



## Effectiveness of Cassava-Based Nuggets as a Local Food Intervention for Children Aged 12–59 Months

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**Abstract:** Child undernutrition remains a public health concern in rural Indonesia, highlighting the need for locally available food-based interventions. Cassava is a potential local food, however, evidence the effectiveness of cassava-based products in improving the nutritional status of children remains limited. This study aimed to evaluate changes in nutritional status among children aged 12–59 months receiving cassava-based nuggets. This quasi-experimental pretest-posttest study compared anthropometric changes in 90 children who received cassava-based or wheat-flour-based nuggets (45 per group), at 100 g/day for four weeks. Weight-for-age (WAZ) and height-for-age (HAZ) Z-scores were assessed before and after supplementation. WAZ improved in both groups. The Mann–Whitney U test showed a significant difference in the distribution of WAZ change scores between groups ( $U = 661$ ,  $p = 0.005$ ), although the arithmetic mean change was numerically larger in the wheat-flour control group. After correction of one confirmed height-entry error and recalculation using WHO Child Growth Standards, mean HAZ changes were  $0.10 \pm 0.45$  in the cassava group and  $0.08 \pm 0.17$  in the control group, with no significant between-group difference ( $U = 865$ ,  $p = 0.236$ ). These findings support further evaluation of cassava-based nuggets as a locally adapted supplementary food but do not establish superiority in mean WAZ change or an effect on short-term linear growth.

**Keywords:** cassava, local food, nugget, nutritional status, under-five children

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## INTRODUCTION

Child malnutrition in Indonesia remains a major public health challenge, particularly in rural areas with limited access to healthcare services and nutritious foods. Poor nutritional status and undernutrition can hinder child growth and development while increasing the risk of stunting and infectious morbidity. According to the 2023 Indonesian Health Survey, the national prevalence of stunting remains at 21.5% (Badan Kebijakan Pembangunan Kesehatan, 2023). Grobogan District, one of Indonesia's main cassava-producing regions, reported 6,382 cases of stunting among children under 5 in 2024, underscoring the urgency of addressing nutritional problems in the local context (Dinas Kesehatan Kabupaten Grobogan, 2024).

Previous studies have shown that the causes of child malnutrition are multifactorial, involving social, economic, educational, and household food security dimensions. Children in rural areas experience higher rates of stunting compared to those in urban areas (32% vs. 27%) (Haq et al., 2021). In the local context, cassava (*Manihot esculenta*) represents a locally available carbohydrate source that can be incorporated into supplementary food products. Formulating cassava-based products using locally available ingredients may therefore provide an alternative approach for community-based supplementary feeding (Bechoff et al., 2018; Maziya-Dixon et al., 2017). Developing cassava-based products, such as nutritious, affordable nuggets acceptable to children, may therefore offer a promising alternative intervention to address malnutrition in the region.

The main issue addressed in this study is the persistently high prevalence of undernutrition and stunting among children under five in Grobogan District, despite the region's potential for local food resources such as cassava. The lack of systematic integration of local food resources into child nutrition interventions limits the effectiveness of stunting reduction programs at the community level (Dinas Kesehatan Kabupaten Grobogan, 2024). This situation is further aggravated by limited nutrition education, the unaffordability of nutritious foods, and the suboptimal role of community health volunteers (Posyandu cadres) in monitoring child growth.

A general solution is implementing community-based nutritional interventions that sustainably use locally available foods. This strategy emphasizes using cassava alongside protein-rich, micronutrient-dense foods, such as chicken and carrots, to create balanced formulations. Furthermore, the involvement of Posyandu cadres as frontline implementers is crucial for improving compliance and ensuring effective distribution of intervention products. Previous studies have confirmed that community-based food strategies can improve child nutritional status and food security (Fristiwi et al., 2023; Marni et al., 2023).

Previous studies have demonstrated the potential of cassava-based products as nutrient-containing food vehicles. Cassava flour blended with legumes has been shown to improve the nutritional profile and sensory properties of snack products, while fortified and biofortified cassava products have demonstrated favorable consumer acceptance (Bechoff et al., 2018; Maziya-Dixon et al., 2017). Furthermore, Maziya-Dixon et al. (2017) reported that cassava flour fortified with legumes or protein-rich ingredients improved protein, fiber, and micronutrient content, while biofortified cassava products achieved high sensory acceptance, especially among children and their parents.

Nevertheless, there is limited research in Indonesia evaluating the effectiveness of cassava-based processed foods in improving nutritional outcomes. Moreover, studies involving Posyandu cadres as distributors and monitors of interventions remain scarce. This highlights a significant research gap in context-specific applied studies, particularly in rural districts such as Grobogan.

Although various studies have examined the use of local foods to improve community nutrition, most focus on products derived from wheat or other non-local carbohydrate sources. The use of cassava nuggets formulated specifically for children under five remains underexplored in Indonesia. Furthermore, existing studies tend to focus only on anthropometric outcomes, without assessing community acceptance or the sustainability of interventions at the household level (Mounika & Kasturiba, 2019; Shahid et al., 2021; Zangina et al., 2023). Community involvement in the production and distribution of local food interventions, such as by Posyandu cadres, has also not been sufficiently investigated. This gap creates an opportunity to design holistic, context-specific, and replicable intervention models. The lack of scientific evidence on the effectiveness of cassava nuggets in improving child nutrition in Grobogan provides a strong rationale for conducting this study.

The objective of this study was to evaluate changes in the nutritional status of children under 5 receiving cassava-based nuggets compared with those receiving wheat-flour-based nuggets over a 4-week intervention period, with particular emphasis on weight-for-age and height-for-age Z-scores. The study also explored the use of cassava, a locally available ingredient, in a community-based supplementary feeding context involving Posyandu cadres. To our knowledge, evidence on the use of cassava-based nuggets for children under five in Grobogan District remains limited. Therefore, this study was conducted to provide preliminary evidence on short-term anthropometric responses following cassava-based nugget supplementation.

## METHODS

### *Materials*

The intervention nuggets were prepared from steamed cassava (40%), minced chicken (30%), grated carrot (20%), and additional ingredients consisting of garlic, salt, egg, and bread crumbs (10%), for a 100-g daily portion. The control group received wheat-flour-based nuggets in an equivalent daily portion of 100 g. Detailed formulation and nutrient composition data for the control product were not available in the study records. The nugget formulation was developed with input from a nutritionist and targets an energy content of at least 150 kcal per 100-g portion.

Body weight was measured using a digital scale with 0.1 kg precision, and standing height was measured using a micrometer with 0.1 cm precision. HAZ was recalculated from the corrected individual-level dataset using the WHO Child Growth Standards and completed age in months. For children younger than 24 months whose standing height had been recorded, 0.7 cm was added before comparison with the WHO length-for-age standard; standing height standards were used for children aged 24 months and older. During source-data verification, one confirmed transcription error in post-intervention height (9.1 cm) was corrected to 84.5 cm based on the original Posyandu record. WAZ values were retained from the verified study analysis.

### *Sample Preparation*

The product formulation was carried out by homogenization: cassava was first steamed, then mixed with minced chicken and grated carrots. The mixture was seasoned, molded into small nuggets, and steamed for 15 minutes until fully cooked. Nuggets were cooled, frozen, and stored at a portion size of 100 grams/day until distribution.

Daily distribution was conducted by trained Posyandu (community health post) cadres to children in the intervention group. Cadres were also provided with monitoring forms to record daily consumption and any potential adverse effects. Standardization of taste, texture, and aroma was performed in preliminary trials with a small number of target subjects to ensure product acceptability prior to the intervention.

### *Experimental Set-up*

This study employed a quasi-experimental design with a pre-test and post-test parallel group approach. A total of 90 under-five children aged 12–59 months who met the inclusion criteria were recruited using purposive sampling and allocated into two groups: the intervention group ( $n = 45$ ) received cassava-based nuggets, while the control group ( $n = 45$ ) received nuggets prepared with wheat flour as the substitute ingredient.

The research was conducted in sequential phases: preparation, recruitment, intervention, and evaluation. The preparation phase included protocol development, cadre training, and production of intervention and control nuggets. Eligible children underwent baseline nutritional assessments before the intervention. For four weeks, the intervention group received 100 grams of cassava-based nuggets daily, whereas the control group received an equivalent amount of wheat-flour-based nuggets. After the intervention period, weight and height were re-measured to evaluate changes in nutritional status. Measurement data were analyzed statistically and presented in a scientific report and manuscript.

### *Parameters*

The primary outcomes were WAZ and HAZ before and after the four-week intervention. Body weight was measured with a digital scale, and standing height with a micrometer to 0.1 cm precision. For the HAZ reanalysis, the completed age in months and sex recorded in the source dataset were used, along with the WHO Child Growth Standards. Standing height in children younger than 24 months was adjusted by +0.7 cm before use of the WHO length-for-age reference.

### *Statistical Analysis and Ethical Clearance*

Continuous data were summarized as mean  $\pm$  standard deviation (SD), and categorical data as frequency and percentage. WAZ results were retained from the verified study analysis. After correction of the confirmed height-entry error, individual HAZ values were recalculated from the source dataset using the WHO Child Growth Standards. Normality of HAZ change scores was assessed using the Shapiro–Wilk test. Because HAZ change scores were non-normally distributed in both groups, within-group HAZ changes were analyzed using the Wilcoxon signed-rank test, while between-group HAZ changes were analyzed using the Mann–Whitney U test. Baseline WAZ and HAZ categorical distributions were compared using Pearson’s chi-square test. Statistical significance was

set at  $p < 0.05$ . Multivariable regression was not included because complete and verifiable model output was not available. Ethical approval was obtained from the relevant ethics committee (Approval No. 47/Kom.etik/VI/2025, dated June 26, 2025), and written informed consent was obtained from parents or legal guardians.

## RESULTS

Ninety children were included, with 45 participants in each group. Baseline characteristics are presented in Table 1. Underweight or severe underweight was observed in 25/45 children (55.6%) in the intervention group and 26/45 children (57.8%) in the control group. The baseline WAZ category distribution did not differ between groups (Pearson chi-square test,  $p = 0.976$ ). After WHO-based HAZ recalculation from the corrected individual-level dataset, stunting or severe stunting was identified in 26/45 children (57.8%) in the intervention group and 34/45 children (75.6%) in the control group. The baseline HAZ-category distribution also did not differ significantly between groups (Pearson chi-square  $p = 0.201$ ), although the proportion of children below -2 SD was descriptively higher in the control group.

**Table 1**  
*Characteristics of Respondents*

| Variables                           | Intervention group | Control group   | Total           | p-value |
|-------------------------------------|--------------------|-----------------|-----------------|---------|
| <b>Maternal age (years)</b>         |                    |                 |                 |         |
| ≤ 20                                | 12 (26.7%)         | 12 (27%)        | 24 (27%)        | 0.736   |
| 21–34                               | 16 (35.6%)         | 24 (53%)        | 40 (44%)        |         |
| ≥ 35                                | 17 (37.8%)         | 9 (20%)         | 26 (29%)        |         |
| <b>Maternal education</b>           |                    |                 |                 |         |
| Elementary School                   | 2 (4.4%)           | 3 (7%)          | 5 (6%)          | 0.452   |
| Junior High School                  | 9 (20%)            | 15 (33%)        | 24 (27%)        |         |
| Senior High School                  | 34 (75.6%)         | 25 (56%)        | 59 (66%)        |         |
| Bachelor's degree                   | 0 (0%)             | 2 (4%)          | 2 (2%)          |         |
| <b>Child age (months)</b>           |                    |                 |                 |         |
| 12 – 36                             | 32 (71%)           | 28 (62%)        | 60 (67%)        | 0.649   |
| 37 – 59                             | 13 (29%)           | 17 (38%)        | 30 (33%)        |         |
| <b>Sex</b>                          |                    |                 |                 |         |
| Male                                | 20 (44.4%)         | 23 (51%)        | 43 (48%)        | 0.546   |
| Female                              | 25 (55.6%)         | 22 (49%)        | 47 (52%)        |         |
| <b>Weight-for-age Z-score (WAZ)</b> |                    |                 |                 |         |
| Severely underweight                | 3 (6.7%)           | 3 (6.7%)        | 6 (7%)          | 0.976   |
| Underweight                         | 22 (48.9%)         | 23 (51.1%)      | 45 (50%)        |         |
| Normal                              | 20 (44.4%)         | 19 (42.2%)      | 39 (43%)        |         |
| <b>Height-for-age Z-score (HAZ)</b> |                    |                 |                 |         |
| Severely stunted                    | 11 (24.4%)         | 14 (31.1%)      | 25 (27.8%)      | 0.201   |
| Stunted                             | 15 (33.3%)         | 20 (44.4%)      | 35 (38.9%)      |         |
| Normal                              | 19 (42.2%)         | 11 (24.4%)      | 30 (33.3%)      |         |
| Tall                                | 0 (0%)             | 0 (0%)          | 0 (0%)          |         |
| <b>Total</b>                        | <b>45(100%)</b>    | <b>45(100%)</b> | <b>90(100%)</b> |         |

The recalculated HAZ change scores were not normally distributed in both groups (Shapiro–Wilk tests:  $p < 0.001$  for the intervention group and  $p = 0.007$  for the control group; Table 2).

**Table 2***Shapiro–Wilk normality test of recalculated HAZ change scores*

| Outcome    | Group              | Shapiro–Wilk W | p-value |
|------------|--------------------|----------------|---------|
| HAZ change | Intervention group | 0.757          | <0.001  |
| HAZ change | Control group      | 0.926          | 0.007   |

Note: intervention group = 100 g cassava-based nuggets; control group = 100 g wheat flour-based nuggets

For WAZ, both groups showed improvement over the four-week intervention. The mean change was  $0.49 \pm 1.31$  in the cassava-based nugget group and  $0.62 \pm 1.05$  in the wheat-flour control group. Although the arithmetic mean change was numerically larger in the control group, the Mann–Whitney U test showed a significant difference in the distribution of WAZ change scores between groups ( $U = 661$ ,  $p = 0.005$ ). Therefore, this result should not be interpreted as evidence of a greater mean WAZ improvement in the cassava-based nugget group.

**Table 3***Changes in weight-for-age and height-for-age Z-scores within and between groups*

| Variables                           | Pre<br>(Mean $\pm$ SD) | Post<br>(Mean $\pm$ SD) | p-value<br>(pre–post) | Change<br>(Mean $\pm$ SD) | Between-group<br>test of change |
|-------------------------------------|------------------------|-------------------------|-----------------------|---------------------------|---------------------------------|
| <b>Weight-for-age Z-score (WAZ)</b> |                        |                         |                       |                           |                                 |
| Intervention group                  | $-2.80 \pm 0.63$       | $-2.31 \pm 0.93$        | 0.015 <sup>a</sup>    | $0.49 \pm 1.31$           | $U = 661$                       |
| Control group                       | $-2.80 \pm 0.60$       | $-2.17 \pm 0.82$        | <0.001 <sup>*a</sup>  | $0.62 \pm 1.05$           | $p = 0.005$ <sup>*b</sup>       |
| <b>Height-for-age Z-score (HAZ)</b> |                        |                         |                       |                           |                                 |
| Intervention group                  | $-2.10 \pm 1.02$       | $-2.00 \pm 1.13$        | 0.318 <sup>a</sup>    | $0.10 \pm 0.45$           | $U = 865$                       |
| Control group                       | $-2.47 \pm 0.97$       | $-2.39 \pm 0.96$        | <0.001 <sup>*a</sup>  | $0.08 \pm 0.17$           | $p = 0.236$ <sup>b</sup>        |

<sup>a</sup> Wilcoxon signed-rank test for within-group pre–post comparison;<sup>b</sup> Mann–Whitney U test for between-group comparison of change scores.<sup>\*</sup> Statistical significance was set at  $p < 0.05$ .

For HAZ, the cassava-based nugget group showed a mean change of  $0.10 \pm 0.45$ , whereas the control group showed  $0.08 \pm 0.17$ . The between-group Mann–Whitney U test showed no significant difference in HAZ change scores ( $U = 865$ ,  $p = 0.236$ ). Thus, no evidence of a differential short-term HAZ response between the two groups was observed.

## DISCUSSION

The present study showed improvement in WAZ over four weeks in both supplementation groups. In the cassava-based nugget group, WAZ increased from  $-2.8015 \pm 0.63242$  to  $-2.3100 \pm 0.93472$ , whereas the control group increased from  $-2.7896 \pm 0.60349$  to  $-2.1700 \pm 0.81684$ . Although the Mann–Whitney U test identified a significant difference in the distribution of WAZ change scores between groups ( $U = 661$ ,  $p = 0.005$ ), the arithmetic mean change was numerically larger in the control group ( $0.62 \pm 1.05$ ) than in the cassava group ( $0.49 \pm 1.31$ ). Therefore, the result should not be interpreted as evidence that cassava-based nuggets produced a greater mean WAZ improvement. Rather, it indicates that the pattern of individual WAZ changes differed between groups. This finding is broadly consistent with evidence that nutritional supplementation can improve short-term anthropometric outcomes in nutritionally vulnerable children, although the

magnitude and direction of benefit depend on the intervention, baseline nutritional status, and study context (Anwar et al., 2023; Bliznashka et al., 2023).

The observed WAZ improvement is also compatible with the broader literature on food-based supplementation. Institutional and home-prepared food interventions have been associated with improvements in growth-related outcomes among preschool or malnourished children (Mounika & Kasturiba, 2019; Shahid et al., 2021; Zangina et al., 2023). Indonesian evidence has likewise suggested potential benefits of locally available food supplementation, although some studies addressed different populations or outcomes and therefore should be considered contextual rather than directly comparable evidence (Rosdiana et al., 2022; Susiloretni et al., 2021). These differences are important because the present study compared two active food products rather than a supplemented group with a non-supplemented group; consequently, within-group improvement alone cannot establish a specific effect attributable to cassava.

From a nutritional perspective, the cassava-based product combined a carbohydrate source with chicken, carrot, egg, and other ingredients. Such a formulation is conceptually relevant to supplementary feeding because inadequate energy and protein intake are important contributors to childhood undernutrition (Rachana et al., 2024), and systematic evidence indicates that nutrition interventions can improve selected outcomes of undernutrition (Tan et al., 2021). However, the current manuscript does not yet provide complete laboratory measurements or validated calculations of nutrient composition for the cassava and wheat-flour nuggets, nor quantitative data on actual intake and adherence. Therefore, the observed WAZ changes cannot be mechanistically attributed to a specific energy, protein, or micronutrient contribution of cassava. An appealing nugget format may support acceptance, but acceptability and intake need to be measured directly before they can be invoked to explain the present findings.

The reanalysis of HAZ provides a different pattern. After correction of the confirmed post-intervention height transcription error and recalculation using the WHO Child Growth Standards, mean HAZ changed from  $-2.10 \pm 1.02$  to  $-2.00 \pm 1.13$  in the cassava group and from  $-2.47 \pm 0.97$  to  $-2.39 \pm 0.96$  in the control group. The mean changes were small in both groups ( $0.10 \pm 0.45$  and  $0.08 \pm 0.17$ , respectively), and the between-group Mann-Whitney comparison showed no evidence of a differential HAZ response ( $U = 865$ ,  $p = 0.236$ ). Thus, the appropriate interpretation is not that cassava-based nuggets are ineffective for height, but that this four-week study did not demonstrate a difference in short-term HAZ change between the two products. This interpretation is consistent with the biological nature of linear growth, which reflects longer-term nutritional and health exposures and may respond less rapidly than weight-related indicators.

Previous studies also show that linear-growth responses vary substantially according to intervention duration, baseline nutritional status, dietary exposure, morbidity, and the specific nutritional strategy. Nutrition-sensitive agriculture and food-based interventions in different settings have produced heterogeneous effects on child growth (Mekonnen et al., 2022; Omer et al., 2022). Studies of oral nutritional supplementation have reported improvements in growth among children at nutritional risk, but the magnitude and timing of height responses vary across populations (Khanna et al., 2021; Fristiwi et al., 2021). Therefore, the absence of a significant between-group HAZ difference after only four weeks should be interpreted primarily as a limitation of the observation

period and the modest magnitude of short-term change, rather than as evidence for or against an effect on stunting.

Longer-term growth is also influenced by factors beyond a single supplementary food. School feeding research has demonstrated that sustained interventions can improve height-for-age in selected subgroups over longer periods (Gelli et al., 2019), while nutrition education may improve nutritional knowledge and related outcomes when integrated with food-based strategies (Annan et al., 2021). In Indonesia, determinants such as maternal factors, birth size, and breastfeeding have been associated with the risk of stunting, underscoring the multifactorial nature of linear growth faltering (Rosdiana et al., 2023). These observations support a broader interpretation of the present findings: a cassava-based supplementary food may provide dietary support, but meaningful prevention or reduction of stunting is unlikely to depend on a single short-duration food intervention.

Community implementation also requires attention to product quality, feeding practices, caregiver engagement, and monitoring. Evidence from Indonesia has highlighted the importance of verifying the nutrient quality of complementary foods (Dreyfuss et al., 2019). In addition, reviews of stunting-prevention programs emphasize the importance of appropriate program design and implementation (Fristiwi et al., 2023). Similarly, Behavioral factors, including awareness and motivation related to stunting prevention, have also been highlighted in community settings (Marni et al., 2023). In the present study, Posyandu cadres were involved in distribution and monitoring, but quantitative data on adherence, acceptability, adverse events, and dietary intake were not fully reported. These aspects should therefore be evaluated directly in future studies before any inferences are made about feasibility, affordability, or scalability.

Overall, the findings support continued investigation of cassava-based nuggets as a locally adapted supplementary food rather than a conclusion of superiority over wheat-flour nuggets. The WAZ results indicate that both groups improved and that the distributions of individual change scores differed, whereas the corrected HAZ analysis showed no significant between-group difference over four weeks. Future studies should characterize the nutrient composition of both products, document actual consumption and background diet, use longer follow-up periods for linear growth outcomes, and report effect estimates with confidence intervals. Such information would allow the nutritional contribution of cassava-based formulations to be distinguished more clearly from the general effects of providing an additional nutrient-containing food.

### *Limitations and Future Directions*

This study has several limitations. First, the four-week intervention period was too short to draw strong conclusions regarding sustained linear growth or stunting. Second, the quasi-experimental allocation may have introduced residual confounding. Third, complete nutrient composition data for both nugget formulations, quantitative adherence data, background dietary intake data, and adverse-event data were not available. Fourth, one confirmed post-intervention height transcription error was identified and corrected from 9.1 cm to 84.5 cm based on the original Posyandu record, after which HAZ was recalculated from the corrected individual-level dataset. Finally, the study was conducted in a single district, which may limit the generalizability of the findings.

Future studies should include longer follow-up, prespecified allocation procedures, complete nutrient characterization of both intervention and control foods, standardized age-appropriate anthropometric measurements, and quantitative assessment of adherence and background dietary intake. Comparative analyses should report effect estimates with 95% confidence intervals, and any adjusted model should be presented in full. Cost, acceptability, and feasibility should also be evaluated directly before making claims about affordability or scalability.

## CONCLUSION

After four weeks of, WAZ improved within both supplementation groups. However, despite a significant between-group difference in WAZ change scores ( $p = 0.005$ ), the mean increases was numerically greater in wheat-flour-based nugget than in the cassava-based nugget intervention (0.62 vs 0.49). For HAZ, the mean changes were small in both groups, and no significant between-group difference was observed ( $p = 0.236$ ). Therefore, this study does not demonstrate the superiority of cassava-based nugget intervention over wheat-flour-based nugget in improving anthropometric outcomes. Further studies with longer follow-up and more comprehensive nutritional assessments are needed to evaluate their potential as a locally based supplementary food for children aged 12-59 months.

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## Author Contribution Statement

**Rahmawati Rahmawati:** Conceptualization, Investigation, Data Curation, and Writing - Original Draft. **Rosdiana Syakur:** Conceptualization, Methodology, Supervision, Project Administration, and Writing - Review & Editing. **Sri Untari:** Methodology, Investigation, Validation, and Writing - Review & Editing. **Sutiyono Sutiyono:** Formal Analysis, Validation, and Writing - Review & Editing. All authors have read and approved the final version of the manuscript.

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