Non-Thermal Processing Technologies to Inactivate Foodborne Viruses

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Norovirus

- Transmission via human feces and vomit — 30 million virions shed in one vomiting episode
- Infectious dose very low — 2-100 virions
- Incubation period 24-40 hours
- Symptoms: Nausea, vomiting, diarrhea, cramps, occasional headache and low-grade fever
- Duration: 1-2 days
Annual Burden of Norovirus Disease in the United States

- 800 Deaths
- 71,000 Hospitalizations
- 414,000 Emergency Dept Visits
- 1.7 million Outpatient Visits
- 21 million Episodes

Hall 2012 CID; Lopman 2011 CID; Gastañaduy 2012 EIS; Hall 2011 EID; Scallan 2011 EID
Foods Implicated* in Norovirus Outbreaks Reported to CDC by Commodity and Point of Contamination, 2001-2008

*Limited to outbreaks with a simple food (consisting of a single commodity) implicated.

**Insufficient or conflicting information provided in outbreak report.

Hall 2011 IAFP
Intervention/Mitigation Strategies

- Depuration and Relaying
- High Powered Ultrasound
- High Pressure Processing
- Thermal/Heat – Cooking and Pasteurization
- Non-thermal Plasma
- Irradiation
- Freezing
- Drying
- Pulsed Light including UV
- Shockwaves
High Pressure Processing (HPP)

24 L High Pressure Sterilization Unit
Max: 890 MPa @ 131°C
High Pressure Processing for Food Applications

200 elephants weighing 3000 kg each standing on a piston with a diameter of a CD, create a pressure of 600 MPa, 6000 bar or 90,000 psi.
Schematic diagram of a HPP system

Data acquisition computer

Sample holder containing pre-packaged food

Pressure-transmitting fluid

High pressure intensifier/pump

Top closure

Pressure chamber

Temperature control jacket

Bottom closure

Sample holder containing pre-packaged food

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Pressure chamber

Temperature control jacket

Bottom closure
Distribution of study subject infection status among oyster treatment groups in a HPP challenge study

<table>
<thead>
<tr>
<th>Phase</th>
<th>Treatment conditions</th>
<th>No. of subjects infected/total (%) postchallenge with:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HPP-treated oysters</td>
<td>Untreated oysters&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>1</td>
<td>400 MPa, 25°C, 5 min</td>
<td>3/5 (60)</td>
<td>7/15 (47)</td>
</tr>
<tr>
<td>2</td>
<td>600 MPa, 6°C, 5 min</td>
<td>0/10 (0)</td>
<td>7/15 (47)</td>
</tr>
<tr>
<td>3</td>
<td>400 MPa, 6°C, 5 min</td>
<td>3/14 (21)</td>
<td>7/15 (47)</td>
</tr>
</tbody>
</table>

Leon et al., 2011, AEM (77) 5476-5482
High Pressure Processing and Viruses

Grove et al., 2008

Poliovirus

Feline Calicivirus

Hepatitis A
HPP and Hepatitis A in various salt

300, 400 & 500 MPa in 15 & 30 ppt salt

FIGURE 1. Survival curves of hepatitis A virus (HAV) after high pressure treatment with 300 (×), 400 (□), and 500 (♦) MPa at room temperature in buffered medium containing salt at (a) 15 g/liter and (b) 30 g/liter. Each data point is the average log S value of triplicate quantitative assays for duplicate or triplicate samples. No infectious HAV was detected (<1.47 log TCID₅₀/ml) after 500 MPa treatment for 300 s in medium with 15 g/liter salt or for 360 s in 30 g/liter salt. Modified from Grove et al. (15).

Grove et al., 2009
MNV-1 inactivation by HPP in various food matrices

Lou et al., 2011, AEM 77(1862-1871)

More at IAFP 2014, Indianapolis
High Power Ultrasound
High-Power Ultrasound

Ultrasonic waves form bubbles via expansion and contraction
- Termed ‘Cavitation’

- Temperature 5000 k (4700°C)
- Pressure 2000 atm (30,000 PSI)
- Frequency ~20 kHz

Acoustic

Human hearing

20 kHz

Low & High Power Ultrasound

Industrial & agricultural cleaning

100 kHz

Medical uses

1 MHz

High Frequency Ultrasound
High Power Ultrasonic Transducer and Sonotrode
HPU and Produce Washing
Chlorine with High Power Ultrasound on Murine Norovirus (MNV-1)

Liu, Grove and Lee, 2009
Sanitizers – POAA on MNV-1

Log reduction of MNV-1 washed from the surface of inoculated romaine lettuce leaves after treatment with peroxycetic acid (POAA) alone or with additional high power ultrasound (HPU) at (a) 4°C or (b) 10°C.

Liu, Grove and Lee, 2009
Pulsed Light

Pulsed light is a food processing method that involves the use of intense and short duration pulses of a broad spectrum.

Xenon Steripulse XL-3000TM pulsed light system
1.27J/cm², 3 pulses/second
• Broad spectrum (100-1000nm) includes 54%, 26% and 20% of the energy at UV light, visible, and infrared region, respectively.

• Inactivation of pathogenic and spoilage microorganisms on foods and packages (surface)
MNV-1 Transfer during Chopping

Polyethylene Board

Knife

Y = -0.325X + 5.5904
r² = 0.7715

Y = -0.4717X + 7.4067
r² = 0.8625
Pulsed Light on Stainless Steel

MNV-1 Inactivation and Temperature on Stainless Steel at Distance of 10.8 cm

- Log Reduction
- Surface Temperature

R² = 0.979

Description: RD128-304 304 stainless steel coupons
Pulsed Light on Glazed Tile

MNV-1 Inactivation and Temperature on Tile Surface at Distance of 10.8 cm

Log Reduction vs. Treatment Time (s)

Surface Temperature (°C)

R² = 0.990
Pulsed Light on Plastic

MNV-1 Inactivation and Temperature on Polypropylene Surface (10.8cm)

MNV-1 Inactivation and Temperature on Polyethylene Surface (10.8cm)
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