

Nutritional Impact of Foods Made from Spirulina on Children of Selected Anganwadis of Siddipet District in Telangana State in India

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ABSTRACT

In the present investigation, we sought to study the impact of introducing spirulina based nutritional supplementation to the children of Siddipet District in Telangana, India. It was observed that beneficiaries are the social community who need help, support and awareness. An integrated, spectrum and holistic study approach was made to reach the beneficiary community. Several attempts were made to find out the answers to questions raised in the concurrent development of malnourished child health status in two ICDS projects, with 30 anganwadis in Bharat Nagar and 34 anganwadis in Cheriya under Siddipet District, with the guidance and help of District Collector and team of company, Sukrutha Organics. The Study encompasses both primary and

secondary source of information, covering anganwadis of ICDS, Bharat Nagar and Cheriya, out of which 2119 children each were selected for the study by using information collected by anganwadi teachers scheduled as tool for data collection. Peanut Chikkis (Brittle) and Biscuits made by the addition of Spirulina were distributed among the test group and no supplement was given in the control group of children who were enrolled under Anganwadis of Bharat Nagar and Cheriya ICDS of Siddipet District. Descriptive analysis was made to draw inferences. The study has come out with some major findings, in spreading the knowledge about the ill effects of malnutrition and benefits of spirulina and foods made with spirulina.

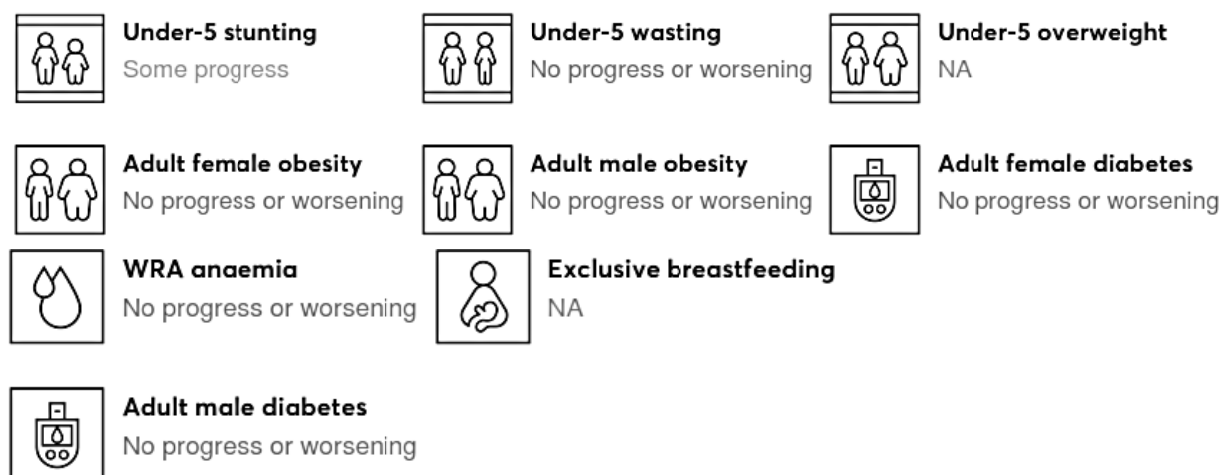
KEYWORDS: Malnutrition; Spirulina supplementation; healthy snacking.

Introduction

India's malnutrition problem results not from calorie intake but from dependence on a carbohydrate-based diet, low in protein and fat. We compromise on the intake of protein, fat and vitamins – all of which are essential for growth and inducing disease-fighting immunity at a young age. It is vital that Indian children get a balanced and nutrient-rich diet which includes all micro- and macronutrients need to bring about a healthy growth.

Poor maternal health and anemia during pregnancy is another reason for induction of stunting in children. This could have roots from adolescent anemia (Uliyar et al., 2000). This compromises resistance to diseases and nutrition value of breast milk. Poor pre-pregnancy body-mass index (BMI) and insufficient weight gain during pregnancy are common, as is blood and urine micronutrient deficiency. All of these, cause low birth weight, damaging the physiological development of a child. In many Indian households, women are taught to eat last, even when expecting.

Malnutrition or malnourishment is a condition that results from eating a diet in which nutrients are either not enough or are too much such that the diet causes health problems. It may involve calories, protein, carbohydrates, vitamins or minerals (Sandhu et al., 2010; Liu et al., 1991, Zhang and Liu, 1999). Not enough nutrients are called undernutrition or undernourishment while too much is called overnutrition. Malnutrition is often used specifically to refer to under nutrition where there is not enough a calorie, protein, or micronutrients. If under nutrition occurs during pregnancy, or before two years of age, it may result in permanent problems with physical and mental development. Extreme under nourishment, known as starvation, may have symptoms that include: a short height, thin body, very poor energy levels, and swollen legs and abdomen. People also often get infections and are frequently cold. The symptoms of deficiencies depend on the micronutrient that is lacking.



(Source: UNICEF/WHO/World Bank Group: Joint child malnutrition estimates, UNICEF global databases: Infant and young Child feeding, NCD risk Factor Collaboration, WHO Global Health Observatory).

Fig. 1. India's Progress against global nutrition targets in the year 2018.

Nutritional problems like protein energy malnutrition (PEM), anemia and vitamin A deficiency continue to plague a large proportion of Indian children. The major nutritional problems are protein energy malnutrition (PEM), vitamin A deficiency (VAD) and iron deficiency anemia (IDA). The main objective is to fight malnutrition and enhance the habit of healthy eating in all possible age groups.

In those with malnutrition, some of the signs of dehydration differ. Children; however, may still be interested in drinking, have decreased interactions with the world around them, have decreased urine output, and may be cool to touch.

TABLE 1
Signs of malnutrition.

Site	Sign
Face	Moon face (kwashiorkor), simian facies (marasmus)
Eye	Dry eyes, pale conjunctiva, Bitot's spots (vitamin A), periorbital edema
Mouth	Angular stomatitis, cheilitis, glossitis, spongy bleeding gums (vitamin C), parotid enlargement
Teeth	Enamel mottling, delayed eruption
Hair	Dull, sparse, brittle hair, hypopigmentation, flag sign (alternating bands of light and normal color), broomstick eyelashes, alopecia
Skin	Loose and wrinkled (marasmus), shiny and edematous (kwashiorkor), dry, follicular hyperkeratosis, patchy hyper- and hypopigmentation, erosions, poor wound healing
Nail	Koilonychia, thin and soft nail plates, fissures or ridges
Musculature	Muscles wasting, particularly in the buttocks and thighs
Skeletal	Deformities usually a result of calcium, vitamin D, or vitamin C deficiencies
Abdomen	Distended - hepatomegaly with fatty liver, ascites may be present

Spirulina is a natural food supplement. It is a blue-green alga (an ancient cyanobacterium) well known worldwide (Becker 1994a, 1994b; Fox 1996)

- Addresses several important micronutrient deficiencies among children;
- Approved as a food supplement & nutraceutical ingredient by the Government of India
- It is low cost, easy to produce locally, long shelf life, easy to store and transport.
- Quality standards are prescribed, and labs exist to test.

A study conducted by MCRC Madras, (volume 36 monograph, 1991) under Department of Bio Technology GoI with 5000 children with 1 gram of spirulina supplementation for 150 days has concluded that 'under prolonged under nutrition, food supplementation alone is not enough to combat malnutrition and there is requirement for micronutrients'. Today, India's national institutions like CFTRI, NIN, NDRC, are recommending Spirulina as a micronutrient supplement, a "Magic wand", enhancing the food absorption among children.

The study intended to report the social impact of intervention by the Sukrutha Organics team with the support of Anganwadi teachers to fight malnourishment among children between the age group of 1 year -5 years. In tune with the objectives mentioned above, the present study is based on detail and extensive survey of sample selected unit for collecting the data needed for the study.

Materials and Methods

Preparation Spirulina Chikki and Biscuit

Spirulina are blue-green microorganisms that was grown in fresh water and was procured from Spirulina Entrepreneurs, Kurnool. Spirulina powder was used in the preparation of the biscuits and chikkis. The chikkis were manufactured at Kriswa industries, Hyderabad, with the recipe and spirulina given as per the requirement and biscuits were manufacture at Sumo Biking foods, Hyderabad, as per the recipe given.

Peanuts, jaggery and liquid glucose were easily procured from local market. Peanut seeds have to be

roasted to golden brown colour (120–130°C), de-husked, de-germed and crushed into small bits of about 2.8 mm. Jaggery is generally crushed and made into syrup with addition of water and 10% weight of liquid glucose and warming and filtered through a nylon mesh of ~ 30 mesh to remove extraneous matter. The clear jaggery syrup is then heated until the temperature reached 145°C and immediately pre-weighed, roasted and de-husked peanuts are added and mixed thoroughly till the nuts get coated with jaggery syrup. This hot mass was then transferred on to a wooden board or clean platform, which was smeared with oil. The addition of required amount of spirulina was done. The product is then spread uniformly by rolling it with the help of a roller. Vertical and horizontal lines are marked with a cutter to make individual slabs then cooled to room temperature (27 ± 2°C) and are packed in polythene pouches.

Locally made hand biscuits are generally very popular among rural children. With a simple change in the recipe involving addition of micronutrients can take care of the wellness of the local community. There are primarily four stages of making the biscuit in a factory – mixing, forming, baking, and cooling. In the mixing stage, ragi flour, whole wheat flour, fat, sugar, water and spirulina ingredients were mixed together in the right proportion in large mixers to form the dough. The mixing time is carefully managed to achieve uniform distribution of ingredients and the right dough consistency. Convection ovens were used with belt operators maintaining a baking temperature on the belt and then cooling and packaging them to wrappers.

Analysis of the Products for their Nutritional Values

All the ingredients were approved as a food supplement & nutraceutical ingredient by the Government of India in their individual monographs. The products were tested for their nutritional values and approved in a NAAC accredited Lab (Vimta Lab, Hyderabad) as per the prescribed data.

TABLE 2
Ingredients and Nutritional value of the products used in the study.

S. No.	Products	Ingredients	Nutritional Value per 100gm
1	Spirulina Peanut Chikki	Spirulina, Peanut, Jaggery, Liquid Glucose	Calories 486, Calories from fat 213, Protein 16.62, Carbohydrates 51.71, Total fat 23.64, Saturated Fat 3.33, Trans Fat <0.1, Calcium 103.84, Iron 6.20, Dietary Fibre 11.71
2	Spirulina Ragi Biscuit	Spirulina, Ragi flour, Whole wheat, Edible Vegetable fat, Sugar, Milk Solids, Glucose, Raising Agents.	Calories 486, Calories From Fat 183, Protein 8.33, Carbohydrates 20.33, Total 20.33, Saturated Fat 11.07, Trans fat <0.1, Calcium 167.01, Iron 6.62, Dietary Fibre 7.64

Study Design

According to a study conducted by Ministry of health and welfare the malnutrition in the districts of Telangana was as follows in the year 2017. Siddipet was a new district formed after division of Medak district and

it can be observed from the table that the Stunting and wasting is relatively higher. Hence, this place was selected for the study.

TABLE 3

District wise Stunting, wasting and underweight details of children in Telangana State.

District	Children Under 5 who are stunted (%)	Children under 5 who are wasted (%)	Children under 5 who are under weight.
Adilabad	38.3	22.1	35.8
Hyderabad	15.7	14.1	16.8
Karimnagar	24.3	19.3	25.4
Khammam	26.5	13.7	22.2
Mahbubnagar	37.1	18.6	34.5
Medak	33.4	20.7	37.0
Nalgonda	28.9	23.1	34.1
Nizamabad	36.6	22.0	36.3
Ranga Reddy	26.2	14.8	25.8
Warangal	26.6	16.6	29.1
TELANGANA	28.1	18.0	28.5

Source: Press Information Bureau, Government Of India, Ministry of Health and Family Welfare, (11 August 2017 16:45 IST).

The multi-stage single blind random sampling method was implemented for the present study. Sampling has been selected from 30 Anganwadis of Bharatnagar ICDS project and 34 anganwadis of Cherial ICDS projects of Siddipet district. The list of children enrolled is as follows.

TABLE 4

Selection of Study groups.

S. No.	Selection	Name of the ICDS selected	Number of Anganwadis selected	Number of children Enrolled
1.	Control Group	Cherial (CH)	34	2119
2.	Test Group	Bharat Nagar (BN)	30	2119

TABLE 5

Study design details.

S. No	Detail	Spirulina Peanut Chikki	Spirulina Ragi Biscuit
1.	Bite Size	~25gm	~20gm
2.	Amount of spirulina	~500 mg/piece	~500mg/piece
3.	No of pieces per day	1	1
4.	Duration of the day	In addition to break-fast or evening snack alternatively	In addition to breakfast or evening snack alternatively
5.	No of days per month	25 days	25 days
6.	Data collected	Every 25 days for test and control groups	Every 25 days for test and control groups

TABLE 6

Number of children enrolled in the Anganwadis.

S. No	Name of the Anganwadi under Cherial ICDS, Siddipet, Telangana	No of children enrolled (Control Group), CH	Name of the Anganwadi under Bharath Nagar ICDS, Siddipet, Telangana	No of children enrolled (Test Group) BN
1	Cheiral - I	50	Barimam 1	71
2	Cheiral - II	83	Barimam 2	60
3	Cheiral - III	59	Bharath nagar 1	71

TABLE 6 Contd...

S. No	Name of the Anganwadi under Cherial ICDS, Siddipet, Telangana	No of children enrolled (Control Group), CH	Name of the Anganwadi under Bharath Nagar ICDS, Siddipet, Telangana	No of children enrolled (Test Group) BN
4	Cheiral - IV	56	Bharath nagar 2	76
5	Cheiral - V	49	Bharath Nagar 3	72
6	Cheiral - VI	75	Bharath Nagar 4	86
7	Gunturpally -VII	70	Charavadan 1	72
8	Cherial-VIII (Pochamma Vedhi)	62	Charavadan 2	80
9	Kadaverugu - I	76	Dogbangla	66
10	Kadaverugu - II	62	Erukawada 1	59
11	Kadaverugu - III	75	Erukawada 2	66
12	Ramsagar	61	Hanuman Nagar 1	69
13	Pothireddipally - I	50	Hanuman Nagar 2	93
14	Pothireddipally - II	61	Kanchariwada 1	60
15	Peddaraupeta	75	Kanchariwada 2	57
16	Nagapuri - I	56	Kanchit Chowrasta	58
17	Nagapuri - II	66	Khadeerpura 1	69
18	Nagapuri - III	75	Khadeerpura 2	74
19	Nagapuri - IV	48	Khadeerpura 3	85
20	Balbajiguda	62	Moinpura 1	58
21	Gandikunta	72	Moinpura 2	57
22	Chuchannakota - I	75	Moinpura 3	72
23	Chuchannakota - II	58	Moinpura 4	64
24	Chuchannakota - III	70	Murshad Gadda 1	72
25	Mustyala - I	67	Murshad Gadda 2	75
26	Mustyala - II	41	Murshad Gadda 3	70
27	Mustyala - III	60	Nasarpura 1	77
28	Veerannapet - I	65	Nasarpura 2	80
29	Veerannapet - II	62	Nasarpura 3	68
30	Veerannapet - III	75	Ramnagar	82
31	Rampur	54	-	-
32	Kasigudiselu	62	-	-
33	Kommuravelli - I	47	-	-
34	Kommuravelli - II	40	-	-
		2119	Total	2119

Anganwadi teachers having experience from their concurrent field work were visited personally for primary data collection. All the selected anganwadis were covered in this study. The children of Bharat Nagar ICDS were supplied with the chikkis and biscuits made from spirulina in addition to their normal routine diet given by anganwadis and the other group was not provided with any supplementation but were following the normal routine diet given by anganwadis. Approximately 25gm peanut chikki and approximately 20gm ragi spirulina biscuit were given to the children. Both were given to the children alternatively during breakfast as additional supplement and during snacking in the evening. The Protein Energy Malnutrition levels were considered and the deficit of 300kcal and 10gm (Daily Nutritional requirements of Indians, NIN) of protein was calculated and the dosage was designed accordingly.

Study Base Line and End Point

The data such as social background, economical background, gender, height, weight and age of the

children were collected prior to the supplementation, during and after the supplementation at regular intervals. The anganwadi helpers were trained and were interviewed and instruction on data collection.

To monitor the growth of children in terms of height, weight, appetite (Observations on the scale of 1-10), physical activities (Observations on the scale of 1-10) and cognitive development (using VSMS tool) over a period of 32 weeks. Number of students enrolled in the each Anganwadi is given in the table below.

Results and Discussion

Data has been analyzed and given in the tabulated form and analyzed based on the obtained frequencies. The table gives clear picture that around 35.67% in Cherial and 33.84% of the respondents belongs to the Scheduled caste (SC) and 32.08% of the respondents belongs to Scheduled Tribes (ST), 49.25% of the respondents belongs to the other backward (OBC) Classes and lastly 1.83% of the respondents belongs to the other categories.

TABLE 7

Caste of the enrolled children.

S. No.	Caste	Frequency CH	%	Frequency BN	%
1	SC	758	35.67	717	33.84
2	ST	609	28.77	527	24.86
3	OBC	713	33.69	823	38.90
4	Others	39	1.87	52	2.45
	Total	2119	100%	2119	100%

The caste-based enrollment was similar in the two ICDS projects selected.

The table below tells that 56.2% of the respondents were male and 43.8% of the respondents were female in Bharat Nagar ICDS, whereas 54.55% were male and 45.44% female children in Cherial ICDS.

TABLE 8

Gender of the enrolled children.

S. No.	Gender	Frequency CH	%	Frequency BN	%
1	Male	1156	54.55	1191	56.2
2	Female	963	45.44	928	43.8
	Total	2119	100%	2119	100%

The table 9 tells that children enrolled under the control group were not given the supplements at all but in the test group, about 96.33% of the respondents have consumed the spirulina chikkis and biscuits regularly, 3.25% of the respondents have not consumed the spirulina chikkis and biscuits regularly and only 0.42% of the respondents have not taken spirulina biscuits and chikkis. It is because they were hesitant towards the smell of spirulina after consuming. So, they could not continue the dosage. 3.25% of the respondents have not taken spirulina regularly because they have been out of the station, migration, change of their houses from one place to another place. So, they could not take the dosage regularly.

TABLE 9
Consumption of spirulina biscuits and chikkis regularly.

S. No.	Consumption of Spirulina biscuits and chikkis regularly	Frequency CH	%	Frequency BN	%
1	Regular	0	0	2041	96.33
2	Irregular	0	0	69	3.25
3	No	2119	100%	9	0.42
	Total	2119	100%	2119	100%

The table 10 expresses the observation of anganwadi teachers of the children after taking spirulina-based biscuits and chikkis and the ones without the supplementation. Only 54.9% of children from the control group and 79.42% of the respondent from the Test group have replied that the child's appetite has increased. With respect to the physical activity, teachers observed that 62.74% children have shown improvement in their physical activities in the control group whereas, 81.92% of the respondents from test group have shown improvement in their physical activities. Regarding cognitive development of the children, teachers told that as less as 45.27% children have shown an improvement in the control group whereas 79.75% of the respondents have shown positive response towards cognitive development in the test group.

TABLE 10
Anganwadi teacher's observation after intervention.

Sl. No	Teachers Observation after intervention	Yes (CH)		No (CH)		Yes (BN)		No (BN)	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	Increase in Appetite	1163	54.90	956	45.1	1690	79.75	429	20.24
2	Physical activities	1329	62.74	790	37.26	1736	81.92	383	18.07
3	Cognitive Development (Response)	959	45.27	1160	54.73	1683	79.42	436	20.58

The below graph represents the improvement of the increase in appetite, physical activities and cognitive development over the period of the study. This shows that there was a considerable increase in the children with supplementation when compared to the children without supplementation.

The difference in the increase in weights and heights of the students were calculated and have been recorded for every 25 days. After 32 weeks, it was found observed that over 82.64% of the children had an increase of their weight of more than 900gm in the test group when compared to only 68.39% children of control group. Also, the increase in height was calculated and analyzed. About 85.04% of the children gained height more than 5cm in the group with the supplementation whereas, only 71.79% of the children gained height above 5cm.

The increase in heights and weights was summarized every month and the growth in the control group was much lesser than that of the test group. Apart from the daily activities the children have shown good development in their BMI.

The graphical representation of the above work is represented in figure 3 here under.

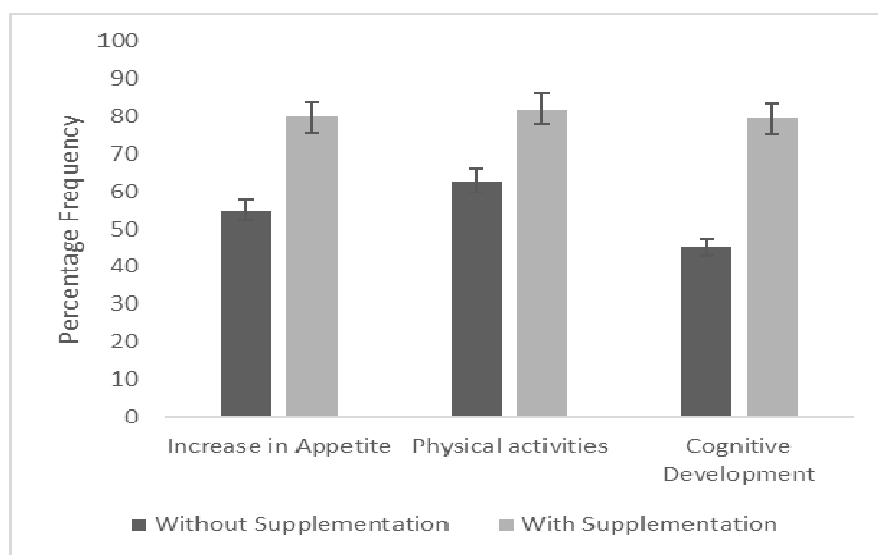


Fig. 2. Graphical representation of the recorded data in control and test groups.

TABLE 11

Calculation of differences in heights and weights after the intervention.

S. No	Data summarized after 32 weeks of intervention	Yes (CH)		No (CH)		Yes (BN)		No (BN)	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	Increase in Weight (>900gm)	1449	68.39	670	31.61	1751	82.64	386	17.36
2	Increase in Height (>5cm)	1522	71.79	597	28.21	1802	85.04	317	14.96

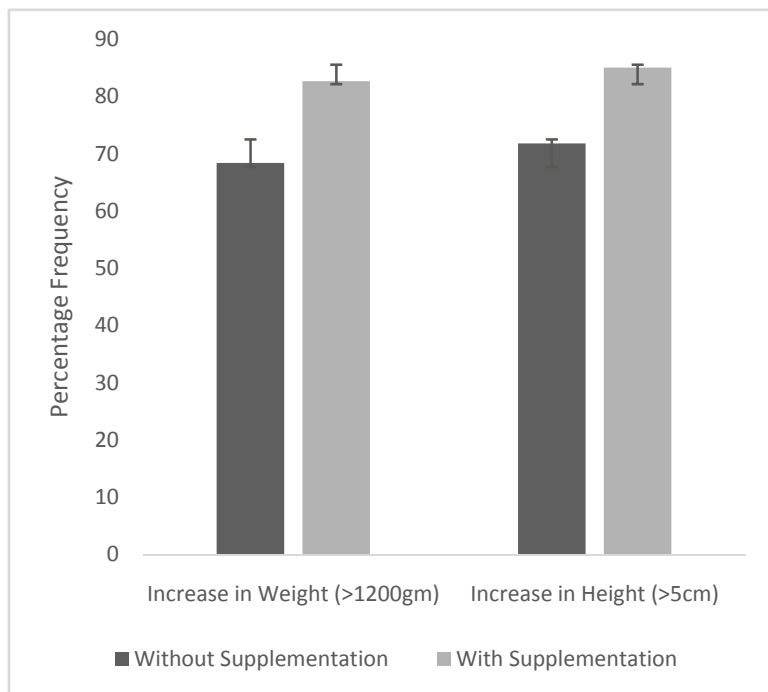


Fig. 3. Graphical representation on increase in heights and weights of the children with and without the spirulina supplementation.

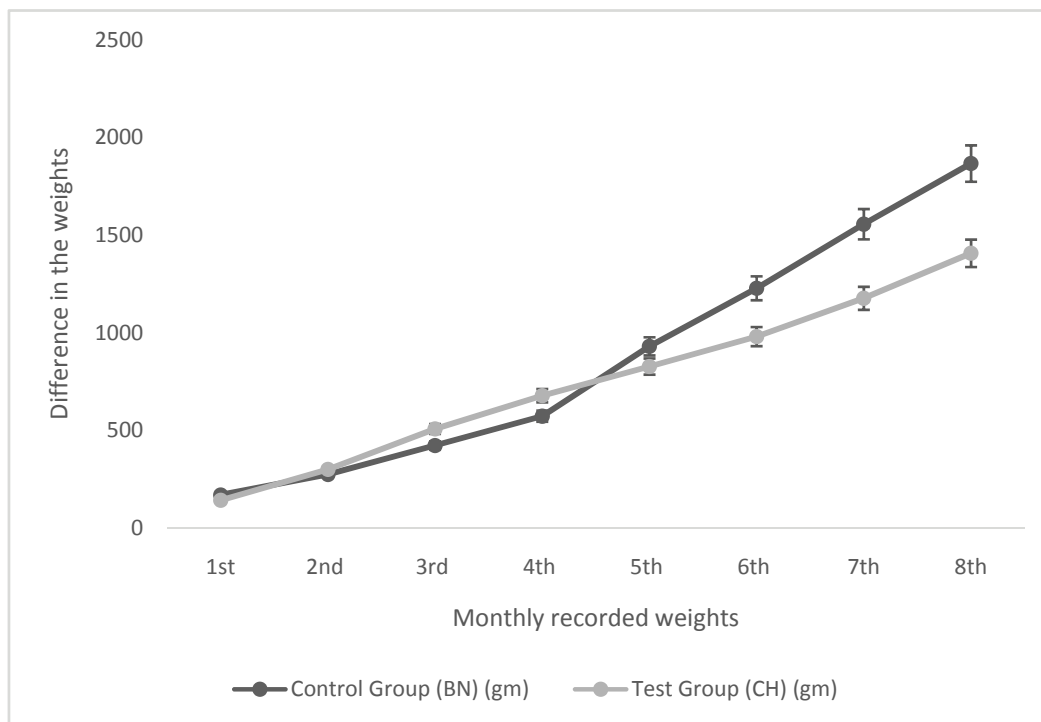


Fig. 4. The monthly increase in the weights of the children.

Also, the taste of the spirulina biscuits and chikkis was much appreciated by the children and the parents of the respondents. The anganwadi teachers referred to an increase in the regularity of the children after the intervention was started. It was also reported by Anganwadi teachers that there were no adverse effects recorded.

TABLE 12

Number of respondents wish to continue at Bharath Nagar ICDS.

Sl. No.	Wish to continue to feed Spirulina chikkis and biscuits	Frequency	Percentage
1	Yes	2080	98.16
2	No	39	1.84
	Total	2119	100%

Conclusions

From the above study, it was found that majority of the parents of the children enrolled under the program at ICDS Bharatnagar and Cherial were ignorant about their child's nutritional requirements. The data collected have given major findings on how micronutrients like spirulina can be given to children by masking its taste and odour. This way the intake was regular and consistent. The study also suggested that the children had benefitted in their height, weight, appetite, physical activities and their psychomotor skills. The average deficit of energy and protein, including the essential micronutrients like iron, calcium, dietary fiber etc., were provided with this healthy snacking. Considering the successful implementation at Siddipet, it can be expanded to other area where severe malnourished children are present. To enhance the scalability of the process and decentralized production of Spirulina, chikkis and biscuits, it would be better to involve rural women and build a capacity to encourage them to initiate small and micro enterprises so that the women and the entire community can produce and made available in the villages at a very reasonable cost to sustainability.

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