Yeast at the Edge of Space:
Exploring Viability in Eukaryotic Organisms

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Abstract

Both humans and yeast are eukaryotic organisms, and since eukaryotic cells do not survive extremely low temperatures or radiation, high altitude research provides an opportunity to explore viability using fast-growing yeast colonies to produce general hypothesis about eukaryotic organisms. A past experiment provided anecdotal evidence indicating that yeast cells subjected to the harsh conditions of the stratosphere fermented sugar into alcohol at a faster rate than grounded control yeast cells. The intention of this experiment is to scientifically verify that two different species of yeast, *Saccharomyces cerevisiae* and *Saccharomyces pastorianus*, ferment at a more rapid rate when exposed to conditions in the stratosphere. This work could be followed by experiments designed to elucidate the specific environmental cause for an increase in fermentation rate.

Hypothesis

*Saccharomyces cerevisiae* and *Saccharomyces pastorianus* subjected to the stressful conditions of the stratosphere will grow and ferment sugars at a faster rate than the control.

Introduction

Survival of microbes in the upper atmosphere could have implications in the potential transport of microbes on NASA payloads to location such as the International Space Station, moon bases, or Mars. In addition, some pathogens have recently been shown to be more virulent on the International Space Station than on Earth. Both observations provided motivation for the study of yeast in the upper atmosphere. Previously, our team sent yeast strains to the stratosphere on a COSGC payload and antidotally observed that the yeast exposed to conditions in the stratosphere fermented sugars to alcohol more rapidly than the ground control. This research focused on scientifically recording both the growth rate and fermentation rate of two different yeast strains, *S. cerevisiae* and *S. pastorianus*, to determine if the previously observed phenomenon was repeatable.
Methods

• To prepare for launch, *S. cerevisiae* and *S. pastorianus* samples were grown in YPD media at 31°C. For both strains, 1mL of sample was micro-centrifuged for each condition; inside payload, outside payload, and ground control. These were stored overnight at 4°C. Samples were transported to Eaton, CO for launch on ice.

• One week after launch, *S. cerevisiae* and *S. pastorianus* samples (inside payload, outside payload, ground) were grown in test tubes with 15 mL of YPD media at 31°C.

• Between 0 – 35hrs, 1mL samples were pipetted from each condition into micro-cuvettes for spectroscopy readings at 660nm to obtain the growth rate. These samples were subsequently used in refractometry to ascertain glucose consumption.

• Growth rates were calculated between 12 – 16hrs during the exponential phase of yeast growth.

Data

![Growth rates graph]

<table>
<thead>
<tr>
<th></th>
<th>Growth rate (hr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground S. cerevisiae</td>
<td>0.1</td>
</tr>
<tr>
<td>Inside S. cerevisiae</td>
<td>0.2</td>
</tr>
<tr>
<td>Outside S. cerevisiae</td>
<td>0.3</td>
</tr>
<tr>
<td>Ground S. pastorianus</td>
<td>0.2</td>
</tr>
<tr>
<td>Inside S. pastorianus</td>
<td>0.3</td>
</tr>
<tr>
<td>Outside S. pastorianus</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Fig 1. Growth rates for *S. cerevisiae* and *S. pastorianus* for samples flow outside the payload, inside the payload and the ground control.

![S. pastorianus Attenuation](image1)

Fig 2. Glucose consumption for *S. pastorianus* for samples flow outside the payload, inside the payload, and the ground control.

![S. cerevisiae Attenuation](image2)
Conclusions

*Saccharomyces cerevisiae* and *Saccharomyces pastorianus* were subjected to the stressful conditions of the stratosphere both inside and outside of the payload. The lowest recorded temperature inside the payload was recorded at 15°C and the lowest recorded temperature outside of the payload was -28°C. These strains were compared to a ground control that was stored at 4°C. For both strains, the growth rates were higher in the launched payload samples than the ground control, with the externally exposed yeast having the fastest growth rate (Fig 1).

The fermentation data for *S. pastorianus* indicated that the consumption of glucose was most rapid in the ground control, followed by the inside payload sample and finally the outside payload sample (Fig 2). The fermentation data for *S. cerevisiae* appears to indicate that the consumption of glucose was similar for the ground and inside payload samples and less rapid in the outside payload sample (Fig 3). However, this data should be normalized to the number of live cells capable of fermenting. This data is currently being collected.