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**The Thesis Submitted for the Degree of Ph.D (in the field of  
Biotechnology Science)**

**Study of the effect of elicitors for the  
production of biomass, astaxanthin,  
fatty acids and gene expression in the  
microalga (*Haematococcus lacustris*)**

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## Abstract

Astaxanthin is a valuable and expensive substance with medicinal, food, cosmetic and other uses. This substance is produced by a few organisms such as some microalgae, fungi, plants and marine crustaceans. Among them, microalgae such as *Haematococcus lacustris* are of special importance. Many researchers have tried to increase the production of astaxanthin by various methods such as biotechnology, inducers, stresses and various culture media. In this study, the effect of different concentrations of linoleic acid (0, 30 and 60  $\mu\text{M}$ ) and titanium dioxide nanoparticles ( $\text{TiO}_2$  NPs) and silicon dioxide nanoparticles ( $\text{SiO}_2$  NPs) each with concentrations of 0 and 40 mg/l as inducers for increasing production of biomass and astaxanthin were investigated in *Haematococcus lacustris* microalga in two completely randomized designs. Types and percentages of fatty acids were measured by Gas Chromatography method, also expression of two important genes of astaxanthin metabolic pathway, *crtO* and *crtR*, evaluated in the microalgae *Haematococcus lacustris* under the mentioned treatments. The pathways of oxylipine in plants and the biosynthesis of astaxanthin in algae have been studied in order to find possible common genes between these creatures. The results showed that 30  $\mu\text{M}$  linoleic acid and  $\text{TiO}_2$  NPs 40mg/l treatments had the highest production of biomass and astaxanthin, as well as Palmitic and Linoleic acid in 60 and 30  $\mu\text{l}$  linoleic acid treatments, Also, *crtO* and *crtR* genes showed the highest expression in 30  $\mu\text{M}$  linoleic acid and  $\text{SiO}_2$  NPs 40mg/l treatments, respectively. There was a direct correlation between production of astaxanthin, biomass and 30  $\mu\text{M}$  linoleic acid with *crtO* gene. No similarity was observed between plants and microalgae in the oxylipine pathway. Due to the added value and domestic and global needs of Astaxanthin, it is suggested that in the future more researchs be done both in the field of biotechnology (genetic engineering) and in the field of using cheap inducers on microalgae and different Producing creatures to produce more of this valuable substance.

Key Words: *crtO*, *crtR*, *Haematococcus Lacustris*, Astaxanthin, Nano particles, Linoleic acid