CHAPTER I

INTRODUCTION

1.1 Motivation

Carotenoids are a family of over 700 natural lipid soluble pigments that are only produced by phytoplankton, algae, plants, and a limited number of fungi and bacteria. The carotenoids are responsible for the wide variety of colors they provide in nature, most conspicuously in the brilliant yellow and red colors of fruits, vegetables and leaves. In plants and algae, carotenoids are vital participants in the photosynthetic process along with chlorophyll and other light-harvesting pigments. Carotenoids, especially astaxanthin, is a red keto-carotenoid (3,3'-dihydroxy-β-β-carotene-4,4'-dione) which attracts a great commercial interest due primarily to its versatile applications and high production costs (approximately $ 2,500-3,000 per kg) (Lorenz and Cysewski, 2000).

Astaxanthin is distinguished by its capacity to interact with chemically reactive species of oxygen known as singlet oxygen and free radical which makes it surpass the antioxidant benefits of beta-carotene, zeaxanthin, canthaxanthin, vitamin C and vitamin E. Astaxanthin has several essential biological functions including protection against oxidation of essential polyunsaturated fatty acid; protection against UV light effect; immune response; pigmentation; communication; reproductive behavior and improved reproduction (Lorenz and Cysewski, 2000).

Haematococcus pluvialis is believed to accumulate the highest level of astaxanthin in nature (Olaizola and Huntley, 2003). *Haematococcus pluvialis* accumulates astaxanthin when exposed to stress conditions, generally high irradiances (Kobayashi et al., 1992a,b) in combination with nutrient deprivation (nitrate and phosphate) (Boussiba et al., 1992), salinity effect (Sarada et al., 2001), carbon dioxide uptake effect (Sobczuk et al., 1999), etc. This strain could accumulate up to 1.5-3 wt% of astaxanthin and has gained general acceptance in aquaculture and other markets as a concentrated form of natural astaxanthin (Olaizola and Huntley, 2003).

Natural astaxanthin from *Haematococcus pluvialis* is currently produced in a two step process. In the first step, green vegetative cells are produced under controlled culture conditions, frequently indoors, using bubble columns (Lopez et al., 2006) or airlift photobioreactors (Kaewpintong et al., 2006). In the second step, green cells are exposed to stress conditions (to induce accumulation of astaxanthin, using bubble columns and tubular reactors (Lopez et al., 2006). The induction of astaxanthin depended significantly on environmental conditions and therefore various methods have been proposed to deal with the different environments. Types of reactors are also significant for the induction of astaxanthin as it could help create hydrodynamic conditions which facilitate the growth of *Haematococcus pluvialis* during the course of astaxanthin accumulation.

In this work, the unicellular green algae, *Haematococcus pluvialis* was chosen as a source of astaxanthin. Optimal induction conditions were investigated where a number of various parameters such as light intensity, nutrient concentration, initial cell concentration, light source etc. were examined subject to local environmental conditions in Thailand.

1.2 Objectives

1.2.1 To search for the most suitable conditions for the induction of astaxanthin from *Haematococcus pluvialis*, subject to local environment conditions in Thailand.

1.2.2 To compare two reactors for astaxanthin production from *Haematococcus pluvialis* in the photobioreactor.

1.3 Scopes of work

1.3.1 The induction of astaxanthin is examined subject to several parameters as indicated below:

- nutrient concentration (F1 medium concentration at harvest of vegetative cells) (dilute the nutrient solution in the range from 1X-15X of the nutrient concentration in the growth stage)
- cell density (dilute the cell concentration in the range from 1X-25X of the stock cell of $1x10^6$ cells/ml)
- light intensity (vary the light intensity by amounts of the fluorescent lamps in the range from 0-6 lamps (0.65, 2.73, 4.83, 6.50 klux).
- local environmental conditions: sunlight, air temperature, natural dark-light cycle.

1.3.2 The induction of astaxanthin is examined in the bioreactor as indicated below:

- airlift photobioreactor 2.7 L
- bubble column photobioreactor 1.5L