CHAPTER V

CONCLUSIONS, CONTRIBUTIONS AND RECOMMENDATIONS

5.1 Conclusions

The induction of astaxanthin from *Haematococcus pluvialis* NIES144 was shown to be possible by manipulating the culture conditions such as light intensity, medium dilution and cell density, and by properly selecting the appropriate type of reactor. Main findings obtained from this work can be summarized as follows:

- Astaxanthin was best induced at initial cell concentration of 10,000 cells/ml. This was equivalent to approximately 1/10 of the harvested cell concentration of 100,000 cells/ml.
- The most appropriate nutrient concentration for the induction of astaxanthin was 10 times less diluted than the spent medium during the harvest of vegetative cells.
- Astaxanthin was accumulated better in a well controlled environment system. Induction under natural condition could only achieve about 20% of the amount of astaxanthin induced under controlled conditions.
- Optimal light intensity for the induction of astaxanthin was 6.5 klux.
- Airlift system might not be suitable for the induction of astaxanthin as the size of cysts was too large to be entrained by liquid circulation induced in the airlift system. Bubble column with cone bottom was more appropriate in this case as it could generate the condition where cysts were being lifted and suspended in the solution instead of precipitate. However, due to the time limitation, the configuration of the employed airlift system was not properly examined. Airlift with tapered bottom might also provide a flow condition that could prevent the precipitation of cysts and this could be proposed as our next research topic.

5.2 Contributions

The main contribution of this work is that there exist cofactors between various induction parameters, e.g. light intensity and cell concentration, which could affect the accumulation of astaxanthin in *Haematococcus pluvialis*. The conditions proposed in this work could lead to the accumulation of astaxanthin in a relatively high percentage (comparable to the reported value). Besides, the results contribute greatly to the knowledge acquisition of the research group as the previous work already presented the success in the cultivation of vegetative cells in airlift photobioreactor. In other words, the results from this work help fulfill the life cycle of the production of astaxanthin as vegetative cells will be harvested and induced using the conditions proposed herein. Astaxanthin could be distributed as dry cysts or could be further extracted to remove other impurities, and the knowledge on the extraction of astaxanthin from the cells of *Haematococcus pluvialis* would finally complete the cycle.

5.3 Recommendations

Experiments in this work generally took a relatively long time which does not allow adequate repetition of the work and this affects the creditability of the results. This issue needs to be revisited to improve the confidence level of the results.

As mentioned in Section 5.1, this work still has not fulfilled the main objective on the most appropriate reactor configuration for the induction of astaxanthin from *Haematococcus pluvialis*. The use of bubble column as proposed in this work might not be convenient as cells have to be transferred from the airlift cultivation system (for vegetative cells) to bubble columns (for cysts). This issue has to be further investigated in more detail. For instance, apart from the design of the reactor bottom that needs to be tapered, other appropriate factors in airlift reactor such as superficial gas velocity (u_{sg}), ratio between downcomer and riser cross section area (A_d/A_r) should be examined. Scale up of such system is also one of the area which should be visited to ensure the target of commercialization of this system.