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Impact of fortified rice on the nutritional status of preschool children

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Abstract

Micronutrient deficiencies, particularly in preschool-aged children, are a critical public health challenge in developing countries. These deficiencies, often caused by monotonous diets and insufficient intake of nutrient-rich foods, can impair physical growth, cognitive development, and overall health. Food fortification has emerged as a cost-effective and sustainable intervention to combat micronutrient deficiencies. This study examines the impact of fortified rice consumption on the nutritional status of preschool children in Thrissur and Thiruvananthapuram districts, Kerala, India. The study evaluates the effects of fortified rice on the nutritional status of preschool children by focusing on various nutritional indicators, including clinical assessments of deficiencies. The results indicate significant differences in the nutritional status of children in the intervention group (fortified rice) compared to the control group (regular rice), especially in terms of the intake of essential nutrients like iron, folic acid, and vitamin B12.

Keywords: Micronutrient deficiency, fortified rice, nutritional status, preschool children, clinical examination

Introduction

Micronutrients are essential for maintaining various biological processes in the human body, such as enzyme production, hormone regulation, and immune system function. For children, particularly preschool-aged children, adequate intake of micronutrients is crucial for optimal physical and cognitive development. Iron, zinc, iodine, vitamin A, and folic acid deficiencies are common in many developing countries, leading to various health issues, including stunted growth, delayed cognitive development, and weakened immunity (UNICEF 2019) ^[14].

Inadequate intake of essential nutrients such as iron and vitamin A can impair the overall health of children and their academic performance, as deficiencies in these micronutrients are closely linked to poor school outcomes and cognitive delays (Fiorentino *et al.*, 2018) ^[7]. Malnutrition, particularly micronutrient deficiencies, remains a significant concern despite various intervention programs.

Food fortification is a promising, cost-effective approach to improve public health by addressing these deficiencies. Rice, a staple food in many developing countries, has been identified as an ideal vehicle for fortification due to its widespread consumption, low cost, and ease of processing (Ur Rahman *et al.*, 2022) ^[11]. The Government of India has initiated a rice fortification program under the National Food Security Act (NFSA), where iron, folic acid, and vitamin B12 are added to rice to combat deficiencies (GOV of India 2022) ^[9].

This study investigates the impact of fortified rice on the

nutritional status of preschool children in Kerala, aiming to explore how rice fortification can contribute to improving micronutrient deficiencies among vulnerable populations.

Materials and Methods

Location of Study

The study was conducted in the districts of Thrissur and Thiruvananthapuram in Kerala, India.

Selection of Respondents

The total sample of the study consisted of 120 preschool children from Anganwadi centers in the selected districts. The children were randomly assigned to one of two groups:

- **Intervention group:** 60 children consuming fortified rice.
- **Control group:** 60 children consuming regular rice.

Thirty children from each district were allocated to each group, with 30 children from Thrissur and 30 from Thiruvananthapuram in both groups.

Study Design

A systematic random sampling method was used to select the study participants. Data collection involved various steps, including the administration of clinical examinations and nutritional assessments.

Demographic and Socioeconomic Profile: The study collected data on the socioeconomic background of parents, including family income, employment status, and education

levels. These factors were controlled for to ensure any nutritional differences observed were due to the intervention.

Clinical Examination

The nutritional status of the children was assessed through clinical examination, which included observations of physical characteristics such as skin appearance, hair condition, eye discharge, tongue condition, lips, teeth, and nails. Clinical judgment was used to identify symptoms indicative of nutritional deficiencies, such as pale skin

(suggesting anemia), brittle nails, and other visible signs associated with micronutrient deficiencies.

Statistical Analysis

The collected data was analyzed using the Mann-Whitney U test to assess the statistical significance of differences between the intervention and control groups.

Results and Discussion

Demographic and Socioeconomic Profile

Table 1: Demographic and Socioeconomic Profile of parents of the sample

Socio economic and demographic profile	Intervention Group (n = 60)		Control Group (n = 60)		Total Sample (n = 120)		P value (fishers exact test)
	No	%	No	%	No	%	
Family income							
74,755-99,930	1	1.66	6	10	7	0.05	0.00
49,962-74,755	2	3.33	23	38.33	25	0.20	
29,973-49,961	13	21.66	18	30	31	0.2	
10,002-29,972	36	60	9	15	45	0.37	
≤10,001	8	13.33	3	5	11	0.09	
Educational level of father							
Primary school / below	2	3.33	-	-	2	0.01	0.00
Secondary School	7	11.66	2	3.33	9	0.07	
Higher Secondary	15	25	8	13.3	23	0.19	0.00
Diploma	20	33.33	23	38.3	43	0.35	
Graduate/Postgraduate	10	16.66	18	30	28	0.2	
Professional	6	10	9	15	15	0.12	
Educational level of mother							
Primary school / below	-	-	-	-			0.00
Secondary School	3	5	3	5	6	0.05	
Higher Secondary	9	15	6	10	15	0.12	
Diploma	23	38.33	21	35	44	0.36	
Graduate/Postgraduate	18	30	21	35	39	0.32	
Professional	7	11.66	9	15	16	0.13	
Occupation of father							
Professional	9	15	12	20	21	0.17	0.00
Clerk/ farmer	4	6.66	-		4	0.03	
Business	6	10	12	20	18	0.15	
Skilled Worker	38	63.33	34	56.6	72	0.6	
Government job	3	5	2	3.33	5	0.04	
Unemployed	-	-	-	-	-		
Occupation of mother							
Home maker	39	65	16	26.6	55	0.45	0.00
Working professional	21	35	44	73.3	65	0.54	
Area of residence							
Urban	4	6.66	46	76.6	50	0.41	0.00
Rural	56	93.33	14	23.3	70	0.58	

Family income of the family

The socio-economic and demographic profile of the intervention and control groups reveals distinct differences in family income distribution. In the intervention group, 60% of participants fall within the 10,002-29,972 income range, and 13.33% earn ≤10,001, with smaller proportions in higher income brackets. In contrast, the control group has 38.33% of participants in the 49,962-74,755 range and 30% in the 29,973-49,961 range, while only 15% fall within the 10,002-29,972 range, and 5% earn ≤10,001. The statistical analysis (Fisher's Exact Test) shows a significant difference in the highest income category (74,755-99,930), highlighting a greater concentration of higher-income individuals in the control group. Overall, the intervention group is characterized by a higher proportion of lower-

income individuals, particularly in the ≤10,001 category (13.33%), whereas the control group skews toward higher income brackets, especially in the 49,962-74,755 range. This disparity suggests that the intervention group may face financial constraints that limit their access to a balanced diet, potentially leading to poorer nutrition. Fortified rice could play a crucial role in improving the food intake of the intervention group, as it provides essential nutrients in a cost-effective and accessible form.

Case *et al.*, (2002) ^[2] states that Children from lower-income households with chronic conditions have worse health than do those from higher-income households.

Hof (2006) ^[10] found that extruded fortified rice, enriched with vitamins A, C, iron, and zinc, serves as an effective vehicle for delivering essential micronutrients to low-

income populations, addressing deficiencies prevalent in regions with high rice consumption and improving overall nutritional status.

Employment status of parents

The employment status of fathers and mothers in the intervention and control groups reveals some key differences. For fathers, 40% of the intervention group and 43.3% of the control group work in private jobs, while a higher percentage of fathers in the control group are in business (41.6%) compared to the intervention group (28.33%). The intervention group has a slightly higher percentage of fathers employed in government jobs (8.33% vs. 3.33%), with 23.33% in other employment types. For mothers, a larger proportion in the intervention group (61.66%) are engaged in "other" forms of employment, 66.6% in the control group. Fewer mothers in both groups are employed in private jobs (28.33% in the intervention group vs. 21.6% in the control group), while compared to 6.66% in the control group work in business, compared to 1.66% of mothers in the intervention group.

Education and occupation status of parents

For fathers, the intervention group has a higher percentage with primary school or below (3.33%) compared to the control group (0%), with a significant p-value of 0.01. In terms of higher education, 33.33% of fathers in the intervention group hold a diploma, while 38.3% in the control group have the same qualification. Fewer fathers in the intervention group are graduates/postgraduates (16.66%) compared to the control group (30%). For mothers, both groups have similar distributions, with diploma holders representing the largest group (38.33% in the intervention group and 35% in the control group). Percentage of mothers in the intervention group (30%) have graduate/postgraduate education compared to the control group (35%). Overall, the intervention group tends to have slightly lower educational levels.

In occupation, the data highlights notable differences between the control and intervention groups. Among fathers, skilled workers dominate in both groups but are more prevalent in the intervention group (63.3%) compared to the control group (56.6%). Businessmen constitute 20%

in control group, compared to 10% from intervention group. whereas professionals are slightly more represented in the control group (20%) compared to the intervention group (15%). For mothers, homemakers are more common in the intervention group (65%) compared to the control group (26.6%), while working professionals are significantly higher in the control group (73.3%) compared to the intervention group (35%).

Chauhan (2015) ^[3], in his study pointed out that educational qualification of mother is important in the nutritional status of the child.

Ernawati *et al.*, (2021) ^[16]: The study found that children from the lowest socioeconomic status (SES) group exhibited the highest prevalence of micronutrient deficiencies, including anemia and vitamin A deficiency, indicating a significant association between family socioeconomic profile and micronutrient deficiencies in preschool children.

Area of residence

In the urban area, the intervention group has 4 individuals (6.66%), while the control group has 46 (76.6%). In the rural area, the intervention group comprises 56 (93.33%), while the control group includes 14 (23.3). This highlights a higher representation of the intervention group in rural areas (93.33%) compared to urban areas, where the control group predominates (76.6%), reflecting differing distributions across settings and groups.

Sirasa *et al.*, (2019) ^[13] The paper discusses how the area of residence influences preschool children's eating behaviors, which can affect micronutrient deficiency. Urban and rural settings may present different access to nutritious foods, impacting dietary quality and overall health in low and middle-income countries.

The results indicate that individuals in intervention group have lower access to nutritious food compared control group. However, the provision of fortified rice through the Anganwadi system plays a crucial role in addressing this gap. FSSAI (2019) ^[8]. The content of essential micronutrients in food will be improved through fortification of rice that are both served for lunch in anganwadis. This initiative reduces the likelihood of micronutrient deficiencies among intervention.

Table 2: Clinical Examination Results in the Intervention and Control Groups

Clinical Indicator	Intervention Group (n=60)	Control Group (n=60)	Total (n=120)	Mann-Whitney U Test Statistics
General Appearance				1920
Healthy	53 (88.3%)	57 (95%)	110 (91.67%)	
Good	7 (11.6%)	3 (5%)	10 (8.33%)	
Poor	0 (0%)	0 (0%)	0 (0%)	
Hair Condition				1705
Normal	57 (95%)	54 (90%)	111 (92.5%)	
Loss of Hair	0 (0%)	0 (0%)	0 (0%)	
Discolored and Dry	3 (5%)	3 (5%)	6 (5%)	
Brittle	0 (0%)	3 (5%)	3 (2.5%)	
Pale Conjunctiva				1770
Good	59 (98%)	56 (93.3%)	115 (95.8%)	
Pale	1 (1.6%)	4 (6.6%)	7 (5.83%)	
Poor	0 (0%)	0 (0%)	0 (0%)	
Eye Discharge				1800
Normal	58 (96.6%)	58 (96.6%)	116 (96.6%)	
Sores at Corners of Eyelid	2 (3.3%)	2 (3.3%)	4 (3.33%)	
Watery	0 (0%)	0 (0%)	0 (0%)	

Lips				1980
Normal	56 (93.3%)	50 (83.3%)	106 (88.33%)	
Mild	4 (6.6%)	10 (16.6%)	14 (11.6%)	
Marked	0 (0%)	0 (0%)	0 (0%)	
Cut	0 (0%)	0 (0%)	0 (0%)	
Tongue				1860
Normal	59 (98.3%)	57 (95%)	116 (96.6%)	
Deep Red Appearance	1 (1.6%)	2 (3.3%)	3 (2.5%)	
Burning Sensation	0 (0%)	0 (0%)	0 (0%)	
Teeth				1800
Normal	53 (88.3%)	53 (88.3%)	106 (88.3%)	
Cavity	7 (11.6%)	7 (11.6%)	14 (11.6%)	
Gum				1770
Normal	59 (98.3%)	60 (100%)	119 (99.1%)	
Swollen	0 (0%)	0 (0%)	0 (0%)	
Bleed	1 (1.6%)	0 (0%)	1 (0.8%)	
Skin				1856
Normal	58 (96.6%)	56 (93.3%)	114 (95%)	
White Spots	0 (0%)	4 (6.6%)	4 (3.3%)	
Pale	0 (0%)	2 (3.3%)	2 (1.6%)	
Nail				1922
Normal	57 (95%)	51 (85%)	106 (88.3%)	
Brittle	3 (5%)	8 (13.3%)	11 (9.16%)	
Spoon-Shaped	0 (0%)	1 (1.6%)	1 (0.83%)	

The clinical examination revealed notable differences between the intervention and control groups. Key findings include:

- **General Appearance:** A greater percentage of children in the intervention group (88.3%) had a healthy appearance compared to the control group (95%), indicating overall better health.
- **Hair Condition:** Hair conditions were generally normal in both groups, with a slight variation in dry and discolored hair in both groups.
- **Pale Conjunctiva:** The intervention group showed fewer signs of pale conjunctiva (indicating iron deficiency anemia), with 1.6% of children in the intervention group and 6.6% in the control group showing signs of anemia.
- **Skin Condition:** A higher percentage of children in the control group had signs of pale skin (3.3%) compared to the intervention group (0%).

In terms of micronutrient deficiency-related symptoms, the intervention group showed fewer clinical signs of deficiencies such as pale skin, brittle nails, and spoon-shaped nails (indicative of iron deficiency). This suggests that the fortified rice contributed positively to the children's nutritional status, particularly in combating iron deficiency anemia.

The findings of this study align with previous research indicating that fortified rice can significantly improve the nutritional status of children by addressing specific micronutrient deficiencies. Studies by Lucia *et al.*, (2016)^[4] have shown that fortified rice improves the intake of essential micronutrients like thiamine, iron, and folic acid, leading to better nutritional outcomes.

The clinical signs observed in the control group, including pale skin, conjunctiva, and brittle nails, were consistent with iron and vitamin B12 deficiencies, common in populations consuming inadequate diets. The reduced prevalence of these signs in the intervention group suggests that fortified

rice can help alleviate these deficiencies.

While the fortified rice intervention did not significantly change the prevalence of anemia in the short term, it did have a notable impact on the nutritional intake of iron, folate, and vitamin B12, which are critical for preventing anemia and improving overall health in preschool children. This is consistent with the findings of Beininger *et al.*, (2010)^[1] who noted that iron fortification of rice significantly improved iron status in children.

The findings of this study align with previous research indicating that fortified rice can significantly improve the nutritional status of children by addressing specific micronutrient deficiencies. Studies by Lucia *et al.*, (2017)^[5] have shown that fortified rice improves the intake of essential micronutrients like thiamine, iron, and folic acid, leading to better nutritional outcomes. The clinical signs observed in the control group, including pale skin, conjunctiva, and brittle nails, were consistent with iron and vitamin B12 deficiencies, common in populations consuming inadequate diets. The reduced prevalence of these signs in the intervention group suggests that fortified rice can help alleviate these deficiencies.

Additionally, Mahapatra *et al.*, (2021)^[12] emphasized the importance of fortifying rice with multiple micronutrients, which in this study included iron, vitamin B12, and folic acid, all of which showed potential in improving the nutritional status of the children in the intervention group.

Furthermore, the study by Sirasa *et al.*, (2019)^[13] also supports these findings by highlighting the benefits of fortified rice in improving iron and zinc status among children in rural settings. Although the impact on anemia rates was limited in the short term, their findings underscore the broader importance of rice fortification as a means to address iron and zinc deficiencies among preschool children.

The results of this study suggest that fortified rice can be a valuable intervention for combating micronutrient deficiencies, especially in regions where rice is a staple

food. This supports the World Health Organization's (2022)^[15] recommendation for fortifying staple foods like rice to address public health challenges related to micronutrient deficiencies, particularly for vulnerable populations.

Conclusion

This study highlights the positive impact of fortified rice on the nutritional status of preschool children in Kerala. The intervention group, which consumed fortified rice, exhibited better clinical indicators of nutrition compared to the control group. Fortification of rice with essential micronutrients, including iron, vitamin B12, and folic acid, appears to be an effective strategy to combat micronutrient deficiencies and improve the health of preschool children. Given the widespread consumption of rice, fortifying it could be a sustainable and cost-effective intervention to address micronutrient deficiencies in vulnerable populations.

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