Chemical Science Review and Letters ISSN 2278-6783

Research Article

Edible Salt Enriched with Ferrous Sulphate Along with Low Cost Benefit Ratio (C:B) Helps in Curbing Iron Deficiency Anaemia (IDA)

Shikha Bathla[1]* and Kiran Grover[2]

[1]Krishi Vigyan Kendra, SBS Nagar, PO: PAU, Ludhiana-141004, Punjab, India
[2]Deptt. of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana-141004, Punjab, India

Abstract

Iron deficiency Anaemia (IDA) is a malnutrtional problem exists among the children, adolescent and vulnerable section of the society, at national and global level. The sound approach to reduce IDA with edible salt enriched with ferrous sulphate along with low cost-benefit ratio. In the present work, an initial survey was performed to detect Iron deficiency Anaemia (Hb>12g/dL) among adolescent girls (n=80) studying at Government schools of Ludhiana, (Punjab). Then the anaemic subjects, were categorized into control (n=30) and experimental (n=30) group. The experimental group were supplemented double fortified salt (containing iron 85ppm+iodine 15ppm/100g) while control group received only iodized salt (iodine 15ppm/100g) to use for three months in daily meals preparations for family. The findings revealed that there was significant improvement observed in terms of dietary intake of iron among the experimental group after supplementation for a period of three months.

Keywords: Anaemia, adolescents, iron, diet

***Correspondence**
Author: Shikha Bathla
Email: shikha_bathla@yahoo.com

Introduction

Iron deficiency Anemia a public health problem continues to be the leading single nutritional deficiency in the world, despite considerable efforts over the past three decades has been done to decrease its prevalence, Despite making rapid economic strides in the last couple of decades and being considered a global success story, India has been unable to address many of the nutritional deficiencies among its people. Globally, anaemia affects 1.62 billion people that correspond to 24.8 per cent of the population. The highest prevalence is in preschool age children-293 million (47.4%), among school children prevalence affected- 305 million (25.4%) and with the greatest number of individuals affected is non-pregnant women- 468.4million (30.2 %). Two billion people over 30 per cent of the world's population are anaemic The prevalence of anaemia in India is 74.3 per cent [1]. Addressing anaemia is a huge medical, social and developmental challenge for nations all around the world. The most important cause for anaemia is inadequate dietary intake of iron. Other causes include poor bio-availability of iron in phytate, fibre-rich diet; infections such as malaria, hook worm infestations and standard of living. Currently, nations have tried three major strategies to improve iron nutrition: Supplementation that includes the provision of iron supplements, especially to those at risk, such as pregnant women and adolescent girls. Dietary diversification includes increase in the iron content of the diet. Fortification implies fortify common food staples with iron. However, all approaches have some limitations. Accessibility and poor compliance are inhibiting factors in the supplementation strategy, while cost and time taken for significant results to be achieved are limitations of the dietary diversification approach. Experiences from other countries in controlling moderately to severe anaemia by adopting these long term intervention measures and also nutrition education to improve dietary intakes for hemoglobin synthesis is important. National programmes to control and prevent anemia have not been successful after a period of even three decades due to several factors responsible for it like use of low fortification level and low consumption of iron fortified food by the population. So, Ministry of women and children have now recommended combination of different approaches for combating Iron Deficiency Anemia (IDA) and Iodine Deficiency Disorders (IDD) that are major public health problems often co-existing in many regions in India. The challenge has been to find a food product that is universally consumed which will not react with high bio-available forms of iron. In the successful control of micronutrient deficiencies, exploration of new options is an ongoing effort. Though there is no one solution that can address the problem, an integrated combination of strategies that work is important. In this milieu, the technical break-through achieved in fortifying iodised salt with iron and thereby delivering a double dose in just one tiny pinch is an exciting development that holds promise with a potential for universal reach [2]. Moreover, Food fortification is often suggested as the best long-term approach to increase iron intake. To establish a successful food fortification program, however, it is essential to consider various important factors, including the choice of food vehicle and iron compound, the fortification level and ways to enhance iron bioavailability from the fortified food. The fortification process should comply strictly with good manufacturing practice and be closely monitored on a regular basis [3]. Double fortified salt (DFS) is high-purity, dry table salt fortified with iron compound and encapsulated potassium iodide. The iodate is encapsulated with dextrin using a spray-drying technique. Encapsulation prevents the iodine and iron from interacting with one another or coming into contact with moisture in the salt. The premix containing iron and iodine is then mixed into salt in dry condition at a specified rate [2]. Salt dual-fortified with iodine and micronized ground ferric pyrophosphate (FePP) is sound approach to control the micronutrient deficiency along with improving upon nutritional status. As per Food Safety and Standards, iron-fortified common salt means a crystalline solid, white or pale, pink or light grey in colour, free from visible contamination with clay and other extraneous adulterants and impurities. Keeping this in mind, National Institute of Nutrition (NIN) has promoted the technology of double fortification of common salt with iodine and iron as a strategy to control both deficiencies under food-based approaches that includes sodium hexa meta phosphate 10g/kg, powdered ferrous sulphate 5.08g/kg and powdered potassium iodate 0.067g/kg. NIN formulation & Nutrisalt have a stabilizer/promoter to maintain the stability of iodine in the presence of iron. The Micronutrient Initiative formulation uses physical separation of iodine by microencapsulation technique [4-6]. Currently, Tata Chemicals Limited is producing double fortified salt at large scale (Tata Salt Plus containing iron and iodine). It passed laboratory tests for nutrition information on the label, it claims to have iodine content (more than 15 ppm) and 850 ppm iron content (legally it is required to be 850–1,100 ppm). So Double-fortified salt (DFS) which is fortified with both iron and iodine is identified as a potential public health tool for delivering nutritional iron to population at large. But scanty of studies are available for the effectiveness of double fortified salt and need for more work to be done. So Keeping all the aspects in view, the present study has been planned with the aim to reduce anaemia among the vulnerable group.

Material and Methods

Selection of subjects

A baseline survey was preformed to screen the anaemia (Hb>12g/dL) among adolescent girls (n=80) studying (16-18 years) at Government schools of Ludhiana District (Punjab). Then the anaemic subjects (n=60) were categorized into control (n=30) and experimental (n=30) group to assess the impact of nutritional status of subjects for a period of three months conducting pre and post test.

Collection of Data

To accomplish the objectives of the study, an interview schedules was developed to obtain the desired the information on various aspects of data collection. The reliability of the schedule was worked out by pre testing on 10 respondents selected randomly on non-samples subject. Based on the response received during pre-testing certain necessary changes were incorporated in the schedule. Hence, the pre-tested and restructured schedules were used to collect the pre and post intervention data. The data pertaining to general profile of the subjects, age, caste, religion, food habits and morbidity status, reproductive profile, dietary intake and salt practices in the home were collected.

Nutritional Intervention

To evaluate the efficacy of supplementation among adolescent girls, both double fortified salt (experimental group-containing iron 85ppm+iodine 15ppm/100g) and iodized salt (control group- iodine 15ppm/100g) were distributed for the use in all meals prepared for the selected family of the subjects for a period of three months. Both double fortified salt (experimental) and iodized salt (control) were distributed for the use in all meals prepared for the family for a period of three months. Deworming tablets (albendazole) were given under medical supervision before the initiation of trials. The dietary intake were recorded by using 24 hour recall method for three consecutive days. The average daily intake of nutrients were calculated using the Indian Nutrition Software [7]. The food and nutrient intake were compared with the suggested dietary intake for balanced diet [8] and recommended dietary allowances [9].

Statistical Analysis

Student's *t* test was used as statistical tools for analysis the efficacy of double fortified salt in terms of improvement in dietary intake among the selected subjects. Results were expressed as Mean±SD and the level of significance was set at ($p \leq 0.05$; $p \leq 0.01$). Wilcoxon signed rank test to determine the improvement in knowledge scores. All statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 16.0 [10].

Results and Discussion

The present research work was undertaken in urban area of Ludhiana district. The results of the investigation have been presented and discussed under the following subheads:

General profile of selected adolescent girls

The general information of selected adolescent girls is presented in **Table 1**. The survey on selected adolescent girls revealed that in the control group, 56.67 per cent were in the age of 17-18 years old followed by 43.33 per cent in the age of 16-17 years old respectively. While in the experimental group, 80 per cent of the selected adolescent girls were in 16-17 years of age followed by rest 20 per cent from 17-18 years old. In the control group, the subjects were studying in 11th (53.33%) and 12th (46.67%) class while all the subjects in the experimental group were studying in 11th class (100%) only.

Table 1 General information profile of selected adolescent girls (n=60)

Characteristics	Control Group (n=30)	Experimental Group (n=30)	Total (n=60)
Age (Years)			
16-17	13(43.33)	24(80.0)	37(61.67)
17-18	17(56.67)	06(20.0)	23(38.33)
Class			
11	16(53.33)	30(100.0)	46(76.67)
12	14(46.67)	-	14(23.33)
Caste			
General	23(76.7)	21(70.0)	44(73.33)
SC	03(10.0)	05(16.67)	18(13.33)
BC	03(10.0)	04(13.33)	07(11.67)
OBC	01(3.33)	-	01(1.67)
Religion			
Hindu	20(66.67)	13(43.33)	33(55.00)
Sikh	09(30.0)	17(56.67)	26(43.33)
Muslim	01(3.33)	-	01(1.67)
Type of family			
Nuclear	23(76.67)	26(86.67)	49(81.67)
Joint	07(23.33)	04(13.33)	11(18.33)
Occupation			
Service	20(66.67)	13(43.33)	33(55.00)
Labour	03(10.00)	05(16.67)	08(13.33)
Business	07(23.33)	10(33.33)	17(28.33)
Farming	-	02(6.67)	02(03.33)
Total Monthly Income(Rs.)			
Less than 10,000	09(30.0)	4(13.33)	13(21.67)
10,000-20,000	14(46.67)	11(36.67)	25(41.67)
20,000-30,000	03(10.0)	10(33.33)	13(21.67)
30,000-40,000	02(6.67)	02(6.67)	04(06.67)
40,000-50,000	-	-	-
>50,000	02(6.67)	02(6.67)	05(08.33)
Food Habits			
Vegetarian	20(66.67)	22(73.3)	42(70.00)
Non-vegetarian	07(23.3)	03(10.0)	10(16.67)
Ovatarian	03(10.0)	05(16.67)	08(13.33)

#Values in the parenthesis represents the percentage

The distribution of subjects on basis of caste revealed that majority of the subjects in the control group, belonged to general category (76.7%) followed by SC (10%), BC (10%) and OBC (3.33%). For experimental group, most of the selected adolescents girls belonged to general class (70%) followed by SC (6.67%) and BC (13.33%) and There was no OBC subject in the experimental group. Sachan *et al* (2012) reported that majority of the anaemic adolescent girls belonged to general category (55.9%). Religion wise distribution of subjects showed that majority of the selected subjects in control group belonged to Hinduism (66.67%) followed by Sikhism (30%) and Muslims (3.33%). The data further showed that the subjects of experimental group belonged to mainly two religions i.e. Hinduism (43.33 %) and Sikhism (56.67 %). Goswami *et al.* (2009) reported that higher proportion (55.2%) of the subjects in Ludhiana city were Hindu followed by Sikh (44%) [11].

The distribution of subjects in control group according to family type revealed that majority of the subjects in control and experimental group were having nuclear family (76.67 vs 86.67 %) and rest were having joint family system (23.33 vs 13.33%). Kaur and Kaur (2011) observed that 58 per cent of the female subjects belonged to nuclear families [12]. The main source of income among the families of selected subjects was service followed by business and labour in both control (66.67, 23.33, 10%) and experimental group (43.33, 33.33, 16.67). Only 6.67 per cent of the selected families in experimental group were engaged in farming as a source of income. Majority of the selected families were having average family monthly income ranged from Rs.10, 000-20,000 in control (46.67%) and experimental group (36.67%). Only 6.67 per cent of the families in both the groups were having average monthly income >Rs.50, 000.

The data (Table 1) based on the food habits of the selected subjects revealed that majority of the selected subjects in control group were vegetarian (66.67%) followed by non-vegetarian (23.33%) and ovatraian (10%) while in the experimental group majority of the selected subjects were vegetarian (73.3%) followed by ovatarian (16.67%) and non-vegetarian (10%).

Morbidity status of selected adolescent girls

The morbidity status of the selected adolescent girls is presented in **Table 2**. The data based on morbidity status of selected adolescent girls in the experimental group showed that headache (76.67%), tiredness (50%), irregular appetite (43.3%), cold or cough (33.33%) was frequently occurred illness. While in control group, headache (56.67%), tiredness (40%), cold or cough (26.67%) and fever (23.33%) was frequently occurred illness faced by selected adolescent girls which are the clear cut symptoms of iron deficiency anaemia leading to low immunity among adolescent girls.

Table 2 Morbidity profile of selected adolescent girls (n=60)

Characteristics	**Control Group (n=30)**		**Experimental Group(n=30)**		**Total (n=60)**	
Illness	**Frequently**	**From last six mo.**	**Frequently**	**From last six mo.**	**Frequently**	**From last six mo.**
Fever	06 (20.0)	08(26.67)	07(23.33)	05(16.67)	13(21.67)	13(21.67)
Typhoid	-	-	-	-	-	-
Diarrhea	02(6.67)	02(6.67)	-	-	02(3.33)	02(3.33)
Jaundice	-	-	-	-	-	-
Cold or cough	10(33.33)	07(23.33)	08(26.67)	03(10.0)	18(30.0)	10(16.67)
Tiredness	15(50.00)	-	12(40.00)	-	27(45.0)	-
Headache	23(76.67)	01(3.33)	17(56.67)	01(3.33)	40(66.67)	02(3.33)
Appetitie	13(43.33)	-	03(10.0)	-	16(26.67)	-
Health check-up						
Yes	13(43.33)		04(13.33)		17(28.33)	
No	17(56.67)		26(86.67)		43(71.67)	
Health care facility availed						
Govt. Hospital	01(3.33)		02(6.67)		03(5.00)	
Private hospital	08(26.67)		01(3.33)		09(15.00)	
Primary health centre	-		-		-	
Chemist Shop	04(13.33)		01(3.33)		05(8.33)	

#Values in the parenthesis represents the percentage

The data further revealed that only 43.33 per cent of the control subjects and 13.33 per cent of the experimental subjects used to go for regular health check-up. Majority of the subjects in the control and experimental group during illness availed health care facilities in private hospital (26.67 vs 3.33%), chemist shop (13.33 vs 3.33%) and government hospital (3.33 vs 6.67%).

Reproductive profile of selected adolescent girls

The reproductive profile of the selected adolescent girls is presented in **Table 3**. The data on the reproductive profile revealed that the mean age of menarche was 13.66±2.53 years in the control and 13.46±2.60 years in experimental group. Mohite *et al*. (2013) reported that 97.0 percent of girls attained menstruation at the age of 12.8±1.06 years [13]. In the present research work, 70 per cent of the selected subjects (control) were having regular menstruation and whereas in experimental group, 83.33 percent have regular menstrual cycle.

Table 3 Reproductive profile of selected adolescent girls (n=60)

Characteristics	Control Group (n=30)			Experimental Group(n=30)			Total (n=60)		
Age of Menarche (Years)									
11	-			01(3.33)			01(1.67)		
12	02(6.67)			04(13.33)			06(10.00)		
13	07(23.33)			08(26.67)			15(25.00)		
14	20(66.67)			14(46.67)			34(56.67)		
15	01(3.33)			03(10.00)			04(6.67)		
Mean age (±)	13.66±2.53			13.46±2.60			13.56 ±2.56		
Menstruation Cycle									
Regular	21(70.0)			25(83.33)			46(76.67)		
Irregular	09(30.0)			05(16.67)			14(23.33)		
Changes in appetite	Normal	↑	↓	Normal	↑	↓	Normal	↑	↓
Appetite during pre-menstruation	27 (90.0)	01 (3.33)	02 (6.67)	24 (80.0)	05 (16.7)	01 (3.3)	51 (85.0)	06 (10.0)	03 (5)
Appetite during menstruation	06 (20.0)	04 (13.3)	20 (66.7)	18 (60.0)	05 (16.7)	07 (23.3)	24 (40.0)	09 (15.0)	27 (45)
Appetite during post-menstruation	26 (86.7)	04 (13.3)	-	22 (73.3)	02 (6.67)	06 (20.0)	48 (80.0)	06 (10.0)	06 (10)
Medicine taken during menstruation									
Yes	03(10.0)			04(13.33)			07(11.67)		
No	27(90.0)			26(86.67)			53(88.33)		
Iron Folic acid supplementation									
Yes	01(3.33)			11(36.67)			12(20.0)		
No	29(96.67)			19(63.33)			48(80.0)		
Others Supplementations									
Yes	02(6.67)			02(6.67)			04(6.67)		
No	28(93.33)			28(93.33)			56(93.33)		
Deworming tablets									
Yes	0(0)			03(10.0)			03(5.00)		
No	30(100)			27(90.0)			57(95.0)		

#Values in the parenthesis represents the percentage

Table 3 further elucidated that 36.67 per cent of the selected adolescent in experimental group used to have iron folic acid (IFA) supplementation as compared to control (3.33%). While only 6.67 per cent of the selected subjects in both the groups were in the habit of taking additional supplements other than IFA. 10 per cent of the subjects in experimental group had taken deworming tablets. Singh (2014) reported that only 19.2 per cent of the adolescent girls were taking IFA tablets and the low adherence to IFA tablet intake was observed because of its side effects like headache, leg pain and nausea among the selected subjects [14].

Impact of intervention on the nutritional status of selected adolescent girls

Dietary Intake

Food intake

The mean daily food intake and per cent adequacy of food intake in selected adolescent girls is presented in **Tables 4-5**.

Table 4 Impact of nutrition intervention on the daily food intake by selected adolescent girl

Food Groups	Control Group (n=30)			Experimental Group (n=30)		
	Before	After	T-test	Before	After	T-test
Cereals	204±9.36	206±10.7	1.03 NS	200.5±31.5	201.2±34.3	0.73 NS
Pulses	41.2±10.9	41±21.8	0.72 NS	42±18.9	42.5±25.8	0.74 NS
Green leafy vegetables	27±8.61	30.3±39.7	0.88 NS	35±25.9	40±63.8	0.91 NS
Roots and tubers	69±15.9	67.5±21.7	0.80 NS	67±31.7	67±18.9	0.70 NS
Other vegetables	35±15.9	36±15.7	0.75 NS	35.1±12.7	38.5±17.3	1.01 NS
Fruits	40.5±20.8	40.3±20.6	0.71 NS	41.5±18.8	46±25.5	1.22***
Milk & Milk Products	205±21.6	205±64.3	0.70 NS	255±78.2	290±90.7	1.71***
Sugar and Jaggery	21.5±4.1	20.5±5.5	0.98 NS	23.5±7.8	23±8.8	0.77 NS
Fats/Oils	23.5±5.7	26±6.5	1.79***	28±6.3	29.5±8.3	0.96

#Values are represented as Mean±SD
##Nutrition Intervention: Control group (Iodized salt) and Experimental group (double fortified salt+nutrition counselling); **Level of significance at 0.05%; ***Level of significance at 0.01%; NS-Non Significant

Table 5 Impact of nutrition intervention on the per cent adequacy of food intake by selected adolescent girls (n=60)

Food Groups	SDI	Control Group (n=30)		Experimental Group (n=30)	
		Before (%)	After (%)	Before (%)	After (%)
Cereals	330	61.8	62.4	60.7	60.9
Pulses	75	54.9	54.6	56.0	56.6
Green leafy vegetables	100	27	30.3	35.0	40.0
Roots and tubers	200	34.5	33.7	33.5	33.5
Other vegetables	200	17.5	18.0	17.5	19.2
Fruits	100	40.5	40.3	41.5	46.0
Milk & Milk Products	500	41.0	41.0	51.0	58.0
Sugar and Jaggery	25	86.0	82.0	92.0	94.0
Fats/Oils	35	67.1	74.2	80.0	84.2

#Suggested Dietary Intake (SDI) by ICMR, 2010
##Nutrition Intervention: Control group (Iodized salt) and Experimental group (double fortified salt+nutrition counselling)

Cereals

On perusal of the results it was observed that the average daily intake of cereals among adolescent girls increased after supplementation in control (204±9.36 to 206±10.7g) and experimental group (200.5±3.1 to 201.2±34g.) However, the per cent adequacy of cereals intake by subjects in control (61.8, 60.7%) and experimental group (62.4, 60.9%) was found to be less than the suggested dietary intake value of 330g by ICMR (2011). Kaur (2009) reported that the lower mean daily intake of cereals in adolescent girls was 236±4.73g [15]. Zanver and Devi (2007) also reported the mean daily consumption of cereals among adolescent girls (13-18 years) ranged between 245.13 to 277.92g which was lesser as compared to ICMR recommendations [16].

Pulses

Consumption of pulses was in the form of staple and whole pulses. Initially the mean pulse consumption was 41.2±10.9 and 41±21.8g/day by the control and experimental group and the corresponding pulse consumption after the supplementation increased to 42±18.9 and 42.5±25.8g/day in both the groups (control and experimental). The per cent adequacy of pulses intake in control (54.9 and 54.6%) and experimental group (56.0 and 56.6 %) before and after supplementation was observed to be nearly half. Kapoor (2012) reported that the mean pulse consumption was 30.9 and 33.4g/day by the control and experimental group before supplementation and corresponding pulse consumption after the supplementation was 33and 34.6 day in control and experimental group respectively [17]. The results of present study are in line with the findings reported by Kaur (2009) and Singh (2008) that adolescent girls had lower daily mean intake of pulses as compared with the RDA [15,18].

Green Leafy Vegetables

The initial mean daily intake of green leafy vegetables by the subjects in control and experimental group was 27±8.61 and 35±25.9g/day. After the supplementation the average daily intake of green leafy vegetables increased in control (30.3±39.7g) and experimental group (40±63.8g/day). However, the intake of green leafy vegetable intake was found to be inadequate in both the groups even after nutritional intervention. Kaur (2000) reported that the daily intake of green leafy vegetable by control group (iodized salt) and experimental group (double fortified salt) during winter season ranged from 15 to 36 and 21 to 41g/day, whereas in summer the consumption of green leafy vegetables was negligible in both the groups due to reduced availability [19]. A non-significant difference was observed in GLV consumption of (iodized salt) and experimental group (double fortified salt) at p>0.01. In several studies, an inadequate consumption of green leafy vegetables was also reported among adolescent girls conducted in India [20-22]. Kaur (2009) showed that the per cent adequacy of green leafy vegetable was inadequate among adolescent girls before (34.75%) and after supplementation (44.25%) [15].

Roots and Tubers

The most commonly consumed roots and tubers by the selected adolescents girls were potatoes, and onion. The average daily intake of roots and tubers by the subjects in control and experimental group before supplementation was 69±15.9 and 67±31.7g/day. The corresponding value after the supplementation was 67.5±21.7 and 67±18.9g/day in control and experimental group. It was further investigated that the mean daily intake was much less than the recommended intake of 200g/day by ICMR (2011). There was non-significant change observed in the per cent adequacy of roots and tubers by the subjects in control and experimental group before (34.5, 33.5%) and after supplementation (33.7, 33.5%). Kapoor (2012) reported the initial mean daily intake of roots and tubers by the adolescent girls in control and experimental group was 88.65and 76.78g/day and after the study was 78.75 and 79.45 g/day [17]. Singla (2011) indicated the mean daily intake of roots and tubers by adolescent girls were 79.6±33.77g/day [23].

Others vegetable

The most commonly consumed others vegetables by all the adolescent girls was capsicum, cauliflower, lady finger and cucurbitaceous. The initial and final daily intake of other vegetables was increased in control (35±15.9 to 36±15.7g) and experimental group (35.1±12.7 to 38.5± 17.3g). However, the mean daily intake of others vegetables was inadequate as compared with the recommended intake of 200g [8]. Nahar *et al* (2009) reported that consumption of other vegetables was 43 and 53g among subjects of Jalandhar and Kapurthala districts which was less than ICMR recommendations [24].

Fruits

The initial average daily intake of fruits by the adolescent girls in control and experimental group was 40.5±20.8 and 41.5±18.8g/day and the corresponding value after supplementation was 40.3±20.6 and 46±25.5g/day. There was a significant increase (p>0.01) observed in the consumption of fruits among the subjects of experimental group which may be due to regular nutrition counselling. But the mean daily intake was observed inadequate in both the groups even after supplementation. In terms of per cent adequacy there was 41.5 to 46.0 per cent increase observed after supplementation in the consumption of fruits by the subjects of experimental group as compared to control (40.5 to 40.3%). Similar results were also reported by Mittal and Srivastava (2006) and Kaur (2009) that adolescents consume less fruits as they have more interest in the junk food rather than taking fresh fruits [25,26].

Milk and Milk Products

It was recorded in the dietary survey that that consumption of milk was in the form of buttermilk, tea, curd and as sweet dish like kheer, custard and vermicelli. The initial mean daily intake of milk and milk products in control and experimental group was 205±21.6 and 255±78.2g/day. After the supplementation, the corresponding values observed were 205±64.3 and 290±90.7g/day. The per cent adequacy of milk and milk products was found constant in control group (41%) whereas an increase was observed in experimental group, after supplementation (51 to 58%) due to nutrition conselling. However, the mean intake of milk and milk products was found less in both the group as compared to suggested dietary intake value of 500g/day [8]. Batra (2009) reported that the milk intake was 99 and 87 per cent among vegetarian and non-vegetarian adolescent girls of Ludhiana [19].

Sugar and Jaggery

The mean daily initial intake of sugar and jaggery among the subjects in control and experimental group before the study was 21.5±4.1 and 23.5±7.8g/ day and after supplementation the corresponding values was 20.5±5.5 and 23±8.8g/day. There was an increase observed in per cent adequacy of sugar and jaggery after supplementation in experimental group (92 to 94 %) as compared to control group (86 to 82%).The data from the present investigation showed that intake of sugar and jaggery was little less than recommended guidelines of 25g/day [8]. Inadequate intake of sugar and jaggery was also reported in the current findings [15, 20, 27].

Fats and Oils

The initial mean daily intake of fats and oils in control (23.5±5.7 to 26.5±6.5g) and experimental group (28±6.3 to 29.5±8.3g) also increased significantly. However, the intake of fats and oils was less than 35g/day as recommended by ICMR (2011). There was increase observed in the per cent adequacy of fats and oils after supplementation in control (67.1 to 80%) and experimental (74.2 to 84.2%) group. In contrast to present study, Kumari and Jain (2005) reported that intake of fats and oils was higher in girls as compared to boys [28].

Nutrient intake

The mean daily intake of nutrients by the selected adolescent girls and per cent adequacy of the nutrients is presented in **Tables 6-7**.

Table 6 Impact of nutrition intervention on the average daily nutrient intake by selected adolescent girls (n=60)

Nutrients	**Control Group (n=30)**			**Experimental Group (n=30)**		
	Before	**After**	**T-test**	**Before**	**After**	**T-test**
Energy (kcal)	1613.35±89.8	1601.35±86.8	0.81 NS	1643.35±93.8	1670.75±99.0	3.54***
Protein (g)	49.08±8.9	48.30±8.1	0.84 NS	49.00±9.2	49.98±10.9	3.10***
Fat (g)	52.23±7.9	52.09±7.8	0.70 NS	53.80±8.4	53.99±8.5	2.76***
Calcium(mg)	448.19±78.9	448.14±78.9	0.68 NS	448.01±78.8	451.60±79.2	1.88**
Iron(mg)	12.66±5.8	12.69±5.8	0.71 NS	12.96±5.9	13.99±6.2	1.93**
Folate (mg)	99.02±44.2	98.41±41.9	0.76 NS	99.82±44.4	99.89±44.6	1.87**
Vitamin$_{12}$(ug)	0.38±0.3	0.38±0.3	1.12 NS	0.41±0.4	0.42±0.4	0.91 NS
Vitamin C(mg)	27.08±12.6	27.81±12.8	0.92 NS	27.08±12.6	28.98±13.1	1.22 NS
Vitamin A(ug)	254.41±54.9	254.04±54.8	0.71 NS	265.56±57.7	267.23±58.1	1.99**
Thiamine (mg)	0.94±0.4	0.94±0.4	0.73 NS	0.98±0.5	0.98±0.5	0.98 NS
Riboflavin (mg)	0.38±0.3	0.37±0.3	1.09 NS	0.37±0.3	0.37±0.3	1.05 NS
Niacin (mg)	6.87±3.5	6.86±3.5	0.69 NS	6.87±3.6	6.89±3.7	1.20 NS
Zinc (mg)	4.18±2.9	4.17±2.9	1.47 NS	4.29±3.2	4.29±3.2	0.86 NS

#Values are represented as Mean±SD
##Nutrition Intervention: Control group (Iodized salt) and Experimental group (double fortified salt+nutrition counselling)
** Level of significant at 0.05%; ***Level of significant at 0.01%

Energy

The initial and final mean intake of energy in control group was 1601.35±86.8 and 1613.35±89.8kcal/day whereas in experimental group a significant increase was observed in the intake of energy after supplementation i.e. 1643.35±93.8 to 1670.75±99.0 Kcal/day. The daily intake of energy was far less than the recommended level of 2440 kcal/day for adolescent girls.

In terms of per cent adequacy, the intake of energy increased after supplementation in experimental group (67.35 to 68.36%) as compared to control group (66.10 to 65.62 %). Kapoor (2012) reported that the mean take of energy by anaemic adolescent girls was increased from 1789.56±19.01 to 1978±17.46 Kcal/day after supplementation as compared to control group (1772.66±18.2 to 1775±15.2 Kcal/day) [17]. The average intake of energy in the adolescent girls was 1729 and 1946 Kcal/day as reported by Singla (2011) and Kaur (2009) respectively [23, 15].

Protein

The initial mean intake of protein by the subjects in control and experimental group was 49.08±8.9 and 49±9.2g/day, respectively. After the supplementation the corresponding values were 48.03±8.1 and 49.98±10.9g/day.

There was a significant (p>0.01) increase observed in terms of protein intake among the subjects of experimental group after supplementation. The data in terms of per cent adequacy revealed that protein intake was increased in experimental group (94.4 to 96.3%) as compared to control (94.5 to 93.0%) after supplementation of double fortified salt and nutrition counseling for three months. Paimalavalli and Sangeetha (2011) reported that mean intake of protein among adolescent girls (13-18 years) was 48.9 and 56 g/day from government and private schools [29]. In contrast to present study, Goswami (2009) reported the mean intake of proteins was 65g.1g/day among adolescents [11].

Table 7 Impact of nutrition intervention on the Nutrient adequacy ratio (NARs) and Mean adequacy ratio (MAR) of selected adolescent girls (n=60)

NAR (%)	**RDA^**	**Control Group (n=30)**		**Experimental Group (n=30)**	
		Before (%)	**After (%)**	**Before (%)**	**After (%)**
Energy	2440	66.1	65.6	67.3	68.3
Protein	51.9	94.5	93.0	94.4	96.3
Fat	40	130.5	130.2	134.5	134.9
Calcium	800	56.0	56.0	56.0	56.4
Iron	26	48.6	48.8	49.8	53.8
Folic Acid	200	49.5	49.2	49.9	49.9
Vitamin B_{12}	0.2-1.0	63.3	63.3	68.3	70.0
Vitamin C	40	67.7	69.5	67.7	72.4
Vitamin A	800	31.8	31.7	33.1	33.4
Thiamine	1.0	94.0	94.0	98.0	98.0
Riboflavin	1.2	31.6	30.8	30.8	30.8
Niacin	14	49.0	49.0	49.0	49.2
Zinc	12	34.8	34.7	35.7	35.7
MAR		54.5	54.6	55.5	55.9

#Values are represented as Mean±SD
##Nutrition Intervention: Control group (Iodized salt) and Experimental group (double fortified salt+nutrition counselling)
^Recommended Dietary Allowance (RDA) by ICMR, 2010

Fat

The initial mean intake of fat by the subjects in control and experimental group was 52.23±7.9 and 53.80±8.4g/day, respectively. After the supplementation, the fat intake was recorded as 52.09±7.8 and 53.99±8.5g/day, in control and experimental group respectively. There was non-significant difference (p>0.05) observed in the intake of fat by the subjects in control group and a significant difference (p>0.01) in fat intake by the subjects of experimental group. Kapoor (2012) also observed a significant (p>0.01) increase in the average fat intake from 51.55 to 53.67g/day after supplementation [17].

Daily micronutrient intake

The mean daily intake of micro nutrients (vitamins and minerals) by the selected adolescent girls and per cent adequacy of the nutrients is presented in Table 6 and 7 respectively.

Thiamine

The initial mean daily intake of thiamine by control and experimental group was observed as 0.94±0.4 and 0.98±0.5mg respectively whereas no change was found after supplementation in both the groups. A non-significant difference (p≤ 0.05) was persisted in the intake of thiamine in both groups. The per cent adequacy was found to be 94 for control and 98 for experimental group. The thiamine intake nearly adequate in both the groups. The results were in line with study conducted by Batra (2009). The study reported thiamine intake by vegetarian and non vegetarian adolescent girls as 0.97 and 0.85 mg respectively [6].

Riboflavin

A non-significant difference in the intake of riboflavin was observed before and after supplementation in both the groups. The intake of riboflavin was incomparable with RDA of 1.2 mg. Kapoor (2012) reported that per cent adequacy of riboflavin intake was lower among the adolescents girls [26]. On the contrary, higher intake of riboflavin was reported by Kaur (2009) before and after supplementation as compared to ICMR recommendations [8,26].

Niacin

The initial mean daily intake of niacin by control and experimental subjects was observed as 6.87±3.5 and 6.87±3.6 mg/day. After supplementation the increase in niacin intake was observed in experimental (6.89±3.7mg) group as compared to control (6.86±3.5mg) subjects. However, the per cent adequacy before and after supplementation in control and experimental group was inadequate. In contrast to present sudy, there was higher intake of niacin after supplementation ($p \geq 0.05$) as observed by Kaur (2009) and Laxmaiah *et al* (2002) respectively [26, 30].

Folate

On perusal of the data, it was further found that the initial and final mean daily folate intake decreased in control group (99.02±44.2 to 98.41±41.9ug) as compared to experimental group (99.82±44.4 to 99.89±44.6μg). A significant difference was observed among the subjects of experimental group ($p \geq 0.05$). The intake was reported less when compared to recommended allowances. The fewer intakes can be attributed to low intake of green leafy vegetables by the subjects. The per cent adequacy of the folate before and after supplementation was less than the recommended allowances in control (49.51 to 49.20%) and experimental group (49.91 to 49.94 %). The results were in line with the study of Singla [23] In contrast to present study, Kaur (2000) reported that intake of folate during summer and winter season in both groups, providing iodized salt (215.1 and 183.3ug) among the control and providing double fortified salt (210.2 and 187.0ug) among the experimental group was higher than the recommended dietary value [19].

Ascorbic Acid

The data (Table 6) showed that initial mean ascorbic acid intake in control and experimental group were 27.08±12.6 and 27.19±12.6 mg/day. A significant difference was observed after the supplementation in experimental (28.98±13.1mg) as compared to control (27.81±12.8mg) group. The per cent adequacy (Table 7) of the ascorbic acid intake before and after supplementation was 67.7 and 69.52 per cent in control, 67.7 and 72.45 per cent in experimental group. The average intake of ascorbic acid was low as compared to the findings of Kaur (2000) which reported average intake of ascorbic acid of 143.5 and 146.2 perent in control (iodized salt) and experimental group [19]. Shekhar (2005) reported the mean daily intake of ascorbic acid among adolescents girls as 98.0±2.81mg/d [31].

Vitamin A

The data (Table 6) showed that initial mean vitamin A intake in control and experimental group were 254.41±5.49 and 265.56±57.5 ug/day. A significant difference was observed after the supplementation in experimental (267.23±58.1 ug) as compared to control (254.04±54.8ug) group. The per cent adequacy (Table 7) of the vitamin A also improved in experimental as compared to control group due to the effect of supplementation. Kapoor (2012) also observed similar results [17].

Calcium

The initial mean daily intake of calcium by the selected adolescent subjects was observed as 448.19±78.9 and 448.01±78.8 mg in control and experimental group. A significant difference was observed in the mean calcium intake among the subjects of experimental (451.60±79.2mg) as compared to control (448.14±78.9mg) group. However, the intake was found to be inadequate when compared to recommended allowances before and after supplementation among the subjects of control (56.02 to 56.01%) and experimental (56.0 to 56.4%) group. Savitha and Narayanan (2007) reported the average intake of calcium as 85.4 per cent of the recommendation [32]. Whereas Kaur (2009) and Agrahar and Pal (2004) reported that calcium intake of more than 100 per cent among the adolescents subjects as compared to suggested value [26, 33].

Iron is a vital micro nutrient for preventing aneamia and for normal synthesis of red blood cell formation. The results (Table 6) revealed the lower average daily iron intake by the subjects before and after supplementation in control (12.66±5.8 to 12.69±5.8mg) and experimental (12.69±5.8 and 13.99±6.2mg) group. A Significant difference

($p \leq 0.05$) was found among the subjects of experimental group having higher intake as compared to subjects of control group due to the effect of nutritional counseling and consumption of double fortified salt. The intake before and after supplementation was 48.69, 48.80 per cent in control and 49.84 and 53.80 per cent in experimental group respectively when compared to recommended allowances (Table 7). The low iron intake of adolescent girls was attributed to the insufficient consumption of green leafy vegetables. The intake of iron was observed lower when compared to the results of Kaur (2009) reported that mean iron intake before and after supplementation was 15.07 mg and 17.05 mg respectively [26]. Kaur (2000) reported that the daily dietary intake of iron by IS (iodized group) during summer and winter season with the mean values of 11.8 and 14.4mg, respectively while in DFS (double fortified salt) the average daily dietary iron intake was 11.4 and 15.6 mg respectively [15, 19]. Kapoor (2012) and Rao *et al* (2006) also reported inadequate iron intake among the adolescent girls [17, 27].

Zinc

The initial mean daily intake of zinc by the subjects was observed as 4.18±2.9 and 4.29±3.2mg in control and experimental group respectively. A non-significant difference was observed after supplementation among the subjects of control (4.17±2.9mg) and experimental (4.29±3.2mg) group.

The intake was inadequate when compared to recommended allowances before and after supplementation among the subjects of control (34.83 to 34.75%) and experimental group (35%). The results were in line with the investigation done by Kaur (2000) which reported the daily dietary intake of zinc by IS (iodized group) during summer and winter season with the mean values of 5.5 and 5.3mg/day while in DFS (double fortified salt) the average daily dietary iron intake was 5.3 and 5.6 mg/day [19]. Kapoor (2012) reported that initial zinc intake of subjects in control and experimental group was 11.11±0.74 and 10.02±0.32mg/day and the corresponding value after supplementation was 10.96±0.31and 11.23±0.16 mg/day [17]. However, the average daily intake of zinc by the subjects was less than the recommended level of 12mg by ICMR [9].

Vitamin B12

The data (Table 6) showed the mean vitamin B12 intake in control group was found constant before and after supplementation (0.38±0.3mg /day). But there was a modest increase observed after the supplementation in experimental (0.41±0.4 to 0.42±0.4mg) as compared to control group. The per cent adequacy (Table 7) of the vitamin B12 intake before and after supplementation was 68.3 and 70 per cent in experimental group, where as in control group, vitamin B12 intake remain unchanged (63.3%). The results were in line with the investigation done by Kapoor (2012) that the daily vitamin B12 increased after the supplementation in experimental group (0.40 to 0.47mg) as compared to control group (0.38 to 0.39 mg) [17]. Singla (2011) reported the mean daily intake of vitamin B12 among the adolescent girls as 0.28mg [23].

Conclusion

The present work was undertaken to investigate the efficacy of double fortified salt in combating the dual problem of iron and iodine deficiency.A higher increase in percent adequacy of dietary intake - green leafy vegetable (35 to 40), other vegetables (17.5 to 19.2), fruits (41.5 to 46), milk and milk products (51 to 58) and fats/oils (80 to 84.2) was observed after nutrition intervention in experimental group. However, the mean daily food intake remained inadequate in both groups (control and experimental). Improvement was also observed after nutrition intervention among adolescent girls of experiment group in terms of percent adequacy of nutrients - energy (67.35 to 68.36%), protein (94.4 to 96.3%), fats (134.5 to 134.9%), calcium (56.0 to 56.4%), iron (49.84 to 53.80%), folate (49.9 to 50.0), vitamin B12 (68.3 to 70%) and vitamin A (33.1 to 33.4 %). Daily consumption of double fortified salt (DFS) proves beneficial in reduction of iron deficiency anaemia [34-36]. None of the beneficiaries complained any side effects of (DFS) over a period of 90 days. The significant improvement in food and nutrient intake was found among adolescent girls after supplementation of double fortified salt along with nutrition counselling. However, the intake of adolescent girls remained inadequate.

Recommendations

Supplementation of double fortified salt among selected adolescent subjects improved the iron stores. So daily use of double fortified salt in regular meals is also cost-benefit along with helps in improving the body iron stores as it has ferrous sulphate in an encapsulated form that has high absorption rate.

Acknowledgement

Authors acknowledge Tata Chemicals Limited (Mumbai, India) for providing the double fortified salt for research purposes.

References

[1] WHO, World Health Organisation, Worldwide prevalence of anaemia 1993-2005, Geneva, WHO global database on Anaemia, 2008.
[2] Micronutrient Initiatives, Prevalence of anaemia and micronutrient deficiencies in children, 2009, p6
[3] M.B. Zimmermann, A. Saad, S. Hess, T. Torresani, N. Chaoki, Eur. J. Endocrinol., 2000, 143, 727–31.
[4] B. Sivakumar, K.M. Nair, Ind. J. Pediatr., 2002, 69, 617-23.
[5] R. Wegmuller, F. Camara, M.B. Zimmermann, P. Adou, R.F. Hurrell, J Nutr., 2006, 136, 1814-20.
[6] K. Joshi, S. Nair, 2011, 2, ISSN., 584-92.
[7] Diet Soft, A solution to Dietary Calcuations, AIIMS, New Delhi, 2009.
[8] ICMR, Dietary Guidelines for Indians. National Institutes of Nutrition, Hyderabad, India, 2011.
[9] ICMR, Nutrient Requirement and Recommended Dietary Allowances for Indians, National Institutes of Nutrition, Indian Council of Medical Research, Hyderabad, Indian, 2010.
[10] Statistical Package for the Social Sciences (SPSS), Version 16.0., Center for Social Science Computation and Research, USA, 206, 543-8110.
[11] P. Goswami, R. Jain, D. Mridula, The. Ind. J. Nutr. Dietet., 2009, 46, 118-26.
[12] I.P. Kaur, S. Kaur, J. Exercise. Sci. Physio., 2011, 7, 11-18.
[13] R.V.Mohite, V.R. Mohite, S.M. Kumbhar, P. Ganganahalli, J. Krsihna. Inst. Med. Sc.i Univ., 2013, 2, 89-97.
[14] A. Singh, Seasonal variation in iron status of adolescent girls and its management. Ph.D. Dissertation. Punjab Agricultural University, Ludhiana, India, 2014. http://krishikosh.egranth.ac.in/handle/1/5810016080.
[15] S. Kaur, Effect of consumption of double fortifies salt on iron and iodine status of young women. Ph D. Dissertation. Punjab Agricultural University, Ludhiana, India, 2000. http://krishikosh.egranth.ac.in/handle/1/5810015700.
[16] V. Zanveer, R. Devi, The. Ind. J. Nutr. Dietet., 2007, 44, 356-66.
[17] N. Kapoor, Impact of Supplementation of health drink using underutilized foods on the nutritional status of adolescent girls. M.Sc. Thesis. Punjab Agricultural University, Ludhiana, India, 2012. http://krishikosh.egranth.ac.in/handle/1/5810025067.
[18] R. Singh, Health. Pop. Pers. Iss., 2008, 31, 198-203.
[19] Bala, Anthropometry and nutrient adequacy of well-to-do school girls of 13-15 years from Punjab. M.Sc. Thesis. Punjab Agricultural University, Ludhiana, India, 2000.
[20] R. Tupe, N. K. Kundu, The dietary patterns of iron and vitamin C rich foods in adolescent girls: implications for community based nutritional education program. In: Abstr IX Asian congress of nutrition, 2003, Pp. 240-41. Nutritional foundation of India, New Delhi.
[21] S. Srimani, M. Bose, T. Saha, D. Chaudhari, J. Ind. Dietet. Assoc., 2008, 33, 42-50.
[22] S. Bathla, K. Grover, Efficacy of double fortified salt in combating the dual problem of iron and iodine deficiency, Ph D. Dissertation. Punjab Agricultural University, Ludhiana, India, 2015. http://krishikosh.egranth.ac.in/handle/ /5810015975.
[23] P. Singla, Efficacy of nutritional counselling on the intake of junk foods among adolescent girls of working mothers. M.Sc. Thesis. Punjab Agricultural University, Ludhiana, India, 2011.
[24] S. Nahar, K. Grover, P. Chawla, J. Res., 2009, 46, 94-108.
[25] P.C. Mittal, S. Srivastava, Diet, nutritional status and food related traditions of oraon tribe of New NAI (West Bengal), India, Rural. Remote. Health., 2006, 6, 385.
[26] S. Kaur, Effect of weekly iron and vitamin C supplementation on the anaemic status of adolescent girls. M.Sc. Thesis. Punjab Agricultural University, Ludhiana, India, 2009.
[27] K.M. Rao, N. Balakrishna, A. Laxmaiah, Asia. Pac. J. Clin. Nutr., 2006, 15, 64-71.
[28] S. Kumari, R. Jain, Ind. J. Nutr. Dietet., 2005, 42, 326-34.
[29] R. Parimavalli, M. Sangeetha, Anthro, 2011, 13, 11-15.
[30] A. Laxmaiah, K. M. Rao, G. N. Brahman, S. Kumar, M. Ravindranath, K. Kashinath, G. Radhaiah, D. H. Rao, K. Vijayaraghavan, Indian. J. Pediatr., 2002, 39, 331-38.
[31] A. Shekhar, The. Ind. J. Nutr. Dietet., 2005, 42, 451-56.
[32] N. Savitha, A. Narayanan, Ind. J. Nutr. Dietet., 2007, 44,189-97.
[33] M. D. Agrahar, P. P. Pal, Nutr, 2004, 20, 268-73.

[34] S. Bathla, K. Grover, Asian. J. Dairy.Fd. Res., 2016, 35, 251-254.
[35] S. Bathla, K. Grover, Int. J. Sci. Res., 2015, 4 (5): 1421-24.
[36] S. Bathla, K. Grover, Chem. Sci. Rev. Lett., 2017, 6 (23): 1630-37.

Publication History

Received	31st May 2018
Revised	28th July 2018
Accepted	04th Aug 2018
Online	30th Aug 2018