

# Draught Beer Quality Summit

## Opening keynote

David Quain

University of Nottingham  
UK

- We offer two postgraduate courses (one year – on campus) MSc in Brewing Science & Practice or (DL - two to four years) MSc in Brewing Science.
- Our research themes are yeast, fermentation, sensory science, flavour stability, malting and dispense.

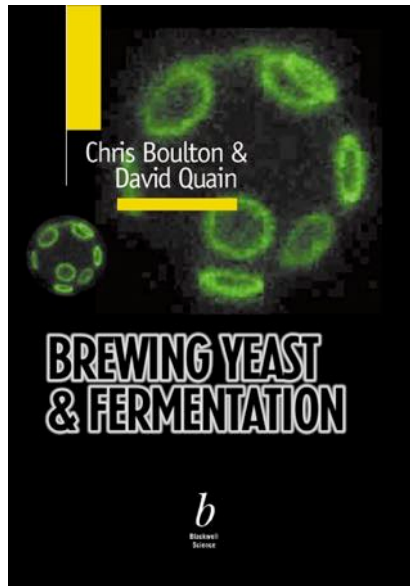
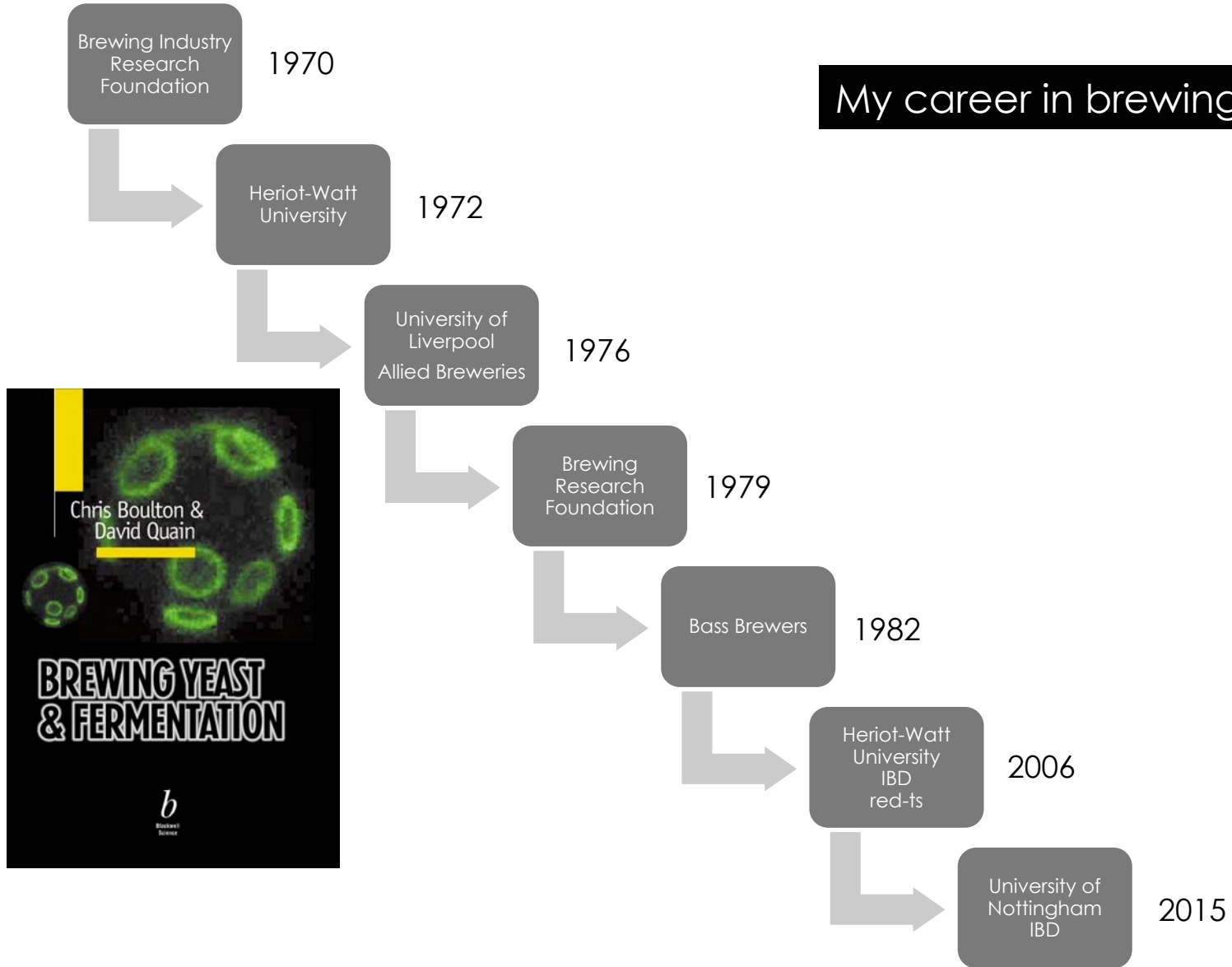


Firstly a big thank you



Validation for travelling a road less well travelled

# My career in brewing



IBD = Institute of Brewing & Distilling



Nothing could be finer

.... but draught beer quality is not always as it should be!

# Content

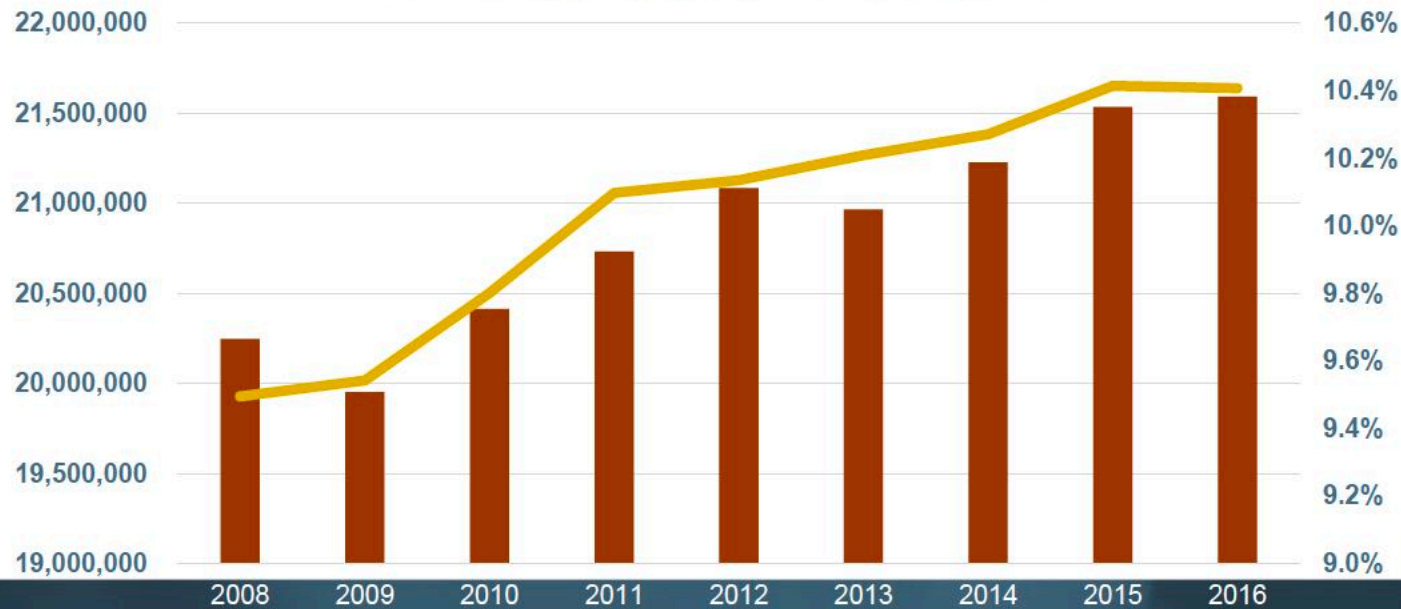
- ▣ The market
- ▣ Quality
- ▣ Testing – a different approach
- ▣ Line cleaning
- ▣ Innovation – sonic technologies
- ▣ Recontamination – post cleaning
- ▣ Best practice
- ▣ Spoilage
- ▣ And finally ....

The market

# US Draught beer volumes

## Draught a Lone Bright Spot

Total US Draught Volume and % of Industry Sales



Source: Beer Institute



Bart Wilson – ‘Draught has never been so important’

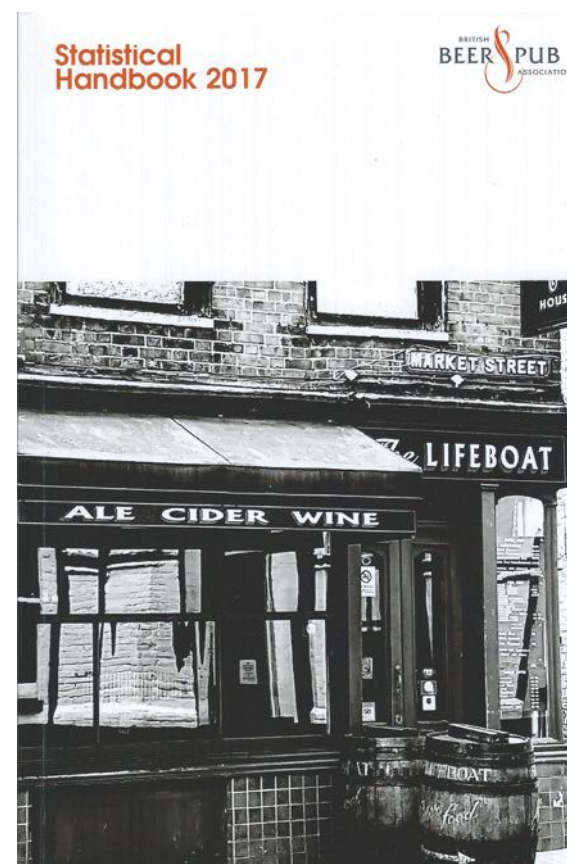


# Top 10 - Beer volumes (000 hL)

in 2015

China*	472,374
USA	253,526
Brazil*	137,712
Germany	86,269
Russia*	76,285
Mexico*	71,180
Japan	54,179
UK	47,424
Poland	38,350
Spain	37,332

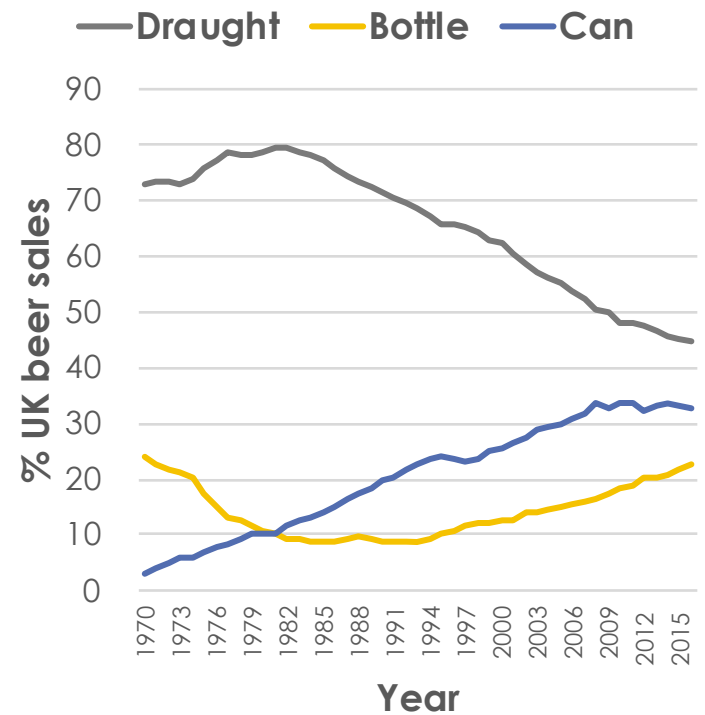
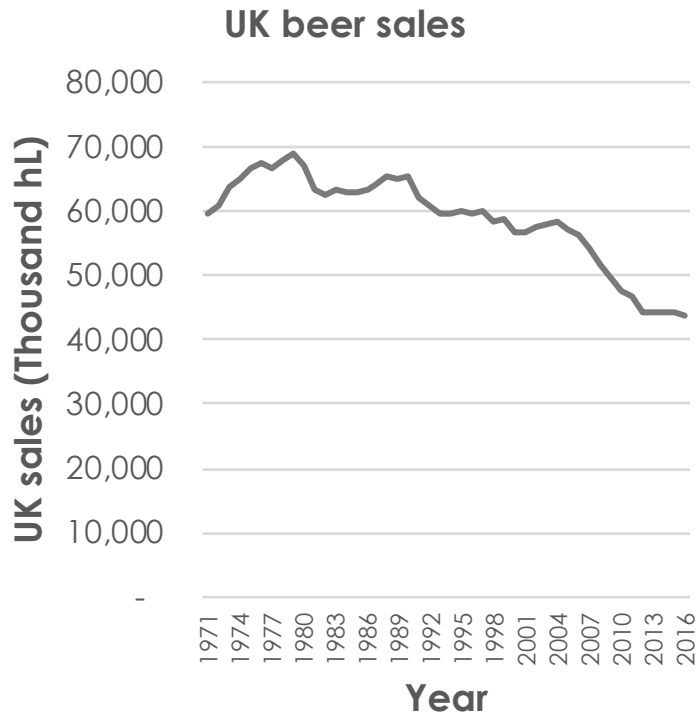
\* No data for on/off premise



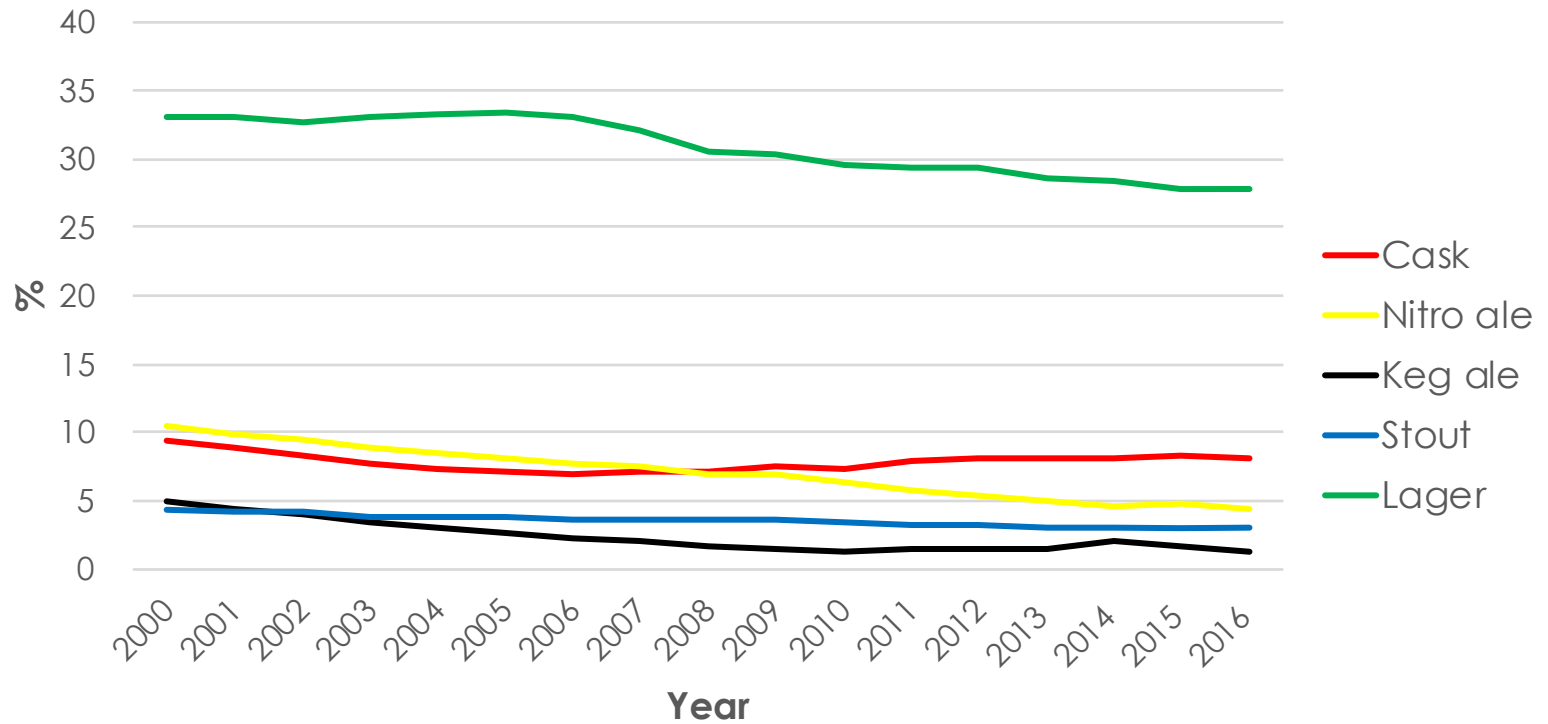
## Top 10 – Europe on-premise (2015)

	On-premise (000 hl)	On-premise sales (%)
Spain	23892	64
UK	23238	49
Germany	16391	19
Italy	7767	42
Czech Republic	6281	40
Poland	5753	15
France	4105	20
Netherlands	4036	35
Ireland	3771	67
Belgium	3498	44

# In the UK, beer is in long-term decline



# Draught beer styles



## Political

- 1989 Beer Orders – cutting the tie
- Monopolies & Mergers Commission
- Drink driving legislation
- Duty
- Smoking ban
- Binge drinking
- Licence reform
- Glass ban

## Economic

- Manufacturing to service economy
- Money rich, time poor
- Growth of the off-premise
- Beer as off-premise 'loss leader'
- Major Brewers without pub estate
- Brewers reduce on-premise training
- Consolidation of Retailers
- Retailers buying own equipment
- Recession
- On-premise pricing

## Social

- Ageing demographic profile
- Wider consumer choice – wine etc
- Drinking less - drinking better
- Responsible drinking
- Wet-led to food-led accounts
- Other leisure opportunities

## Technological

- RTD's
- Growth of 'extra cold' lager
- Decline of keg ale
- Introduction of chilled nitro ale
- Growth of bottled beers
- Bottled cider served over ice
- Innovation
- **Quality issues**

**Some reasons - UK on-premise PEST analysis**

Quality



# Draught beer quality

- On packaging, beer in keg is 'commercially sterile'.
- Good quality draught beer ex-dispense will contain  $< 1000$  microorganisms/ml of beer.
- As microorganisms grow, beer quality can become increasingly compromised (flavour, aroma and clarity).
- Poor quality beer can contain  $>50,000$  microorganisms/ml.

# Quality – definitions and insight

- ▣ A couple of definitions
  - ▣ Quality is meeting the customer requirements.
  - ▣ Quality is the achievement of consistency and elimination of unwanted surprises.
- ▣ Beer Quality Report 2017 (from Vianet & Cask Marque)
  - ▣ One in three pints served by a beer line overdue a clean,
  - ▣ 60% of all pubs not achieving target yield,
  - ▣ Pubs over ranging by an average of at least 3 pumps,
  - ▣ 6% of all pints served too warm.

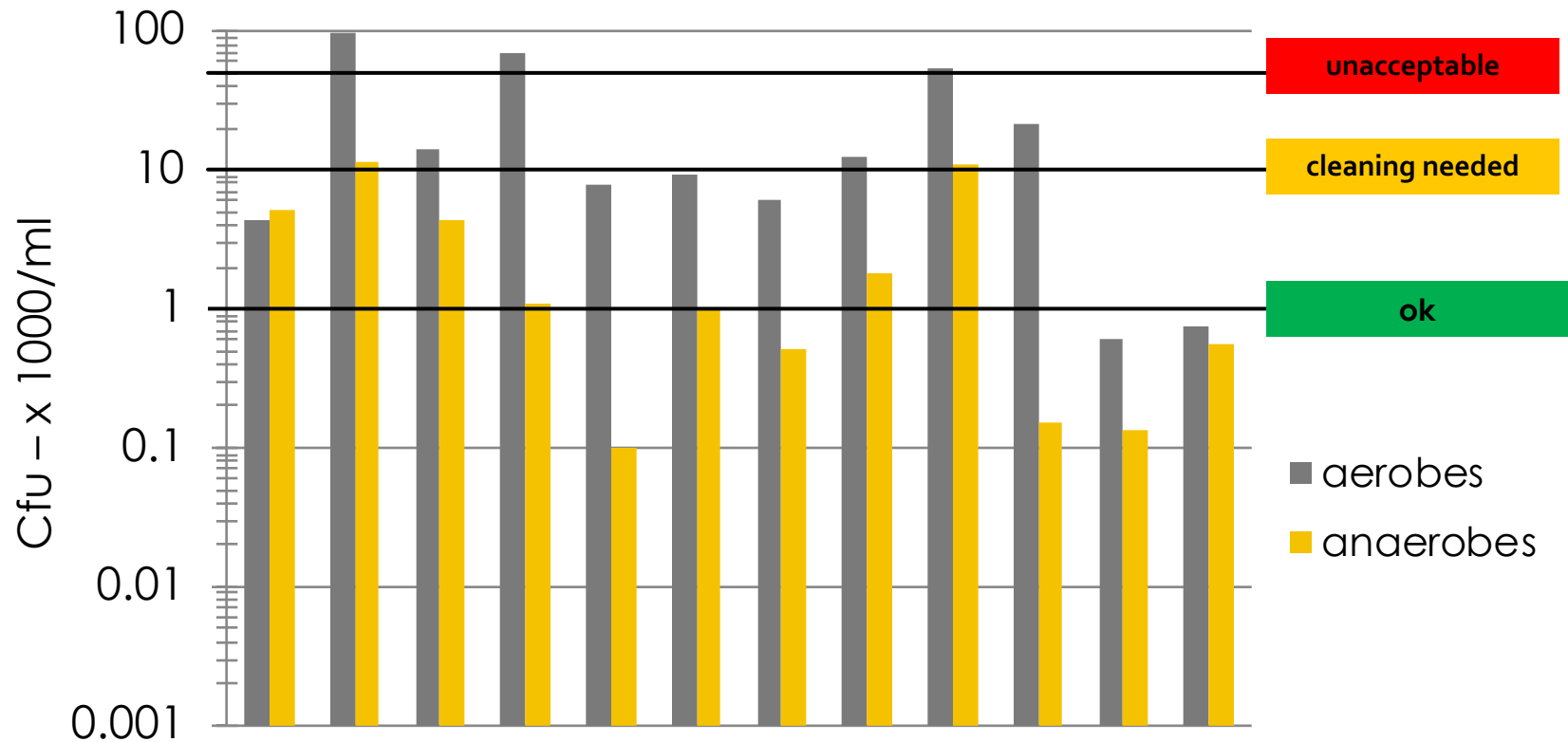


# Quality standard – there is only one!

- ▣ The German Institute for Standardization or Deutsches Institut für Normung (DIN) is the ISO (International Organization for Standardization) body for Germany.
- ▣ For draught beverages in general including water, wine, soft drinks and beer.
- ▣ Accordingly no guidance on microbiological media or incubation conditions.
- ▣ DIN 6650-612 comments as follows –
  - ▣ ‘a typical guideline value for a positive result with respect to microbial contamination would be 1000 colony-forming units per milliliter (cfu/ml),
  - ▣ If the count is 10,000 or higher, cleaning is necessary,
  - ▣ a value of more than 50,000 cfu/ml being considered unacceptable’.

# Beer microbiology

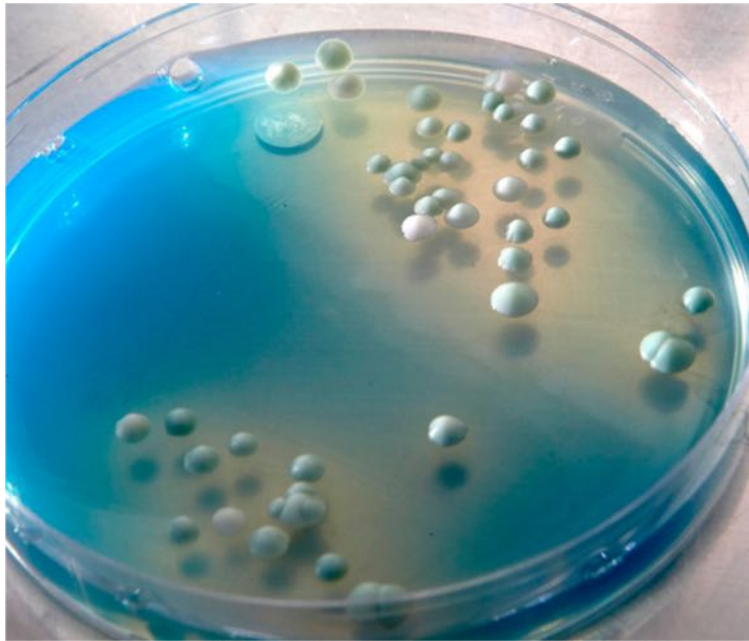
- Beer is microbiologically robust – (highish) [ethanol], hop acids are antimicrobial to many bacteria, some sulphur dioxide, pH < 4.5, low [oxygen], nutrient depleted.
- Draught beer is 'commercially' sterile, is stored coldish and dispensed cold.
- But during the dispense process, draught beer is susceptible to spoilage by yeast and bacteria
  - Yeasts include *Saccharomyces* and *Brettanomyces*.
  - Bacteria include *Acetobacter*, *Lactobacillus*, *Pediococcus* etc.



# Draught beer ex-trade

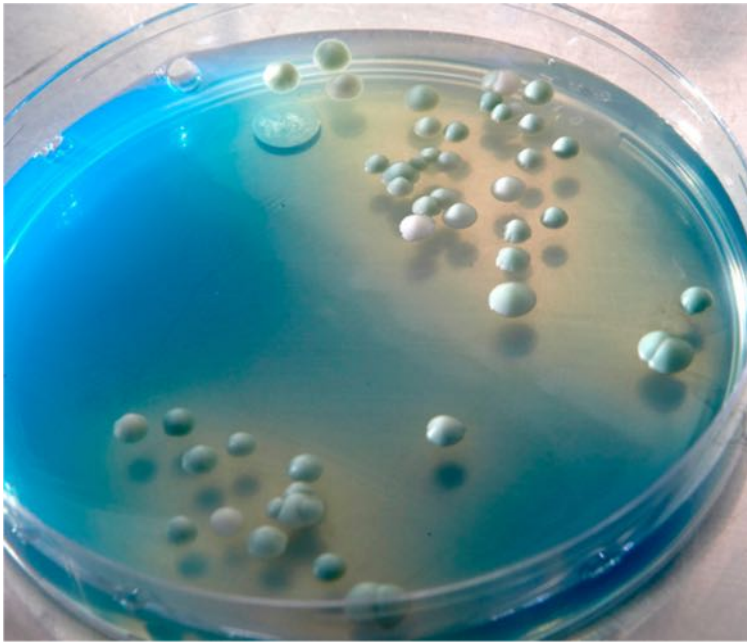
Same brand sampled in 12 pubs and categorized according to DIN standard microbial loadings

# Microbiological testing – for



- ▣ The relatively few studies on draught beer quality have focused on the loading of microorganisms.
- ▣ Conventional plate testing remains the standard reference method in brewing microbiology

# Microbiological testing – against



- ▣ How do 'counts' relate to spoilage and what is the impact of cell size?
- ▣ Microbiological media are invariably 'selective'.
- ▣ Microorganisms can be dormant, non-culturable or nutritionally fastidious.
- ▣ Requires specialist capability and equipment. 'Dilutions' can be tricky.

Testing - a different approach

# 'Forcing'

- ▣ 'Forcing' or accelerated shelf life testing by storage at elevated temperatures has long been used in the brewing industry.
- ▣ Horace Brown developed the method in the 1870's to predict the spoilage of Burton ales brewed between October and May for sale in the Summer (when there was no brewing and no refrigeration!)



147 years later ...

# Draught beer hygiene: a forcing test to assess quality

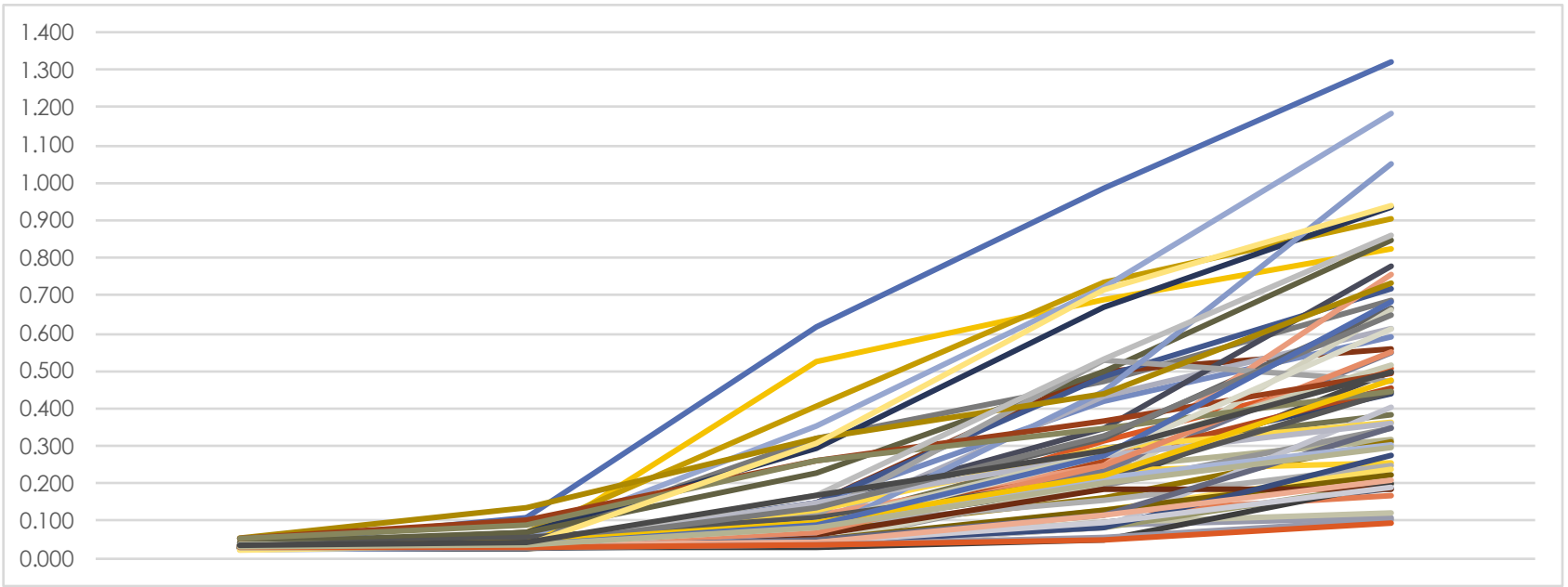
James R. Mallett, Melanie S. Stuart and David E. Quain\* 

**ABSTRACT:** The quality of draught beer is important to consumers but can be inconsistent, ranging from excellent through to unacceptable. The few, dated studies of draught beer quality have focused on the number of microorganisms that are present in the product. Work reported here suggests that this approach has its limitations and fails to relate to beer quality post-dispense. An alternative approach using the long-established 'forcing' method provides a better but still retrospective assessment of draught beer quality. Samples post dispense are 'forced' by static incubation at 30°C for four days and beer quality is ranked by the measurement of absorbance at 660 nm. The increase in absorbance reflects the growth of beer spoilage microorganisms present in the beer at dispense. Four quality bands are proposed, where quality is described as excellent (absorbance increase of  $<0.3$ ), acceptable (0.3–0.6), poor (0.6–0.9) and unacceptable ( $>0.9$ ). The method is straightforward, requires no special skills and enables, for the first time, the robust quantification of draught beer quality. It is anticipated that the method will have widespread application in the measurement and improvement of the quality of draught beer. Copyright © 2017 The Institute of Brewing & Distilling

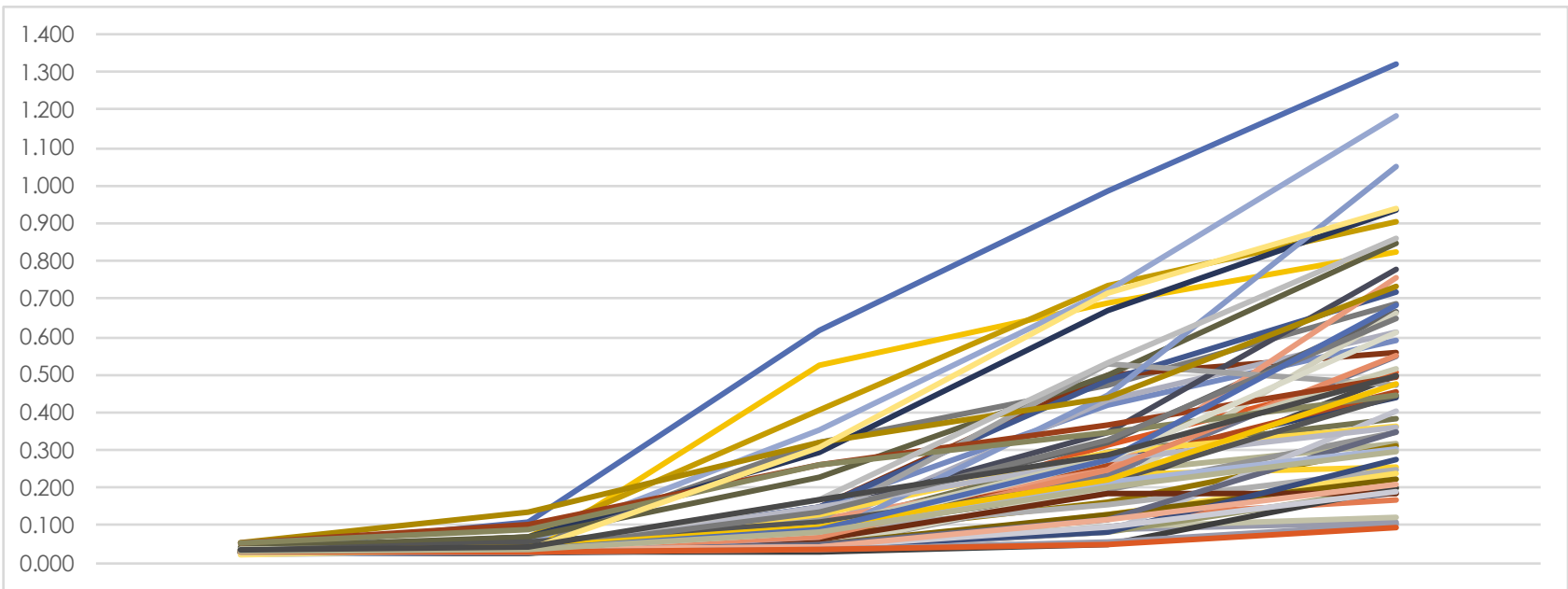


# Forcing and applications

- ▣ Beer sampled ex dispense.
- ▣ 'Forcing' at 30°C and 'clarity' measured at 0 h and after 96 hours. The difference in absorbance is a measure of draught beer quality.
- ▣ Four categories based on change in absorbance
  - ▣ A/excellent,
  - ▣ B/acceptable,
  - ▣ C/poor and
  - ▣ D/unacceptable.
- ▣ Applications of the method include .....
- ▣ Measurement of beer quality in the trade
- ▣ Assessing the efficacy of line cleaning in accounts.
- ▣ Troubleshooting quality issues.
- ▣ Benchmarking quality of brands across the bar pre- and post best practice.
- ▣ 'Overfonting and 'hot spots'.
- ▣ Evaluating dispense innovation initiatives.



Forcing



## Forcing - principle

The principle behind the 'forcing' approach is simple. Beer of 'excellent' quality will contain relatively few beer-spoilage microorganisms which, on forcing, grow to a limited extent with a small increase in haze. Conversely, with heavily contaminated and 'unacceptable' beer, the spoilage microorganisms grow (at a similar or slower rate) but develop a very hazy product. The method is retrospective but provides a measure of the initial microbial loading which reflects on the hygienic practices in the account.

Trade audit

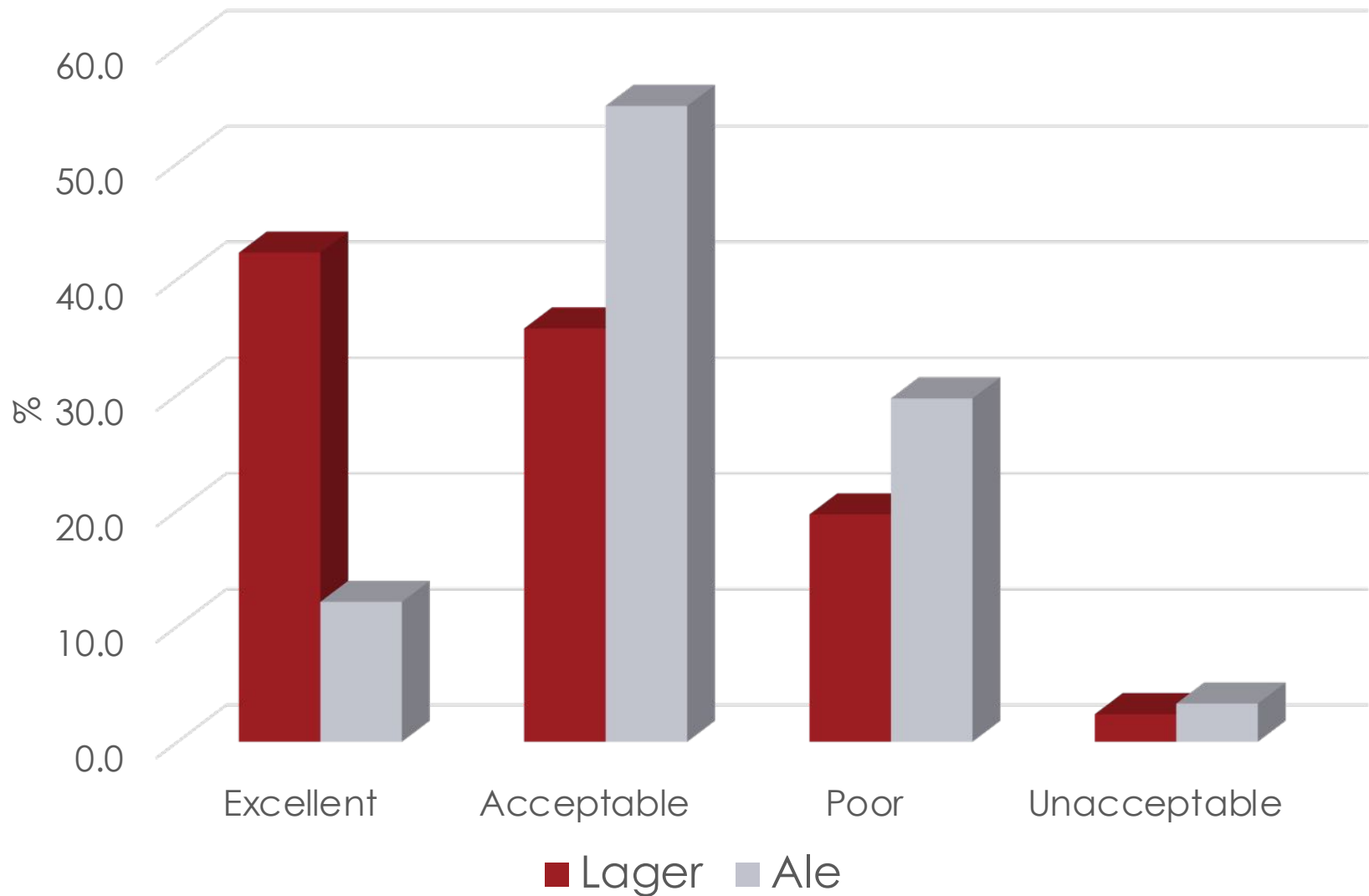
# Draught beer quality audit

- ▣ Scope – 10 locations - villages, towns and cities in the East Midlands.
  - ▣ 237 beers – 149 lager, 88 ale from 57 accounts.
  - ▣ All accounts sampled at least twice.
  - ▣ Primary focus on keg ales ( $\leq 3.8\%$  abv) and standard lager (4% abv).
  - ▣ Half pints purchased (mystery shopper style) and transferred to sterile containers.
- ▣ Account parameters include
    - ▣ Number of taps and brands,
    - ▣ Cost,
    - ▣ Served in branded glassware or not,
    - ▣ Approximate number of customers,
    - ▣ Any accreditation e.g. Cask Marque, food hygiene rating, Good Beer Guide.

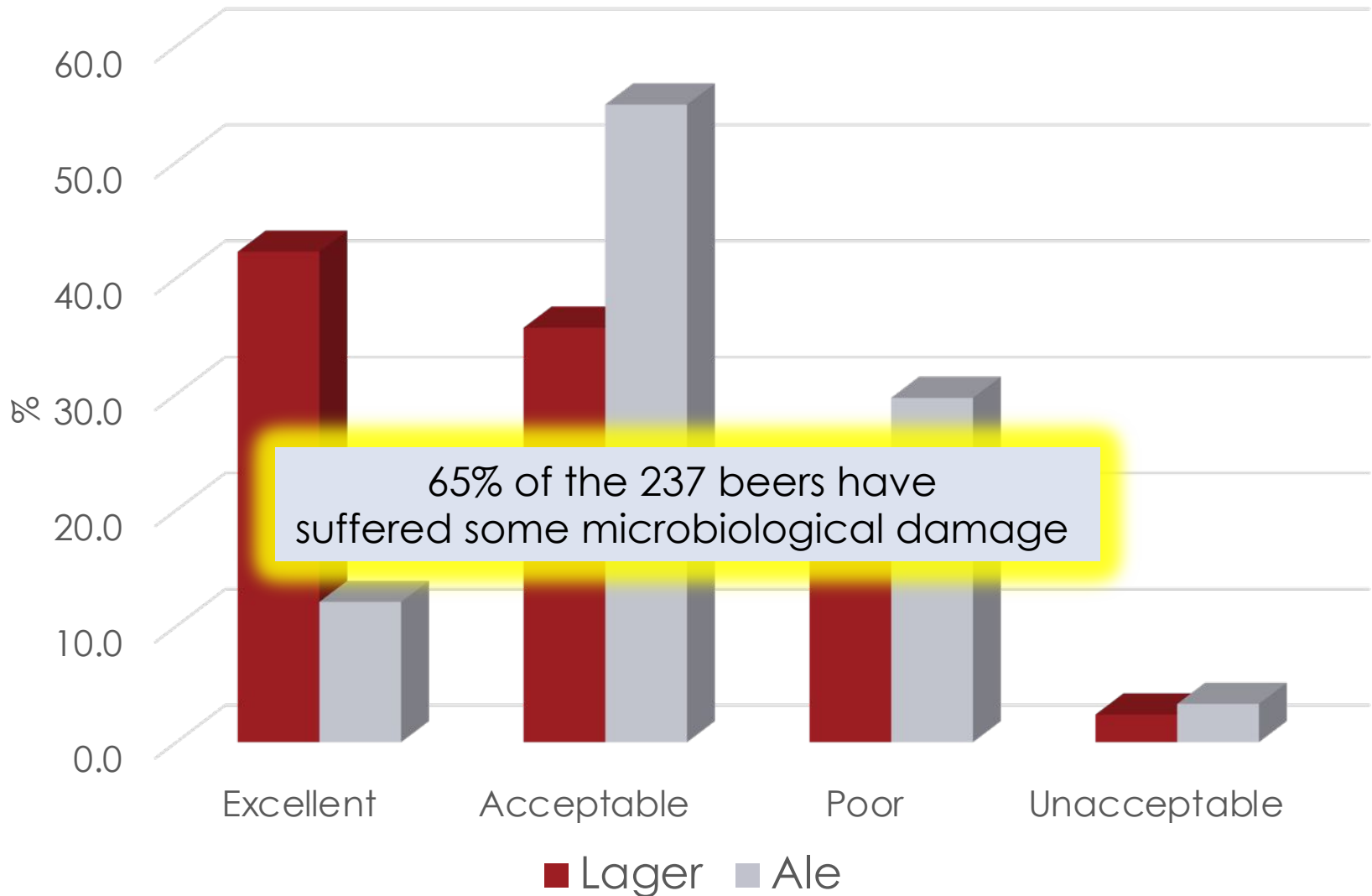
# 57 accounts - what we don't know

- ❑ When were the lines last cleaned
- ❑ Are the lines cleaned regularly
- ❑ Is the line cleaning effective
- ❑ How long are the lines
- ❑ How old are the lines
- ❑ The lines are MDP but are they 'lined' (nylon) to minimise biofilm attachment
- ❑ Are the lines 'new generation' and minimise gas transfer in (O<sub>2</sub>) and out (CO<sub>2</sub>)
- ❑ Are nozzles treated hygienically (and **not** soaked in soda water!)
- ❑ Are the keg couplers and spears clean/sprayed on changing
- ❑ Are keg beers turned over in < five days
- ❑ Are there 'peaks' and 'troughs' in throughput
- ❑ What is the cellar temperature
- ❑ Are there too many taps
- ❑ Where's the 'hot spot'
- ❑ Are the bar staff trained, understand their importance in hygiene

# Quality - keg ale v lager



# Quality - keg ale v lager





## Other insights ....

- ▣ **Overfonting** - The quality index declined as the number of taps increased from  $\leq 10$  (88%) to 11-20 (76.7%) and  $\geq 21$  (75.9%).
- ▣ **Pricing** - The most expensive price band (£3.31-4.00) had a notably lower quality index. Prices were higher in village accounts than towns and cities.
- ▣ **Cask Marque** - no difference in individual quality bands or overall beer quality in accounts with Cask Marque (QI = 76.8%) and those without (QI = 76.1%).

# This is not new ....

- ▣ 'it is not possible to find a subject fraught with greater importance to the brewing trade than cellar management'.
- ▣ 'the national beverage, as it is served over the counter of many of the public-houses in England today, has not the flavour and appearance commensurate with the care bestowed upon its manufacture in the brewery, a fact that often leads the public into the mistaken notion that the beers of to-day are inferior to those of our forefathers'.
- ▣ 'it (is) difficult to understand why at the most critical point in its passage from the brewery to the consumer, viz., the public-house, beer is allowed to be treated under conditions which are in direct antithesis to those strictly enforced in the brewery'.

Seton, G.R. (1912), Cellar management.  
*Journal of the Institute of Brewing*, 18, 389-406.

# Quality – lager brands

	Lager SL3			Lager SL6		
Quality band	No	%	QI	No	%	QI
A	57	52.3	84.0	8	23.5	69.9
B	34	31.2		15	44.1	
C	10	16.5		3	23.5	
D	0	0		2	5.9	
	109					

- Quality index is the sum of the individual quality band measurements where 'A' = excellent (4 marks), 'B' = acceptable (3 marks), 'C' = poor (2 marks) and 'D' = unacceptable (1 mark). The total is divided by number of samples x 4 and the result multiplied by 100. All samples achieving A/excellent would result in a quality index of 100.

# Quality – ale brands

	Ale KA1			Ale KA5		
Quality band	No	%	QI	No	%	QI
A	6	9.5	68.3	4	21.1	71.1
B	37	58.7		8	42.1	
C	17	27		7	36.8	
D	3	4.8		0	0	
	63					

- Quality index is the sum of the individual quality band measurements where 'A' = excellent (4 marks), 'B' = acceptable (3 marks), 'C' = poor (2 marks) and 'D' = unacceptable (1 mark). The total is divided by number of samples x 4 and the result multiplied by 100. All samples achieving A/excellent would result in a quality index of 100.

# Line cleaning – the root of the problem (and the solution!)

The more effective the clean the better!

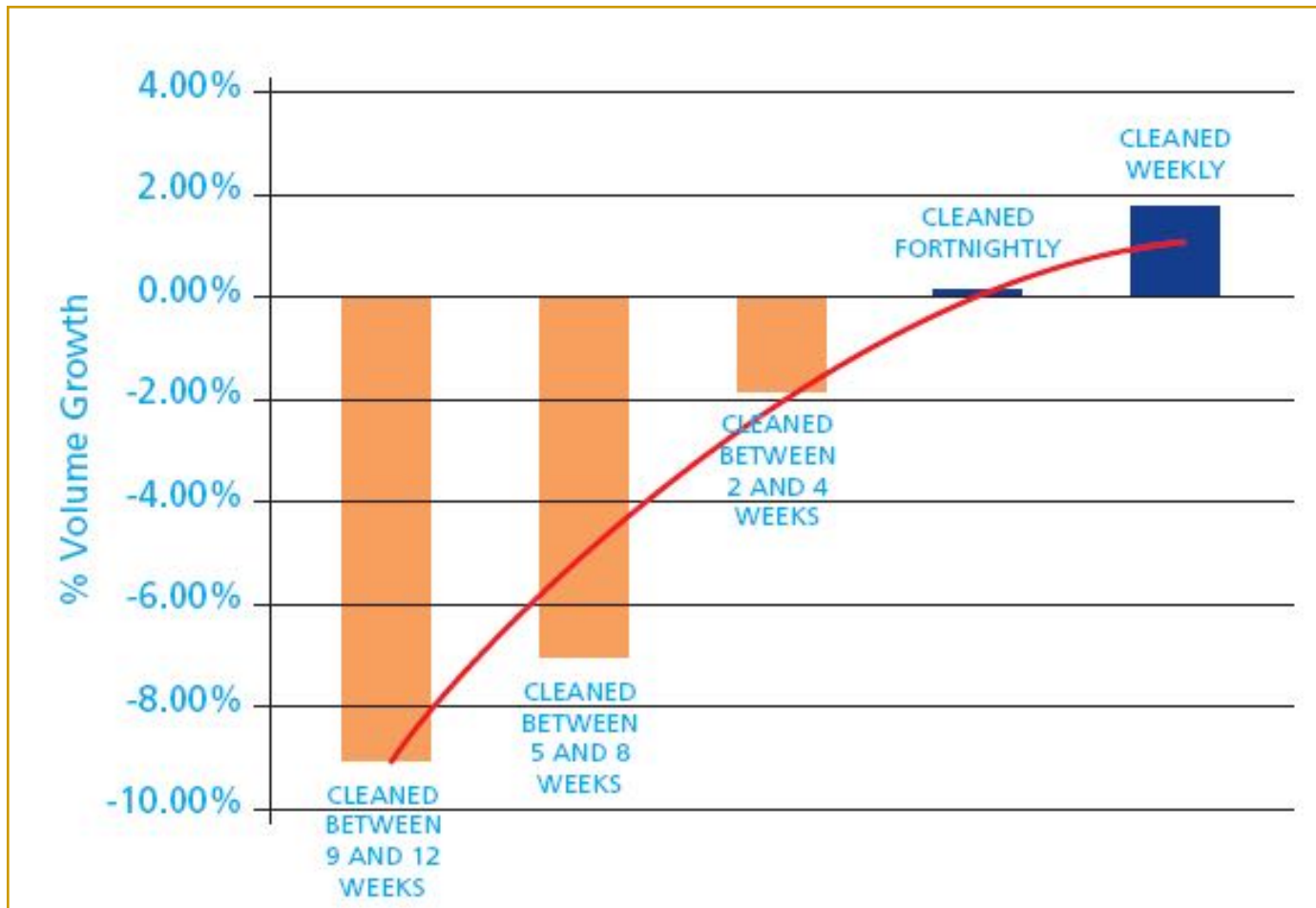
# Line cleaning – some assumptions

- ❑ The cleaner the system the longer it will stay clean!
- ❑ But deadlegs, fittings and 'complexity' will harbour microorganisms which reseed the system.
- ❑ Recontamination will reflect the growth rate of beer spoilage microorganisms.
- ❑ The growth rate will be determined by temperature and nutrients for growth.

# Frequency

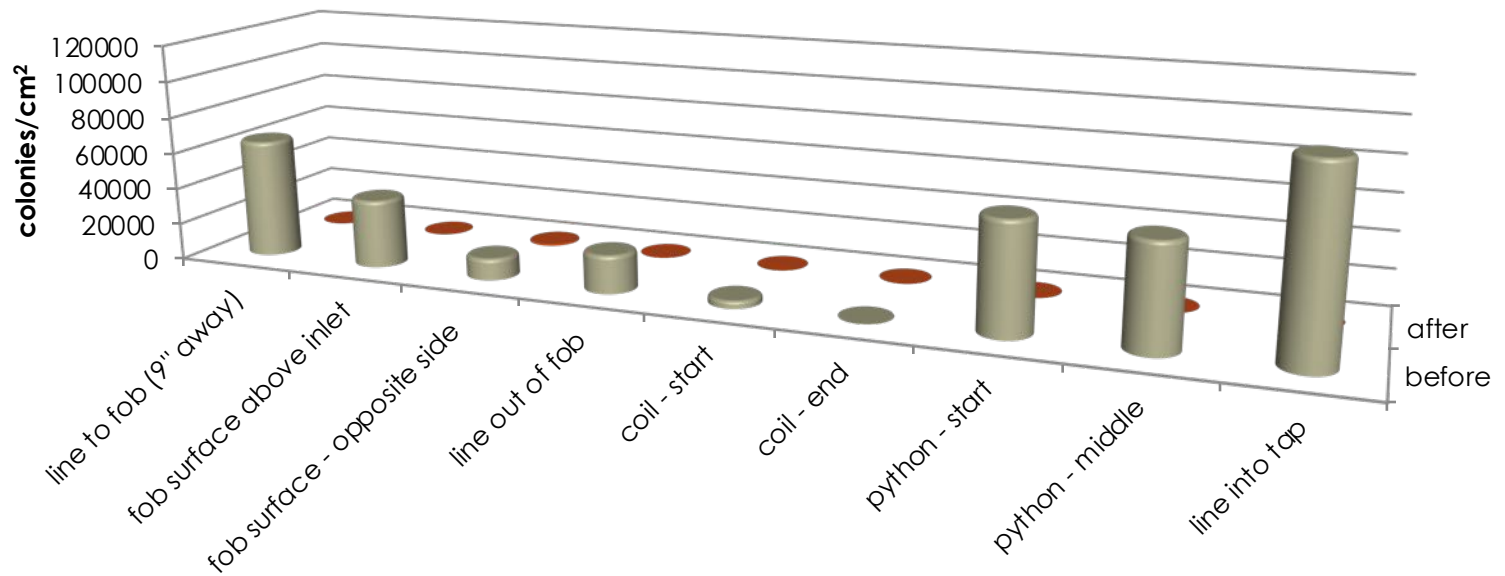
Market	Frequency	Storage °F/C	Dispense °F/C
UK	7 days	54 12	36-54 2-12
USA	14 days	37 3	34-41 1-5
Canada	21-28 days	34-41 1-5	34-41 1-5
Australia	7 days	32-50 0-10	31-37 -0.5-3
Spain	> 28 days	ambient	36-39 2-4
Ireland	21 days	45-48 7-9	36-43 2-6

# Line cleaning and profit

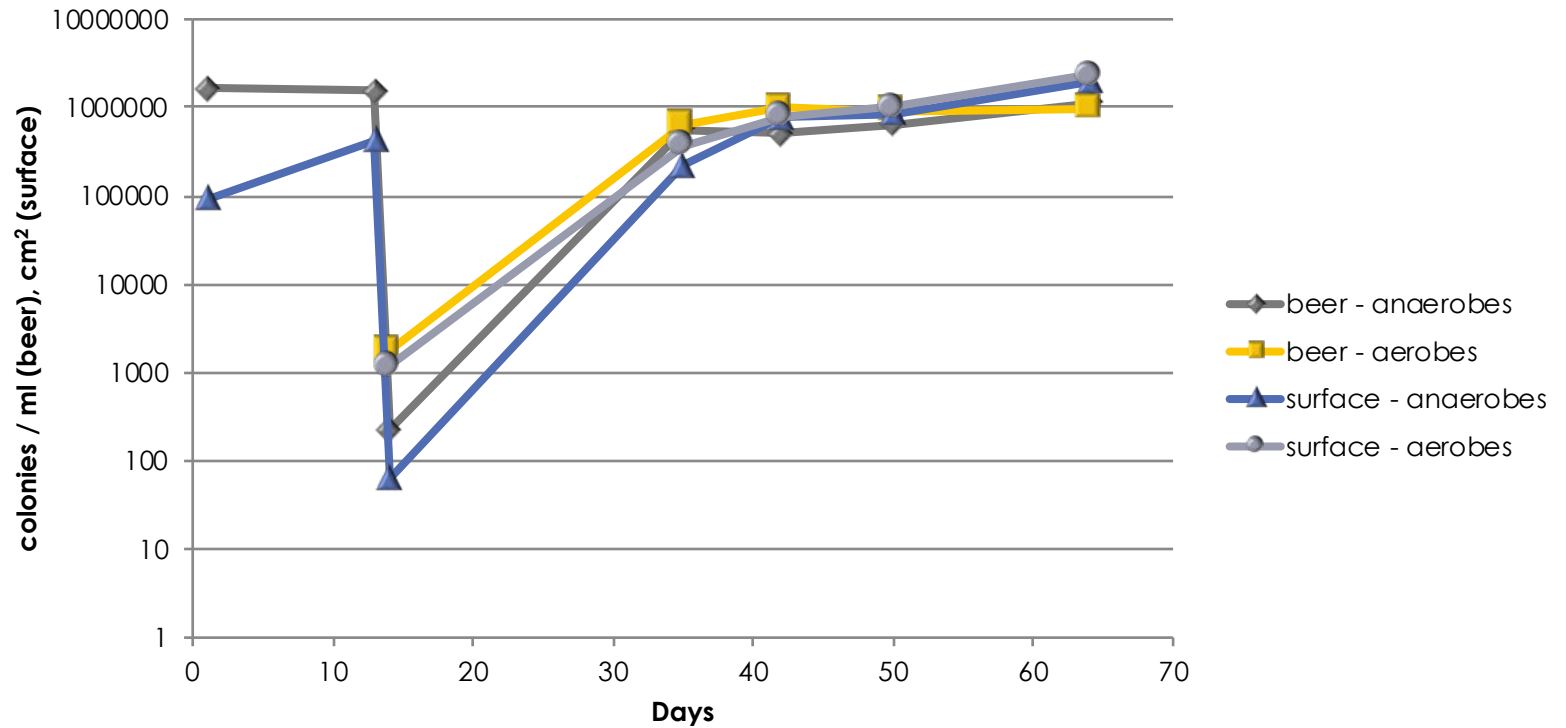




# Line cleaning works? (i)

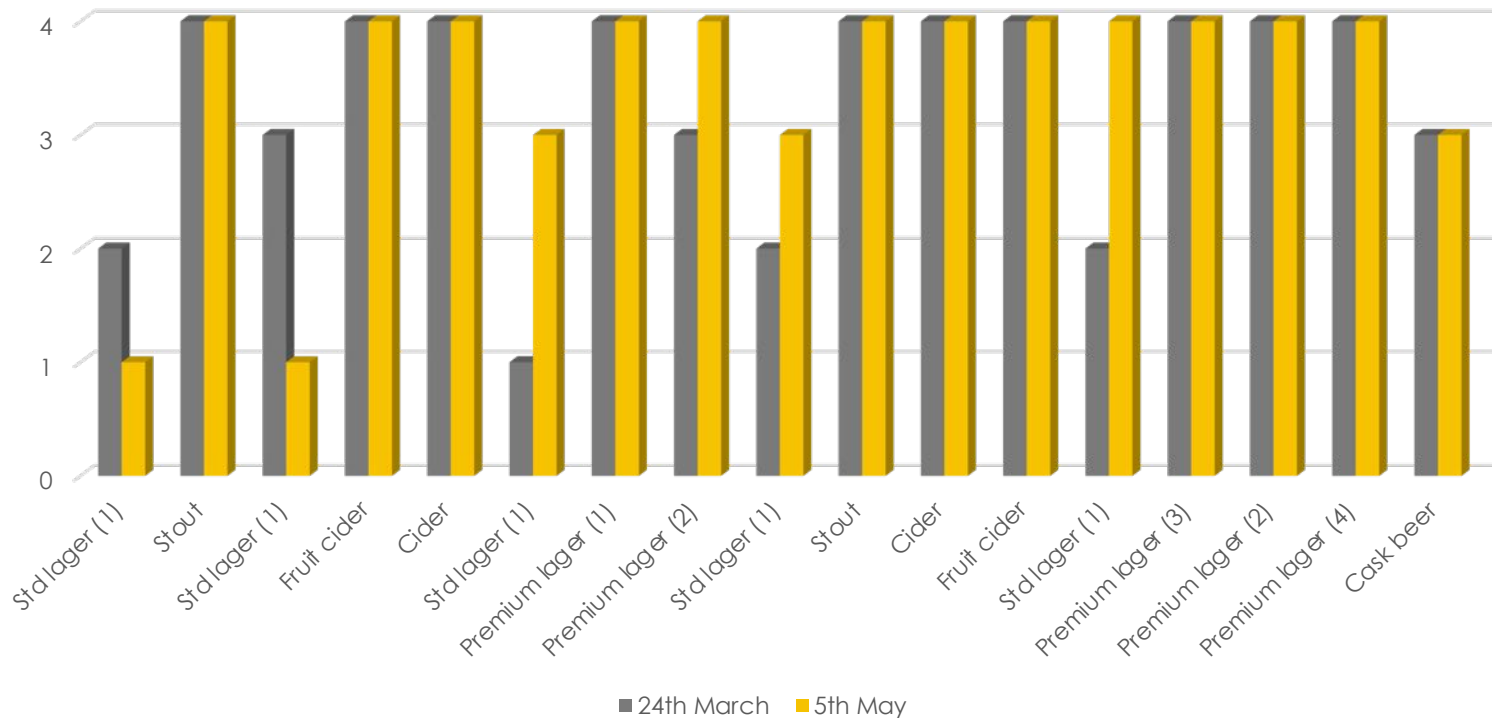


# Line cleaning works? (ii)



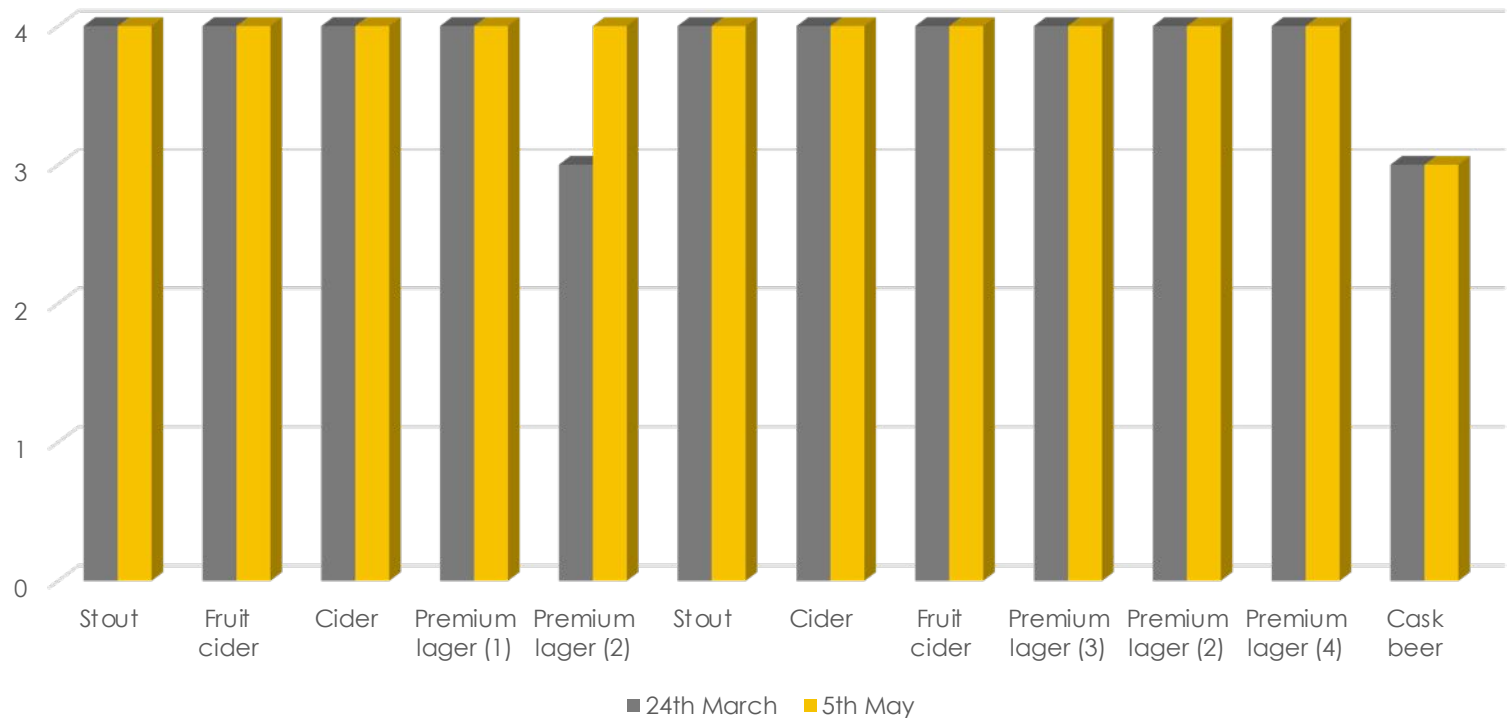
# But in trade (i)

High Street (primarily) wet account – 17 taps



Where 4 = excellent, 3 = acceptable, 2 = poor & 1 = unacceptable

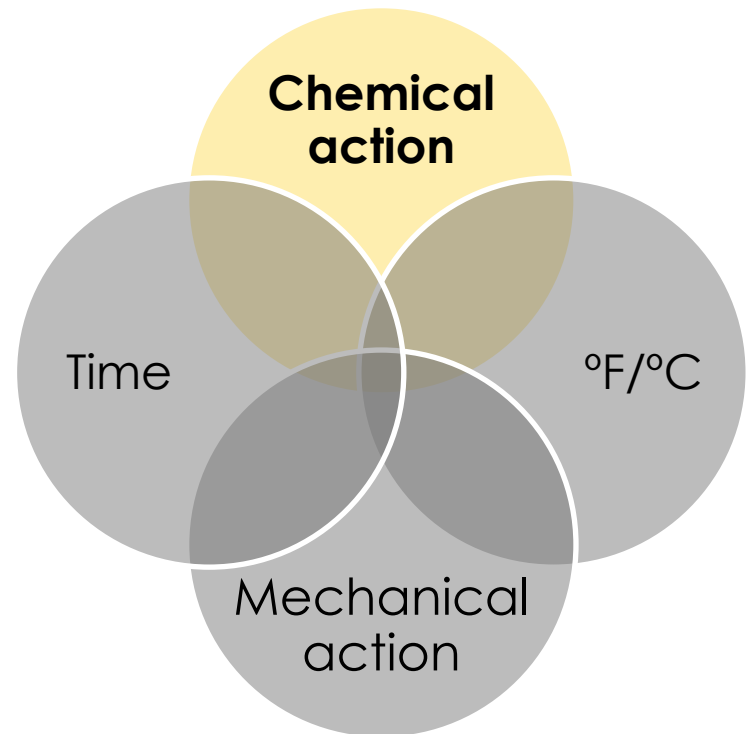
# But in trade (ii)



Cleaning deadleg – three std lager lines (to five taps) in the center of the cleaning 'circuit' which is cleaned from either end

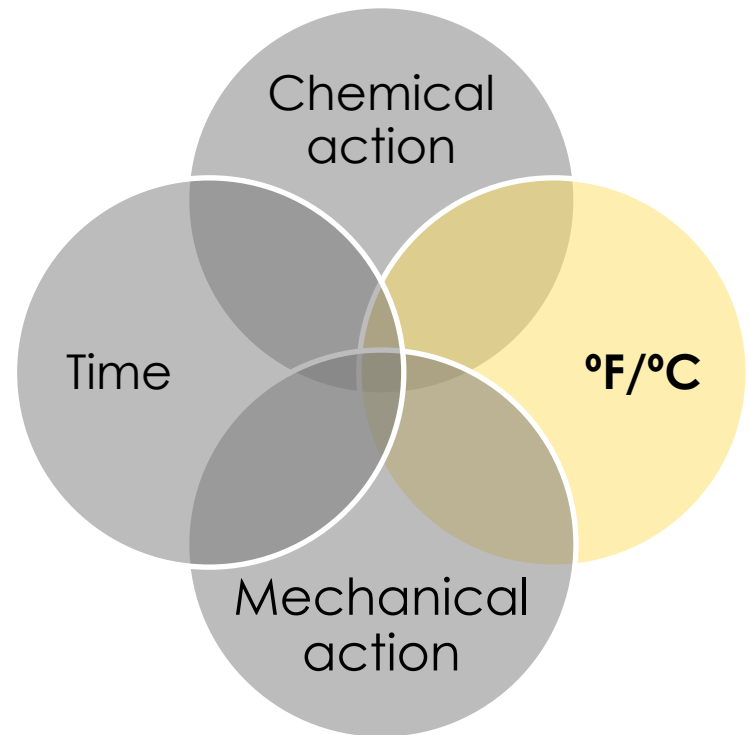
# Improving line cleaning

- ❑ In the UK, the majority of line cleaning solutions are 'caustic' based + chlorine.
- ❑ Mix of sodium (or potassium) hydroxide (%) and chlorine (mg/L) 0.065/250, 0.14/350, 0.1625/500, 0.2/200, 0.325/1000. No acid cleaning. Much [lower] than the US.
- ❑ Some include potassium permanganate to reveal 'soil' – good for process control.
- ❑ Growing availability of cleaning solutions which are H&S friendly.



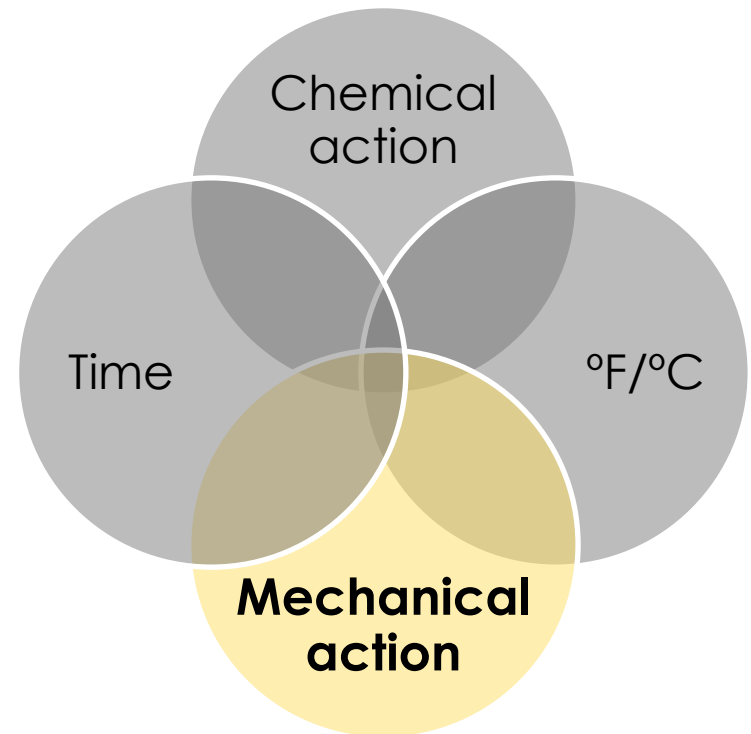
# Improving line cleaning

- ❑ In the UK, use cold mains water with no temperature control.
- ❑ 'As temperature increases, the cleaning rate increases'.
- ❑ BA recommends 80-120°F/27-43°C.
- ❑ Would a controlled warmer clean be beneficial?
- ❑ Water quality varies - should rinse water be sanitised?



# Improving line cleaning

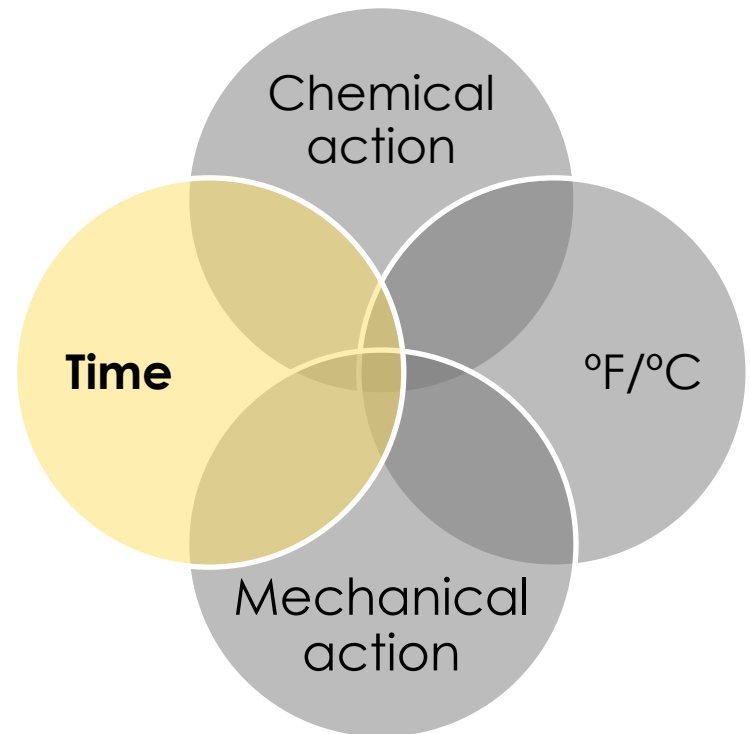
- ▣ Static cleaning is the norm in the UK. Mechanical action is limited to a 'pull through' after 15-20 minutes.
- ▣ Recirculation and the associated mechanical action will achieve a much more effective clean.
- ▣ Better still – if possible – circulate in both directions!



# Improving line cleaning

## ❑ UK Typical Process

- ❑ Pushing beer out of the line by flushing with water.
  - ❑ Filling with cleaning detergent.
  - ❑ Standing for 30 minutes and 'moving' (pulling a pint or two) halfway.
  - ❑ Flushing with water before replacing with beer.
- 
- ❑ Timing around convenience – can be longer, can be shorter.
- 
- ❑ Would longer be better?  
Would it damage the line?

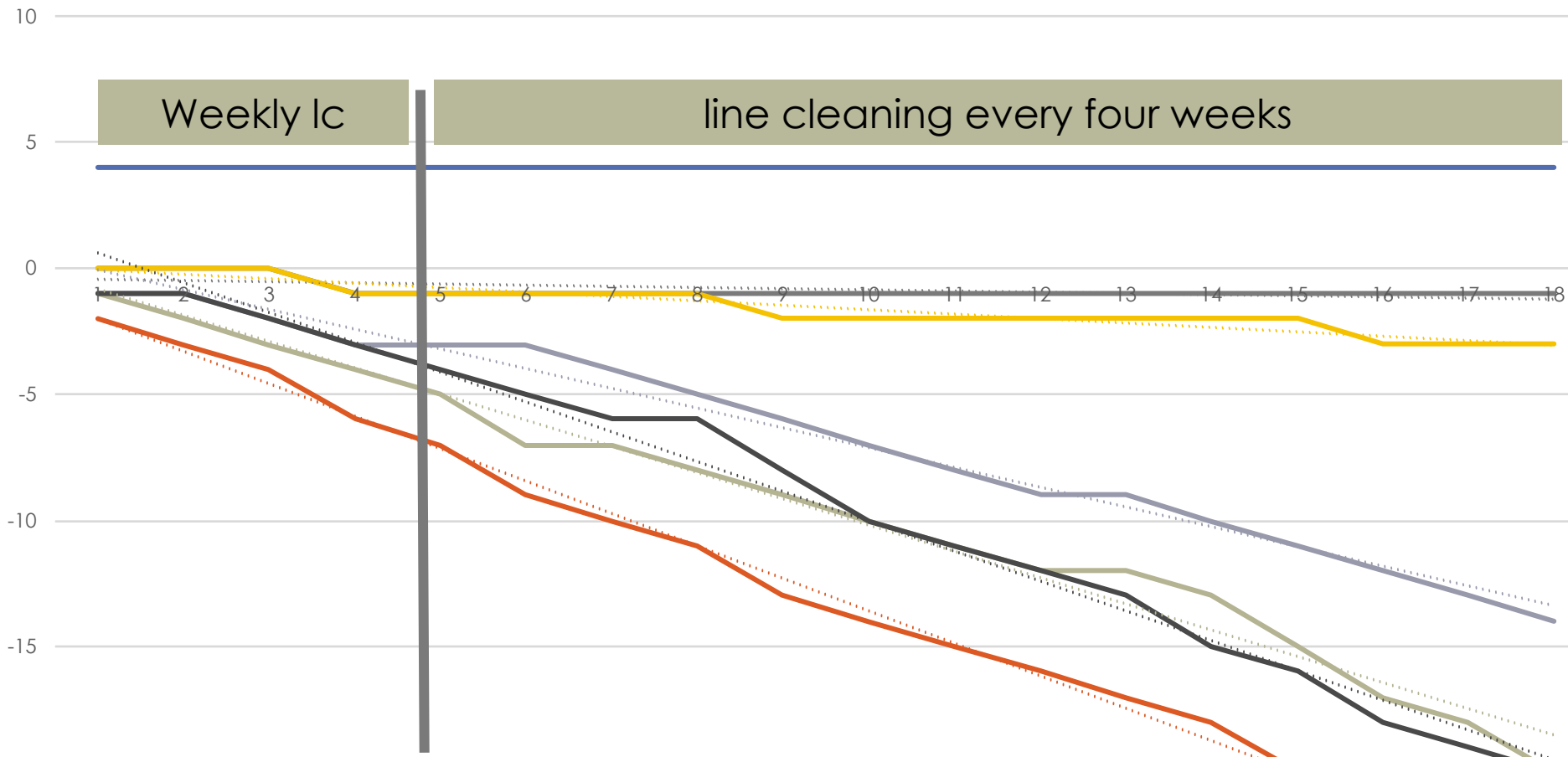




# Innovation – sonic technologies

Reducing the frequency of line cleaning

# Sonic system – 18 week trial



Beer quality was unchanged on switching from weekly cleans to  
– post install of the system - cleaning every four weeks.

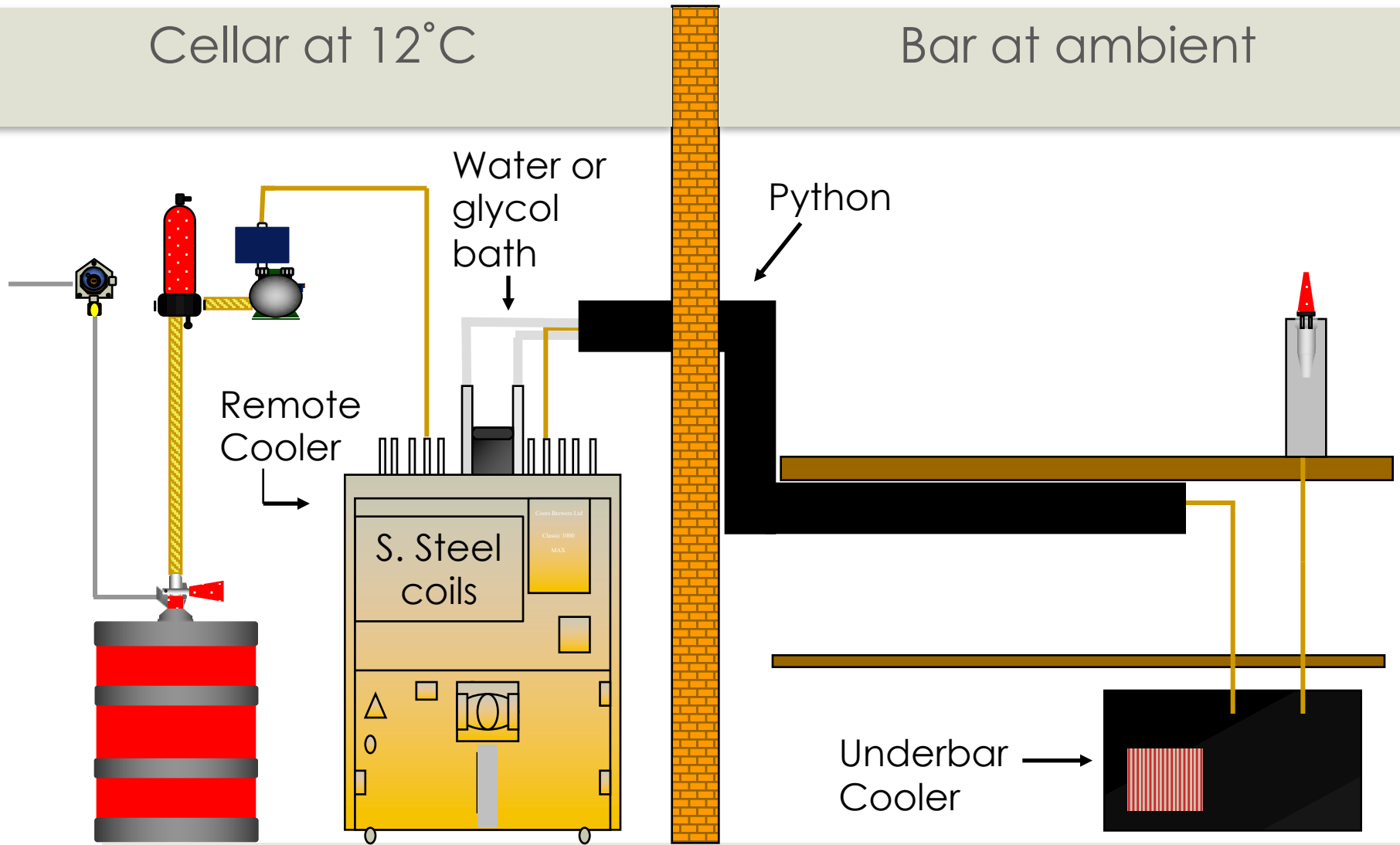
Is the system impacting on keg contamination?

Recontamination post cleaning

# Likely sources of contamination?

Cellar at 12°C

Bar at ambient



# A word about nozzles

## Draught beer hygiene: cleaning of dispense tap nozzles

David E. Quain\*

Draught beer quality can be compromised by the growth of spoilage microorganisms. Whilst best practice for assuring dispense hygiene is broadly recognized, it is not always fully or regularly implemented. In some markets, tap nozzles are removed and stored overnight at room temperature in carbonated (soda) water. The next morning they are returned (sometimes after rinsing) to the dispense tap. The effectiveness of this approach is compared with soaking in diluted line-cleaning solution (UK best practice) or a solution containing hypochlorous acid (commercial sanitizing tablets). Two novel approaches – ozonated water and use

Maybe relevant to faucet hygiene plugs if stored in soda water?

4-log reduction in bioluminescence compared with carbonated water. The efficacy of hypochlorous acid was confirmed by incubating cleaned nozzles in fresh beer without any increase in turbidity. Diluted line-cleaning solution was less effective and achieved a 2-log reduction. Ultrasonics reduced microbial attachment but effectiveness was aligned to increasing process time. Soaking in ozonated water was without antimicrobial impact. This work has shown carbonated water to be ineffective in cleaning microbiologically contaminated nozzles. This is a concern as these microorganisms derive from the dispense line, the environment and likely human interaction. To minimize the risks of transfer to dispensed product or back-contaminating the dispense line, soaking draught beer nozzles in an effective sanitizing solution is strongly recommended. Copyright © 2016 The Institute of Brewing & Distilling

# Best practice

\* Staff trained, weekly line cleaning with 'quality' cleaning solution, sanitised nozzles and couplers



Best practice includes .....

# Impact of best practice on quality

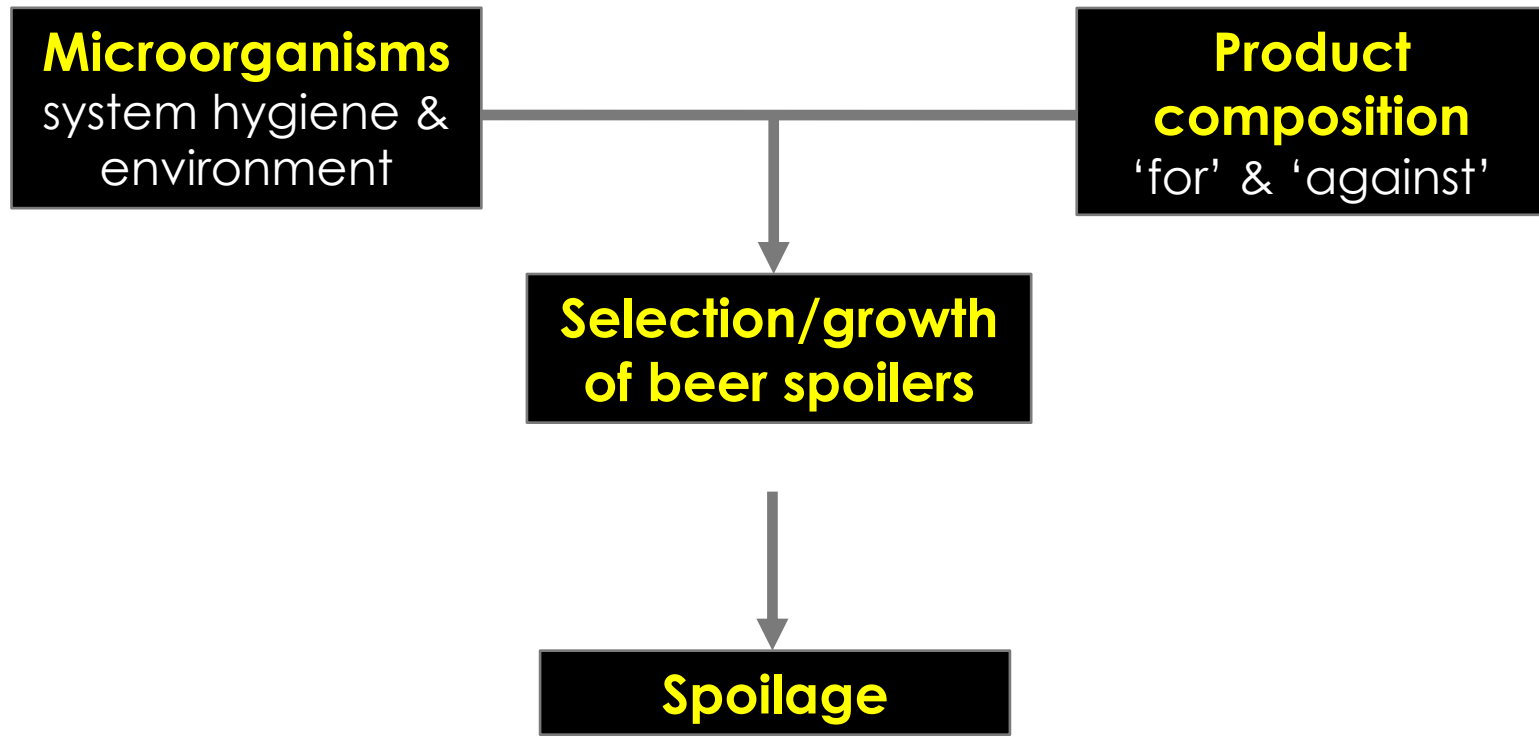


Gastro Pub with nine taps – 3 x cask ale, 2 x premium lager, 2 standard lager, stout and a cider



Spoilage

# Spoilage depends on ....



# Spoilage depends on ....

## Microorganisms system hygiene & environment

Best practices – line cleaning, nozzles, couplers, materials, temperature, turnover

## Product composition 'for' & 'against'

For - sugars, amino acids, dextrans, ions, organic acids. Against pH, iso  $\alpha$  acids, SO<sub>2</sub> melanoidins, abv (?)

## Selection/growth of beer spoilers

## Spoilage

Haze, sulphur, VDK, acetic acid, amines, lactic acid, phenols, short chain fatty acids etc.,

# Brand quality varies (10 week study)

Product	Abv (%)	Quality band	Quality index (%)*
Lager	5	A (9), B (1)	97.5
Cider	4.7	A (8), B (2)	95
Stout	4.2	A (2), B (6), C (2)	75
Lager	4	B (7), C (3)	67.5
Cask ale	4.4	A (9), B (1)	97.5

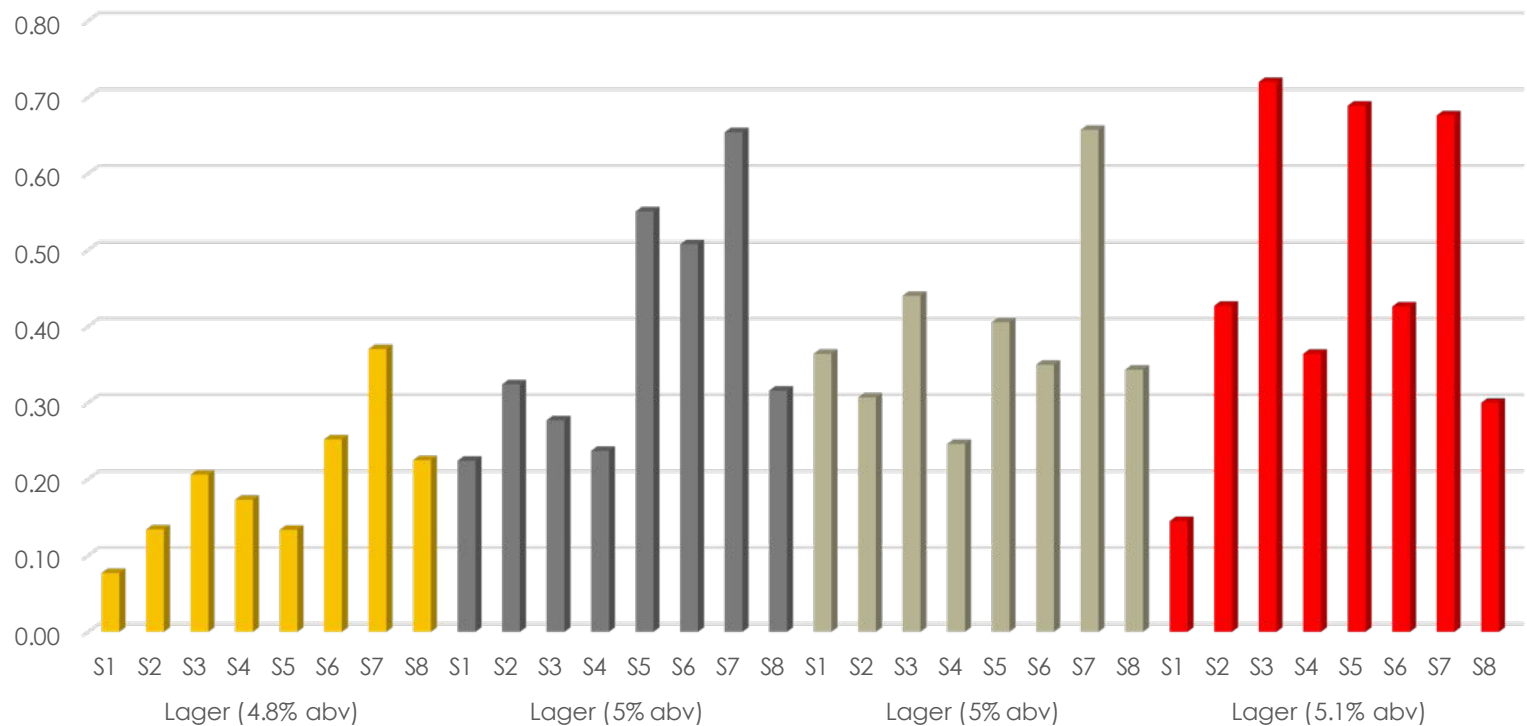
- Quality index is the sum of the individual quality band measurements where 'A' = excellent (4 marks), 'B' = acceptable (3 marks), 'C' = poor (2 marks) and 'D' = unacceptable (1 mark). The total is divided by number of samples x 4 and the result multiplied by 100. All samples achieving A/excellent would result in a quality index of 100.

# Spoilage screen

- ▣ An approach to assess the 'spoilability' of different beers.
- ▣ Samples are taken ex-dispense and forced.
- ▣ Post forcing, the equivalent of 0.02 OD<sub>660</sub> is added to 25 mL of the test beer.
- ▣ The beers are forced and the OD<sub>660</sub> determined.

# Brand spoilage ( $\Delta OD_{660}$ )

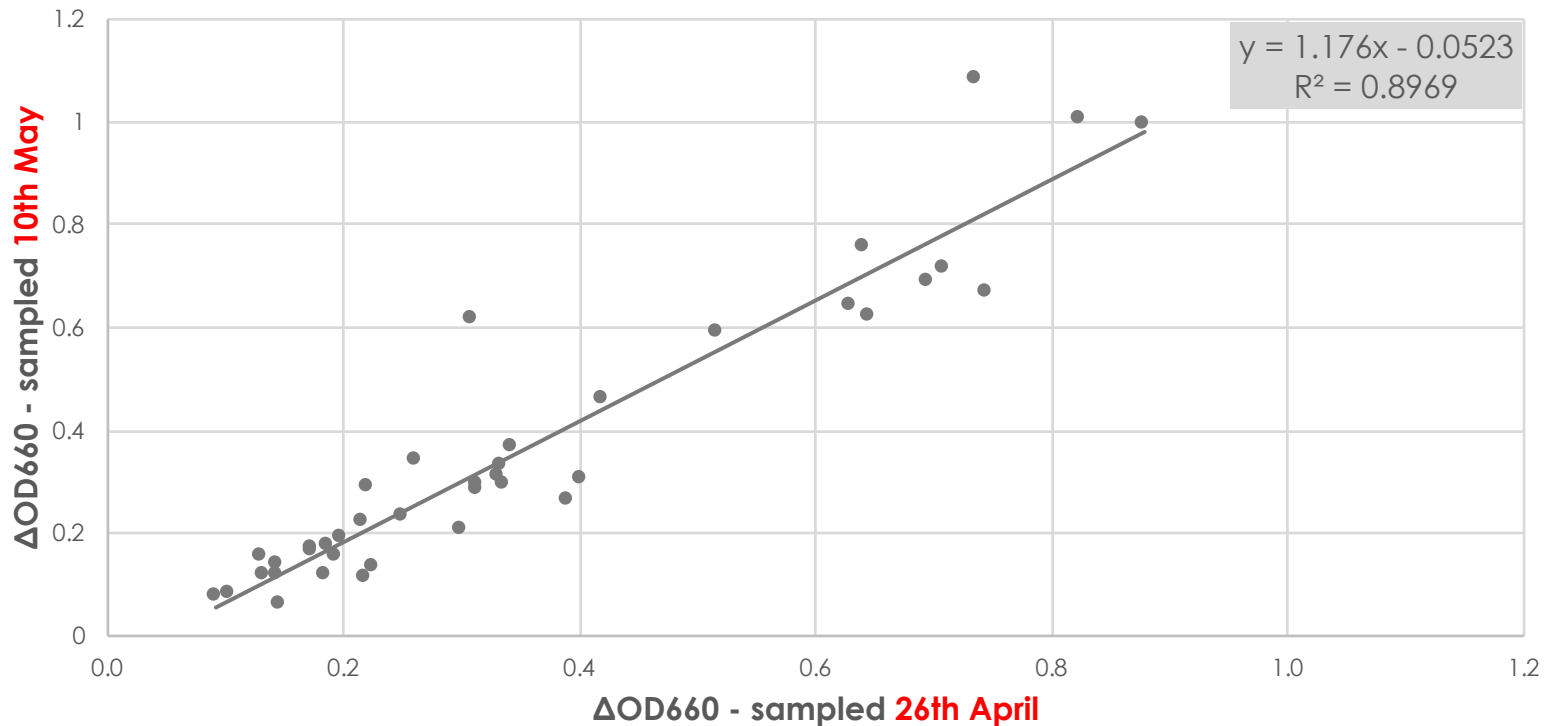
QI = 96.9%, 81.3%, 75.0% and 71.9%



Spoilage organisms – sourced from six brands and four accounts

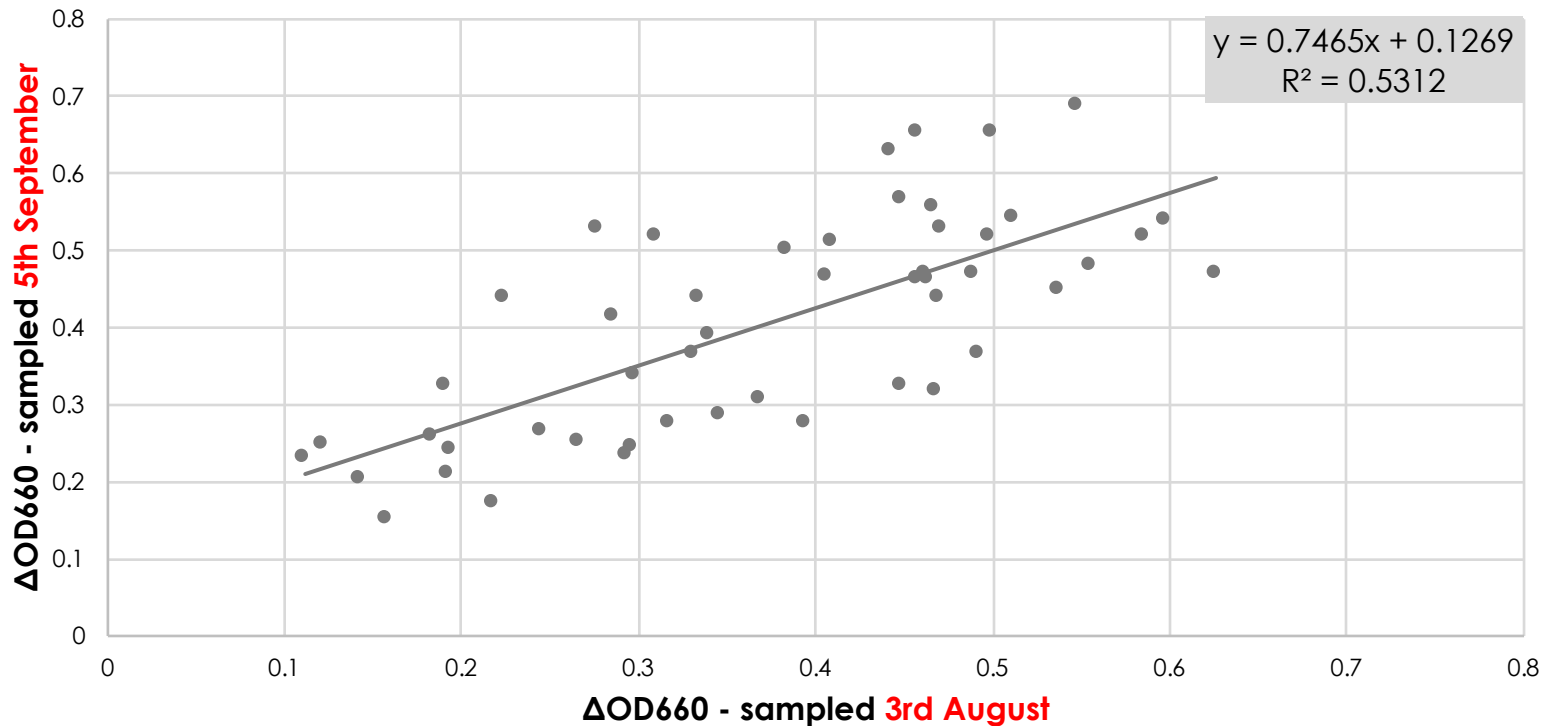
Four brands sampled from the same account on different dates – forced, and inoculated (0.02 OD<sub>660</sub>/25 mL) into 10 beers (0-8% abv) and then forced.

# Four brands from one account



One brand sampled from the five accounts on different dates – forced, and inoculated (0.02 OD<sub>660</sub>/25 mL) into 10 lager beers (4-5.1% abv) and then forced.

# One brand from five accounts





# Microflora – same brand, five accounts

- ▣ *Brettanomyces bruxellensis* in all five accounts
- ▣ *Brettanomyces anomalus* in three.
- ▣ *Pichia manshurica* in two.
- ▣ Acetobacter species in all five accounts
- ▣ *Lactobacillus brevis* in two.
- ▣ *Lactobacillus paracollinoides* in two (other) accounts
  
- ▣ **Is the microflora determined by the account, the brand or both?**

And finally

# Some reflections ....

- ▣ There is remarkably little published 'science' regarding draught beer quality.
- ▣ Effective line cleaning is key to assuring beer quality. Innovations focus on line material, line cleaning solutions and 'sonic' technologies.
- ▣ Validation of these developments is scanty (at best) or non-existent.
- ▣ The forcing test provides a tool to validate the impact (good or bad) of innovation.
- ▣ Assessment needs to be robust and long-term.

# Thank you for listening!



- And thanks to my co-workers Mel Stuart, Alex Jevons and, in particular, James Mallett