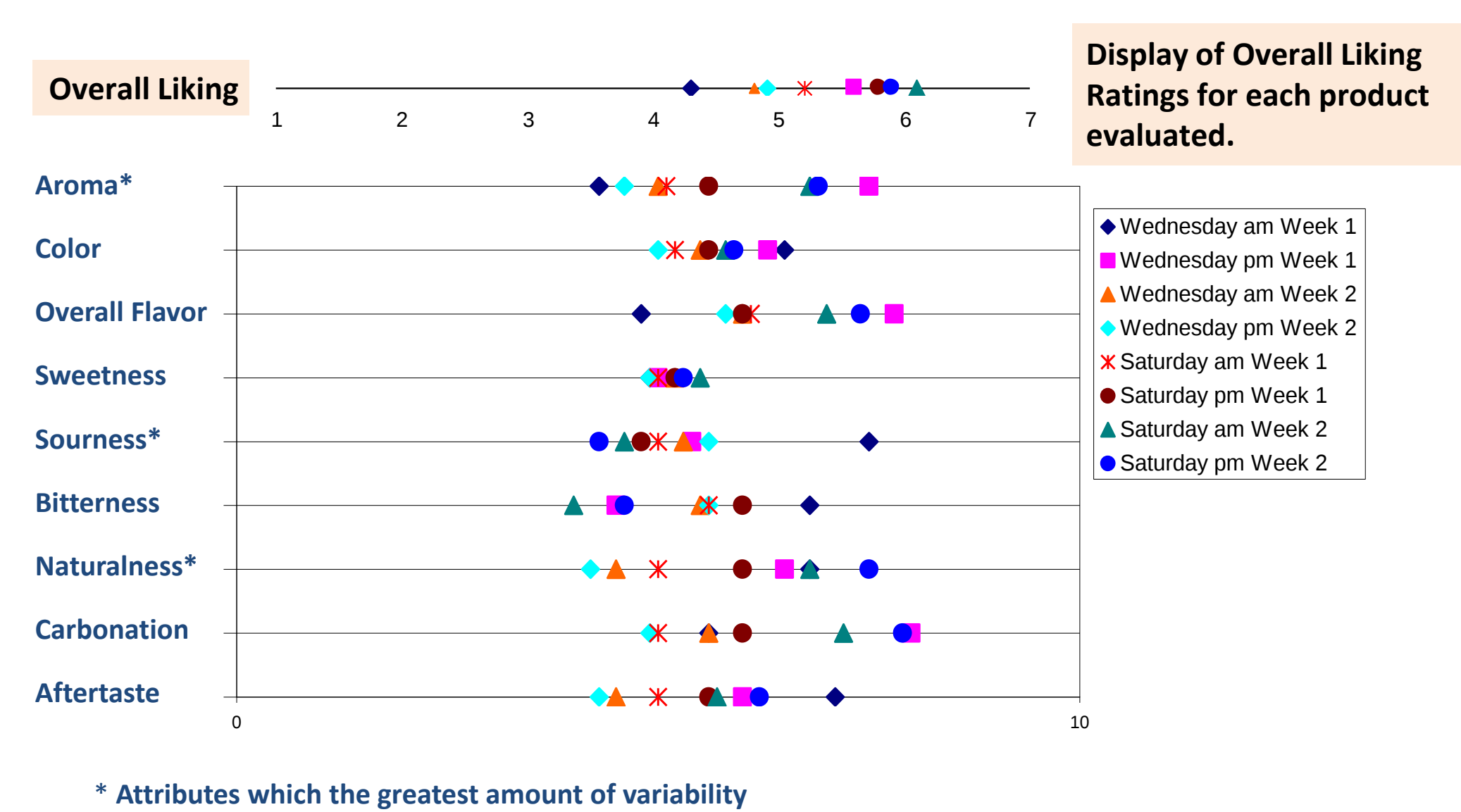
- Sourness is one of several attributes with a large amount of variability. The biplot shows that sourness has a negative relationship (correlation) with Overall Liking. The trend chart highlights the fact that products high in sourness had lower overall liking ratings.

- Next Steps:

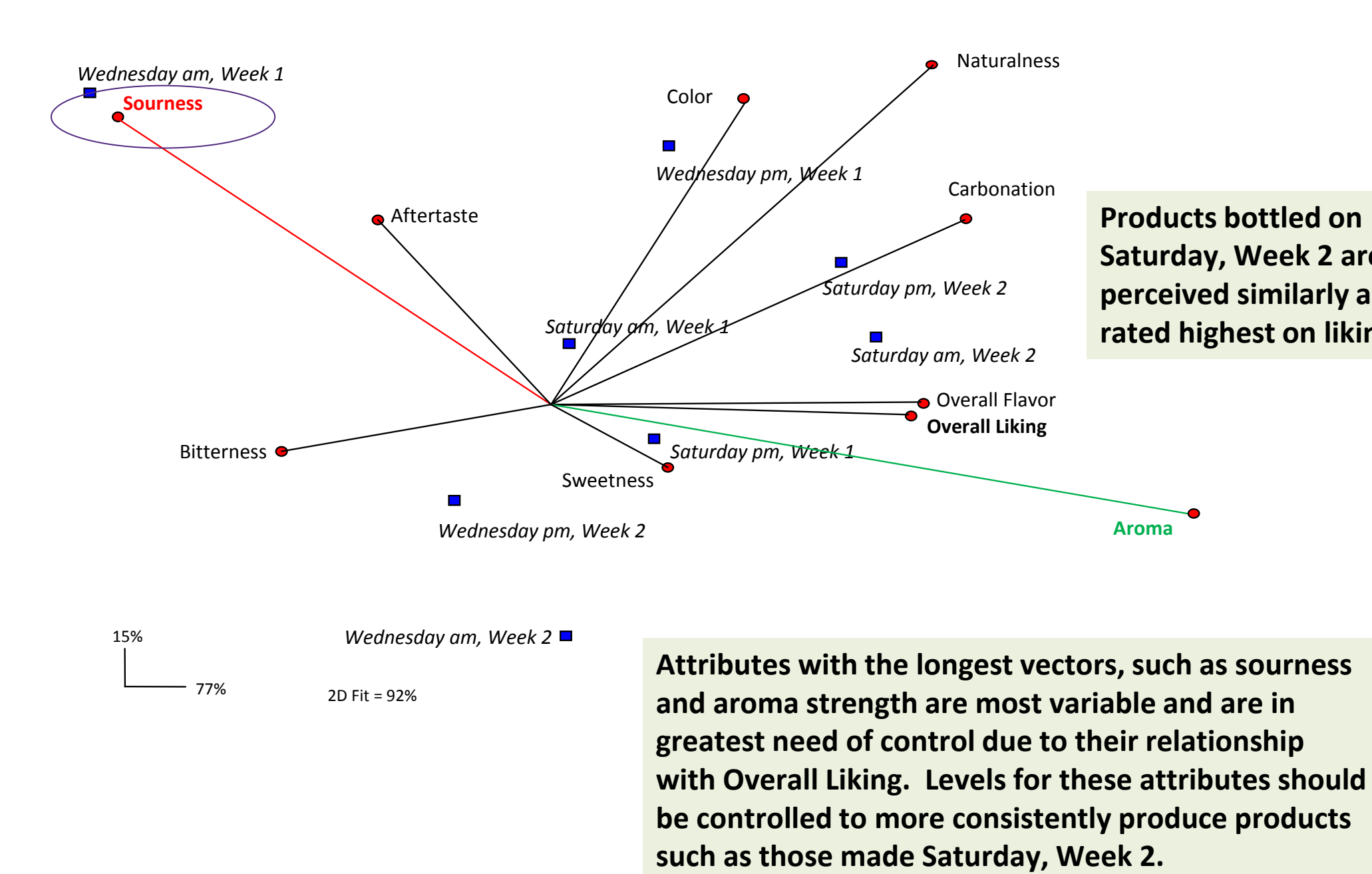
- Investigate likely causes (ingredients and processes) most affecting variation in sourness and other variable attributes. Bring these attributes into control consistent with the “best” production sample.

* The product category and attributes have been altered, and data generalized to protect client confidentiality

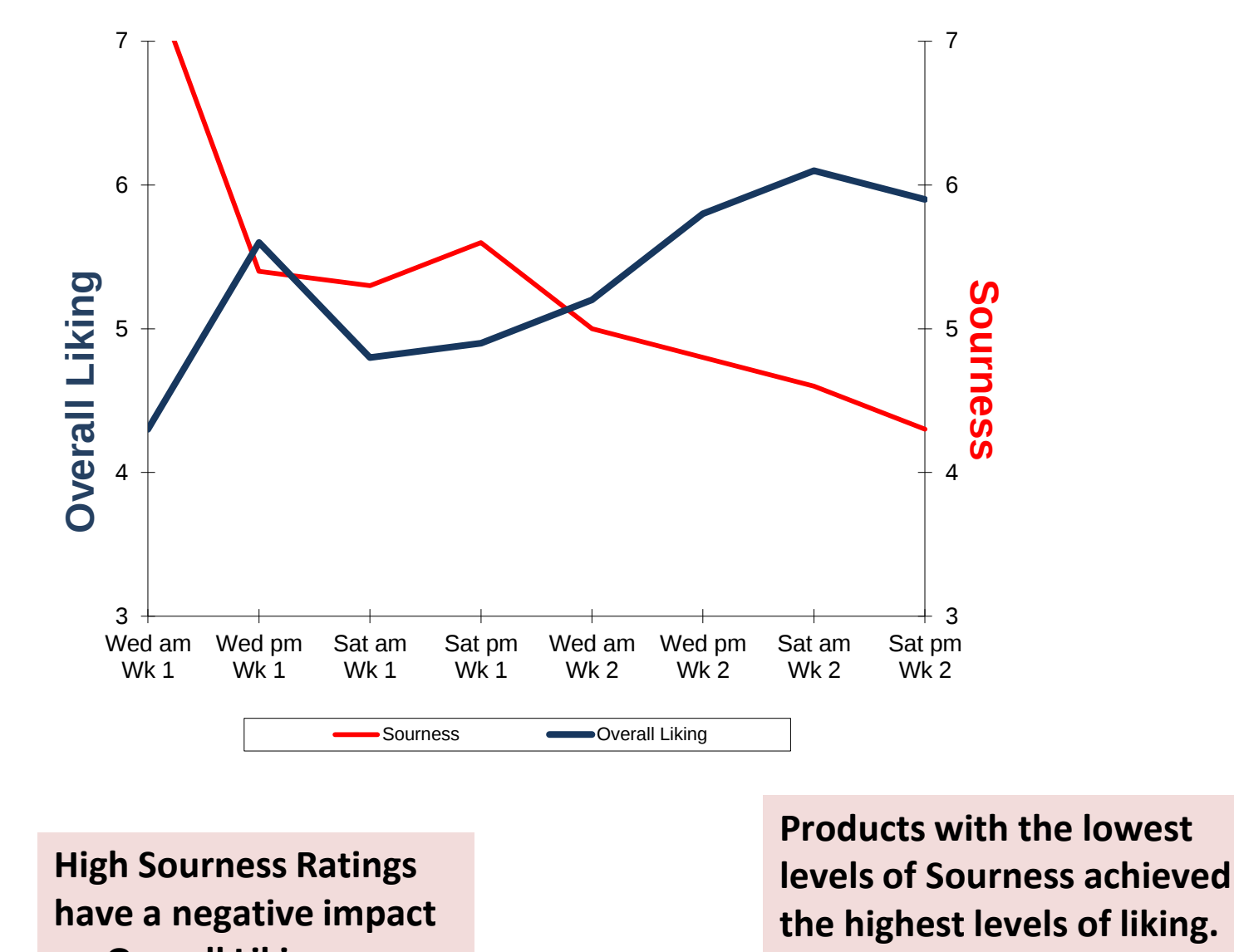
The profile plot shows which production pulls differ most on liking and sensory characteristics (as measured by consumers or a trained panel)



A biplot identifies positive and negative drivers of consumer liking, in this case aroma strength (+) and sourness (-)



The trend chart shows that the products perceived to have a higher level of sourness had lower consumer acceptance ratings



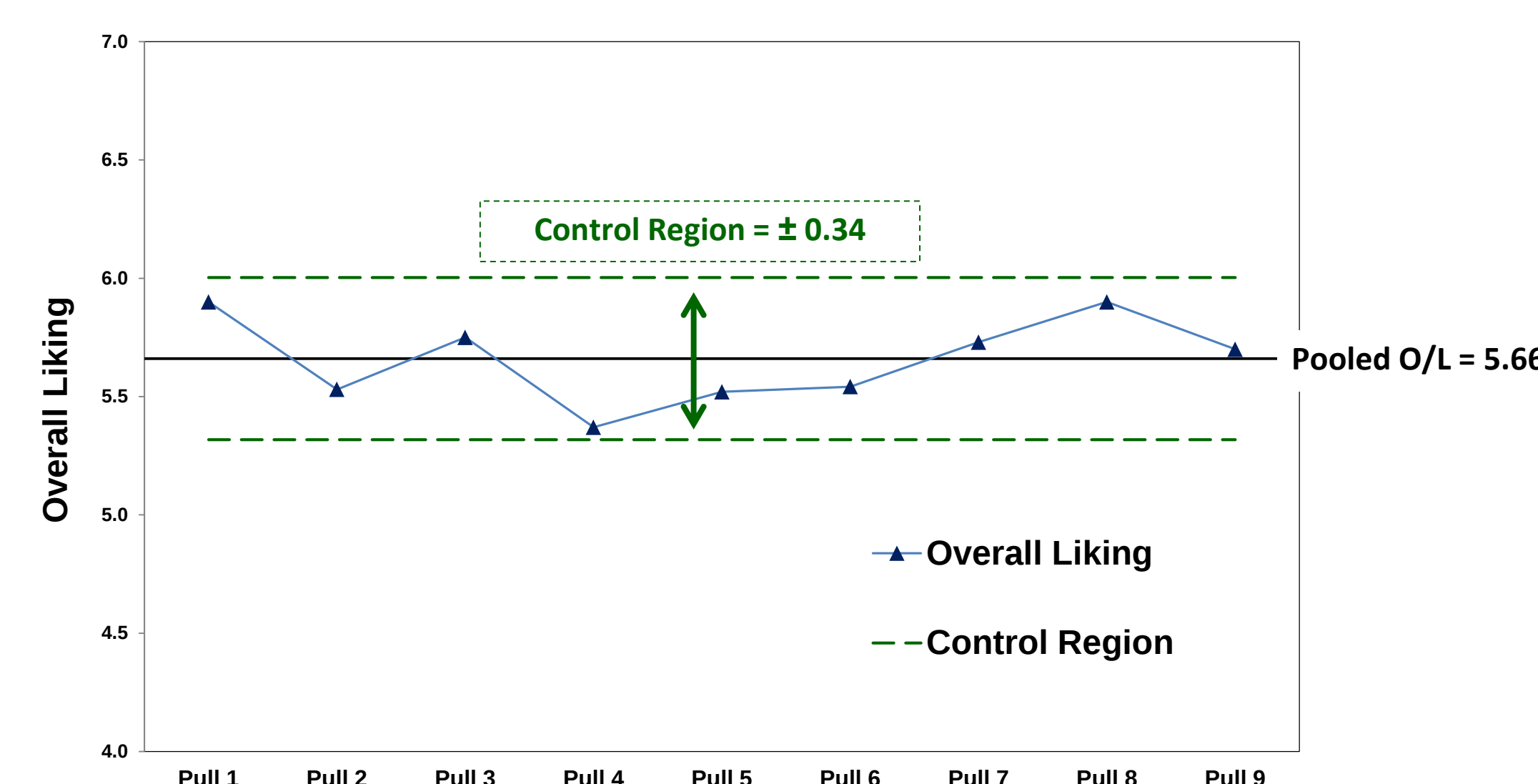
Process Monitoring

- Current variability for a core product was measured to serve as a baseline against which to evaluate future formulation and process changes.

- Product was pulled from ongoing production over regular intervals and evaluated by N=50 target consumers

- Results are summarized in a control chart, which displays:

- The mean Overall Liking score per pull
- The average Overall Liking score computed over all pulls
- The control region (95% CL) computed on the basis of the standard deviation in Overall Liking across the pulls



With a process in control, measures of production variability can be used to gauge the effect of productivity changes based on the estimates of the control region and differences in Overall Liking observed historically.

The control region is calculated on the basis of the standard deviation between product means, which reflects the expected or inherent product variability for this SKU.

Assessing Productivity Initiatives

- Some product changes are meant to have minimal consumer impact (resulting in small sensory differences and equal liking). These include ingredient substitutions, process changes, and various cost saving measures.

- A test is conducted in which consumers evaluate the current product (Control) and its potential replacement (Test).

- Data on current product variability can be used as one of the criteria to assess how noticeable a proposed change is likely to be.

- These data can be derived from a process monitoring study AND/OR from past research in which the current product was included in multiple studies.

- In addition to testing whether any statistically significant differences are obtained between Control and Test, the results are evaluated in the context of historical variability.

- The virtue of this approach is that production changes that yield significant differences in liking but fall within normal consumer expectations would still pass, avoiding Type I errors in statistically based conclusions.

- While the focus here is on Overall Liking, a similar analysis can be conducted for key sensory attributes as evaluated by consumers.

- Action Standards (based on Overall Liking) for Productivity Initiatives:

- No statistically significant difference in Overall Liking between Test and Control

- Test and Current scores both fall within control limits

- Difference between Test and Control is in line with historical differences observed between repeated tests of Control

- Three scenarios illustrate the application of these action standards

