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ORIGINAL ARTICLE

The Efficacy of Fortified Rice Consumption on Nutritional Status of Stunted Children Less Than Five Years Old in Yogyakarta, Indonesia

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ABSTRACT

Background: Stunting still remains a priority issue of malnutrition in Indonesia. Nutrition deficiency during the first 1000 day of life is the main factor of stunting in children. The strategy to address the nutrition deficiency through food fortification showed a positive impact of malnourished children in several studies. This study aimed to examine the effect of consuming fortified rice on nutritional status of stunted children.

Methods: A double-blind randomized controlled trial study enrolled 96 children aged 12-59 months with the height-for-age z-score lower than -2 SD. Participants were assigned to treatment fortified rice (FR) and control non-fortified rice (NFR) group. FR group received fortified rice; while NFR received non-fortified rice for 24 weeks of intervention. The comparison of heigh-for age z-score (HAZ), weight-for-age z-score (WAZ), and weight-for-height z-score (WHZ) between groups was undertaken.

Results: No significant differences were noticed for HAZ, WAZ, and WHZ between groups. FR group showed a greater improvement in the number of participants transitioning from stunted to normal status when compared to NFR group. Linear regression analysis revealed that consumption of fortified rice could significantly increase the HAZ in children aged 4-5 years, particularly among those whose mothers had high self-efficacy. Factors associated with the increase in HAZ coefficient included adequate energy intake, infrequent milk consumption, and effective feeding practices.

Conclusion: Consumption of fortified rice had no significant impact on nutritional status of stunted children. Maternal or caregiver self-efficacy had a potential positive influence on the HAZ of stunted children.

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Introduction

Stunting is a major public nutrition concern that the Indonesian government is currently focusing on. Indonesia ranks fifth globally for the highest number of stunted children (1). According to the 2018 Indonesia Basic Health Research (Riskesdas), the prevalence of stunting among children under five years old was 30.8%; while this figure represents a decline in comparison to the 2013 survey results (2). Stunting can significantly affect growth, brain development, and immunity, and can lead to relatively lower productivity in the future when compared to children who are not stunted (3).

Stunting has raised a national health concern in Indonesia based on 2020-2024 National Medium-Term Development Plan (RPJMN). Specific and sensitive programs to accelerate stunting reduction are promoted by the Indonesian government and are implemented in a convergent, holistic, and multi-sectoral strategy. Although stunting primarily occurs in the first 1000 days of life, from pregnancy to the child's age two, prevention must be carried out as early as possible since adolescence (4). Stunting is commonly linked to deficiencies in both macro and micronutrients due to inadequate intake during the first 1000 days of life. The World Health Organization states that food fortification could be one of the strategies to address micronutrient deficiencies, which involves adding micronutrients to the foods. Fortification usually uses the staple food that is common in the population as a vehicle. This approach not only helps improve the micronutrient status of the population; but is also regarded cost-effective (5).

Rice is the primary staple consumed by almost the entire population of Indonesia (6). Fortified rice has also been used as a strategy to address nutrition problems in several other countries. A Randomized Controlled Trial (RCT) conducted in Cambodia found that providing fortified rice for 6 months could significantly reduce the risk of vitamin A deficiency by five times in school-age children of 6-16 years (7). Another RCT study in Bangalore, India, demonstrated that feeding school-age children of 6-12 years with fortified rice for 6 months led to significant improvements in plasma level of vitamin B12, homocysteine concentration, and physical performance. In addition, the incidence of diseases such as diarrhea, fever, and cough also decreased notably in these children (8).

Children with micronutrient deficiencies, such as those with stunting, require essential micronutrients, including vitamin A, vitamin B complex (B1, B2, B3, B5, B6, B12), and vitamin C. A lack of vitamin A deficiency impairs protein synthesis and cell growth, and increases the risk of growth failure in children (9). Vitamin B complex has a direct effect on brain function, and emotional and behavioral changes, and plays an important role in converting nutrients into energy to sustain brain activity (10). A study has shown that providing multi-micronutrients, followed by interventions to boost energy and protein intake, had a positive influence on improving child growth (11). Inadequate intake of energy, protein, vitamin B2, vitamin B6, Fe, and zinc in children can become risk factors for stunting (12). Other studies have highlighted the positive impact of combining zinc supplementation with iron to promote children's linear growth (13, 14). Zinc administration has proven to be effective and feasible to prevent growth retardation in children too (15).

Fortified rice is available in the market and is enriched with several nutrients, including vitamins A, B1, B3, B12, B9, iron and zinc. Rice fortification is essential because these nutrients are largely lost during the milling process. In addition, fortification of rice with iron, vitamin A, and folic acid (B9) can be used as a public health strategy to improve the status of these nutrients in a population, mainly when rice is the main staple food. Rice provides calories and contains low micronutrients. Therefore, rice fortification in Indonesia holds potential as a strategy for addressing micronutrient deficiencies for stunting (16). This study targeted a group of stunted children less than five years, who were particularly vulnerable to stunting, to examine the impact of fortified rice on their nutritional status.

Materials and Methods

In a randomized controlled trial design, 96 research participants were divided into two groups of the treatment group and the control group. The treatment group received fortified rice (FR), while the control group was given non-fortified rice (NFR). A random allocation was done so that each participant had an equal chance of being assigned to either group. This technique ensured an even distribution of any external variables. Both groups underwent pre-treatment assessments to analyze the homogeneity of the sample, followed by post-treatment evaluations to compare the effectiveness of the intervention between the two groups. The study used a double-blind method, where both the participants and the researchers were unaware of which group received the intervention products. The intervention code was only known to the team that was not directly involved in administering the intervention.

This study aimed to examine the impact of fortified rice consumption on the nutritional status of stunted children. The independent variable was

the consumption of fortified or non-fortified rice. In contrast, the dependent variable was nutritional status indicated by height for age z-score (HAZ), weight for age z-score (WAZ), and weight for height z-score (WHZ). The primary outcome in this study was HAZ; while the secondary outcomes were other nutritional indicators of the WAZ and WHZ. The intervention lasted for 24 weeks, with baseline data collected at week 0 and endline data at week 25th. The study was conducted from October 2023 to June 2024 in the Seyegan District (including the villages of Margoluwih, Margodadi, Margokaton, Margomulyo, and Margoagung) and the Mlati District (Tirtoadi Village), Sleman, Yogyakarta, Indonesia.

The study included children aged 12 to 59 months who were stunted with HAZ less than -2 Standard Deviation (SD), were accustomed to consuming rice, and whose parents consented to their child's participation. Children with physical or mental disabilities, those receiving supplementary food interventions from other parties, and those who moved out of the study area were excluded. A written parental consent was obtained before the screening of the participants. After screening, participants who met the criteria were randomly assigned to groups using an online random picker application managed by a research team member (LA). The sample size was determined using a power of 95% and a significance level of 5%, resulting in 44 participants per group. An additional 10% was added to account for potential dropouts, increasing the sample size to 48 per group as NFR (n=48) and FR (n=48). Therefore, the total required sample size was 96 stunted children under five.

The intervention consisted of providing fortified rice, which is the rice enriched with single or multiple nutrients that are either naturally absent or present in very low quantities. The type of rice between the two groups used the same variety. The fortified rice used in this study was prepared by mixing 1% of kernels (nutrient-enriched) into the rice. The kernels contained vitamins B1, B3, B6, B9, and B12, as well as zinc and iron. As a comparison, the NFR group received regular or non-fortified rice. The rice was supplied by the local producer in Yogyakarta. Before the intervention began, the mothers or caregivers in both groups received education on stunting. The rice cooking methods and recommended rice portioning techniques were explained to mothers by the enumerators.

The research protocol had been thoroughly reviewed. Nutritional status data was collected through anthropometric measurements of height and weight, conducted by trained enumerators. The measurement process used OneMed scale with a precision of 0.01 kg and microtoise with a precision of 0.1 cm. The anthropometry was measured every 4 weeks. The participants' dietary intake was assessed before and after the intervention using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) questionnaire. To assess intake during the intervention, a 24-hour recall was conducted monthly (considering week-days, weekends and holidays). Rice consumption was monitored every week by the enumerator. Rice consumption compliance was monitored using a control card, which the mother or caregiver was required to complete daily after each meal. The mother was asked to record the portion of rice consumed using household measurement units (HMU) which was a tablespoon. Additionally, the mother was instructed to note any incidents, such as complaints or side effects that occurred during the intervention. This study has received approval/Ethical Clearance from the Medical and Health Research Ethics Committee (MHREC) Faculty of Medicine, Public Health and Nursing, Gadjah Mada University with the ethical number KE/FK/0943/EC/2023.

SPSS software was used for statistical analysis (Version 20, Chicago, IL, USA). Univariate analysis was used to examine the data distribution between the groups; while bivariate analysis was employed to test the difference in nutritional status between the groups. The analysis utilized the independent t-test when the data were normally distributed and the Mann-Whitney U test when the data were not normally distributed. Multivariate analysis was applied to assess the effects of other variables, such as energy intake, compliance, incidence of illness, frequency of milk consumption, feeding practices, breastfeeding history, immunization history, and maternal self-efficacy, on the nutritional status indicators (HAZ, WAZ, WHZ). Multivariate analysis was performed using Generalized Estimating Equations regression.

Results

During the intervention, 2 participants from the NFR group and 3 participants from the FR group were dropped out. At study completion, 46 participants in the NFR group and 45 in the FR group were available for analysis. Two participants among those who dropped out due to diarrhea was an adverse event in this study (Figure 1). The characteristic of the participants and parents between NFR and FR groups were similar (Table 1). The number of boys was higher than the girls, with the majority of participants belonging to the 12-36 months age group. Regarding parental characteristics, most of parents (mothers and fathers) had completed senior high school, with 67.71% and 69.79%, respectively.

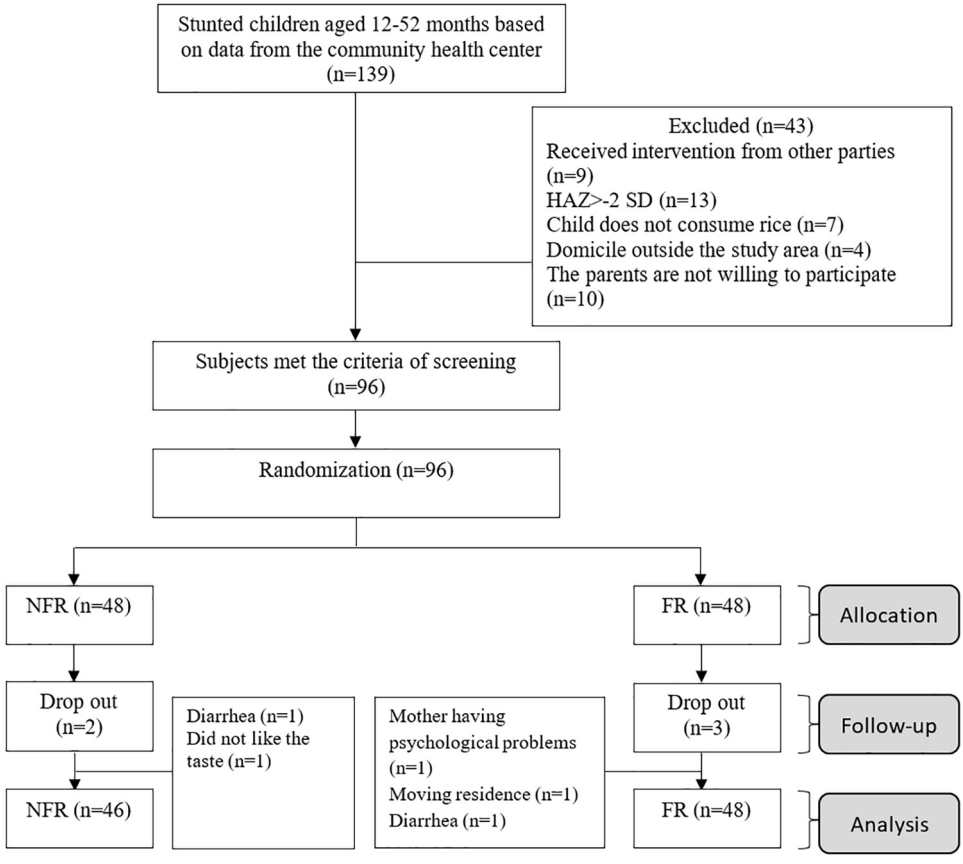

Figure 1: Study flow diagram. Fortified rice (FR), non-fortified rice (NFR), heigh-for age z-score (HAZ), number (n), standard deviation (SD).

The majority of fathers worked as laborers (52.08%) and mothers were housewives (81.25%). Economically, 51.04% of the participants came from families with low incomes, earning below the minimum wage of Sleman Regency in 2023, which was Dietary Reference Intake (IDR) 1,981,782.00 (Table 1).

The comparison between groups resulted in no significant differences in the pre-test and post-test values for all variables but the WHZ. The WHZ score of NFR group had higher values than the FR group and this difference remained after the intervention (p=0.02, Table 2). The delta values for all variables showed no significant differences between the groups (p>0.05). The change in weight for both groups was slightly greater in the FR group when compared to the NFR group (mean difference=0.13). The WAZ and HAZ decreased in both groups, but the FR group showed higher values compared to the NFR group (Table 2).

Nutrient intake analysis was categorized into two age groups according to Indonesian Recommended Dietary Allowance (Angka Kecukupan Gizi) as 1-3 years and 4-5 years. Nutrient intake was classified as deficit [<80% of the Recommended Dietary Allowances (RDAs)] or adequate (≥80% of the RDA). Among participants aged 1-3 years, significant differences in nutrient intake were observed between groups for vitamin B1, vitamin B6, and iron (Table 3), with the FR group showing superior intake. No significant differences were noted for other nutrients. Inadequate energy intake was observed in 57.14% of the NFR group and 70.97% of the FR group (Table 3). In participants aged 4-5 years, significant differences in nutrient intake between groups were found only for vitamin B1, vitamin B6, and zinc (Table 4). Participants in the FR group had better intake of vitamin B1, B6, and zinc compared to the NFR group. No differences were observed in other nutrients. In the FR group, the intake of fat, carbohydrates, vitamin B9, vitamin C, calcium, magnesium, and phosphorus were predominantly insufficient, while the intake of vitamins B1, B3, B6, B12, and zinc was adequate (Table 4).

Multivariate analysis showed that fortified rice had no significant effect on any outcome variables, except for the maternal self-efficacy variable. A stratified linear regression analysis was performed based on maternal self-efficacy (good vs. poor) and the age groups (1-3 years and 4-5 years). Tables 5 presents the linear regression models examining the effect of other variables such as energy intake, adherence to rice consumption, incidence of illness, frequency of milk consumption, feeding practices, exclusive

Table 1: Characteristics of children and parents.

Characteristics	NFR group (n=48) n (%)	FR group (n=48) n (%)	Total (n=96) n (%)	*P* value
Children Characteristics				
Age (months)				
12-36	29 (60.42)	25 (52.08)	54 (56.25)	0.413
37-59	19 (39.58)	23 (47.92)	42 (43.75)	
Gender				
Boy	28 (58.33)	29 (60.42)	57 (59.38)	0.836
Girl	20 (41.67)	19 (39.58)	39 (40.63)	
Parent's characteristics				
Father's educational level				
Elementary school	8 (16.67)	0 (0.00)	8 (8.33)	
Junior high school	5 (10.42)	8 (16.67)	13 (13.54)	0.217
Senior high school	30 (62.50)	35 (72.91)	65 (67.71)	
Diploma/Bachelor's degree	5 (10.42)	5 (10.42)	10 (10.42)	
Mother's educational level				
Elementary school	3 (6.25)	2 (4.17)	5 (5.21)	
Junior high school	9 (18.75)	4 (8.33)	13 (13.54)	0.098
Senior high school	32 (66.67)	35 (72.92)	67 (69.79)	
Diploma/Bachelor's degree	4 (8.33)	7 (14.58)	11 (11.46)	
Father's occupation				
Civil Servant/Soldier/Police	1 (2.08)	2 (4.17)	3 (3.13)	
Farmer	1 (2.08)	0 (0.00)	1 (1.04)	
Labor	24 (50.00)	26 (54.17)	50 (52.08)	0.721
Private employee	14 (29.17)	13 (27.08)	27 (28.13)	
Entrepreneur	6 (12.50)	4 (8.33)	10 (10.42)	
Teacher	1 (2.08)	1 (2.08)	2 (2.08)	
Other	1 (2.08)	2 (4.17)	3 (3.13)	
Mother's occupation				
Housewife	38 (79.17)	40 (83.33)	78 (81.25)	
Labor	3 (6.25)	1 (2.08)	4 (4.17)	0.690
Private employee	4 (8.33)	3 (6.25)	7 (7.29)	
Entrepreneur	1 (2.08)	1 (2.08)	2 (2.08)	
Teacher	2 (4.17)	3 (6.25)	5 (5.21)	
Family income				
<IDR 1,981,782	24 (50.00)	25 (52.08)	49 (51.04)	0.920
≥IDR 1,981,782	24 (50.00)	22 (45.83)	46 (47.92)	
Did not specify	0 (0.00)	1 (2.08)	1 (1.04)	

Dietary Reference Intake (IDR), fortified rice (FR), non-fortified rice (NFR).

breastfeeding history, and immunization history on nutritional status (HAS, WAS, WHZ). Table 5 shows that the consumption of fortified rice significantly improved the HAZ by 2.91 in stunted children aged 4-5 years with good maternal self-efficacy (p=0.003), but had no effect in the 1-3-year age group. For WAZ, the consumption of fortified rice significantly reduced the z-score by -2.364 in participants aged 4-5 years with good maternal self-efficacy (p<0.001). Fortified rice also significantly increased WHZ by 5.661 points in the same subgroup (p<0.0001).

This may be due to the better adherence to fortified rice consumption in the 4-5 year age group compared to the 1-3 years group. The variables that significantly influenced the increase in the HAZ coefficient included adequate energy intake, infrequent milk consumption, and good feeding practices. Factors associated with lower WAZ included incidence of illness, frequency of milk consumption, and history of exclusive breastfeeding. Energy intake, incidence of illness, frequency of milk consumption, and feeding practices also influenced WHZ (Table 5).

Discussion

The results of this study showed that the provision of fortified rice for 24 weeks did not have a statistically significant positive effect on the weight and height of stunted children less than five years old. Changes in nutritional status, as measured by height-for-age (HAZ), were indicated by an increase in the number of participants who experienced an improvement in nutritional status from stunted to normal, 10 participants in FR group and 7 participants in the NFR group.

Table 2: Weight, height, HAZ, WAZ, and WHZ, before and after the intervention.

Variable	NFR group (n=46)				FR group (n=45)				Mean diff	*p*-value
	Mean (Median)	SD	Min	Max	Mean (Median)	SD	Min	Max		
Weight (kg)										
Pre-test weight	10.43 (10.6)	1.31	6.3	13.3	10.25 (10.40)	1.20	7.5	12.6	-0.18	0.494[b]
Post-test weight	11.21 (11.5)	1.31	7	13.4	11.03 (11.1)	1.20	8.5	13.6	-0.18	0.146[d]
Δ weight	0.78 (0.75)	0.49	-0.6	1.7	0.78 (0.7)	0.45	-0.5	1.95	0.00	0.498[b]
Height (cm)										
Pre-test height	83.59 (85.2)	6.02	68.8	93.7	84.26 (85.5)	5.71	72	94.8	0.66	0.92[b]
Pos test height	87.73 (88.8)	5.56	74	97.6	88.53 (89.5)	5.30	76.8	99.5	0.80	0.243[b]
Δ height	4.14 (4.05)	1.14	1.6	7.4	4.27 (4)	1.86	0	9.7	0.13	0.852[d]
HAZ										
Pre-test HAZ	-2.89 (-2.35)	0.65	-4.73	–2.01	-2.83 (-2.75)	0.52	-4.17	-2.07	0.05	0.648[b]
Post-test HAZ	-2.69 (-2.70)	0.57	-4.40	-1.73	-2.57 (-2.58)	0.69	-4.1	-0.87	0.12	0.185[b]
Δ HAZ	0.20 (0.21)	0.28	-0.32	1.16	0.26(0.20)	0.47	-0.81	1.88	0.06	0.674[d]
WAZ										
Pre-test WAZ	-2.29 (-2.36)	0.65	-3.55	-0.66	-2.51 (-2.49)	0.51	-3.54	-1.16	-0.22	0.083[b]
Post-test WAZ	-2.30 (-2.34)	0.71	-3.81	-0.41	-2.50 (-2.48)	0.53	-3.72	-1.3	-0.20	0.932[b]
Δ WAZ	-0.01 (-0.01)	0.35	-0.81	0.79	0.01 (-0.04)	0.35	-0.91	1.02	0.006	0.409[b]
WHZ										
Pre-test WHZ	-0.97 (-1.04)	0.90	-2.62	1.47	-1.34 (-1.34)	0.68	-2.71	0.48	-0.37	0.029*[b]
Post-test WHZ	-1.1 (-1.08)	0.94	-2.88	1.86	-1.49 (-1.54)	0.71	-3.02	0.16	-0.39	0.028*[b]
Δ WHZ	-0.13 (-0.15)	0.51	-1.2	1.11	-0.15 (-0.15)	0.61	-1.65	1.39	-0.02	0.870[b]

Fortified rice (FR), non-fortified rice (NFR), heigh-for age z-score (HAZ), weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), [b]analysis using Independent t-test, [d]analysis using Mann-Whitney test, *statistically significant with 95% confidence level.

Table 3: Categories of nutrient intake during the study in subjects aged 1-3 years.

Nutrients	NFR group (n=35)		FR group (n=31)		*P* value[d]
	Deficit intake n (%)	Adequate intake n (%)	Deficit intake n (%)	Adequate intake n (%)	
Energy	20 (57.14)	15 (42.86)	22 (70.97)	9 (29.03)	0.248
Protein	0 (0)	35 (100)	0 (0)	31 (100)	.
Fat	17 (48.57)	18 (51.43)	19 (61.29)	12 (38.71)	0.304
Carbohydrates	19 (54.28)	16 (45.71)	24 (77.42)	7 (22.58)	0.051
Vitamin A	14 (40.00)	21 (60.00)	15 (48.39)	16 (51.61)	0.497
Vitamin B1	10 (28.57)	25 (71.43)	0 (0)	31 (100)	0.001*
Vitamin B3	1 (2.86)	34 (97.14)	3 (9.68)	28 (90.32)	0.250
Vitamin B6	12 (34.29)	23 (65.71)	1 (3.22)	30 (96.78)	0.002*
Vitamin B9	32 (91.43)	2 (8.57)	28 (90.32)	3 (19.68)	0.877
Vitamin B12	4 (11.43)	31 (88.57)	8 (25.81)	23 (74.19)	0.134
Vitamin C	28 (80.00)	7 (20.00)	27 (87.10)	4 (12.90)	0.444
Iron	26 (74.29)	9 (25.71)	12 (38.71)	19 (61.29)	0.004*
Zinc	2 (5.71)	33 (94.29)	1 (3.22)	30 (96.78)	0.631
Calcium	27 (77.14)	8 (22.86)	27 (87.10)	4 (12.90)	0.300
Magnesium	17 (48.57)	18 (51.43)	16 (51.61)	15 (48.39)	0.807
Phosphor	17 (48.57)	18 (51.43)	20 (64.52)	11 (35.48)	0.196

Fortified rice (FR), non-fortified rice (NFR), [d]analysis using Mann-Whitney, *statistically significant with a 95% confidence level.

However, this change in nutritional status was not caused by the effect of the fortified rice supplementation. A recent systematic review on the impact of food-based interventions on children's linear growth showed that food-based interventions did influence changes in stunting (HAZ) nutritional status. Still, it did not affect underweight (WAZ) or wasting (WHZ) status in children (17). However, other studies indicated that food-based interventions could address issues such as underweight (WAZ), wasting (WHZ), and overweight (BMI for age) in children (18, 19).

Table 4: Category of nutrient intake during the study in 4-5 years old subjects.

Nutrients	NFR group (n=11)		FR group (n=14)		*P* value[d]
	Deficit intake n (%)	Adequate intake N (%)	Deficit intake n (%)	Adequate intake N (%)	
Energy	4 (36.36)	7 (63.64)	8 (57.14)	6 (42.86)	0.312
Protein	0 (0)	11 (100)	0 (0)	14 (100)	.
Fat	7 (63.64)	4 (36.36)	11 (78.57)	3 (21.43)	0.419
Carbohydrates	5 (45.45)	6 (54.55)	8 (57.14)	6 (42.86)	0.569
Vitamin A	5 (45.45)	6 (54.55)	7 (50)	7 (50)	0.825
Vitamin B1	6 (54.55)	5 (45.45)	0 (0)	14 (100)	0.002*
Vitamin B3	2 (18.18)	9 (81.82)	1 (7.14)	13 (92.86)	0.409
Vitamin B6	5 (45.45)	6 (54.55)	0 (0)	14 (100)	0.006*
Vitamin B9	11 (100)	0 (0)	12 (85.71)	2 (14.29)	0.200
Vitamin B12	1 (9.09)	10 (90.91)	1 (7.14)	13 (92.86)	0.861
Vitamin C	11 (100)	0 (0)	14 (100)	0 (0)	.
Iron	10 (90.91)	1 (9.09)	8 (57.14)	6 (42.86)	0.067
Zinc	8 (72.73)	3 (27.27)	0 (0)	14 (100)	0.0001*
Calcium	11 (100)	0 (0)	14 (100)	0 (0)	.
Magnesium	9 (81.82)	2 (18.18)	12 (85.71)	2 (14.29)	0.796
Phosphor	9 (81.82)	2 (18.18)	8 (57.14)	6 (42.86)	0.198

Fortified rice (FR), non-fortified rice (NFR), [d]analysis using Mann-Whitney, *statistically significant with 95% confidence level.

The lack of impact of fortified rice consumption on nutritional status could have been caused by the low adherence to consumption guidelines. The low adherence in this study was attributed to several factors. First, the children's usual portion sizes were smaller than the portions recommended in the study, which resulted in the energy intake from rice reaching only 30% in the NFR group and 26% in the FR group. The recommended carbohydrate intake was 50-60% of the daily energy requirements (20). In addition to fortified rice, the children's intake was supplemented with other foods, such as milk and snacks. The second reason was that some children did not consume rice due to illness or long trips (e.g., traveling to their hometown). Participant-related factors, such as appetite, also played a role. Illnesses such as fever, cough, and colds reduced the children's appetite. In this study, the incidence of illness was more than twice as high in children aged 1-3 years compared to those aged 4-5 years. Moreover, nutrient loss during the washing and cooking processes could have reduced the contribution of the fortified rice to daily intake. It was shown that washing and cooking could reduce the nutritional value by 20-36% (21).

Various studies have discussed the relationship between stunting in children and the quality and quantity of food. Inadequate food intake, poor food quality such as low energy content, infrequent meals, low dietary diversity, and an imbalance in the consumption of animal and plant-based foods have been significantly associated with stunting (22-24). A study conducted in Egypt on 497 children aged 2-5 years found that 76.3% of the 19.1% stunted children had an energy intake that was insufficient to meet their needs (25). This finding was consistent with our study, where 71% of the participants in the 1-3 year age group experienced an energy deficit, which may have contributed to lower height growth compared to the participants in the 4-5 years age group.

Age-related factors could have influenced the outcomes of this study. This is related to developmental stages that affect children's eating behaviors. For example, participants aged 4-5 years had better adherence to rice consumption when compared to participants aged 1-3 years, as children aged 1-3 years were still transitioning from complementary feeding to family meals. Feeding difficulties in stunted toddlers, caused by exposure to media and ready-to-eat foods, led to food preferences, where children selectively ate foods, they liked and rejected those they did not. Children aged 1-3 years also tended to consume more formula milk and snacks, which were less nutritious when compared to main meals (12). This aligns with the theory of child development for 1-3 years old, who at this stage exhibited behaviors such as defiance, stubbornness, and a desire to act according to their own will, including selecting foods they preferred (26). In contrast, children aged 4-5 years, who were entering preschool age, showed rapid motor development, were more active, and were more exposed to new experiences, including food (27, 28).

In this study, the fortified rice intervention decreased the WAZ in all participants with good maternal self-efficacy. This decrease in WAZ was caused by weight gain that did not correspond to

Table 5: Linear regression analysis of other variables on HAZ, WAZ, in subjects with good maternal self-efficacy.

Independent Variable	HAZ				WAZ				WHZ			
	Coeffi-cient (B)	Standard error	*P* value	95% confidence interval	Coeffi-cient (B)	Standard error	*P* value	95% confidence interval	Coeffi-cient (B)	Standard error	*P* value	95% confidence interval
Subject aged 4-5 years												
Treatment												
NFR	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
FR	2.91	0.97	0.003*	1.02-4.81	-2.36	0.56	<0.001*	-3.46 - (-1.27)	5.66	0.30	<0.001*	5.08-6.24
Energy intake												
Deficit	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
Adequate	2.25	0.72	0.002*	0.84-3.65	-0.03	0.59	0.957	-1.18-1.12	-1.08	0.46	0.018*	-1983 - (-0.19)
Rice compliance rate												
<80%	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
≥80%	-1.278	0.74	0.085	-2.73-0.17	0.80	0.75	0.282	-0.66-2.27	-5.70	0.60	<0.001*	-6.88 - (-4.53)
Incidence of illness												
<2 times	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-5	-
≥2 times	2.748	0.70	<0.001*	1.37-4.12	2.75	0.70	<0.001*	1.37-4.12	2.69	0.33	<0.001*	2.03-3.33
Frequency of milk consumption												
Often	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
Sometimes	-1	0.00	<0,001*	-1 - (-1)	-1	0,00	<0.001*	-1- (-1)	-8.25	3.03E-007	<0.001*	-8.25- (-8.25)
Seldom	-	0	-	-	-	-	-	-	-	-	-	
Rarely	3.02	0.90	0.001*	1.25-4.78	3.01	0.63	<0.001*	1.77-4.26	7.65	0.50	<0.001*	- 6.67-8.63
Mother's feeding practice												
Poor	0[a]	-	-	-	0[a]	-	-	-s	0[a]	-	-	-
Good	-0.1579	0.702	0.025*	-2.96 -(- 0.20)	-5.12	0.39	<0.001*	-5.95 - (-4.35)	-2.32	0.33	<0.001*	-2.97 - (-1.67)
History of exclusive breastfeeding												
No	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
Yes	0.492	0.418	0.24	-0.33-1.31	2.03	0.41	<0.001*	1.22-2.84	-0.80	0.50	0.108	-1.78-0.18

Immunization												
No	-	-	-	-	-	-	-	-	-	-	-	-
Yes	0	-	-	-	0	-	-	-	0	-	-	-
Subject aged 1-3 years												
Treatment												
NFR	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
FR	0.47	0.27	0.085	-0.07-1.01	-0.33	0.38	0.386	-1.08-0.42	-0.69	0.74	0.356	-2.15-0.77
Energy intake												
Deficit	0[a]	-	0	-	0[a]	-	0	-	0[a]	-	-	-
Adequate	0.22	-0.20	0.278	-0.17-0.61	-0.38	0.39	0.325	-1.14-0.38	-0.50	0.91	0.584	-2.27-1.28
Rice compliance rate												
<80%	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
≥80%	0.37	0.72	0.639	-1.07-1.74	0.6	0.61	0.295	-0.56-1.89	0.55	0.76	0.470	-0.94-2.04
Incidence of illness												
<2 times	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
≥2 times	0.15	0.23	0.537	-0.31-0.6	0.25	0.39	0.521	-0.51-1.01	0.49	0.64	0.446	-0.77-1.74
Frequency of milk consumption												
Often	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
Sometimes	-0.15	0.30	0.612	-0.74-0.43	-0.18	0.35	0.601	-0.88-0.51	-0.259	0.62	0.674	-1.47-0.95
Seldom	0.82	0.64	0.201	-0.44-2.08	0.30	1.25	0.810 0.347	-2.16-2.76	-0.787	2.32	0.734	-5.33-3.76
Rarely	0.30	1.02	0.768	-1.69-2.29	-0.91	0.97		-2.82-0.99	-0.531	1.66	0.749	-3.78-2.72
Mother's feeding practice												
Poor	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
Good	-0.05	0.29	0.868	-0.62-0.52	-0.11	0.38	0.765	-0.85-0.63	-0.11	0.69	0.879	-1.45-1.24
History of exclusive breastfeeding												
No	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
Yes	0.45	0.49	0.359	-0.52-1.42	0.30	0.56	0.578	-0.78 - 1.40	-0.24	1.40	0.857	-2.80-2.33
Immunization												
No	0[a]	-	-	-	0[a]	-	-	-	0[a]	-	-	-
Yes	0.40	0.36	0.266	-0.31-1.12	0.22	0.66	0.734	-1.06 - 1.51	-0.29	0.81	0.724	-1.88-1.30

Fortified rice (FR), non-fortified rice (NFR), heigh-for age z-score (HAZ), weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), Statistical analysis using Generalized Estimating Equations. HAZ: subject aged 4-5 years old: Score (QIC)[b]=717.38; Score (QICC)[b]=240.68 ; subject aged 1-3 years old: Score (QIC)[b]=285.21; Score (QICC)[b]=153.4. WAZ: subject aged 4-5 years old: Score (QIC)[b]=1318.739; Score (QICC)[b]=457.129; subject aged 1-3 years old: Score (QIC)[b]=351.602; Score (QICC)[b]=132.566. WHZ: subject aged 4-5 years old: Score (QIC)[b]=874.976; Score (QICC)[b]=428.976; subject aged 1-3 years old: Score (QIC)[b]=677.086; Score (QICC)[b]=171.714.

the children's age. Based on growth curves, children aged 1-5 years typically experienced a weight gain of 1 to 1.5 kg over 6 months; however, as the children's age increased, the rate of weight gain became smaller. In contrast, in our study, the weight gain was very small; only 0.78 kg in both NFR and FR groups. Furthermore, some participants even experienced a weight loss of up to 0.5 kg. The small weight changes could have been due to insufficient energy, carbohydrate, and fat intake in the majority of the participants. Macronutrients, particularly energy, carbohydrates, fats, and proteins, are crucial for weight gain in children under 5 years of age. Increased intake of starch, added sugars, and total glucose have been linked to greater weight gain (29).

Further analysis was conducted by stratifying participants based on age and maternal self-efficacy, considering other factors that might have influenced the results through multivariate analysis. The participants were stratified into two age groups of 1-3 years and 4-5 years, following the Recommended Nutrient Intake guidelines from the Ministry of Health, Republic of Indonesia. Self-efficacy was defined as an individual's belief in their ability to perform a task (30). By considering the result of further analysis, it was found that fortified rice consumption had a positive impact on improving HAZ and WHZ scores, but not on WAZ scores, in children aged 4-5 years with good maternal self-efficacy. This indicates that both age and maternal self-efficacy were related to the intervention provided. In our study, self-efficacy referred to a mother's confidence in her ability to practice child feeding, such as seeking information and learning about appropriate feeding practices, providing the best food, and addressing feeding problems. Several studies have shown that maternal self-efficacy can influence child-feeding practices, such as improving breastfeeding quality, making children's diets healthier, increasing food variety, and improving responsive feeding (31, 32).

The findings of our study indicated that having more than two episodes of illness could improve HAZ, WAZ, and WHZ. The children in the age group fell within a stage of rapid growth and development, so even when sick, if they still had energy and nutritional reserves in the form of fat and muscle tissue, the body could use these reserves to support growth (33). Children less than 5 years old have also continued to produce growth hormones, although in smaller amounts when compared to periods of health status. Additionally, acute illnesses such as fever and diarrhea could indeed affect growth in the short term. However, once children younger than 5 years old have recovered from the acute phase of illness, they would enter a catch-up growth phase, provided that they received adequate nutrition (34).

Adequate energy intake was found to be linearly associated with improvements in HAZ score of stunted children aged 4-5 years with good maternal self-efficacy. This indicates that sufficient energy intake plays a critical role in promoting height growth in children less than 5 years old. Energy is crucial for growth as it supports metabolism, maintains vital organ functions, and contributes to the production of growth hormones. Furthermore, energy helps in protein synthesis, which is a key component in bone growth for height development (35). Restricting energy and protein intake in children less than 5 years old has been shown to decrease level of insulin-like growth factor 1 (IGF-1), which is essential for promoting growth during early childhood (36). Additionally, essential amino acids from protein are particularly needed during growth because they help repair damaged body tissues, build and regulate body systems, and contribute to the formation of serum, hemoglobin, enzymes, hormones, antibodies, and other critical components, while also assisting in overall bodily regulation (37).

Our study revealed a decrease in WAZ and WHZ scores in stunted children aged 4-5 years with adequate energy intake. This result is contrary to the findings for the HAZ score as this decrease was likely due to monthly increases in weight and height that were insufficient in relation to the child's age, which could result in a lower z-score. Additionally, there is a possibility that the food composition contributing to energy intake was of low quality, leading to unmet nutritional needs. For example, children under 5 years of age who frequently consumed snacks such as extruded snacks or sweets may have a high-calorie intake. However, these snacks or sweets did not provide other essential nutrients, thus failing to support healthy weight gain (38).

Good feeding practices reduced the z-score coefficients -1.256 for HAZ, -5.122 for WAZ, and -2.321 for WHZ variables in participants aged 4-5 years and were statistically significant. The same results were also obtained at the age of 1-3 years; but were not statistically significant. These findings contradict the idea that good feeding practices will lower the z-score. The questions explored relation to mothers' feeding practices for their children. These practices are also related to the mother's level of knowledge of good food and good feeding practices. There are times when mothers who have provided good feeding practices; but children under 5 years of age refused to eat. This is because children less than 5 years old who experienced stunting and weight problems had eating habits that followed

their mood or eat according to their wishes. So what was consumed could affect their nutritional status (39). When associated with the results of recalling children under 5 years old intake, there are still many who experienced energy deficits, as much as 59.34% of the total participants. This indicates that even though mothers felt that their feeding practices were good, it could be that these practices were not fully accepted by children younger than 5 years old. So the nutritional status of children did not change for a better status.

Children less than five years old with very infrequent milk drinking frequency significantly increased Z scores for HAZ, WAZ, and WHZ among participants aged 4-5 years with good maternal efficacy. The rare frequency of drinking milk in children, where consumption was weekly or monthly, increased children younger than 5 years old's food intake from foods other than milk. If children younger than five years old were given milk when approaching the main meal, usually they would refuse to eat because they still felt full. Conversely, if they did not drink milk, the desire for main meals increased. This may have caused an increase in the z-score in children with an infrequent milk-drinking frequency category. Mothers' lack of awareness of proper feeding rules, for example when to give the main meal and when to give formula, can cause obstacles in children. Some gave milk as a substitute for main meals and let children continue to eat their favorite fast food (40). This may be the reason why the category of milk consumption as 2-4 times a week could reduce the value of WHZ score coefficient in our study. The limitation of this study was the low compliance of rice in both groups, which led to energy deficits in most participants, especially those aged 1-3 years. As a result, the effect of the intervention could not be observed. Other variables, such as child hygiene and sanitation, can be assessed as factors that may influence stunting in children.

Conclusion

Intervention of fortified rice for 24 weeks did not affect the nutritional status based on HAZ, WAZ, and WHZ scores of stunted children less than five years old. Fortified rice consumption improved HAZ and WHZ scores only in stunted children aged 4-5 years with good maternal self-efficacy. Further research recommendations should focus on ensuring better compliance with rice consumption with a minimum target of 80% to fulfill nutrition needs. It is also important to ensure that energy intake and other nutrients, especially carbohydrates and fats, fulfill the nutrition requirements. A potential strategy to complement fortified rice consumption with balanced nutrition principles, along with active assistance for mothers, can be implemented in the future. This could include assistance in preparing a nutritious meal for children and counseling to motivate mothers to overcome challenges in feeding practice, such as choosing quality food options.

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Authors' Contribution

S.H. drafted the research design. S.H. and L.A.L supervised the research process and validated the research data. L.A., H.D., and U.K. managed the administration, conducted data collection, and analyzed the research data. S.H., and L.A.L., wrote the manuscript assisted by L.A., H.D., and U.K. S.M.M.H., A., D.A., E.C., I.R.A., A.P., E.M., and C.G.M supervised the project. All authors discussed the results and contributed to the preparation of the manuscript.

Conflict of Interest

The authors have no conflict of interest.

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