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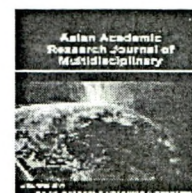
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**EFFECT OF SUPPLEMENTATION OF SPIRULINA INCORPORATED NUTRIENT
DENSE BALL TO THE SELECTED ADOLESCENT GIRLS (13-15) YEARS**

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Abstract

Globally, iron deficiency anemia affects 4 to 5 billion people. In India it is a major public health problem among preschoolers, adolescent girls, pregnant and lactating women. The overall prevalence of anemia among 12 – 14 years adolescent girls is 69 percent and for older adolescent girls (15-17 years) it is around 70 percent. Malnutrition and other micronutrient deficiency can be alleviated by dietary modification and other supplementation. Supplementation of foods rich in nutrients is cost effective and a sustainable solution. It plays a major role in improving the diet and meeting the micronutrient needs of the population. Spirulina- blue green algae are a food supplement combining proteins, vitamins, iron and many other micronutrients that the human body needs. Spirulina is a low fat, low calorie, cholesterol free source of easily digestible vegetable protein containing all the essential amino acids. The study was carried out to assess the nutritional status of adolescent girls and study the impact of supplementation.

INTRODUCTION

Adolescence is the period of transition from childhood to adulthood, and it is a very dynamic period of human life with rapid growth, weight gain and blood volume expansion¹. Adequate nutrition should be ensured to adolescent girls, to meet the increased demand for nutrients. In India, iron deficiency Anaemia is a major health problem among adolescent girls and the overall prevalence of anaemia among 12-14 year adolescent girls is 69 percent and for older adolescent girls of 15-17 years, is 70 percent². Prevention and control of anaemia is essential for substantial and significant improvement in adolescent growth and iron supplementation remains an important strategy for prevention and treatment of anaemia³. Diet based strategies are the most promising approach for sustainable control of iron deficiency. Hence spirulina was supplemented in the form of spirulina nutrient dense balls which is rich in protein, iron and vitamin A along with bengal gram dhal, ground nut and jaggery, to prevent anaemia and protein deficiency.

Spirulina is a natural product that provides a comprehensive solution to malnutrition and one gram per day is sufficient to correct malnutrition of a child in few weeks. Spirulina is a relatively cost-effective solution to alleviate malnutrition and micronutrient deficiency and hence it was selected for supplementation along with other ingredients.

Objectives of the study was to

1. Assess the health and nutritional status of the selected adolescent girls
2. Develop, standardize and analyze the nutrient composition of the spirulina incorporated nutrient dense ball.
3. Supplement and assess the impact of supplementation of spirulina nutrient dense ball among the selected adolescent girls

METHODOLOGY

The study was carried out in Madurai district of Tamil Nadu. The study was conducted at Pandian Nedunchezian School. It was selected due to easy accessibility, availability of adequate subjects and due to the co-operation extended by the subjects to participate in the study. The area for the study was selected by using convenient sampling method.

Ninety adolescents between the age group of 13-15 years, who were anaemic by haemoglobin and malnourished by anthropometric and clinical assessments, were selected for the study.

The details regarding their socio economic background, food consumption pattern and medical history were gathered and anthropometric, clinical and bio chemical assessments were also carried out.

The most commonly used anthropometric measurements like height, weight and BMI was taken for all the 90 subjects. Diet history plays a vital role in determining the nutritional status of the individuals. Hence to assess the food consumption pattern of selected adolescent girls twenty four hour recall method was followed for three consecutive days.

Biochemical test helps to diagnose deficiencies / disease at the subclinical stage and confirm it as a diseased state. The following biochemical parameters were carried out before and after supplementation with spirulina incorporated nutrient dense ball.

- i. Blood Hemoglobin
- ii. Total Protein Level (Albumin and globulin)
- iii. Total Iron Binding Capacity

Clinical assessment was done for all anaemic and malnourished children by a doctor using the standard pro forma and the observations were recorded.

To study the effect of spirulina on anaemia and protein deficiency, spirulina was supplemented in the form of spirulina nutrient dense ball along with Bengal gram, green gram dhal, groundnut and jaggery. The ingredients were carefully selected in such a way that it was locally available and affordable by common population and also based on its nutritive value. Spirulina is a spiral shaped blue green micro algae. Spirulina is rich in easily digestible proteins, vitamin A, vitamin B₁, B₂ and minerals especially iron which are essential in forming red blood cells, maintaining the immune system and preventing anaemia.

TABLE I
INGREDIENTS USED FOR SPIRULINA INCORPORATED NUTRIENT DENSE BALL

Ingredients	Experimental group A	Experimental group B
	Spirulina incorporated Nutrient dense ball quantity (gm)	Nutrient dense ball quantity (gm)
Roasted Bengal gram dhal	5	6
Roasted ground nut	5	6
Roasted green gram	5	6
Jaggery	7	7
Spirulina	3	-
TOTAL	25	25

All the selected ingredients were roasted and powdered separately, mixed and made into balls in the proportion given in Table I. In experimental group A adolescents were supplemented with spirulina incorporated nutrient dense ball and in experimental group B they were supplemented with nutrient dense ball.

PREPARATION OF SPIRULINA INCORPORATED NUTRIENT DENSE BALL

Bengal gram, Green gram dhal, Ground nut each weighing six gm



Roasted all the ingredients separately



Powdered them separately



Mixed all the above ingredients with seven gm of jaggery,



Sprinkled little warm water



Made the mixture into balls of each weighing 25 gm

PREPARATION OF NUTRIENT DENSE BALL

Bengal gram, Green gram dhal, Ground nut each weighing five gm



Roasted all the ingredients separately



Powdered them separately



Added three gms of spirulina



Mixed all the above ingredients with seven gms of jaggery,



Sprinkled little warm water



Made the mixture in to balls of each weighing 25 gm

SUPPLEMENTATION OF DEVELOPED PRODUCT

The adolescents who had haemoglobin level below 10 g/dl and who appeared malnourished by anthropometry and clinical assessment were selected for supplementation. A group of 90 adolescents were selected with or less than 10g/dl of haemoglobin and 7.8g/dl below of total protein was selected. The ninety adolescents were grouped into three groups such as A, B and C with thirty numbers in each group. Experimental Group A was supplemented with spirulina incorporated nutrient dense ball, Experimental Group B was supplemented with pulse dense ball prepared only with grams without the addition of spirulina and Group C served as control and hence no supplementation was given. The supplementation was carried out every day for a period of 120 days with 25g of nutrient dense ball. To find out the effect of supplementation of spirulina on the selected adolescent girls all the parameters like height, weight, body mass index, hemoglobin, total protein and total iron binding capacity were assessed initially and at the end of the study for the selected adolescent girls.

RESULTS OF THE STUDY

In the present study, 90 adolescent girls were selected. Among them majority of 51 per cent of them were in the age group of 12-13 years and 27 per cent of the adolescents were in the age group of 13-14 years. About 17 per cent of the selected adolescents were in the age group of 14-15 years and a minimum of five per cent were in the age group of 15 years or greater. Sixty seven per cent of the respondents were non-vegetarians and 23 per cent followed ova vegetarian type of diet and remaining 10 per cent only followed a vegetarian diet. Thirty seven per cent of respondents had the habit of skipping meals and 63 per cent took meals regularly.

Table II presents data on the distribution of adolescent girls according to diet restriction.

TABLE II
DIET RESTRICTION OF ADOLESCENT GIRLS

Diet restriction		No. of respondents (90)	Percentage
Follows diet restriction	Yes	59	66
	No	31	34
If, yes foods restricted	Fried foods	10	16
	Fast foods	9	14
	Refined foods	10	16
	Non-vegetarian foods	16	28
	Bottled drinks	14	26
Reasons for * restricted food intake	To maintain body weight	18	30
	Beauty conscious	13	22
	Lack of time	21	35
	Food allergy	8	29
	Ulcer	7	25
	Gastro Intestinal problem	9	32
	Other Reason	11	18

* Multiple responses

With regard to diet restriction 66 per cent of adolescent girls followed diet restriction. Out of the respondents who followed diet restriction 16 per cent of the respondent restricted fried foods, 14 per cent restricted fast food 16 per cent restricted refined foods and 26 per cent restricted bottled drinks. The various reasons explained by adolescents for restricting food intake was to maintain body weight by 30 per cent, beauty conscious by 22 per cent and due to lack of time by 35 per cent of adolescents.

Mean nutrient intake of adolescents

Table III presents the data about the mean nutrient intake of adolescent girls.

TABLE III
MEAN NUTRIENT INTAKE OF ADOLESCENT GIRLS

Mean nutrient intake	RDA	Control group		Experimental group A		Experimental group B	
		Actual intake	%Excess / deficit	Actual intake	%Excess /deficit	Actual intake	%Excess / deficit
Energy (kcal)	2328	2314	-0.60	2075	-10.8	2038	-12.5
Protein (g)	51.9	31.7	-38.9	40.6	-21.7	41.6	+9.8
Fat (g)	20.0	30.2	+51.0	24.6	+23.0	24.6	+23.0
Iron (mg)	27.0	11.5	-57.6	23.04	-14.6	20.04	-25.7
Calcium (mg)	700	543.7	-22.3	608.5	-13.0	588.5	-15.9
Beta-carotene (mcg)	2400	2060	-14.1	2174	-9.3	2064	-14
Thiamine (mg)	1.0	1.12	+12	1.04	+4.0	1.01	+1.0
Riboflavin (mg)	1.2	1.31	+9.1	1.27	+5.8	1.13	-5.8
Nicotinic acid (mg)	14	14.9	+6.4	14.3	+2.1	13.4	-4.2
Pyridoxine(mg)	2.0	1.18	-41.0	1.52	-24.0	1.44	-28.0
Ascorbic acid (mg)	50	58.3	+16.64	61.63	+23.26	57.61	+15.2
Folic acid (g)	160	162.3	+1.45	170.41	+6.5	159.7	-0.18

ICMR (2009)

From the table III, it was inferred that calories, protein and micro nutrients like iron, calcium, beta carotene and pyridoxine in all the three groups was deficient when compared with recommended dietary allowance. Protein deficiency was high in control group (38.9%) than the experimental group A (21.7%) while it was excess in experimental group B by 9.8 per cent. Deficit in intake of green leafy vegetables is reflected in iron and calcium intake. Iron was deficit by 57.6, 14.6 and 2.7 percent in control group, experimental group A and B respectively. The same pattern was observed with regard to calcium intake also (22.3, 13.1 and 15.9 percent) in control group, experimental A and B respectively.

Clinical signs observed among adolescent girls

Table IV presents the data on clinical signs observed among selected adolescent girls.

TABLE IV
CLINICAL SIGNS OBSERVED AMONG ADOLESCENT GIRLS

Clinical signs	Control Group		Experimental A		Experimental B	
	No.	%	No.	%	No.	%
Eyes						
i. Poor vision	2	7	3	10	4	13
ii. Cataract	3	10	2	7	3	10
iii. Conjunctiva xerosis	4	13	5	17	4	13
iv. Pale conjunctiva	12	40	17	57	12	40
Mouth						
i. Cheilosis	4	13	3	10	7	23
ii. Angular stomatitis	18	30	21	71	9	30
iii. Swollen bleeding gums	12	40	15	50	14	47
Hair						
i. Loss of luster	24	80	28	93	28	93
ii. Easy pluckability	21	70	22	73	29	97
Skin						
i. Dermatitis	8	27	11	36	13	43
ii. Pallor of the skin	9	30	7	23	3	10
iii. Follicular hyperkeratosis	3	13	2	7	4	13
Nails						
i. Dryness	21	70	23	77	21	70
ii. Brittleness	28	27	11	36	13	43
iii. Koilonychias	23	77	2	7	4	13
Teeth						
i. Dental caries	27	90	28	73	21	70
ii. Flurosis	23	77	17	36	8	27
iii. Mottled enamel	12	40	7	23	9	30

Table IV revealed that 40 per cent of the experimental group A, 57 per cent of the experimental group B and 40 per cent of the control group had pale conjunctiva which showed that majority of the adolescent were anaemic. Forty, 50 and 47 per cent of the experimental group A, B and Control group respectively were suffering from swollen and bleeding gums and it indicates that most of the adolescents had vitamin B complex deficiency due to inadequate intake of food especially green leafy vegetables and other vegetables and hence lacking in micronutrients.

Nutrient content of the spirulina incorporated nutrient dense ball

Table V presents data about the nutrients present in the developed products for 100 g.

TABLE V

NUTRIENTS PRESENT IN THE DEVELOPED PRODUCTS FOR 100 G

Nutrients	Nutrient dense ball	Spirulina Nutrient dense ball
Moisture (%)	15.0	14.2
Total ash (g)	2.5	4
Energy (kcal)	394	373
Fat (g)	14	10
Protein (g)	15	19
Carbohydrate (g)	52	53
Crude fibre (g)	1.2	98
Sodium (mg)	22	70
Potassium (mg)	61	103
Calcium (mg)	49	88
Magnesium (mg)	25	37
Copper (mg)	6	4
Manganese (mg)	8	7
Iron (mg)	3	7
Beta carotene (mcg)	9	21
Vitamin C (mcg)	2	5

The nutrient analysis of the developed dense ball revealed about nutrient composition. Spirulina nutrient dense ball has protein 19g, calcium 88 mg, iron 7 mg, beta carotene 21 mcg which is higher compared to nutrient dense ball which has protein 15g, calcium 49 mg and iron three mg.

IMPACT OF SUPPLEMENTATION OF DEVELOPED PRODUCTS

Anthropometric measurement

Table VI depicts data about impact of the supplementation on the mean height, weight and BMI of the selected adolescent girls.

TABLE VI
IMPACT OF SUPPLEMENTATION ON THE MEAN HEIGHT, WEIGHT AND BMI
OF THE ADOLESCENT GIRLS

	Control group	Experimental group A	Experimental group B
Height			
Before supplementation	150.56 ± 3.65	150.79 ± 3.04	148.55 ± 3.50
After supplementation	150.36 ± 3.47	152.86 ± 2.86	149.86 ± 2.75
't' value	1.191 ^{Ns}	8.404**	2.278*
Weight			
Before supplementation	39.60 ± 3.19	41.35 ± 2.12	37.64 ± 2.70
After supplementation	39.72 ± 2.96	42.64 ± 1.93	38.44 ± 2.63
't' value	3.735 ^{Ns}	8.597**	6.597*
BMI			
Before supplementation	17.26 ± 1.57	18.46 ± 1.30	16.37 ± 1.22
After supplementation	17.60 ± 1.43	18.76 ± 1.21	16.43 ± 1.50
't' value	1.029 ^{Ns}	4.249**	0.423 ^{NS}

*Significant at five per cent level; **Significant at one per cent level; Ns – Not significant

From table VI it could be inferred that the mean height, weight and BMI increased after supplementation of nutrient dense ball and spirulina incorporated nutrient dense ball.

After supplementation, the height, increased from 150.79 ± 3.04 to 152.86 ± 2.86 in the experimental group A and from 148.55 ± 3.50 to 149.86 ± 2.75 in the experimental group B. After supplementation, the weight increased from 41.35 ± 2.12 to 42.64 ± 1.93 in the experimental group A and from 37.64 ± 2.70 to 38.44 ± 2.63 in the experimental group B.

After supplementation the BMI increased 37.64 ± 2.70 to 38.44 ± 2.63 in the experimental group A and from 16.37 ± 1.22 to 16.43 ± 1.50 in the experimental group B and it was significant at 1 percent level.

TABLE VII
IMPACT OF SUPPLEMENTATION ON THE MEAN
HAEMOGLOBIN LEVEL OF THE ADOLESCENT GIRLS

Normal Value of hemoglobin* (11-12 g/dl)	Before supplementation	Control group	Experimental group A	Experimental group B
		8.24 ± 1.33	9.63 ± 1.73	8.97 ± 1.73
	After supplementation	8.84 ± 1.54	12.06 ± 1.29	9.64 ± 1.65
't' value		5.728^{Ns}	12.868^{**}	11.050^{**}

Ns – Not significant; ** - Significant at one per cent level.

After supplementation, the haemoglobin level increased from 9.63 ± 1.73 to 12.06 ± 1.29 in the experimental group A and from 8.97 ± 1.73 to 9.64 ± 1.65 in the experimental group B when compared to normal value, statistical analysis revealed that increase is significant at one per cent level. In the control group the increase was not significant.

Impact of supplementation on the mean total protein - albumin and globulin level of the adolescent girls

Table VIII presents data about impact of supplementation on the mean total protein level of the adolescent girls.

TABLE VIII
IMPACT OF SUPPLEMENTATION ON THE MEAN TOTAL PROTEIN -
ALBUMIN AND GLOBULIN LEVEL OF THE ADOLESCENT GIRLS

		Control group	Experimental group A	Experimental group B
Normal value of Total protein* (6-8 g/dl)	Before supplementation	5.06±1.20	4.56±1.13	5.12±0.89
	After supplementation	5.33±0.79	6.76±0.69	7.184**
	't' value	6.184 ^{Ns}	14.319**	12.577**
Normal value of Albumin* (3.7-5.3 g/dl)	Before supplementation	3.34±0.80	2.80±0.75	3.24±0.64
	After supplementation	4.067±.80	3.87±0.64	4.48±0.51
	't' value	2.627 ^{Ns}	8.969**	8.021**
Normal value of Globulin* (2.3-3.6 g/dl)	Before supplementation	2.71±0.50	1.86±0.73	2.02±0.57
	After supplementation	2.54±0.47	2.47±0.55	2.56±0.51
	't' value	2.627 ^{Ns}	8.969**	8.021**

** Significant at one per cent level; Ns – Not significant

*- (Park, 2002)

After supplementation, the total protein level increased from 4.56±1.13 to 6.33±0.79 in the experimental group A and from 5.12±0.89 to 6.76±0.69 in the experimental group B. The albumin level increased from 2.80±0.75 to 3.87±0.64 in the experimental group A and from 3.24±0.64 to 4.48±0.5 in the experimental group B and the globulin level increased from 1.86±0.73 to 2.47±0.55 in the experimental group A and from 2.02±0.57 to

2.56±0.51 in the experimental group B when compared to normal value, statistical analysis revealed that increase was significant at one per cent level.

Impact of supplementation on the mean TIBC level of the adolescent girls

Table IX presents data about Impact of supplementation on the mean TIBC level of the adolescent girls.

**TABLE IX
IMPACT OF SUPPLEMENTATION ON THE MEAN
TIBC LEVEL OF THE ADOLESCENT GIRLS**

		Control group	Experimental group A	Experimental group B
Normal Value of TIBC* (228-428 g/dl)	Before supplementation	332.00±80.35	370.67±78.37	337.67±79.34
	After supplementation	315.33±88.91	292.3±75.29	299.47±7.1
	't' value	2.617 ^{Ns}	6.602**	2.539**

Ns – Not significant; ** - Significant at one per cent level

*- (Park, 2002)

After supplementation, the TIBC level decreased from 370.67±78.37 to 292.3±75.29 in the experimental group A and from 337.67±79.34 to 299.47±7.1 in the experimental group B when compared with normal value the statistical analysis revealed that decreased is significant at one per cent level.

CONCLUSION

Iron deficiency anemia affects 4 to 5 billion people and in India it is a major health problem among adolescent girls. This micronutrient deficiency can be alleviated by dietary modification and supplementation. Spirulina supplementation is cost effective and a sustainable solution. Supplementing with spirulina incorporated nutrient dense ball for a period of 120 days had resulted in increased height, weight, and BMI and biochemical parameters - mean haemoglobin, total protein (albumin and globulin).TIBC decreased and reached the normal range.

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