Synergistic antimicrobial activity of food-grade compounds in wax coatings on fruits during wax drying

Summary

Wax coating is the final step in the postharvest processing of many fruits, making it a critical control point to prevent microbial contamination of fruit. This research focuses on incorporating generally recognized as safe (GRAS) compounds or plant-derived extracts into commercial wax coatings to achieve synergistic inactivation of bacteria on fruits during the wax coating and drying processes. The potential synergistic antimicrobial activities between different antimicrobial compounds and mild heat (50–60°C) were explored and characterized in both carnauba-based and non-carnauba wax formulations, using oranges and apples. Additionally, shelf-life studies were conducted to evaluate the effectiveness of these interventions in reducing microbial risk while maintaining fruit quality. The results provide practical approaches to improve fresh produce safety during the wax coating process.

Objectives

1. Assess the synergistic interaction of food-grade antimicrobial compounds or extracts with mild-heat to achieve rapid inactivation of bacteria in wax suspensions.
2. Assess the role of synergistic treatment (optimal combination of food-grade antimicrobial compounds in a wax coating and mild heat identified in Objective 1) in the inactivation of the pathogens inoculated in a wax composition on the surface of apples and citrus fruits.
3. Measure the influence of synergistic treatment in the inactivation of the pathogens inoculated on the surfaces of apples and citrus, including the stem and calyx regions.
4. Evaluate the influence of the optimal synergistic treatments identified in Objectives 2 and 3 on the quality, microbial load, and shelf-life of fruit during storage.

Methods

- *In vitro* antimicrobial tests were performed to evaluate the potential synergistic antimicrobial activity of olive pomace extract (OPE; 1.0 mg GAE/mL) or propyl gallate (PG; 5 mM) with mild heat (40°C) in carnauba-based wax (EF100; non-morpholine) against *Escherichia coli* O157:H7 and *Listeria innocua*.
- Antimicrobial tests were performed to assess the synergistic antimicrobial activity of EF100 supplemented with OPE or PG and dry heat (55°C) against *E. coli* O157:H7 on orange skins.
- Antimicrobial test was performed on whole fruits to evaluate the potential synergistic antimicrobial activity of PG-supplemented EF100 with dry heat (55°C) on different regions of the orange surface, including the side, stem, and calyx areas.

Results to Date

- Both OPE and PG exhibited synergistic activity with mild heat (40°C) in EF100, achieving >4-log reductions of bacterial pathogens within 10 min (**Figures 1** and **2**).
- *L. innocua* was more susceptible to the combined treatments than *E. coli* O157:H7 (**Figures 1** and **2**).
- EF100 supplemented with OPE or PG, combined with dry heat (air temperature of 55°C), achieved >3-log reductions of *E. coli* O157:H7 on orange skins within 2 min (**Figure 3**).
- The combined treatment of PG-supplemented EF100 and dry heat effectively reduced *E. coli* O157:H7 populations on the side and stem regions of oranges, though reductions in the calyx region were more limited (~2-log reductions) (**Figure 4**).

Benefits to the Industry

The potential impact on the produce industry would be in two areas: (1) reduce the risk of cross-contamination of apples and citrus fruits during the wax coating step; (2) reduce microbial load on fruit surface and thus improve the safety of fruit products. The proposed approach can provide a novel process control step in augmenting the safety of the fruits. The outcome of this research will identify the food-grade compounds and extracts that can be blended with the commercial wax formulations to achieve the goals of reducing the risk of cross-contamination and improving the reduction of potential pathogens on the fruit surface, including hard-to-sanitize sections such as the calyx and stem regions of the fruit.

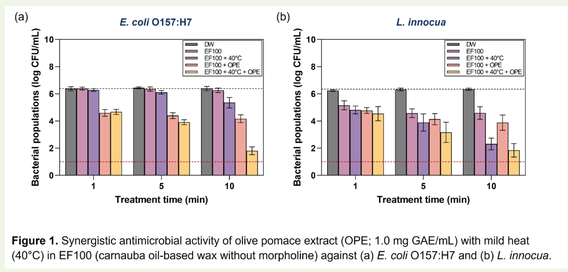

Figure 1. Synergistic antimicrobial activity of olive pomace extract (OPE; 1.0 mg GAE/mL) with mild heat (40°C) in EF100 (carnauba oil-based wax without morpholine) against (a) *E. coli* O157:H7 and (b) *L. innocua*.

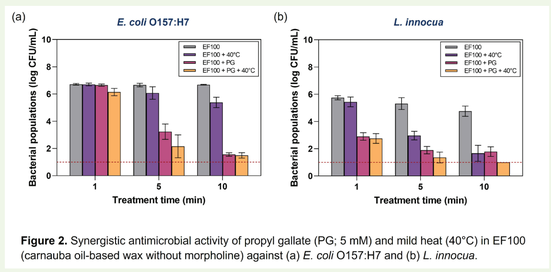

Figure 2. Synergistic antimicrobial activity of propyl gallate (PG; 5 mM) and mild heat (40°C) in EF100 (carnauba oil-based wax without morpholine) against (a) *E. coli* O157:H7 and (b) *L. innocua*.

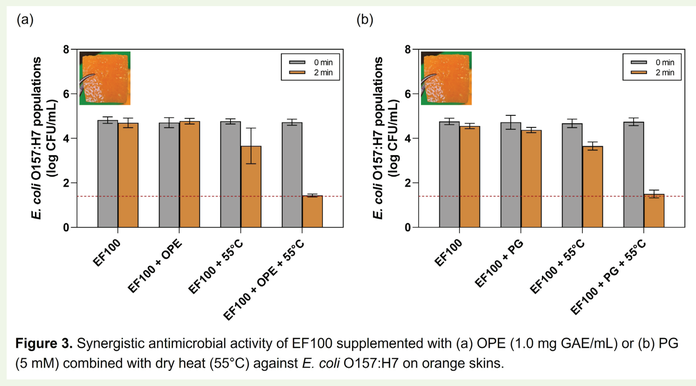

Figure 3. Synergistic antimicrobial activity of EF100 supplemented with (a) OPE (1.0 mg GAE/mL) or (b) PG (5 mM) combined with dry heat (55°C) against *E. coli* O157:H7 on orange skins.

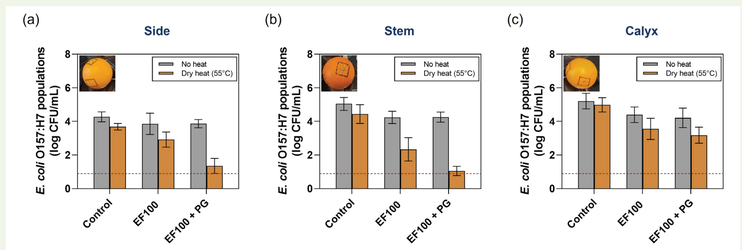

Figure 4. Synergistic antimicrobial activity of PG-supplemented EF100 combined with dry heat (55°C) against *E. coli* O157:H7 on different regions of orange skins: (a) side, (b) stem, and (c) calyx.

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