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Intervention Trials with Pearl Millet Based Iron Rich *Ladoo* and Iron Folic Acid (IFA) Tablets on Hemoglobin Status of Adolescent Females in Bikaner City

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ABSTRACT Anemia in adolescent girls has far reaching implications, as they may grow anemic with probable complications during pregnancy and child birth. Several investigators have reported rise in mortality in the women of reproductive age due to anemia. Food based approach against anemia has been now gaining popularity over the world. Pearl millet being the staple food of Rajasthan with potentially better amount of dietary iron is therefore explored for improving the hemoglobin [Hb] status of adolescent girls. The present study aim to develop and standardize pearl millet based iron rich *ladoo*, to assess the impact of pearl millet based iron rich product on anemic subjects in comparison to Iron Folic Acid [IFA] tablets. A randomized clinical trial was undertaken in which three groups viz. A, B and C were selected wherein group A received iron rich *ladoo* (15mg) along with lemon water; group B received IFA tablets providing 60 mg of elemental iron and group C remained as the control group. Results: Intervention program showed significant rise in mean Hb levels by 2.24g/dl, 2.28 g/dl and 0.54 g/dl for Group A, B and C respectively. Conclusion: Food based approach using pearl millet *ladoo* may be effectively used for improving the Hb status of adolescent girls at par with elemental iron supplementation.

INTRODUCTION

"Increasing awareness and knowledge among health care providers and correction of iron deficiency anemia during adolescence will go a long way in improving the health of future parents" title of the booklet of Government of India's 12 by 12 initiative (2007) in collaboration with WHO and UNICEF magnifies significance of the investigated issue.

The National Family Health Survey-3 (2005-2006) data suggests that anemia is widely prevalent among all age groups, and is particularly high among the most vulnerable group – nearly 58 per cent among pregnant women, 50 per cent among non-pregnant non-lactating women and 56 per cent among adolescent girls (15–19 years).

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Children and women of reproductive age are most at risk, with global anemia prevalence estimates of 47 per cent in children younger than 5 years, 42 per cent in pregnant women, and 30 per cent in non-pregnant women aged 15–49 years. Africa and Asia account for more than 85 per cent of the absolute anemia burden in high-risk groups and India is the worst hit (Benoist et al. 2008).

Adolescence is a crucial phase of growth in the life cycle of an individual. Due to rapid growth, there is an increase in iron requirement in both adolescent boys and girls. Though the exact prevalence has not been determined, at least 65-75% adolescent girls in India are anemic. Anemia not only affects the present health status of adolescents, but also has deleterious effects in the future. The rates of low birth weight, prematurity, neonatal and infant mortality among children born to undernourished adolescent girls is high (Mittal 2007). Not only this, one in five, that is, 20% of all the maternal deaths in India are attributed to anemia during pregnancy and in another 40% anemia is a contributory factor (Upadhyay et al. 2012). In order to prevent high

maternal mortality and high incidence of low birth weight babies in India, there is a need to combat anemia during adolescence.

Food-based intervention programs, dietary enhancement and diversification, and food fortification including biofortification play a critical role in alleviating micronutrient malnutrition. Food-based strategies focus on improving the availability of, access to, and consumption of vitamin and mineral rich foods. Benefits of such food-based strategies include not only improved intakes of specific nutrients but also improved overall diets and health status (Thompson 2007).

Thus, the present study stridently supported the food-based therapy implying pearl millet based iron rich *ladoos*. Pearl millet is an important staple food of Rajasthan, Gujarat and Uttar Pradesh, where it is commonly grown and consumed by millions of people. In these regions, the prevalence of anemia among children is a staggering 66% (Harvest Plus 2009). It has been observed that, consumption of pearl millet is very high among these regions, thus presenting significant potential to provide additional iron in the diet. In spite of greater availability, low cost and comparatively good nutritive value, use of pearl millet in food industry is very low because of some major constraints act as obstacles in its wide spread diversification and acceptability. It is nutritionally comparable and even superior to many cereal and is called as nutri-cereal as it contains fair quantity of protein, fat, energy, vitamins and minerals. Pearl millet contains the highest amount of iron among all the cereals; it is also a rich source of calcium and dietary fibre, phytochemical and micronutrients (Sehgal and Kwatra 2006). Although, this millet is immensely nutritious with a high content of iron; it is not utilized by the body due to the presence of phytates and polyphenols, which can be substantially reduced by germination process, as there is good correlation between anti nutritional factors reduction and the increment in extractable mineral with germination time (Abdelrhaman et al. 2007). Therefore, to assess the prospects of dietary intervention, pearl millet based iron rich *ladoo* was developed by incorporating germinated pearl millet along with other iron rich foods. Amount of each ingredient was standardized while developing the most acceptable and feasible form of product. The developed product was supplemented to the diet of iron deficient subjects, along with a glass of lemon water, which essentially enhance the absorption of non-heme iron. This dietary iron was also compared with the elemental iron [IFA tablets] in order to signify the magnitude of dietary iron versus the commercial form by exercising the impact analysis of over-all intervention.

In this way, the present study knocks iron deficiency anemia among the adolescent girls of College of Home Science, SKRAU, Bikaner implying dietary intervention with the locally available dietary ingredients.

MATERIAL AND METHODS

Selection of Subjects

Sample of 102 adolescent girls of under graduate classes in the age group of 16-19 years were randomly selected from College of Home Science, SKRAU, Bikaner, of which thirty moderately anaemic adolescent girls were purposively selected for the intervention trials.

Background Information

An open-ended questionnaire was used to collect the background information of the subjects pertaining to the age, economic status, and educational qualification.

Determination of Hemoglobin

Hemoglobin level of the selected subjects was estimated by Sahli's method (Anand et al. 2009) before and after the intervention. Based on Hb level, the subjects were classified as normal, mild, moderate or severely anaemic (WHO 2001).

Procurement of the Material

Pearl millet and other iron rich components were procured from the local market of Bikaner city while the IFA tablets were incurred from the local government hospital (Medical College, Bikaner).

Development and Standardization of Pearl Millet Based Iron Rich Ladoo: The preparation of iron rich *ladoo*, included processed pearl millet flour (20g), Lotus stems flour (10g), Soybean flour (10g), Niger seeds (10g), Jaggery (50g), Fat (5g) and Water (15ml). These foods were selected based on their local availability, low cost and greater iron contents (Gopalan et al. 2004). *Ladoo*

was prepared by the following processes- Niger seeds were roasted and grinded coarsely, all flours were roasted separately without fat, jaggery syrup was prepared by adding fat and water, Niger seeds and flours were added to the prepared syrup. The mixture was shaped into balls *(ladoo)*, cooled and stored until served. The iron content of 100g prepared *ladoo* was determined to be 15.56 mg.

Intervention Programme

Thirty moderately anemic subjects with the Hb level ranging from 8.0 g/dl – 10.9 g/dl were classified into group A, B and C.

Intervention group (A) received pearl millet based iron rich product of 100g (15mg non-heme iron) per day with 200ml lemon water, Intervention group (B) received iron folic acid tablets (60 mg elemental iron) and group (C) remained as a control group hence received no supplementation during the course of intervention program of 45 days.

Impact Analysis

The Hb level was measured in all the groups at 0, 15, 30 and 45 days. Statistical analysis was exercised in order to justify the impact of intervention trials.

RESULTS

The background information of the subjects revealed that majority of them were from middle income group (47.05%) and lower income group (33.33%). Most of the subjects were in the age of nineteen (56.86%) and eighteen (32.35%) years. Almost 67% subjects were studying in B.Sc. III and II year of their graduation program (Table 1).

The baseline data on Hb levels of 102 subjects (Table 2) revealed that almost 28 % of the subjects had the Hb levels between 11- 11.9g/dl, while 22.54% were mildly anemic and 24.50 % of the adolescents found to be moderately anemic. Prevalence of anemia was determined to be 75 % in the studied group.

Table 3 signifies that there is a non-significant($P>0.05$) difference between the three investigated groups, prior to intervention as their mean Hb levels were 9.81, 9.65 and 9.39 g/dl for group A, B and C respectively, whereas at the end of the intervention program group A and B showed a significant ($P<0.001$) rise in the mean Hb levels as compared to control group C ($P>0.05$) and the difference between group A and B on the basis of mean gain in Hb levels (Table 4) found to be non-significant ($P>0.05$). The overall impact of intervention trial was analysed to be highly significant ($P<0.001$), while the prevalence of anemia among the studied group was reduced by 34 per cent (Table 5).

Table 1: Background information of the subjects

Criteria	*Particulars*	*No. of subjects*	*%*
Age	16 years	2	1.96
	17 years	9	8.82
	18 years	33	32.35
	19 years	58	56.86
Class	I year	25	24.5
	II year	32	31.37
	III year	38	37.25
	IV year	7	6.86
Income Group	LIG	34	33.33
	MIG	48	47.05
	UMIG	20	19.6
	HIG	0	0

Table 2: Prevalence of different degrees of anemia in adolescent girls

*Hb Levels (g/dl)***	*Grades of anemia*	*Respondents [n=102]*
> 12.0	Normal	24.50 percent (25)
< 12.0	Any anemia	28.43 percent (29)
10.0-10.9	Mild	22.54 percent (23)
7.0-10.0	Moderate	24.50 percent (25)
< 7.0	Severe	NIL

** WHO (2001), Values in parenthesis denotes no. of subjects

DISCUSSION

Present study implied germinated pearl millet anticipating enhanced bioavailability of non-heme iron as Badau et al. (2005) reported a good correlation between phytic acid reduction and increase in extractable minerals of pearl millet. With a similar view, Kodkany et al. (2013) also revealed through a randomized controlled trial, that bio-fortification of pearl millet with iron and zinc, resulted in an increased absorption of these minerals.

Pearl millet based iron rich *ladoo* was prepared involving other iron rich foods with a objective to magnify the impact of dietary intervention of an under profiled cereal- pearl millet which

Table 3: Mean hemoglobin levels of the subjects during intervention

	Mean Hb (g/dl) levels of the subjects							
	0 Days		*15 Days*		*30 Days*		*45 Days*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	SD
Group (A) Laddoo	9.81^{a} ±	0.56	11.15^{b} ±	0.59	11.76^{b} ±	0.81	12.05^{b} ±	0.68
Group (B)Tablet	9.65^{a} ±	0.64	10.63^{b} ±	0.39	11.34^{b} ±	0.40	11.93^{b} ±	0.47
Group (C)Control	9.39^{a} ±	0.62	9.69^{a} ±	0.44	9.84^{a} ±	0.81	9.93^{a} ±	0.51

F=9.150** *Note*- The un-identical superscripts within a column between the rows indicate significant difference between them.

Table 4: Mean gains in hemoglobin levels in the subjects during intervention

	Mean gain in Hb (g/dl) levels					
	15 Days		*30 Days*		*45 Days*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Group (A) Laddoo	1.34 ±	0.84	1.95 ±	0.82	2.24 ±	0.85
Group (B) Tablet	0.98 ±	0.66	1.69 ±	0.82	2.28 ±	0.85
Group (C) Control	0.30 ±	0.44	0.48 ±	0.94	0.54 ±	0.74

is superiorly nutritious in terms of iron content. With the same prospects, based on the prevailing dietary patterns in India, Agte et al. in 1995 studied the comparative performance of pearl millet based (PM) diets against rice based (RB) diets in terms of trace mineral bioavailability, revealed that total dialyzable iron, copper and manganese in PM diet was 2 to 4 times higher than RB diet.

Present study documented high prevalence of anemia, which is also projected in various studies conducted in India and abroad in the recent past (Shirode et al. 2010; Benoist et al. 2008; Balarajan et al. 2012).

Obtained results of the present study clearly indicates that incorporation of iron rich dietary elements can be an effective tool to combat nutritional deficiencies especially iron deficiency anemia, likewise Gera et al. (2012) concluded that consumption of iron-fortified foods results in an improvement in hemoglobin, serum ferritin, and iron nutriture and a reduced risk of remaining anemic and iron deficient.

Table 5: Effect of intervention on prevalence of anemia among the subjects

Particulars	*Before intervention*	*After intervention*
Prevalence	100 percent	65.62 percent
Mean hemoglobin levels	9.65-9.81 g/dl	11.93-12.05 g/dl

Present investigation also confirmed that dietary iron intervention is at par when compared to the elemental form. Vyas et al. revealed similar observation in the year 2009 wherein they found leaf concentrate fed to adolescent girls was as effective as IFA in improving serum iron parameters and treating anemia and they concluded that leaf concentrate was more palatable and could be used as an alternative therapy to iron and folic acid supplements.

From the statistical analysis of the obtained data, it is evident that after forty-five days of intervention program the gain in hemoglobin in Group A and B was significant, at 1 per cent level of significance. While, for the control group C the mean gain in the hemoglobin was non-significant at 5 percent level of significance. Moreover, the Hb level of remaining subjects was noted to be in the range of 11.0 – 12.0 g/dl clearly depicting the effectiveness of intervention. Similarly Miglioranza et al. (2008) confirmed a pronounced reduction in the prevalence of Iron deficiency anemia in children and adolescents following 6 months' ingestion of corn flour-derived products enriched with elemental Iron.

Results and discussions of the present investigation draw out the fact that nutritional intervention is no more a fallible endeavour regarding the corrections in nutritional deficiencies. Present research only strove to determine the impact of dietary intervention but also its competition with the commercial form.

Observations obtained from the present study has compelling reasons to support the idea of food-based strategies which addresses the root causes of micronutrient malnutrition and assist communities and households to adequately feed and nourish themselves in both the short and long-term resources.

CONCLUSION

The study concluded that pearl millet can be improved in terms of its bioavailability of iron through the process of germination and thus can be an effective medium for extirpating iron deficiency anemia at par with the elemental iron.

FUTURE IMPLICATIONS OF THE STUDY

(1) To determine the impact of pearl millet based iron rich *ladoo* on the complete blood iron profile of adolescent girls.
(2) To determine the impact of the iron rich *ladoo* on Hb status of population with different age groups particularly population at risk viz. children under age of five years, pregnant and lactating mothers.
(2) To determine efficacy of pearl millet based dietary iron over commercial/elemental iron.
(4) Development and standardization of pearl millet based other iron rich products
(5) To propagate the consumption through commercialization of pearl millet based iron rich products in order to improve the overall health pattern of needy group.

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REFERENCES

Abdelrahaman SM, Elmaki HB, Idris WH, Hassan AB, Babiker EE, El Tinay AH 2007. Antinutritional factor content and hydrochloric acid extractability of minerals in pearl millet cultivars as affected by germination. *Int J Food Sci Nutr*, 58(1): 6-17.

Agte V V, Gokhale M K, Paknikar K M, Chiplonkar S A 1995. Assessment of pearl millet vs. rice based diet for bioavailability of four-trace metal. *Plant foods for Human Nutrition*, 42(2): 149-158.

Anand H, Mir R, Saxena R 2009. HCS a diagnostic dilemma. *Indian J Pathology and Microbilogy*, 52(3): 360-362.

Badau M H, Nkama, I, Jideani I A 2005. Phytic acid content and hydrochloric acid extractability of minerals in pearl millet as affected by germination time and cultivar. *Food Chemistry*, 92(3): 425-435.

Balarajan Y, Ramakrishnan U, Özaltin E, Shankar A H, Subramanian S V 2012. Anaemia in low-income and middle-income countries. *The Lancet*, 378 (9809): 2123-2135.

Benoist B D, McLean E, Egll I, Cogswell M 2008. *Worldwide Prevalence of Anemia 1993-2005: WHO Global Database on Anemia*. Geneva: World Health Organization.

Shirode A R, Bhanushali M M, Joshi Y M, Kadam V J 2010. An intervention on iron deficiency anaemia and change in dietary behavior among adolescent girls. *International Journal of Pharmacy and Pharmaceutical Sciences*, 3(1): 40-42.

Gera T, Sachdev HS, Boy E 2012. Effect of iron-fortified foods on hematologic and biological outcomes: systematic review of randomized controlled trials. *The American Journal of Clinical Nutrition*, 96(2): 309-324.

Gopalan C, Rama Sastri BV, Balasubramanian SC 2004. *Nutritive Value of Indian Foods*. Hyderabad: National Institute of Nutrition ICMR.

Harvest Plus 2009b. Iron-Pearl Millet Strategy, Harvest Plus, IFPRI, Washington D.C. From <http://www.harvestplus.org/sites/default/files/HarvestPlus_Pearl_Millet_Strategy.pdf> (Retrieved June 2012).

International Institute for Population Sciences 2007. *India National Family Health Survey (NFHS-3), 2005-06*. Volume 1. Mumbai: International Institute for Population Sciences.

Kodkany BS, Bellad RM, Mahantshetti NS, Westcott JE, Krebs NF, Kemp JF, Hambidge KM 2013. Biofortification of pearl millet with iron and zinc in a randomized controlled trial increases absorption of these minerals above physiologic requirements in young children. *The Journal of Nutrition*, 143(9): 1489-1493.

Miglioranza LH, Bregano JW, Dichi I, Matsuo T, Dichi JB 2008. Effectiveness of fortification of corn flour-derived products with hydrogen-reduced elemental iron on iron-deficiency anemia in children and adolescents in southern Brazil. *Public Health Nutrition*, 12(2): 244-248.

Mittal S 2007. Overview of 12 by 12 Initiative. From <http://www.12by12initiative.com/iis.asp.> (Retrieved on March 18, 2012).

Sehgal S, Kwatra A 2006. Pearl millet. In: M Goyal, S Sharma (Eds.): *Prospects and Dimensions for Utilization of Arid Foods*. Bikaner: Yash Publishing House pp.131-132.

Thompson B 2007. Food-based approaches for combating iron deficiency. In: Klaus Kraemer, Michael B Zimmermann (Eds.): *Nutritional Anemia*. Switzerland: Sight and Life Press, pp. 337-358.

Upadhyay RP, Palanivel C, Kulkarni V 2012. Unrelenting burden of anaemia in India: Highlighting possible prevention strategies. *International Journal of Medicine and Public Health*, 2(4): 1-6.

Vyas S, Collin SM, Bertin E, Davys GJ, Mathur B 2009. Leaf concentrate as an alternative to iron and folic acid supplements for anaemic adolescent girls: A randomised controlled trial in India. *Public Health Nutrition*, 26: 1-6.

World Health Organization 2001. Iron Deficiency Anemia: Assessment, Prevention, and Control: A Guide For Programme Managers. Geneva (WHO/NHD/01.3). 12 by 12 Initiative 2007. Official Home Page. From <http://www.12by12initiative.com/iis.asp.> (Retrieved on March 18, 2012).