BIOAG PROJECT PROGRESS REPORT

TITLE: Sustainable sanitation technique for postharvest quality and safety of organic fruits

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KEY WORDS: *Listeria monocytogenes,* Produce safety, Ultraviolet light

ABSTRACT

The project investigates the use of ultraviolet-C light for sanitizing surfaces of selected organic fruits. During past few months, we evaluated the surface morphology of several organic fruits. In particular, we determined the surface roughness and surface energy of cherry, pear and cantaloupe. The average surface roughness of these fruits varied from 8.79 µm for cherry to 47.7 for cantaloupe, and root mean square surface roughness 10.7 for cherry to 55.8 µm for cantaloupe, respectively. The efficacy of ultraviolet-C light for inactivating pathogenic bacteria *Listeria monocytogenes* on organic apples was also evaluated. Maximum reductions of 1.61±0.01 log CFU/g were achieved for *Listeria monocytogenes* on apple surfaces, after 5 min of UV-C exposure at 3.75 kJ/m^2 UV dose.

PROJECT DESCRIPTION

Fresh fruits are generally considered safe from pathogenic bacteria because of their high acid content. However, there are several incidents when bacterial pathogens including *Listeria monocytogenes* have been isolated in fresh and frozen fruits (Bower et al., 2003). Recent outbreaks of *Listeria* in fresh fruits have challenged the belief that pathogenic bacteria cannot grow in high-acid foods. Therefore, microbial safety during postharvest handling is one of the major concerns of the organic industry. The U.S. Food and Drug Administration (FDA) Food Safety Modernization Act now requires growers and packers of all fresh produce to adapt preventive strategies for microbial controls to minimize the risk of human pathogens.

This project is our continued effort to obtain mechanistic understanding of pathogenic bacteria inactivation on diverse fruit surfaces using UV-C light technology.

Specific objectives of the proposed research are:

1. Determine the ultraviolet-C light inactivation kinetics of *Listeria monocytogenes* on organic strawberries, cherries, apples, pears and cantaloupe.
2. Develop an innovative, economical and effective means of sanitizing organic fruit against a variety of pathogens, thereby protecting consumers and the reputation of the industry. We will integrate the UV-C inactivation kinetic data from our previous research with data being gathered from ongoing investigation for the design of UV-C treatment processes.

OUTPUTS

Work Completed:

We have completed UV-C inactivation of pathogenic bacteria *Listeria monocytogenes* on organic apples (Table 1). The results indicated that the maximum reductions of 1.61±0.01 log

CFU/g were achieved for *Listeria monocytogenes* on apple surfaces. Currently, we are evaluating UV-C inactivation of *Listeria monocytogenes* on organic cantaloupe, pear, strawberry and cherry. The surface roughness and surface energy data have been obtained for several fruits (Tables 2 and 3, Figure 1). The inactivation kinetics of *Listeria monocytogenes* on different fruit surface will be correlated to surface roughness and surface energy to elucidate the importance of fruit surface properties for the design of UV-C processes for inactivation of pathogens.

Table 1. Average logarithmic reduction levels of *Escherichia coli O157:H7* on organic apples (N = 5)

Time (sec)	UV dose (kJ/m^2)	Log reduction
0	0.000	0
10	0.16±0.008	0.72±0.15
20	0.31±0.009	0.79±0.15
30	0.47±0.012	0.86±0.15
40	0.66±0.014	0.83±0.14
50	0.79±0.010	1.01±0.07
60	0.86±0.017	1.03±0.11
90	1.27±0.012	1.08±0.14
120	1.60±0.014	1.12±0.20
180	2.33±0.008	1.16±0.05
240	3.25±0.012	1.35±0.10
300	3.75±0.010	1.61±0.08

Table 2: Root mean square surface roughness (R_q) and average surface roughness (R_a) values of selected fruits

Fruit	S_q (µm)	S_a (µm)
Cherry (Stemilt)	10.7	8.79
Cantaloupe (Guatemala origin)	55.8	47.7
Pear (D'Anjou)	40.2	32.8
Strawberry[1]	296	287
Apple[1]	30.3	25.4
Raspberry[1]	78.6	62.4

[1]The data was obtained during first year of project

Table3: Average and standard deviation values of surface energy parameters of selected fruits (N= 20)

Fruit surface	Contact angle (ϑ)		$\gamma_s \times 10^3$ (mN/m)	$\gamma_s^d \times 10^3$ (mN/m)	$\gamma_s^p \times 10^3$ (mN/m)	$W_a \times 10^3$ (mN/m)	$W_s \times 10^3$ (mN/m)
	Water	Diiodomethane					
Cherry	84.1±5.4	65.2±6.9	31.3±3.3	25.6±3.9	5.7±2.6	80.4±6.8	-65.5±6.7
Cantaloupe	76.3±12.8	63.7±11.3	36.4±2.0	26.4±6.3	9.8±7.9	89.7±15.0	-56.1±14.6
Pear	96.8±7.7	38.7±5.0	40.6±2.9	40.2±2.5	0.49±0.9	64.3±9.7	-81.5±9.5
Strawberry[1]	76.3±9.2	35.6±11	46.4±6.1	41.3±5.2	5.07±3.6	90.2±12	-55.6±11
Apple[1]	81.8±12.5	42.5±8.4	42.9±6.4	38.7±4.3	4.31±3.2	84.6±15	-61.2±15
Raspberry[1]	91.0±10.0[a]	77.3±8.0	24.4±5.9	19.0±4.2	5.4±4.3	71.7±13	-74.2±12
Cherry[1]	84.1±5.4[b]	65.2±6.9	31.3±3.3	25.6±3.9	5.7±2.6	80.4±6.8	-65.5±6.7

[1]The data was obtained during first year of the project

where γ_S = surface energy (mN/m), γ_S^d = Dispersion component of the surface energy of the solid (mN/m), γ_S^p = Polar component of the surface energy of the solid (mN/m), W_a = Reversible work of adhesion (mN/m), W_s = Spreading coefficient (mN/m)

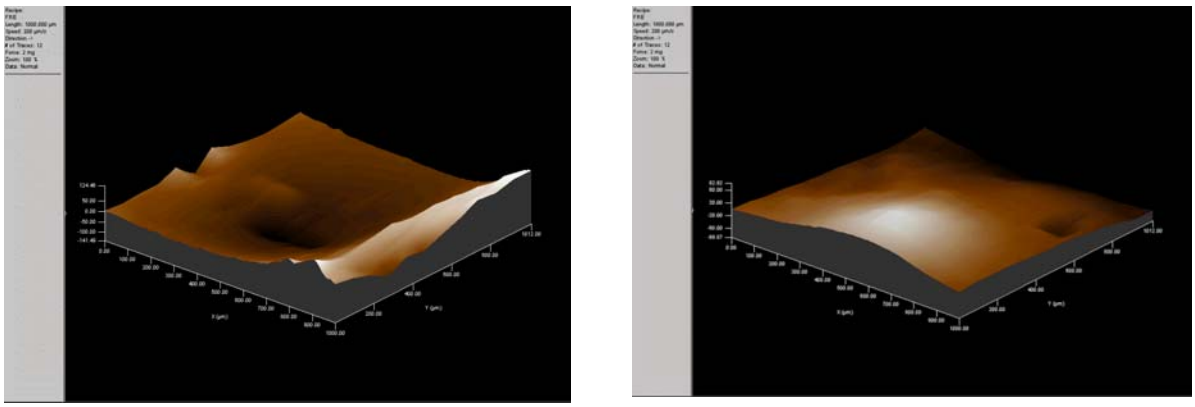

Figure 1: Surface topography of cantaloupe and pear using profilometer

- Publications, Handouts, Other Text & Web Products:

We presented following paper at 2013 Annual meeting of Institute of Food Technologists, Chicago, IL, July 13-16:

Syamaladevi, R., Adhikari, A., Lupien, S., Dugan, F., Killinger, K., Rasco, B. and Sablani, S. S. (2013) Ultraviolet-C Light Inactivation of *Penicillium Expansum* and *Escherichia Coli* on Organic Fruit Surfaces

- Outreach & Education Activities:

Workshops planned for the spring semester include Hazard Analysis and Critical Control Points (HACCP) workshops. During discussion of potential antimicrobial interventions for produce, the potential use of UV-C technology and our preliminary results will be included.

IMPACTS:

- Short-Term: Preliminary results suggest that the UV-C light can potentially reduce population of pathogenic bacteria *Listeria monocytogenes* on organic apples.
- Intermediate-Term: The information acquired will be used in designing UV C system for sanitization of organic fruit surface thus increasing the microbial safety of organic produce.
- Long-Term: The improved microbial safety and extended postharvest life of organic produce will provide economic incentives to Washington growers/packers and the organic agriculture industry. The research findings and new methods developed by this project may also lead to more environmentally-sound food production methods and improved consumer health and safety throughout the nation.

ADDITIONAL FUNDING APPLIED FOR / SECURED:

Results obtained from this study will help us to strengthen following proposals which will be resubmitted to AFRI Food Safety program:

Ultraviolet Light based Hybrid Technologies to Control Foodborne Pathogens on Fresh Produce, USDA AFRI Food Safety Program, 2014

GRADUATE STUDENTS FUNDED:

This project has supported two doctoral students: (1) Poonam Bajaj, Biological Systems Engineering, and (2) Kim Thayer, School of Food Science.

RECOMMENDATIONS FOR FUTURE RESEARCH:

Our research results have indicated that UV-C treatment alone can reduce pathogen population by 1 to 2.5 log CFU/g depending upon fruit surface properties, but effective processing technologies are needed to achieve 3 to 4 log CFU/g reduction in pathogenic microorganisms on fresh fruit surfaces. We believe that combined treatment of UV-C and electrolyzed water wash may increase the effectiveness of treatment process and realize 3 to 4 log reduction of pathogenic bacteria as desired by the regulatory agencies and the fruit industry.