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# Physico-chemical Variables of Ambient Media and Astaxanthin Content of Mangroves in Hooghly-Matla Estuarine Complex of Indian Sundarbans

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## Abstract

Astaxanthin, one of the naturally occurring carotenoid pigments possessing strong antioxidant property, has been pointed to play an essential role in the protection against peroxidation of lipid and oxidative damage of LDL cholesterol, cell membrane, cells and tissues. The salt tolerant mangrove vegetation present in the deltaic lobe of Indian Sundarbans has been documented as one of the prime sources of astaxanthin. This paper reflects the accumulation pattern of astaxanthin in six species of mangroves namely- *Avicennia officinalis*, *Avicennia alba, Avicennia marina*, *Sonneratia apetala*, *Aegiceros corniculatum* and *Bruguiera gymnorrhiza* at ten different stations having different environmental conditions in the Hooghly-Matla estuarine complex of Indian Sundarbans. Although these six species share the same brackish water media, but significant variation in the leaf astaxanthin level confirms the concept of species specificity and effects of various Physico-chemical factors in terms of this secondary carotenoid.

**Keywords**
Astaxanthin, salt tolerant mangroves, Indian Sundarbans

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## INTRODUCTION

Astaxanthin is one of the members of carotenoid pigment family. These molecules are associated with many of the natural colours observed in vegetative parts of plants. This pigment is very unique in nature and is probably well known for eliciting the pinkish-red hue in the flesh of marine fish and crustaceans. In marine ecosystem, astaxanthin is biosynthesized by microalgae or phytoplankton. Microalgae being primary producer are consumed by zooplankton, insects or crustaceans that accumulate these secondary carotenoids and these, in turn, are taken up by larger animals that will then take on a pinkish-red colour [1]. In nature, a typical xanthophyll-producing unicellular microalga is *Haematococcus pluvialis*, well known for its massive accumulation of ketocarotenoids, mainly astaxanthin upto 4% of its dry mass and its acyl esters, in response to various

stress conditions, e.g. nutrient deprivation or high irradiation [2,3]. Also, the yeast *Phaffia rhodozyma* has been widely used for astaxanthin production in fed-batch fermentation processes using low cost materials as substrates [4-6]. Because of antioxidative properties and the increasing amounts of astaxanthin needed as a supplement in the aquaculture of salmonoids and other seafood [7], there is growing interest in the biotechnological production of astaxanthin. The present paper is the outcome of a research endeavour taken during postmonsoonal season, 2017 to search the mangrove vegetation in the Indian Sundarbans region for astaxanthin in diverse environmental conditions of estuarine complex. This deltaic lobe is situated at the apex of the Bay of Bengal and has been designated as World Heritage site for its marvelous genetic diversity with respect to mangroves and its associated flora and fauna. Mangroves are special types of vegetation, usually restricted in the coastal areas and are characterized with the presence of special adaptive features like presence of stilt roots, pnematophores, prop roots and salt glands in their leaves. 34 species of true mangroves in the present geographical locale are documented having various ecological, pharmaceutical and economic utilities [8-10], but only six dominant species at ten different stations were selected for the present study.

## MATERIALS AND METHODS

The present programme consists of the sampling of the leaves of selected mangrove species during the low tide period from ten different stations, namely Canning, Gosaba, Bali Island, Chotomollakhali Island, Jharkhali, Sagar Lighthouse, Kachuberia, Chemaguri, Harinbari and Henry's Island located in the eastern and western sector of Indian Sundarbans (Table 1). Salinity, pH, surface water temperature, dissolved oxygen and nutrient load of the ambient water were analysed simultaneously to pinpoint hydrological parameters to which the vegetation are exposed in natural condition. The collected leaves were thoroughly washed with ambient water followed with deionized water and oven dried at $110^0$C overnight. The extraction of carotenoid were separately carried out for each species through Dimethyl sulphoxide (DMSO) with maximum absorbance (approximately 471-477nm) against an acetone blank on the spectrophotometer and finally converted to astaxanthin percent as per the expression:

**Carotenoid (mg) extracted= Abs. Max. / 250 × 25ml acetone × dilution**

**Percent Astaxanthin = Carotenoid (mg) extracted / sample wt (mg) × 80**

**Table 1: Co-ordinates of selected stations located in Hooghly-Matla estuarine complex of Indian Sundarbans**

| Station | Latitude | Longitude |
|---|---|---|
| Canning | 22°18′37.01"N | 88°40′36.03" E |
| Gosaba | 22°15' 45.03" N | 88° 39'46.01" E |
| Bali Island | 22º04'35.17'' N | 88º44'55.70'' E |
| Chotomollakhali Island | 22º10'21.74'' N | 88º53'55.18'' E |
| Jharkhali | 22°02′49.17′′ N | 88°39′39.82′′ E |
| Sagar Lighthouse | 21°38′54.37′′ N | 88°03′06.17′′ E |
| Kachuberia | 21°52′26.50′′ N | 88°08′04.43′′E |
| Chemaguri | 21°39′58.15′′ N | 88°10′07.03′′ E |
| Harinbari | 21°47′01.36′′ N | 88°04′52.98′′ E |
| Henry's Island | 21°34'12.03′′ N | 88°18'01.05" E |

## RESULTS

The Physico-chemical variables namely, surface water pH, temperature, dissolved oxygen concentration, concentration of $NO_3$, $PO_4$ and $SiO_3$ are tabulated in Table 2. Astaxanthin concentrations in 6 different mangrove species selected for this study during postmonsoon, 2017 are shown in Figure 2. Astaxanthin concentration was found to range from 53.03 ppm dry wt. (in case of *Bruguiera gymrorrhyza* in Kachuberia) to 896.13 ppm dry wt. (In case of *Avicennia alba* in Henry's island).

**Table 2: Physico-chemical variables of aquatic environment of ten selected stations during postmonsoon, 2017**

| Stations | pH | Temp ($^0$C) | Salinity ($^0/_{00}$) | DO (mg/l) | $NO_3$ (µgat/l) | $PO_4$ (µgat/l) | $SiO_3$ (µgat/l) |
|---|---|---|---|---|---|---|---|
| Canning | 7.2 | 24.8 | 8.91 | 4.7 | 17.65 | 2.22 | 65.90 |
| Gosaba | 7.3 | 24.5 | 15.64 | 5.4 | 15.20 | 1.89 | 73.10 |
| Bali Island | 7.3 | 24.0 | 23.86 | 6.4 | 13.80 | 1.26 | 80.05 |
| Chotomollakhali Island | 7.2 | 27.5 | 21.09 | 5.3 | 8.94 | 0.91 | 54.87 |
| Jharkhali | 7.4 | 27.6 | 24.99 | 6.1 | 8.68 | 0.56 | 96.82 |
| Sagar Lighthouse | 7.7 | 27.8 | 27.32 | 5.6 | 10.05 | 1.25 | 108.57 |
| Kachuberia | 7.3 | 26.4 | 6.46 | 4.8 | 16.88 | 2.05 | 79.44 |
| Chemaguri | 7.4 | 25.9 | 26.09 | 5.0 | 14.10 | 1.85 | 85.21 |
| Harinbari | 7.5 | 26.0 | 25.01 | 4.9 | 13.85 | 1.39 | 80.52 |
| Henry's Island | 7.8 | 27.8 | 28.05 | 6.3 | 15.29 | 1.62 | 116.59 |

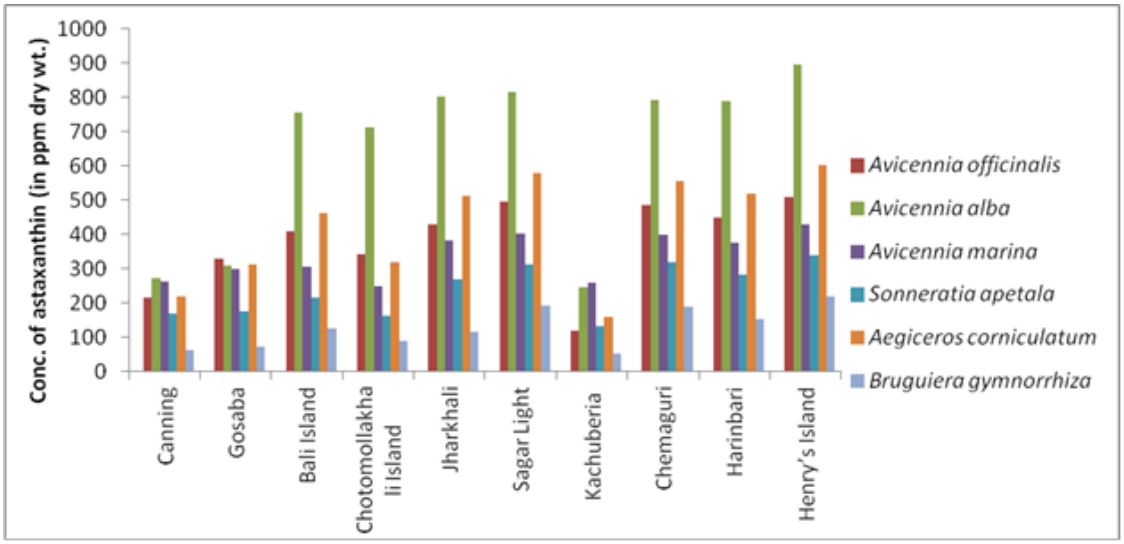


**Figure 2: Concentrations of astaxanthin in selected mangrove species in selected stations during postmonsoon, 2017**

## DISCUSSION

The astaxanthin content in most of the mangrove plants in this study are quite high confirming stressful condition of ambient media [11-14], which may arise from hypersalinity of aquatic compartment. This is evident from the strong positive correlation between surface water salinity and astaxanthin content of mangrove leaves ($p < 0.01$) (Table 3). To establish this fact, extensive research in future is essential. The present paper may be regarded as baseline information in consequence to relationship between physico-chemical variables of ambient media and astaxanthin content of different mangrove leaves. The finding that under stressful condition astaxanthin concentration is increasing may provide a route map of new research trend towards production of considerable amount of astaxanthin under hypersaline condition in future. This may be an adaptation of the mangrove species in stressed conditions. Figure 2 provides an insight of species wise differential production of astaxanthin, which may lead to another route of biochemical research to find the most potent candidate species of mangrove for production of astaxanthin.

**Table 3**: **Inter-relationship between astaxanthin content of mangrove species and physico-chemical variables in the study area**

| Sl.no. | Combinations | 'r' value | 'p' value |
|---|---|---|---|
| 1. | *Avicennia officinalis* × pH | 0.64880 | P < 0.01 |
| 2. | *Avicennia officinalis* × Temperature | 0.31761 | IS |
| 3. | *Avicennia officinalis* × Salinity | 0.90224 | P < 0.01 |
| 4. | *Avicennia officinalis* × Dissolved oxygen | 0.50670 | P < 0.05 |
| 5. | *Avicennia officinalis* × $NO_3$ | -0.44646 | P < 0.05 |
| 6. | *Avicennia officinalis* × $PO_4$ | -0.51662 | P < 0.05 |
| 7. | *Avicennia officinalis* × $SiO_3$ | 0.47465 | P < 0.05 |
| 8. | *Avicennia alba* × pH | 0.62940 | P < 0.01 |
| 9. | *Avicennia alba* × Temperature | 0.51083 | P < 0.01 |
| 10. | *Avicennia alba* × Salinity | 0.96558 | P < 0.01 |
| 11. | *Avicennia alba* × Dissolved oxygen | 0.67963 | P < 0.01 |
| 12. | *Avicennia alba* × $NO_3$ | -0.61590 | P < 0.01 |
| 13. | *Avicennia alba* × $PO_4$ | -0.67381 | P < 0.01 |
| 14. | *Avicennia alba* × $SiO_3$ | 0.55255 | P < 0.01 |
| 15. | *Avicennia marina* × pH | 0.87393 | P < 0.01 |
| 16. | *Avicennia marina* × Temperature | 0.44764 | P < 0.05 |
| 17. | *Avicennia marina* × Salinity | 0.81236 | P < 0.01 |
| 18. | *Avicennia marina* × Dissolved oxygen | 0.41644 | P < 0.05 |
| 19. | *Avicennia marina* × $NO_3$ | -0.78594 | P < 0.01 |
| 20. | *Avicennia marina* × $PO_4$ | -0.25872 | IS |
| 21. | *Avicennia marina* × $SiO_3$ | 0.85821 | P < 0.01 |
| 22. | *Sonneratia apetala* × pH | 0.52928 | P < 0.01 |
| 23. | *Sonneratia apetala* × Temperature | 0.43877 | P < 0.05 |
| 24. | *Sonneratia apetala* × Salinity | 0.86011 | P < 0.01 |
| 25. | *Sonneratia apetala* × Dissolved oxygen | 0.40087 | P < 0.05 |
| 26. | *Sonneratia apetala* × $NO_3$ | -0.26869 | IS |
| 27. | *Sonneratia apetala* × $PO_4$ | -0.23662 | IS |
| 28. | *Sonneratia apetala* × $SiO_3$ | 0.79922 | P < 0.01 |
| 29. | *Aegiceros corniculatum* × pH | 0.80741 | P < 0.01 |
| 30. | *Aegiceros corniculatum* × Temperature | 0.38945 | P < 0.05 |
| 31. | *Aegiceros corniculatum* × Salinity | 0.96114 | P < 0.01 |
| 32. | *Aegiceros corniculatum* × Dissolved oxygen | 0.55824 | P < 0.01 |
| 33. | *Aegiceros corniculatum* × $NO_3$ | -0.43377 | P < 0.05 |
| 34. | *Aegiceros corniculatum* × $PO_4$ | -0.46696 | P < 0.05 |
| 35. | *Aegiceros corniculatum* × $SiO_3$ | 0.73032 | P < 0.01 |
| 36. | *Bruguiera gymnorrhiza* × pH | 0.86660 | P < 0.01 |
| 37. | *Bruguiera gymnorrhiza* × Temperature | 0.44280 | P < 0.05 |
| 38. | *Bruguiera gymnorrhiza* × Salinity | 0.86649 | P < 0.01 |
| 39. | *Bruguiera gymnorrhiza* × Dissolved oxygen | 0.41724 | P < 0.05 |
| 40. | *Bruguiera gymnorrhiza* × $NO_3$ | -0.23763 | IS |
| 41. | *Bruguiera gymnorrhiza* × $PO_4$ | -0.22043 | IS |
| 42. | *Bruguiera gymnorrhiza* × $SiO_3$ | 0.76212 | P < 0.01 |

## REFERENCES

[1] Amaya E & Nickell D, Feed and Feeding practices. In: Woodhead publishing series, Editor: D. Allen Davis. Elsevier publishers Inc. (2015) p. 12. ISBN: 978-0-08-100506-4.

[2] An GH, Jang BG & Cho MH. Cultivation of the carotenoid hyperproducing mutant 2A2N of the red yeast *Xanthophyllomyces dendrorhous* (*Phaffia rhodozyma*) with molasses. *J Bio Sci Bio Engg*, 92(1) (2001) 121-125.

[3] Banerjee K, Biswas M & Mitra A. Astaxanthin level of mangroves in Indian Sundarbans. *Sci Cul* (Indian Science News Association), 74 (5-6) (2008) 207 - 210.

[4] Banerjee K, Roy Chowdhury, M, Sengupta K, Sett S & Mitra A. Influence of anthropogenic and natural factors on the mangrove soil of Indian Sundarbans wetland. *Arch. Environ Sci.*, 6 (2012) 80-91.

[5] Chaudhuri AB & Choudhury A. Mangroves of the Sundarbans. The World Conservation Union, Bangladesh (1994) p. 17.

[6] Chekanov K, Lobakova E, Selyakh I, Semenova L, Sidorov R & Solovchenko A. Accumulation of Astaxanthin by a New *Haematococcus pluvialis* Strain BM1 from the White Sea Coastal Rocks (Russia), *Mr. Drugs*. 12 (2014) 4504-4520.

[7] Chociai MB, Machado IMP & Fontana JD. Cultivo da levedura Phaffia rhodozyma (*Xanthophyllomyces dendrorhous*) em processo descontínuo alimentado para produção de astaxantina. *Brazilian J Pharm*., 38(4) (2002) 457-462.

[8] Ekpe L, Inaku K & Ekpe V. Antioxidant effects of astaxanthin- a review. *J molecular pathophy.*, 7 (1) (2018) 1-6.

[9] Mitra A. In Sensitivity of Mangrove ecosystem to changing Climate. *Springer* ISBN 81-322-1509-7, (2013) 323 pp.

[10] Mitra A & Zaman S. Blue carbon reservoir of the blue planet, published by *Springer*, (2015) ISBN 978-81-322-2106-2107.

[11] Mitra A & Zaman S. Basics of Marine and Estuarine Ecology, *Springer* (2016) ISBN 978-81-322-2705-2.

[12] Pal N, Saha A, Biswas S, Zaman, S & Mitra A. Loss of carbon sinks with the gradual vanishing of *Heritiera fomes* from Indian Sundarbans. Research Article 4. In Environmental Coastguards - Understanding Mangrove Ecosystem and Carbon Sequestration (Climate Change Publication Series 3). (2016) ISBN: 978-81-7236-352-9, 202 - 206.

[13] Shah MR, Liang Y, Cheng JJ & Daroch M. Astaxanthin-Producing Green Microalga *Haematococcus pluvialis*: From Single Cell to High Value Commercial Products, *Front Plant Sci*., 7 (2016) 531.

[14] Vazquez M, Santos V & Parajo JC. Fed batch cultures of *Phaffia rhodozyma* in xylose containing media made from wood hydrolysates. *Food Biotech*., 12 (1998) 43-55.