Iron fortification of rice by cooking and incubating in iron vessels

1Malathi varma, 2Muddapuram Deeksha goud, 3Digumarthy Niharika
1Assisstant Professor, 2Student, 3Student
1Department of Biochemistry

St. Francis college for women, Begumpet, Hyderabad, Telangana, India - 500016

ABSTRACT: The objective of the present study is to estimate and compare the iron concentrations in uncooked rice, Rice cooked in steel utensil, Rice cooked in microwave, Rice cooked in iron utensil, Rice cooked and incubated in iron utensil, Rice cooked with tamarind in iron utensil, Rice cooked and incubated along with tamarind in iron utensil. Rice was chosen for the experiment, as it is the most staple food in various parts of the world. Iron estimation in 7 differently processed rice samples was carried out by thiocyanate method using ferrous ammonium sulphate as standard. From the results, it was observed that (i) cooking and incubating food in iron vessels increases the iron content in the food for 3 times. (ii) Usage of tamarind accelerates this effect even more. Iron deficiency anaemia is one of the most common disorders seen in budding children, adolescents and women during menstruation. As a treatment, iron supplements or iron rich diet is recommended. This study perceived from our observation, throws light on fortification of food with iron by cooking and incubating in an iron vessel as an alternative to iron supplements to manage or treat anaemia. This method is comparatively simple, cost efficient and more effective to fortify rice with iron.

INDEX TERMS: Iron, fortification, Rice, Thiocyanate, colorimeter, Anaemia.

INTRODUCTION

WHO – Category1 interventions advise fortification of rice with iron as major area to be focussed as a public health strategy to improve the iron status of populations, in settings where rice is a staple food[1]. According WHO, 2004 reports, 1/3rd of the worldwide population are anaemic due to imbalance of their wholesome food consumption.

There are quite a few methods available, still fortification of rice has been a challenge because of the reasons:

i) Dusting adds nutrients to rice, but they are lost during washing of rice before cooking.
ii) makes them unfit for use in fortification. However ferric pyrophosphate, a white powder can be used for fortification of rice. The disadvantage is its low bioavailability.
iii) Fortification can be effective, only when implemented properly and legislatively enforced.
iv) Rice fortification on a national scale requires cost effective, continuous supply of rice kernels.

There is a serious need for a new, innovative, simple and most cost effective method of fortification of rice with various vitamins, minerals (micronutrients) etc., for the benefit of public health[2].

Iron deficiency anaemia is one of the most common disorders found in children with prevalence of 64%, and in menstruating women. Food based strategies (dietary diversification and food fortification), food supplementation and enhancement of health services are necessary to decrease the load of anaemia among Indian female population[3]. Acceptability of the utilize of iron cooking pots to reduce iron deficiency anaemia in developing countries[4].Consumption of food cooked in iron benefits the iron status and growth of young children[5].

Cooking in a cast iron skillet can add considerable amounts of iron to your food and into your body. In addition to eating foods rich in iron like meats, beans and spinach, cooking in a cast iron pot is an easy way to boost your iron intake. Malawian adults in rural areas in a high malaria diffusion area who consistently consume food prepared in iron cooking pots show a considerable rise in haemoglobin after 6 weeks use[6].Co- fortification with iron and citric acid into extruded rice grains increases iron bioavailability up to two times.

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MATERIALS AND METHODS

2.1 SAMPLE:
Rice was chosen as the sample as it is the staple food consumed regularly in the preparation of many local dishes.

2.2 SAMPLE COLLECTION:
Sona masoori rice was collected from a local supermarket in Alwal, Hyderabad, Telangana.

2.3 SAMPLE PREPARATION:
Step I: Rice was processed into various samples as follows:

- Sample 1: Uncooked rice (UR)
- Sample 2: Rice cooked in steel utensil (RS)
- Sample 3: Rice cooked in microwave (RM)
- Sample 4: Rice cooked in iron skillet (RI)
- Sample 5: Rice cooked and incubated in iron utensil (RII)
- Sample 6: Rice cooked along tamarind in iron utensil (RTI)
- Sample 7: Rice cooked and incubated with tamarind in iron utensil (RTII)

![Iron skillets used to cook rice](image)

Materials required:
- Iron skillet
- Rice
- Water
- Tamarind

Procedure:
1. A handful of rice is washed and cooked with distilled water.
2. After the rice is cooked, it was transferred into separate, labelled polythene bags.
3. From the iron skillets, half part was transferred and the other half of the rice was left in the skillets for four hours.
Step II - Materials required:

- Silica crucibles
- Mortar and pestle
- 1M HCl
- Distilled water
- Filter paper
- Standard flask
- Bunsen burner

Procedure:

1. The rice from each method is weighed 5 grams separately and transferred to crucibles.
2. All the samples in were taken in crucibles and burnt to ashes on Bunsen burner.
3. Using mortar and pestle, the ashes were crushed into fine powder.
4. The powdered ashes were soaked in 1 mol/lit HCl.( few drops)
5. 5mL distilled water was added to the ashes and made into solution.
6. Using a filter paper, the solution was filtered into a 100mL standard flask.
7. The volume of solution was made upto 100mL with distilled water.
2.4 ESTIMATION OF IRON:

Iron was estimated using Thiocyanate method.

PRINCIPLE:

Iron is determined experimentally making use of the fact that the Fe$^{3+}$ gives blood red color with potassium thiocyanate. Ferrous (Fe$^{2+}$) form is converted into ferric (Fe$^{3+}$) form by treating with oxidising agents like potassium persulphate. Fe$^{3+}$ reacts with excess thiocyanate to give ferric thiocyanate complex [Fe(SCN)$_6$]. A large excess amount of thiocyanate should be used as this increases the intensity and stability of the colour. Strong acids like sulphuric acid should be present to suppress hydrolysis. Fe$^{3+}$ is usually colourless but its complex with thiocyanate gives red colour. Absorbance is measured at 490nm.

STANDARD IRON CALIBRATION CURVE:

Materials required:

- 30% H$_2$SO$_4$
- 7% K$_2$S$_2$O$_8$
- 40% KCNS
- Distilled water
- Stock standard - 50μg/mL
- 351 mg of ferrous ammonium sulphate in 100ml of distilled water
- Working standard - 5μg/mL
- 25mL of stock solution diluted to 250mL with distilled water

Procedure:

1. Different volumes of standard iron solution from 0.2 to 1.0 mL were taken.
2. The volume was made up to 6.5 using distilled water.
3. 1mL of 30% H$_2$SO$_4$ was added in each tube.
4. 1mL of 7% K₂S₂O₈ was added in each tube.
5. 1mL of 40% KCNS was also added in all the tubes
6. Red colour was developed in all the tubes except blank. Measure the absorbance at 490nm.

Figure 9 – Tubes with Standard Iron for calibration curve

Procedure:

1. Take 0.5 and 1ml of each of the unknown sample solution prepared.
2. The volume was made up to 6.5 using distilled water.
3. Add 1 ml of each 30% H₂SO₄, 7% K₂S₂O₈, 40% KCNS into every tube.
4. A red colour develops eventually. Measure its absorbance colorimetrically at 490nm.

Figure 10, 11 & 12 – Unknown sample
RESULTS

TABLE 1 – Standard Iron Calibration

<table>
<thead>
<tr>
<th>S.No</th>
<th>Standard iron (mL)</th>
<th>Distilled water (mL)</th>
<th>Concentration (μg/mL)</th>
<th>30% H₂SO₄ (mL)</th>
<th>7% K₂S₂O₈ (mL)</th>
<th>40% KCNS (mL)</th>
<th>O.D @490nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>6.5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>6.3</td>
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<td>1</td>
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<td>0.4</td>
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<td>1</td>
<td>1</td>
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<td>4</td>
<td>0.6</td>
<td>5.9</td>
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<td>1</td>
<td>1</td>
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<tr>
<td>5</td>
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<td>1</td>
<td>1</td>
<td>0.41</td>
</tr>
<tr>
<td>6</td>
<td>1.0</td>
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<td>1</td>
<td>1</td>
<td>0.51</td>
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</tbody>
</table>

A graph was plotted taking the concentrations (μg/mL) on X-axis and absorbance values of standard iron on Y-axis.

GRAPH 1 – Standard Iron Calibration Curve

STANDARD IRON CALIBRATION CURVE

\[ y = 0.0052x \]

\[ R^2 = 0.9918 \]
TABLE 2 – ABSORBANCE OF UNKNOWN IRON SAMPLES

<table>
<thead>
<tr>
<th>S.No</th>
<th>Sample</th>
<th>Unknown (mL)</th>
<th>Distilled water (mL)</th>
<th>30% H₂SO₄ (mL)</th>
<th>7% K₂S₂O₈ (mL)</th>
<th>40% KCNS (mL)</th>
<th>O.D @ 490nm</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>UR</td>
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<td>6.0</td>
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<td>1</td>
<td>1</td>
<td>0.02</td>
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<tr>
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<td>0.03</td>
</tr>
<tr>
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<td>0.04</td>
</tr>
<tr>
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<td>RI</td>
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<td>1</td>
<td>0.04</td>
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<td>1</td>
<td>0.05</td>
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<td>1</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>6</td>
<td>RII</td>
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<td>1</td>
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<td>0.10</td>
</tr>
<tr>
<td>7</td>
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<td>0.08</td>
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<tr>
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<td>1</td>
<td>0.16</td>
</tr>
</tbody>
</table>

By using the standard graph, the concentrations of unknown samples was calculated on Microsoft excel using formula:

|=trend(X axis values, Y axis values, unknown value)|

The concentrations of unknown samples were as follows:

TABLE 3 – CONCENTRATIONS OF UNKNOWN OBTAINED FROM GRAPH

<table>
<thead>
<tr>
<th>Sample</th>
<th>Concentration (μg/mL)</th>
<th>Concentration of iron converted to 100mL (μg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>1.278</td>
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<td>RS</td>
<td>2.2725</td>
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<tr>
<td>RM</td>
<td>2.2725</td>
<td>227.25</td>
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<tr>
<td>RI</td>
<td>7.244</td>
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<tr>
<td>RTI</td>
<td>10.227</td>
<td>1022.7</td>
</tr>
<tr>
<td>RII</td>
<td>11.221</td>
<td>1122.1</td>
</tr>
<tr>
<td>RTII</td>
<td>20.17</td>
<td>2017.1</td>
</tr>
</tbody>
</table>
GRAPH 2 – BAR GRAPH SHOWING IRON CONCENTRATIONS OF VARIOUS SAMPLES

UR = Uncooked rice
RS – Rice cooked in steel vessel
RM – Rice cooked in microwave
RI – Rice cooked in iron skillet
RII – Rice cooked and incubated in iron skillet
RTI – Rice cooked along with tamarind paste in iron skillet
RTII – Rice cooked and incubated along with tamarind paste in iron skillet

The concentration of iron in rice cooked in iron skillets have been observed to be increased drastically. The rice samples that have been cooked and incubated in cast iron skillet had improved much more than the sample only cooked in iron skillet.

DISCUSSION

Cooking and incubating food in iron skillets increase amount of iron in the food.

Anaemia is one of the most common nutritional deficiency disorder and universal health problem affecting both the developing and developed countries with major consequences for human health and their social and financial development.

Types of Anaemia:

1. Aplastic Anaemia (production defect)
2. Megaloblastic Anaemia (maturation defect)
3. Iron deficiency Anaemia (Dietary intake or absorption defect)
4. Thalassemia (genetic defect)
5. Haemoglobinopathies / Sickle Cell Anaemia (synthesis of abnormal Hb)
6. Haemolytic Anaemia (loss of RBC)
Among all the different types of anaemia, the iron deficiency anaemia is the most common type. This form is common in adolescents and in women. There are studies stating cooking in iron pots is a traditional method to manage and prevent iron deficiency anaemia\[7\]. Use of iron pots, iron alloy cooking pots have given promising prevention of anaemia in pre-schoolers and in anaemia control programmes\[8,9\].

Findings of the present study showing the high increase in iron in foods cooked and incubated is definitely a new, innovative and a simple approach to manage and prevent anaemia more efficiently.

CONCLUSION

- The rice samples cooked in iron skillets have more iron content than the rice cooked in steel and microwave.
- The amounts of iron increased significantly in the incubated samples.
- Rice cooked along with tamarind paste (a rich source of ascorbic acid) had been observed to absorb very high amounts of iron in both with and without incubation samples.

From the above results, it is observed that by cooking in iron utensils, there is an increase in the iron intake in the diet. Also by adding tamarind or any other substitute of ascorbic acid, we can supplement high doses of iron without using iron supplements. But the high dosage of iron in RTII sample could cause overload of iron in the body for people without iron deficit if consumed on a daily basis. Hence the diet choices should be taken wisely.

ACKNOWLEDGEMENTS

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REFERENCES

2. Luz M. De-Regil, Juan Pablo, Peña-Rosas, Arnaud Laillou, Regina Moench-Pfanner Considerations for rice fortification in public health: conclusions of a technical consultation, September 2014
3. Rajesh Kumar Rai1, Wafaie W Fawzi2, Anamitra Barik3, Abhijit Chowdhury4 Rajesh Kumar Rai1, Wafaie W Fawzi2, Anamitra Barik3, Abhijit Chowdhury4The burden of iron-deficiency anaemia among women in India: how have iron and folic acid interventions fared? April, 2018