A Scalable Aggregated and Non-destructive Sampling Approach for Food Safety Monitoring of Fresh-Cut Produce During Commercial Processing

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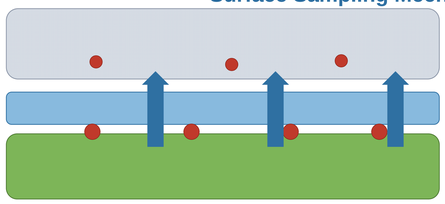
About Cloth-Based Aggregated Sampling

- **Surface process:** Pathogens on fresh-cut produce sit on cut and outer surfaces, so a contact cloth samples exactly where contamination lives.
- **Dynamic equilibrium, not saturation:** Microbes transfer onto the cloth toward an exchange equilibrium rather than saturating it, so one sampler scales to large aggregated volumes.
- **Combats heterogeneity:** Aggregating across many units averages out the patchy, uneven contamination that spot-testing individual samples routinely misses.
- **Well established in protein foods:** Sponge and cloth surface sampling is already validated and routine for carcass, meat, and poultry monitoring.
- **Non-destructive:** Sampling does not consume saleable product, so tested lots can still ship.
- **Scalable and aggregated:** A single cloth can represent an entire batch, raising the effective sample size without a proportional rise in cost.
- **Fits commercial processing:** The sampler is designed to fit pocket-scale distribution machines, so it drops into existing lines with minimal disruption.
- **Cost-effective:** Fewer tests cover more product than testing many individual tissue composites.
- **Approximates randomization:** Cloth contact across the flow of product mimics randomized sampling of the lot.
- **Knowledge gap:** Aggregated cloth sampling has not been validated on fresh-cut produce on commercial production lines.

Surface Sampling Mechanism



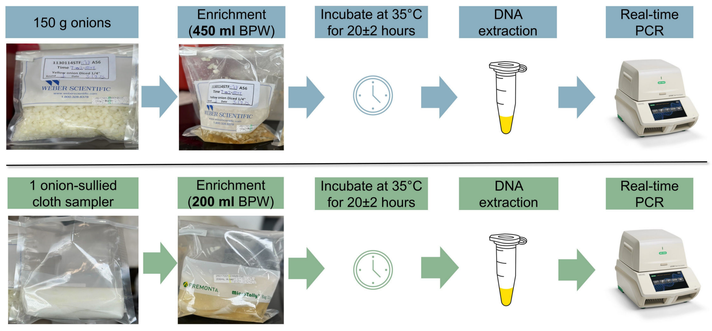
Sampling cloth — collects transferred cells

Water film — transfer medium

Produce surface with target cells on the surface

Surface sampling is a contact process. In most cases, water — either from pre-moistened samplers or from the product — acts as a transfer medium affecting the actual contact. Sampling efficiency is generally enhanced by pre-moistening samplers for fresh-cut product sampling.

Workflow



Cloth-based Aggregated Sampling of Fresh-cut Produce

Using **MicroTally® MicroCap™ samplers,** a sterile square with a 6- or 8- inch hole in the center designed to fit over the distribution cones of various pocket-scale machines, **Five fresh-cut produce products:** onions, lettuce, carrots, tomatoes, and peppers, **were sampled** and **tested for Index targets:** EB-set1, *tet*A, *tet*B, *Lacto*, *ybb*W, *fli*C, *pho*E, and *Leuco-mesen.*

Conclusions & Limitations

Conclusions

- Aggregated cloth sampling performed equivalent to conventional grab sampling across multiple fresh-cut produce matrices and microbial index targets under commercial processing conditions, while providing improved detection for selected low-prevalence targets.
- By capturing a larger and more representative subset of the microbial population present on the produce over time, aggregated cloth sampling generated composite samples that better reflect the microbiological status of the production lot.
- Importantly, this study highlights that appropriate target selection is critical for method evaluation, as targets with excessively high or low prevalence provide limited discriminatory value.
- In addition to its comparable sampling performance, cloth sampling offers clear operational advantages, including reduced labor, standardized workflows, and potential cost savings.
- Together, these findings support cloth sampling as a robust, scalable, and practical alternative to grab sampling for representative sampling in fresh produce safety systems under commercial processing conditions, pending further validation across additional matrices and optimized index-target panels.

Limitations

- This study was designed as a field-based comparison under commercial processing conditions and did not include controlled laboratory validation.
- Another limitation is that this study evaluated naturally occurring microbial index targets rather than direct pathogen detection. Because foodborne pathogens are expected to occur at very low prevalence in commercial produce-processing environments.

Index Results

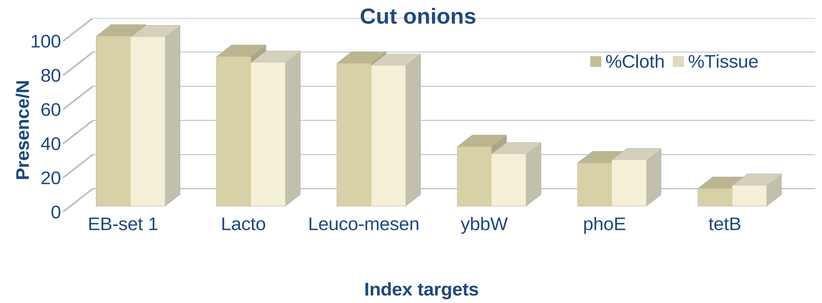


Figure 1. Detection frequencies (% positive) of selected index targets in cut onions (N = 233) using aggregated cloth sampling (%Cloth) and grab sampling (%Tissue), * indicates significant difference between %Cloth and %Tissue (p<0.05).

Index targets: EB-set 1, indicator of *Enterobacteriaceae*; ***tetA*** and ***tetB***, tetracycline resistance genes indicating gram-negative bacteria; ***Lacto***, indicator of *Lactobacillus* spp.; ***ybbW***, indicator of generic *E. coli*; ***fliC***, indicator of H7 flagella antigen; ***phoE***, indicator of *Klebsiella pneumoniae*; ***Leuco-mesen***, indicator of *Leuconostoc mesenteroides*.

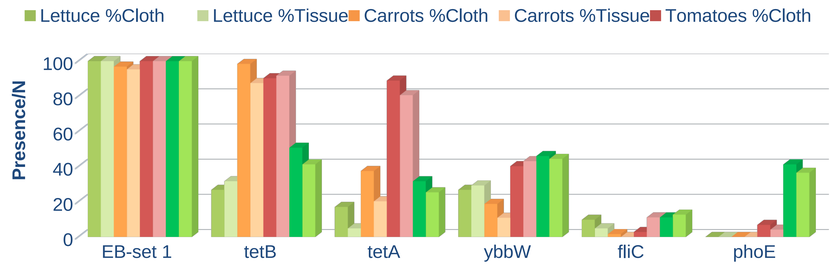


Figure 2. Detection frequencies (% positive) of selected index targets in cut lettuce (N = 41), diced carrots (N=64), diced tomatoes (N=72), and diced peppers (N=63) using aggregated cloth sampling (%Cloth) and grab sampling (%Tissue), * indicates significant difference between %Cloth and %Tissue (p<0.05).

Index targets: as defined in Figure 1.

Key Findings

- Cloth sampling gave significantly higher detection for *tet*A (37.5%) and *tet*B (98.4%) in diced carrots (p<0.05).
- For all other targets and matrices, cloth sampling matched grab sampling (p>0.05).
- *Enterobacteriaceae* (EB-set 1) was detected near-universally by both methods, while low-prevalence targets like *pho*E and *fli*C gave limited discriminatory power.
- Larger sampled surface area and time-integrated capture produce representative composite samples while reducing labor.
- Aggregated cloth sampling is a promising, scalable alternative to grab sampling under commercial processing conditions.

References & Acknowledgements

References: This poster referred to the manuscript "A Scalable Aggregated and Non-destructive Sampling Approach for Food Safety Monitoring of Fresh-Cut Produce During Commercial Processing" submitted to Journal of Food Protection. It is currently under review.

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ABSTRACT

Introduction: Fresh-cut produce is often linked to outbreaks. Many customers require finished product microbial testing before packaging, typically by hand-collecting specimens every minute for an hour to create a 150g structured sample. This method approximates randomness but does not target the product surface, where contamination is most likely, so any contaminants may be diluted by internal tissue.

Objective: Compare cloth-based aggregated sampling to conventional tissue composites for 5 fresh-cut products at commercial scale given the extremely low prevalence of pathogens.

Methods: During commercial operation, extra tissue samples were collected for five fresh-cut items (diced carrots, diced tomatoes, cut onions, diced peppers, and cut Romaine lettuce) alongside routine pathogen sampling. At the same time, a cloth sampler was installed on the weigh scale's distribution cone. A total of 473 sample pairs were enriched and tested for six markers that are loosely linked to pathogens (tetA, tetB, phoE, ybbw, Entero-set 1, and fliC), as no actual pathogen detections were expected. Prevalence for each item-marker pair were compared using the Fisher's exact test for difference, and pair-wise correlations were analyzed with the PSI Correlation Coefficient.

Results: Among five commodities, only diced carrots had significantly different prevalence with higher detection of tetA and tetB with cloth-based sampling (P=0.05 and P=0.03, respectively). Overall, cloth-based sampling was as effective as, or better than, tissue grabs. Positive correlations appeared in some cases, while other correlations may reflect random detection patterns.

Significance: These findings show that processors can use cloth-based aggregated sampling with the MicroTally® MicroCap™ sampler to save time and costs without affecting results. With its continuous approach and complete coverage, this method provides a random sample.

Notes — differences from original abstract:

- *Marker naming differs: abstract "Entero-set 1" / "ybbw" vs. poster "EB-set 1" / "ybbW".*
- *Marker count differs: abstract says six vs. poster panel of eight (adds Lacto, Leuco-mesen).*
- *Statistics differ: abstract P=0.05 / 0.03 vs. poster p<0.05.*
- *Correlation metric: abstract "PSI Correlation Coefficient" — verify vs. Phi (φ).*