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# Assessment of Iron Fortified Spice Blends and its Sensory Attributes

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**A B S T R A C T**

This article was aimed at formulating iron fortified spice blends with ferrous salts for the fortification of iron in Indian diets. As iron deficiency continues to be a complex intricacy, WHO estimated that 52% of the population in India is anguished with anemia. It provides an information of iron fortification with spice blends and thus introduces a sequence of articles in this context, to delineate the current affirmation of fortification of iron with spice blends and also reviews our current knowledge of deficiency of anemia among children, women and men and the method used for iron fortification. In this case, to reach the recommended dietary allowance of iron in Indian diet, a tamarind based Indian diet Rasam was preferred, as tamarind is acidic in nature which enhances iron absorption. It summarizes the optimization of fortification of iron in Indian diets and the evaluation of iron proportion in control samples, fortified spice blends, ferrous salts and the sensory attributes of fortified spice blends. Subsequently spice blends with higher percent of iron in ferrous sulfate and ferrous fumarate was chosen, since the results showed significant higher values that ferrous fumarate with 1% of dosage had a higher proportion of iron and more palatable sensory characteristics than ferrous sulfate.

## Introduction

One of the most prevalent illnesses caused by nutritional deficiencies is anemia. WHO estimated that in India the prevalence of anemia is about 52%.In order to reduce the high prevalence of mild, moderate, and severe anemia, particularly in women. Fortifying the food using novel, creative, and cost-effective approaches is necessary to address these issues (Panyang *et al.,* 2018). The prevalence of anemia among six groups is 25.0 percent in men (15–49 years) and 57.0 percent in women (15-49 years). Teenage boys (15-19 years old) made up 31.1% of the population, while teenage girls made up 59.1%, pregnant women (15-49 years old) made up 52.2%, and kids made up 67.1 percent (6-59 months) (Belwal *et al.,* 2021). National Cancer Institute showed that in mild stage the hemoglobin should be 10.0 g/dL to lower limit of normal; in moderate level the hemoglobin is 8.0 to 10.0 g/dL; In severe stage the hemoglobin is 6.5 to 7 g/dL and in life-threatening the hemoglobin is less than 6.5 g/dL (Badireddy *et al.,* 2021). The Indian Council of Medical Research and National Institute of Nutrition had established that Recommended Dietary Allowance of Iron for 8% absorption of iron for Men, Women, and Adolescents and 6% absorption for Children, (Men – 19 mg/d; Women – 29 mg/d; Pregnant women – 27 mg/d; Lactating women – 23 mg/d; Infants(6-12months) – 3mg/d; Children (1-3y): 8mg/d; Children (4-6y): 11mg/d; Children(7-9y): 15mg/d, Boys (10-12y): 15mg/d; Girls (10-12y): 28mg/d; Boys (13-15y): 22mg/day; Girls (13-15y): 30mg/d; Boys (16-18y): 26mg/d; Girls (16-18y): 32mg/d.) (National Institute of Nutrition (NIN) *et al.*, 2020). Poor iron absorption rather than low iron intake is the main contributing factor in developing nations (Mamatha and Jamuna Prakash *et al.,* 2016). This can take the form of "mass medicine" by adding iron to commonly consumed items like cereals, milk, salt, and condiments that are taken by both at-risk groups and people who don't need any more iron (Barley *et al.,* 2015). As an alternative, a targeted fortification program that fortifies a food item that is mostly consumed by one of the at-risk groups can be taken into consideration.

In Indian cuisine, Tamarind (*Tamarindus indica* L.) is mostly used as an acidulant spice. It contains a lot of tartaric acid, which helps the body to absorb iron (Tuntipopipat *et al.,* 2006). Polyphenols reduce iron percentage, according to the research on the proportion of iron from herbs, spices, and tamarind. In the small intestine, iron inhibitors are created, reducing its bioavailability.

Except for tamarind, which is high in polyphenols and can contain tartaric acid as a result, this can be seen as a dose-dependent decrease relationship (Almeida *et al.,* 2009). Heme iron is claimed to be absorbed between 20% and 30% and is mostly untouched by dietary or physiological factors, but non-heme iron absorption is impacted by a wide range of dietary factors (Lakshmi *et al.,* 2006). The original forms of non-heme iron in food are reportedly solubilized into a common pool, where it subsequently equilibrates with all dietary components to which iron may bind. Rasam powder contains various ingredients like Coriander, Red Chilli Powder, Cumin, Turmeric, Black Pepper, Compounded Asafoetida, Fenugreek, Garlic and Salt, as they have more vitamins and minerals. Tamarind has more anti-nutritional factors like tannins, phytates, total oxalates and total phenols (Richa *et al.,* 2018). When these anti-nutrient bind with minerals and decrease the bio availability of iron. Phytic acid is considered as most potent anti-nutrient as it can bind both minerals and proteins either directly or indirectly by changing the solubility, functionality, absorption and digestibility (Thakur *et al.,* 2019). Phytates also bind zinc and calcium. But the presence of tartaric acid in tamarind nullifies the inhibitory effect (Gupta *et al.,* 2015). This is because of organic acids such as citric acid, ascorbic acid, tartaric acid and malic acid are known to enhance iron absorption. Hence, tartaric acid in tamarind can be considered as a potent iron absorption promoter.

In a research study it showed 50.4% of iron proportion at the initiation of digestion when tartaric acid is added with ferrous sulfate. However, food matrix, food vehicle for fortification, form of iron, concentration of organic acid and processing methods are equally important to conclude the effect of organic acid (Justi *et al.,* 2022). Another difficulty has been the choice of the iron fortification compound and the definition of the iron fortification level.

A major problem has been that the higher proportion of soluble iron compounds often cause frequent color and flavor changes in some food vehicles, whereas the organoleptically acceptable, more insoluble compounds are less well absorbed (Vatandoust *et al.,* 2022). Another challenge is that cereal flours, the major iron fortification vehicle, are high in phytate, a potent inhibitor of iron absorption (Charles *et al.,* 2009). In 2013, International Centre for Diarrhoeal Disease Research studied that Iron from ferrous sulfate adds to a portion of food is absorbed to the same extent as native food iron, because it is influenced in the same way by inhibitory and enhancing food components by the physiological state of the consumer. Ferrous fumarate is poorly water-soluble but dissolves completely in the dilute acid of the gastric fluid during digestion and is considered to have the same bioavailability as ferrous sulfate.

## Materials and Methods

The food ingredients needed for formulation of Rasam Powder (Spice Blends) namely Coriander, Red Chilli Powder, Cumin, Turmeric, Black Pepper, Compounded Asafoetida, Fenugreek, Garlic and Salt were procured from the local market. The ferrous salts (ferrous sulfate and ferrous fumarate) used for analysis were of analytical grade and procured from Hexagon Nutrition Private Limited, India. Proportion of iron in rasam spice blend, ferrous salts and fortified masalas were analyzed in Scientific Food Testing Service, Chennai, and all samples were carried out in duplicates.

The study method adopted for formulation of spice mixtures for preparation of rasam using ferrous salts and spices. Control product was standardized with basic ingredients and the Physio – Chemical Parameters were analyzed by AOAC method followed by preparation of iron fortified masala powders. The Standardized spice blends were analyzed for percentage of iron content and used for preparation of dishes which were subjected to sensory analysis.

Rasam is a famous traditional soup prepared based on spices, which is used along with rice or even as a soup or beverage with a meal (Devarajan *et al.*, 2017*)*. For the Optimization of rasam powder, the ingredients are taken in various variation and roasted separately and were uniformly mixed in a primary blender and grounded finely using a hammer mill then transferred to the secondary blender for final mixing. For an approximate yield of 100g of Rasam Powder the percentage of ingredients used are Coriander Powder, 32g; Red Chilli Powder, 13g; Cumin, 15g; Turmeric Powder, 3g; Black Powder, 5g; Asafoetida, 2.5g; Fenugreek, 1g; Garlic Flakes, 12g; Curry Leaves, 1.5g; Toor dhal, 10g; Salt, 5g.

The variation S3 was finally optimized as it shows good aroma and flavor releasing and subjected to testing of Physio-Chemical Parameters subsequently fortified with ferrous fumarate and ferrous sulfate. Finally the fortified rasam powder were analyzed for proportion of iron and subjected to sensory analysis.

### Fortification of Rasam Powder

Food grade ferrous sulfate and ferrous fumarate were used as a fortificant to yield 18mgof iron as per RDA Value. The ferrous sulfate and ferrous fumarate salts were added in different ratios of 0.5%, 1.0% and 1.5% into it. The mixture was uniformly mixed in a blender. The rasam powder fortified in various ratios and the ferrous salts were analyzed for different constituents to check the proportion of iron and their results were obtained.

The percentage of iron is analyzed using an Atomic Absorbance Spectrophotometer. The analysis were done with six replicate samples and the mean was recorded.

### Sensory analysis of the product

The formulated rasam powder were prepared and subjected to sensory evaluation based on quantitative descriptive analysis with 15 trained and untrained panelists on different days (O'Sullivan *et al.,* 2003). Each of the fortified product was presented with a control product with 5 Point hedonic scale (Mihafu *et al.*, 2020).

The appearance of the product shows a substantial difference compared to the control product. Product fortified with ferrous sulfate shows a significant color change, whereas ferrous fumarate shows a very little. Hence, ferrous fumarate was finally chosen to fortify with rasam powder and the proportion of iron was tested.

## Statistical Analysis

The results were expressed in Mean ± Standard Deviation (SD). One-way ANOVA was used to determine the statistical significance of differences between the proportion of iron among the fortified spice blends. Each value of $P < 0.05$ is considered to be statistically significant (Feldsine *et al.,* 2002).

## Results and Discussion

The bioavailability of iron in the rasam powder was analyzed using an absorbance spectrophotometer, the samples are coded in different alphanumeric names and given for testing the proportion of iron (Sahin *et al.,* 2010). First and foremost the bioavailability of iron between ferrous salts are analyzed by using Atomic Absorbance Spectophotometer, the bioavailability of iron are 306760 mg/kg and 326516 mg/kg. Compared to ferrous sulfate, ferrous fumarate has higher percentage of iron. The results of the iron percentage in fortified rasam powder all are set out in Table II.

From the interpretation of results there was a wide range of variations in the proportion of iron from the two salts. It shows that there was a significant difference between the two ferrous salts ($P > 0.05$).

The proportion of iron in the control sample is notably low, ranging from 178mg/kg to 463mg/kg when compared to the fortified rasam powder. These levels are inadequate for human consumption to reach the recommended dietary allowance (RDA). However, in the ferrous sulfate fortified rasam powder, a dosage of 0.5% results in a proportion of iron ranging from 2033 mg/kg to 2746 mg/kg.

Increasing the dosage to 1.5% results in a proportion of iron ranging from 1449 mg/kg to 3887 mg/kg, while a dosage of 1.5% provides a proportion of iron ranging from 3477mg/kg to 3944 mg/kg. On the other hand, the ferrous fumarate fortified rasam powder yields iron percentages of 1370 mg/kg to 3963 mg/kg for 0.5%, 2955 mg/kg to 3374 mg/kg for 1%, and 3401 mg/kg to 3751mg/kg for 1.5%.

From the above consideration, 0.5% fortified spice blend reaches the RDA value, after cooking and consumption of rasam with cooked rice the dilution of iron will be reduced than RDA value.

The interpretation is that ferrous fumarate at a dosage of 1.0% offers superior bioavailability of iron compared to ferrous sulfate. Therefore, the masala fortified with 1.5% is preferred and subjected to sensory analysis.

The results of the sensory evaluation in fortified rasam powder are set out in Table V. From the data interpretation it shows that there was a significant difference between the two ferrous salts ($P > 0.05$). Overall acceptability of rasam with ferrous sulfate shows lesser significant difference than rasam fortified with ferrous fumarate ($P < 0.05$). In 1.5% trail both ferrous sulfate and ferrous fumarate shows high metallic taste and the color of the rasam changed to darker in ferrous sulfate fortified rasam. Finally 1.0 percentage is finalized for fortification and subjected to sensory evaluation and the percentage of iron were analyzed.

The bioavailability of iron in both control and sample fortified with ferrous fumarate is 1343 mg/kg and 2201 mg/kg. Therefore, 3g serving of fortified rasam powder yield 10.8mg of iron. While after cooking and consumption of rasam with cooked rice, intake of iron may reduce to 6.6mg of iron. Hence their contribution towards iron intake will reach the RDA value while consumption of rasam in their diet.

In India, anemia is a common symptom of iron deficiency in women who are not pregnant. Women who suffer from this iron deficit experience fatigue quickly owing to low hemoglobin levels. In this study, fortifying masala with ferrous salts helps to some extent decrease the iron deficit. Rasam is a popular south Indian meal that is taken by people of all ages and contains a variety of spice components with additional medical benefits. It is advised as one of the general methods for the control of fever, cold, cough, and respiratory illnesses.

**Table.1** Physio - Chemical Properties of Rasam Powder

| S. No. | Parameter | No. of Subjects | Range | Mean | Standard Deviation |
|---|---|---|---|---|---|
| 1 | Moisture (%) | 5 | 0.80 - 0.82 | 0.81 | ±0.01 |
| 2 | Crude Fibre on dry basis (%) | 5 | 15.0 - 15.06 | 15.0 | ±0.03 |
| 3 | Total Ash on dry basis (%) | 5 | 7.50 - 7.52 | 7.50 | ±0.01 |
| 4 | Acid insoluble ash on dry basis (%) | 5 | 2.10 - 2.30 | 2.18 | ±0.11 |
| 5 | Volatile oil on dry basis (%) | 5 | 0.19 - 0.23 | 0.21 | ±0.02 |
| 6 | Non-volatile ether extract on dry basis (%) | 5 | 7.50 - 7.53 | 7.51 | ±0.01 |
| 7 | Total Aflatoxin (%) | 5 | 30.11 - 30.16 | 30.16 | ±0.1 |

**Table.2** Proportion of iron in fortified samples of Rasam Powder

| S. No. | Ferrous Salts | No. of Subjects | Iron dosage (%) | Range (in mg/kg) | Mean (in mg/kg) | Standard Deviation (in mg/kg) |
|---|---|---|---|---|---|---|
| 1 | Control | 6 | 0 | 178-463 | 348.33 | ±108.8 |
| 2 | Ferrous Sulfate | 6 | 0.5 | 2033-2746 | 2310.33 | ±255.53 |
| | | 6 | 1.0 | 1449-3887 | 3093.66 | ±887.96 |
| | | 6 | 1.5 | 3477-3944 | 3758.05 | ±191.80 |
| 3 | Ferrous Fumarate | 6 | 0.5 | 1370-3963 | 2656.66 | ±1237.83 |
| | | 6 | 1.0 | 2955-3374 | 3175.33 | ±180.55 |
| | | 6 | 1.5 | 3401-3751 | 3530.15 | ±135.3269 |

**Table.3** Proportion of iron in fortified samples of Rasam Powder

| S. No. | Ferrous Salts | No. of Subjects | Iron dosage (%) | Range | Mean | Standard Deviation |
|---|---|---|---|---|---|---|
| 1 | Control | 6 | 0 | 163-459 | 347 | ±117.2 |
| 2 | Ferrous Sulfate | 6 | 0.5 | 2124-2616 | 2400.16 | ±22.10 |
| | | 6 | 1.0 | 1956-3985 | 3033.33 | ±722.48 |
| | | 6 | 1.5 | 3152-3578 | 3445.16 | ±154.92 |
| 3 | Ferrous Fumarate | 6 | 0.5 | 1564-3564 | 1745.83 | ±940.13 |
| | | 6 | 1.0 | 3335-3741 | 2539.5 | ±144.32 |
| | | 6 | 1.5 | 3495-3722 | 3509.83 | ±110.40 |

**Table.4** Sensory Evaluation of Rasam Powder

| Parameters | Control | | | Ferrous Sulfate | | | Ferrous Fumarate | | |
|---|---|---|---|---|---|---|---|---|---|
| | Range | Mean | Standard Deviation | Range | Mean | Standard Deviation | Range | Mean | Standard Deviation |
| Color | 3.6 - 4.0 | 3.9 | ±0.17 | 2.8 - 3.1 | 3.0 | ±1.01 | 3.0 - 4.0 | 3.25 | ±0.96 |
| Appearance | 3.1 - 3.8 | 3.6 | ±0.51 | 2.5 - 3.0 | 2.9 | ±0.92 | 3.0 - 4.0 | 3.33 | ±0.93 |
| Flavor | 3.3 - 3.8 | 3.6 | ±0.51 | 3.5 - 4.0 | 3.8 | ±0.97 | 2.5 – 3 | 3.00 | ±0.96 |
| Texture | 3.5 - 4.0 | 3.8 | ±0.4 | 3.5 - 4.0 | 3.8 | ±0.99 | 3.9 - 4.1 | 4.00 | ±1.01 |
| Taste | 3.2 - 3.8 | 3.5 | ±0.54 | 2.0 - 4.0 | 2.8 | ±1.04 | 3.0 - 4.0 | 3.5 | ±1.02 |

**Fig.1** Comparative effects of proportion of iron in Control, 0.5%, 1% and 1.5% of ferrous sulfate fortified rasam powder.

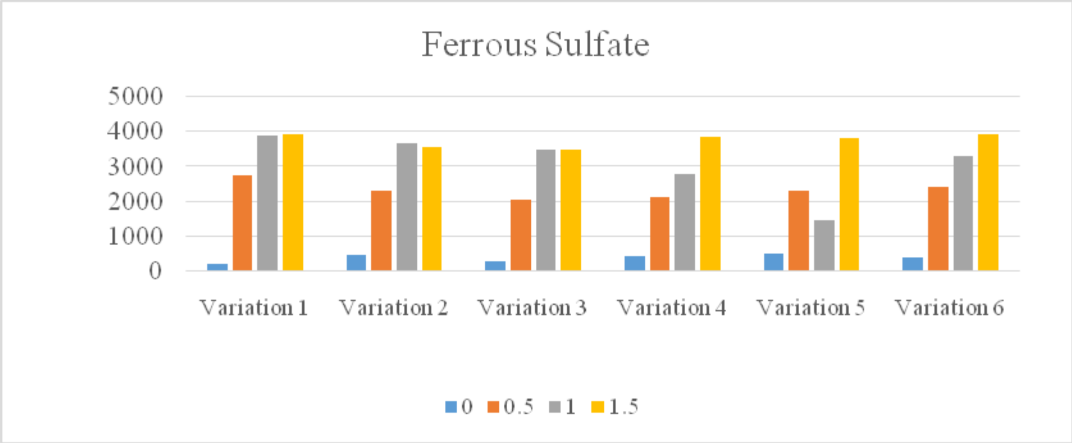
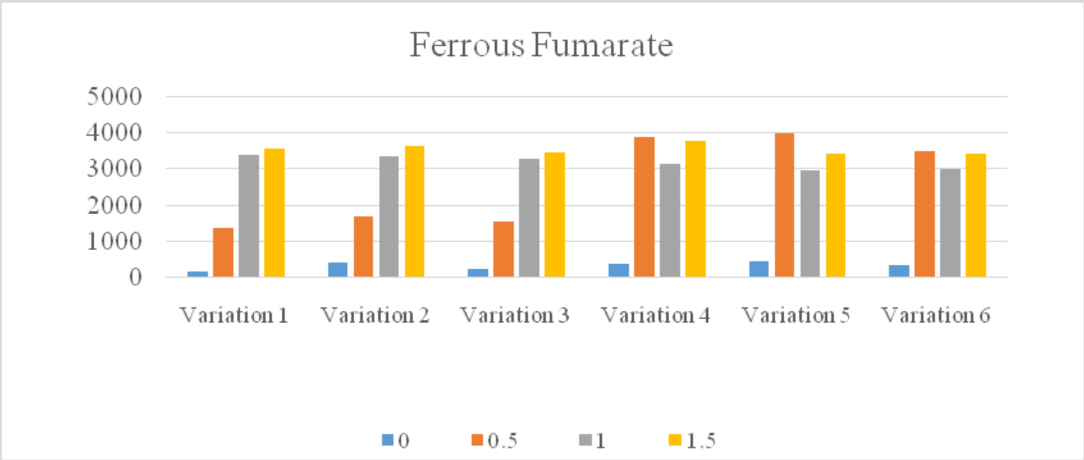



**Fig.2** Comparative effects of Proportion of iron in Control, 0.5%, 1% and 1.5% of ferrous fumarate fortified rasam powder.



Rasam, while having numerous anti-nutritional qualities, was chosen as an effective fortificant because it contains a lot of tartaric acid and helps with iron absorption. According to the study's findings, rasam powder that has been enriched with 1% ferrous fumarate has less metallic taste than ferrous sulfate and improves iron absorption to the RDA value. We may draw the conclusion that ferrous fumarate exhibits outstanding sensory qualities and a suitable fortificant for rasam powder.

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