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OPTIMIZATION OF NUTRITIONAL RICE USING MORINGA LEAF AND FENUGREEK SEED:A KEY TO TACKLE MALNUTRITION

[1]Ashok kumar A, [2]Andrew nallayan W, [3] Vijayakumar K.R, [4]Jayaseelan J,

[1]PG Scholar, [2]Professor, [3]Professor, [4]Professor,
[1]Department of Mechanical Engineering,
[1]DR MGR Educational and Research Institute, Chennai, India.

Abstract : Malnutrition is prevalent globally, especially in developing countries, where around 2 billion people suffers from severe deficiencies. Illness is associated with malnutrition in women and children of all ages. Scientists are investigating methods of fortifying rice or condiments consumed with rice to combat micro nutrients deficiencies among population that consumes rice as a stable food.It is extremely important to select the right method or technique for the job. This study aims to get the highly nutritious premix dough which can be used for rice fortification. The ingredients taken are the locally available (rural) Moringa leaves , fenugreek seeds, plant based folic acid and vitamin B12 . Moringa leaves (M) and fenugreek (F) are the power house for the vitamins and minerals. While conducting various testing and analysing, it concluded that increase in iron(M-4.025 ,F -33.87) mg/100g , zinc (M-0.89 ,F-3.1) mg/100g, Thiamin (M -0.45 ,F-0.591) mg/100g, Riboflavin (M-0.9 ,F-0.604) mg/100g, niacin(M-2.7 ,F-2.2) mg/100g, vitamin B6 (M-1.8 ,F -0.9) mg/100g and folate (M-40 ,F-57) µg/100g. These values are generally estimated values that can be varied locally. It is important to monitor and evaluate the impact of rice fortification.

IndexTerms **- Malnutrition,fortification,moringa olifera,fenugreek,iron deficiency.**

I. INTRODUCTION

Nearly 1 billion people, according to the Food and Agriculture Organisation (FAO) [1], are now undernourished. Vulnerable people are being pushed farther into poverty and hunger by high and unpredictable food costs [2]. Evidence exists that suggests that less fortunate households, those most impacted by the food crisis, are consuming less nutritious staple foods that are less expensive and still provide necessary caloric input [3]. The foods include meat, fish, and dairy products, as well as vegetables and fruits that are higher in vitamins and minerals (also known as micro nutrients). This change places an even greater burden of insufficiency on those who are already at risk for it due to low intakes of vitamins and minerals being too low.

In order to increase the nutrient value of rice, it is fortified by adding essential micro-nutrients like folic acid, iron, and vitamin B12.Fortification of rice aims to address the widespread problem of micro-nutrient deficiencies, especially in low- and middle-income nations where rice is a reliable food source. For those who depend on rice as a daily food source, fortification makes it a more nutrient-dense source of food. The rice's flavour or appearance are not changed by the straightforward, inexpensive process. Fortifying rice offers hope in the fight against malnutrition and has the potential to benefit millions of people's health and quality of life.

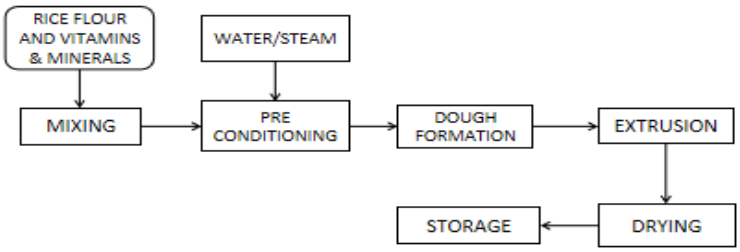
MALNUTRITION : THE PROBLEM

Micronutrient deficiencies are common, particularly in developing nations. Micronutrient deficiencies are linked to a number of diseases and stunt growth, which in turn affects physical and mental function and raises the risk of morbidity and mortality [4]. All age groups are affected by micronutrient deficiencies, but young children and women who are close to menstruating suffer the most. Micronutrient deficiencies occur when a person's intake and absorption of vitamins and minerals are consistently insufficient to give their body the amount needed for a healthy and active life. Around the world, 2 billion people are thought to be iron-deficient [5]. Anemia caused by severe iron deficiency during pregnancy has been linked to a higher probability of preterm labor, low birth weight in neonates, as well as increased mortality rates for both the mother and newborn. In addition, iron deficiency may make a person more susceptible to infections, lead to heart failure, and trigger restless leg syndrome[6].

II. NEED FOR FORTIFICACTION IN RICE

Rice is a rich source of macro and micronutrients in its unmilled form. To create brown rice, the outer husks, germs, and bran of paddy rice are removed during milling. White rice is made by further milling brown rice to remove the bran layer [7]. Paddy rice

typically yields 65% white rice, 25% husk, and 10% bran [8]. B vitamins and minerals such as iron and zinc, which can essentially be a gift in the outer germ and bran layers of rice (Fig. 1), are significantly lost during milling [7, 9]. In addition, losses of these nutrients may occur when rice is washed or rinsed before cooking, as well as using precise cooking strategies [10]. Rice grains do not absorb all the nutrients and minerals they contain without difficulty, but fortification can ensure that those nutrients and minerals are restored in a bioavailable form, thereby ensuring intake and reducing the incidence of mineral deficiencies[11].



Flowchart 1 : Rice fortification process

III. NECESSARY VITAMINS AND MINERALS FOR DAILY INTAKE

IRON : Iron deficiency and iron-deficiency anaemia are usually caused by inadequate dietary intake and/or blood loss from intestinal worm colonization in developing countries. However, in higher-income countries, specific eating habits such as a vegetarian diet and chronic blood loss or malabsorption are the leading causes[12]. The elderly population in developed countries is especially prone to iron deficiency. Iron is crucial for various biological processes, such as respiration, energy production, DNA synthesis, and cell proliferation[13]. The body typically absorbs 1 to 2 mg of dietary iron daily, and this amount is compensated for by natural bodily processes, such as menstruation, shedding of intestinal mucosal cells, and other forms of blood loss. The body requires a minimal amount of iron to produce erythroid precursors responsible for generating hemoglobin that transports oxygen throughout the body. Consequently, iron deficiency often results in anaemia[14]. Pregnant females who have insufficient levels of iron are more prone to unfavorable pregnancy consequences such as difficulties during childbirth, babies with low birth weight, and premature births[15].

'B' VITAMINS: Although rice is a widely consumed staple food, it has low levels of B vitamins, including vitamin B12, which can lead to micronutrient deficiencies in populations. To address this issue, fortifying rice with B vitamins has been proposed, and numerous studies have investigated the feasibility of this approach. According to one study, fortifying rice with thiamin (vitamin B1), riboflavin (vitamin B2), and niacin (vitamin B3) using a dusting method was effective in increasing the B vitamin content of the rice. However, it was found that fortified rice stored at high temperatures had stable vitamin B1, while fortified kernels with vitamin B2 had decreased consumer acceptability due to changes in colour[16].

ZINC: The insufficiency of zinc is believed to be linked with sickness and death in countries with low- and middle-income levels. In kids, a severe lack of zinc can cause impaired immune system functioning, short stature, and other disorders. It is also a major contributor to respiratory infections, malaria, and diarrhoeal diseases, as stated by WHO in 2002[17]. The estimated prevalence of inadequate zinc intake varies across regions, with rates ranging from 7.5% in high-income areas to 30% in South Asia. These percentages were calculated based on the estimated amount of absorbable zinc found in the national food supply of each country[18].

IV. COATING AND EXTRUSION TECHNOLOGY

Fortified rice is produced using a two step process. First, coating or extrusion technology is used to produce fortified kernels. Second, the fortified kernels are blended with non-fortified rice at a ratio of 0.5 % to 2% to result in fortified rice.

If the mixer is filled manually, it is important that all ingredients are added in correct amounts as per the required formulation. This should be monitored and documented. Manual mixers must be operated very carefully due to open access to the mixing chamber, which can be hazardous. The use of covers, safety switches and warnings are recommended. Insulation of the hopper, as well as a cover, also helps maintain temperature control while the dough is being moved to the extruder, which improves the effect of hot water addition to the starch.In spite of the difficulties faced, the hot extrusion process has proven to be a successful method for creating enriched rice in different environments, even in developing nations where nutrient inadequacies are prevalent. The fortified rice that is produced through this technique has demonstrated its efficacy in addressing nutrient insufficiencies and enhancing the overall health of individuals who consume it on a regular basis.

V. SELECTION OF NUTRITIONAL PREMIX

MORINGA LEAF POWDER: Moringa leaf powder is a highly nutritious food that can enhance the nutritional value of rice fortification. It contains significant amounts of vitamins, minerals, and antioxidants, making it an excellent addition to fortified rice. A balanced and healthy diet should provide sufficient quantities of essential nutrients such as vitamin C, vitamin A, calcium, and potassium, all of which can help maintain a healthy body. Moringa leaf powder is an excellent source of these vitamins, and its leaves are also rich in protein, containing all nine essential amino acids[19]. The high antioxidant content of moringa leaf powder is a key nutritional benefit. Antioxidants play an essential role in protecting the body against damage from free radicals, which can contribute to chronic diseases like cancer. Additionally, Moringa leaf powder is high in dietary fiber, promoting healthy digestion and potentially reducing the risk of chronic diseases like diabetes[20].

Apart from antioxidants and fiber content, moringa leaf powder is also rich in several essential vitamins and minerals, including iron and calcium. Iron is crucial for haemoglobin production, which carries oxygen into the blood, while calcium is necessary for strong bones and teeth. Adding Moringa leaf powder to rice fortification is a simple and effective way to improve the nutritional value of this crucial staple food. However, it is recommended to consume 70 grams of moringa per day to avoid over accumulation of nutrients[18]. Studies have shown that Moringa leaves contain arginine and histidine, two amino acids that are especially necessary for infants who require adequate protein for growth and development. Thus, Moringa leaf powder may help alleviate malnutrition among children and women [21].

Moringa leaves powder is known for its high nutritional value and has been used as a traditional medicine for centuries. Here are the nutritional values of Moringa leaves powder, as per the USDA National Nutrient Database for Standard Reference:

Table 1 : Moringa olifera (raw)

NUTRIENTS	VALUES PER 100g	PERCENT OF RDA
Calories	64 kcal	3.2%
Protein	9.4 g	17%
Ash	2.26	10%
Fat	1.4 g	7%
Carbohydrates	8.3 g	6%
Fiber	2.0 g	5%
Calcium	185 mg	18.5%
Iron	4.0 mg	50%
Magnesium	42 mg	10.5%
Phosphorus	112 mg	16%
Potassium	337 mg	7%
Zinc	0.6 mg	5.5%
Vitamin A	378 µg	252%
Vitamin C	220 mg	57%
Vitamin E	2.6 mg	4.8%
Vitamin K	622 µg	19%
Thiamin	0.2 mg	21%
Riboflavin	0.6 mg	5%
Niacin	2.2 mg	14%
Vitamin B6	1.2 mg	9%
Folate	40 µg	10%

*RDA- Recommended dietary allowance

FENUGREEK : Fenugreek (Trigonella foenum graecum) is an annual plant belongs to the family Leguminosae.Fenugreek powder, also known as methi powder, is derived from the fenugreek plant, which is native to the Mediterranean region and Asia. It has been used for centuries in traditional medicine and cuisine due to its many health benefits. Fenugreek powder is a rich source of nutrients and has a number of nutritional benefits[22]. Fenugreek seeds contain 45.4% fiber (32% insoluble and 13.3% soluble), and the gum is made up of galactose and mannose. The latter compounds have been implicated in hypoglycemic effects. The hypoglycemic effects of fenugreek have been particularly well documented in humans and animals with type 1 and type 2 diabetes[23]. Fenugreek powder is a valuable source of dietary fiber, which is crucial for maintaining digestive health. Fiber can help regulate bowel movements, prevent constipation, and reduce the risk of colon cancer[24]. It is also important for regulating blood sugar levels, which is particularly important for individuals with diabetes[25]. Additionally, fenugreek powder is a good source of protein, which is essential for building and repairing body tissues, maintaining muscle mass, and regulating hormones. The seeds of fenugreek have been used as a substitute for insulin to reduce blood glucose levels, and seed extracts have been shown to have blood glucose-lowering properties [26]. Fenugreek powder may also possess anti-cancer properties and aid in weight loss. Overall, fenugreek powder is an extremely nutritious and beneficial food that can provide numerous health advantages when consumed as part of a balanced diet[27].

According to the latest report by the USDA, fenugreek powder is a rich source of iron 33.53mg(419%), which is essential for the production of red blood cells and the transportation of oxygen throughout the body. Moreover, fenugreek powder contains a range of other essential vitamins and minerals that are vital for overall health and well-being[28].

According to the USDA's report, fenugreek powder (per 100 grams) contains Energy 323 kcal (16%),Zinc 2.5mg(23%), Vitamin C 3mg(5%), Thiamin 0.322mg(27%), Riboflavin 0.366mg(28%), Niacin 1.640mg(7%),Vitamin B6 0.600mg(46%) and Vitamin A 8IU(2%).

Table 2 :Trigonella foenum graecum

NUTRIENTS	VALUES PER 100g	PERCENT OF RDA
Energy	323 kcal	16%
Protein	23g	41%
Fat	6g	21%
Carbohydrates	58g	45%
Fiber	25g	65%
Calcium	176mg	18%
Iron	33.53mg	419%
Magnesium	191mg	48%
Phosphorus	269mg	42%
Potassium	770mg	16%
Zinc	2.5mg	23%
Copper	1.110mg	123%
Manganese	1.230mg	48%
Selenium	6.3µg	11%
Vitamin C	3mg	5%
Thiamin	0.322mg	27%
Riboflavin	0.366mg	28%
Niacin	1.640mg	7%
Vitamin B6	0.600mg	46%
Folate	57µg	14%
Vitamin A	8IU	2%
Vitamin E	0.41mg	7%

*RDA- Recommended dietary allowance

Note: The nutritional value may vary depending on factors such as the quality of the leaves, the method of processing, and the storage conditions.

VI. RAW MATERIAL PREPARING PROCESS

Firstly, Moringa leaves are collected from a Moringa tree. Make sure that the leaves are clean and free of any dirt or insects. the Moringa leaves were Spread out on a clean and dry surface, such as a large tray, and allowed them to dry in a well-ventilated area. Making sure that the leaves are completely dry, which may take several days depending on the weather conditions. The dried Moringa leaves were Grinded into a fine powder using a blender, food processor, or mortar and pestle. Be sure to grind the leaves in small batches to ensure that they are processed evenly. To remove large particles and impurities after grinding Moringa leaves, passed the powder through a fine-mesh sieve. This will give you a smooth and fine powder. The Moringa leaves powder was Stored in an airtight container in a cool and dry place away from direct sunlight. It will remain fresh for up to six months.

The same procedure is also done for the fenugreek seed powder making process.When fortifying rice with vitamins and minerals, a binding agent is often needed to ensure that the added nutrients are evenly distributed and do not clump together. The binding agent used in fortified rice premix is typically a starch, such as corn starch or tapioca starch. The starch helps to bind the powder to the rice grains and prevent it from separating during storage or transportation[29].

VII. DETERMINATION OF VITAMINS AND MINERALS CONTENT

The most preferred analysis is done by using atomic absorption spectrophotometry in laboratory. These are extracted using a suitable organic solventsto find the iron content[30].

Analysis Nutrients of the Sample : The nutrient content of drumstick leaves powder was examined using established techniques to assess levels of both macro and micronutrients, including moisture, carbohydrates, energy, protein, fat, crude fiber, β-carotene, vitamin C, iron, and calcium. (AOAC, 1980) [31].

Composition of energy : The composition of energy was computed for all the samples.

$$\text{Energy (Kcal)} = \text{Protein (g)} \times 4 + \text{Fat (g)} \times 9 + \text{Carbohydrate (g)} \times 4$$

Moisture content of the samples: To determine moisture content, a sample weighing 10 g was placed in a petri dish and subjected to drying in a hot air oven at a temperature of 60°C. After drying, the sample was allowed to cool before being weighed again.

$$\text{Moisture per cent} = \text{Fresh sample (g)} - \text{Dry sample (g)} \times 100 \text{ Fresh sample (g)}$$

Protein content estimation of the sample : The Kjeldhal method was utilized to calculate the protein content of the dried tender drumstick leaves sample, which was expressed as a percentage of the total nitrogen present.

$$\text{Protein (g/100g)} = \frac{\text{Titre value} \times \text{Normality of HCL} \times 14.001 \times 6.25 \times 100}{\text{Sample weight (g)} \times 1000}$$

Fat content estimation of the sample : The fat content of the sample, which was free of moisture, was determined through extraction using crude ether. The solvent was then removed via an evaporation process, and the residue of the fat was weighed.

$$\text{Fat content (g/100g)} = \frac{\text{Weight of the ether extract}}{\text{Weight of the sample taken}} \times 100$$

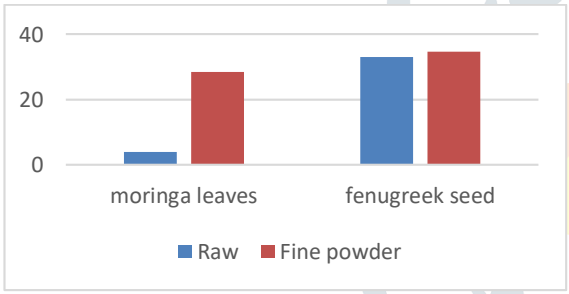
Crude fiber content estimation of the sample: The estimation of crude fiber was carried out by using moisture and fat free samples and expressed as g/100 g of sample.

$$\text{Crude fibre (g/100g sample)} = \frac{[100-(\text{moisture}+\text{fat})] \times (We - Wa)}{\text{Wt. of sample taken (moisture and fat free)}}$$

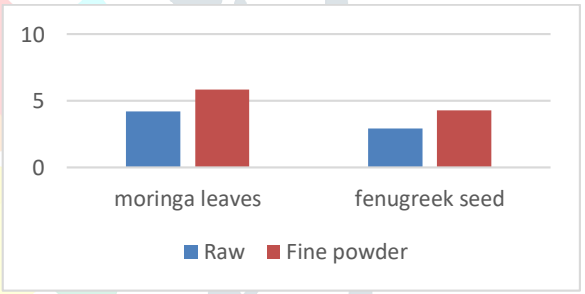
Ash content estimation of the sample : To determine the ash content of the sample, 5 grams were placed in a crucible and slowly charred in a muffle furnace for approximately 240 to 300 minutes at a temperature of 600°C. The sample was then removed from the furnace, allowed to cool, and weighed.

$$\text{Ash content (g/100g sample)} = \frac{\text{Weight of the ash}}{\text{Weight of the sample}} \times 100$$

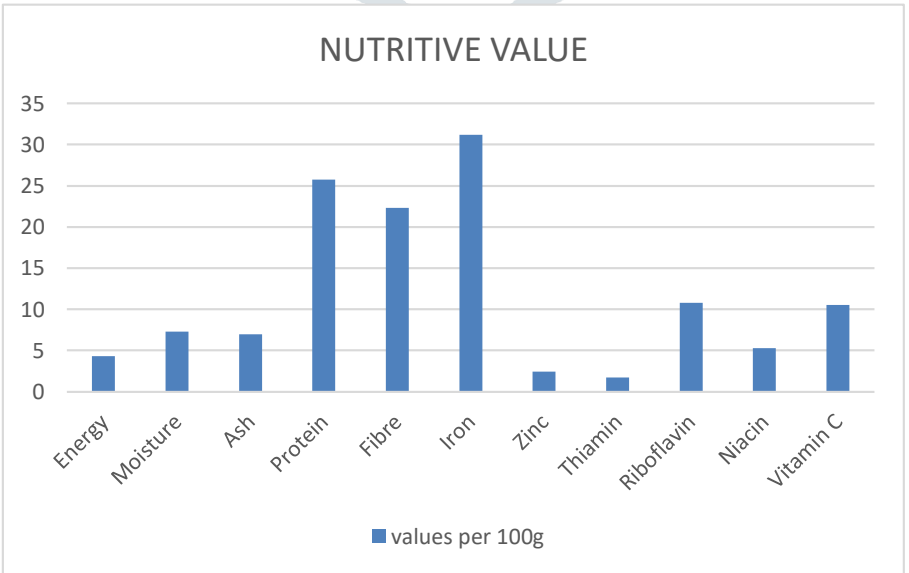
Important Nutrients sample value



Graph 1: value of iron content (mg)



Graph 2: value of B vitamins (mg)



VIII. RESULT AND DISCUSSION

To sum up, moringa leaf powder and fenugreek seed are highly beneficial components for rice fortification as they contain essential nutrients that enhance the nutritional value of rice. The process of adding these ingredients to rice kernels is simple and economical, as it

can be done during the cooking process. Incorporating moringa leaf powder and fenugreek seed into rice fortification programs can be an effective strategy to tackle malnutrition and improve the health of communities that heavily rely on rice as a staple food. The results are shown below.

Table 3 : sample values of moringa leaf and fenugreek seed premix

NUTRIENTS	Values of Moringa leaves powder after processing Per 100g	Values of fenugreek seed powder after processing Per 100g	Difference values obtained from requirements ±mg/100g		Approx value of combination of mixture per 100g
			M	F	
Energy	345	326	281	30	335.5
Moisture	7.8	6.8	2.5	2.3	7.3
Protein	27.5	24	18.1	3.5	25.75
Ash	8.8	5.2	6.54	1.2	7
Fiber	19.2	25.4	17.2	0.4	22.3
Iron	28.5	33.94	24.5	0.53	31.22
Zinc	1.8	3.1	2.5	0.6	2.45
Vitamin C	17.3	3.8	54	0.8	10.55
Thiamin	2.8	0.59	2.47	0.25	1.69
Riboflavin	21	0.604	20	0.238	10.8
Niacin	8.4	2.2	6.76	0.56	5.3
Vitamin B6	1.5	0.9	0.9	0.3	1.2
Folate (in mcg)	40	57	-	-	48.5

IX. CONCLUSION:

The results which we obtained through this extracts shows that the Moringa olifera leaves extract and fenugreek seed extract had high nutritive values. Fortification of rice with these extract powder will enhance the nutritional power to the undernourished people without any high expenses on foods.

Note : Our strategy is based on the basic research done previoulsy by the scholars and some handouts by the private articles. Further research will be necessary to evaluate the bioavailability and bioefficacy of fortifified rice as well as vitamins and minerals stability over long storage periods typical for grain products.

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