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Effect of moringa oleifera leaf powder and egg supplementation on weight gain and hemoglobinin undernourished children aged 36-59 months

Pengaruh pemberian serbuk daun kelor (moringa oleifera) terhadap peningkatan berat badan dan kadar hemoglobin pada balita gizi kurang usia 36-59 bulan

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Abstract

Malnutrition and anemia remain major public health challenges among children under the age of five, adversely affecting their growth and overall health. In East Nusa Tenggara Province, particularly in South Central Timor, these conditions are prevalent. *Moringa oleifera* leaves are rich in protein, iron, and essential micronutrients, suggesting their potential as a local food-based intervention. This study aimed to evaluate the effect of Moringa leaf powder combined with egg consumption on weight gain and hemoglobin levels in undernourished children aged 36–59 months at the Batuputih Health Center, South Central Timor, from March to May 2025. A quasi-experimental pre–post test with a control group design was conducted with 40 children, divided equally into an intervention group (15 g/day moringa leaf powder + 1 egg) and a control group (1 egg) for 60 days. Paired and independent t-tests were used, with significance set at p<0.05. The results demonstrated significant weight gain in both groups (p<0.001), with a greater increase in the intervention group (p=0.001). Height and hemoglobin levels increased within groups (p=0.596; p=0.225) but did not differ significantly between the groups. In conclusion, daily supplementation with Moringa leaf powder and eggs for 60 days effectively enhanced body weight but did not significantly affect height or hemoglobin levels in undernourished children.

Keywords: Hemoglobin, malnutrition, moringa oleifera, pre school children, weight gain

Abstrak

Malnutrisi dan anemia masih menjadi masalah gizi utama pada anak usia di bawah lima tahun, yang berdampak negatif pada pertumbuhan dan kesehatan secara keseluruhan. Di Provinsi Nusa Tenggara Timur, khususnya di Timor Tengah Selatan, kedua kondisi ini masih sangat prevalen. Daun *Moringa oleifera* kaya akan protein, zat besi, dan mikronutrien penting, sehingga berpotensi sebagai intervensi berbasis pangan lokal. Penelitian ini bertujuan untuk menilai pengaruh bubuk daun kelor yang dikombinasikan dengan konsumsi telur terhadap peningkatan berat badan dan kadar hemoglobin pada anak kurang gizi usia 36–59 bulan di Puskesmas Batuputih, Timor Tengah Selatan, selama Maret hingga Mei 2025. Penelitian ini menggunakan desain kuasi-eksperimental pre–post test dengan kelompok kontrol, melibatkan 40 anak yang dibagi sama rata ke dalam kelompok intervensi (15 g/hari bubuk daun kelor + 1 telur) dan kelompok kontrol (1 telur) selama 60 hari. Analisis menggunakan uji t berpasangan dan uji t independen dengan signifikansi p<0,05. Hasil menunjukkan peningkatan berat badan yang signifikan pada kedua kelompok (p<0,001), dengan kenaikan lebih tinggi pada kelompok intervensi (p=0,001). Tinggi badan dan kadar hemoglobin meningkat dalam kelompok masing-masing (p=0,596; p=0,225) tetapi tidak berbeda signifikan antar kelompok. Kesimpulannya, suplementasi harian bubuk daun kelor dan telur selama 60 hari efektif meningkatkan berat badan, tetapi tidak memengaruhi tinggi badan maupun kadar hemoglobin pada anak kurang gizi.

Kata Kunci: Anak prasekolah, hemoglobin, malnutrisi, moringa oleifera, peningkatan berat badan,

Introduction

Malnutrition and anemia remain major global public health challenges, particularly among children under five years of age. According to the World Health Organization (WHO), the global prevalence of undernutrition and wasting in 2024 reached 23.2% among children under five years of age, while the prevalence of anemia in the same age group was approximately 40% (World Health Organization, 2025). In Indonesia, the 2018 Basic Health Research (Riskesdas, 2018) reported a prevalence of 17.7% for underweight and severely underweight children, with East Nusa Tenggara (NTT) Province ranking the highest at 29.5%. Furthermore, the 2017 NTT Provincial Health Profile reported that the Timor Tengah Selatan (TTS) District had the highest number of undernutrition cases, totaling 58 (TTS District Health Office Report, 2024). These data indicate that nutritional problems remain a serious concern in Eastern Indonesia (Kemenkes RI, 2022; SSGBI, 2022; UNICEF, 2023).

Children under five years of age are particularly vulnerable to nutritional deficiencies because their high nutrient requirements are often unmet. Undernourished children are defined as those whose weight-for-age (WAZ) falls between −2 and −3 SD z-scores (Kemenkes RI, 2019; UNICEF Indonesia, 2023; World Health Organization, 2009). This condition increases the risk of recurrent infection, growth retardation, and iron deficiency anemia.

One promising intervention is the use of *Moringa oleifera* (moringa) leaves. Moringa leaves are rich in iron, protein, vitamin A, vitamin C, and various micronutrients and bioactive compounds, such as flavonoids and polyphenols, which support iron absorption and hematopoiesis (Al Rahmad, 2023; Fauziah & Khairun, 2022; Kemenkes RI, 2019; Sri Almatsier, 2019). Its comprehensive nutrient profile, including nine essential amino acids, calcium, magnesium, potassium, zinc, and vitamins A, C, E, and B complex, makes moringa an excellent candidate for complementary food supplementation in young children (Haque et al., 2022).

Several studies have demonstrated the effectiveness of Moringa supplementation. Recent systematic reviews and meta-analyses have confirmed that *Moringa oleifera* supplementation significantly improves nutritional status indicators, including body weight and hemoglobin levels, particularly among undernourished children (Brar et al., 2022). Research in Indonesia has reported that moringa leaf powder–based products, such as cookies, can improve body weight, nutritional status, and hemoglobin levels in undernourished children (Boateng et al., 2019). Similarly, studies in Ghana found that complementary foods fortified with moringa leaf powder improved growth and hemoglobin levels in infants (Malla et al., 2022), whereas six-month supplementation with moringa leaf powder in Tanzania significantly reduced anemia prevalence (Yadav et al., 2022).

However, research examining the combined effects of moringa leaf powder and a simple animal protein source, such as chicken eggs, on body weight and hemoglobin levels in undernourished children aged 36–59 months remains limited, particularly in the NTT Province. This combined plant-animal protein approach is relevant for children in this critical growth period with high nutritional demands but remains underexplored in resource-limited settings, such as eastern Indonesia. Therefore, this study aimed to determine the effect of moringa leaf powder combined with eggs on body weight and hemoglobin levels in undernourished children in the working area of Batuputih Public Health Center, Timor Tengah Selatan District. Unlike previous local studies focusing solely on moringa-based foods, this study uniquely evaluated the combined effect of plant-based (*Moringa oleifera*) and animal-based (egg) protein supplementation on both anthropometric and hemoglobin outcomes in undernourished preschool children.

Methods

This study employed a quasi-experimental design with a pre–post test and a control group, conducted in the working area of Batuputih Public Health Center, Timor Tengah Selatan District, East Nusa Tenggara Province, from May to July 2025. The study sample comprised 40 undernourished children aged 36–59 months, selected through purposive sampling and divided into two groups: 20 children in the intervention group and 20 in the control group. Group allocation was based on baseline eligibility criteria, with participants assigned to the intervention or control groups prior to outcome assessment. All participants completed the study protocol according to the predefined intervention scheme.

The inclusion criteria were as follows: children residing in the Batuputih Public Health Center area, free from chronic diseases or congenital disorders, and whose parents or guardians provided written informed consent. Children who developed acute illnesses during the study, had edema, or had a history of egg allergy were excluded from the study. Sample size calculation using the Lemeshow formula yielded a minimum of 17 participants per group, which was increased by 20% to account for potential dropouts. This adjustment aligns with common methodological practices in community-based intervention studies to maintain sufficient statistical power, despite participant attrition.

The intervention group received 15 g of *Moringa oleifera* leaf powder per day combined with one chicken egg, whereas the control group received one egg per day without Moringa powder. The intervention lasted for 60 consecutive days and was accompanied by basic nutritional counseling for the parents.

Moringa oleifera leaf powder was chosen for its high protein, vitamin, and mineral content, particularly iron, calcium, zinc, and vitamin A, which are crucial for growth and hemoglobin synthesis. Moringa is locally available, inexpensive, and easy to process, and has documented potential as a nutritional intervention in various studies. The nutrient composition of the Moringa leaves is presented in Table 1.

Table 1. Nutrient composition of fresh, dried, and powdered moringa leaves (per 100 g) (Sokhela et al., 2023b; Sokhela et al., 2023a).

Nutrient	Fresh Leaves	Dried Leaves	Leaf Powder
Energy (kcal)	92.0	329.0	205.0
Protein (g)	6.7	29.4	27.1
Fat (g)	1.7	5.2	2.3
Carbohydrate (g)	12.5	41.2	38.2
Fiber (g)	0.9	12.5	19.2
Vitamin B1 (mg)	0.06	2.02	2.64
Vitamin B2 (mg)	0.05	21.3	20.5
Vitamin B3 (mg)	0.8	7.6	8.2
Vitamin C (mg)	220.0	15.8	17.3
Vitamin E (mg)	448.0	10.8	113.0
Magnesium (mg)	42.0	448.0	368.0
Phosphorus (mg)	70.0	252.0	204.0
Potassium (mg)	259.0	1236.0	1324.0
Copper (mg)	0.07	0.49	0.57
Iron (mg)	0.85	25.6	28.3
Sulfur (mg)	-	-	870.0

Eggs were selected as a high-quality animal protein source, rich in iron, vitamin B12, folate, and choline, which are essential for hemoglobin synthesis and tissue development. The combination of moringa leaf powder and eggs was expected to provide a synergistic effect between plant- and animal-based proteins and enhance the bioavailability of iron. The 60-day intervention period was considered sufficient to detect changes in body weight and hemoglobin levels as early indicators of nutritional improvement while ensuring participant compliance.

Anthropometric measurements were performed at the beginning and end of the study period. Body weight was measured using a calibrated digital scale, height was assessed using a microtoise, and hemoglobin levels were analyzed at a hospital laboratory in Kupang City, following standard procedures. No blinding was applied, as both intervention and outcome assessments were conducted in a community-based setting, and the assessors were aware of the group allocation.

Dietary intake was monitored using the 24-hour recall method, which was conducted five times on the first day of the study, every two weeks, and on the final day of the intervention. To enhance data reliability, dietary recalls were repeatedly administered by trained personnel using a standardized interview procedure.

Data analysis began with univariate descriptive statistics to summarize the participants' characteristics, followed by the Shapiro–Wilk test to assess normality. Paired t-tests were used to analyze within-group differences before and after the intervention, and independent t-tests were used for between-group comparisons. Although one hemoglobin measurement before the intervention in the intervention group showed a non-normal distribution according to the Shapiro–Wilk test, parametric tests were applied because most variables met the normality assumption.

This study was approved by the Health Research Ethics Committee of the Faculty of Medicine, Diponegoro University (approval number 084/EC/KEPK/FK-UNDIP/IV/2025).

Result and Discussion

The Shapiro–Wilk test was used to assess the normality of the data. The results showed that most variables, including body weight, height, and hemoglobin level, were normally distributed ($p > 0.05$) in both groups, except for the hemoglobin level before the intervention in the intervention group ($p = 0.020$). As the majority of the data met the normality assumption, parametric tests (paired and independent *t*-tests) were applied for further analysis.

Table 2. Results of normality test (Shapiro–Wilk)

Variable	Group	p-value	Interpretation
Body weight (pre)	Control	0.638	Normal
	Intervention	0.837	Normal
Body weight (post)	Control	0.080	Normal
	Intervention	0.889	Normal
Height (pre)	Control	0.752	Normal
	Intervention	0.656	Normal
Height (post)	Control	0.599	Normal
	Intervention	0.782	Normal
Hemoglobin (pre)	Control	0.643	Normal
	Intervention	0.020	Not normal
Hemoglobin (post)	Control	0.405	Normal
	Intervention	0.692	Normal

Based on the normality test results, the data were normally distributed. Therefore, further analyses were conducted using parametric tests. The following table presents the characteristics of the study participants in both the control and intervention groups.

Table 3. Characteristics of study subjects

Variables	Control (n=20)	Intervention (n=20)	Total (n=40)
Age (months)	45.15 ± 5.8	46.90 ± 5.9	46.03 ± 5.8
Sex			
Female	12 (60.0%)	9 (45.0%)	21 (52.5%)
Male	8 (40.0%)	11 (55.0%)	19 (47.5%)
Parents' Occupation			
Farmer	11 (55.0%)	12 (60.0%)	23 (57.5%)
Trader	2 (10.0%)	2 (10.0%)	4 (10.0%)
Employee	2 (10.0%)	2 (10.0%)	4 (10.0%)
Craftsman	3 (15.0%)	2 (10.0%)	5 (12.5%)
Fisherman	2 (10.0%)	1 (5.0%)	3 (7.5%)
Laborer	0	1 (5.0%)	1 (2.5%)

Parents' Education			
Completed primary school	7 (35.0%)	8 (40.0%)	15 (37.5%)
Completed junior high school	8 (40.0%)	9 (45.0%)	17 (42.5%)
Completed senior high school	3 (15.0%)	3 (15.0%)	6 (15.0%)
Did not complete primary school	2 (10.0%)	0	2 (5.0%)
Immunization			
Complete	20 (100%)	20 (100%)	40 (100%)
Incomplete	0	0	0
Exclusive Breastfeeding			
Complete	20 (100%)	20 (100%)	40 (100%)
Incomplete	0	0	0
Type of House			
Temporary	5 (25.0%)	0	5 (12.5%)
Semi-permanent	12 (60.0%)	10 (50.0%)	22 (55.0%)
Permanent	3 (15.0%)	10 (50.0%)	13 (32.5%)
Family Income			
< Rp 1 million	15 (75.0%)	12 (60.0%)	27 (67.5%)
> Rp 1 million	5 (25.0%)	8 (40.0%)	13 (32.5%)

The characteristics of the study participants in both the control and intervention groups are shown in Table 3. The mean age of the children was 46.03 ± 5.8 months, with a relatively balanced distribution between the control (45.15 ± 5.8 months) and intervention groups (46.90 ± 5.9 months). Age homogeneity is crucial in nutrition research because energy, protein, and micronutrient requirements are strongly influenced by the child's developmental stage. At the preschool age, children experience rapid growth and high metabolic demands; therefore, maintaining comparable age ranges between groups helps minimize potential bias in response to the intervention (World Health Organization, 2009).

The sex distribution was also relatively balanced, with 52.5% females and 47.5% males in the sample. This indicates that sex dominance is unlikely to have influenced the study outcomes. Although nutritional needs differ slightly between boys and girls, these differences are not substantial at ages 3–5 years, allowing sex to be considered a controlled variable (Kemenkes RI, 2019).

Regarding parental education, most parents had a basic educational background: 42.5% completed junior high school, 37.5% completed primary school, and 5% did not complete primary schooling. Parental education is closely related to nutrition-related parenting practices, knowledge of food selection and compliance with intervention protocols. Low educational levels may increase the risk of undernutrition, as limited knowledge often affects the quality of children's diet (Fauziah & Khairun, 2022). These findings align with international studies that have reported significant associations between maternal education and child nutritional status (Abuya et al., 2012; Al Rahmad & Shavira, 2024; Rezaeizadeh et al., 2024a; Aslam & Kingdon, 2012; Ijaiya et al., 2024; Prasetyo et al., 2023; Rezaeizadeh et al., 2024b).

Most parents were farmers (57.5%), reflecting the agrarian context of the Timor Tengah Selatan region. Moringa is a locally abundant crop, making it suitable for food-based nutritional intervention. Other occupations included laborers, traders, craftsmen, and fishermen, in smaller proportions. Economically, half of the families earned less than Rp 1,000,000 per month, indicating limited purchasing power to meet their nutritional needs. This underscores the importance of using affordable, nutrient-dense local foods, such as moringa leaf powder, to improve nutritional status, which has been shown to increase body weight and height in under five years undernourished children (Veterini et al., 2023).

Regarding basic child health, all participants had complete immunization records and a 100% history of exclusive breast feeding. This suggests that the observed undernutrition was more likely due to inadequate dietary quality and quantity rather than poor immunization or infant feeding practices. Regarding the living environment, most families lived in semi-permanent houses (55%), followed by permanent (32.5%) and temporary houses (12.5%). Housing conditions may influence sanitation, infection risk, and overall child health; however, the relatively balanced distribution between the groups indicates minimal environmental bias.

Overall, the baseline characteristics of the study participants were homogeneous between the two groups. The comparability of age, sex, parental education, occupation, economic status, immunization, breastfeeding, and housing conditions strengthens the study's methodological validity. Such homogeneity ensured that the observed effects could be confidently attributed to the combination of MLP and egg supplementation. Therefore, differences observed in subsequent results, particularly weight gain, can be interpreted as intervention effects, while changes in linear growth and hemoglobin levels are discussed in the following sections (Boateng et al., 2019).

Table 4. Changes in body weight, height, and hemoglobin of children before and after intervention

Variables		Control Group (n = 20)	Intervention Group (n = 20)	p-value
Body Weight (kg)	Before	11.47 ± 0.81	11.89 ± 0.76	0.102
	After	11.88 ± 0.72	12.74 ± 0.75	0.001
	p-value	p = 0.000	p = 0.000	
Height (cm)	Before	93.50 ± 3.03	93.06 ± 3.93	0.694
	After	94.50 ± 3.63	93.88 ± 3.76	0.596
	p-value	p = 0.000	p = 0.000	
Hemoglobin (g/dl)	Before	10.48 ± 0.54	10.30 ± 0,57	0.288
	After	11.33 ± 0.70	11.07 ± 0.63	0.225
	p-value	p = 0.000	p = 0.000	

The changes in body weight, height, and hemoglobin levels before and after the intervention are presented in Table 4. Overall, the measurements demonstrated an upward trend in body weight in both groups, with a more pronounced increase observed in the intervention group over the 60-day period.

Paired t-test analysis showed that both groups experienced significant increases in body weight, height, and hemoglobin levels after the intervention ($p < 0.001$). In the control group, the mean body weight increased from 11.47 ± 0.81 kg to 11.88 ± 0.72 kg, whereas in the intervention group, it increased from 11.89 ± 0.76 kg to 12.74 ± 0.75 kg. Height increased significantly within each group, from 93.50 ± 3.03 cm to 94.50 ± 3.63 cm in the control group and from 93.06 ± 3.93 cm to 93.88 ± 3.76 cm in the intervention group. Hemoglobin levels also increased significantly, from 10.48 ± 0.54 g/dL to 11.33 ± 0.70 g/dL in the control group and from 10.30 ± 0.57 g/dL to 11.07 ± 0.63 g/dL in the intervention group. The magnitude of body weight increase was greater in the intervention group, indicating a meaningful effect of the intervention, whereas changes in height and hemoglobin levels were comparable between the groups.

Independent t-test analysis of baseline data showed no significant differences between the control and intervention groups for any of the variables (body weight: p= 0.102; height: p= 0.694; hemoglobin: p= 0.288), indicating homogeneity at baseline. After the intervention, significant differences were observed only in body weight (p = 0.001), whereas height (p= 0.596) and hemoglobin levels (p= 0.225) remained statistically similar between the groups. This indicates that the intervention effectively increased body weight but not linear growth or hemoglobin levels. Clinically and from a public health perspective, the observed weight gain among undernourished children reflects a short-term improvement in nutritional status, which is a primary goal of community-based interventions. In contrast, meaningful changes in height and hemoglobin levels typically require longer intervention periods.

Physiologically, *Moringa oleifera* leaves are rich in high-quality proteins, essential amino acids, iron, vitamin A, vitamin C, calcium, and zinc, which are critical for energy metabolism and tissue growth (Hanif & Berawi, 2022). This nutrient profile explains the greater weight gain observed in the intervention group. These findings align with those of previous studies showing that moringa-based biscuits significantly improve body weight in undernourished children (Veterini et al., 2023). Similarly, research in Ghana demonstrated that complementary foods fortified with moringa leaf powder improved infant growth in terms of weight and overall nutritional status (Boateng et al., 2019).

Moringa oleifera leaves also contain proteins, nine essential amino acids, calcium, phosphorus, and zinc, which are important for bone tissue formation and ossification (Sri Almatsier, 2019). Theoretically, these components support the linear growth of children. However, height gain in children aged 3–5 years occurs relatively slowly, with an average increase of 6–8 cm per year or approximately 0.5–0.7 cm per month (World Health Organization, 2006, 2009). Therefore, meaningful changes in height generally require monitoring for at least three months. Additionally, linear growth is influenced by genetics, growth hormones, and recurrent infection. Other nutritional intervention studies have also shown that improvements in children's nutritional status are often more quickly reflected in weight gain, whereas linear growth requires a longer intervention period (Shija et al., 2019; Shija et al., 2019). This explains why, despite the nutrient-rich composition of Moringa, this study did not find a significant difference in height between the groups.

Moringa oleifera has the potential to increase hemoglobin levels because of its high non-heme iron content (±28 mg/100 g powder), vitamin A, which mobilizes iron stores, and vitamin C, which enhances iron absorption (Irwan, 2020; Dhaniar Mudita et al., 2021; Sokhela et al., 2023; Zaki Irwan, 2020). However, non-heme iron has a lower bioavailability than heme iron from animal sources. For children aged 3–5 years, normal hemoglobin levels according to the WHO are ≥11 g/dL, and a clinically meaningful increase from nutritional interventions is typically around 0.5–1 g/dL within 2–3 months, depending on the initial anemia status (World Health Organization, 2025).

In this study, although there was a trend of increasing hemoglobin levels in both groups, no significant differences were observed between them. This suggests that daily egg consumption, which provides heme iron, vitamin B12, and folate, contributed substantially to the improvement of anemia, whereas the addition of moringa did not produce an optimal effect due to the limited bioavailability of non-heme iron (Angela E. Shija et al., 2019; Sokhela et al., 2023a). The absorption of non-heme iron is influenced by dietary enhancers and inhibitors, as well as the individual iron status. This limited bioavailability may explain why hemoglobin levels increased in both groups but did not differ significantly between the intervention and control groups.

Overall, the study findings confirmed that moringa supplementation had a more pronounced effect on body weight than on height or hemoglobin levels. Proteins and essential amino acids from Moringa are rapidly utilized for enzyme and hormone synthesis and muscle tissue formation, resulting in faster changes in body weight (Kumar et al., 2025). Linear growth depends on bone ossification, which is regulated by growth hormone (GH) and insulin-like growth factor-1 (IGF-1), and requires minerals such as calcium, phosphorus, and zinc over a longer period (Wong et al., 2016; Inzaghi et al., 2022). Hemoglobin synthesis involves the hematopoietic pathway in the bone marrow, where non-heme iron from moringa must undergo reduction and transport, assisted by vitamin C and vitamin A, to mobilize iron from stores (Warner, 2025; Loganathan et al., 2023; Yani et al., 2023). This process is complex and is influenced by body iron stores, infection status, and iron bioavailability. Therefore, while moringa nutrients support linear growth and hemoglobin formation, the primary measurable effect within the 60-day intervention was on body weight, whereas height and hemoglobin levels did not differ significantly between groups (World Health Organization, 2025).

Several limitations of this study should be noted. The 60-day intervention may have been insufficient to capture the long-term effects on linear growth and sustained hemoglobin improvement. The relatively small sample size may have limited the statistical power to detect between-group differences in height and hemoglobin. Additionally, dietary intake outside the intervention was not fully controlled, which could have introduced bias.

Future studies should investigate moringa-based interventions over longer periods (at least 3–6 months) to better evaluate their effects on linear growth and hemoglobin levels. Combining moringa leaf powder with animal-source foods may produce synergistic effects on growth and anemia improvement by enhancing nutrient adequacy and iron bioavailability in the body. Larger sample sizes and the assessment of biochemical iron status markers are recommended to improve the rigor of the study and strengthen causal inference.

Conclusion

Daily supplementation of *Moringa oleifera* leaf powder combined with egg consumption for 60 days effectively increased body weight among undernourished children aged 36–59 months. However, no significant effects were observed on height or hemoglobin levels. These findings indicate that the intervention effectively improves short-term nutritional status, particularly weight gain, but is insufficient to produce measurable changes in linear growth or hematological outcomes within the study period.

The public health perspective, moringa-based supplementation combined with eggs can be considered for integration into community-level nutrition programs, such as supplementary feeding activities at primary health centers or integrated health posts, especially in resource-limited rural settings where moringa is available locally. This approach may contribute to efforts addressing undernutrition among preschool children, while longer-term and more comprehensive interventions are needed to improve their height and hemoglobin status.

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