

### Determining the best parameters of the specific light uptake rates for astaxanthin production in bubble column photobioreactors

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Light intensity is most important for astaxanthin production from *H. pluvialis*. Lumostatic operation has been developed and proved as an efficient supplying method for light intensity by our research group. Lumostatic operation were performed with three different types of specific light uptake rates: cell concentration (1D), projection area (2D), and fresh weight (3D). From the lumostatic operation results, the optimum  $q_e$  value from cell concentration were obtained at  $13.5 \times 10^{-8} \mu\text{E} \cdot \text{cell}^{-1} \cdot \text{s}^{-1}$  among the various values tested and the maximal astaxanthin production was increased over 150% compared with that of the control. The optimum  $q_e$  values by cell projection area and fresh weight were found to be  $195 \mu\text{E} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$  and  $10.5 \mu\text{E} \cdot \text{g}^{-1} \cdot \text{s}^{-1}$  for astaxanthin production, respectively. The maximal astaxanthin production of the lumostatic cultures using the parameters from cell concentration and cell projection area were increased to 1.36 times and 1.22 times of the standard method, respectively. When the optimal  $q_e$  values of the three different types were compared, the lumostatic cultures using  $q_e$  based on fresh weight were reached the highest astaxanthin concentration for *H. pluvialis* cultures.