



Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

Effect of Chlorine Dioxide Treatments on Pecan Safety and Quality

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Pecans

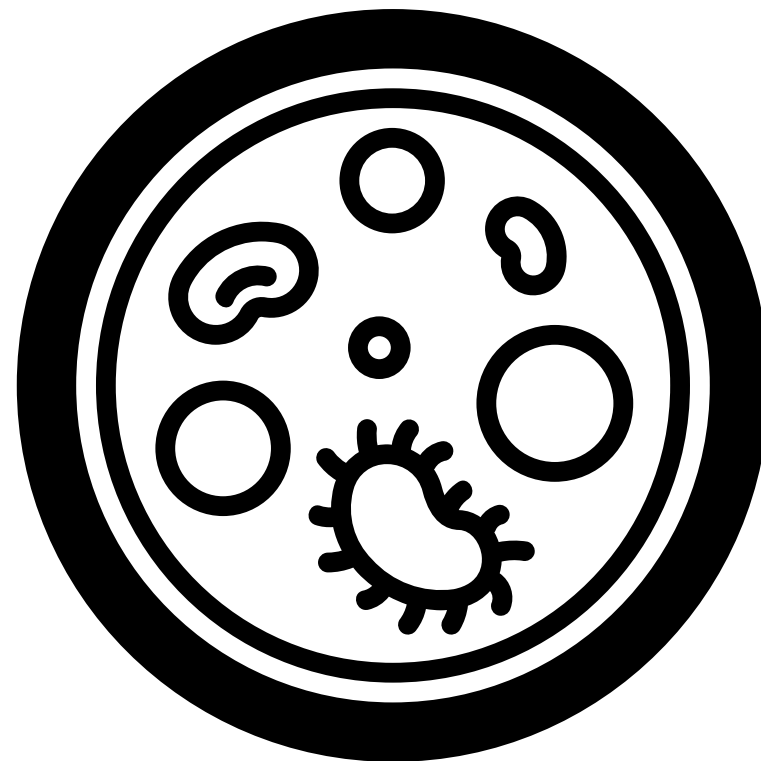
- 271 million pounds of pecans were produced in the USA as of 2023 (USDA NASS, 2024)
- Increasingly common to be consumed raw
- Despite being a low moisture food, temperature swings after packaging can cause microbial blooms and increase biological load
- High amounts of Volatile Fatty Acids increases risk of early oxidation (rancidity) due to processing





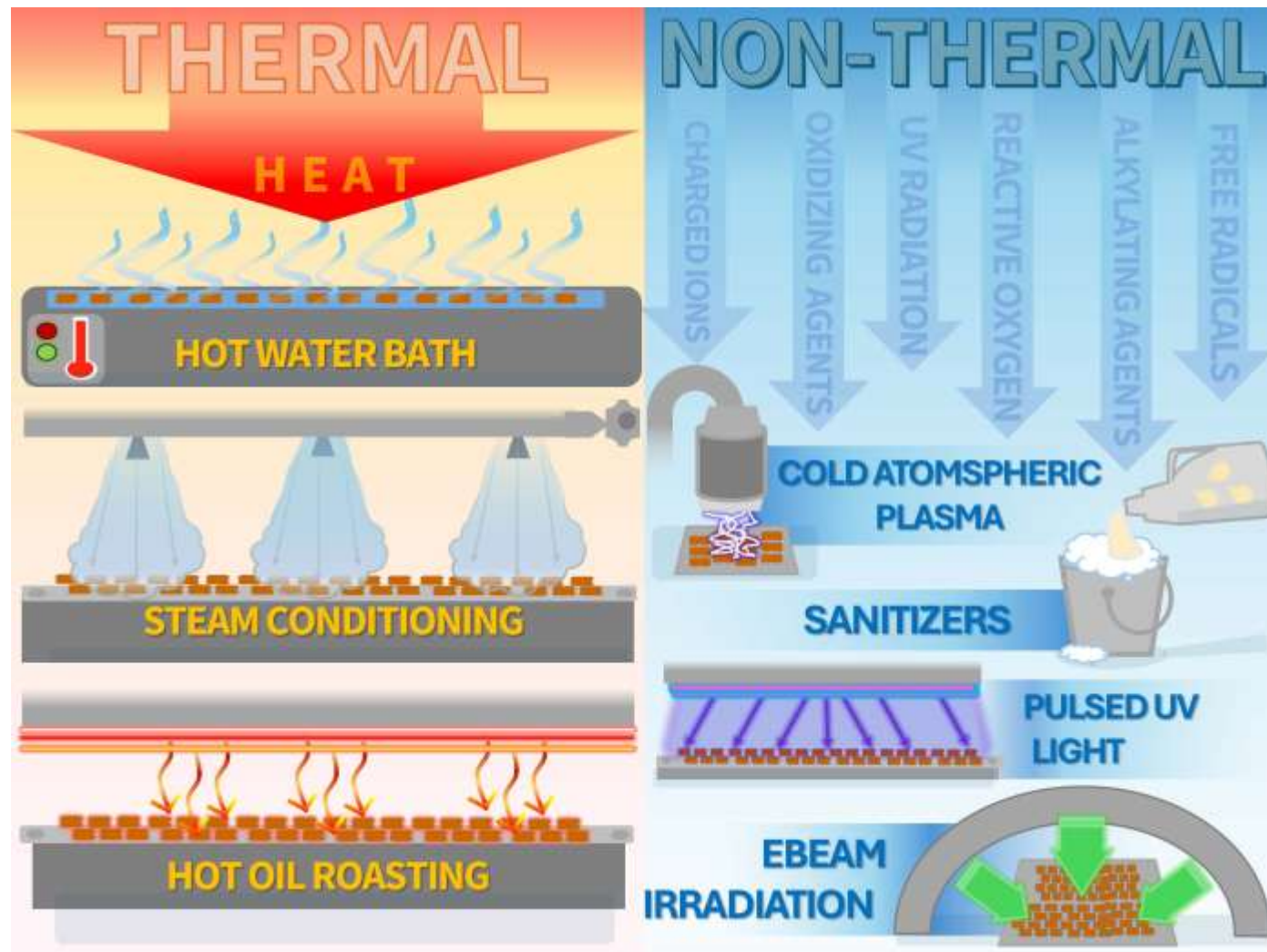
Foodborne Illness in Low Moisture Foods

- Low-moisture foods such as tree-nuts with water activity lower than 0.7 are presumed to be low-risk food (Blessington, Theofel, & Harris, 2013)
- *Salmonella* and pathogenic *E. coli* have been isolated from almonds, cashews, hazelnuts, pecans, pinenuts, pistachios, and walnuts (Zhang et al., 2017)
- Pathogens can potentially exist in a dormant state for long periods of time
- Consumers assume no risk, potentially exposing more vulnerable populations to pathogens



Nonthermal Sanitization

- Used instead of, or in addition to thermal sanitization
- Chemical and non-chemical treatments
- Potentially less impact on quality



ClO₂ powder

A solid form of chlorine dioxide precursors.

- Activated release system - solid chlorite impregnate powder is mixed with acid impregnate powder in equal parts to release chlorine dioxide at a controlled rate.
- Available in slow and quick release format, low level chlorine dioxide can be delivered over hours to months.
- Currently used for microbial control in produce to extend shelf life and reduce pathogen presence





Goals

- Determine viability of use of ClO_2 on pecan halves to reduce microbial load
 - Effective dosages
 - Residual activity
- Determine impact of short term ClO_2 exposure on quality markers
 - Oxidation markers
 - Color
 - Firmness
 - Oil yield



Microbial

Inoculum

- Salmonella cocktail applied to pecan halves via airbrush under biosafety hood
- Target level after drying ~ 7 log CFU/g
- For each repetition 35g inoculated halves 0.5 pint jars with screw top lids





Treatments

- Control, 0.1g, 0.25g, and 0.50g ClO₂ Part A & B
- Part A& B of fast reacting ClO₂ product combined in permeable packet and secured under lid of jar after activation
- Samples taken for 24h experiment at 0,2h,4h,8h, and 24h.
- Samples taken for 7 day experiment at 0, 1d, 2d, 3d, and 7d.
- ClO₂ levels monitored via Chlorine sensor fit to the lid of a 24h sample jar.





Quality

Treatments

- 0.1g, 0.25g, and 0.50g ClO₂ Part A & B, Control
- Part A & B of fast reacting ClO₂ product combined in permeable packet and secured under lid of jar after activation
- Samples taken for 24h experiment at 0, 2h, 4h, 8h, and 24h.

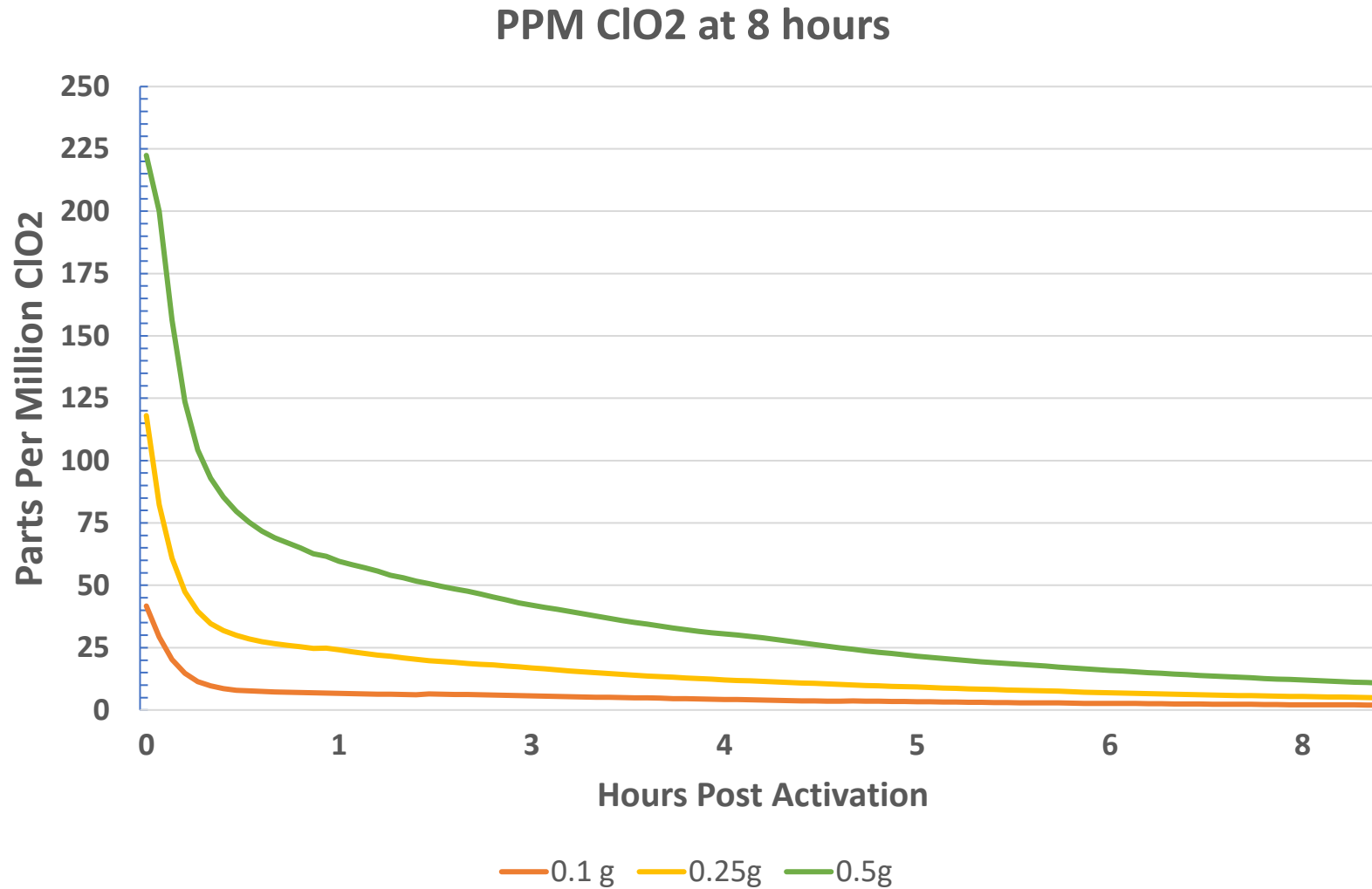
Data Collected

- Quality indicators recorded:
 - Peroxide Values (oxidation)
 - Free Fatty Acid content (oxidation)
 - Oil yield
 - Brix
 - Total Polyphenol content (mg GAE/g extract)
 - Firmness
 - Color
- ClO₂ levels monitored via Chlorine sensor fit to the lid of a 24h sample jar.





Chlorine Dioxide Concentrations

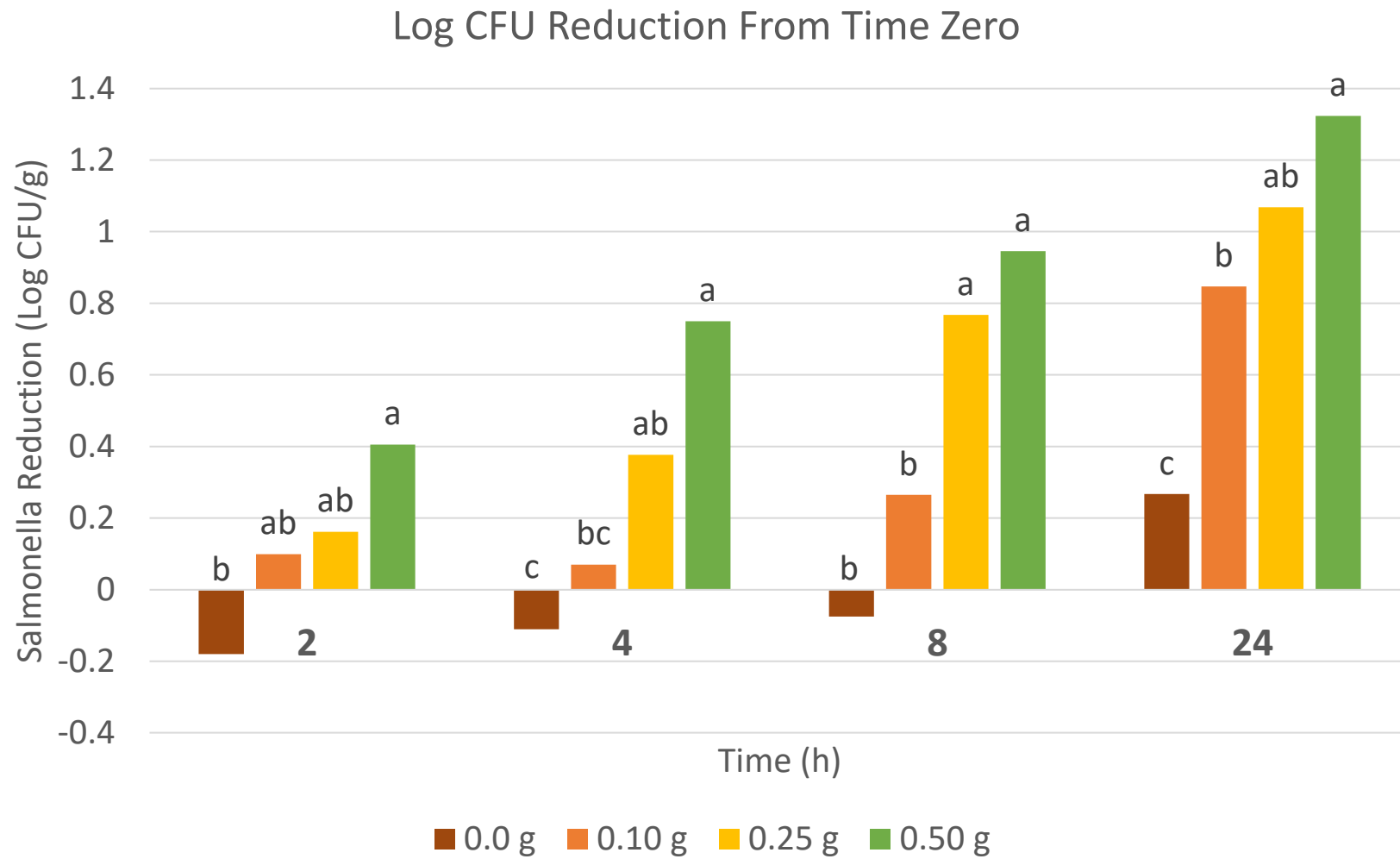


Pictured: PortaSens III Chlorine sensor and attached jar



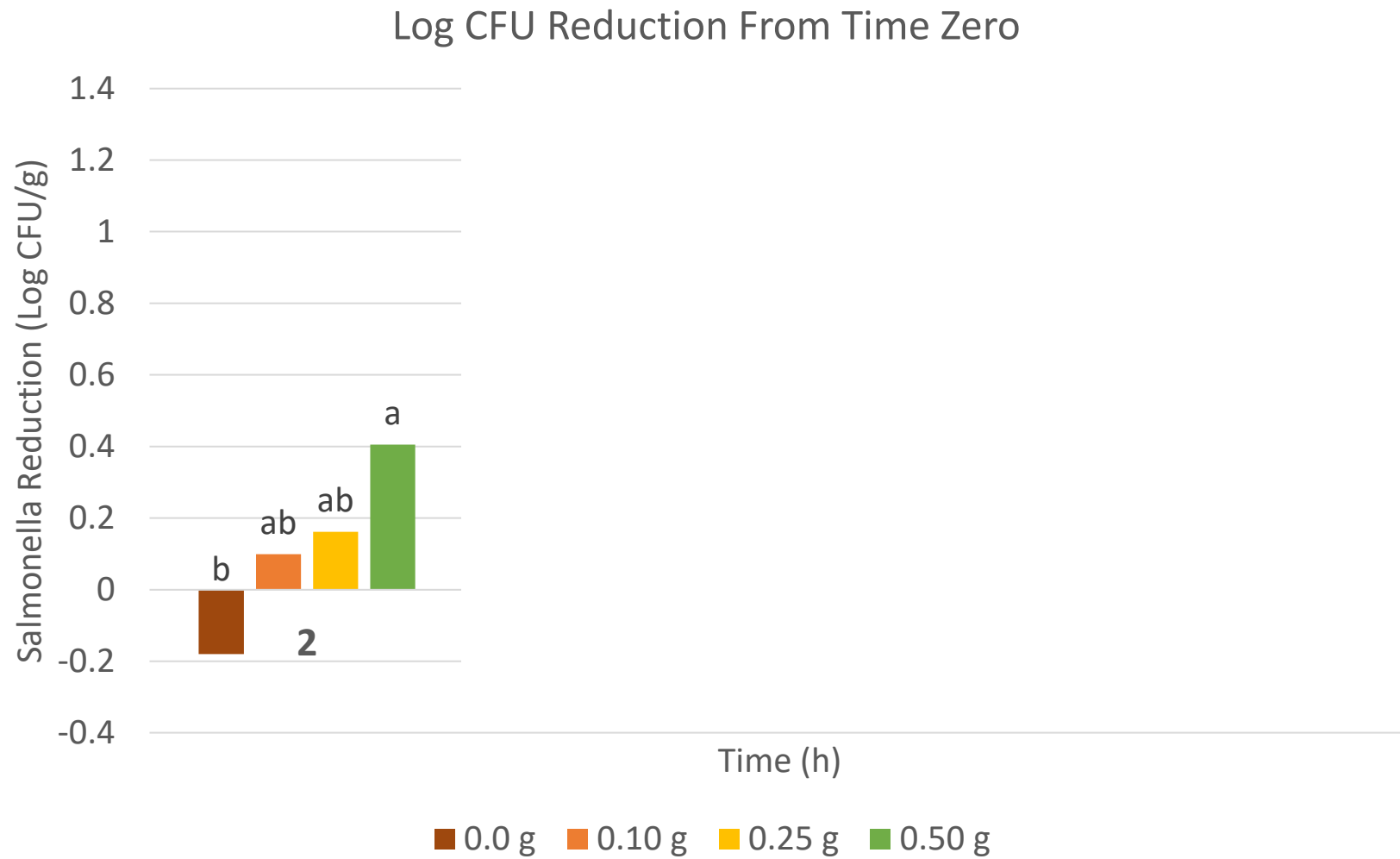
24 hour Treatment

- Log CFU/g reduction calculated from time zero samples.



24 hour Treatment

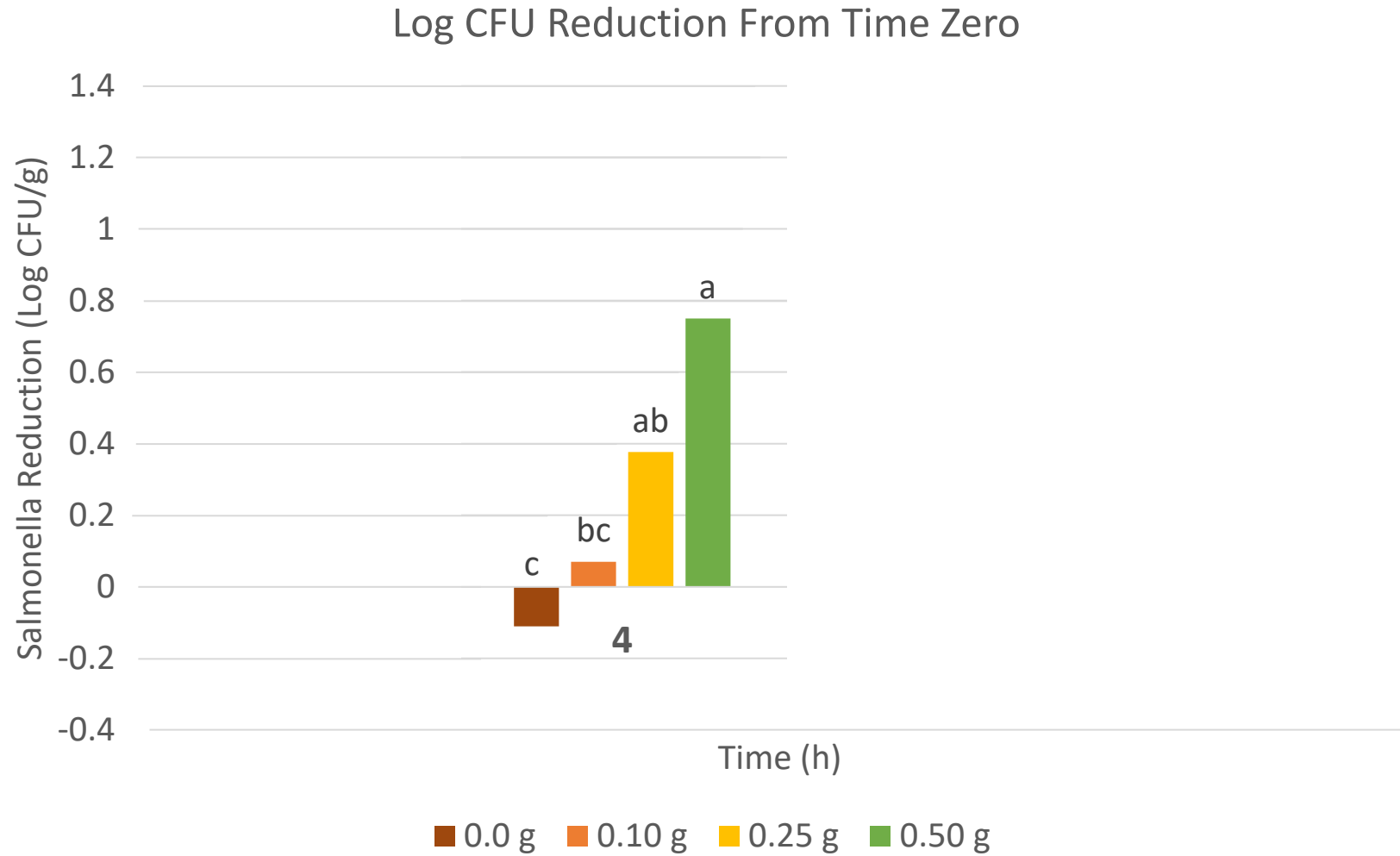
- At 2 hours:
 - 0.5g separate from control





24 hour Treatment

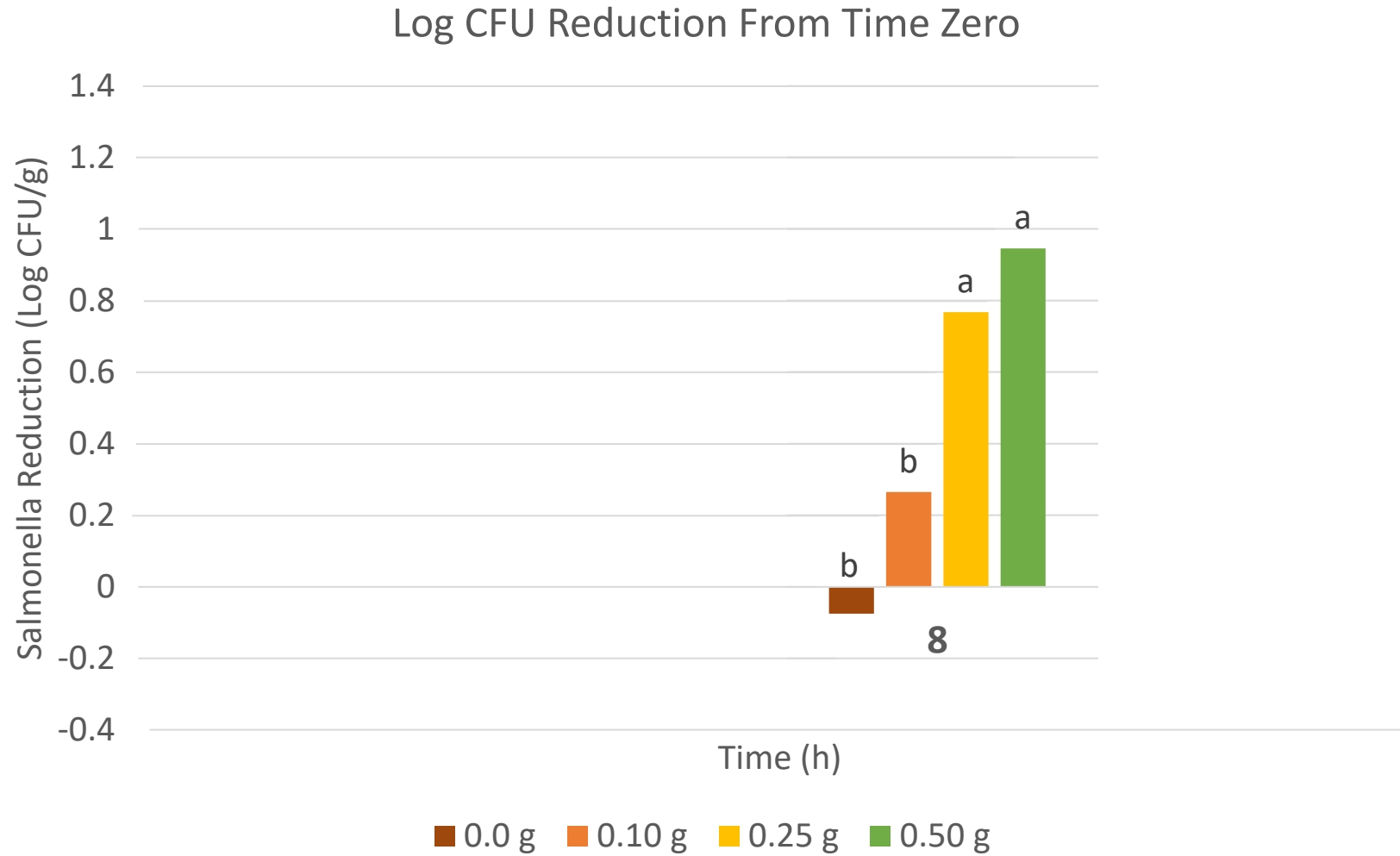
- At 4 hours:
 - 0.25g & 0.5g separate from control





24 hour Treatment

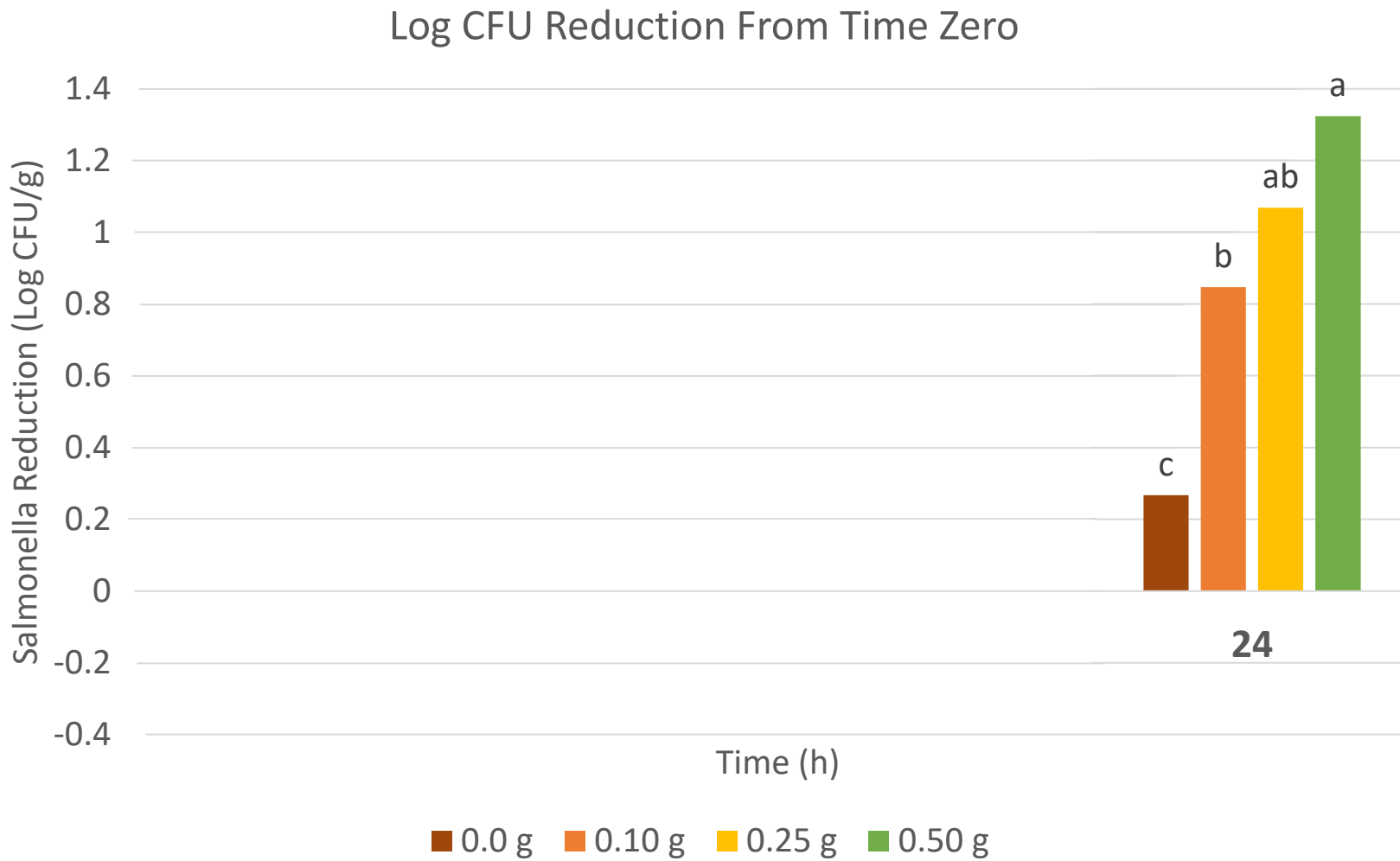
- At 8 hours:
 - 0.25g & 0.5g
separate from
control





24 hour Treatment

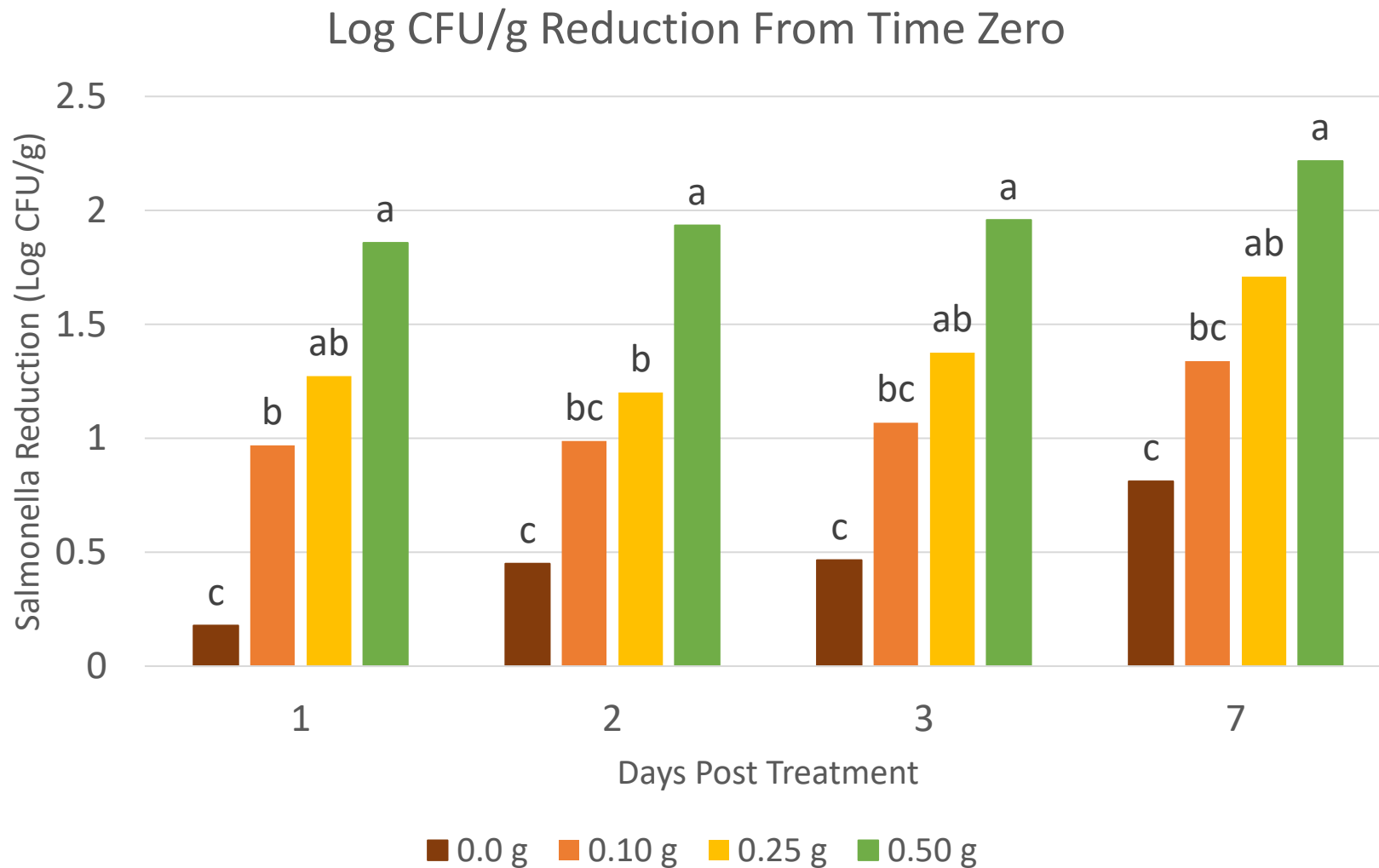
- At 24 hours:
 - All separate from control





7 Day Treatment

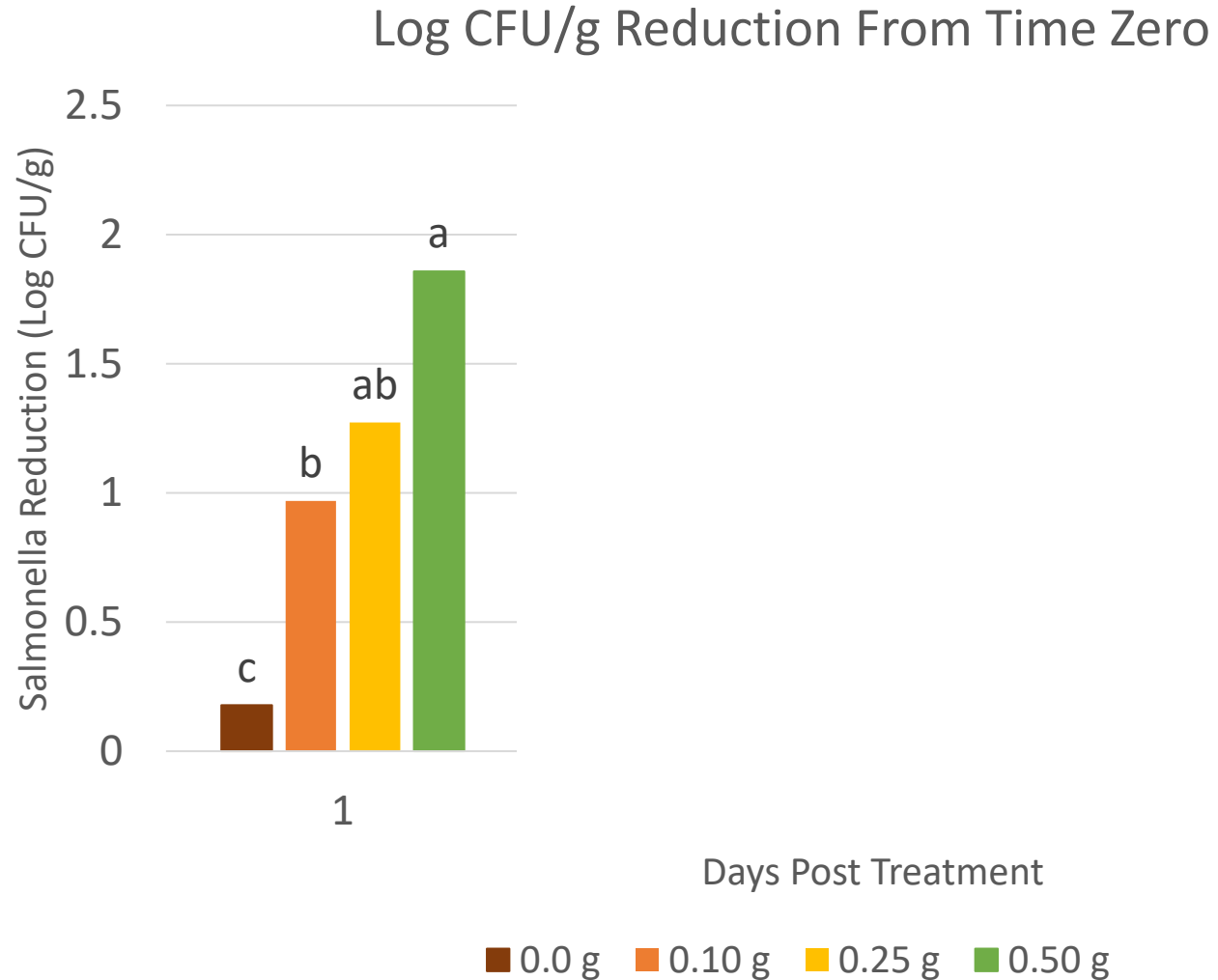
- Log CFU/g reduction calculated from time zero samples.





7 Day Treatment

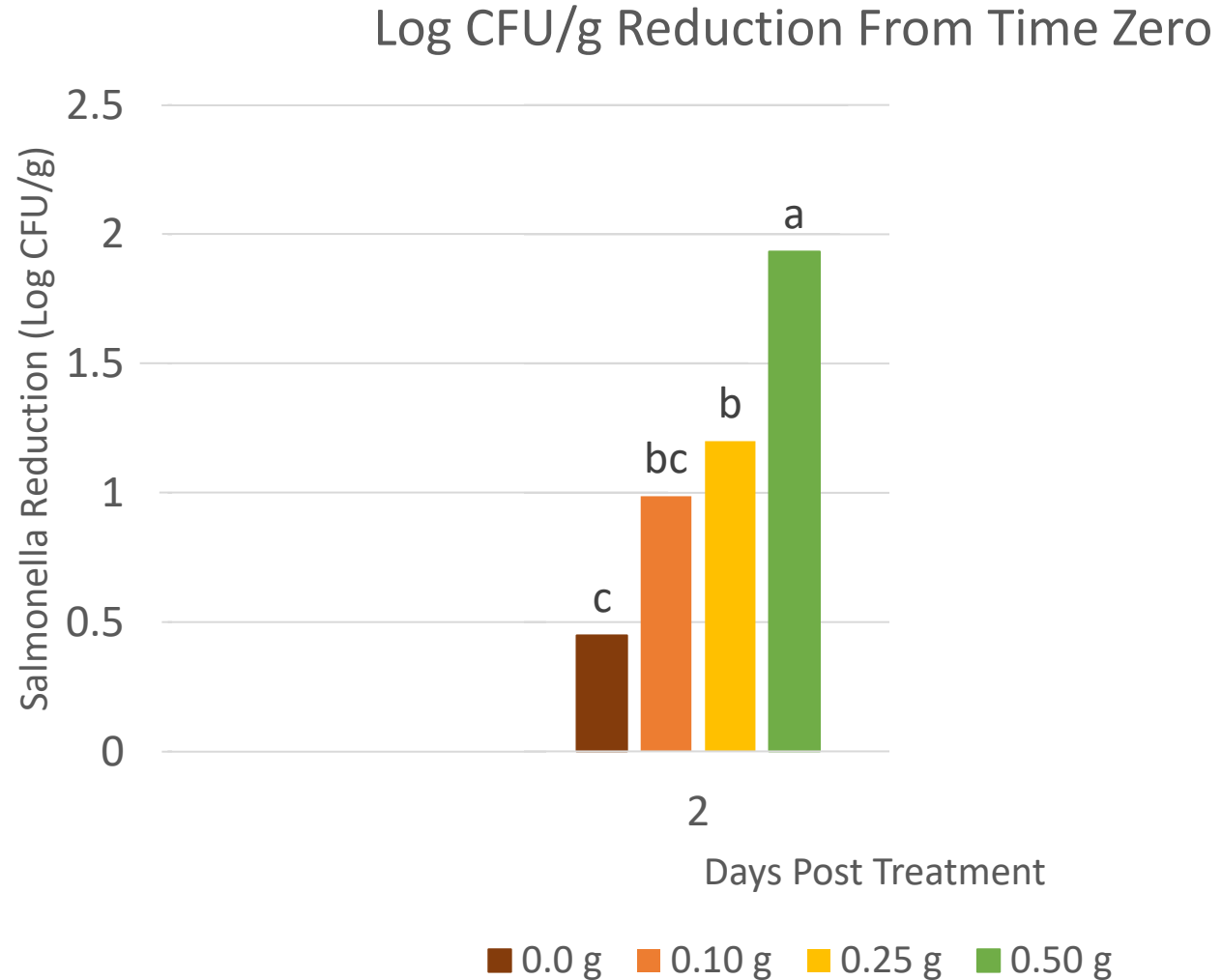
- 1 day:
 - All treatments separate from control





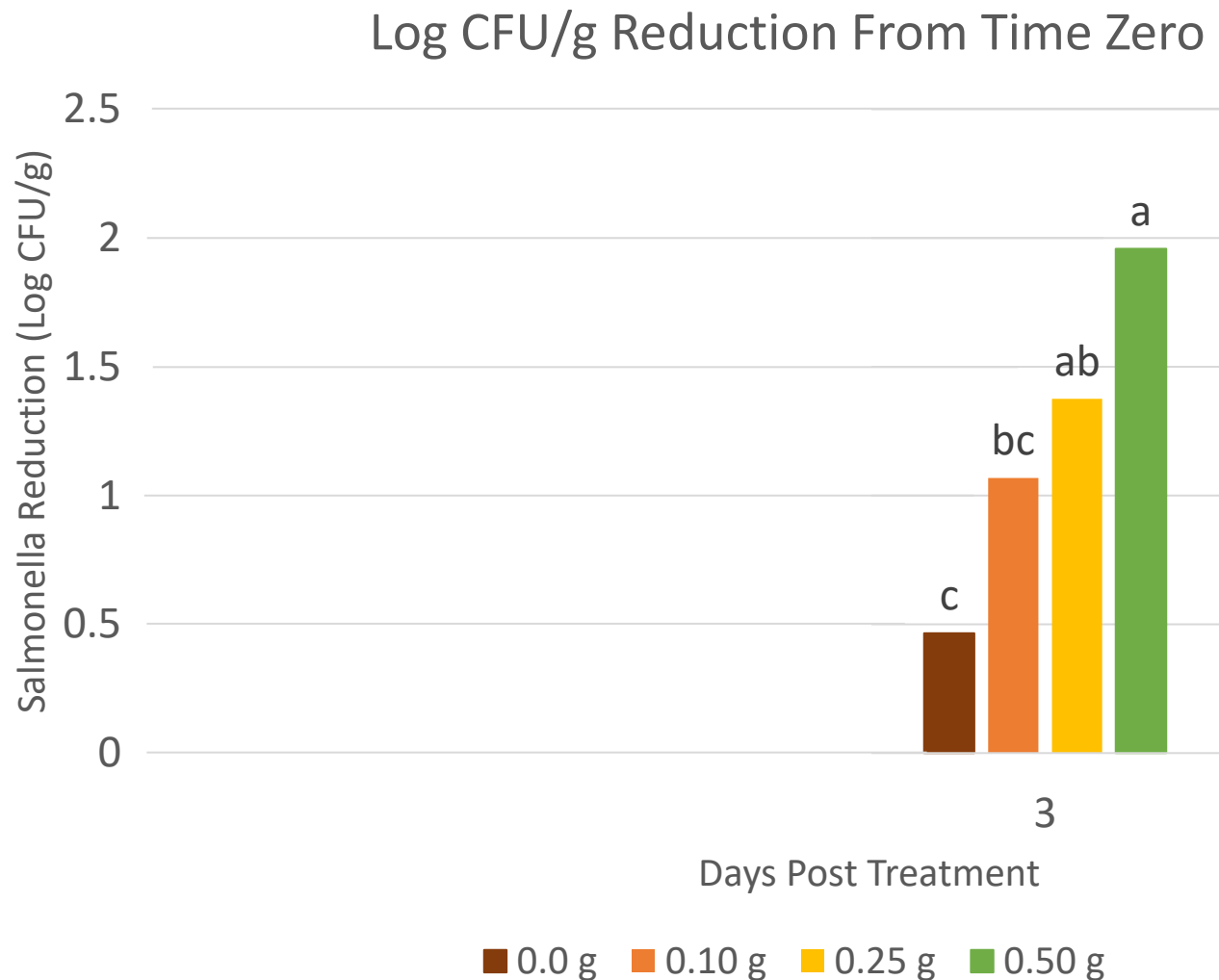
7 Day Treatment

- At 2 days:
 - 0.25g & 0.5g separate from control



7 Day Treatment

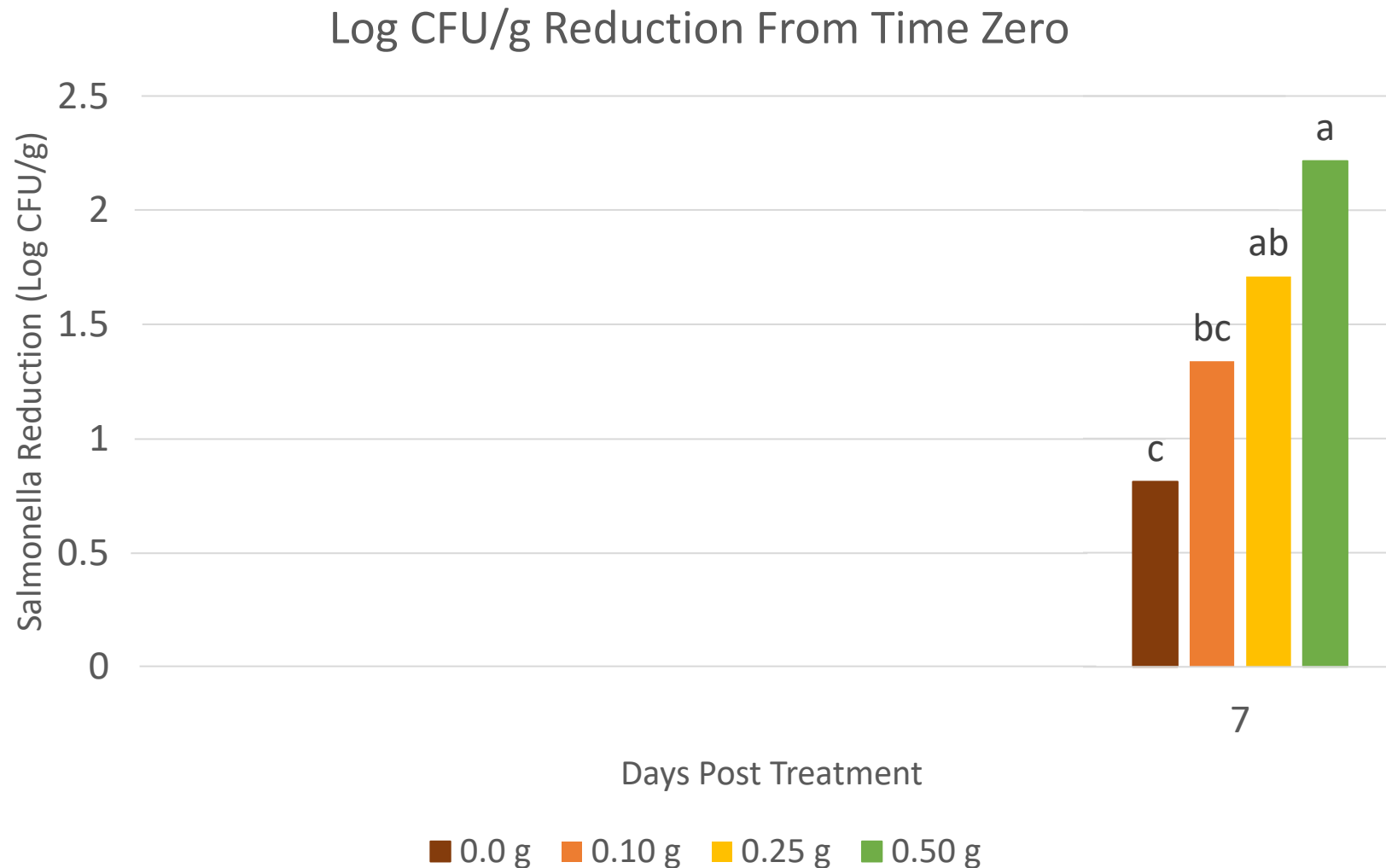
- At 3 days:
 - 0.25g & 0.5g separate from control





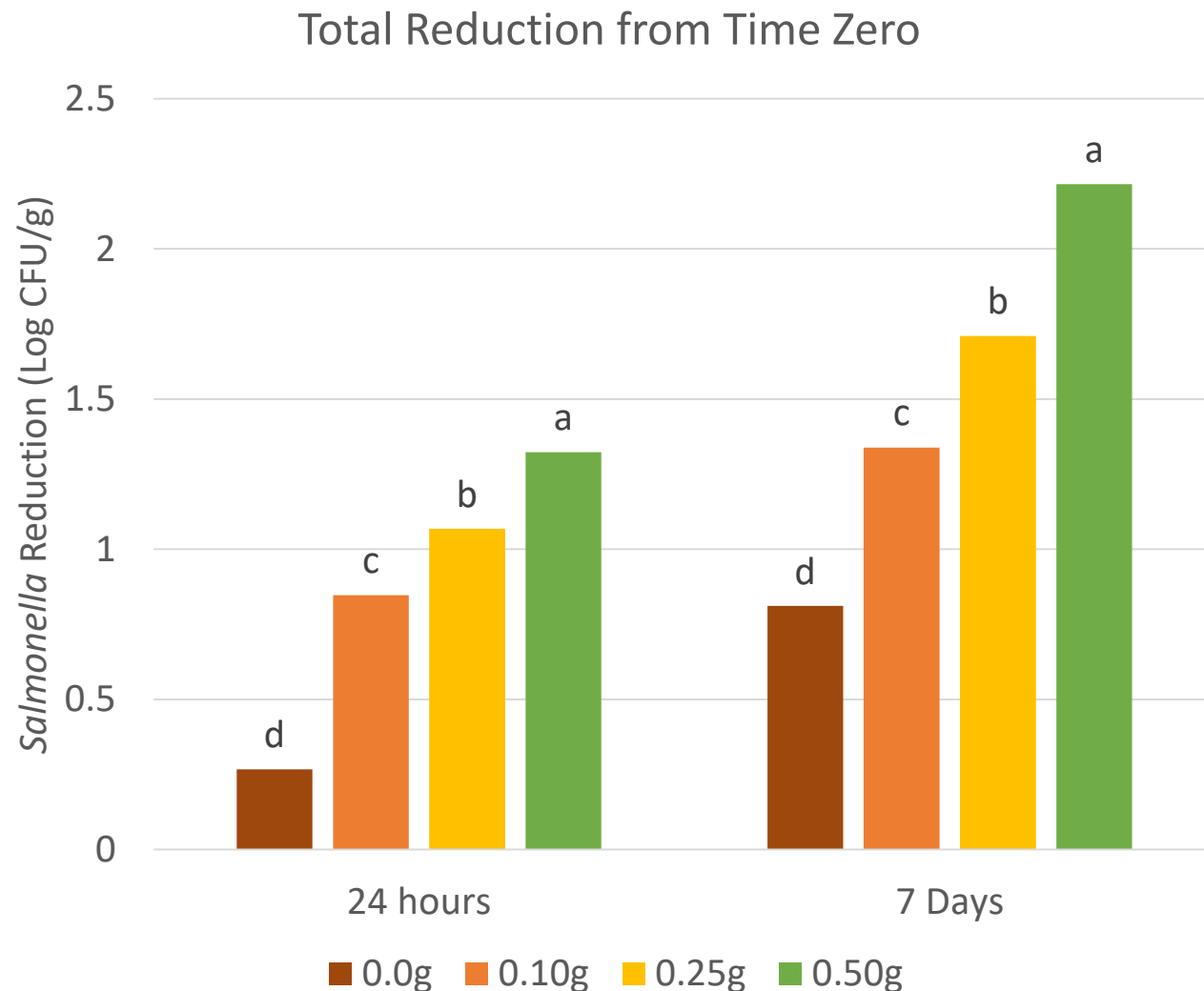
7 days Treatment

- At 7 days:
 - 0.25 & 0.50 different from control



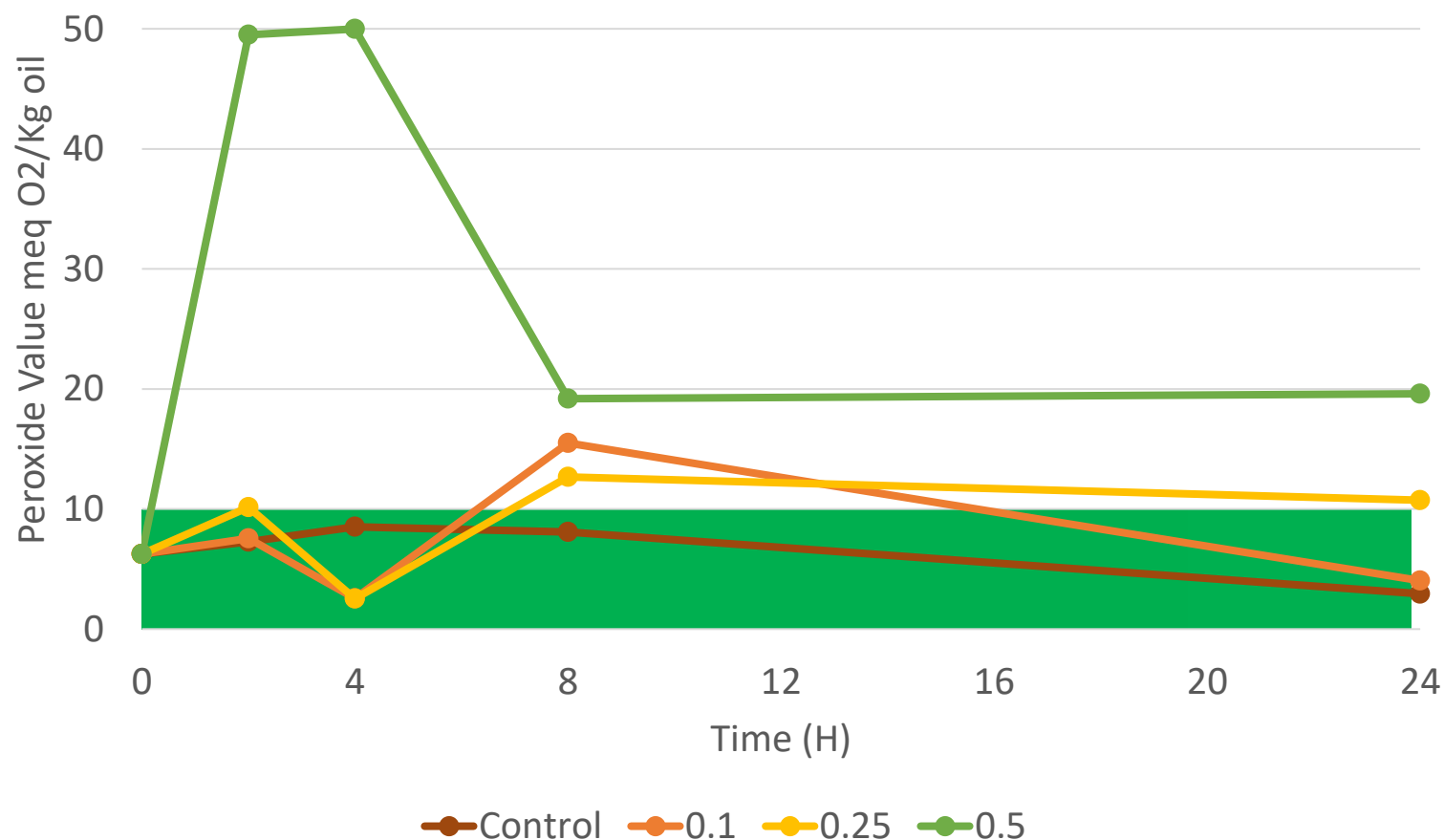
Microbial Results

- ClO₂ dosage and exposure time effected reduction
- All treatment levels were significantly different from control for both trials
- At 24 hours:
 - 0.5g average of 1.32
 - 0.25g average of 1.08
 - 0.1g average of 0.85
 - Control average of 0.27
- At 7 days
 - 0.5g average of 1.99
 - 0.25g average of 1.39
 - 0.1g average of 1.09
 - Control average of 0.48



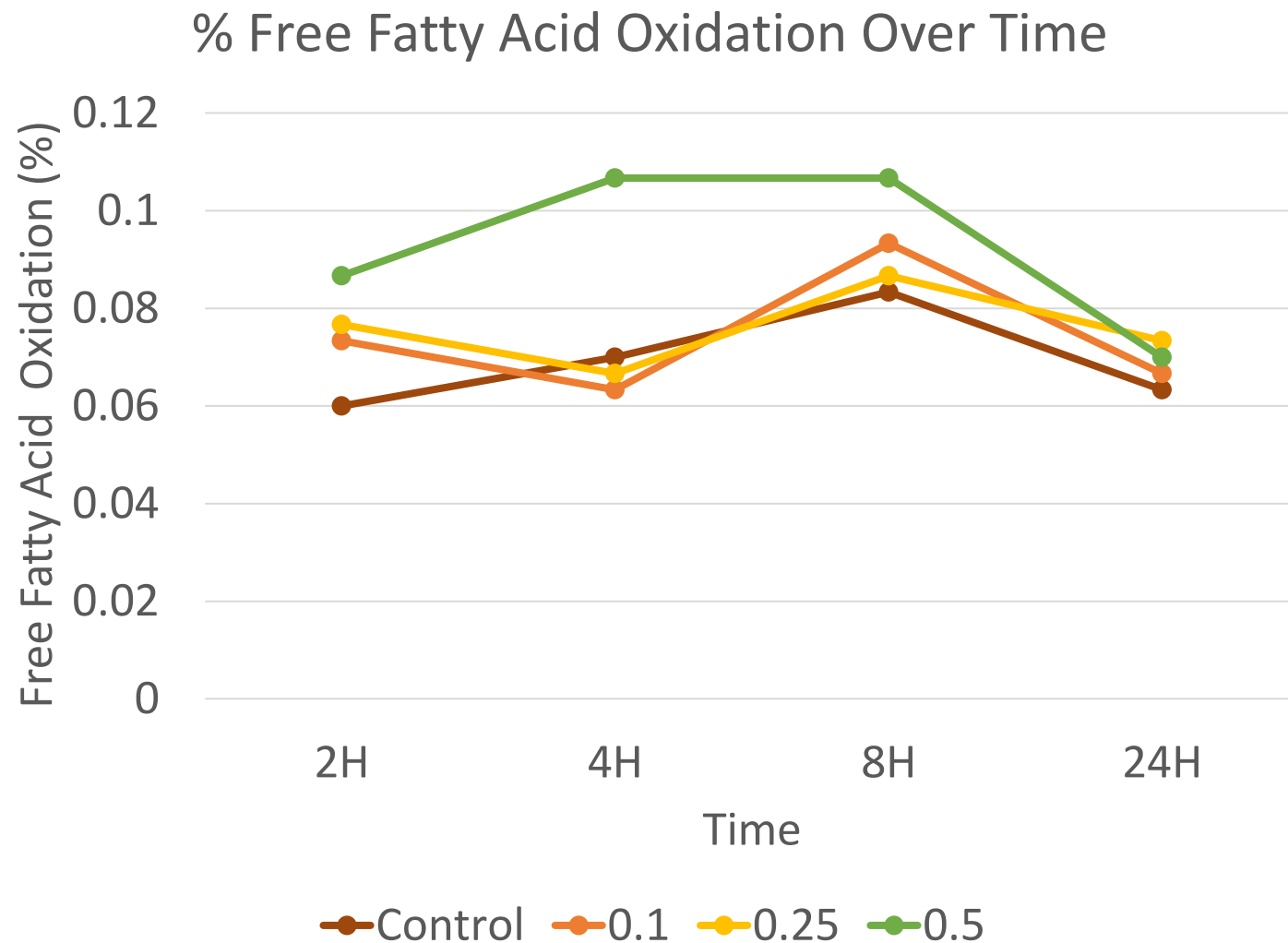
- At 2 hours:
 - 0.5g sig. from all other treatments
 - 0.25 sig. from control and 0.1g
- At 4 hours:
 - 0.5g significantly different from all other treatments
 - 0.25 sig. from control
- At 8 hours:
 - No treatments sig. from control
- At 24 hours:
 - 0.5g sig. from all other treatments
 - 0.25 sig. from control and 0.1g
- >10 meq O₂/Kg oil indicates increasing oxidation and decrease in oil quality

Peroxide Value Over Time



Quality Results

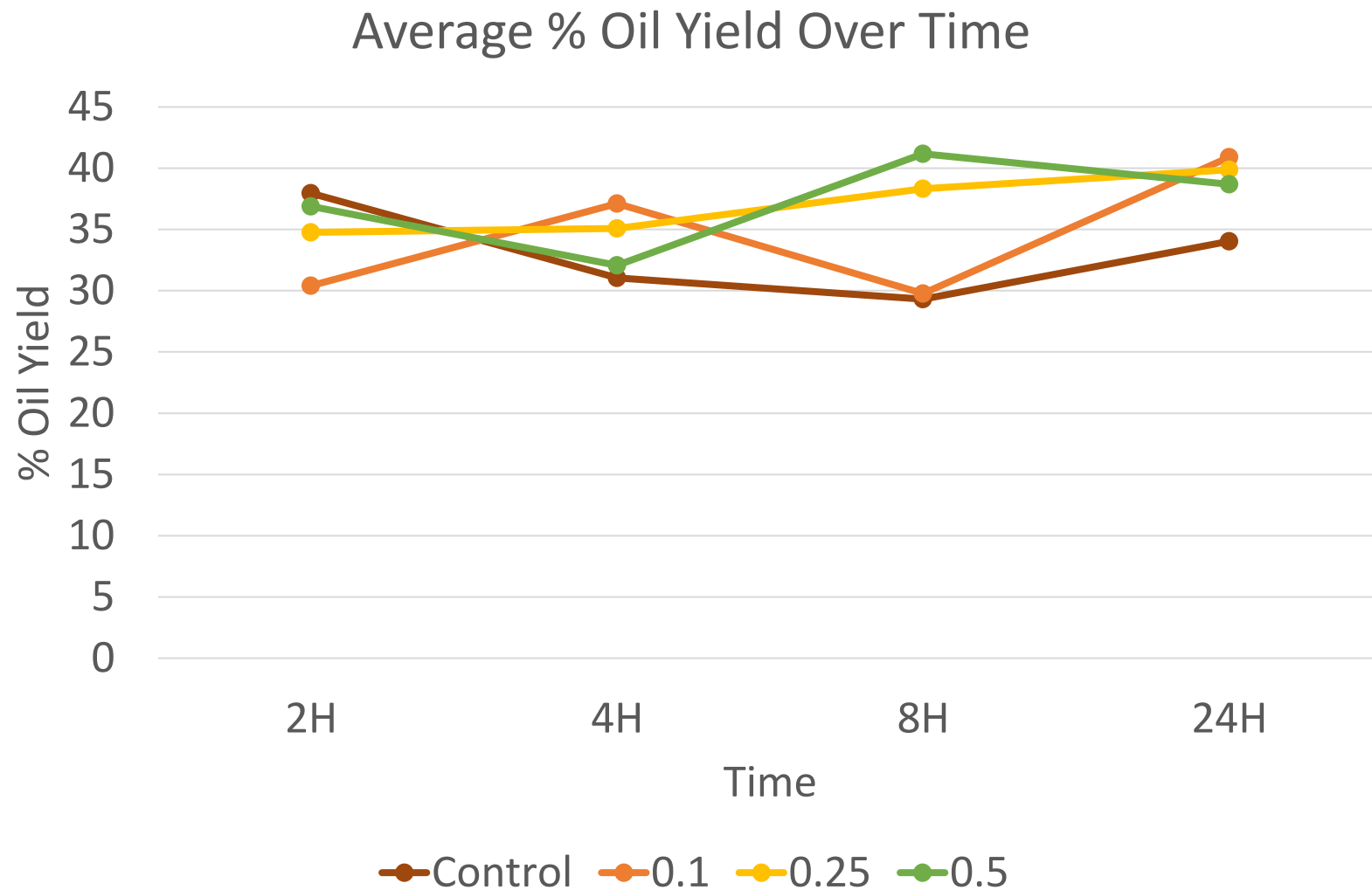
- **0.5g at 4 hours** was significantly different from all other treatments
- All other time treatment interactions were non-significant
- Acceptable level of oxidation percentage > 0.6%
- All treatments below maximum acceptable level





Quality Results

- **0.5g at 8 hours** was significantly different from 0.1g and control
- All other time treatment interactions were non-significant
- Total average 35.88% oil yield





No Significant Differences

- Total Polyphenol Content
 - Average of 12.84 mg GAE/g extract
- Brix
 - Average of calculated Brix of 5.95 Total Soluble Solids
- Firmness
 - Average firmness of 23.82 N
- Color
 - Average L of 42.39, a of 14.07, b of 28.41



- Increased ClO₂ exposure negatively impacts Peroxide Values
 - Increased Peroxide Values indicate increase in development of potential off flavors
- Slight numerical increase in oil yield percentage, and Free Fatty Acid degradation
 - Increase in FFA degradation for 0.5g corresponds with PV increase
May indicate an overall rise in oxidation and potential shortening of shelf life
 - Statistically significant but may not practically impactful
- No notable impact on Firmness, Color, TPC, and Brix



Conclusions

- ClO₂ is moderately effective at reducing *Salmonella* load
- Increased dosage increases bacterial reduction
- Increased dosage also increases Peroxide values & Free Fatty Acid degradation
- 0.25g treatment at 4 hours strikes a balance of increased reduction and minimized effect on Peroxide values & Free Fatty Acids



Acknowledgements

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Thank you!

Any Questions?

Further questions can be directed to
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