Abstract
The reliability of the incident light intensities, the average light intensities and the light energy supplied per unit photobioreactor volume () as indices of light conditions inside photobioreactors was investigated in cuboidal photobioreactors of various sizes. There was no good relationship between the linear growth rates of Chlorella pyrenoidosa and the incident or average light intensities in the photobioreactors of various sizes. Although the linear growth rate increased with increase in , there was much scatter of data near the curve. At a given , the linear growth rates decreased with increase in the photobioreactor depth, indicating that the light distribution inside the photobioreactor must be considered for the rational design and scale-up of photobioreactors. A concept of light distribution coefficient (Kiv) defined as the cell concentration at which 50% of the photobioreactor volume receives enough light for photosynthetic growth was therefore proposed. The linear growth rates increased with increase in Kiv but the data were scattered. At a constant Kiv, however, a linear relationship was observed between the linear growth rate and the . Similarly, when the was held constant, there was a good correlation between the Kiv and the linear growth rate. A light supply coefficient, defined as . Kiv was then proposed as an index of the light supply efficiency of photobioreactors. There was a linear relationship between the light supply coefficient and the linear growth rates of both C. pyrenoidosa and Spirulina plantensis in cuboidal photobioreactors of various sizes. However, the slopes of the curves were different for the two microorganisms. When various other types of both internally illuminated and externally illuminated cylindrical photobioreactors were used, good correlation was found between the linear growth rates of Chlorella and the light supply coefficient. This demonstrates that irrespective of the cell type, photobioreactor type and size, the proposed light supply coefficient can be used for quantitative evaluation of light condition inside the photobioreactor. It is thus a useful engineering parameter for design and scale-up of photobioreactors.