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Effect of Iron Fortified Milk and Milk Products on Anemia Status among the Population – A Review

Review Article

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Abstract

Background: Iron deficiency is the most prevalent nutritional deficiency in the world, primarily affecting infants, young children, and women of childbearing age. Different products like animal milk, fermented milk and yoghurt can be used as the vehicle for iron fortification.

Objective: To assess the iron status among the population consuming iron-fortified milk and milk products.

Methods: A Systematic, thorough search was done from the available online literature. Different web-based search engines like google scholar and PubMed were used to search the relevant literature on this topic. Different keywords like 'fortification', 'iron', 'milk and milk products', 'anaemia' and 'iron status' were used to search related articles. Mainly randomized control trial and intervention studies were selected. Research articles relevant to the topic were screened, a total of 652 articles were found through a systematic literature search. Out of 652, 15 articles were read by two authors independently, and results were analyzed.

Results: Significant decrease in the prevalence of anaemia (ranging from 40% to 13.7%) was observed when consuming iron fortified milk and milk products. There is a positive correlation between the intake of fortified milk and haemoglobin status. In most of the studies, a significant increase in the haemoglobin status was observed. A Positive correlation was seen of different vitamins like vitamin A, vitamin C and vitamin D with iron absorption in the body.

Conclusion: Iron fortification of milk and milk products can be used as an effective and efficient way to combat anemia at the national level.

Keywords: Anemia; Iron; Fortification; Heamoglobin; Milk and milk products; Ferrous sulphate; Microencapsulation

Introduction

Iron deficiency, a nutritional deficiency affecting approximately 20% of the world population specifically women and young children are at high risk. Iron is an essential component of hemoglobin, the substance in red blood cells that carries oxygen from the lungs and transports it throughout the body [1]. In the state of anemia, oxygen is not adequately delivered to tissue due to iron insufficiency.

The World Health Organisation (WHO) defines iron deficiency as a condition in which there are no mobilizable iron stores and in which signs of a compromised supply of iron to tissues, including the erythron, are noted [2]. Globally, anaemia affects 1.62 billion people (1.50–1.74 billion), which corresponds to 24.8% of the population (22.9–26.7%). The highest prevalence is among preschool-age children (47.4%), and the lowest prevalence is in men (12.7%). However, the population group with the most significant number of individuals affected is non-pregnant women (468.4 million, 95%). In the year 2015-2016, according to NFHS-4, the prevalence of anemia is more in rural parts than in urban areas. 58.5% of children aged 6-59 months followed by non- pregnant women (53.1%) and pregnant women (50.3%) are anemic. The prevalence of anemia has reduced for all the age groups from NFHS-3 (2005-06) to NFHS-4, a drop of 2% in non-pregnant & all women (15-49 years) to nearly 10% in children 6-59 months of age (NFHS-3 2006; NFHS-4 2015).

Anaemia has an adverse effect on health, survival, productivity, income and development of a person. Iron deficiency with or without anaemia impairs cognitive development, limits attention span and shortens memory capacity, resulting in poor classroom performance, high absenteeism, and early dropout rates among schoolchildren. Anaemia due to iron deficiency is among the top 10 leading causes of years lost to disability in low- and middle-income countries, while anaemia is the 7th leading cause of years lost to disability in women .It is estimated that 12.8% of maternal deaths in Asia could be related to anaemia [5]. For Indian population, the normal level of hemoglobin are (Women: 12.1 to 15.1 gm/dl, Men: 13.8 to 17.2 gm/dl, Children: 11 to 16 g/dl, Pregnant women: 11 to 15.1 g/dl) [6].

There are a number of factors which affect the iron status and iron availability in the body. The RDA of iron is different for different age groups as there is an increased demand of iron during childhood, reproductive years and pregnancy. The main factors associated with iron deficiency anemia include consumption of non heme iron-based food as vegetarian diet is prevalent among Indian population. Consumption of more inhibitors for example: consumption of tea and coffee along with the meals is a common practise followed in India resulting in increased intake of inhibitors like tannin in the meal corresponding to poor iron absorption [7]. Also, Lack of education and awareness among the population and food myths are the major contributors.

Cause of anemia is divided into three parts namely nutrition, infectious disease and genetic hemoglobin disorder. Infections, particularly parasitic diseases, including malaria and helminth infections that cause extracorporeal iron loss. Increased inflammation leads to decreased bioavailability of iron to host tissues, genetic disorders such as thalassemia traits in the population also contribute towards the problem. Poor water, sanitation and hygiene (WASH) also play an important role in contributing to high anaemia rates through gastrointestinal infections [8].

The various strategies used to combat the problem of anemia include different government policies, food fortification, iron supplementation and dietary diversity [9]. Home based interventions such as diet diversification, germination and fermentation are cost effective techniques to enhance bioavailability of iron. Behaviour change communication and iron folic acid supplementation are of key importance to prevent the onset of anemia among different age groups. Fortification of food is a safe, cost effective way to improve micronutrient content. According to WHO, Fortification refers to "the practice of deliberately increasing the content of an essential micronutrient, i.e. vitamins and minerals (including trace elements) in a food, so as to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health" [10]. Commonly fortified foods include staple products such as salt, maize flour, wheat flour, sugar, vegetable oil, milk and rice. Milk and milk products are usually used for the fortification process as it is safe, acceptable and is consumed by the majority of the population. They are fortified with a variety of vitamins like Vitamin A, B vitamins, Vitamin D and folic acid and minerals like calcium, iron, zinc. Fortified milk and milk products have several advantages [11].

Iron fortified milk has a high content of ferric sulphate. In addition, vitamin C in fortified milk boosts immunity and increases the body's absorption of iron. Fortification of milk with Iron will help in preventing iron deficiency anemia in children, a common problem. Moreover, milk is often fortified with iron and other nutrients, such as zinc and B vitamins to increase its nutritional content [12].

This review focuses on the iron fortification of milk and milk products to address the problem of anemia. The paper provides an overview of study design, methodology and sample characteristics from baseline survey data and key lessons learned. A total of 15 studies were reviewed and analysis was done on the basis of different parameters used in different studies like hemoglobin level, ferritin level etc. The study will be helpful to plan appropriate programmes and policies related to iron deficiency anemia and will form the basis of different interventional studies to combat the problem of iron deficiency anemia. Main objective of this review was to evaluate the potential effects of iron fortification in milk and milk products on the haemoglobin status of the participants. Other objectives were:

- To study the acceptance of the fortified products.
- To assess the effect of iron fortified milk and milk products along with other nutrients like Vitamin A, Vitamin C and Zinc.
- To assess the effect of iron fortification on sensory characteristics of milk and milk products.

Methodology

A systematic, thorough search using different databases like Cochrane Systematic Reviews, google scholar and PubMed was done for relevant literature on the topic. Keywords like 'fortification', 'iron', 'milk and milk products', 'anaemia' and 'iron status'. Free texts and Medical Subject Headings (MeSH) such as 'micronutrients', 'iron', 'haemoglobin' were also used. The available published data were enormous; appropriate articles relevant to the study were chosen. The citations of relevant articles were also referred to find further relevant articles. Only experimental and correlational studies were selected for the review. The quality assessment was performed by two authors who worked independently, and data were extracted from the selected articles and summarized into the tabular form.

Selection criteria

Full text articles available in english language were selected for the review. Animal studies, review articles, conference proceedings, editorials bulletins and reports were excluded. To limit the number of articles, articles published after 1996 till June 2019 were selected. Studies were not excluded according to age, sex, gender or location was established.

Finally, selected articles were read by both the authors independently and relevant information like sample description, key

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intervention given to intervention group and control group, methods of assessment of impact of the intervention and lastly the impact and key findings were extracted from the articles.

Data Handling and Analysis

Study setting

Both national and international studies were taken for the review. Out of 15, four studies were reported from Chile and two from Spain (Murica and Madrid) & Brazil (Sao Paulo) and one study each from Birmingham (UK), Brazil, Morocco, Mexico, Jamaica, Senegal (Africa) and Delhi(India).

Vehicle used for Iron fortification of Dairy products

In this article, we aimed to assess the interventions using iron fortified milk and milk products in relation to its effect on Hb level, bioavailability of iron, acceptability of the product and its overall feasibility to combat the major problem of iron deficiency in the population.

Various vehicles such as cow milk, pasteurized milk and fermented products were used for the fortification. In most of the studies, full fat acidified milk or pasteurized milk were used as the key product for the intervention like in a before and after study by Brito A et al [13]. However, infant formula feed was also fortified with iron and other micronutrients for the intervention product in the Randomized Control Trial (RCT). Few studies used fermented products such as yoghurt and fermented beverages. In a RCT by Port et al, yoghurt was the main test product for the intervention group while in another study, strains of L. bulgaricus and S. thermophilus were incorporated into the fortified fermented beverage. In one of the studies, absorption of iron from iron fortified milk products was compared with iron fortified noodles [14].

Chemical compounds used for fortification

Different elemental and compositional forms of Iron were used for Iron fortification. Studies in this review article include various methods and forms of iron for fortification of dairy products.

In almost half of the studies, milk or test product was fortified with ferrous sulphate ($FeSO_4$). Some RCTs used iron amino chelate for the fortification of the intervention product. It was seen that along with iron, other elements like Zn and Cu were also added to the product to address other nutritional deficiencies. Along these elements, some vitamins were also added like influence of ascorbic acid was seen on iron absorption in longitudinal study done by Davidsson et al in 2018 and Vitamin D was added in a study done by Toxqui et al in 2013 to increase the effect of iron fortification [15]. New techniques like microencapsulated ferric saccharate were used to increase the acceptability of the product.

Indicators used for assessment of effectiveness of intervention

In most of the studies conventional clinical methods were used for the estimation of iron level in the body. One of such methods is serum ferritin level, which is most often used for estimation of total body iron store concentration. Three studies included haematocrit level i.e. ratio of RBC volume to the total blood volume used for the assessment of the effectiveness of intervention. C-reactive protein was also analysed in one of the studies to assess the past inflammation and infection in the population. Other indicators such as stool test, total transferrin saturation and iron isotope for knowing the impact in other studies.

Each study is summarized in Table 1 with the characteristics of participants, key interventions, and assessment of effectiveness of intervention along with key findings of the research.

Result

This review article aimed to assess the effect of iron fortification in milk and milk products on the hemoglobin status. Research articles relevant to the topic were screened, a total of 652 articles were found through a systematic literature search. Review articles, animal studies, Duplicate studies and articles not relevant to the topic were excluded. Finally, 15 studies were found relevant and were carefully analysed.

Impact of Iron fortification of milk on the prevalence of Anemia

Fortification of milk with Iron shows a significant decrease in the prevalence of anemia. The major vehicles used for fortification were cow's milk, pasteurized milk, infant milk formula, fermented milk products etc. Significant decrease in the prevalence of anaemia (ranging from 40% to 13.7%) was observed when consuming iron fortified milk and milk products. The study suggested that if an infant is consuming 600 to 700 ml of 10mg/L iron fortified milk then 65% to 70% of the daily RDA is met. In another randomized control trial, the prevalence of anemia from baseline to 6 and 12 months decreased from 44.5% to 12.7 % and 4% respectively in the intervention group [17]. In another study by Brito A et al. (2013), a threefold decrease was observed in anemia prevalence (27% before fortification to 9% after fortification) by the end of 1 year.

Effect on hemoglobin level

Positive correlation between the intake of fortified milk and the hemoglobin status was observed in a Randomized control trial by Silva et al [18]. In this study, there was a 38.2% increase in the hemoglobin among the preschool children consuming the iron fortified beverage. In before-after study by Brito et al., after intervention (iron fortification), there was significant change in hemoglobin level (11.5 ±1.2 g/dL to 12.7 ±1.3 g/dL) [13].

Effect of fortification on bioavailability of iron

Milk fortified with ferrous sulfate is shown to increase the bioavailability of iron. An intervention study done by Pizarro et al. showed the geometric mean iron absorption corrected to 40% [18]. The fortified formula milk contains highly bioavailable iron, covering toddler's requirements of the micronutrient.

Effect of different vitamins

Along with the iron, incorporation of other vitamins improved the bioavailability of iron. In a longitudinal study by Davidsson et al, the geometric mean iron absorption was significantly greater when 25 mg ascorbic acid was added to the test meal than meal without

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Table 1: Summary table of research article.

Author and publication year	Study design, site and participants	Intervention	Assessment	Key findings
Pizarro et al. 2015 [18]	Intervention study, Chile, 33–47 years old women (n=15)	**Reference dose:** 200 mL of **Formula A**; 200 mL of **Formula B**; 30 mL of a solution of **iron and ascorbic acid** **Milk formula:** 200 mL of full fat cow's milk fortified with iron labelled with **radioisotopes 59Fe or 55Fe**.	Blood analysis**:** Hb, MCV & SF	Mean iron absorption corrected to 40% of the reference dose; 20.6% for Formula A; 20.7% for Formula B, versus 7.5% of iron fortified cow's milk ($p < 0.001$). Formulas A and B contain highly bioavailable iron
Torrejon et al. 2004 [21]	Intervention Study, Chile, male children (n=42)	2 kg of pd milk/mo fortified with 10 mg/LFe, 5 mg/L Zn & 0.5 mg/L Cu to be provided to 18 mo infants & pregnant women.	Anthropometric Assessment; Blood and hair samples: Hb, HCT & SF; Dietary Assessment	Fortified powdered cow's milk- prevalence of anemia decreased from 40% to 12%. Consumption of 600 to 700 mL of milk daily- receive 6 to 7 mg/d of iron, equal to 65% to 70% of RDA.
Stekel et al. 1998 [23]	Experimental, longitudinal, RCT, Chile, infants (n= 554)	Full-fat acidified milk fortified with 15 mg of elemental Fe (FeSO4 & 100 mg of ascorbic acid/100g powder) 278 control infants received milwithout additives.	Blood test: SF Stool test	Significant differences observed in the fortified group at 9 and 15 month (p less than 0.001). 25.7% anaemia (Hg less than 110 g/L) in unfortified infants while 2.5% in those fortified at age 15 month.
Daly et al. 1996 [24]	Longitudinal Randomized ,prospective study, UK, infants(n=100)	**6 to 18 months:** Control:Receive Cow's milk Intervention:Receive Fortified Milk. **18 to 24 months:** Control:Receive Cow's Milk Intervention:Transferred Back to cow's Milk	Haematological Parameters; Capillary blood (lithium heparin Sarstedt tubes). Dietary Assessment; Anthropometric assessments	**At enrollment**- no difference in hematological status. **At 12 month** - 31% anemic in cow's milk group. **18 months-** 33% of the cow's milk group were anemic compared with only 2% of the follow-on formula group **24 months-** none of the follow-on formula group was anemic
Silva et al. 2008 [17]	RCT, Before after Study, Brazil, preschool children aged 2 to 5 year (n= 215)	Daily dose of 80 mL of the beverage during the interval between lunch and the afternoon snack (Monday to Friday). The beverages (test and control) provided 3 mg of iron per 80-mL dose.	Anthropometric assessment; Haematological Assessment: RBC, HCT, Hbconc, MCV & cell Hb& conc. Diet ass	Positive correlation between iron intake and Hb in the probiotic group. Children receiving the probiotic beverage (test)- higher increase (38.2%, n = 45) in the Hb levels than the group without the probioticsmicroorganism
El Menchawyet al. 2015 [25]	longitudinal interventional,placebo-controlled double blind study, Morocco , 7 to 9 yrs children (N=195)	**Control group:** Received daily a non-fortified Ultra-High-Temperature (UHT) milk. **Interventiongroup:**received daily UHT milk fortifiedwithmicronutrients like **iron sulfate.**	Biochemical Analyses: Hb, SF & CRP.	At 9 months- intervention group: reduction in anemiafrom 50.9% to 37.2%. Prevalence of iron deficiency by 27% in schoolchildren.
Rivera et al 2010 [26]	RCT, Double Blind study, Mexico, n=798 1 year 2 months	**Intervention Group:** Cow's Milk: fortified with **iron, zinc and vitamin C** 400 mL, administered as two 200 mL drinking episodes per day for 12 months. **Control Group:**Cow's Milk without fortification is given for 12 months.	Anthropometric Measurements; Blood Test:Hb, SF, sTfr, Serum Zinc deficiency	% decrease in anemia from baseline to 6 and 12 mo is 42.6% to 19.7% and 9.4%, respectively, in the NFM group and from 44.5% to 12.7% and 4.0%, respectively, in the intervention group
Brito et al. 2013 [13]	A before and after study, Chile, Children aged 11 to 18 months(n = 125)	**Intervention:** Each child receives 2 kg of powdered milk each month. **Comp:** Whole cow's milk (26% fat) fortified with **10 mg** Fe , 5 mg of Zn, 0.4 mgC u, and 70 mg of ascorbic acid per 100 g of powder. This milk is delivered up to the 18th month of age.	Anthropometric Assessment; Hb level: HemoCue	1. Increase in hemoglobin level was seen (11.5 ±1.2 g/dL to 12.7 ±1.3 g/dL) 2.Threefold decrease in anemia prevalence, (27% before fortification to 9% after fortification)
	Chile,Mothers with young children(n=320)	No intervention	Anthropometric Assessment; Dietary assessment; Biochemical assessments:Hb, MCV,zinc protoporphyrin,SF & CRP	11% anemic children (consuming iron-fortified milk), **significantly lower** ($p = .028$) than the 21% anemic children without consumption. Iron-fortified milk **was positively associated** with hb
Davidsson et al. 1998 [19]	Longitudinal study, Jamaica, healthy schoolchildren aged 6–7 year (n=20)	Each child received two test meals labeled with ^{57}Fe and ^{58}Fe $FeSO_4$ on 2 consecutive days.	Haematological Assessment:Hb (HemoCue),Ferritin Analysis, CRP, Iron isotope ratios	Study 1: Geometric mean iron absorption of 5.1% and 1.6% for the two test meals, respectively. Study 2: Geometric mean iron absorption of 5.4% and 7.7% respectively (significant difference $p < 0.05$).
Semba et al. 2010 [22]	Correlational study, Indonesia, 81,885=rural and 26,653= urban slum	No intervention	Questionnaire	Children consuming iron-fortified milk were less likely to be anemic than children who did not.

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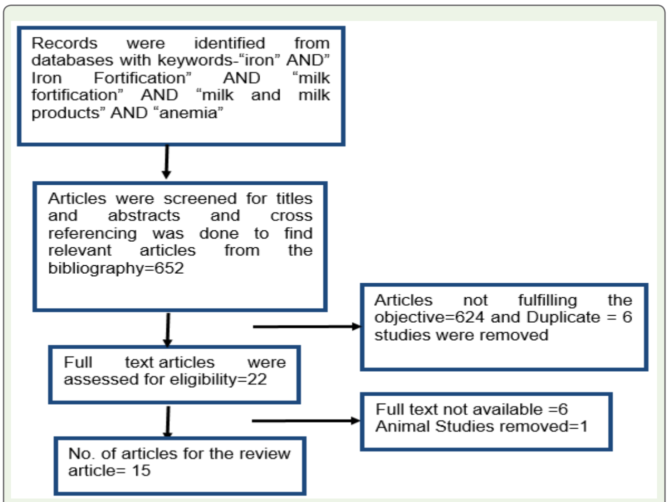
Le Port et al. 2017 [14]	Clustered RCT,West Africa **Intervention group:**children 24 to 59 months of age (n=204) **Controls**: children of 1 year of age (n=245)	**Intervention group:** MNFY along with BCC campaign focusing on anemia **Controls**: receiving BCC only	Questionnaire	Anemia prevalence dropped from 80% to 60% At end line Hb level in intervention group =10.62 ±1.37 g/dL compared to control group 10.38 ±1.40 g/dL and Mean Hb level at baseline = 9.41 g/dL.The impact was greater (0.72 g/dL) for boys, compared to girls (0.38 g/dL).
Torres, et al. 1996 [27]	Before and after study , Sao Paulo, children aged 6 to 42 months (n=269)	1liter of fresh milk fortified with 3 mg of **iron amino acidchelate (ferroquel),** daily for 12 months.	Clinical, Anthropometric Assessment; Hematological test	Significant reduction in anemia (62.3% at baseline to 26.4% after 1 year). Anemia decreased from 62.7% to 19.4% in families with only 1 U5 child while in families with 2 or more U5 children, reduction was from 61.9% to 35.2%
Sazawal et al. 2010 [28]	Double Masked, RCT, India, 1–4 Year Old Children (n=633)	**Intervention Group :**Each week 21 sachets- to feed the child 3 sachets a day for 1 yr. **Control group:** milk with natural levels of micronutrients	Anthropometric Assessment; Biochemical assessment.	Mean Hb (difference of 13.6 g/L); and serum ferritin levels (difference of 7.9 mg/L) improved. MN group had 88% lower risk of iron deficiency anemia.
Contreras et al. 2014 [29]	Double blinded, crossover and randomized, Spain, 18 and 35years volunteers (n=22)	**Test product:** 50 L of cow's whole milk +25 mL Vanilla flavour+18 g of acesulfame K & MFS. **Control product:** cow's whole milk +25 mL Vanilla flavour+18 g of acesulfame K + ferrous sulfate	Anthropometric Assessment; Analytical methods laboratory: total serum iron and total iron	sTfR significantly increased after the intake of both products. Iron absorption from MFS is equivalent to absorption from FS.
Toxqui L, et al. 2013 [15]	randomized, controlled, doubleblind, parallel design trial, Spain, Women aged 18–35 years (n=109)	**Intervention group 1:** 500 mL/day of the iron-fortified dairy product (Fe group, *n* = 54) **Intervention group 2**: consumed 500 mL/day of the iron + vitaminD–fortified dairy product (Fe + D group, n = 55).	Dietary Assessment; Anthropometric; Biochemical Assessment: RBC,HCT, MCV, RBC distribution width (RDW) and Hb	Serum 25-hydroxyvitamin D significantly increased in Fe + D group during the assay (p <0.001) and at week 16 it was highercompared to the Fe group (p <0.05). Higher values of erythrocytes (p = 0.01), hematocrit (p = 0.05), and hemoglobin (p = 0.03) at week 8 in the Fe + D group compared to Fe group.

MFY: Micronutrient-fortified Yoghurt; BCC: Behaviour Change Composition; MFS: Microencapsulated Ferric Saccharate; MCV: Mean Corpuscular Volume; BMI: Body Mass Index; RDW: Red Blood Cell Distribution Width; Hb: Hemoglobin; NFM: Non Fortified Milk Group; RDA: Recommended Dietary Allowance; CRP: C-reactive protein; AGP: a-1-glycoprotein; SF: Serum Ferritin; sTfR: Soluble Transferrin Receptor; Hb: Hemoglobin ; HCT: Hematocrit; PF: Plasma Ferritin; BI: Body Iron ; NPNL: Non Pregnant Non- Lactating.



Flow chart: Literature Search Strategy.

ascorbic acid, geometric mean iron absorption was 5.1% and 1.6% for the two test meals, respectively [19]. Also, a significant difference in iron absorption was observed when the ascorbic acid content was increased from 25 to 50 mg; geometric mean iron absorption was 5.4% compared with 7.7% respectively. Another type of study by Toxqui L et al. indicated that if the milk is fortified with both iron and vitamin D then there is higher value of erythrocytes, hematocrit and hemoglobin, at week 8 as compared to iron fortification only [15].

So, fortification of milk with iron along with vitamins like vitamin C and vitamin D show a reduction in the prevalence of anemia, increase in the bioavailability of iron and is positively associated with the increase in the hemoglobin concentration.

Effect of Iron fortification on sensory characteristics of milk and milk products

Iron fortification of milk and milk products has been done using different forms of iron using different techniques. Some forms of iron are able to mask the changes in the characteristics of the product while some forms are unable to do so. For example, ferrous sulfate, and many other soluble iron compounds, cannot be used to fortify liquid whole milk and other dairy products because they cause rancidity and off-flavours [10]. Ferric ammonium citrate, ferrous bisglycinate and micronized ferric pyrophosphate are more suitable as they mask the sensory changes. Ferrous bisglycinate is widely used to fortify whole milk and dairy products in Brazil and Italy while in Japan micronized ferric pyrophosphate is used to fortify the dairy products. A study done by Siddique & Park stated that the process of microencapsulation failed to mask the sensory changes due to fortification of iron such as taste, colour, texture and odour [20]. It was also observed that small microencapsulation was more acceptable than large encapsulation of ferrous salt in terms of flavour and other sensory qualities.

Discussion

In this review article, it was observed that fortified milk and milk products can significantly improve the iron status in all the age groups thereby decreasing the prevalence of anemia. Similar findings were observed in a study where after fortification there was a reduction in the prevalence of anemia from 40% to 12 % by the end of 6 months [21] . In another randomized control trial by Villalpando et al. (2007), the prevalence of anemia from baseline to 6 and 12 months decreased from 44.5% to 12.7 % and 4% respectively in the intervention group [16].

Clear reductions in the indicators of iron deficiency (low SF and high sTfR) associated with the group consuming fortified milk were documented. Effects on iron stores (SF) were evident both at 6 months and 12 months of intervention [22].

The intake of fortified milk and hemoglobin status was positively correlated in many studies. There was a 38.2% increase in the hemoglobin status among the preschool children consuming the iron fortified beverage [17]. Milk fortified with ferrous sulfate is shown to increase the bioavailability of iron. The fortified formula milk given contains highly bioavailable iron.

Along with the iron fortification, incorporation of other vitamins showed to increase the bioavailability of iron. In a study by Toxqui L et al. indicate that if the milk is fortified with both iron and vitamin D then there is higher value of erythrocytes, hematocrit and hemoglobin, at week 8 as compared to iron fortification only [15]. Also, Fortification of milk with iron along with vitamins like vitamin A, vitamin C and micronutrients like zinc and copper showed a reduction in the prevalence of anemia, increase in the bioavailability of iron and is positively associated with the increase in the hemoglobin concentration [15,19].

So, fortification can be used as a safe method to deliver health promoting, nutritionally dense food products to combat iron deficiency anemia. Fortified dairy products are the most consumed healthy and nutritious food around the country. Therefore, it offers an appropriate potential to reduce this problem by making it a public health intervention at the national level. Fortification of different food products is done in different parts of the world to correct nutrient deficiencies. Fortification of food products like wheat flour, milk and salt etc is done with different nutrients like Vitamin A, iodine, iron, calcium etc. Fortification of milk and milk products is also done with different nutrients like Vitamin A, Vitamin D, Calcium and Iron. Fortification of milk and milk products with Iron is not common. One such program was the Food Fortification Program of Costa Rica to combat iron related deficiencies. Fortification of wheat flour with ferrous fumarate and liquid and powdered milk with ferrous bisglycinate was also done. It was seen that anemia was reduced in children and women when fortified products were used by the population.

Limitations of the Article

There are technological issues relating to food fortification, especially with regard to appropriate levels of nutrients, stability of fortificants, nutrient interactions, physical properties, as well as acceptability by consumers. Also, research on iron fortification in milk and milk products among Indians was limited, thus paper from all over the world was reviewed.

Conclusion

This study provides evidence that delivery of iron via a food-based vehicle, milk and milk products in this instance, is a feasible option and produces a positive effect on iron status. It provides a potential strategy for achieving reduction in mortality, morbidity, and malnutrition among children due to iron deficiency. Milk provides an acceptable and effective vehicle for delivery of specific micronutrients, especially zinc and iron.

Micronutrient bundles improved growth and iron status and reduced anemia. Further research can also be done in terms of its affordability, availability and acceptance. Fortification of milk and milk products will be an effective measure to combat the problem of anemia among all the age groups. It will also be beneficial for the policy makers to reduce the prevalence of anemia by using these fortified milk and milk products.

References

1. Stephanie Watson (2011) What You Need to Know About Iron Supplements.
2. World Health Organization (2001) Iron deficiency anemia. Assessment, prevention, and control. A guide for programme managers 47-62.
3. National Family Health Survey (NFHS-3) (2005-2006) India: National Fact Sheet 2005-2006.
4. National Family Health Survey (NFHS-4) (2015-2016) India: National Fact Sheet 2015-2016 .
5. World Health Organization (2016) Strategies to prevent anaemia: recommendations from an expert group consultation, New Delhi, India, 5-6 December 2016.
6. National Health Portal (2016)Iron Deficiency Anemia.
7. Pawlak R, Berger J, Hines I (2016) Iron Status of Vegetarian Adults: A Review of Literature. American journal of lifestyle medicine 12: 486-498.
8. World Health Organization (WHO) (2004) Water sanitation hygiene.
9. Thompson B (2007) Food-based approaches for combating iron deficiency. Nutritional anemia 337: 1-21.
10. Dary O, Hurrell R (2006) Guidelines on food fortification with micronutrients. World Health Organization, Food and Agricultural Organization of the United Nations: Geneva, Switzerland: 1-376.
11. Yeh EB, Barbano DM, Drake M (2017) Vitamin Fortification of Fluid Milk. Journal of Food Science 82: 856-864.
12. Food Safety and Standards Authority of India (FSSAI) (2019), What Is Fortified Milk? Benefits and Uses.
13. Brito A, Olivares M, Pizarro T, Rodríguez L, Hertrampf E (2013) Chilean complementary feeding program reduces anemia and improves iron status in children aged 11 to 18 months. Food and nutrition bulletin 34: 378-385.
14. Le Port A, Bernard T, Hidrobo M, Birba O, Rawat R, et al. (2017) Delivery of iron-fortified yoghurt, through a dairy value chain program, increases hemoglobin concentration among children 24 to 59 months old in Northern Senegal: A cluster-randomized control trial. PloS one 12: e0172198.

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15. ToxquiL, Pérez-Granados AM, Blanco-Rojo R, Wright I, González-Vizcayno C, et al. (2013) Effects of an iron or iron and vitamin D–fortified flavored skim milk on iron metabolism: a randomized controlled double-blind trial in iron-deficient women. Journal of the American College of Nutrition 32: 312-320.

16. Villalpando S, Shamah T, Rivera JA, Lara Y, Monterrubio E (2006) Fortifying milk with ferrous gluconate and zinc oxide in a public nutrition program reduced the prevalence of anemia in Toddlers. Journal of Nutrition 136: 2633-2637.

17. Silva MR, Dias G, Ferreira CL, Franceschini SC, Costa NM (2008) Growth of preschool children was improved when fed an iron-fortified fermented milk beverage supplemented with Lactobacillus acidophilus. Nutrition Research 28: 226-232.

18. Pizarro F, Olivares M, Maciero E, Krasnoff G, Cócaro N, et al. (2015) Iron absorption from two milk formulas fortified with iron sulfate stabilized with maltodextrin and citric acid. Nutrients 7: 8952-8959.

19. Davidsson L, Walczyk T, Morris A, Hurrell R F (1998) Influence of ascorbic acid oniron absorption from an iron-fortified, chocolate-flavored milk drink in Jamaican children. The American journal of clinical nutrition 67: 873-877.

20. Siddique A, Park YW (2019) Effect of iron fortification on microstructural, textural, and sensory characteristics of caprine milk Cheddar cheeses under different storage treatments. Journal of dairy science102: 2890-2902.

21. Torrejón CS, Castillo-Durán C, Hertrampf ED, Ruz M (2004) Zinc and iron nutrition in Chilean children fed fortified milk provided by the Complementary National Food Program. Nutrition 20: 177-180.

22. Semba RD, Moench-Pfanner R, Sun K, De Pee S, Akhter N, et al. (2010) Iron-fortified milk and noodle consumption is associated with lower risk of anemia among children aged 6–59 mo in Indonesia. The American journal of clinical nutrition 92: 170-176.

23. Stekel A, Olivares M, Cayazzo M, Chadud P, Llaguno S, et al. (1988) Prevention of iron deficiency by milk fortification. II A field trial with a full-fat acidified milk. The American journal of clinical nutrition 47: 265-269.

24. Daly A, MacDonald A, Aukett A, Williams J, Wolf A, et al. (1996) Prevention of anaemia in inner city toddlers by an iron supplemented cows' milk formula. Archives of disease in childhood 75: 9-16.

25. El Menchawy I, El Hamdouchi A, El Kari K, Saeid N, Zahrou FE, et al. (2015) Efficacy of multiple micronutrients fortified milk consumption on iron nutritional status in Moroccan schoolchildren. J Nutr Metab 2015: 690954.

26. Rivera JA, Shamah T, Villalpando S, Monterrubio E (2010) Effectiveness of a large-scale iron-fortified milk distribution program on anemia and iron deficiency in low-income young children in Mexico. The Am J Clin Nutr 91: 431-439.

27. Torres MA, Lobo NF, Sato K, Queiroz SS (1996) Fortification of fluid milk for the prevention and treatment of iron deficiency anemia in children under 4 years of age. Revista de saudepublica 30: 350-357.

28. Sazawal S, Dhingra U, Dhingra P, Hiremath G, Sarkar A, et al. (2010) Micronutrient fortified milk improves iron status, anemia and growth among children 1–4 years: a double masked, randomized, controlled trial. PloS one 5: e12167.

29. Contreras C, Barnuevo MD, Guillén I, Luque A, Lázaro E, et al. (2014) Comparative study of the oral absorption of microencapsulated ferric saccharate and ferrous sulfate in humans. European journal of nutrition 53: 567-574.

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