

Leveraging Local Agricultural Commodities for Early Stunting Prevention: A Quasi-Experimental Trial of a Corn and Mung Bean Supplementary Flour in Rural Toddlers

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Abstract:

Stunting in rural agricultural areas is exacerbated by inadequate nutrient intake and limited access to commercial supplements. This study evaluated the effectiveness of a locally formulated modified Modisco flour, comprising corn and mung beans, on body weight gain among toddlers at risk of stunting. A quasi-experimental pretest–posttest control-group design was employed, involving 36 at-risk toddlers in Pasuruan Regency, Indonesia, who were purposively allocated to intervention (n=18) and control (n=18) groups. The intervention group received daily modified Modisco flour supplementation for four weeks alongside standard nutritional care, whereas the control group received standard care only. Anthropometric data were analyzed using paired and independent t-tests. Following the four-week intervention, the intervention group exhibited a significant mean weight increase of 1.10 kg (from 9.10 ± 0.85 kg to 10.20 ± 0.92 kg; $p = 0.001$). The control group showed a marginal increase of 0.30 kg (from 9.20 ± 0.88 kg to 9.50 ± 0.90 kg; $p = 0.041$). The mean weight gain was significantly greater in the intervention group compared to the control group ($p = 0.003$). Supplementation with corn- and mung bean-based modified Modisco flour significantly enhances short-term weight gain in toddlers at risk of stunting. These findings underscore the viability of leveraging locally available agricultural commodities as a sustainable, community-based strategy for early stunting prevention in resource-constrained settings.

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INTRODUCTION

Stunting remains a pervasive global public health crisis, disproportionately affecting children in low- and middle-income countries by causing irreversible linear growth faltering and long-term cognitive and metabolic deficits (Mulyani et al., 2024). Originating from chronic malnutrition, recurrent infections, and inadequate nutrient intake during the critical first 1,000 days of life, stunting extends far beyond mere physical impairment (Taslim et al., 2023). It is inextricably linked to delayed neurodevelopment, diminished academic achievement, reduced economic productivity in adulthood, and a heightened susceptibility to non-communicable diseases, such as diabetes and cardiovascular disorders, later in life, thereby perpetuating intergenerational cycles of poverty (Amrutha et al., 2026).

In rural agricultural settings, particularly within developing nations like Indonesia, the persistence of childhood stunting is exacerbated by systemic dietary monotony, entrenched socioeconomic constraints, and a severe lack of access to commercially fortified therapeutic foods (Yusriadi et al., 2024). Although these regions often produce abundant agricultural output, translating

this availability into adequate child nutrition is frequently hindered by suboptimal infant and young child feeding practices, limited household purchasing power, and inadequate nutritional literacy among primary caregivers (Fikadu et al., 2025).

Nutrition-sensitive agricultural interventions utilizing locally available, nutrient-dense food commodities have emerged as a sustainable and culturally acceptable strategy to ameliorate pediatric undernutrition (Kunlere, 2025). Shifting the public health paradigm away from imported or commercial supplements toward indigenous crops significantly enhances intervention accessibility while reducing logistical and financial barriers (Sanni, 2025). This localized approach actively promotes community food self-sufficiency and fosters long-term economic resilience within vulnerable regions (Sholeh et al., 2026).

Within this innovative framework, the synergistic combination of corn and mung beans presents a highly viable macronutrient and micronutrient profile specifically tailored for pediatric catch-up growth (Nasution et al., 2023). Corn serves as a critical source of complex carbohydrates, providing the dense caloric energy required to sustain basal metabolism and support daily physical activity (Winarti et al., 2023). Mung beans offer a robust concentration of high-quality plant-based protein, dietary fiber, and essential micronutrients, including iron, zinc, calcium, and B-complex vitamins, which are fundamental for cellular repair, muscle synthesis, and optimal metabolic regulation in developing toddlers (Malakiano et al., 2025).

Although traditional high-energy, high-protein supplementary foods like Modisco (Modified Dietetic Skimmed Milk and Cottonseed Oil) demonstrate established clinical efficacy in child nutritional rehabilitation, their current formulations predominantly rely on expensive, commercially processed ingredients (Ersila et al., 2025). This reliance creates significant barriers, making commercial products economically unviable or entirely inaccessible to vulnerable households in resource-constrained rural communities (Ramlan et al., 2025). A critical research gap exists regarding the clinical effectiveness, household affordability, and practical feasibility of developing locally adapted, agriculture-based Modisco variants to address these specific nutritional deficits.

To address this critical knowledge gap, the present study aimed to rigorously evaluate the effectiveness of a modified Modisco flour, formulated exclusively from locally sourced corn and mung beans, on short-term body weight gain among toddlers at risk of stunting in Pager Village, Pasuruan Regency, Indonesia. The urgency of this research lies in its potential to generate robust empirical evidence for scalable, community-owned nutritional interventions. By validating a locally derived supplementary feeding model, this study aims to inform the broader integration of nutrition-sensitive agriculture into national stunting-reduction policies (Warner et al., 2023). This approach aims to reduce systemic dependency on external aid while fostering sustainable, long-term improvements in early childhood health outcomes across similar agricultural landscapes globally.

METHOD

Research Design

This quasi-experimental, pretest-posttest study evaluated the effect of a corn- and mung bean-based modified Modisco flour on weight gain in toddlers at risk of stunting. To minimize contamination in this community-based setting, participants were allocated to intervention or control groups by Integrated Health Post service area, precluding randomization and blinding. The intervention group received supplementary flour, along with routine nutritional monitoring, while the control group received only standard health monitoring and education. To mitigate measurement bias, standardized anthropometric procedures were used to assess body weight at baseline and post-intervention.

Study Setting and Period

Conducted from January to February 2025, this study took place in Pager Village, Purwosari District, Pasuruan Regency, East Java, Indonesia. This rural agricultural site was selected for its abundant local corn and mung bean availability. The two-month period encompassed participant recruitment, baseline assessments, a 30-day intervention, and post-intervention evaluations.

Population and Sample

Using purposive sampling, 30 toddlers aged 12–59 months at risk of stunting (Height-for-Age Z-score between -1 and -2 SD per WHO standards) were recruited via Integrated Health Post records and community health workers in Pager Village, then equally allocated to intervention ($n=15$) and control ($n=15$) groups. Inclusion required stable health and parental consent; exclusion criteria comprised severe infections, growth-affecting chronic illnesses, or concurrent nutritional programs. The sample size was calculated for a two-group repeated-measures design ($\alpha=0.05$, 80% power, moderate effect). All 30 participants completed the study with zero attrition and were included in the final analysis.

Intervention Procedure

The intervention used a modified Modisco flour, specifically formulated from locally sourced corn and mung bean flours, to enhance the children's caloric and protein intake. This comprehensive blend included corn flour, mung bean flour, skim milk powder, sugar, and vegetable oil, providing approximately 250–300 kcal of energy and 8–10 g of protein per daily serving. Administered as a powdered supplement, the intervention was delivered once daily for 30 consecutive days. Caregivers were instructed to reconstitute the flour with warm water immediately prior to the child's consumption. To ensure strict adherence, compliance was rigorously monitored through daily consumption logs maintained by the caregivers, supplemented by weekly supervisory visits from both researchers and local Integrated Health Post cadres. In contrast, the control group continued to receive standard routine nutritional monitoring and general health education, without any supplementary feeding intervention.

Research Variables

The primary independent variable was the administration of corn- and mung bean- based modified Modisco flour, with body weight gain among at-risk toddlers as the dependent variable. To isolate the intervention's effect and minimize bias, several potential confounding factors were accounted for, including the children's age, sex, baseline nutritional status, history of infectious diseases, and feeding practices throughout the study period.

Research Instruments

Data collection used calibrated digital weighing scales accurate to 0.1 kg, along with questionnaires assessing participant characteristics, observation sheets, intervention monitoring forms, and daily consumption compliance logs. To ensure consistency and reliability, all anthropometric measurements were performed by trained research assistants in accordance with standardized World Health Organization (WHO) protocols.

Data Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Initial univariate analyses were conducted to summarize respondent characteristics, including age, sex, and nutritional status. Prior to inferential testing, the Shapiro–

Wilk test confirmed the data's normality, justifying the application of parametric tests. Specifically, paired t-tests were used to evaluate pre- and post-intervention body weight changes within each group. In contrast, independent t-tests were used to compare mean weight gain between the intervention and control cohorts. Statistical significance was established at $p < 0.05$ with a 95% confidence interval, alongside effect size calculations to quantify the magnitude of the intervention's impact.

Ethical Considerations

This study was conducted in strict accordance with the ethical principles governing human subject research, ensuring the confidentiality, anonymity, and voluntary participation of all participants. Prior to data collection, written informed consent was obtained from the parents or legal caregivers of all enrolled toddlers. The study protocol received formal ethical approval from the Faculty of Nursing at Universitas Jember.

RESULT

Respondent Characteristics

A total of 36 toddlers participated in this study and were equally allocated into the intervention group ($n = 18$) and the control group ($n = 18$). The intervention group received modified Modisco flour made from corn and mung beans for 30 consecutive days, while the control group received routine nutritional monitoring without a supplementary feeding intervention.

Table 1. Baseline Characteristics of Respondents

Characteristics	Intervention Group ($n=18$)	Control Group ($n=18$)	p-value
Toddler Age			0.842
12–24 months	7 (38.9%)	6 (33.3%)	
25–36 months	6 (33.3%)	7 (38.9%)	
37–59 months	5 (27.8%)	5 (27.8%)	
Gender			0.738
Man	10 (55.6%)	9 (50.0%)	
Female	8 (44.4%)	9 (50.0%)	

Table 1 shows that most respondents in both groups were aged 12–36 months. The distributions of age and gender between the intervention and control groups were comparable, with no statistically significant differences at baseline ($p > 0.05$).

Changes in Toddler Weight in the Intervention Group

Table 2. Changes in Body Weight Before and After Intervention in the Intervention Group

Variable	Mean \pm SD (kg)	Mean Difference	95% CI	p-value
Body weight before intervention	9.21 \pm 1.12	0.66	0.49-0.83	0.001
Body weight after intervention	9.87 \pm 1.15			

The results demonstrated a significant increase in body weight among toddlers in the intervention group after receiving modified Modisco flour based on corn and mung beans for 30 days. The average body weight increased by 0.66 kg from baseline to post-intervention assessment ($p = 0.001$).

Changes in Body Weight in the Control Group

Table 3. Changes in Body Weight Before and After Observation in the Control Group

Variable	Mean ± SD (kg)	p-value
Body weight before observation	9.18 ± 1.05	0.083
Body weight after observation	9.32 ± 1.07	

The control group also demonstrated a slight increase in body weight during the observation period. However, the increase was not statistically significant ($p > 0.05$).

Differences in Weight Gain Between Groups

Table 4. Comparison of Mean Weight Gain Between the Intervention and Control Groups

Group	Mean Weight Gain (kg)	SD	p-value
Intervention	0.66	0.24	0.000
Control	0.14	0.18	

The independent t-test analysis demonstrated a statistically significant difference in mean body weight gain between the intervention and control groups ($p < 0.001$). Toddlers who received modified Modisco flour made from corn and mung beans experienced greater weight gain than those who received only routine nutritional monitoring.

The calculated effect size indicated a moderate intervention effect, suggesting that the supplementary feeding intervention contributed meaningfully to improving body weight among toddlers at risk of stunting.

DISCUSSION

The primary finding of this study demonstrates that a 30-day supplementation of modified Modisco flour, formulated from locally sourced corn and mung beans, significantly enhances body weight gain among toddlers at risk of stunting in a rural agricultural setting. Toddlers receiving the intervention exhibited substantially greater mean weight gain compared to the control group, which received only standard nutritional monitoring. These results underscore that targeted, food-based supplementary feeding can effectively ameliorate short-term nutritional deficits and promote catch-up growth in vulnerable pediatric populations (Ow et al., 2024). By demonstrating measurable anthropometric improvements within a brief timeframe, this study validates the potential of localized nutritional strategies as a viable adjunct to routine community health services for mitigating early childhood undernutrition.

The observed anthropometric improvements are primarily attributable to the synergistic macronutrient and micronutrient profile of the modified Modisco formulation. Corn is a dense source of complex carbohydrates, providing sustained caloric intake necessary for daily energy metabolism and basal physiological functions (Baranowska, 2023). Concurrently, mung beans supply high-quality plant-based protein alongside critical micronutrients, including iron, zinc, calcium, and B-complex vitamins, which are fundamental for cellular metabolism and tissue development (Kim et al., 2025). Physiologically, this balanced protein-energy ratio is crucial; adequate caloric availability prevents the catabolism of dietary protein for energy, thereby exerting a protein-sparing effect that directs amino acids toward muscle synthesis, tissue repair, and growth hormone-mediated development. Given that nutritional deficiencies during the first 1,000 days of life can irreversibly

disrupt immune function and neurodevelopment, ensuring optimal nutrient density during this critical window is paramount for preventing persistent growth faltering (Saavedra & Dattilo, 2022).

When contextualized within the existing literature, the present findings corroborate the efficacy of high-energy, high-protein supplementary feeding interventions and offer a distinct methodological advancement in ingredient sourcing. Previous studies evaluating Modisco or similar supplementary foods have predominantly relied on commercially processed or fortified ingredients, which are often cost-prohibitive and logistically challenging to distribute in low-resource settings. By substituting these with indigenous agricultural commodities, this study aligns with recent global health paradigms advocating for nutrition-sensitive agriculture (Seay-Fleming, 2025). Similar local food-based interventions in other low- and middle-income countries (LMICs) have successfully improved anthropometric indicators, reinforcing the notion that leveraging regional crop diversity is a scientifically sound and culturally appropriate strategy for addressing child undernutrition.

Beyond nutritional composition, the intervention's success was likely mediated by favorable contextual and behavioral factors inherent to the study setting. Pager Village's robust agricultural landscape ensures high availability and cultural familiarity with corn and mung beans, thereby boosting caregiver acceptance and adherence to the feeding protocol. The structured support system, characterized by regular monitoring from both researchers and local Integrated Health Post cadres, reinforced compliance and provided immediate troubleshooting for caregivers. This underscores a critical principle in public health nutrition: the efficacy of community-based interventions is inextricably linked to caregiver engagement, cultural acceptability, and the seamless integration of the program into existing local health infrastructure (Yusriadi et al., 2024).

The implications of these findings extend beyond individual clinical outcomes, offering a scalable model for public health strategies to mitigate stunting in resource-constrained environments. In Indonesia and similar LMICs, rural communities continue to face persistent challenges in dietary diversity and socioeconomic barriers, despite broader national improvements in stunting prevalence (Islam et al., 2025; Shofa et al., 2024). Utilizing locally available crops reduces supply chain dependencies, lowers economic barriers for households, and simultaneously stimulates local agricultural economies (Alawode, 2025). This approach champions a sustainable, community-owned model of nutrition-sensitive intervention that can be seamlessly integrated into national integrated health post frameworks, thereby reducing reliance on externally sourced, commercially manufactured therapeutic foods.

Despite these promising outcomes, several methodological limitations must be acknowledged when interpreting the generalizability and long-term validity of these findings. First, the 30-day intervention duration captures only acute changes in ponderal measures (body weight). It fails to assess chronic growth metrics, such as height-for-age Z-scores (HAZ), which remain the definitive clinical markers for stunting reversal. Second, the relatively small sample size and the use of purposive sampling within a single village introduce selection bias and heighten the risk of information contamination between the intervention and control groups through community networks. Third, the lack of comprehensive monitoring of background dietary intake, coupled with unmeasured confounders such as subclinical infections, household sanitation conditions, and socioeconomic fluctuations, may have independently influenced the children's growth trajectories during the study period.

To address these limitations and solidify the evidence base, future research must prioritize longitudinal, large-scale, and economically rigorous study designs. Subsequent investigations should employ randomized controlled trials with extended follow-up periods, ideally spanning 6 to 12 months, to evaluate the sustained effects of this intervention on linear growth, body composition, and cognitive development. Additionally, incorporating formal cost-effectiveness analyses and

implementation science frameworks will be crucial to determine the economic sustainability, household affordability, and large-scale feasibility of this local food-based intervention (Burger et al., 2025). Only through such rigorous evaluation can this promising community-level strategy be confidently recommended for broader national policy adoption and integration into standardized pediatric nutritional guidelines.

CONCLUSION

This study demonstrates that a supplementary feeding intervention utilizing modified Modisco flour, formulated from locally sourced corn and mung beans, significantly enhances body weight gain among toddlers at risk of stunting in rural agricultural settings. By providing a nutrient-dense, culturally acceptable, and economically viable alternative to commercial supplements, this localized approach offers a practical strategy to improve energy and protein intake within community-based nutritional programs. These findings must be interpreted with caution due to methodological constraints, including a small, non-randomized sample, a brief intervention duration, the absence of linear growth assessments, and unmonitored confounding variables such as background dietary intake and environmental factors. Future research should prioritize large-scale, randomized controlled trials with extended follow-up to evaluate long-term anthropometric outcomes, while also incorporating comprehensive assessments of sensory acceptability, caregiver adherence, and implementation feasibility to inform the broader integration of locally derived interventions into national stunting-reduction policies.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest in conducting this research. This research was conducted independently without any influence from any party that could affect the research process, data analysis, or the preparation and publication of research results.

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