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Research article

SEAWEED SUPPLEMENTATION TO PREVENT IODINE DEFICIENCY

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ABSTRACT: Iodine is considered as one of the essential elements for the proper functioning of the hormones of human and animal thyroid glands. In many parts of the world iodine deficiency disorders develop because of deficiency of iodine in water and food supply. An iodine deficient goitrous mother may give birth to a cretinous baby because the fetus requires an adequate secretion of thyroxine during the later stages of pregnancy. Seaweed has such a large proportion of iodine compared to dietary minimum requirements, that it is primarily known as a source of this nutrient. A trial study on supplementation of iodine rich seaweed *Caulerpa racemosa* availed from Gujarat coast was conducted on iodine-deficient or thyroid-insufficient (n=10) pregnant women. They were supplemented daily with 0.17 g of algae in 20 g wheat flour *ladoo* for one month so as to provide 50μg/day of iodine and 0.343 mg/day of iron. A slight non-significant increase (104.75 to 121.05 μg/L) in median urinary iodine concentration (UIC) was observed after one month of supplementation. No significant effect of supplementation was observed on thyroid function parameters of the subjects. They also showed slight increase in hemoglobin level. Prolonged supplementation needs to be carried out further to opine on the impact of algae.

Keywords: Iodine, Seaweed, Urinary iodine concentration

INTRODUCTION

Seaweeds are good sources to meet dietary requirements of iodine. Goiter precipitation caused by iodine deficiency is less prevalent in countries where marine algae form a part of the diet. The Japanese are extraordinarily free from goiter, apparently due to high iodine content of their diet of which seaweed forms a constant ingredient.

Seaweed has such a large proportion of iodine compared to dietary minimum requirements, that it is primarily known as a source of this nutrient. The highest iodine content is found in brown algae, with dry kelp ranging from 1500-8000 ppm (parts per million) and dry rockweed (Fucus) from 500-1000 ppm. In most instances, red and green algae have lower contents, about 100-300 ppm in dried seaweeds, but remain high in comparison to any land plants. Daily adult requirements, currently recommended at 150 μg/day, could be covered by very small quantities of seaweed. Just one gram of dried brown algae provides from 500-8,000 μg of iodine and even the green and red algae (such as the purple *nori* that is used in Japanese cuisine) provides 100-300 μg in a single gram.

Benthic marine macroalgae, commonly known as seaweeds, are increasingly viewed as potential sources of bioactive compounds with immense pharmaceutical, biomedical and nutraceutical importance. Many macroalgal species have been used as ingredients in both medicinal and food preparations, traditionally, in different regions across the world (Cardozo, *et al.*, 2007, Chandini, *et al.*, 2008). There are 250 macroalgal species which have been listed as commercially utilized worldwide, among which 150 are consumed as human food (Barrow, 2007). They are also considered as low calorie foods with high contents of minerals, vitamins, proteins and carbohydrates. Being rich in minerals, vitamins, trace elements and bioactive substances, seaweeds are called medical food of the 21st century (Khan and Satam, 2003). Species of *Ulva, Porphyra, Gracilaria, Suhria, Caulerpa, Laminaria, Sargassum and Codium* are utilized in Japan, China and other countries. These algae are consumed by people as salads, puddings, jellies, soup etc.

Although the main source of iodine is *Chilie Salt Petre*, it is also being produced at present in smaller quantities from marine algae in France, Norway, Java and Japan from brown seaweeds and in Russia from red seaweeds. Certain seaweeds have the capacity to accumulate iodine in their tissues and therefore some of them can become natural source of iodine. *Ascophyllum* can concentrate iodine up to 220 times that of seawater (0.01-0.007 ppm) while *Asparagopsis taxiformis* can accumulate up to 0.3% (Thomas, *et al.* 1987).

The edible seaweeds present in Indian coastal waters are species belonging to *Ulva, Enteromorpha, Chaetomorpha, Caulerpa, Codium, Hydroclathrus, Dictyota, Padina, Colpomenia, Rosenvingea, Chnoospora, Sargassum, Turbinaria, Porphyra, Halymenia, Grateloupia, Centroceras, Gracilaria, Hypnea, Rodymenia, Acanthophora and Laurencia* (Kathiresan, 1990)**.**

Thyroid deficiencies during pregnancies are always a risk and hormonal approach of treatment becomes essential. Alongwith the hormonal induction dietary supplements can also help in sustaining the circulating levels of iodine which is the major element in thyroxine. Various seaweeds and algae are reported to have rich iodine content. A few were reported by (McClendon, 1933). The role of iodine in goiter control with a population of Far East was studied by the author on Japanese coast containing good quantity of iodine. The author further opines that the Japanese diet contains thousand times much iodine compared to other foods and is the only non-goitrous country of the World. The average iodine intake from seaweeds in Japan is 1.2 mg/day (Nagataki, 2008). The author further reported ingestion of 10 mg of iodine in one week increases response of thyrotropin in normal subjects. Studies with 20-30 mg iodine was carried out for 4 weeks, significant changes were observed in 30 mg intake which reported normality of thyroid by echogram. The abnormalities disappeared after 2 weeks of withdrawal of the dose, due to adaptive changes of autoregulation of pitutary-thyroid axis.

Variability of iodine content available in commercially available edible seaweeds was reported by (Teas, *et al.*, 2004). Bioavailability of iodine from seaweeds for human beings was studied by (Aquaron, et al., 2002). The study was on two species *Laminaria hyperborea*; *Gracilaria verrucosa* due to high level of iodine in a population from France. One group of subjects from Marseille (iodine sufficient area) had median UIC at 137 µg/day and the other population from Brussels had 73 µg/day (the subjects were in mild deficient areas). The results revealed that, bioavailability for *Gracilaria verrucosa* was better than *Laminaria hyperborea*, 101 percent *vs.* 90 percent in Marseille and 85 percent *vs.* 61.5 percent in Brussels, though urinary excretion of iodine was lower in Brussels when compared to Marseille population.

It was of great interest to review the reports on marine algae and its iodine content in coastal India. Few reports by (Ganga Devi, *et al.*,1996, Sobha, *et al.*, 2008, Manivanna, *et al.*, 2008, Manivannan, *et al.*, 2009) revealed the species, content, composition etc. Recipes with these algae were reported by (Sobha, *et al.*, 2008) (Ulva toffy, Ulva squash, mixed algae pickle, algae cutlet, algae biryani, algae thoran). Thus it was of interest in our study to incorporate the species availed in Gujarat.

MATERIALS AND METHODS

Collection and Processing of seaweeds

The various group of marine macroalgae or seaweeds such as Chlorophyceae members (*Caulerpa racemosa, Caulerpa scalpelliformis, Caulerpa veravelense*) and Phaeophyceae member (*Padina tretastromatica*) were collected from Veraval, Adri and Porbandar Coast of Gujarat.

The seaweeds were handpicked and immediately cleaned with seawater to remove foreign particles, sand and epiphytes. Then the seaweed was kept in an ice box containing slush ice and immediately transported to the laboratory and cleaned thoroughly using tap water to remove the salt on the surface of the sample. It was spread on the blotting paper to remove excess amount of water. It was air dried and milled to a coarse powder and stored in refrigerator for chemical analysis and preparation of supplementation product (wheat flour *ladoos*).

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Subjects

Total of thirty pregnant women irrespective of either trimester of pregnancy were enrolled for this part of the study. Their anthropometric measurements were recorded. Blood was drawn and was tested for thyroid hormones & hemoglobin. Urine was also collected for iodine estimation. Subjects who were found iodine deficient or thyroid insufficient were supplemented for one month with seaweed incorporated *ladoos*.

Tests

Chemical analysis of the algae was carried out using standard methods AOAC, 2000 (Association of Official Analytical Chemists, 2000).

FT_3, FT_4 and TSH were estimated by the electrochemiluminescence (ECL) technique using commercially available kits from Roche Diagnostics (Mannheim, Germany) with Elecsys 1010 analyzer. Hemoglobin was assessed by Cyanmethemoglobin method (Cook, 1985)**.** Urinary iodine was estimated by simple microplate method using ammonium persulphate digestion is used (Ohashi, *et al.*, 2000).

Statistical analysis

Data was subjected to appropriate statistical analysis. Simple descriptive analysis was carried out and results expressed as mean ± SD. Non-parametric test was used for group comparison.

RESULTS

Baseline characteristics

Total of thirty pregnant women irrespective of either trimester of pregnancy were enrolled for this part of the study. The mean age and height of the study group was 23.9 ± 3.2 yr and 155.8 ± 5.5 cm, respectively. The mean parity and abortion rate was 1.23 ± 1.1 and 0.17 ± 0.46. Majority of the subjects (68 percent) enrolled had normal BMI while rest of them were underweight.

The women were subdivided into two groups based on their urinary iodine concentration and thyroid function tests. It was found that out of thirty subjects ten of them had below normal (<150µg/L) UIC. These women were supplemented for one month with seaweed (Group B). Other 20 subjects (Group A) were not provided with any supplementation.

Proximate composition and mineral content of seaweed

Four species of seaweeds namely *Caulerpa scalpelliformis*, *Caulerpa racemosa*, *Caulerpa veravelense* and *Padina tretastromatica* were collected from Gujarat coast and were analyzed at National Institute of Nutrition for proximate and mineral composition. After analysis it was found that *Caulerpa racemosa* has the highest content of iodine as well as iron when compared to other seaweeds (Ganga Devi, *et al.*, 1996). The moisture, protein and total dietary fiber content of all the species was almost similar (Table 1). Hence, it was decided to supplement *Caulerpa racemosa* to iodine deficient pregnant women for one month.

The study was planned as per experimental design and the subjects were supplemented accordingly. Constituency of the *ladoos* (20 g) was taken into consideration when the seaweed was incorporated to provide 50µg/day of iodine and 0.343 mg/day of iron from 0.17g of the seaweed.

Urinary iodine status

The median UIC of the non-supplemented group (Group A) before and after one month was 171.5 (153.8 – 207.8 µg/L) and 167.8 (154.1 – 198.7 µg/L), respectively. The median UIC of the supplemented group (Group B) before and after one month of supplementation was 104.75 (87.9 – 134.8 µg/L) and 121.05 (90.7 - 154.4 µg/L), respectively. Though the median UIC was still below the normal levels after supplementation in Group B, slight improvement was observed (Table 2). This is suggestive that prolonged period of supplementation may bring a positive change in iodine status of the subjects.

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Thyroid function parameters

The TSH of supplemented group before supplementation was significantly higher than that of non-supplemented group. No significant effect of supplementation was observed in the thyroid function parameters of the subjects (Table 3). This could be due to the short period of supplementation and the low dose by which it was supplemented.

Hemoglobin profile

The hemoglobin profile of supplemented group was better than that of non-supplemented group both before and after supplementation (Figure 1). The mean and median hemoglobin concentration of supplemented group was better than that of non-supplemented group after one month of supplementation (Table 4).

Table 1 Proximate composition and mineral content of the seaweeds

S.No.	Parameters	*C.scalpelliformis*	*C.racemosa*	*C.veravelense*	*P. tretastromatica*
1.	Moisture (g/ 100g)	7.37	6.47	7.25	12.44
2.	Protein (g/100g)	23.12	22.32	25.39	12.57
3.	Total Ash (g/100g)	5.6	12.24	9.18	13.21
4.	Fat (g/100g)	2.32	1.41	2.94	1.21
5.	Total dietary fiber (g/100g)	46.08	47.85	49.27	48.28
	Insoluble dietary fiber (g/100g)	36.77	37.52	39.63	39.33
	Soluble dietary fiber (g/100g)	9.31	9.33	9.64	8.95
6.	Carbohydrates (g/100g)	15.51	9.70	5.97	12.29
7.	Energy (Kcal)	194	159	171	128
8.	Minerals (mg/100g)				
	Iron	56.45	201.89	53.18	89.76
	Iodine	2.69	28.31	3.58	4.26

Daily 0.17g of the seaweed was supplemented to these subjects so as to provide 50µg/day of iodine and 0.343 mg/day of iron.

Table 2 Distribution of pregnant women according to urinary iodine

UIC (µg/L)	Group A		Group B	
	Before	After	Before	After
<150	-	-	10 (100)	9 (90)
150-249.9	20 (100)	20 (100)	-	1 (10)

Value in parentheses indicate percentage

Table 3 Thyroid function parameters of the groups before and after one month

Parameters	Group A		Group B	
	Initially	After 1 month without supplementation	Initially	After 1 month with supplementation
FT_3 (pM/L)	3.98 ± 0.57	4.01 ± 0.49	4.11 ± 0.77	4.25 ± 0.68
FT_4 (pM/L)	14.32 ± 1.5	13.58 ± 0.69*	13.67 ± 2.25	13.8 ± 1.4
TSH (µIU/ml)	1.71 ± 0.57	1.82 ± 0.49	2.4 ± 0.87*	2.32 ± 0.71†

* $p<0.05$ when compared to Group A initially

† $p<0.05$ when compared to Group A after 1 month without supplementation

Table 4 Mean and median hemoglobin concentration of the groups before and after one month

Hemoglobin (g/dl)	Group A		Group B	
	Initially	After 1 month without supplementation	Initially	After 1 month with supplementation
Mean	9.68 ± 1.3	9.53 ± 1.14	10.23 ± 1.2	10.39 ± 0.8†
Median	9.86	9.75	10.44	10.58†

† $p<0.05$ when compared to Group A after one month without supplementation

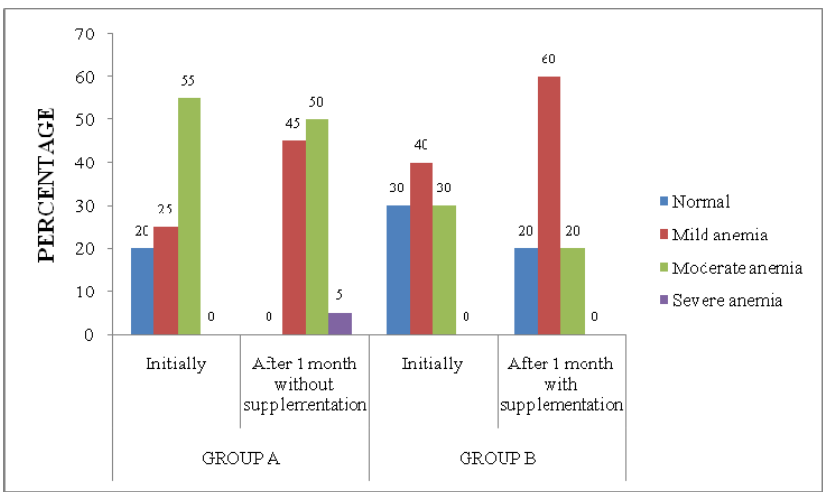

Figure 1 Distribution of pregnant women according to hemoglobin level

Though the increase in iron level is very little and the change was significant when hemoglobin concentration of group B after supplementation was compared to group A after one month without supplementation. This could be due to other minerals present in the algae along with Iron and Iodine.

CONCLUSION

Thus, it can be stated that supplementing these seaweeds can bring a positive shift in iodine and iron status, thereby combating micronutrient deficiency. Prolonged supplementation needs to be carried out further to opine on the impact of algae.

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