An independent report on the application of BeerSaver technology in the assurance of beer hygiene in the on-trade

Prepared for and confidential to

Cambridge Scientific Solutions Ltd

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Contents

Headlines

Trial overview

- The BeerSaver technology was evaluated in the 'real world' of three on-trade accounts.
- The draught products that were tested included three lagers, stout (conventional and extra cold), keg ale and two cask ales.
- Products were paired (where possible in the same account) and monitored (microbiology and beer quality parameters) for 16 weeks. After three weeks sighting (all lines being cleaned weekly), BeerSaver was installed in the fourth week (trial) and thereafter not cleaned. The control lines continued to be cleaned weekly up to 12 weeks, after which they were not cleaned.

BeerSaver and beer microbiology

- Compared to products subject to weekly line cleaning, the microbiology of beers with BeerSaver (and lines uncleaned for up to eight weeks) was
  - better – lager (anaerobes, aerobes), stout (anaerobes) – Figs 1, 2, 4b
  - similar – stout (aerobes), ales (anaerobes) – Figs 4a, 5b
  - poorer – ales (aerobes) – Fig 5a
- BeerSaver had a greater impact on managing 'anaerobes' (beer spoilage organisms) than 'aerobes' (typically viewed as 'environmental', less impactful on quality).
- BeerSaver 'protected' the three lager brands for eight weeks beyond which the microbiological loading increased outwith typical levels (Fig 10).
- When weekly line cleaning of control lagers (x3) stopped for four weeks there was a marked deteriation in beer microbiology (Fig 3) and associated related increase in the off-flavour diacetyl (Fig 9 v 'anaerobes').
- Room temperature incubation of aseptically taken samples vividly indicates the enhanced microbiological robustness of the 'BeerSaver beers' over those of the control (Figs 11-13).

BeerSaver and beer quality

- Acetaldehyde is typically present in beer with a flavour threshold of 10-20 mg/l. Here levels were similar (< 7 mg/l) in the three lagers with BeerSaver or cleaned weekly.
- Although typically present in beer, diacetyl (2,3-butanedione) can be formed by contaminating *Lactobacillus* or *Pediococcus* species (aka 'anaerobes') see Fig 9. Diacetyl is notably flavour-active (butterscotch flavour and aroma) with a threshold (depending on type of beer) of 0.15 mg/l (0.6 mg/l in some ales). Throughout the eight week BeerSaver trial diacetyl levels were comparable in trial and control beers for three lagers (Fig 7), stout (Fig 8a) and (combined keg and cask) ales (Fig 8b).
- Measurements of other volatiles (higher alcohols and esters) also indicated no differences in quality of beers from uncleaned BeerSaver lines or those cleaned weekly.

General observations

- The loading of 'aerobes' in dispensed beer are typically higher than those of 'anaerobes'.
- Microbiological loadings were in a similar range to those previously reported for draught lager (4 taps, one account) in 1998 (Boulton and Quain, *Brewing Yeast & Fermentation* pages 563-565) and in a survey of a standard draught lager in 75 accounts in 2003 (Quain unpublished).
- Product parameters had no discernable influence on the susceptibility of draught beer to spoilage. For example ABV ranged from 3.5 to 5% and present gravity from 1.004 to 1.010. All products contained maltotriose (1.5–3.2 g/l). Typically no other fermentables were present with the exception of a standard lager containing maltose (2.5 g/l) and a cask conditioned ale with glucose, fructose and maltose (total < 2g/l).

Background

Excellent beer quality is a critical element to the success of on-trade accounts. Key to this is regular (the BBPA recommend a weekly frequency) and effective line cleaning. Whilst recognised as 'best practice', implementation across the industry is not consistent and – where practiced – there are concerns about beer losses, time and utilities.

The strategy of Cambridge Scientific Solutions (CSS) Ltd has been to establish a completely robust technology that compares favourably with weekly line cleaning **but** *defers the need to physically clean* for four weeks (or longer).

Although experience with this technology in the trade has been most encouraging, it was important to scientifically evaluate the performance of BeerSaver technology in real world accounts. Accordingly an independent and protracted trial was commissioned by CSS Ltd and was performed in three accounts in Edinburgh. The trial was sampled, monitored and managed through the International Centre for Brewing and Distilling at Heriot-Watt University.

Trial design

The trial involved monitoring on a weekly basis for analysis of microbiological and beer quality parameters for trial and control beer in three accounts. The product portfolio for the trial included lagers, ales and stout (see below table).

All lines were sampled weekly (just prior to cleaning). The BeerSaver technology was installed in week 4 – the previous three weeks providing a

baseline for microbiology and beer quality indices (see below table for subsequent details). The trial ran between April 17th and the 31st July 2008.

Weeks	Control	Trial
1-3	Weekly cleaning	Weekly cleaning
4-12	Weekly cleaning	No cleaning
13-16	No cleaning	No cleaning

Three accounts participated in this trial - Bert's Bar (William Street in central Edinburgh), and - at Heriot-Watt's Riccarton campus - the Student Union and the (now closed) Lectern bar.

Brand	%ABV	Student Union	Lectern bar	Bert's bar
Standard lager	3.8	control + trial		
Standard lager	4	control + trial		
Stout (std and extra cold)	4.2	trial	control	
Premium lager (cold)	5	control		trial
Cask ale	4.3			control + trial
Cask ale	3.8			control + trial
keg ale	3.5		control	trial

Programme

Sampling of accounts was typically on the same day of week. Two pints being drawn from each line after which the sample (500ml) was taken aseptically. The weekly regime being as follows;

- Monday – preparation for sampling and testing, data capture/reporting
- Tuesday – sample campus accounts – microbiological analysis
- Wednesday – beer analyses
- Thursday – sample Bert's Bar – microbiological analysis
- Friday - beer analyses/data capture/reporting

Analyses

Microbiological

- Anaerobes – Raka Ray (including the inhibitors cyclohexamide (yeast), vancomycin (non-beer spoilage gram +ve bacteria) and phenylethanol (non-beer spoilage Gram -ve bacteria). Selective for wild yeast, *Lactobacillus* and *Pediococcus* species.
- Aerobes – WLD – selective for wild yeast and (acetic acid) bacteria.

Analytical

- 'Volatiles' – esters, higher alcohols, acetaldehyde, diacetyl and pH.

Results

Figure 1 – Lager aerobes ± BeerSaver

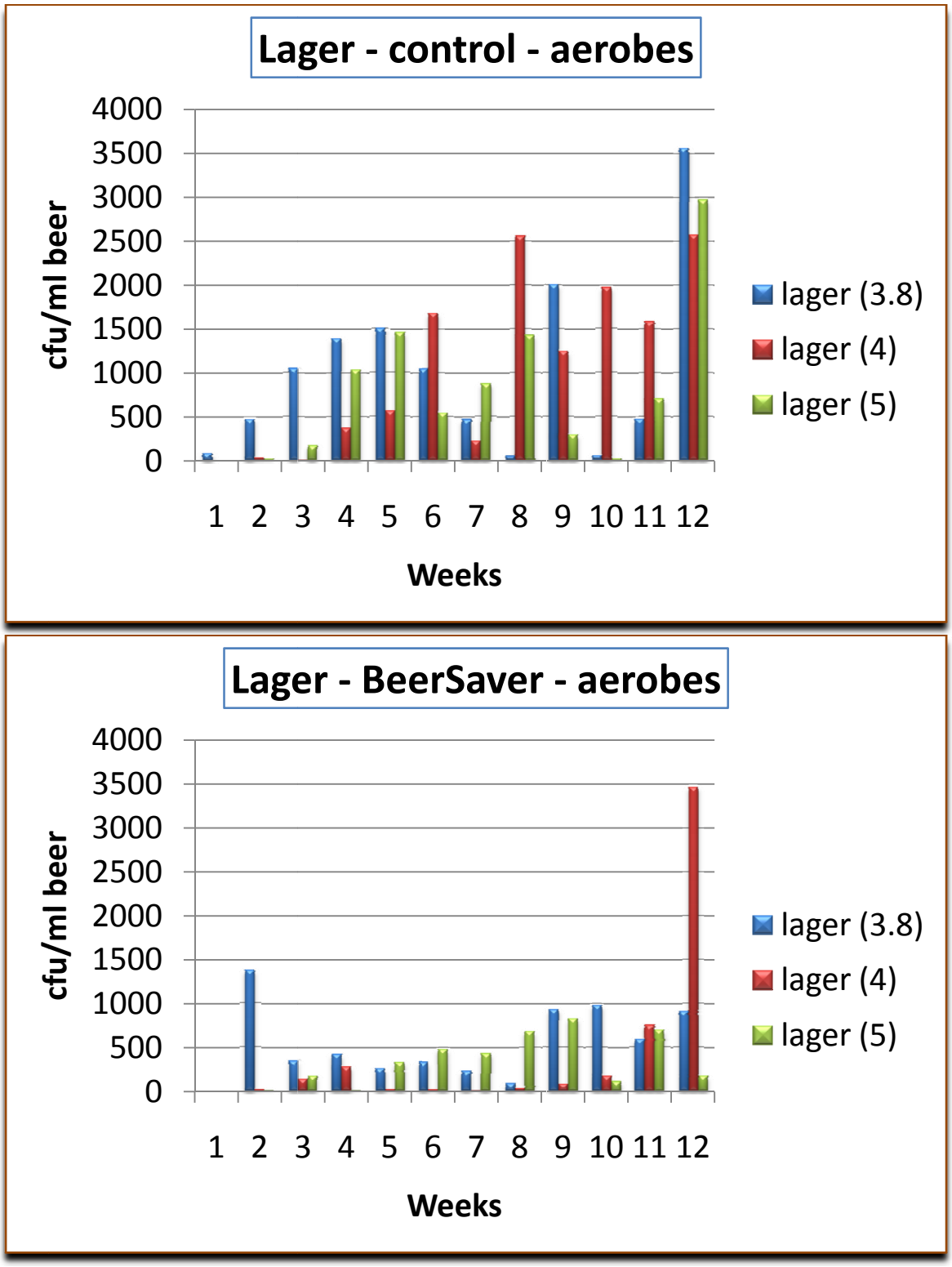
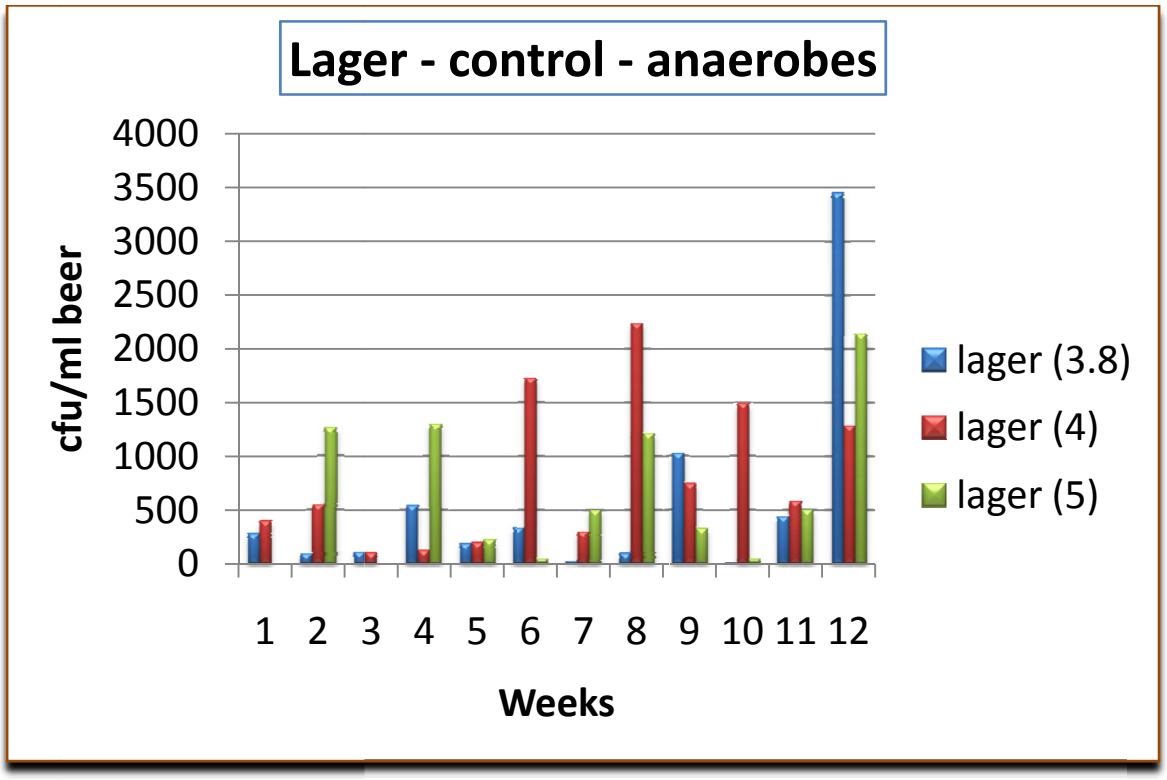


Figure 2 – Lager anaerobes ± BeerSaver



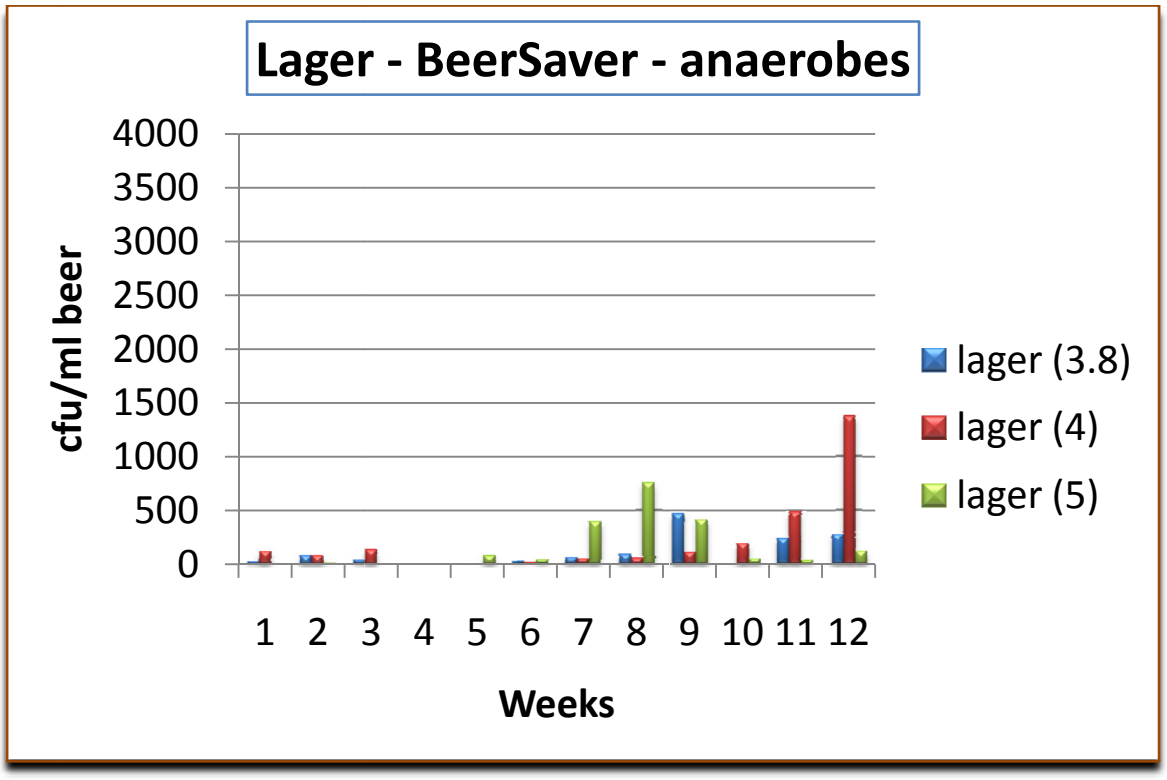
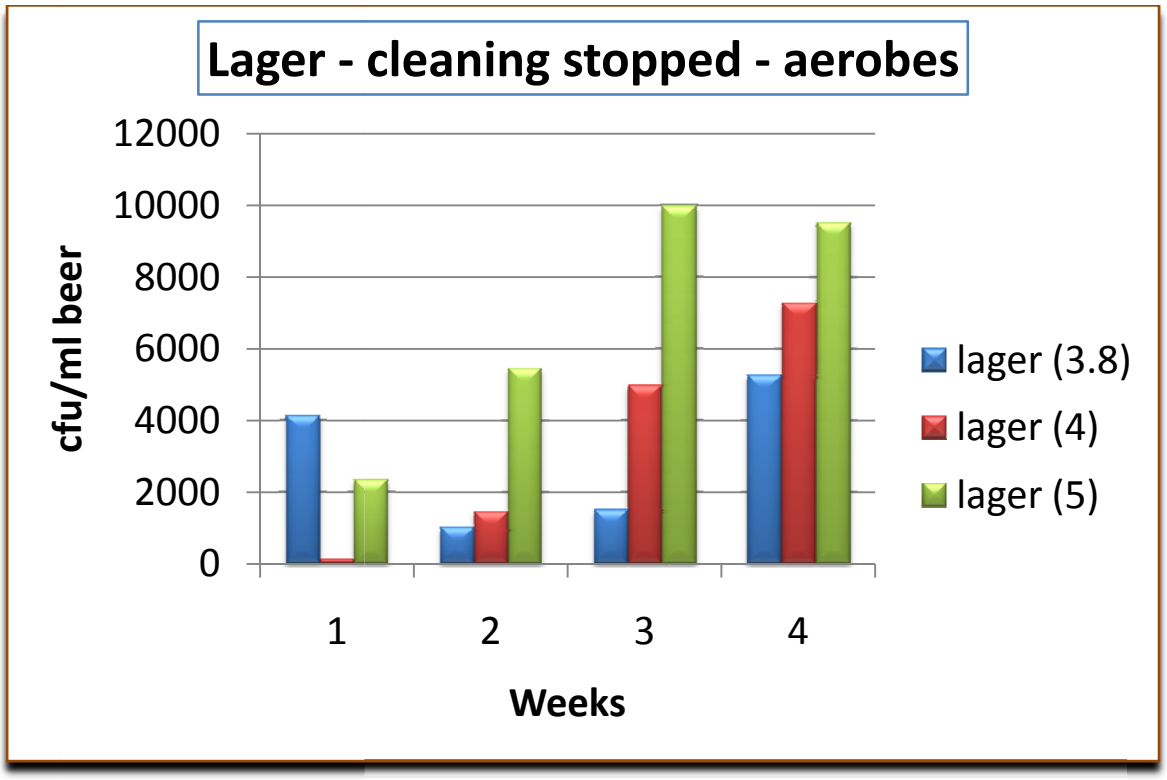


Figure 3 – Impact of stopping cleaning - lager aerobes & anaerobes



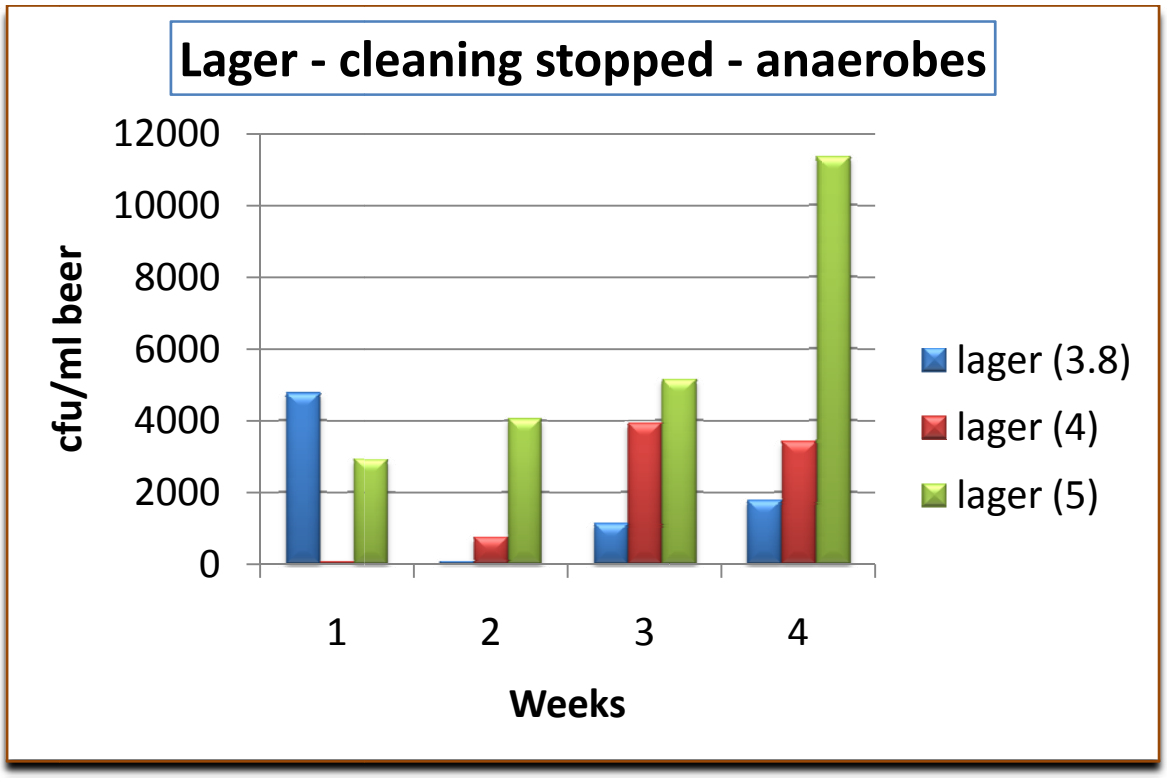
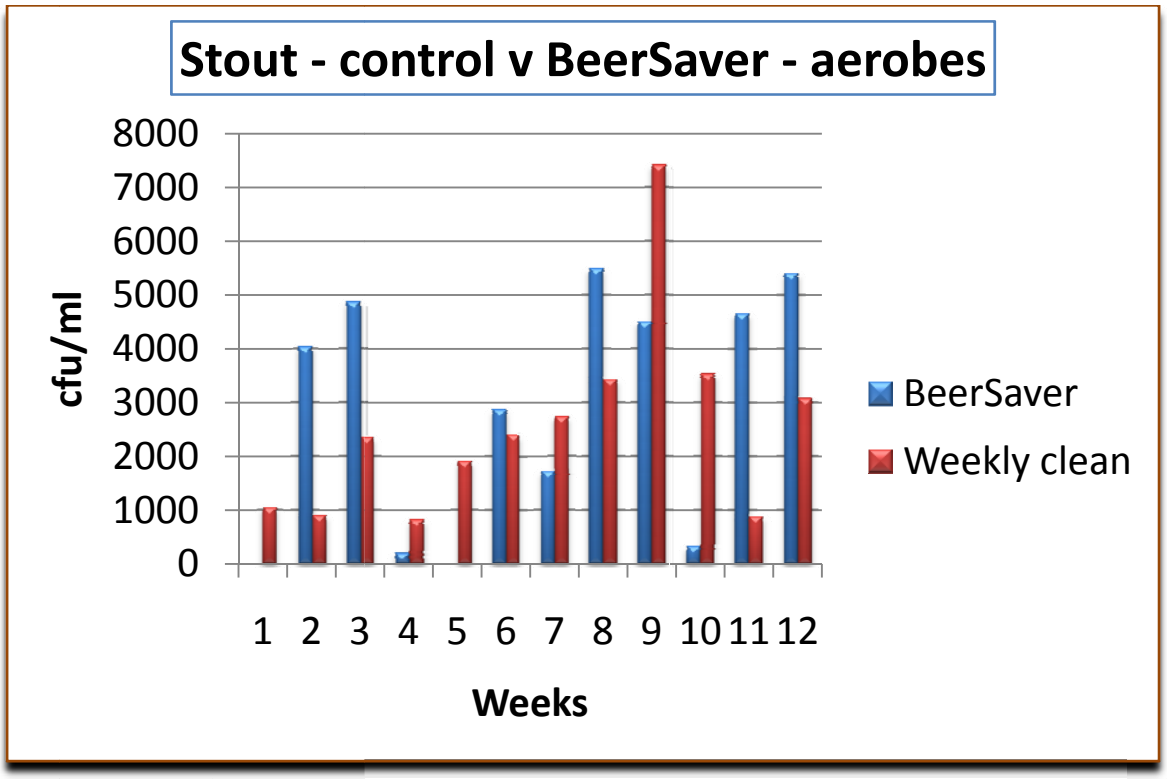


Figure 4 – Stout aerobes & anaerobes ± BeerSaver



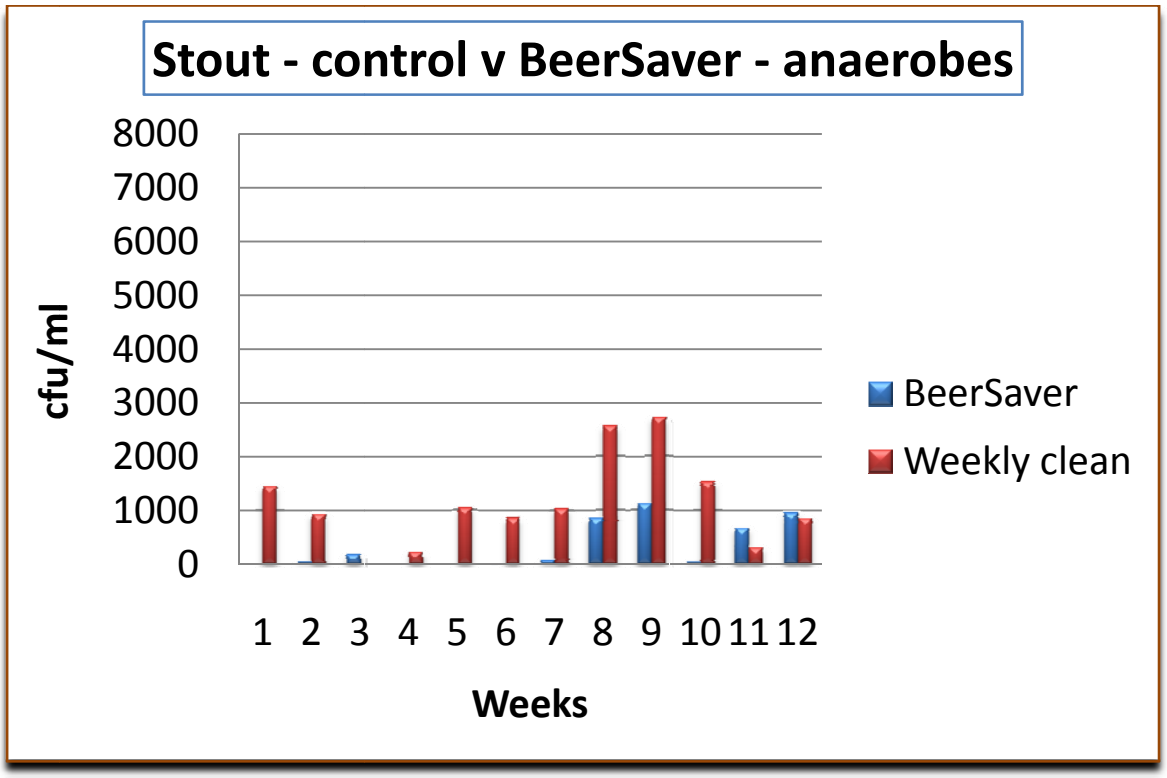
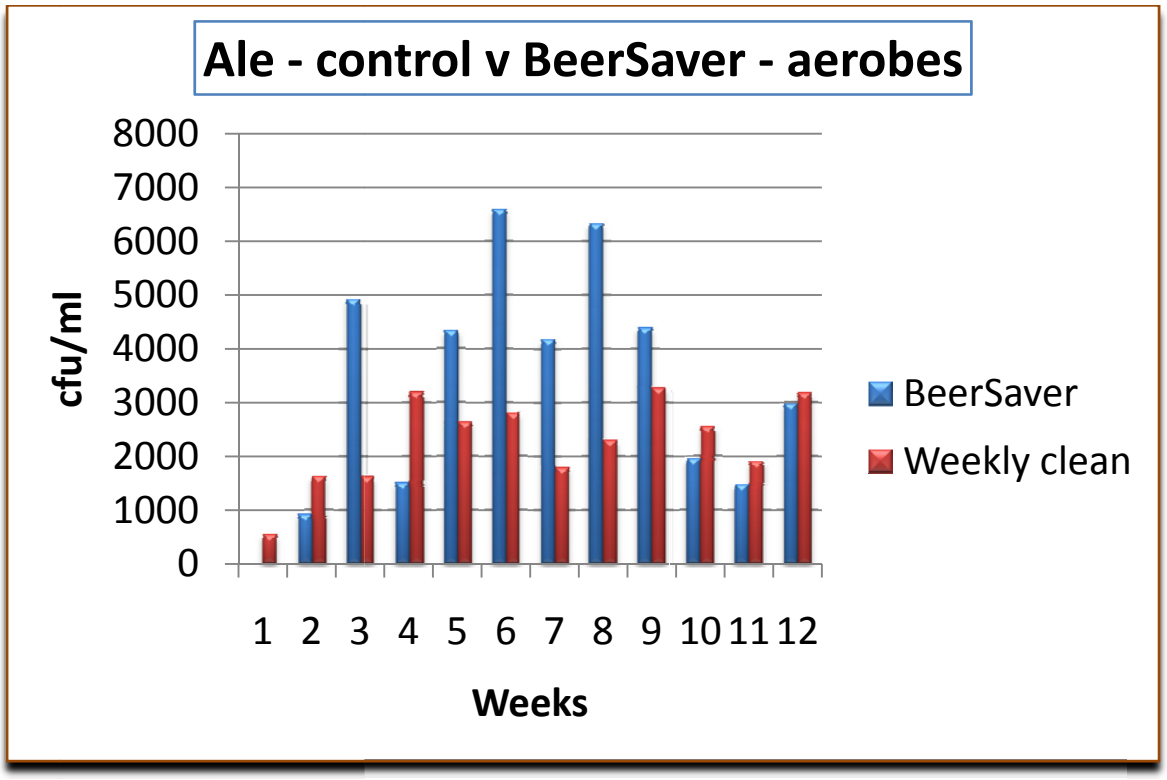


Figure 5 – Ale aerobes and anaerobes ± BeerSaver



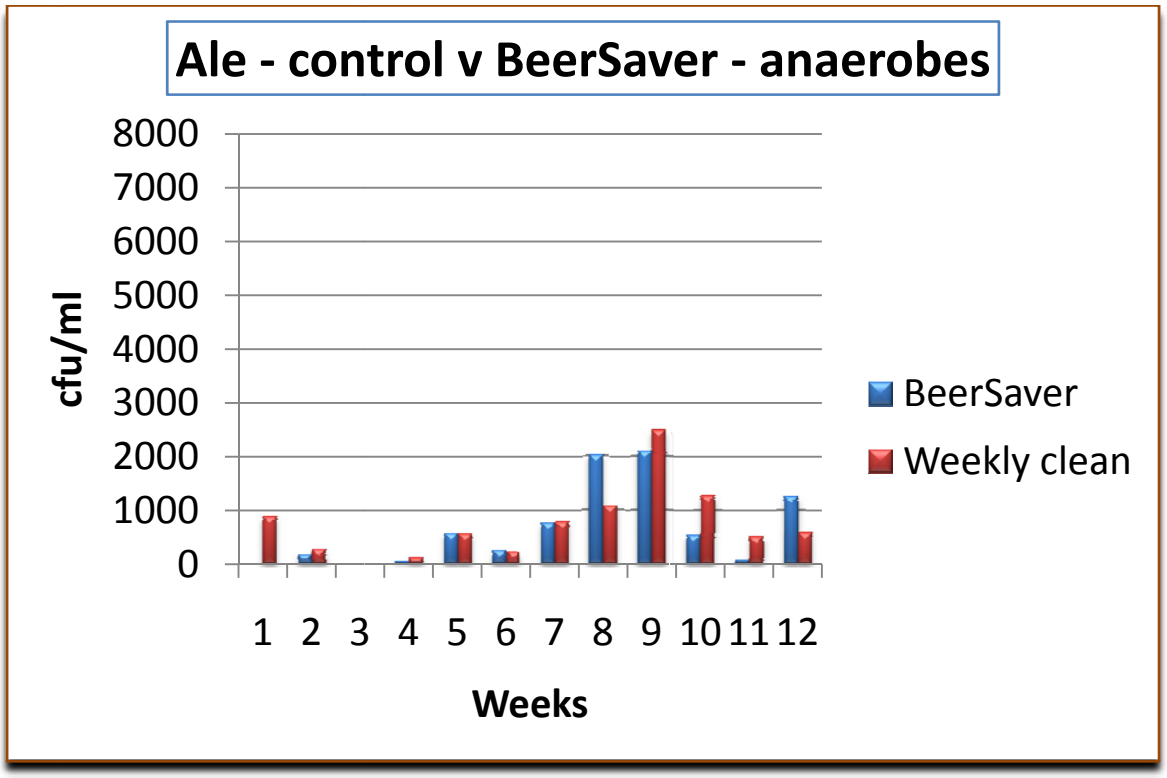
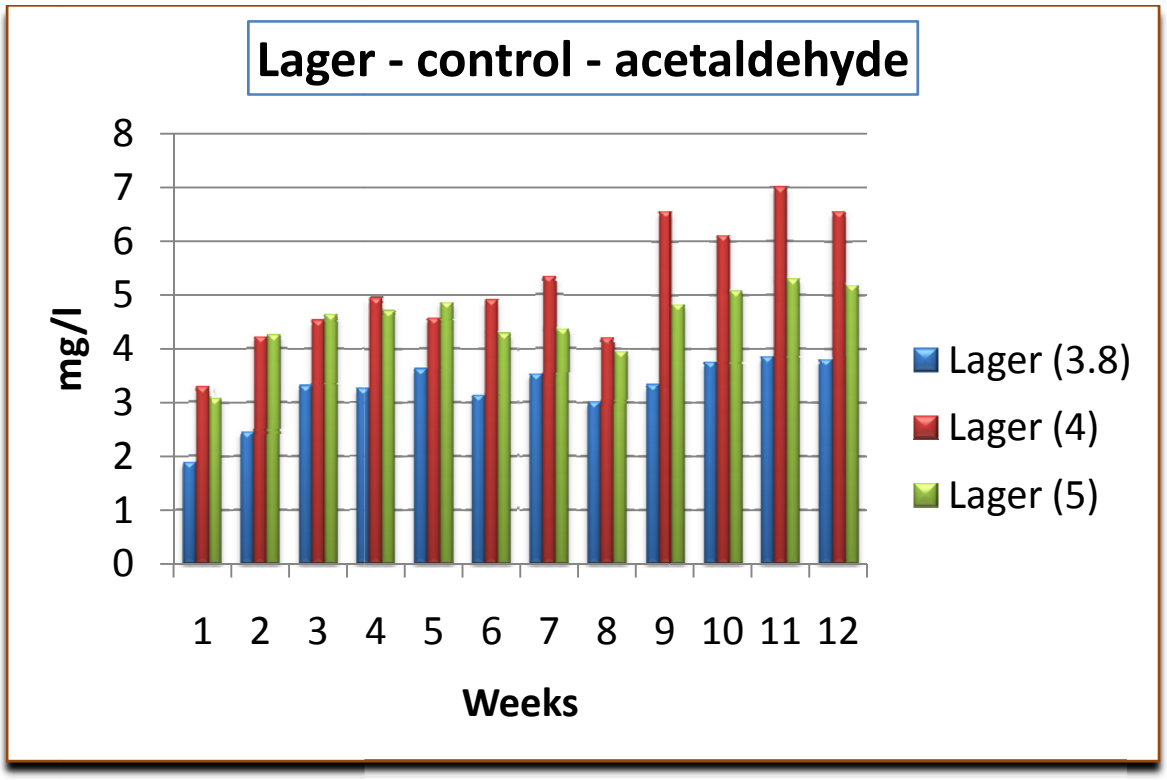


Figure 6 – Acetaldehyde in lager ± BeerSaver



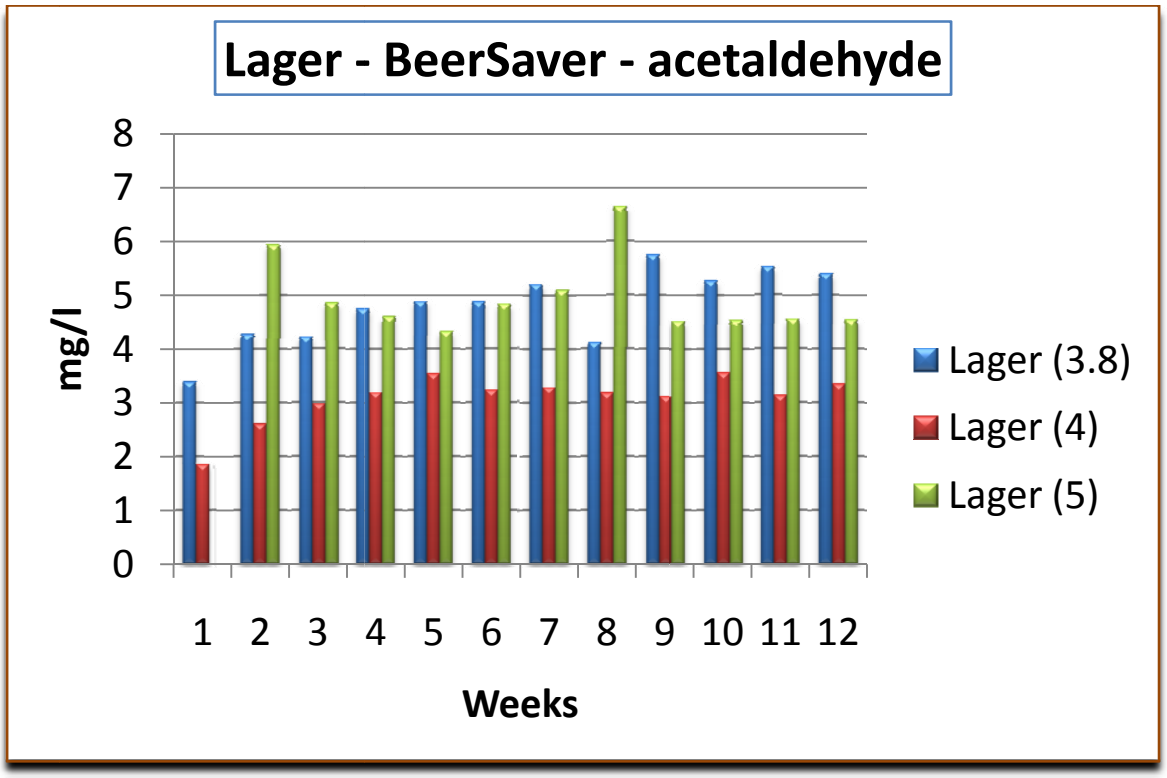
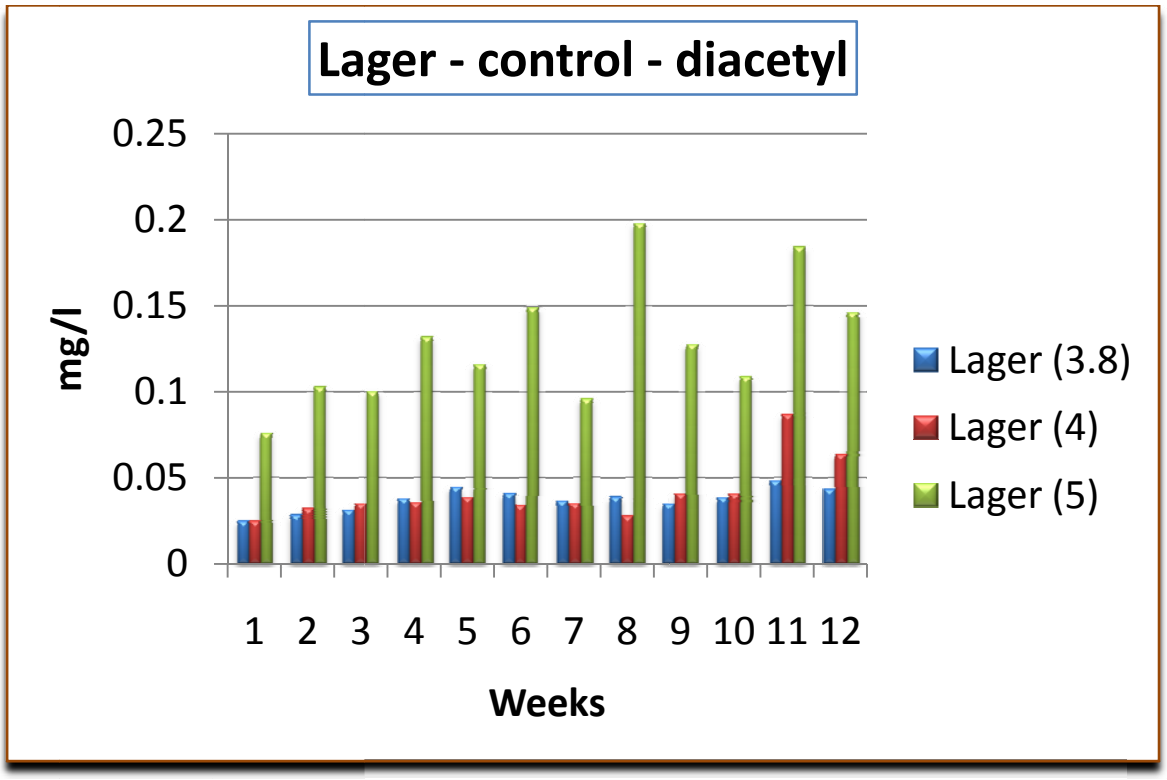


Figure 7 – Diacetyl in lager ± BeerSaver



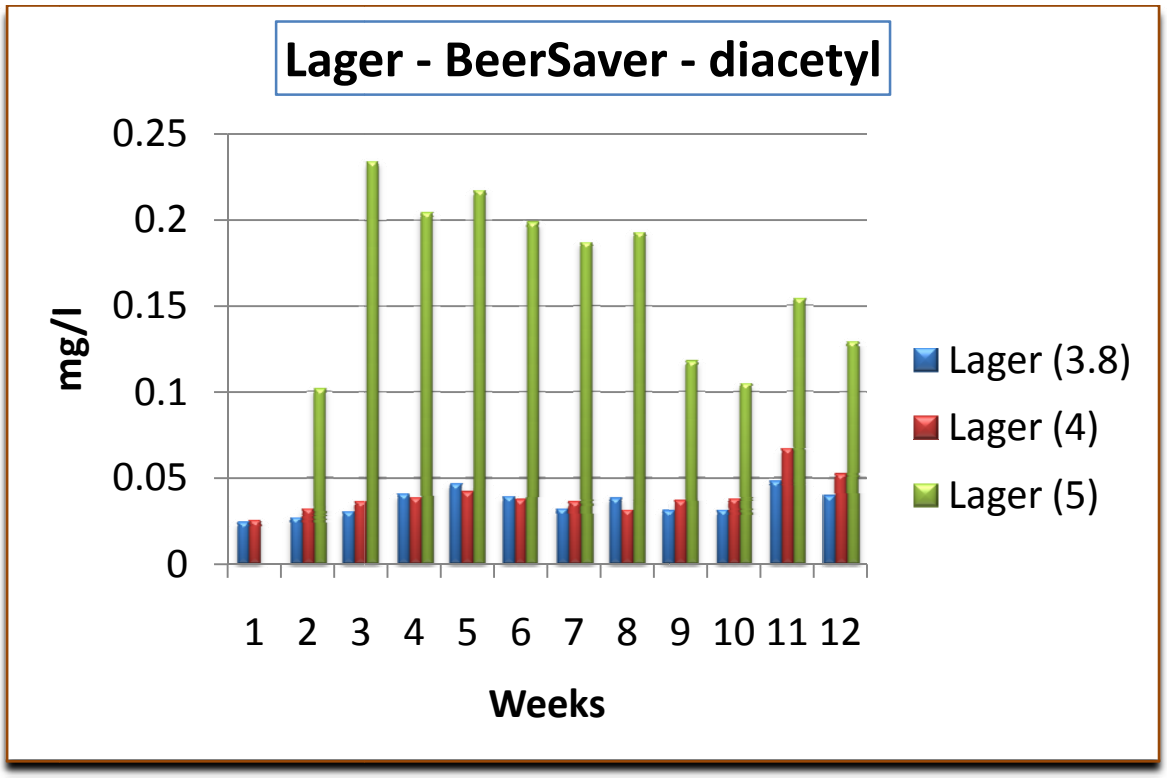
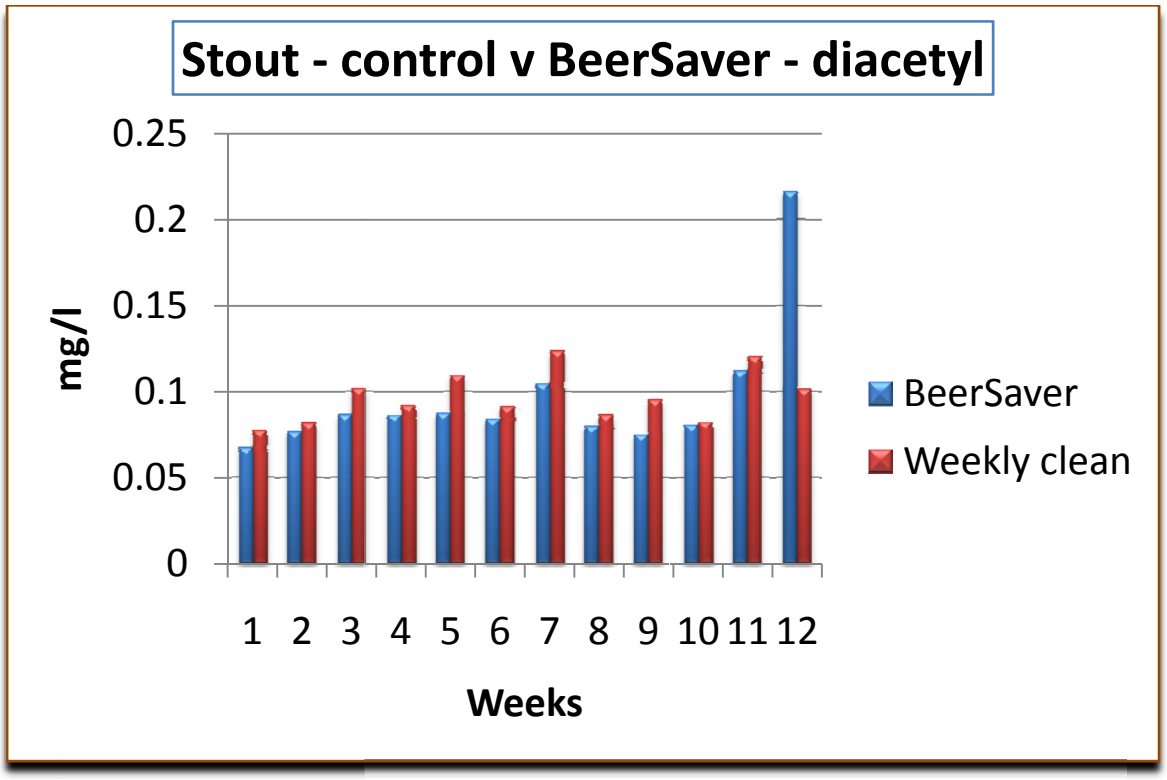


Figure 8 – Diacetyl in Stout & ales ± BeerSaver



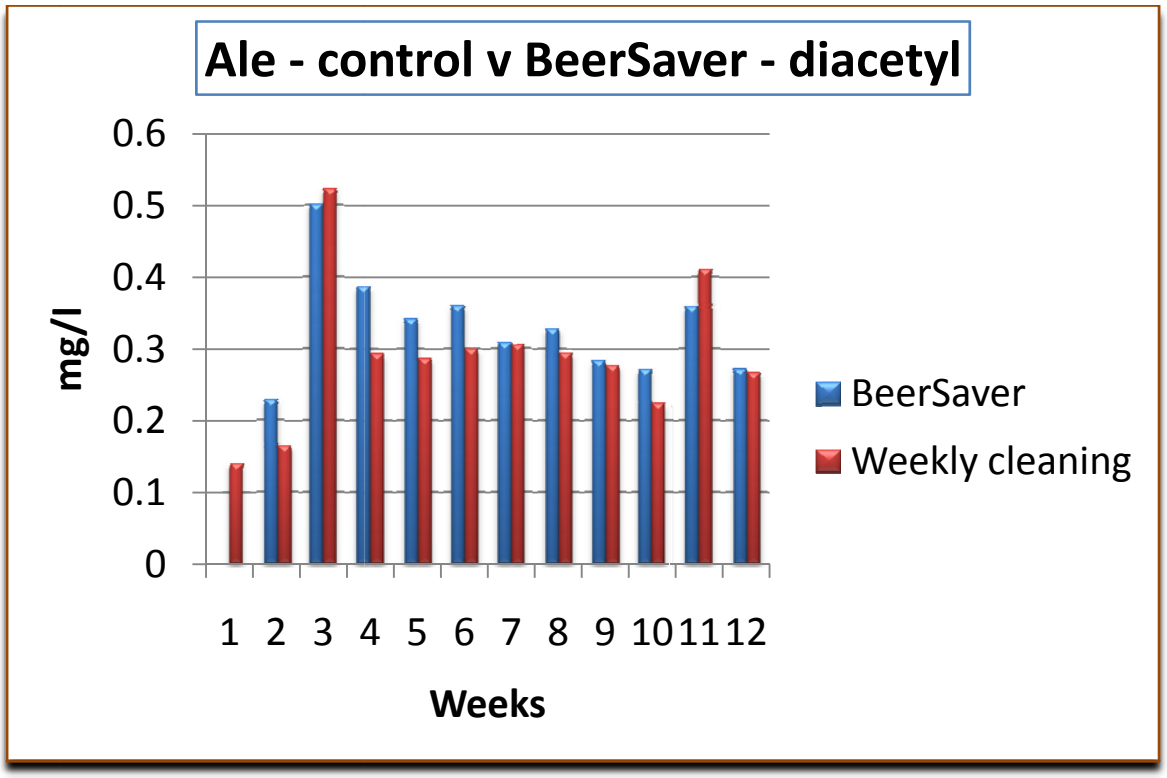


Figure 9 – Relationship between anaerobes and diacetyl content of lager

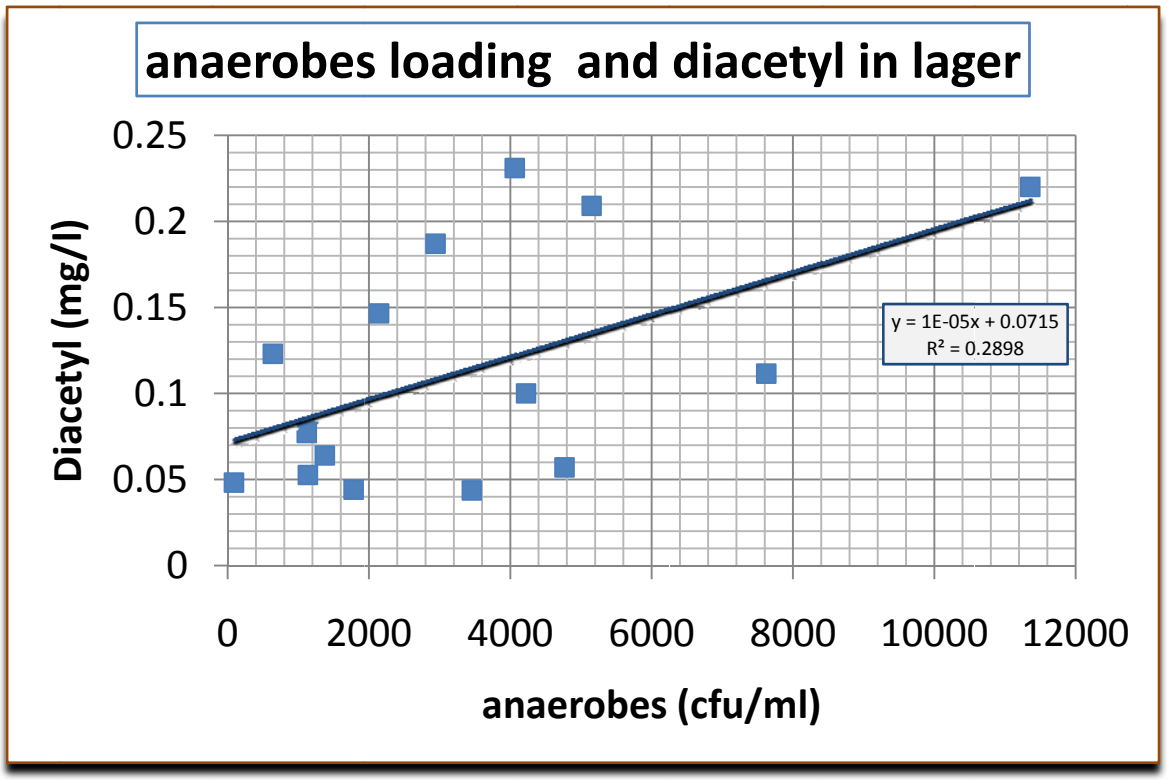


Figure 10 – BeerSaver v time – lager aerobes and anaerobes

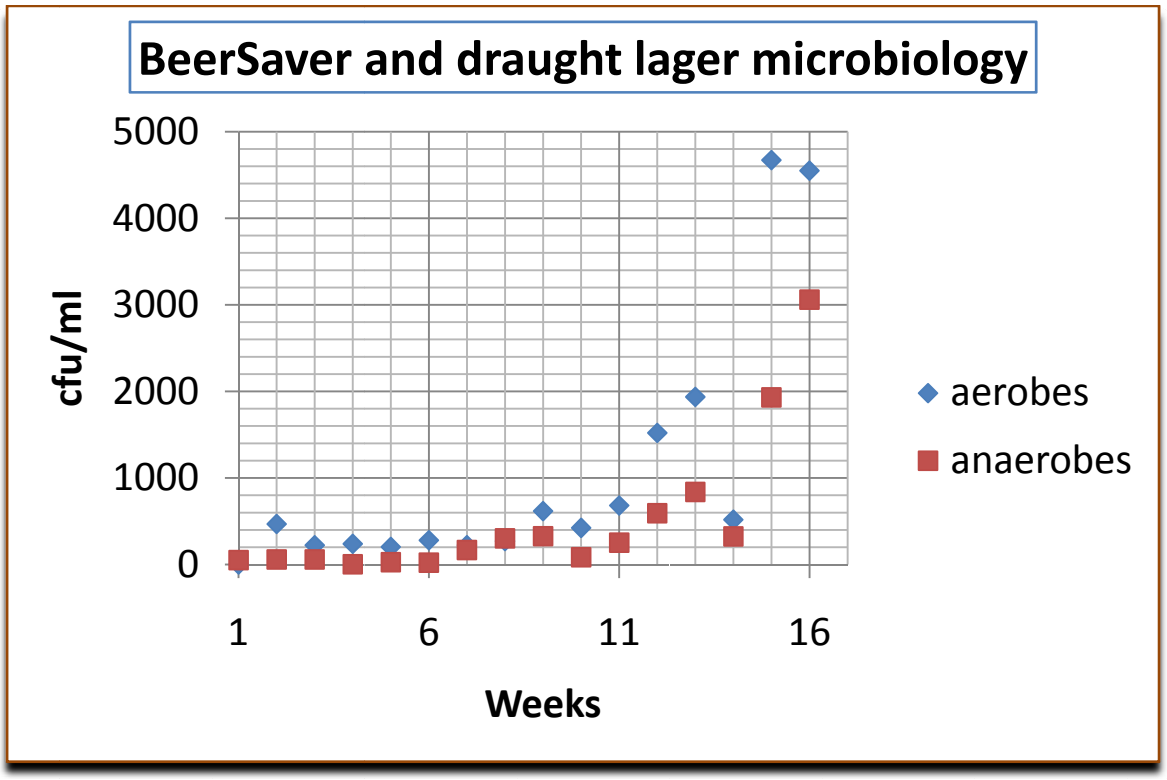


Figure 11 – Lager (3.8% ABV) clarity after 'forcing' – trial (l), control (r)

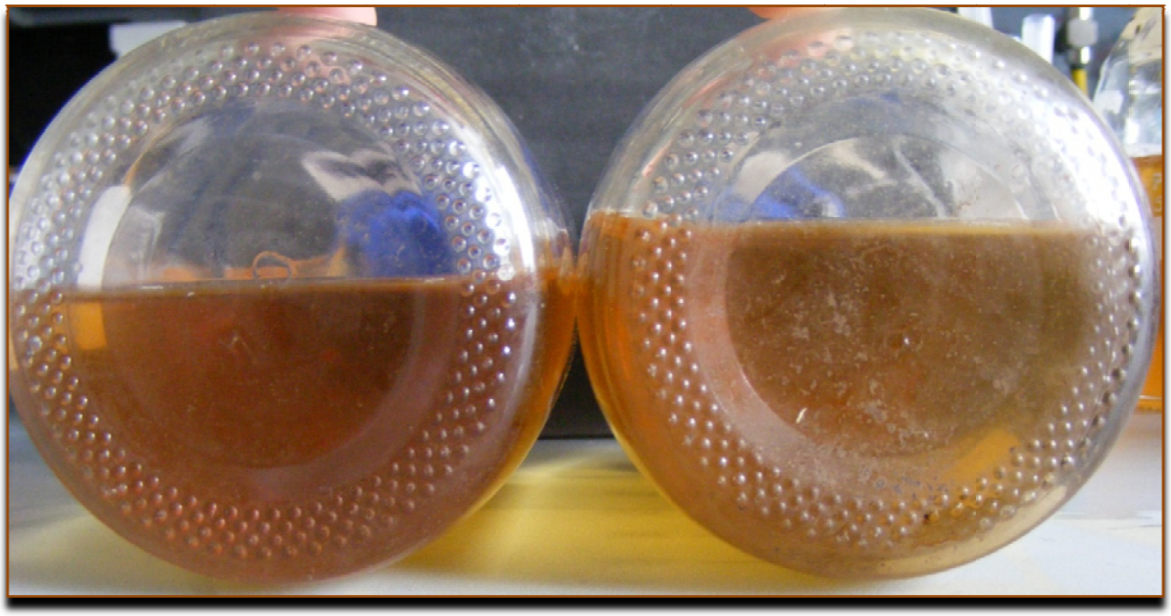


Figure 12 – Stout clarity after 'forcing' – trial (l), control (r)

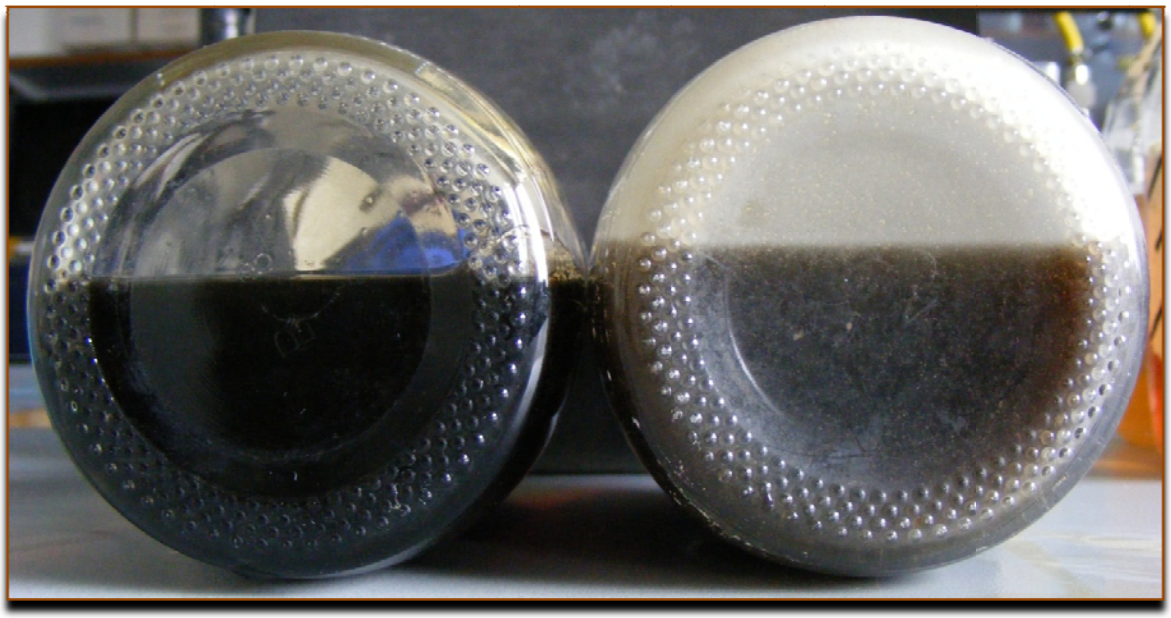
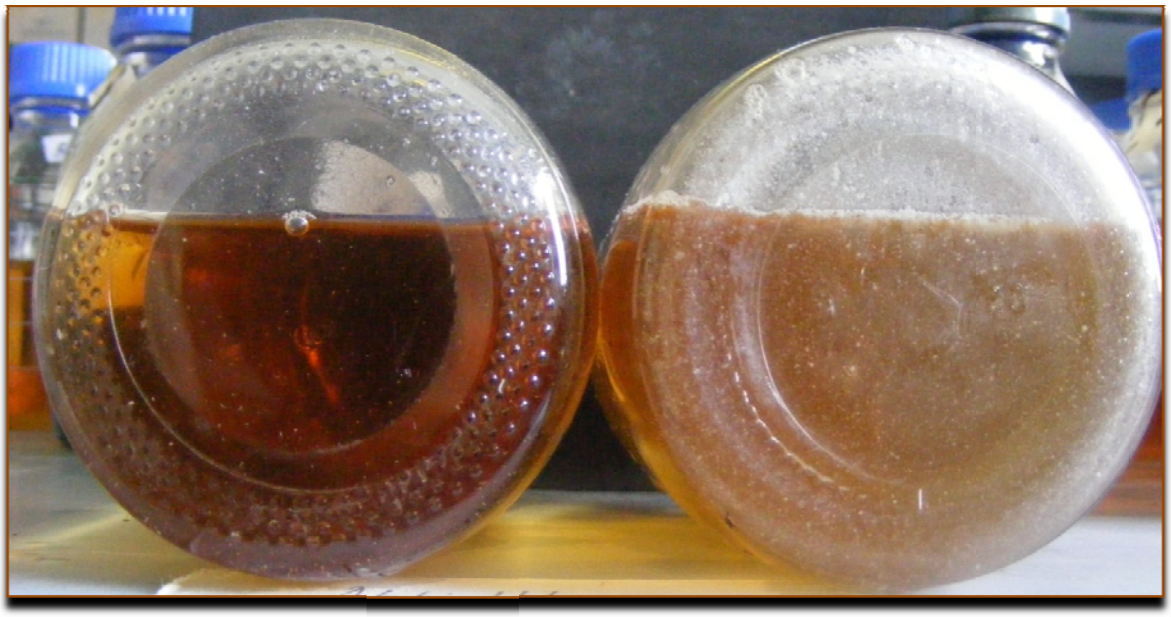


Figure 13 – Premium lager clarity after 'forcing' – trial (l), control (r)



Technology

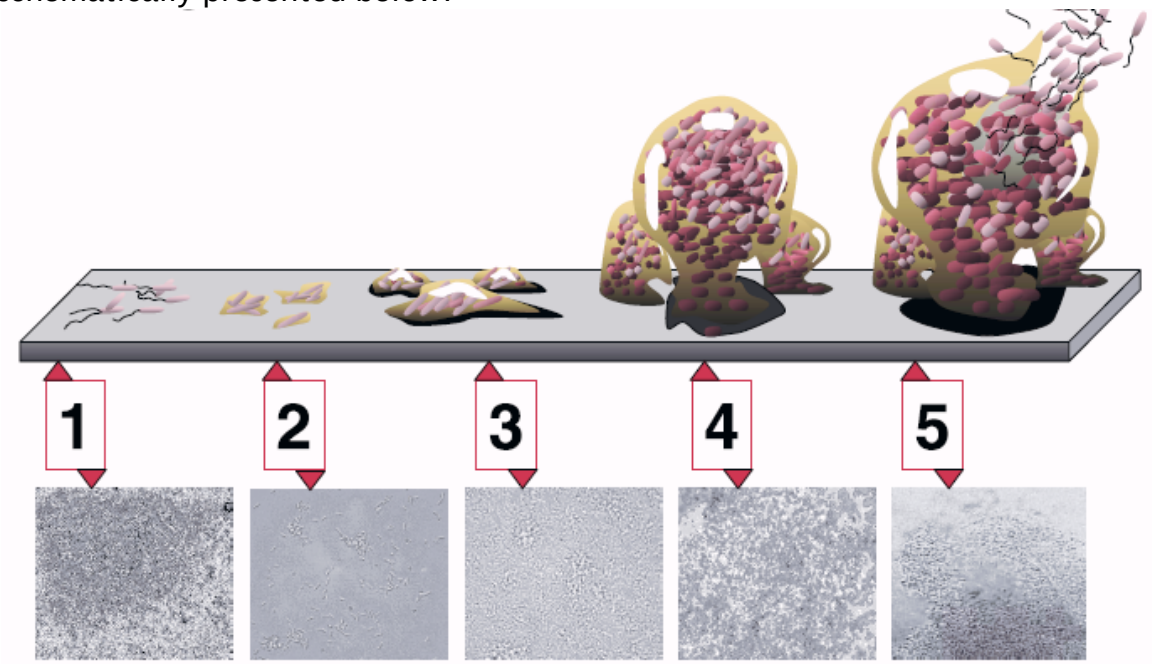
The technology is based upon a magnetic field pattern which is generated by a patented pulsed waveform between the audio and RF frequencies. This is applied through a patented extruded line with the coil built into the wall. The signal is digitally derived. Typically the BeerSaver line is located between the keg/cask and the fob detector/flojet/cellarbuoy.

A patent has been granted in the UK – 'method and apparatus for treatment of multiple beer conveying conduits' (GB 2367106, filed 16.03.2001) together with a further application 'a fluid conveying conduit' (GB 2442011, filed 20.09.2006).

BeerSaver – a possible mechanism

It is now generally accepted that microorganisms in the 'real world' exist as highly organised communities of bacteria and yeast that are attached to surfaces. These 'sessile' organisms have been shown to express sophisticated communication systems, and are significantly more resistant to antibiotics and cleaning agents through a combination of genetics and physiology together with the barrier effect of the slime encased biofilm. 'Planktonic' free roving microorganisms are released from biofilms as a consequence of 'dispersal' or liquid shear and represent the 'advanced party' of biofilm colonisation. Alarmingly the planktonic cells represent 0.01% of biofilm population with 99.99% being found in the attached biofilm.

The attachment, maturation and dispersal of an idealised biofilm is schematically presented below.



Biofilm development – (1) initial attachment, (2) irreversible attachment, (3) maturation I, (4) maturation II and (5) dispersion. Photomicrographs show developing *Pseudomonas aeruginosa* biofilm. From D. Monroe (2007), '*Looking for chinks in the armour of bacterial biofilms'*, PLoS Biology, 5, (11), 2458-2461.

As noted above the BeerSaver technology delivers a magnetic field pattern which is generated by a patented pulsed waveform between the audio and RF frequencies. This report confirms practical experience that this technology acts on microorganisms (presumably in a biofilm) in the lumen of a beer dispense line.

'Electric fields (10MHz)' and a 'radio frequency alternating electric current (10MHz)' have been used in studies on biofilms. A number of reports have noted a 'bioelectric effect' where weak electric currents increase the efficacy of antibiotics to bacterial biofilms. A recent report describes the effect of prolonged exposure (up to seven days) of low intensity electrical direct currents on *P. aeruginosa, Staphyloccocus aureus* and *Staph epidermis* biofilms with the conclusion that 'low intensity electrical current substantially reduced numbers of viable bacteria in … biofilms'. This observation clearly connects with the work reported here.

*'The electricidal effect: Reduction of *Staphylococcus* and *Pseudomonas* biofilms by prolonged exposure to low-intensity electrical current' by del Pozo *et al*., *Antimicrobial Agents and Chemotherapy* (2009), 53, 41-45.

Biography of the author

Dr David Quain has been a part-time Professor of Brewing at the ICBD since 2007. He is also a Director and founder of red-ts Ltd, a drinks industry consultancy (see www.red-ts.com).

He is a graduate of Heriot-Watt University (B.Sc in Brewing and Biochemistry) and has a doctorate in yeast biochemistry from the University of Liverpool. He previously worked at Coors Brewers (24 years) (where he was latterly Head of Technology and Dispense Development) and BRi (five years). He has 61 publications, 15 patent applications and co-authored the book *Brewing Yeast and Fermentation*. Whilst at Coors he headed the technical dispense team that delivered Carling Extra Cold, Coors Sub-Zero (previously Arc) and the Cold Beer Station and was previously Company Microbiologist.