

The cell morphology and pigment composition of red snow algae in Japanese and Alaskan mountain ranges

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Snow algae are photosynthetic microbes that adapt to low temperature environment and grow on snow and ice surface. When they bloom, they can change color of snow from white to red or green. This phenomenon is known as "red snow" or "green snow". The coloring snow is caused by various pigments in algal cells. The algal pigments mainly consist of chlorophylls and carotenoids and have physiologic functions in their cells. Variation in snow color may be associated with environmental conditions and/or taxa of the algae. Red snow can be seen at snowfield or glaciers all over the world. However, there has been still limited information of their pigment composition and relationship with the environmental condition. In this study, we analyzed microscopic cell morphology and pigment compositions of red algal snow collected in the melting season of Japanese and Alaskan mountain regions. We aim to understand the relationship between environmental conditions and pigments of algae in each region.

Red snow sample collections were carried out in Mt. Tateyama, Toyama prefecture, Japan in June and July 2015, and on Gulkana Glacier in Alaska Range in August 2015. Algae in the samples were observed with an optical microscope. To analyze pigment composition, another samples of snow algae were filtered through a grass-fiber filter and pigments were extracted with N, N-dimethylformamide as a solvent, and then absorption spectra were measured. Pigment compositions were also analyzed using high-pressure liquid chromatography (HPLC).

Microscopy of the red snow revealed that there were various morphologies of algal cells. Red sphere, orange sphere and green sphere cells accounted for a high proportion. Green oval and orange oval cells were also present but had low abundance. Small amounts of red sphere cells, which crust shaped like petals, and red oval cells were only observed in the samples of Gulkana Glacier. Absorption spectra of pigment extracted from red snow were different among the samples and can be classified into 4 types (Type A-D) based on the absorption features. The HPLC pigment analysis showed that there were at least three major pigments (Chlorophyll *b*, Astaxanthin and Lutein) in all spectral types, and no difference in their composition among the types. The HPLC analysis revealed that the astaxanthin had two chemically distinct structures: free and ester bodies. In addition, the content of astaxanthin differed among the spectral type: a high proportion of ester body were present in Types A and C, free body and ester body were present in Type B, a high proportion of free body were present in Type D.

There was no difference in cell morphologies, but significantly different in pigment composition between Japanese and Alaskan red snow. Four spectral types (Type A-D) were present in Japanese red snow, while Type A was only present in Alaskan snow. The results indicate that red snow contains more diverse algal cells in Japan compared with in Alaska in terms of pigment compositions, probably due to different species and environmental conditions.

Keywords: snow algae, red snow, pigment composition, Astaxanthin