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Biochemical Composition of Seaweeds from Mandapam Coastal Regions along Southeast Coast of India

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INTRODUCTION

Seaweeds have been used since ancient times as food, fodder, fertilizer and as source of medicine today seaweeds are the raw material for many industrial productions like agar, algin and carrageenan but they continue to be widely consumed as food in Asian countries [1]. They are nutritionally valuable as fresh or dried vegetables, or as ingredients in a wide variety of prepared foods [2]. In particular, certain edible seaweeds contain significant quantities of protein, lipids, minerals and vitamins [3-5], although nutrient contents vary with species, geographical location, season and temperature [6, 7].

The nutritional properties of seaweeds are not yet noted and they are usually estimated from their chemical composition alone [8, 9]. Compared to land plants, the chemical composition of seaweeds has been poorly investigated and most of the available information deals only with traditionally Japanese seaweeds [10-12]. The chemical composition of seaweeds varies with species, habitats, maturity and environmental conditions [13].

The protein content in the marine algae was estimated by [14-18]. Chidambaram and Unny [14] analyzed proteins in the species of *Sargassum*, *Turbinaria* and *Gracilaria*. Neela [15] estimated the protein, fat, calcium, phosphorous, iron, iodine and vitamin-C contents in *Gracilaria* sp. *Gracilaria lichenoides, Hypnea* sp. *a*nd *Ulva lactuca*. In CMFRI, studies were carried out on the chemical composition of the marine algae growing in the vicinity of Mandapam [16, 19-21].

Extensive works were carried out by Lewis and Gonazalves [22-27]; Lewis [28-34] on amino acids present in free state on protein and peptide hydrolysates in many green, brown and red seaweeds. A considerable amount of work on the volatile components, biochemical composition, proteins, amino acids, nutritive values, fats, lipids, vitamins and mineral composition of different species of *Enteromorpha* have been reported [35-42].

Parekh *et al*. [43] studied the chemical composition of 27 species of green seaweeds of Saurashtra coast. The biochemical contents of *Ulva lactuca*, *Sargassum swartzii* and *Gelidiella acerosa* from Port Okha were studied in relation to ecological factors by [44], presented the month-wise protein, fat, carbohydrate, crude-fibre, sodium, potassium, calcium and phosphorous contents of these species. Dhargalkar [45] estimated the major metabolites such as proteins, carbohydrates and lipids. Seasonal variations in biochemical composition of some seaweed from Goa coast was followed by [46]. Dhargalkar *et al*. [47] estimated protein, carbohydrate and organic carbon in 43 marine algal species from different stations along the Maharashtra coast.

Studies on the chemical composition of seaweeds have shown that these are good sources of minerals, trace elements [18, 20], proteins, lipids and carbohydrates [48-51]. High carbohydrate (24-44%) and lipid (6-23%) contents were reported in seaweeds in Indian shores. The caloric values are more in seaweeds [52]. Seaweeds like *Cladophora pinnulata*, *Levringia boergesenii*, *Sargassum wightii*, *Sarconema furcelatum* and *Asparagopsis taxiformis* are good sources of iodine [53].

However, only a few studies have been undertaken on the quality of seaweed protein [13, 54-56] because of the difficulties of extraction and preparation of seaweed protein concentrates (PCs). The extraction of seaweed protein by classical procedures is hindered by the presence of large amounts of cell wall polysaccharides, such as the alginates of the brown seaweed or the carrageenans of some red seaweed. The high content of neutral polysaccharides (xylans and cellulose) in some red and green seaweeds can also limit the protein accessibility

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[57]. The protein content of some red seaweeds of different coasts of India has been reported [16, 34, 46, 47]. Most studies on nutritional evaluation were carried out from all parts of the world. Hence, the present study is concentrated on different groups of seaweeds and its proximate composition of Mandapam, southeast coast of India.

MATERIALS AND METHODS

The seaweeds were collected from Mandapam coastal regions, Southeast coast of India. Seaweed sample was picked with hand and immediately washed with seawater to remove the foreign particles, sand particles and epiphytes. Then it was kept in an ice box containing slush ice and immediately transported to the laboratory and washed thoroughly using tap water to remove the salt on the surface of the sample. Then the seaweeds were spread on blotting paper to remove excess water.

Protein Estimation: The total protein was estimated using the Biuret method of Raymont *et al*. [58].

Lipid Estimation: The extraction of lipid was done by the chloroform-methanol mixture Folch *et al.* [59].

Carbohydrate Estimation: The total carbohydrate was estimated by following the Phenol-sulphuric acid method of Dubois *et al*. [60].

RESULT

Totally twelve species of seaweeds which includes 4 species (*Enteromorpha intestinalis, Enteromorpha clathrata, Ulva lactuca* and *Codium tomentosum*) from Chlorophyceaean member 5 species (*Padina gymnospora, Colpomenia sinuosa, Sargassum tenerimum, Sargassum wightii* and *Turbinaria conoides*) from Phaeophyceae (Brown algae) and 3 species (*Gracilaria folifera, Hypnea valentiae* and *Acanthophora spififerа*) from Rhodophyceae (Red algae) collected from Mandapam coastal regions southeast coast of India for proximate composition evaluation. In that protein content varied from 3.25±0.36 to 17.08±0.28%; maximum protein was recorded in *P. gymnospora* (17.08±0.28%) followed by *E. intestinalis* (16.38±0.50%) and *S. tenerimum* (12.42±0.63%). The minimum protein concentration was observed from *U. lactuca* (3.25±0.36%) followed by *C. tomentosum* (6.13±0.23%), *G. folifera* (6.98±0.08%) and *H. valentiae* (8.34±0.30%) Fig. 1.

The carbohydrate concentration of seaweeds varied from 20.47±0.50 to 23.9±0.19%, in that the maximum carbohydrate concentration was recorded from *T. conoides* (23.9±0.19%) followed by *E. intestinalis* (23.84±0.14%), *H. valentiae* (23.60±0.33%), *S. tenerimum* (23.55±0.44%), *A. spicifera* (23.54±0.10%) and *S. wightii* (23.50±0.65%). The minimum carbohydrate content was observed from *C. tomentosum* (20.47±0.50%) followed by *P. gymnospora* (21.88±1.22%), *G. folifera* (22.32±1.40%) and *C. sinuosa* (22.46±1.79%) Fig. 2.

The lipid content of seaweeds varied from 1.33±0.20 to 4.6±0.17; in that the maximum lipid content was observed from *E. clathrata* (4.6±0.17%) followed by *G. folifera* (3.23±0.13%), *C. tomentosum* (2.53±0.27%), *C. sinuosa* (2.33±0.37%) and *S. wightii* (2.33±0.37%). The minimum lipid concentration was recorded from *E. intestinalis* (1.33±0.20%) followed by *P. gymnospora* (1.4±0.30%), *S. tenerimum* (1.46±0.20%) and *U. lactuca* (1.6±0.17%) Fig 3.

DISCUSSION

The biochemical contents of *Ulva lactuca*, *Sargassum wightii* and *Gelidiella acerosa* from Port Okha were studied in relation to ecological factors by [44]. They presented the month-wise proteins, carbohydrates, fat, crude-fibre, sodium, potassium, calcium and phosphorus contents of these species. Dhargalkar [45], estimating the major metabolites such as proteins, carbohydrates, lipids, found carbohydrate is decreasing in *Ulva reticulate*, probably due to the extensive growth of the thallus. Protein values also followed the same trend while lipids did not show any significant seasonal variation. Marked changes in the chemical constituents were found to occur with change of seasons, environmental conditions as well as in the various phases of plants growth and fruiting cycle. Pillai [20, 21, 16] studied the seasonal variation in the major and minor constituents of green, brown and red algae.

The present study percentage of carbohydrate content of *H. valentiae* was higher than those of several seaweed species of the red algae genus *Hypnea* collected in Darwin Harbour [61], the Indian Tuticorin Coast [62] and coastal Hong Kong [5].

In the present study, the protein contents of *G. folifera* ranged from 7.76±0.64 to 9.63±0.75% which is similar to the earlier works in several marine algae estimated by Chidambaram and Unny [14]; Pillai [16]; Sitakara Rao and Tipnis [17, 18]. Species of *Sargassum*,

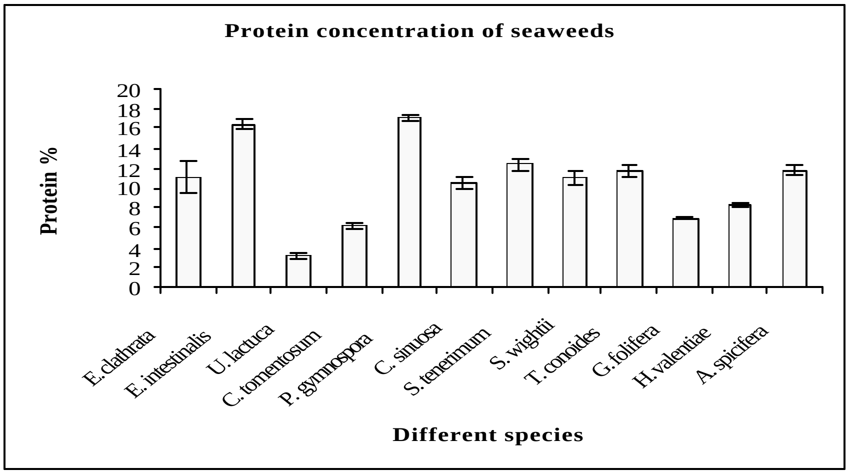

Fig. 1: Shows the protein concentration of different seaweeds

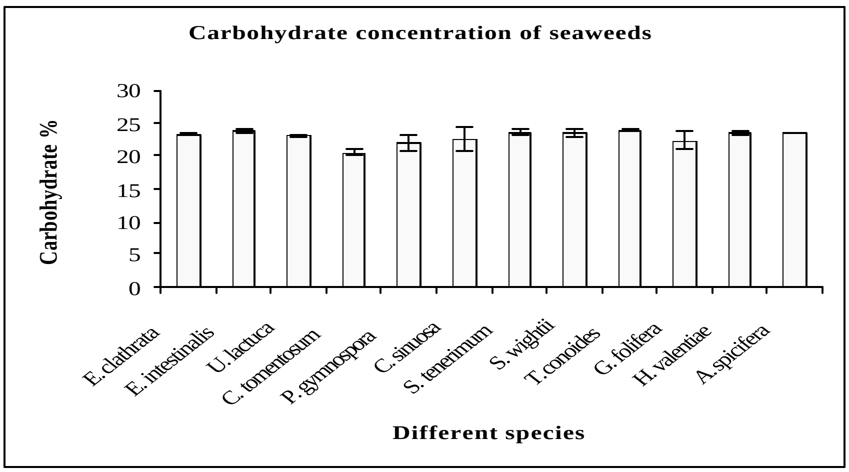

Fig. 2: Shows the carbohydrate concentration of different seaweeds

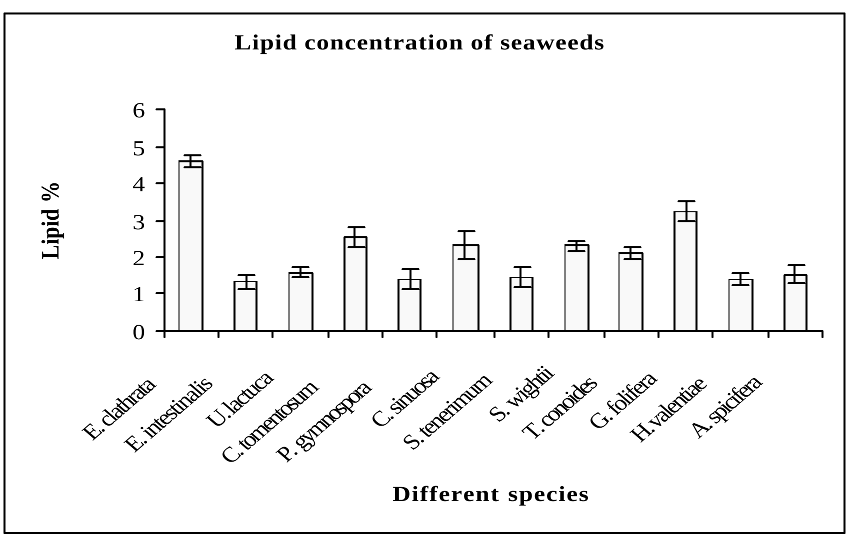

Fig. 3: Shows the lipid concentration of different seaweeds

Turbinaria and *Gracilaria* were analyzed by Chidambaram and Unny [14], the protein content was found to be less than 10% whereas in *Acanthophora muscoides* and *Centroceras clavulatum* it was estimated as 22-26%. Dave and Parekh [62] studied 8 genera of green algae of Saurashtra coast, found significant variation in protein in the same species of algae grown in different localities and different periods.

In general, seaweeds exhibit low lipid contents [63, 64]. In fact, in comparison to other chemical constituents, lipid contents were the smallest component observed for the species studied. The lipid content of the seaweeds significantly varies throughout the year. The present investigation exhibit lipid content of *P. gymnospora* (1.4±0.30%),

S. tenerimum (1.46±0.20%) and *U. lactuca* (1.6±0.17%) values were smaller than those obtained for most of the seaweeds, which range from 2.80±0.23% to 3.49±0.28 %. This value is relatively low; it is comparable to results obtained previous studies [65]. The literature has established that in seaweeds in general the lipid content is less than 4% [66]. The differences could have been due to factors such as climate and geography of development of the seaweed. The percentages of lipid found in this study were slightly higher than previous reports for Phaeophytes, Chlorophytes and Rhodophytes [66-68].

REFERENCE

1. Mishra, V.K., F. Temelli, P.F. Ooraikul Shacklock and J.S. Craigie, 1993. Lipids of the red alga *Palmaria palmata*. Botanica Marina, 36 (2): 169-174.
2. Robledo, D. and Y.F. Pelegrin, 1997. Chemical and mineral composition of edible seaweed species of Yucatan. Botanica Marina, 45: 58-65.
3. Norziah, M.H. and Y. Ching Ch, 2002. Nutritional composition of edible seaweeds *Gracilaria changgi*. Food Chemistry, 68: 69-76.
4. Sanchez-Machado, D.I., J. Lopez-Hernandez and P. Paseiro-Losada, 2002. High-performance liquid chromatographic determination of "-tocopherol in macroalgae. J. Chromatography, 976: 277-284.
5. Wong, K.H. and P.C.K. Cheung, 2000. Nutritional evaluation of some subtropical red and green seaweeds. Part I-proximate composition, amino acid profiles and some physico-chemical properties. Food Chemistry, 71: 475-482.
6. Dawes, C.J., C. Kovach and M. Friedlander, 1993. Exposure of *Gracilaria* to various environmental conditions II. The effect on fatty acid composition. Botanica Marina, 36: 289-296.
7. Kaehler, S. and R. Kennish, 1996. Summer and winter comparisons in the nutritional value of marine macroalgae from Hong Kong. Botanica Marina, 39: 11-17.
8. Darcy-Vrillon, B., 1993. Nutritional aspects of the developing use of marine macroalgae for the human industry. Intl. J. Food Sci. Nutrition, 44: 23-35.
9. Mabeau, S. and J. Fleurence, 1993. Seaweed in food products: Biochemical and nutritional aspects. Trends in Food Sci. Technol., 4: 103-107.
10. Fujiwara-Arasaki, T., N. Mino and M. Kuroda, 1984. The protein in human nutrition of edible marine algae in Japan. Hydrobiologia., 116/117: 513516.
11. Nisizawa, K., H. Noda, R. Kikuchi and T. Watanabe, 1987. The main seaweed foods in Japan. Hydrobiologia, 151/152: 5-29.
12. Watanabe, T. and K. Nisizawa, 1984. The utilization of wakame (*Undaria pinnatifida*) in Japan and manufacture of “haiboshi wakame” and some its biochemical and physical properties. Hydrobiologia, 116/117: 106-111.
13. Ito, K. and K. Hori, 1980. Seaweed: Chemical composition and potential uses. Food Review International, 5: 101-144.
14. Chidambaram, K. and M.M. Unny, 1953. Note on the value of seaweeds as manure. Ist Intl. Seaweed Symposium., pp: 67-68.
15. Neela, M.V., 1956. Analysis of seaweeds. Home. Sci. Bull. Women`s Christian Coll. Madras.
16. Pillai, V.K., 1957 a. Chemical studies on Indian seaweeds. II: Partition of Nitrogen. Proceedings of Indian Academic Sci., B 45: 43-63.
17. Sitakara Rao, V. and U.K. Tipnis, 1964. Protein content of marine algae from Gujarat coast. Current Sci., 33: 16-17.
18. Sitakara Rao, V. and U.K. Tipnis, 1967. Chemical constituents of marine algae from Gujarat coast. Proceeding and Seminar in Sea Salt and Plants, CSMCRI, Bhavanagar, pp: 277-288.
19. Pillai, V.K., 1955. Observations on the ionic composition of bluegreen algae growing in saline lagoons. Proceeding of National Institute of Science, India, 21: 90-102.

20. Pillai, V.K., 1956. Chemical studies on Indian seaweeds. I: Mineral constituents. Proceeding of Indian Academic Science, B 45: 3-29.
21. Pillai, V.K., 1957b. Chemical studies on Indian seaweeds. III: Partition of Sulphur. Proceeding of Indian Academic Science B 45: 101-121.
22. Lewis, E.J. and E.A. Gonzalves, 1959 a. Studies on the free amino acid contents of some marine algae from Bombay. J. Bombay University, 28: 1-5.
23. Lewis, E.J. and E.A. Gonzalves, 1959b. Aminoacid contents of the erect and creeping fronds of species of *Caulerpa* from Bombay. J. Marine Biological Association of India, 1: 54-56.
24. Lewis, E.J. and E.A. Gonzalves, 1959 c. Studies on the free aminoacid contents of species of *Caulerpa* from Bombay. J. Marine Biological Association of India, 1: 203-205.
25. Lewis, E.J. and E.A.Gonzalves, 1962 a. Studies on the protein, peptide and free aminoacids in cystocarpic and tetrasporic plants of *Agardhiella roubusta* from Bombay. New Phytology, 61: 288-290.
26. Lewis, E.J. and E.A. Gonzalves, 1962 b. The protein, peptide and free amino acid contents of some species of marine algae from Bombay. Annals of Botany. N.S, 26: 301-316.
27. Lewis, E.J. and E.A. Gonzalves, 1962 c. Periodic studies of the proteins, peptides and free aminoacid in *Enteromorpha prolifera*, *E. capillaris* and *Ulva lactuca* var.*rigida*. Annals of Botany, N.S, 26: 317-327.
28. Lewis, E.J., 1962 a. Studies on the proteins, peptides and free aminoacid contents in some species of *Padina* from South-eastern coast of India. Current Sci., 31: 90-92.
29. Lewis, E.J., 1962 b. Studies on the proteins, peptides and free aminoacid contents in some species of brown algae from South-eastern coast of India. Review of Algalogy, 6: 209-216.
30. Lewis, E.J., 1963 a. Studies on the proteins, peptides and free aminoacid contents in some species of marine algae form South-eastern coast of India. Review of Algology, 7: 15-25.
31. Lewis, E.J., 1963 b. Studies on the proteins, peptides and free aminoacid contents in some species of *Acanthopora* from South east coast of India. Review of Algalogy, 7: 237-241.
32. Lewis, E.J., 1963 c. Studies on the proteins, peptides and free aminoacid contents in some species of red algae from south-eastern coast of India. Proceeding of National Institute of Science., India, 29: 137-145.
33. Lewis, E.J., 1963 d. Studies on fortnightly analysis of the proteins, peptides and free amino acids in some marine algae from Bombay. Proceeding of National Institute of Sci., 29:363-386.
34. Lewis, E.J., 1967. A review of protein, peptide and free aminoacid contents of Indian Marine Algae. Proceeding and Seminar on Sea Salt and Plants, CSMCRI, Bhavanagar, pp: 296-308.
35. Miller, C.D., 1927. Food values of Poi Tard and Limu. Bernice P Bishopmus Bulletin., 37: 1-25.
36. Katayama, A., 1962. Volatile constituents. In (R. A. Lewin, Ed.) Physiology and Biochemistry of Algae, Academic Press, New York, pp: 467-473.
37. Kanazava, A., 1962. Studies on the vitamin B complex in marine algae. On vitamin content. Food. Fish., Kagoshima University, 10: 31-69.
38. Takagi, M., 1975. Seaweed as medicine. In: Advance of Phycology in Japan (Jan Tokida and H. Hirose Jena, G. Fisher, Ed.) pp: 321-325.
39. Piferrer, D., 1979. Constitution and potentialities of Caribbean marine algae in Pharmacology. In Marine Algae in Pharmaceutical Sci., 1: 473-478.
40. Pohl, P.C. and F. Zurheide, 1979. Fatty acids and lipids of marine algae and control of their biosynthesis in environmental factors. In Marine Algae in Pharmaceutical Sci., 1: 473-478.
41. Bonotto, S., 1979. List of multicellular algae of commercial uses. In Marine Algae in Pharmaceutical Science., 1: 121-138.
42. Yamamoto, T., Y. Otsuka, M. Okazaki and K. Okamoto, 1979. The distribution of chemical elements in algae. In (Hoppe, H. A., T. Levring and Y. Tanaka, Eds.) Marine algae in Pharmaceutical Science., Berlin: Walter de Gruyter, 569607. Chapman, V.J., 1979. Seaweeds in pharmaceuticals and medicine. Review in Marine Algae in Pharmaceutical Sci., pp: 140.
43. Parekh, R.G., L.V. Maru and M.J. Dave, 1977. Chemical composition of green seaweeds of Saurashtra Coast. Botanica Marina, 20: (6): 359-362.
44. Murthy, M.S. and Radia, 1978. Eco-biochemical studies on some economically important intertidal algae from Port Okha (India). Botanica Marina, 21(7): 417-422.
45. Dhargalkar, V.K., 1979. Biochemical studies on *Ulva reticulata* Forsskal. Proceeding International Symposium on Marine Algae of the Indian Ocean Region, CSMCRI, Bhavnagar, pp: 40.

46. Sumitra Vijayaragavan, M., D. Rajagopal and M.V.M. Wafar, 1980. Seasonal variations in biochemical composition of seaweeds from Goa coast. Indian J. Marine Sci., 9(1): 61-63.
47. Dhargalkar, V.K., T.J. Jatap and A.G. Untawale, 1980. Biochemical constituents of seaweeds along the Maharastra coast. Indian J. Marine Sci., 9(4): 297-299.
48. Reeta Jayasankar, J.R. Ramalingam and N. Kaliaperumal, 1990. Biochemical composition of some green algae from Mandapam coast. Seaweed Research Utilisation, 12 (1and2): 37-40.
49. Kaliaperumal, N., J.R. Ramalingam, S. Kalimuthu and R. Ezhilvalavan, 2002. Seasonal changes in growth, biochemical constituents and phycocolloid of some marine algae of Mandapam coast. Seaweed Research Utilisation, 24(1): 3-77.
50. Roslin, A.S., 2001a. Seasonal variation in the carbohydrate content of some marine algae in relation to environmental parameters in the Arockiapuram Coast. Seaweed Research Utilisation, 23: 109-118.
51. Roslin, A.S., 2001b. Seasonal variation in the lipid content of some marine algae in relation to environmental parameters in the Arockiapuram Coast. Seaweed Research Utilisation, 25: 77-86.
52. Nageswara Rao, I., R. Ratnakumari and G. Kurpanidhi, 1999. Biochemical composition of some marine algae along the Visakhapatnam Coast, East coast of India. In: Recent trends in Algal Research, (G. Subbarangiah, Ed.), Department of Botany andhra University, Waltair, pp: 129-138.
53. Reddy, M.P., S.H. Zaidi, Vasuki Subramanian and P.V. Subba Rao, 2004. Seasonal variation in iodine content of promising iodine yielding seaweeds of Indian coast. Seaweed Research Utilisation, 26: 159-166.
54. Dam, R., S. Lee, P.C. Fry and H. Fox, 1986. Utilization of algae as a protein source for humans. J. Nutrition, 65: 376-382.
55. Amano, H. and H. Noda, 1990. Proteins of protoplast from red alga *Porphyra yezoensis*. Bulletin Japan. Society of Science of Fish, 56: 1859-1864.
56. Fleurence, J., 1999 a. Seaweed proteins: Biochemical, nutritional aspects and potential uses. Trends Food Sci. Technol., 10: 25-28.
57. Fleurence, J., 1999 b. The enzymatic degradation of algal cell walls: A useful approach for improving protein accessibility? J. Applied Phycol., 11: 313-314.
58. Raymont, J.E.G., J. Austin and E. Lineford, 1964. Biochemical studies on zooplankton. 1. The biochemical composition of *Neomycis integer*. J. Cans. Perm. Emplor. Mer., 28: 354-363.
59. Folch, J., M. Lees and G.H. Solane Stanley, 1956. A simple method for the isolation and purification of total lipids from animal tissues. J. Biological Chemistry, 226: 497-509.
60. Dubois, M., K.A. Giles, J.K. Hamilton, P.A. Rebors and F. Smith, 1956. Calorimetric method for determination of sugars and related substances. Analytical Chemistry, 28: 350-356.
61. Renaud, S.M., G. Lambridinis, T. Luong-Van, D.L. Parry and C. Lee, 1997. Chemical composition of algae for use in *Trochus niloticus* studies. In:.L. Lee and P. W Lynch, Eds.), Trochus: Status, Hatchery Practice and Nutrition, Australian Centre for International Agricultural Research, Canberra, 88-96.
62. Kumar, V., 1993. Biochemical constituents of marine algae from Tuticorin coast. Indian J. Marine Sci., 22: 138-140.
63. Dave, M.J. and R.G. Parekh, 1975. Protein content of green seaweeds from the Sourashtra coast. Salt Research India, 11(2): 41-44.
64. Dawes, C.J., 1998. Marine Botany. John Wiley and Sons, Inc., New York, pp: 480.
65. Integaard, M. and J. Minsaas, 1991. In animal and human nutrition. Seaweed Resources in Europe. Uses and Potential (Guiry, M.D. and G. Blunden, Eds.) John Wiley and Sons, 21-64.
66. Herbetreau, F., L.J.M. Coiffard, A. Derrien and Y. De Roeck-Holzhauer, 1997. The fatty acid composition of five species of macroalgae. Botanica Marina, 40: 25-27.
67. Banaimoon, S.A., 1992. Fatty acids in marine macroalgae from Southern Yemen (Hadramout) including occurrence of Eicosatetraenoic (20:4) and Eicosapentaenoic (20:5) acids. Botanica Marina, 33: 165-168.
68. Mercer, J.P., K.S. Mai and J. Donlon, 1993. Comparative studies on the nutrition of two species of abalone, *Haliotis tuberculata* Linnaeus and *Haliotis discus hannai* Ino. I. Effects of algal diets on growth and biochemical composition. Invertebrate Reproductive Development, 23: 2-3.