Response of *Staphylococcus aureus* to Simulated Microgravity

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Microbiology
Goal: Mitigate microbial risk to crew health, safety, and performance during the human exploration of space
Microgravity Microbiology

- ISS microbiome
- Compromised immune system
- Altered bacterial virulence
- Mutations or expression changes?

Color-enhanced scanning electron micrograph showing Salmonella typhimurium (red) invading cultured human cells. Credit: Rocky Mountain Laboratories, NIAID, NIH
Low Shear Modeled Microgravity

- NASA-Designed Rotating Zero-Head-Space Tissue Culture Vessel
  - Rotating Wall Vessel (RWV)

- **Simulated** Microgravity

- Used to culture 3D tissue aggregates

- Alters bacterial behavior
  - Attachment independent biofilms
  - Altered virulence
S. aureus

- Opportunistic pathogen
- Common in humans
- Spaceflight isolates/Clinical isolates

- Infection models
  - Mice - skin
  - Nematodes - intestine
Virulence Assay

*S. aureus* N315 clinical isolate (MRSA)
Hyperpigmented *S. aureus*

- Spaceflight Isolate
- Increased carotenoid production
- LSMMG comparison between N315 clinical isolate and this strain
  - Biofilms
  - Growth patterns
  - Carotenoid production
Altered Carotenoid Production

<table>
<thead>
<tr>
<th></th>
<th>Absorbance at 460 nm</th>
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<tbody>
<tr>
<td>LSMMG</td>
<td>Control</td>
</tr>
<tr>
<td>0.053</td>
<td>0.080</td>
</tr>
<tr>
<td>0.116</td>
<td>0.307</td>
</tr>
<tr>
<td>0.092</td>
<td>0.169</td>
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<tr>
<td>0.099</td>
<td>0.160</td>
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<tr>
<td>Average</td>
<td>.550</td>
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<tr>
<td>Standard Dev</td>
<td>.125</td>
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LSMMG and Control values are statistically significant.

p < .05
Oxidative Stress Assays

LSMMG induced mutation or just altered expression?
Pigmented *S. epidermidis*

- Spaceflight Isolate
- Possibly the Violagabriellae variant described in the ’60s by Marples and Steele
- Unknown pigment molecule
  - Siderophore?
Pulcherrimin Gene Presence

B. subtilis  S. epidermidis

cyclodeptide synthase (Bs): Bs-γγγγγγC

cyclo(L-leucyl-L-leucyl)

putcherrinic acid synthase (Bs): Bs-γγγγγγX

putcherrinic acid

2 L-leucyl-tRNA

2 H'
2 tRNA

3 oxygen
S reduced ferredoxin

4 H₂O
S an oxidized ferredoxin

2 Fe³⁺
pulcherrimin

spontaneous
Summary

1. The virulence of *S. aureus* N315 is not significantly altered in response to LSMMG culture, as determined by a *C. elegans* infection model.

2. A hyperpigmented spaceflight isolate of *S. aureus* responds in a parallel manner to LSMMG culture as previously studied clinical isolates.

3. The identity of the pigment displayed by a *S. epidermidis* variant isolated from spaceflight is not known, but potential candidate pigments were ruled out.
Sources


