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RESEARCH ARTICLE

EFFECT OF SPIRULINA SUPPLEMENTATION ON VITAMIN A AND IRON NUTRITIONAL STATUS AMONG PRIMITIVE TRIBAL CHILDREN IN NILGIRIS DISTRICT

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Key words:

VAD- Vitamin A Deficiency,
IDA- Iron Deficiency Anemia,
WHO- World Health Organisation,
PTG- Primitive Tribal Group,
PTC- Primitive Tribal Children,
PCM- Protein Calorie Malnutrition,
CED- Chronic Energy Deficiency,
ST – Scheduled Tribe,
EWS- Economically Weaker Section,
LIG-Low Income Group,
SC- Spirulina Candies,
OC- Ordinary Candies.

ABSTRACT

Indian tribal people account for 8.14 per cent of the total population of the country, numbering 84.51 million (Census, 2001). There were 635 tribal groups including 75 designated as 'primitive' based on pre-agricultural level of technology, low literacy, diminishing population size, relative seclusion from the main stream of population, economical backwardness, extreme poverty, dwelling in remote inaccessible hilly terrains, maintenance of constant touch with the natural environment, and unaffected by the developmental process undergoing in India. There is a consensus that these scheduled tribes are the descendants of aboriginal population in India. Using Random sampling method, 4376 PTG Children in the age group of 1 –14 years from Nilgiris were screened clinically for symptoms of VAD, IDA and other micronutrient deficiencies. Among them, 84 children showing moderate to severe clinical symptoms of VAD and IDA in the age group of 7- 14 years were selected for the Spirulina supplementation for a period of 180 days. The clinical observations revealed that the prevalence of VAD and IDA is beyond the cutoff points of WHO standards and thereby making it a problem of public health significance among the screened PTG children. Spirulina supplementation showed a significant impact on clinical symptoms, nutritional anthropometry, serum retinol and blood haemoglobin when compared to placebo.

INTRODUCTION

The Nilgiris has a tribal population, (known as the PTG) of about 26,000. The traditional life style of tribals and their lack of awareness play a major role in determining their nutritional status. The problem of micronutrient malnutrition, particularly those of VAD and IDA have been found to have devastating effects, of reported low birth weights, still births, neonatal deaths, conjunctival inflammation and koilonychia. According to Simpore (2006), spirulina is acclaimed to be an inexpensive source of complete proteins providing all essential amino acids and all micronutrients (expect Vitamin C). Spirulina is used for boosting the immune system, lowering cholesterol, heart health, diabetes treatment, wound healing, improving digestive health and as an antidote to depression and anxiety. Ciferri (1983) reported that spirulina by its dry weight contain 60-70% protein. Switzer (1980) analyzed and found spirulina powder contain 65% protein. Spirulina is cultivated all around the world and is used as a human dietary supplement as well as whole food which is available in tablet, flake and powder for (Henrikson, 1994). Empowerment of the PTG and bringing them to the national mainstream is one of the major policies of the Government and non Governmental organisations. Nutritional empowerment is fundamental to achieve this empowerment. Towards this end a multipronged strategy would be necessary for the holistic development of the tribals. For this, it is necessary to 'catch em young', for required health interventions and educating them of correct dietary practices.

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MATERIALS AND METHODS

Phase I: Assessment of Socioeconomic and Nutritional Status of Primitive Tribal Children

A.Selection of Area and Children

The study was conducted in the Nilgiris district which abounds in tribal population. The PTG in Nilgiris comprising of Thodas, Kotas, Kurumbas, Irulas, Paniyas and Kattunayakans. The total population of PTC in the Nilgiris is 7810, of whom, nearly 60 percent, i.e., 4376 tribal children in the age group of

1 –14 years were selected by stratified systematic sampling method in order to ensure that the selection is proportional and representative of the whole. Random sampling technique was used for the selection of individuals in order to ensure that every member in the population has an equal chance of being included in the study without any bias.

B.Assessment of Socioeconomic Status

Of the 4376 children, 84 children showing moderate to severe clinical symptoms of VAD and IDA were included for the assessment of socioeconomic status.

C.Assessment of Nutritional Status

1.Nutritional Anthropometry

Standing height (HAZ), ii) Body weight (WAZ) iii) BMI (BAZ) iv) Mid Upper Arm Circumference (MUAZ) were recorded for the 84 children.

2. Biochemical picture

Three milliliters of blood were drawn from (totally 30 children) the selected 84 children. Blood Hemoglobin was determined using Sahlis method. Serum Retinol was estimated using HPLC method.

3.Dietary Survey

In the present study, through the 24 hour food recall method, the amount of raw ingredients used for cooking, the total amount of food consumed by the individuals were measured using the standard cups and utensils (Kapil *et al*, 2004) and recorded. The average food intake of the children was calculated and compared with the suggested allowances of ICMR (2010).

Phase- II Supplementation and Impact Evaluation

A.**Nutrient content of Spirulina Candies**

Nutrient content of spirulina candies as analyzed by Food Safety and Standards Division, National Agro Foundation-R&D center, Chennai (Table 1).

B.Selection of Tribal Children

Since supplementation involved candies, it was felt that children (<6 years) would find it difficult to swallow them and would probably encounter choking hazard. Hence children in the age group of 7-14 years were included. Hence, 84 children showing moderate to severe symptoms of VAD and IDA in the age group of 7-14 years were included for supplementation based on their acceptance, willingness and cooperation.

The children were then divided into two groups, constituting two experimental group E (52) Supplemented with SC and placebo group P (32) Supplemented with OC, for a period of 180 days.

C.Impact Analysis on supplementation

Changes in the Nutritional Anthropometry, Biochemical Picture, Clinical symptoms and Dietary were assessed twice once before the start and the other after 180 days of supplementation.

Table 1. Nutrient content of spirulina candies

Parameter*	100 g	Per Serving (6.4g)
Moisture%	1.1	0.0704
Total Ash %	1.0	0.064
Fat%	0.16	0.01024
Protein%	6.6	0.4224
Crude Fibre%	0.18	0.01152
Carbohydrates%	91.0	5.824
Sodium (mg/100g)	448	28.672
Potassium(mg/100g)	121	7.744
Calcium(mg/100g)	869	55.616
Iron(mg/100g)	4.8	0.3072
Magnesium (mg/100g)	292	18.688
Zinc(mg/100g)	1.2	0.0768
Manganese(mg/100g)	0.2	0.0128
Copper(mg/100g)	1.5	0.096
Beta Carotene(mg/100g)	39.2	2.51
Energy (kcal)	392	25.09

*(National Agro foundation, 2011)

RESULTS AND DISCUSSION

Phase I: Assessment of Socioeconomic and Nutritional Status of Primitive Tribal Children

A.Background Information of the Children

On the whole, 24.6 per cent of the tribal children lived in joint and 75.4 per cent were from nuclear families (Figure 1). These findings are similar to those reported by Rao (2013) wherein he states that 83 per cent of Chenchu tribals belong to nuclear families. Thus it is evident that even among tribals the joint family system of life is fast changing. The number of boys and girls in the study were almost equal on the whole, 47.9 per cent were boys, 52.1 per cent were girls.

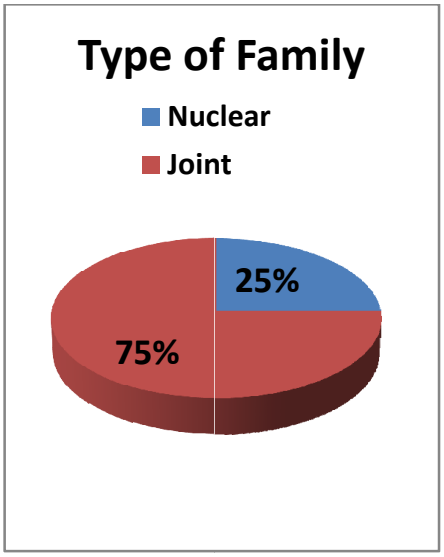

Fig. 1. Type of Family

2. Monthly Income and Expenditure of the Families

On the whole, 99.4 per cent of the families belonged to EWS and only 0.6 per cent were in LIG (Figure 2). The average monthly per capita income for Indians reported by NNMB (2012) was Rs. 1356/-in the present study. Regarding the expenditure pattern, 57.6 , 5.8, 16 , 7.4, 4.4 and 2.5 per cent of income was spent on various expenses namely, food, clothing, paan/betel nut/ smoking/ alcoholic drinks, maintenance of household /repair work, transport and debts.

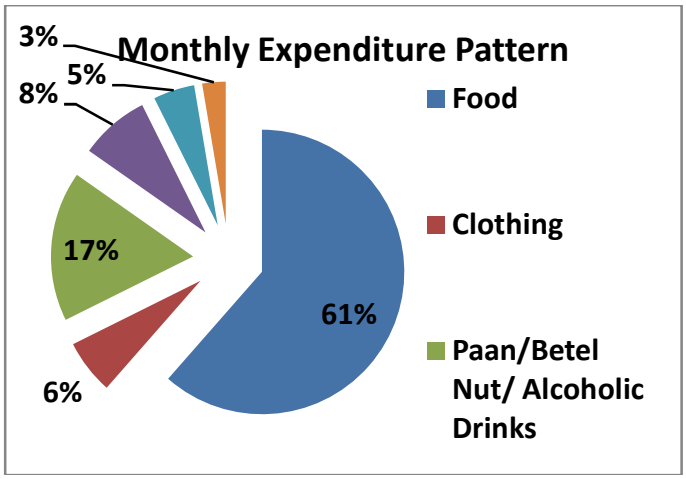

Fig. 2. Monthly Expenditure Pattern

B.Nutritional status of Children

1. Nutritional Anthropometry

Mean height and weight of children in all age and intervention groups were much below the standard values of the respective age groups. This study coincides with NNMB 2012 survey where the mean anthropometric measurements such as height, weight and MUAC had a marginal increase especially among school age children and adolescents in all the states. In a separate study conducted by Regional Medical Research Centre (RMRC, 1998-1999), Bhubaneswar, 66 per cent of primitive tribal population (6 – 15 years age group) of Mayurbhanj and Sundergarh districts was found to be malnourished.

4. Dietary pattern

i)Dietary Habits

All the families were non-vegetarians and all of them consumed three meals a day.

ii) Consumption of Beverages

All the children consumed black tea probably because tea is relatively inexpensive and easily available in the Nilgiris.

iii)Cooking Methods

The predominant method adopted for cooking all food items was boiling. None of the families used steaming and pressure cooking methods.

Phase- II Supplementation and Impact Evaluation

1.Nutritional Anthropometry

A, Mean Height of Boys

In the E group, the mean initial heights of boys were below the standard values and the mean final height of boys were significantly ($p<0.01$; $p<0.05$) increased and still the final height was less than the height values reported by WHO (2007), which brings out the need for earlier intervention. In the placebo group there was no marked improvement or normal pattern of growth throughout the study period, which points out the absence of even discernible height increments in the absence of spirulina supplementation (Table 2).

B. Mean Height of Girls

The final mean height of girls in all age groups, were significantly (at 1 per cent and 5 per cent level) higher compared to the mean initial values but were not on par with the standard values of the respective age groups in E. This again stresses the need for early intervention among girl children also. The increase in height in the placebo group was only marginal, which reiterates the status of height increase in the absence of supplementation (Table 3).

Table 2. Mean height (cm) of boys (N=39)

Age Group (years)	Standard Values		Mean Height			
			E I (N=23)			
	WHO (2006)	ICMR(1990)	Before	After	D	t value
7+	124.3	121.7	117.61±4.62	122.29±4.04	4.68	14.00**
8+	130.1	127.0	123.28±2.83	128.21±4.60	4.93	3.40*
9+	134.6	132.2	124.99±1.73	130.97±3.46	5.98	6.00*
10+	140	137.5	129.80±8.28	134.21±8.58	4.41	7.46**
11+	144.8	140.0	137.57±6.35	140.89±6.93	4	10.00**
12+	151.1	147.0	142.65±2.89	146.72±2.83	3.32	61.00**
13+	157	153.0	137.98±11.88	142.14±11.70	4.16	3.00**
14+	163.0	160.0	151.67±0.58	155.46±1.01	3.79	15.10**
			P I (N=16)			
7+	124.3	121.7	121.05±0.07	122.15±0.21	1.1	5.50^{NS}
8+	130.1	127.0	123.56±0.71	124.75±0.35	1.19	5.0^{NS}
9+	134.6	132.2	124.50±0.71	125.30±0.42	0.8	4.0^{NS}
10+	140	137.5	129.90±7.07	131.42±6.36	1.52	3.0^{NS}
11+	144.8	140.0	134.50±0.71	136.50±0.71	2	5.0^{NS}
12+	151.1	147.0	137.97±4.24	140.23±6.08	2.26	1.7^{NS}
13+	157	153.0	139.49±2.12	141.99±2.83	2.5	5^{NS}
14+	163.0	160.0	157.49±2.12	159.69±2.40	2.2	11.0*

Table 3. Mean height (cm) of girls (N=45)

Age Group (years)	Standard Values		Mean Height			
			E I (N=29)			
	WHO (2006)	ICMR(1990)	Before	After	D	t value
7+	123.6	120.6	117.28±5.90	121.40±5.99	4.12	56.07**
8+	129.2	126.4	123.98±2.83	128.21±4.60	4.23	3.40*
9+	135	132.2	124.49±2.12	129.97±4.24	5.48	3.67*
10+	140	138.3	129.10±10.01	133.54±9.55	4.44	6.487**
11+	145.3	142.0	132.78±6.23	137.06±6.15	4.28	61.00**
12+	150.2	148.0	144.78±8.26	148.62±8.27	3.84	33.17**
13+	153.8	150.0	145.93±5.57	149.25±6.11	3.32	10.00**
14+	157.0	155.0	147.61±4.41	151.44±4.55	3.83	23.00**
			P I(N=16)			
7+	123.6	120.6	112.25±0.35	113.15±0.35	0.9	9^{NS}
8+	129.2	126.4	122.96±16.26	123.92±16.19	0.96	19*
9+	135	132.2	124.25±0.35	124.95±0.07	0.7	3.5^{NS}
10+	140	138.3	132.50±0.71	132.95±0.07	0.45	1.0^{NS}
11+	145.3	142.0	135±1.41	135.74±1.77	0.74	3.0^{NS}
12+	150.2	148.0	141.50±0.71	141.90±0.85	0.15	4.0^{NS}
13+	153.8	150.0	145.43±6.36	146.23±6.22	0.8	8.0^{NS}
14+	157.0	155.0	148.95±5.66	149.91±5.16	0.96	2.7^{NS}

** (p<0.01) 1% significance, * (p<0.05) 5% significance

Table 4. Mean weight (Kg) of boys (N=39)

Age Group (years)	Standard Values		Mean Weight			
			E I (N=23)			
	WHO (2006)	ICMR(1990)	Before	After	D	t value
7+	22.7	22.9	19.01±3.06	19.62±2.66	0.61	2.43*
8+	25.2	25.3	21.52±1.63	24.10±0.14	2.58	2.43*
9+	28.0	28.1	19.94±1.15	22.53±0.23	2.59	4.81*
10+	30.8	31.4	24.74±5.24	26.95±5.58	2.21	6.29**
11+	34.1	32.2	29.90±3.12	30.58±2.89	0.68	5.00**
12+	38.0	37.0	31.98±1.39	34.15±1.10	2.17	13.00**
13+	43.3	40.9	30.51±8.89	32.73±9.01	2.22	14.00**
14+	48.0	47.0	38.69±1.21	41.53±0.40	2.84	3.04**
			P (N=16)			
7+	22.7	22.9	20.05±0.07	21.03±1.20	0.98	1.2^{NS}
8+	25.2	25.3	24.15±0.21	24.30±0.42	0.15	1.0^{NS}
9+	28.0	28.1	25.25±0.35	25.35±0.21	0.1	1.0^{NS}
10+	30.8	31.4	26.73±1.48	25.92±1.77	0.81	0.3^{NS}
11+	34.1	32.2	30.80±0.14	31.25±0.07	0.45	9.0^{NS}
12+	38.0	37.0	32.20±0.71	33.18±1.41	0.98	0.6^{NS}
13+	43.3	40.9	35.28±4.74	35.29±4.10	0.01	0.1^{NS}
14+	48.0	47.0	43.35±2.83	43.72±2.19	0.37	0.7^{NS}

** (p<0.01) 1% significance, * (p<0.05) 5% significance

C. Mean Weight of Boys

In the E, the mean final body weights of boys were increased significantly (p<0.01; p<0.05) near normal pattern on spirulina supplementation. There was no remarkable difference between the initial and final weights in the placebo group and the initial and final growth curves were nearly flat (Table 4).

D. Mean Weight of Girls

In girls also, the same trend was observed as among boys. In E the mean weight has increased significantly at 1 and 5 per cent level when compared with the initial values (Table 5). Both initial and final weights of girls in the placebo group were less than the initial weights of the E group at all age points. Similar findings were observed by Taskeen and Subapriya (2010) who reported that supplementation of 2g of spirulina tablets for four months could improve appetite, food intake, BMI and physical performance significantly among female athletes in Tamil Nadu.

E. Mean MUAC of Children

Tthe final mean MUAC values in the E, were significantly (1 and 5 per cent level) higher than the initial mean MUAC and increased progressively according to age, which reiterates the efficacy of spirulina supplementation. MUAC of boys was higher than those of girls at all age points (Table 6). Most of the children were mesomorphic. Prabhakar and Gangadhar (2009) report that children of Jenukuruba tribe of Karnataka were also mesomorphic. The higher than standard readings of MUAC could probably be due to the body build and ethnicity of these tribal groups.

2.Biochemical Picture

a)Mean Hemoglobin of Children

The mean final haemoglobin values had increased significantly at 1 and 5 per cent level in E and reached near the standard values of the respective age groups.

Table 5. Mean weight (Kg) of girls (N=45)

Age Group (years)	Standard Values		Mean Weight			
			E I (N=29)			
	WHO (2006)	ICMR(1990)	Before	After	D	t value
7+	22.3	21.8	18.89±2.55	20.68±3.19	1.79	2.32*
8+	25	24.8	20.55±0.21	23.60±0.57	3.05	5.55*
9+	27.6	28.5	20.79±0.71	23.60±0.28	2.81	9.33**
10+	31.2	32.5	26.15±6.39	27.15±4.72	1	1.83**
11+	34.8	33.7	26.56±3.72	28.83±3.67	2.27	5.75**
12+	39	38.7	24.56±5.70	26±5.06	1.44	2.29*
13+	43.4	44.0	29.86±0.78	35.14±1.76	5.28	1.76*
14+	47.1	48.0	30.10±3.64	34.99±3.53	4.89	2.29**
13+	43.4	44.0	35.13±0.75	39.47±0.40	4.34	6.50**
14+	47.1	48.0	37.19±2.25	40.23±0.68	3.04	3.00**
				P I (N=16)		
7+	22.3	21.8	17.10±0.14	18.15±0.21	1.05	21.0*
8+	25	24.8	22.67±4.03	23.32±5.09	0.65	1.0^{NS}
9+	27.6	28.5	27.74±1.06	27.98±1.41	0.24	1.0^{NS}
10+	31.2	32.5	27.74±1.06	28.43±2.83	0.69	4.3^{NS}
11+	34.8	33.7	31.35±0.35	33.10±0.14	1.75	5.0^{NS}
12+	39	38.7	33.76±2.40	35.89±2.90	2.13	6.1^{NS}
13+	43.4	44.0	35.55±0.64	36.24±1.06	0.69	2.3^{NS}
14+	47.1	48.0	36.55±2.69	37.79±3.04	1.24	5.0^{NS}

** (p<0.01) 1% significance, * (p<0.05) 5% significance

Table 6. Mean muac (cm) of children (N=84)

Age Group (years)	Mean MUAC E (N=52)							
	Boys				Girls			
	Before	After	D	t value	Before	After	D	t value
7+	15.29±1.44	16.49±2.02	1.2	3.70*	15.05±1.15	16.33±1.45	1.28	8.57**
8+	15.97±1.41	17.08±1.27	1.11	11.00**	15.97±1.41	16.71±1.20	0.74	7.67**
9+	15.64±1.15	16.47±1.21	0.83	25.00**	15.97±1.41	16.82±1.48	0.85	17.00*
10+	17.27±2.02	17.91±2.20	0.64	4.00**	16.87±2.40	17.62±2.16	0.75	6.22**
11+	19.14±1.15	19.72±0.92	0.58	4.25**	17.66±1.95	18.45±1.84	0.79	14.00**
12+	18.35±0.98	19.48±1.04	1.13	34.00**	19.90±2.45	20.79±2.43	0.89	3.25**
13+	19.15±2.65	20.05±2.64	0.9	13.00**	20.83±0.58	21.43±0.57	0.50	2.38*
14+	21.16±0.58	21.59±0.69	0.43	6.50**	20.38±1.02	21.28±0.96	0.9	8.867**
			P (N=32)				P (N=16)	
7+	15.37±0.42	15.60±0.76	0.23	1.0^{NS}	14.34±1.14	14.77±0.55	0.43	1.0^{NS}
8+	15.93±0.71	16.65±0.07	0.72	1.5^{NS}	15.36±0.27	15.87±0.72	0.51	1.6^{NS}
9+	16.52±0.11	16.80±0.14	0.28	14.0*	16.28±0.71	16.36±0.78	0.08	1.8^{NS}
10+	17.88±0.41	18.49±0.94	0.61	1.6^{NS}	17.28±0.71	17.36±0.78	0.08	1.8^{NS}
11+	18.70±0.37	19.50±0.14	0.8	4.8^{NS}	17.57±0.15	17.99±0.22	0.42	8.6^{NS}
12+	19.31±0.19	19.80±0.31	0.49	1.4^{NS}	18.43±0.50	18.49±0.59	0.06	1.0^{NS}
13+	19.82±0.25	20.19±0.27	0.37	25.0*	20.89±0.46	21.10±0.75	0.21	1.0^{NS}
14+	20.56±0.79	20.98±1.01	0.42	2.6^{NS}	21.64±0.46	21.72±0.40	0.08	1.6^{NS}

** (p<0.01) 1% significance, * (p<0.05) 5% significance

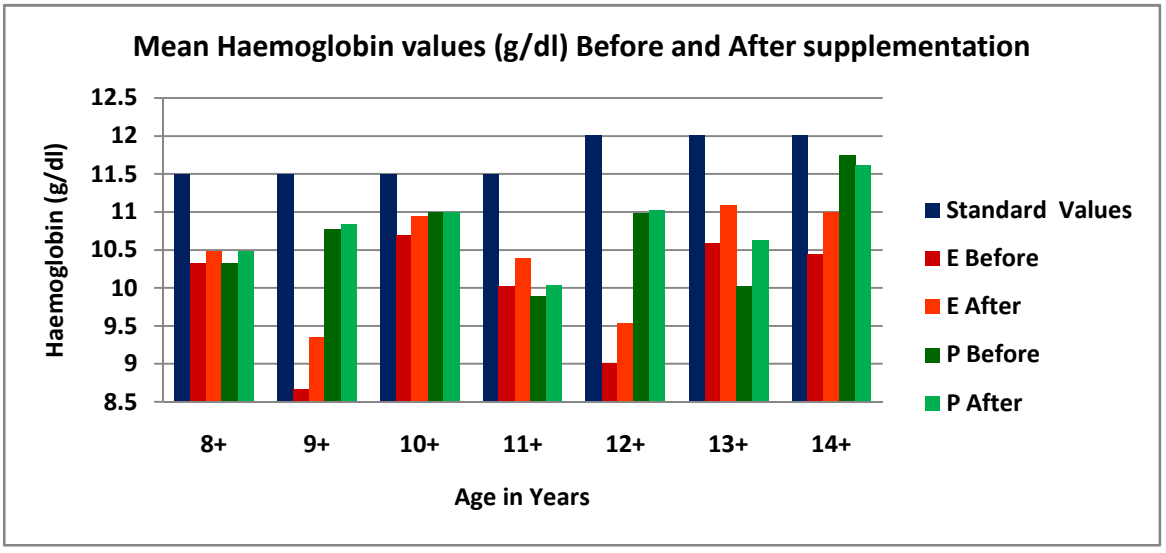

Fig. 3. Mean Haemoglobin values (g/dl) before and after supplementation

In placebo group the difference is less when compared with the experimental age group (Figure 3). This results coincides with the findings of Henrikson (1989) in Japan which report that, supplementation of 4 g of spirulina each for 30 days to eight young hypochromically anemic women, who had been limiting their meals to stay thin, could increase their blood hemoglobin content from 10.9 to 13.2 percent.

respective age groups. There is decrease in the final mean serum retinol value in the P group when compared with the initial mean serum retinol value in all age group (Figure 4).

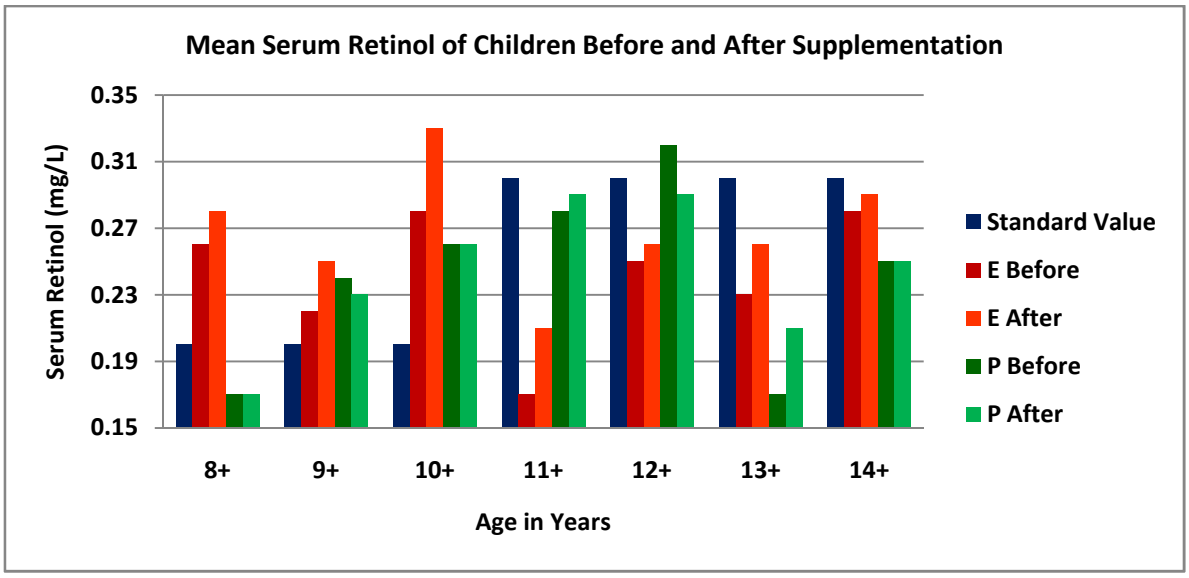

Fig.4. Mean Serum Retinol (mg/L) before and after supplementation

Table 6. Grouping of children according to degree of anaemia (N=30)

Degree of Anemia (WHO,2001)	E			P		
	Before	After	D	Before	After	D
Normal (Hb>12g/dl)	0	0	0	3	0	3
Mild anaemia (Hb: 11-11.9 g/dl)	2	6	-4	4	8	-4
Moderate anaemia (Hb: 8-10.9 g/dl)	11	9	2	8	7	-1
Severe anaemia (Hb: 8-10.9 g/dl)	2	0	2	0	0	0

Table 8. Clinical picture

Clinical Picture	E (N=52)					P (N=32)				
	Before		After		D	Before		After		D
	No	%	No	%		No	%	No	%	
Emaciation	4	7.7	1	1.9	3	1	3.1	1	3.1	0
Conjunctival Xerosis	5	9.6	3	5.8	2	2	6.3	1	3.1	1
Angular Stomatitis	35	67.3	25	48.1	10	10	31.3	8	25	2
Bitot's spot	8	15.4	8	15.4	0	1	3.1	1	3.1	0
Cheilosis	20	38.5	10	19.2	10	8	25	7	21.8	1
Glossitis	10	19.2	5	9.6	5	5	15.6	4	12.5	1
Gingivitis	18	34.6	5	9.6	13	5	15.6	4	12.5	1
Koilonychia	5	9.6	3	5.8	2	1	3.1	1	3.1	0
Dental Caries	2	3.8	2	3.8	0	1	3.1	1	3.1	0
Thyroid gland Palpable	1	1.9	1	1.9	0	-	-	-	-	-
Dermatitis	10	19.2	2	3.8	8	3	9.4	3	9.4	0

b)Grouping of Children According to Degree of Anemia

After six months of supplementation 6 children were in mild anaemic group and 9 in moderate anaemic group in E, but in placebo group the shifting over from moderate to mild is very less when compared with the E group (Table 7).

c) Mean Serum Retinol of Children

The mean final values of serum retinol have increased in the E group when compared with the mean initial values of the

3. Clinical Examination

The prevalence of emaciation, was 7.7per cent in selected E Group. After supplementation, it reduced to 1.9 per cent. The mean prevalence of Bitot's spots, an objective sign of VAD was 15.4 per cent before supplementation. No change was observed among children in the E and placebo groups. Prevalence of Conjuctival xerosis was about 9.6 per cent in E before and after supplementation it reduced to 5.8 per cent. The incidence of B- complex deficiencies such as glossitis,

Angular stomatitis, Cheilosis were 19.2, 67.3 and 38.5 per cent in E before and after supplementation it reduced to 9.6, 48.1 and 19.2 per cent. Gingivitis, a symptom of Vitamin C deficiency was observed among 34.6 per cent. Due to supplementation, it has come down to 9.6 per cent in E. Koilonychia, the most visible symptom of IDA was observed among 9.6 per cent of E and it reduced to 5.8 per cent. Dermatitis was 19.2 per cent and there is change as 3.8 per cent in E group. There was no change in the P group. The incidence of dental caries remained the same after the supplementation also (Table 8).

4.Dietary

I)Mean Food Intake

The amount of food consumed by each group was similar. The mean intake of foodstuffs was below the recommended dietary intakes (ICMR, 2009). Though spirulina as a supplement did not provide substantial quantities of macronutrients, yet it was observed in the study, that the food intake of the children increased. The teachers in the schools/mothers/care givers also reported the same finding. Hence it was concluded that spirulina could stimulate their appetite which increased their food intake.

i)Mean Nutrient Intake

The intake of almost all the nutrients was below the Recommended Dietary Allowances (2010), and increased after spirulina supplementation.

Conclusion

- According to HUDCO, 2010 Income classification, about Ninety nine per cent of the families belonged to EWS and less than one per cent were in LIG.
- Sixty one per cent of the monthly income was spent on food and 17 per cent on alcoholic drinks, smoking, paan and betel leaves.
- All were non vegetarians, consumed three meals and black tea daily.
- Food intake pattern was dismal. Most of the foods cooked by boiling, Parboiled rice was consumed daily, pulses and fleshy foods were not included daily; roots and tubers, green leafy vegetables and other vegetables consumed only once a week; fruits and milk intake was very rare.
- Spirulina supplementation showed a significant impact on clinical symptoms, nutritional anthropometry, serum retinol and blood haemoglobin when compared to placebo.
- Spirulina supplementation improved the food intake of the children.

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