Characterization and mitigation of food safety risks associated with waxing roller brushes

Summary

Waxing roller brushes made with different materials and patterns play an essential role when waxes are applied to fruit surfaces. However, food safety risks associated with waxing roller brushes have not been well characterized, and the cleaning and sanitizing of roller brushes have been challenging for the industry. This study addresses the needs of the produce industry by better characterizing the impact of waxes on the survival and changes of microorganisms on brushes made with different materials (nylon versus 50% horsehair/50% polyethylene [50/50]) and of different patterns (spiral versus tufted), and by evaluating and optimizing cleaning and sanitizing protocols for waxing roller brushes.

Objectives

1. Investigate the behavior of *Listeria monocytogenes* (LM) and *Enterococcus faecium* (EF) on waxing roller brushes made with different materials and with the presence of dried waxes.
2. Evaluate the levels of indigenous microbial populations present on waxing roller brushes in commercial packinghouses.
3. Characterize the physical and chemical properties of hydrolyzed waxes and optimize and validate the cleaning and sanitizing protocols for the effective removal of wax and microorganisms from waxing roller brushes.

Methods

Microbial survival on brushes: Waxed and unwaxed tufted brushes (nylon and 50/50) were inoculated with LM at ~8 Log CFU/coupon to investigate the impact of filament materials and the presence of dried wax. To investigate the impact of brush pattern, unwaxed spiral and tufted brushes were dip-inoculated with EF at ~8 Log CFU/coupon. Inoculated brushes were dried and stored at ambient temperature for ~3 months.

Packinghouse sampling, 2024: Samples were collected before and after cleaning and sanitation in July, August, and September, and analyzed from culture-dependent and culture-independent approaches to investigate the indigenous microflora.

Cleaning efficiency: Brush filaments coated with different waxes (wet and dried) were cleaned with different approaches, of which the wax removal rates were measured, compared, and optimized.

Results to Date

- LM declined by ~3-4 log on unwaxed 50/50 and nylon brushes and ~5-6 log on waxed 50/50 and nylon brushes over 84 days; LM survived better on 50/50 brushes; the presence of dried wax influenced LM survival (**Figure 1**).
- EF declined by ~1 log on spiral and tufted 50/50 brushes and declined by ~2 and 1.5 log on spiral and tufted nylon brushes over 60 days (**Figure 2**).
- Culturable microbial populations at packing facilities were influenced by cleaning and sanitation (c/s); intense c/s practices and cleaning out of place reduced microbial levels (**Figure 3**).
- Wet waxes were easily removed by rinsing (>99% removal rates); for dried waxes, alkaline cleaner was more effective than neutral cleaner; dried carnauba-based wax was the hardest to remove (**Figure 4**).

Benefits to the Industry

Results of this study will bridge knowledge gaps on how different brush patterns, filament materials, and the presence of wax residues influence the pathogen survival on waxing roller brushes and the effectiveness of current cleaning and sanitation protocols on the removal of different wax residues as well as microorganisms. Outcomes will assist the design, optimization, and validation of protocols used by the industry for the cleaning and sanitizing of waxing roller brushes, thus mitigating microbial safety risks associated with waxing.

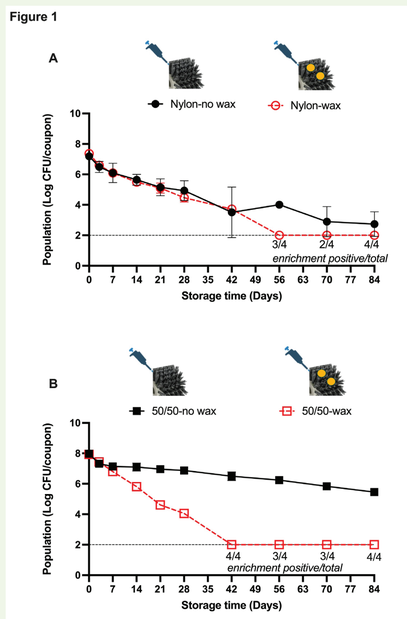

Figure 1: Survival of *Listeria monocytogenes* on **(A)** nylon and **(B)** 50/50 waxing roller brushes with and without the presence of dried wax over 84 days of storage under ambient conditions. When counts were below the limit of detection (LOD, 2 Log CFU/coupon), LOD was used for calculating mean values. Mean ± SD, n ≥ 4.

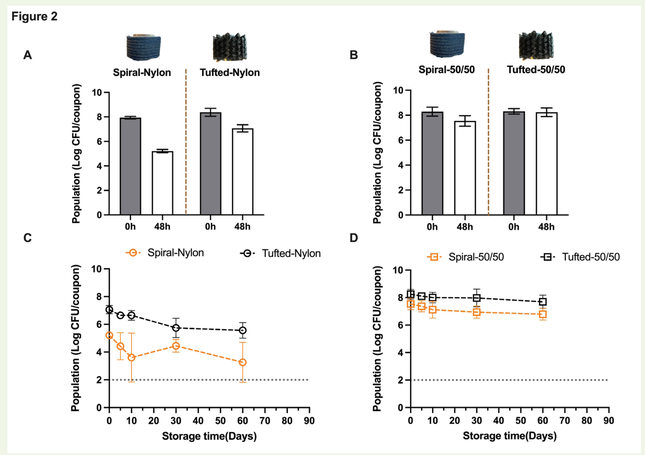

Figure 2:
Population of *Enterococcus faecium* on **(A)** nylon brushes and **(B)** 50/50 brushes immediately after inoculation (0 h) and drying for 48 h (Day 0 for storage). Survival of EF on spiral and tufted waxing roller brushes over 90 days of storage under ambient conditions: **(C)** nylon brushes and **(D)** 50/50 brushes. When counts were below the limit of detection (LOD, 2 Log CFU/coupon), LOD was used for calculating mean values. Mean ± SD, n = 6.

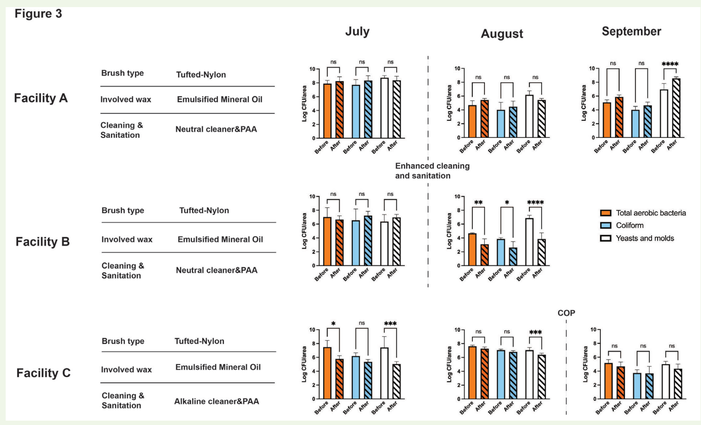

Figure 3:
Changes of microbial populations (total aerobic bacteria, coliforms, and yeasts/molds) on waxing roller brushes in commercial packinghouses (stone fruit) before and after daily cleaning and sanitation practices in the beginning, during, and at the end of the season in 2024. Between July and August, facility A used scrub brushes to aid in cleaning, and facility B did not change its process but doubled efforts. In September, the brushes in facility C were cleaned out of place (COP). Facility B in September: not accessible. Mean ± SD, n = 6.

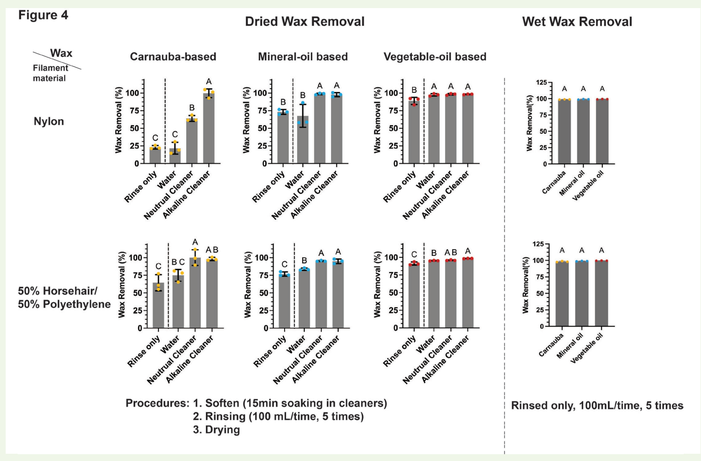

Figure 4:
Wax removal rate (%) under different cleaning conditions (wet and dried waxes), wax types (carnauba-based, mineral-oil-based, and vegetable-oil-based wax), cleaners (neutral and alkaline), and brush filaments (nylon versus 50/50). Different letters above bars indicate statistically significant differences among treatments ($p < 0.05$). Mean ± SD, n = 3.

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