Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [3] 2017: 612-615

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95

FULL LENGTH ARTICLE **OPEN ACCESS**

Iron Fortification of Rice for Combating Iron Deficiency Anaemia

M. Mohibbe Azam*[1], Amtul Waris[1], T. Ram[1], Aparna Kuna[2] and Supta Sarkar***[2]**
[1]Indian Institute of Rice Research, Rajendranagar, Hyderabad-500 030, TS.
*Corresponding author,
[2] PJTSAU, Rajendranagar, Hyderabad - 500 03. TS.
**Scientist, Food & Nutrition, Quality Control Laboratory
***M. Sc., Food & Nutrition

ABSTRACT

Iron deficiency is thought to be the most common cause of anaemia globally. Nearly 58% pregnant women, 50% non-pregnant non-lactating women, 56% adolescent girls, 30% adolescent boys and around 80% children under 3 years of age are anaemic in India. Interventions to prevent and correct iron deficiency and iron deficiency anaemia, include measures to increase iron intake through food-based approaches, iron supplementation and improved health services and sanitation. Fortification of food with Iron is considered more cost-effective and economically more attractive than iron supplementation. Since rice is the staple food of India, Sampada, a popular rice variety, was fortified through parboiling using Na2FeEDTA as source of iron. The present process of fortification is simple and cost effective and provided iron in the range of 35-40 ppm in the fortified rice. Sensory evaluation and consumer acceptability studies showed that the iron fortified rice product was well accepted by the respondents. Feeding trials of the fortified rice showed that haemoglobin level in severe anaemic subjects significantly ($p<0.01$) increased from 6.77 ± 0.28g /dl on 0^{th} day to 10.36 ± 1.35g /dl on 60^{th} day while in moderate group it significantly ($p<0.01$) increased from 9.25 ± 0.73g /dl on 0^{th} day to 10.83 ± 1.40g /dl on 60^{th} day. The haemoglobin level also increased from 0^{th} day to 60^{th} day in subjects with mild anaemia from 11.75 ± 0.21g /dl at baseline (0^{th} day) to 11.83 ± 0.46g /dl on 60^{th} day, but the increase was not statistically significant. The study also showed that there was no significant change in the haemoglobin level of the anaemic subjects of control group. Hence it can be concluded that the rice fortified with NaFeEDTA can be an effective solution to prevent the enormous prevalence of anaemia.

KEY WORDS: *Fortification, Iron Deficiency, anaemia, Haemoglobin, Sensory evaluation, Consumer acceptability.*

Received 29.07.2017 Revised 12.08.2017 Accepted 28.08. 2017

INTRODUCTION

Anaemia is a condition in which the number and size of red blood cells, or the haemoglobin concentration, falls below an established cut-off value, consequently impairing the capacity of the blood to transport oxygen around the body. The function of the RBCs is to deliver oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs by using haemoglobin (Hb) that contains iron molecules. Anaemia has three main causes: blood loss, high rate of RBCs destruction and decreased production of RBCs. A diet that lacks iron, folic acid or Vitamin B12 or the condition that make it hard for our body to absorb nutrients can also prevent our body from making enough RBCs. Iron deficiency is thought to be the most common cause of anaemia globally. Iron deficiency can be caused by several factors such as decreased iron intake, increased iron loss from the body, and increased iron requirement.

Prevalence of Anaemia

Based on available data (Cheema et al., 2016; WHO 2008), anaemia affects 1.62 billion people globally with about 293 million children of preschool age, 56 million pregnant women, and 468 million non-pregnant women. Children and women of reproductive age are most at risk, with global anaemia 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. Anaemia is estimated to contribute to more than 115,000 maternal deaths and 591,000 prenatal deaths globally per year.

The National Family Health Survey (NFHS-3, 2006) reveals that anaemia is widely prevalent among all age groups in India. This is particularly high among the most vulnerable with nearly 58% among pregnant women, 50% among non-pregnant non-lactating women, 56% among adolescent girls (15–19 years), 30% among adolescent boys and around 80% among children under 3 years of age. Nutritional anaemia is a major public health problem in India and is primarily due to iron deficiency. Physical and cognitive losses due to iron deficiency anaemia, in India, is 1.18% of GDP (Cheema et al., 2016).

Government's Initiatives for combating Anaemia

The Iron and Folic Acid Program (IFA) was introduced by the government of India in the 80s (GOI, 2013). It is aimed at reducing the levels of anaemia among pregnant and lactating women; and children. Both the Central and the State Governments are involved in this scheme. The responsibility of Central Government is to procure medicines and the State Government will distribute the medicines to the various health units across the state.

Even though supplementation of diet with iron and folic acid (IFA) has been a part of Government of India programming for over three decades, NFHS data shows that the levels of IFA intake remain low. Taking cognizance of ground realities, the Ministry of Health and Family Welfare took a policy decision to develop the National Iron+ Initiative(GOI, 2013). This initiative will bring together existing programmes (IFA supplementation for pregnant and lactating women and; children in the age group of 6–60 months) and introduce new age groups. Thus, National Iron+ Initiative will reach the following age groups for supplementation or preventive programming:

- Bi-weekly iron supplementation for preschool children 6 months to 5 years
- Weekly supplementation for children from 1st to 5th grade in Govt. & Govt. Aided schools
- Weekly supplementation for out of school children (5–10 years) at Anganwadi Centres
- Weekly supplementation for adolescents (10–19 years)
- Weekly supplementation for women in reproductive age

Fortification of Foods

Prevention of both iron deficiency and anaemia require approaches that address all the potential causative factors. Interventions to prevent and correct iron deficiency and IDA, therefore, must include measures to increase iron intake through food-based approaches, namely dietary diversification and food fortification with iron; iron supplementation and improved health services and sanitation.

Fortification of food with Iron is considered more cost-effective and economically more attractive than iron supplementation and/or dietary interventions (Hurrell, 2002). The WHO recommends iron compounds for cereal fortification purposes and the choice of the compound should be made considering local regulations, sensory properties and its bioavailability (WHO, 1999). Ferrous sulfate is the principal iron compound used in cereal fortification studies. However, it can only be added satisfactorily to a small number of food vehicles.

The disadvantage of ferrous sulfate is that it readily reacts with other substances that are naturally present in the food matrix and can modify the physical properties of the final product made with the fortified product. Presence of absorption inhibitors, such as phytic acid or phenolic compounds reduces iron absorption.

Sodium iron ethylenediaminetetraacetec acid (NaFeEDTA) is another FAO approved food additive (WHO, 1999) which has the advantage over other fortification compounds. It prevents iron binding to inhibitors of iron absorption and to phytic acid in particular. Thus iron absorption from NaFeEDTA, which is added to foods containing a considerable amount of phytic acid, is two- to threefold higher than from ferrous sulfate. NaFeEDTA can be used in areas with a high prevalence of iron deficiency, at a maximum intake of 0.2 mg Fe/kg body weight per day (WHO, 1999).

Rice is the staple food of India and its Per capita consumption (in 2016-17) is 74.2 kg while the world average is 61.2 kg (Anonymous, 2017). Unfortunately, polished rice which is mainly consumed contains only 4- 5 parts-per-million (ppm) of iron. But, the recommended daily allowance of iron as per Indian Council of Medical Research (ICMR) for adult is in the range of 17-35 milligrams (NIN 2009). Therefore, iron fortification of rice appears to be the best long-term nutrition intervention strategy for combating iron deficiency anaemia.

MATERIALS AND METHODS

Iron Fortification of Rice

Six rice varieties were grown in field plots with the same soil type. The experiment was laid out in completely randomized block design with three replicates per cultivar. Rice grains were harvested at maturity, with a great care to minimise the chance of Fe contamination in the field. Approximately 150 g of paddy rice were sub-sampled and rinsed thoroughly in three changes of distilled deionised water (DDI) before applying treatments. For Fe fortification treatments, rinsed paddy rice were soaked with 150 ml of Fe solutions. NaFeEDTA was used as source of Iron. For the control unfortified parboiled rice, rinsed paddy rice was soaked with 150 ml of distilled triple deionised water (TDI) for 24 h at room temperature.

Soaked grains were steamed for 10 min. The grains were cooled and sun-dried to approximately 12% moisture content.

Husking and milling

The dried grains (approximately 12% moisture content) of parboiled rice were separated into brown rice and husk with a testing husker (Satake, Japan). For each sample, 40 g of the brown rice were milled for 120 s to yield white rice by using a laboratory milling machine (Satake, Japan). Metal parts of the husker and polishing machine were cleaned by sand-blasting and coated with Teflon to minimise Fe contamination in rice samples (Prom-u-thai, et al., 2007). Weights of milled grains were recorded for calculating the percentage of head rice yield and degree of milling (Prom-u-thai et al., 2007). Iron content was estimated using XRF (Azam et al., 2017).

Sensory Evaluation and Consumers Acceptability

In order to know the consumer acceptability of the fortified product, sensory properties were studied using six rice products (plain rice, carrot rice, vegetable biryani, pudina rice, kheer and pulihora) prepared with both iron fortified and normal rice and were subjected to sensory evaluation according to the procedure mentioned elsewhere (Sarkar et al, 2015, Rizwana et al., 2017).

A total of 100 subjects, including 18 males and 82 females were randomly selected for the consumer acceptability study from the age group of 18-60 years and serve them vegetable biryani made from normal and iron fortified rice.

Effect of Iron-fortified Rice on Haemoglobin level

A study was planned to assess the effect of iron-fortified rice on the blood haemoglobin levels of anaemic girls. Details have been mentioned elsewhere (Sarkar et al., 2016). In short, vegetable *Biryani* was cooked with 100 g of raw iron fortified / normal rice for each subject and served thrice weekly to the selected subjects for a period of 2 months (60 days) to the experimental group and control group, respectively. The blood haemoglobin levels were checked on 0, 30 and 60 days according to the procedure mentioned earlier (Sarkar et al., 2016).

RESULTS AND DISCUSSIONS

Iron Content in the fortified Rice

Iron content in these samples was in the range of 35-45 ppm. For further study, three lots of paddy (50 kg each, total 150 kg) of Sampada, which is a known rice variety, were fortified. Iron content in this bulk sample was 35-40 ppm. This process was found better than the other reported methods (Chanakan et al., 2011). The loss of iron during washing with water or cooked in excess of water is comparatively less as during parboiling iron gets absorbed inside the grain.

Sensory Evaluation and Consumers Acceptability

There was no significant difference in overall acceptability between the six products of normal and iron fortified rice. However a significant ($p<0.01$) difference existed within the products of normal and iron fortified rice. The products vegetable Biryani (VBI) prepared with iron fortified rice scored the highest (6.26±0.70), thus, it was most acceptable product prepared with iron fortified rice. Hence Vegetable Biryani was selected to carry out the consumer acceptability study.

The results showed that there was no significant difference in the sensory attributes of the product prepared with normal rice and iron fortified rice. The iron fortified rice product was well accepted by the respondents (n=100).

Effect of Iron-fortified Rice on Haemoglobin level

The results indicate that there was no significant change in the haemoglobin level of the subjects in control group, whereas, in case of experimental group, the haemoglobin level increased significantly ($p<0.01$) from the 0^{th} day to 60^{th} day in moderate (Hb 8.0 -10.9g /dl) and severe anaemic (Hb<8.0g/dl) subjects. The haemoglobin level also increased from 0^{th} day to 60^{th} day in the experimental subjects with mild anaemia (Hb 11.0 - 11.9g /dl), but the increase was not statistically significant. The mean haemoglobin level in the mild anaemic experimental subjects was 11.75 ± 0.21g /dl at baseline (0^{th} day), which increased to 11.83 ± 0.46g /dl on 60^{th} day. The mean haemoglobin level increased from 9.25 ± 0.73g /dl on 0^{th} day to 10.83 ± 1.40g /dl on 60^{th} day and 6.77 ± 0.28g /dl on 0^{th} day to 10.36 ± 1.35g /dl on 60^{th} day respectively in cases of moderate and severe anaemic experimental subjects.

There are four types of rice fortification technology (Sajid et al., 2008) being commercially used namely 1) Hot Extrusion, 2) Cold Extrusion, 3) Coating process, and 4) Dusting process. Our technology of rice fortification which is done by parboiling process is simple and economically cheaper than the above existing technology because

1) All the existing technologies require specific type of equipments/machine
2) Hot extrusion process involves multiple steps and is very expensive

3) Cold extrusion process also involves multistep and produces opaque and slightly off-colour products.
4) Coating process produces kernels of distinctive colour, smell and taste which may not be liked by consumers
5) Kernels obtained from the Dusting process loose the micronutrients when is rinsed or washed with before cooking.

Hence it can be concluded that the rice fortified with NaFeEDTA can be an effective solution to prevent the enormous prevalence of anaemia and the process of fortification is simple and cost effective.

ACKNOWLEDGEMENTS

We would like to thank our Director, ICAR-Indian Institute of Rice Research for providing required facilities for this study. Thanks are also due to In-charge, XRF Instrument for allowing to analyse samples for iron content.

REFERENCES

1. Anonymous 2017. Per Capita Rice Consumption of Selected Countries. http://www.uark.edu/ua/ricersch/pdfs/per_capita_rice_consumption_of_selected_countries.pdf, Retrieved on 09/02/2017.
2. Azam MM, Ram T and Babu VR. 2017. A Guide to Rice Quality Traits Analysis. ICAR-IIRR Technical Bulletin No. 96. ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad-500030, TS, India. Pp72.
3. Chanakan P., Longbin H., Shu F. and Benjavan R., 2011. Iron Fortification in Parboiled Rice—A Rapid and Effective Tool for Delivering Iron Nutrition to Rice Consumers. *Food and Nutrition Sciences*, 2, 323-328.
4. Cheema H.K., Bajwa B. S., Kaur K., Joshi H. 2016. Prevalence and possible risk factors of anaemia in different trimesters of pregnancy. International Journal of Contemporary Medical Research, 3(4):1194-1197.
5. GOI, 2013. Guidelines for Control of Iron Deficiency Anaemia: National Iron+ Initiative. Ministry of Health and Family Welfare, Government of India. http://www.pbnrhm.org/docs/iron_plus_guidelines.pdf. Retrieved on 08/02/2017.
6. Hurrell R., 2002. How to Ensure Adequate Iron Absorption from Iron-fortified Food, *Nutrition Reviews, 60(7), (II)S7–S15.*
7. NFHS-3 2006. Ministry of Health and Family Welfare Government of India. National Family Health Survey 2005-2006. http://pdf.usaid.gov/ pdf_docs/PNADK385.pdf. Accessed on Feb 6th 2017.
8. NIN 2009. Nutrient Requirements and Recommended Dietary Allowances for Indians, 2009. National Institute Of Nutrition, Hyderabad. http://icmr.nic.in/final/rda-2010.pdf, retrieved on 09/02/2017.
9. Prom-u-thai, C., Sanchai, C., Rerkasem, B., Jamjod, S., Fukai, S., Godwin, D. I., et al. (2007). The effect of grain morphology on degree of milling and iron loss in rice. Cereal Chemistry, 84: 384–388.
10. Sajid Alavi et al. 2008. Rice Fortification in Developing Countries: A Critical Review of the Technical and Economic Feasibility. Academy for Educational Development 1825 Connecticut Avenue, NW Washington, DC 20009. https://www.spring-nutrition.org/sites/default/files/a2z_materials/508-food-rice-fortification-report-with-annexes-final.pdf, Retrieved on 07/02/2017.
11. Sarkar S, Kuna A, Azam MM, Sowmya M, Kumar ES, and Ram T. (2016). Supplementation of $Na_2FeEDTA$-fortified rice improves haemoglobin status in anaemic girls. Oryza 53 (1):74-80.
12. Sarkar S, Kuna A, Azam MM, Sowmya M, Kumar ES. (2015). Sensory and consumer evaluation of iron fortified rice. Oryza 52 (3): 231-236.
13. Shaik R, Kuna A, Azam MM, Ram T, Kanuri M, and Samala G. (2017). Effect of rice bran oil spread on the physical, sensory and fatty acid profile of cake. J. Food Science and Technology, 54(7): 2126–2134
14. WHO 2008. Worldwide prevalence of anaemia 1993–2005: WHO global database on anaemia / Edited by Bruno de Benoist, et al. ttp://apps.who.int/iris/bitstream/10665/43894/1/9789241596657_eng.pdf.
15. WHO, 1999. Joint FAO/WHO Expert Committee on Food Additives. Fifty-third meeting. Geneva.

CITATION OF THIS ARTICLE

M. Mohibbe Azam, Amtul Waris, T. Ram, Aparna Kuna and Supta Sarkar. Iron Fortification of Rice for Combating Iron Deficiency Anaemia. Bull. Env. Pharmacol. Life Sci., Vol 6 Special issue [3] 2017: 612-615