

## Introduction

Multiple factors contribute to contamination, cross-contamination, and spoilage of fresh produce from farm to fork. The incidence of foodborne outbreaks caused by improperly handled fresh fruits and vegetables has increased globally (Abadias, et al., 2008). The pathogens most frequently linked to produce-related outbreaks are: *Salmonella* spp, *E. coli* O157:H7, *L. monocytogenes*, Hepatitis A, Norovirus and some parasites. The fresh produce industry has mostly used synthetic chemical such as chlorine, ammonium, hydrogen peroxide etc. to assure the safety of products as a chemical sanitizer. However, there is a trend in eliminating the uses of these chemical sanitizers from the disinfection process because of risks on environmental and public health (Gill et al., 2009). Currently, various research has focused on alternative sanitizers using natural antimicrobial agents. This research is focused on natural decontamination technique of fresh produce at household level.

## Objectives

- To develop household washing solutions to decontaminate fresh produce using natural antimicrobials (Essential oil, vinegar, lemon crude juice extract and their combinations).
- To determine antimicrobial activities of natural antimicrobials against artificially contaminated fresh strawberries and spoilage organisms.

## Materials and Methods



**Inoculation:** Strawberries were inoculated with *Listeria* and *Salmonella* (6.0-7.0 log<sub>10</sub> CFU/g), and left for 2 h.



**Washing:** Strawberries were dipped in 5 selected solutions: 0.1% Origanum oil (T1), 0.5% white vinegar (T2=V), and 50% crude lemon extract (T3=L), were selected and their combinations Vinegar + Origanum oil (VO), (C1: T1+T3=LO; C2: T1+T2+T3= VLO) for 5 min with shaking at 100 rpm:



**Microbial Assay:** Enumeration of total aerobic and yeast/mold counts was investigated with 3M petri-films. *Listeria* and *Salmonella* was retrieved with selective agar Oxford Listeria and Hekton Enteric Agar, respectively.



**Color Measurement:** CIE L\* a\* b\* was measured before and after inoculation, and at day 5.

## Results

Table 1. Optical density (OD) of *Salmonella* at 600 nm

Treatment	Concentration (%)						
	1.0	0.50	0.25	0.12	0.06	0.03	0.01
V	0.06 <sup>c</sup>	0.05 <sup>c</sup>	0.06 <sup>c</sup>	0.06 <sup>c</sup>	0.54 <sup>b</sup>	1.09 <sup>a</sup>	1.09 <sup>a</sup>
L	0.34 <sup>b</sup>	0.23 <sup>c</sup>	0.15 <sup>c</sup>	0.11 <sup>c</sup>	0.36 <sup>b</sup>	0.46 <sup>b</sup>	1.04 <sup>a</sup>
VO	0.07 <sup>c</sup>	0.05 <sup>c</sup>	0.06 <sup>c</sup>	0.06 <sup>c</sup>	0.44 <sup>b</sup>	1.04 <sup>a</sup>	1.02 <sup>a</sup>
LO	0.55 <sup>b</sup>	0.35 <sup>c</sup>	0.20 <sup>de</sup>	0.13 <sup>e</sup>	0.32 <sup>cd</sup>	0.48 <sup>b</sup>	0.94 <sup>a</sup>
VLO	0.31 <sup>c</sup>	0.15 <sup>d</sup>	0.14 <sup>d</sup>	0.09 <sup>d</sup>	0.31 <sup>c</sup>	0.63 <sup>b</sup>	0.83 <sup>a</sup>

<sup>a</sup>abcd<sup>e</sup> Superscript across row not followed by same letter differ (P < 0.05). V: Vinegar; L: Lemon juice extract; VO: V+ Origanum oil; LO: L+ Origanum oil; VLO: V+L+ Origanum oil.

Table 2. Minimum Inhibitory Concentration (MIC) and Minimum Bacterial Concentration (MBC) of various treatments.

Treatment	Organism	MIC (%)	MBC (%)
V	<i>L. monocytogenes</i>	0.12	0.5
	<i>S. Thyphimurium</i>	0.12	0.3
L	<i>L. monocytogenes</i>	3.12	6.3
	<i>S. Thyphimurium</i>	6.25	13
VO	<i>L. monocytogenes</i>	0.78	1.6
	<i>S. Thyphimurium</i>	0.78	1.6
LO	<i>L. monocytogenes</i>	0.06	0.1
	<i>S. Thyphimurium</i>	0.12	0.3
VLO	<i>L. monocytogenes</i>	0.03	0.1
	<i>S. Thyphimurium</i>	0.25	0.3

V: Vinegar; L: Lemon juice extract; VO: V+ Origanum oil; LO: L+ Origanum oil; VLO: V+L+ Origanum oil

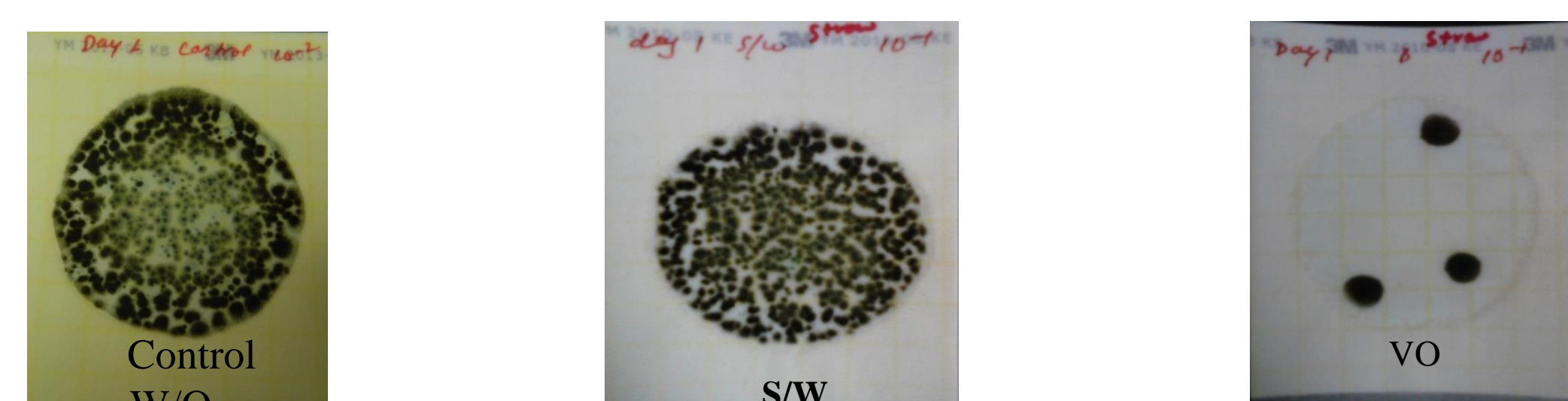


Figure 1. Inhibition effect of washing solution with Vinegar and Origanum oil (V+O) compared with Sterile Water (S/W) and control (W/O) against yeast/mold growth

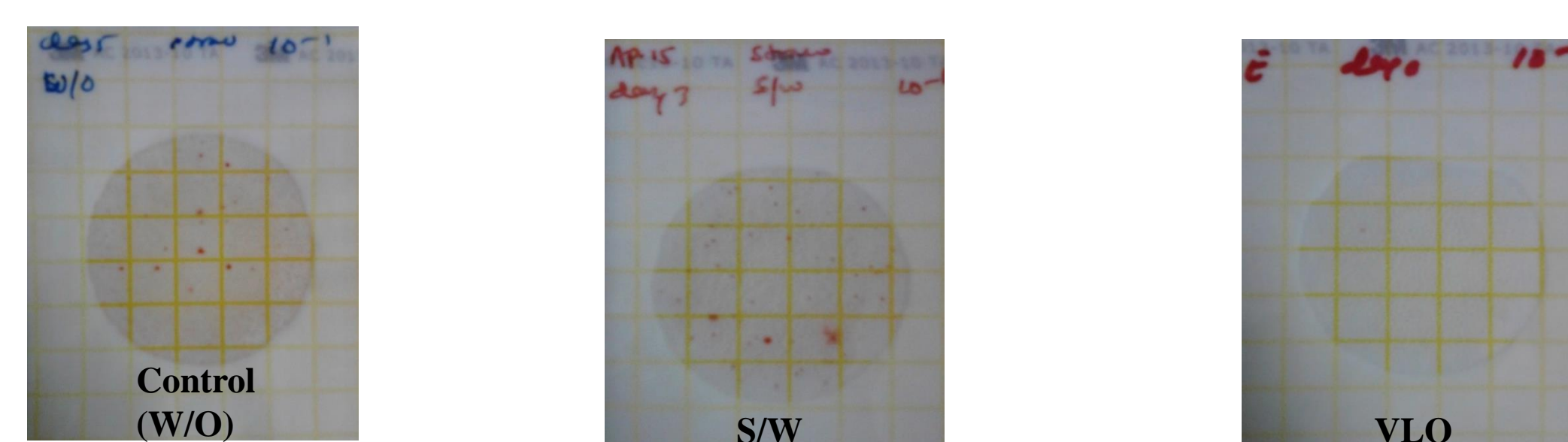


Figure 2. Inhibition effect of washing solution with combination of Vinegar, Lemon juice and Origanum oil (VLO) compared with Sterile Water (S/W) and Control (W/O) against aerobic bacteria

## Results – cont'd..

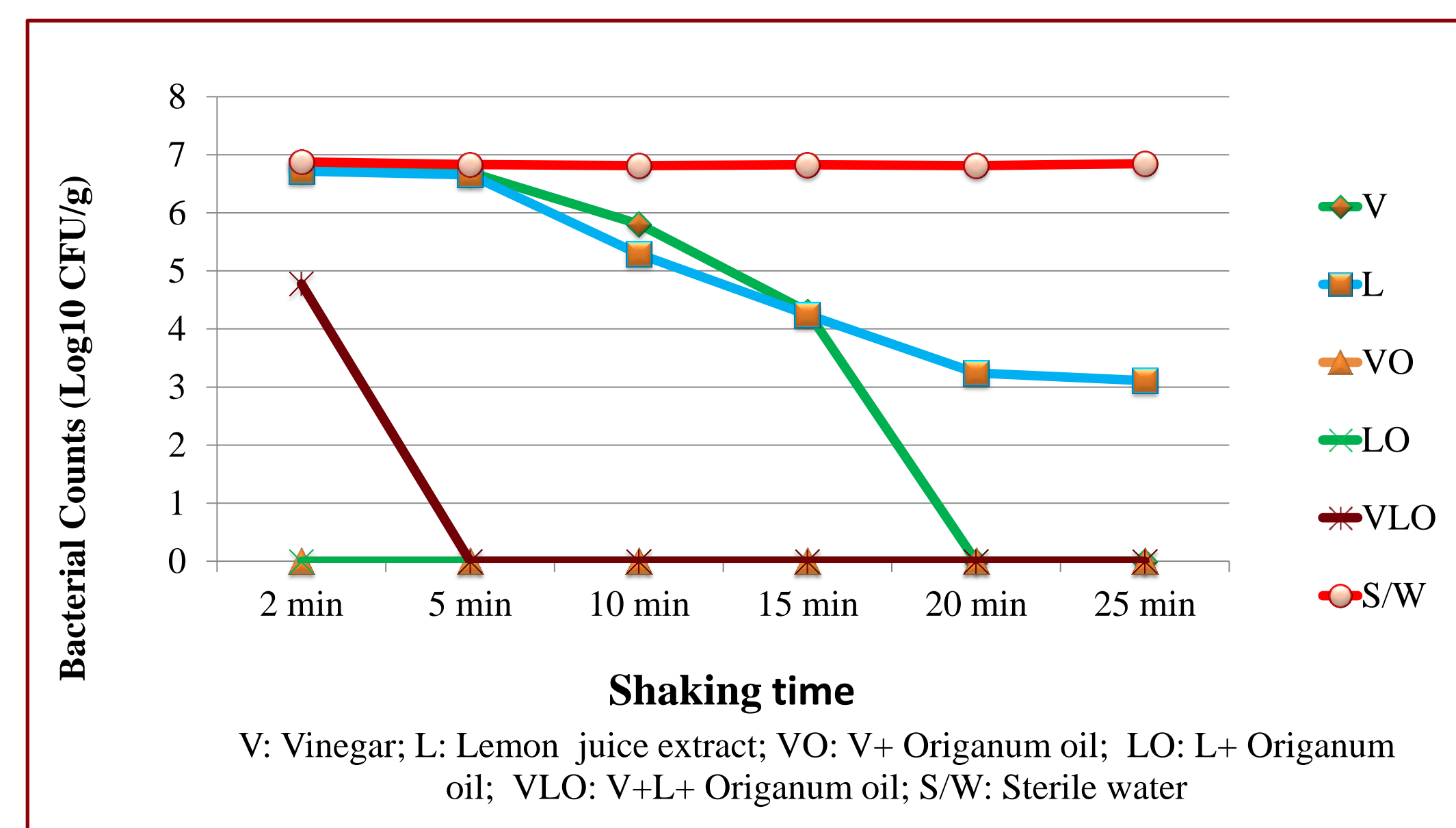


Figure 3. Changes in bacterial growth in washing solution.

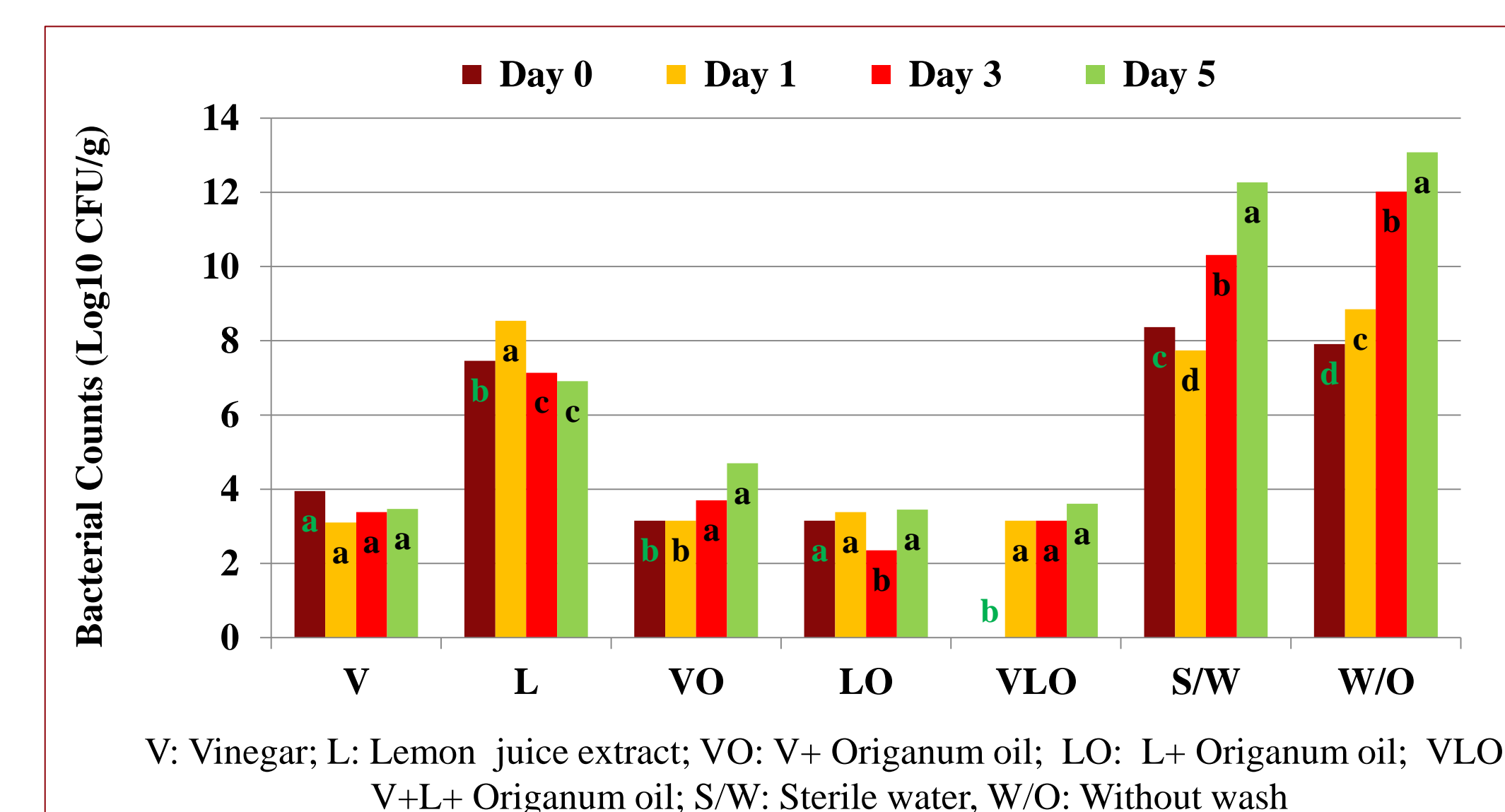


Figure 4. Changes in total aerobic counts of washed and unwashed strawberries during refrigerated storage.

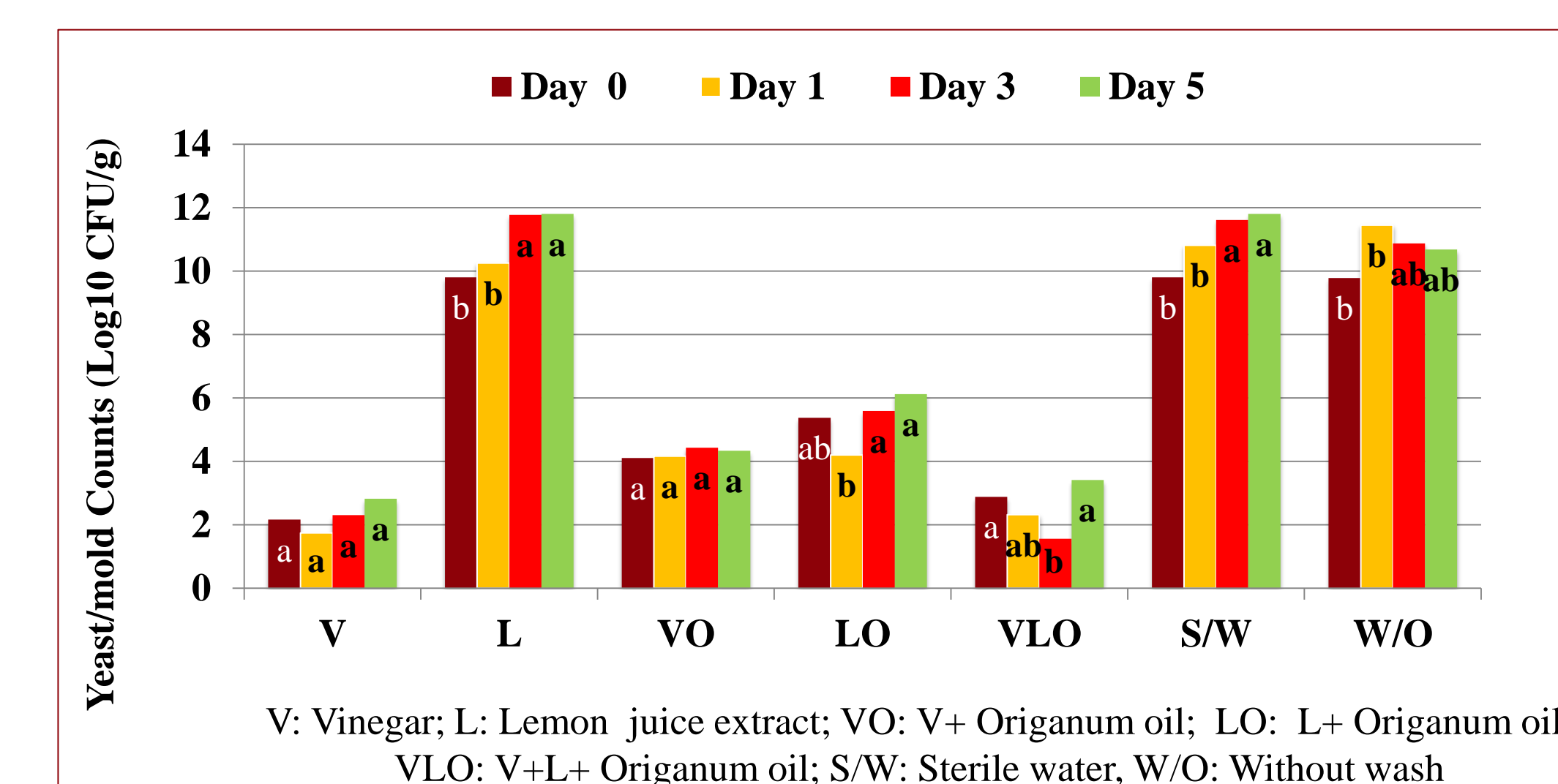


Figure 5. Changes in total yeast/mold counts of washed and unwashed strawberries during refrigerated storage.

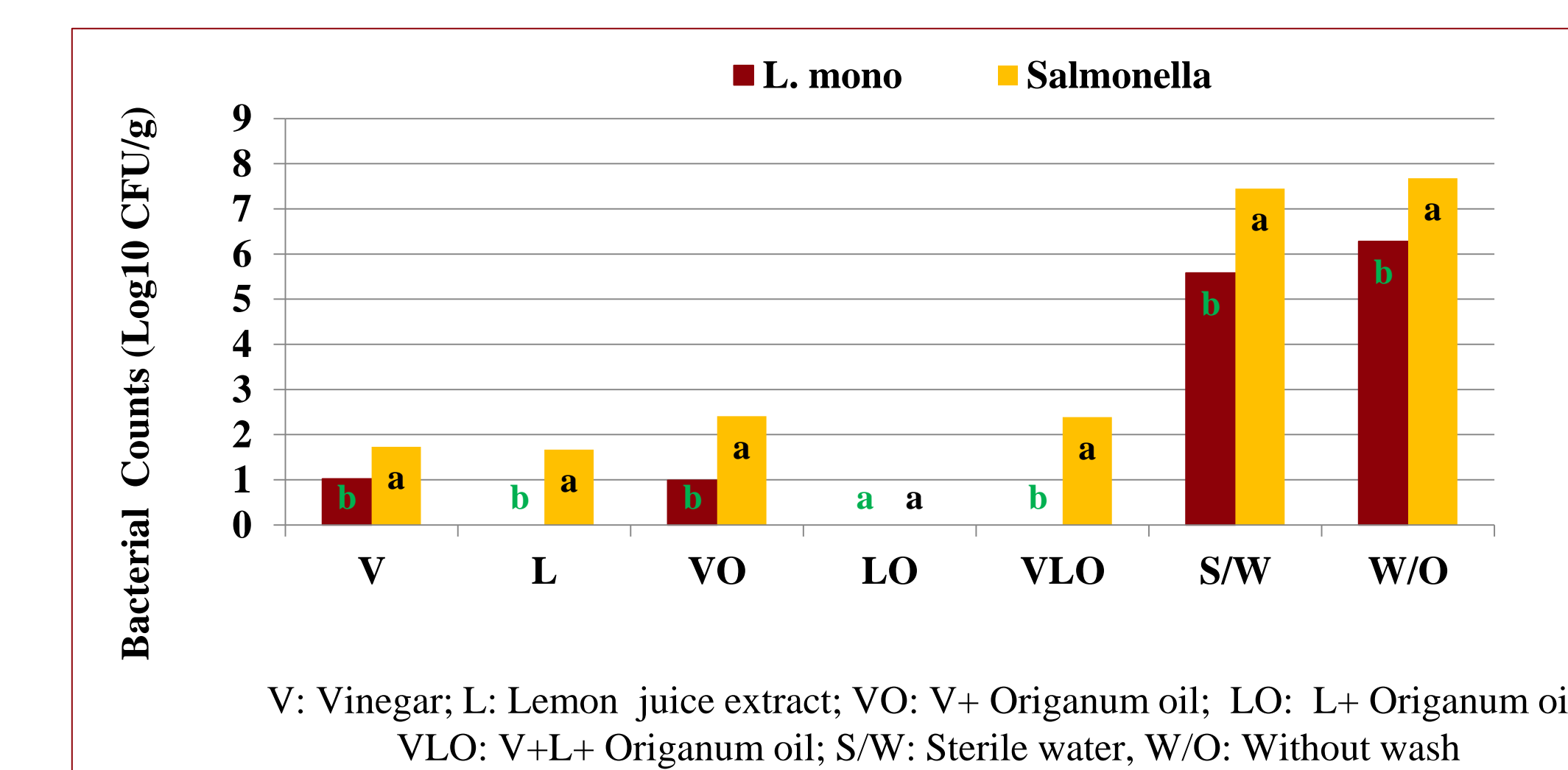


Figure 6. Effectiveness of treatments against *L. monocytogenes* and *Salmonella* spp in strawberries throughout storage.

## Results – cont'd..

Table 3. Mean value of delta E (change on color) of strawberries and carrots before washing, after washing and at day 5.

Treatments	ΔE <sub>BA</sub>	ΔE <sub>B5</sub>	ΔE <sub>A5</sub>
V	6.41±2.12a	8.87±2.57a	6.54±1.59a
L	6.44±2.12a	7.86±2.57a	4.90±1.59a
VO	6.64±2.12a	6.75±2.57a	4.27±1.59a
LO	6.24±2.12a	6.76±2.57a	9.60±1.59a
VLO	10.83±2.12a	8.77±2.57a	8.78±1.59a
S/W	8.13±2.12a	7.86±2.57a	4.66±1.59a
W/O	7.12±2.12a	5.35±2.57a	5.42±1.59a

Mean±SE, <sup>a</sup> Treatment mean with the same superscript across the row and within column does not differ (P<0.05). ΔE<sub>BA</sub>= Changed in color before and after washed; ΔE<sub>B5</sub>= Changed in color before washed and after day 5; ΔE<sub>A5</sub>= Changed in color after washed and after day 5; S/W: Sterile water; W/O: Without wash; V: White vinegar; L: Crude lemon juice extract; VO: V+ origanum oil; LO: L+ origanum oil; VLO: V+L+ origanum oil.

## Conclusion

From the results, it is suggested that the combination of essential oil with vinegar and crude lemon juice extract might be suitable as natural sanitizer for fresh produce and could be the washing solution at the household level.

## References

- Abadias, M., Usall, J., Anguera, M., Solsona, C., & Vinas, I. (2008). Microbiological quality of fresh, minimally-processed fruit and vegetables and sprouts from retail establishments. *International Journal of Food Microbiology*, 123, 121-129.
- Gill, A.O., & Holley, R. A. (2009). Disruption of *Escherichia coli*, *Listeria monocytogenes* and *Lactobacillus sakei* cellular membranes by plant oil aromatics. *International Journal of Food Microbiology*, 108, (1), 1-9.

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