Impact of variable light intensities and wavelengths on growth and oxygen production of algae cultivated under low-pressure conditions relevant to Mars and their differential gene expression analysis.

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Human exploration of extraterrestrial environments poses unique challenges for the biology of photosynthetic organisms intended for use in greenhouses for extraterrestrial habitats. The challenges include alterations in atmospheric pressure and exposure to varying light spectra. Greenhouse, such as those on Mars and the moon, often incorporate low atmospheric pressures and variable light spectra to overcome engineering limitations. Here we investigate the growth and oxygen generation of *Chlorella vulgaris*, *Chloromonas brevispina*, and *Dunaliella salina* under combined stressors of low-pressure (160 mbar), low light intensity (500µmol $m^{-1}s^{-2}$), and different wavelengths (red, blue, white). We also examined the differential gene expression (DEG) of extremophilic algae *C. brevispina* and *D. salina* growing under low-pressure compared to normal atmospheric conditions. The O_2 concentration and biomass production analysis of *C. vulgaris*, *D. salina* and *C. brevispina* growing under low-pressure and variable light spectra showed significant difference among the species. *C. vulgaris* produced the highest concentration of O_2 at about 19.1% with maximum carrying capacity of $140 \pm 8.88 \times 10^6$ cells/ml under white light. Whereas, *D. salina* produced 19.4% of O_2 concentration with carrying capacity of $61.5 \pm 3.82 \times 10^5$ cells/ml under red light. *D. salina* did not prefer blue light and produce maximum O_2 of 5.5%. *C. vulgaris* did not prefer red light with maximum O_2 production of 7.4%. *C. brevispina* did not produce substantial amount of O_2 under blue and red light. However under white light, *C. brevispina* produced 11% O_2 with carrying capacity of $49.3 \pm 5.68 \times 10^4$ cells/ml. The DEG analysis indicated clear difference between the transcriptome profiles of *C. brevispina* and *D. salina with* average fold change of 2-fold or higher from the control, signifying substantial variance between control and treatment groups. The Principal Component analysis (PCoA) also revealed about 70% variability among the treatment and control samples.