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Effects of Néré (Parkia Biglobosa), Honey and Powdered Milk on Moderate Malnutrition in Children Aged 12 - 59 Months at INSE, Guinea: Prospective Intervention Study

Ismaël Wagué[1,2], Mohamed Kerfalla Camara[2], Almamy Amara Touré[1], Aboubacar Soumah[1], Kabinet Tounkara[1], Elhdj Saidou Baldé[2,3]

[1]National Institute of Public Health (INSP), Conakry, Guinea
[2]Department of Pharmacy, Gamal Nasser University of Conakry, Guinea (UGANC), Conakry, Guinea
[3]Guinean Institute for Research and Development of Medicinal and Food Plants (IRDPMAG), Dubreka, Guinea
Email: wagueismael@gmail.com

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Abstract

Introduction: According to the World Health Organization (WHO), approximately 7% of children worldwide suffer from moderate malnutrition. In Guinea, it remains common, and local nutritional interventions could promote weight gain. This study aimed to evaluate the effect of Néré (*Parkia biglobosa*), honey, and powdered milk on weight gain in children aged 12 to 59 months with moderate malnutrition. **Methods:** A prospective single-arm interventional study was conducted from October 2023 to June 2024 at INSE. Children aged 12 to 59 months with moderate malnutrition (Z-score W/H or W/A between −2 and −3 SD or MUAC 11.5 - 12.5 cm) received a daily ration of *Parkia biglobosa* flour, honey, and Nido powdered milk for 13 weeks. The feeds underwent sensory, physicochemical, and microbiological analyses according to ISO standards. Weights and heights were measured regularly, and weight gain was calculated as the difference between final and initial weights. Weight change was analyzed using the Friedman test with $p < 0.05$ as the significance threshold. **Results:** A total of 31 children were included. Initial nutritional analysis showed that the majority had a weight-for-height (W/H) Z-score of −2 (64.5%), while 12.9% had a mid-upper arm circumference (MUAC) between 115 and 124 mm. Children measuring less than 80 cm showed higher weight gain compared to the other groups ($Chi^2 = 10.87$; $p = 0.012$). A significant increase in weight was observed over the weeks ($Chi^2 = 60.06$; $p < 0.001$), with the mean rank increasing from 1.03 at week 1 to 3.00 at week 13. **Conclusion:** The combination of *P. biglobosa*, honey, and powdered milk significantly improved the nutritional

status of moderately malnourished children and could be integrated into pediatric nutritional programs in Guinea.

Keywords

Malnutrition, Parkia Biglobosa, Nutritional Adherence, Weight Gain, Children

1. Introduction

Malnutrition in children, particularly those aged 12 to 59 months, remains a major public health problem worldwide, with devastating consequences for physical growth, cognitive development, and survival [1]. According to the World Health Organization (WHO), approximately 7% of children worldwide suffer from moderate malnutrition, which can have adverse consequences on their physical and cognitive health [2]. In Africa, the situation remains worrying, with 24% of children under five suffering from stunted growth and 6.4% suffering from wasting, with higher prevalence in Sahelian and rural areas [3].

In Guinea, several policies have been implemented to address acute malnutrition. The prevalence of global acute malnutrition among children aged 6 to 59 months has improved, declining from 8% in 2015 to 6.7% in 2022 [4]. While severe acute malnutrition often attracts attention due to its high mortality risk, moderate acute malnutrition (MAM), although less directly lethal, affects a much larger number of children and has equally deleterious effects on their long-term physical, cognitive, and immune development [5].

The wild fruits consumed and sold in Guinean markets are numerous and varied. They grow in all regions of Guinea at specific times of the year. For a large part of the population, they represent a dietary supplement, a vitamin source, and a source of income [6].

Néré flour (*P. biglobosa*) is an excellent source of plant-based protein. Studies have shown that the seeds, and therefore the flour derived from them, contain significant crude protein levels, ranging from 28% to over 40% of dry matter. It is also rich in lipids, with percentages reaching 35% to 40% [7]. Its potential in the fight against malnutrition has been highlighted by recent studies, which have demonstrated its impact on weight recovery in malnourished children [8].

Honey is rich in simple carbohydrates such as fructose and glucose, making it a rapidly absorbed energy source. It also contains vitamins (B2, B3, B5, B6, C) and minerals such as calcium, magnesium, potassium, and zinc [9]. According to these authors, honey is recognized for its rapid energy provision, antimicrobial and antioxidant properties, and represents a potentially beneficial food supplement to support nutritional recovery.

Finally, powdered milk is a key ingredient in Ready-to-Use Therapeutic Food (RUTF) formulations, such as Plumpy'Nut, used to treat moderate or severe acute malnutrition [10]. It provides significant amounts of high-quality protein, cal-

cium, vitamins A, B, C, and D, as well as minerals such as iron, zinc, and iodine [11]. These nutrients are crucial for the health, immune function, and cognitive abilities of malnourished children [12]. A randomized study found that incorporating fortified powdered milk into the diet of moderately malnourished children led to improved weight and height gains compared to the control group [13].

This study, carried out at the National Institute of Child Health (INSE) of Donka National Hospital in children aged 12 to 59 months presenting with moderate malnutrition, aims to evaluate the nutritional effectiveness of a supplement combining *P. biglobosa* flour, honey, and Nido powdered milk.

2. Materials and Methods

2.1. Study Design and Type

This was a longitudinal cohort study of children (12 - 59 months) admitted to INSE HN Donka for moderate malnutrition from October 2023 to June 2024. This study included a phase of food sampling and quality control, targeted recruitment of participants, a nutritional intervention, and regular monitoring of anthropometric parameters. It aimed to evaluate the impact of a food combination composed of *Parkia biglobosa*, honey, and powdered milk.

2.2. Study Framework

The first phase of the study was carried out at the laboratory of the National Office of Quality Control, located in Matoto (Conakry). This office is a public service with a scientific and technical vocation, placed under the supervision of the Ministry of Commerce and Industry. Its mission is to control the application of regulations relating to the quality of food consumption needs in the Republic of Guinea.

The second phase of the study took place in the neonatology department of the Institute of Nutrition and Child Health (INSE), a public institution founded in 1989 and dedicated to care, research, and training. The INSE comprises several departments: an administrative department, a neonatology department (with maternal counseling, vaccination, and physiotherapy units), a nutrition department (with renutrition, nutritional education, and milk preparation units), a research and training department, as well as a laboratory and pharmacy department (grouping together various specialized units).

2.3. Study Population

The study population consisted of children aged 12 to 59 months who came for consultation at INSE HN Donka, were diagnosed with moderate malnutrition, and whose parents/guardians gave informed consent.

2.4. Study Criteria

For the selection of children, the following criteria were observed:

2.5. Inclusion Criteria

The inclusion criteria were as follows: children aged 12 to 59 months with moderate acute malnutrition (Z-score W/H or W/A between −2 and −3 standard deviations, or mid-upper arm circumference between 11.5 cm and 12.5 cm) [14], and voluntary parents/guardians (informed consent).

2.6. Non-Inclusion Criteria

Non-inclusion criteria included children under 12 months or over 59 months, those with severe malnutrition or no malnutrition, and children with acute conditions requiring immediate hospitalization.

2.7. Sampling

Children meeting the inclusion criteria and admitted to INSE HN Donka between October 2023 and June 2024 were consecutively included using a purposive, exhaustive, hospital-based convenience sampling approach. This approach is regularly used in clinical settings to cover all available cases without resorting to formal random selection. A total of 31 children were enrolled during the study period.

2.8. Preparation and Quality Control of Food before Combining

Before any use, each food, namely *P. biglobosa* flour, honey, and Nido powdered milk, was subjected to laboratory analyses by the National Office of Quality Control (ONCQ) located in Conakry to guarantee their safety and quality. The *P. biglobosa* flour and honey were purchased in the province of Kankan and stored hermetically at room temperature. Boxes of Nestlé powdered milk (800 g) were obtained from wholesalers in Conakry.

Sensory analyses were carried out according to the standard [15] to evaluate color, odor, flavor, and texture. Simultaneously, physicochemical analyses were conducted, including pH, humidity [16], total acidity [17], Brix degree [18], and ash rate [19] of the ingredients. Finally, microbiological analyses were performed, including enumeration of Total Aerobic Mesophilic Flora [20], *Escherichia coli* [21], fecal streptococci [22], as well as yeasts and molds [23].

2.9. Recipe Preparation Methods

This was a sequential process that began by mixing 3 tablespoons of *P. biglobosa* flour in a container with 50 ml of mineral water, then boiling for approximately 2 minutes. After cooling, 1 tablespoon of Nido milk was added, stirring evenly before also adding 1 tablespoon of honey. Finally, the remaining 40 ml of water was added while continuing to mix with a spoon to obtain a smooth paste.

2.10. Data Collection

Data collection was structured around several key stages.

2.11. Nutritional Intervention

The recorded cases of moderate acute malnutrition were subjected to the *P. biglobosa* flour-honey-Nido powdered milk combination during their care period. The entire care period was thirteen (13) weeks. Each week, the child received the combination, followed by anthropometric measurements. Semi-structured interviews with parents/guardians made it possible to assess the acceptability of the formula and any challenges related to its administration. The records documented the quantity of formula consumed and the frequency of intake.

2.12. Study Variables

2.12.1. Variables of Interest

Weight gain or net weight gain

This is the weight increase from the first week to the thirteenth week (quantitative variable).

2.12.2. Adherence Score

This is the number of times you take a food supplement per day.

2.12.3. Sociodemographic Variables

- Gender: binary variable (male, female);
- Age: quantitative variable (in months);
- Origin: qualitative variable (multi-level);
- Marital status of the mother: qualitative variable (multi-level);
- Mother's profession: qualitative variable (multi-level);
- Education level: categorical variable (primary, middle school, high school and university).

2.12.4. Anthropometric Variables

- Size: quantitative variable (cm);
- Weight: quantitative variable (gram);
- Brachial Circumference (BC): quantitative variable (cm);
- The Z-score: binary quantitative variable (severe and moderate).

Anthropometric data were collected on the first day of the study and at regular intervals (weekly) to assess the children's growth. These measurements, carried out by trained personnel, were standardized to ensure their reliability [24]. These included mid-upper arm circumference (MUAC) (measured on the left arm with a non-stretchable tape to the nearest 0.1 cm), weight (measured with an electronic pediatric scale calibrated to the nearest 100 g), and height (measured with a height rod to the nearest 0.1 cm). For analysis, these data were then converted into Z-scores (weight-for-height, height-for-age, weight-for-age, and mid-upper arm circumference-for-age) based on WHO growth references [25].

2.13. Data Analysis

Data were entered and analyzed using SPSS version 22 software. Descriptive analyses focused on quantitative variables (weight, height) expressed as mean ± stand-

ard deviation and on qualitative variables as numbers and percentages. The weight gain variable was obtained by calculating the difference (Weight_S13 - Weight_S1).

The normality of the distributions was verified by the Shapiro-Wilk test, and the homogeneity of variances (sphericity) by Mauchly's test.

To compare the evolution of anthropometric parameters between the first and last week (W1 to W13) of follow-up, a repeated measures ANOVA (factor "time") was applied when the parametric conditions were satisfied (normality and sphericity, with Greenhouse-Geisser correction if necessary). In case of non-normality or violation of the parametric assumptions, a non-parametric alternative was used: the Friedman test, the non-parametric equivalent to repeated measures ANOVA [26]. The statistical significance threshold was set at 0.05 ($p < 0.05$) [27]. All analyses were two-tailed.

2.14. Ethical Considerations

Ethical approval was obtained from the Institute Ethics Committee of the National Public Health Agency. Informed consent from parents/guardians was a prerequisite for each child's participation. Data confidentiality was strictly respected.

3. Results

3.1. Sociodemographic Characteristics of Children

The most represented age group was 30 - 39 months (32.3%), followed by 20 - 29 months (29.0%). Children aged 50 - 59 months were the least numerous (3.2%). Regarding gender, boys (54.8%) were slightly more numerous than girls (45.2%). Table 1 shows the distribution of children (12 - 59 months) according to age group and gender.

Table 1. Distribution of children (12 - 59 months) by age group (months) and sex from October 2023 to June 2024 INSE HN Donka.

Features	Number of children (N = 31)	Percentage
Age group (months)		
10 - 19	7	22.6
20 - 29	9	29.0
30 - 39	10	32.3
40 - 49	4	12.9
50 - 59	1	3.2
Sex		
Female	14	45.2
Male	17	54.8

3.2. Sociodemographic Characteristics of Mothers

In terms of origin, the majority of mothers resided in Matoto (25.8%), followed

by Kaloum (22.6%) and Ratoma (19.4%). Maneah and Dixinn were the least reported origins (3.2% and 6.5%, respectively).

Marital status reveals that the vast majority of mothers were married (87.1%), which suggests a stable family structure for most of the children in the study. Single (9.7%) and divorced (3.2%) mothers were in the minority.

As for the mothers' occupation, shopkeepers represented the largest proportion (51.6%), which is an important socioeconomic factor to consider. Accountants and seamstresses had similar proportions (12.9% each), while hairdressers were the least represented (6.5%). "Other" occupations (16.1%) included civil servants and vendors. Table 2 describes the sociodemographic characteristics of the mothers of the children studied.

Table 2. Distribution of children aged 12 - 59 months according to the mother's sociodemographic characteristics from October 2023 to June 2024 INSE HN Donka.

Features	Number of employees (N = 31)	Percentage
Origins		
Coleah	2	6.5
Dixinn	2	6.5
Kaloum	7	22.6
Maneah	1	3.2
Matam	5	16.1
Matoto	8	25.8
Ratoma	6	19.4
Mothers' profession		
Hairdresser	2	6.5
Shopkeeper	16	51.6
An accountant	4	12.9
Sewing	4	12.9
Others	5	16.1
Marital status of mothers		
Bachelor	3	9.7
Divorcee	1	3.2
Bride	27	87.1

Others: Civil servants (4), merchants (1).

3.3. Anthropometric Characteristics of Children

Only 3.2% of children were between 100 - 109 cm tall. The majority of children's heights were between 80 - 89 cm (51.6%), followed by children under 80 cm (29%).

The weight-for-height (W/H) Z-score indicated that 81.3% of children had a Z-score of −2 and 18.8% had a Z-score of −1.

Regarding mid-upper arm circumference (MUAC), 87.5% of children had a MUAC between 11.5 and 12.4 cm, and 12.5% had a MUAC greater than 12.6 cm.

All children therefore met at least one of the WHO criteria for moderate acute malnutrition (MUAC 11.5 - 12.5 cm or $-3 \leq$ WHZ < -2) at baseline. Table 3 details the anthropometric characteristics of the children.

Table 3. Anthropometric characteristics of children aged 12 - 59 months from October 2023 to June 2024 INSE HN Donka.

Features	Number of employees (N = 31)	Percentage
Size (cm)		
<80	9	29
80 - 89	16	51.6
90 - 99	5	16.1
100 - 109	1	3.2
Weight/Height (W/H) Z score		
−2	26	81.3%
−1	6	18.8%
Upper Arm Circumference (MUC)		
11.5 - 12.4 cm (moderate)	28	87.5%
>12.6 cm	4	12.5%

3.4. Acceptability of the Formula

The semi-structured interviews conducted with mothers revealed high acceptability of the Néré-honey-milk mixture. Caregivers reported good palatability, improved appetite and energy among children, and willingness to continue preparing the mixture at home after the study. No adverse effects were reported.

3.5. Weight Distribution by Follow-Up Weeks

Analysis of children's weight change over the 13-week follow-up was performed using the non-parametric Friedman test, appropriate for paired data with repeated measures. This test allowed comparison of weights recorded at different follow-up time points (weeks 1, 7, and 13). The results revealed a statistically significant difference in weights measured over time (Friedman's $\chi^2 = 60.06$, $p < 0.001$).

The two-way analysis of variance by Friedman rank-ordering of related samples is illustrated in Figure 1, which presents the distribution of children's weights over the 13 weeks of follow-up.

The analysis of weight change, carried out using the non-parametric Friedman test, showed a statistically significant difference ($p < 0.001$) in the weights measured at weeks 1, 7, and 13. This result, with a chi-square value of 60.06, indicates a significant improvement in the children's weight over time, which is a positive result in the follow-up.

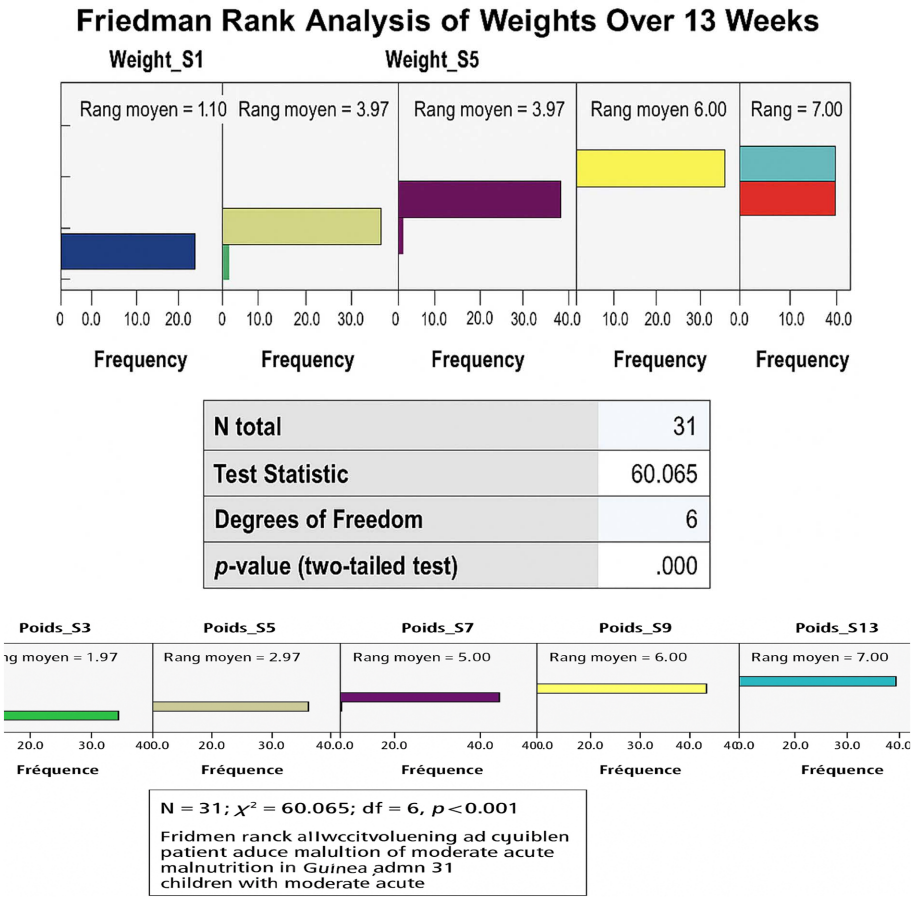

Figure 1. Friedman non-parametric test for children from S1 to S13.

3.6. Factors Associated with Weight Gain

Figure 2 explores the relationship between weight gain and children's origin.

There is no statistically significant difference according to the Kruskal-Wallis test between weight gain and the origin of the children (p = 0.600) $\alpha = 0.05$ CI 95.

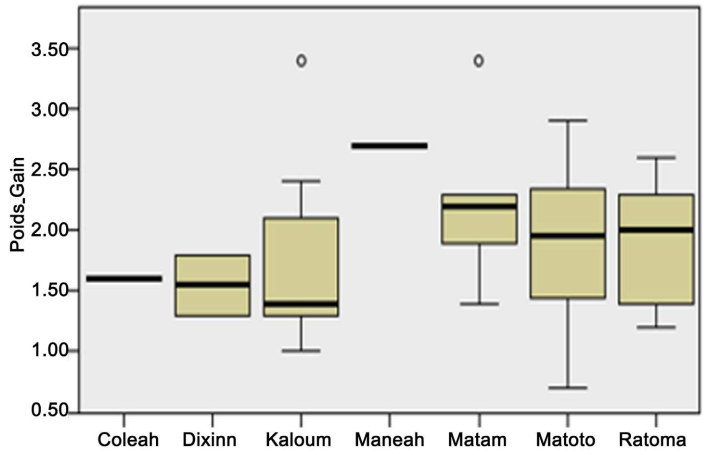

Figure 2. Weight gain distributions according to the origin of children (12 - 59 months) from October 2023 to June 2024 INSE HN Donka.

Again, the analysis (p = 0.131) reveals no statistically significant difference between children's weight gain and their mothers' marital status. Figure 3 examines the relationship between children's weight gain and mothers' marital status.

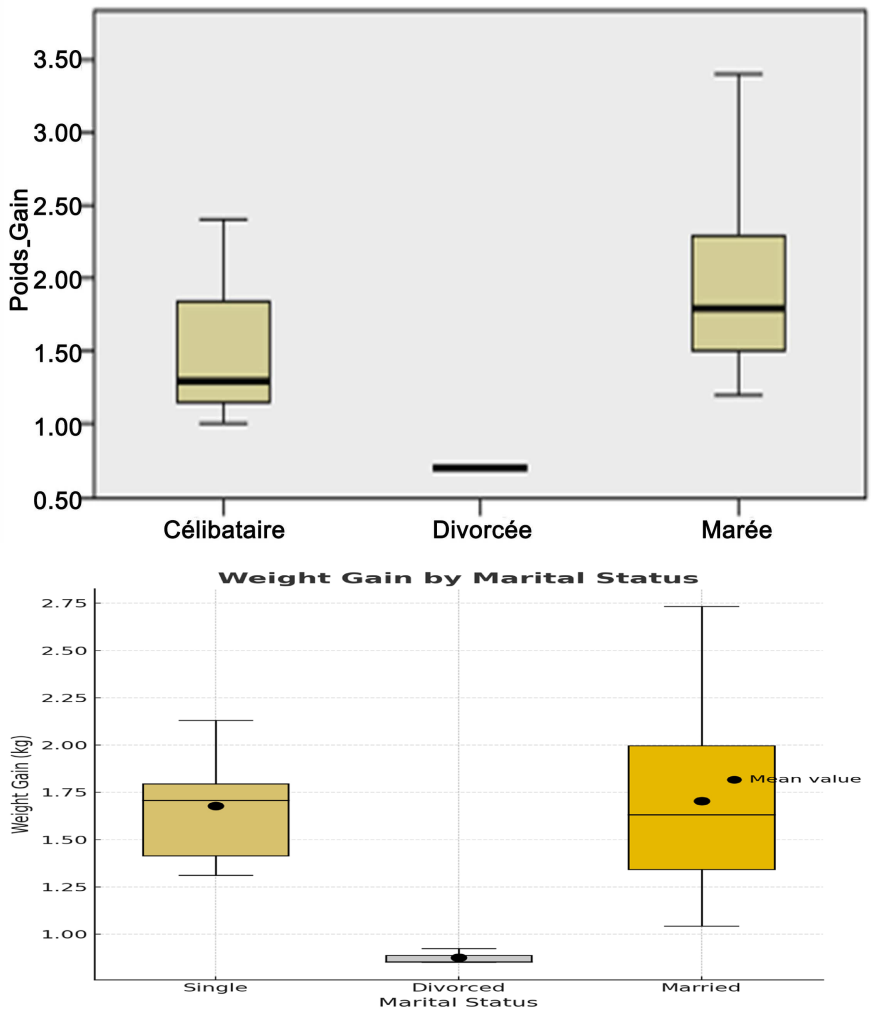

Figure 3. Weight gain distributions according to the marital status of the mothers of children (12 - 59 months) from October 2023 to June 2024 INSE HN Donka.

For age, the Kruskal-Wallis test (Chi-square = 7.686, p = 0.104) indicates no significant association between age and weight gain, although a trend can be observed with a higher mean rank for younger children (10 - 19 months).

Regarding height, there was a statistically significant association (Chi-square = 10.871, p = 0.012) with weight gain. The shortest children (<80 cm) had a higher mean weight gain rank (24.33) compared to other height groups, which could suggest that the shortest children at the start of follow-up had more pronounced weight gain.

Finally, MUAC (Chi-square = 1.47, p = 0.225) was not significantly associated with weight gain, suggesting that initial nutritional status (as assessed by MUAC) did not directly influence the weight gain observed during follow-up.

Table 4 analyzes the relationship between weight gain and children's age and height, as well as their mid-upper arm circumference.

Table 4. Weight gain, age and height, as well as their mid-upper arm circumference of children (12 - 59 months) from October 2023 to June 2024 INSE HN Donka.

	Features	Number of employees (N = 31)	Average rank	Chi-square	p-value
Weight gain	**Age (months)**				
	10 - 19	7	23.36	7686	0.104
	20 - 29	9	16.83		
	30 - 39	10	11.65		
	40 - 49	4	12.25		
	50 - 59	1	15.50		
	Size (cm)				
	<80	9	24.33	10,871	0.012
	80 - 89	16	12.25		
	90 - 99	5	13.10		
	100 - 109	1	15.50		
	Arm circumference				
	115 - 124 mm (moderate)	4	21.13	1.47	0.225
	≥125 mm (Normal)	27	15.24		

Adherence score: The mean adherence score was 8.4 ± 1.2 out of 10, reflecting a high level of compliance with the feeding protocol. No significant correlation was found between adherence score and weight gain (p = 0.24), although a positive trend was observed among children with the highest adherence.

4. Discussion

This study aimed to evaluate the nutritional impact of a preparation based on Néré (*Parkia biglobosa*), honey, and powdered milk on the weight gain of children with moderate malnutrition in Conakry, Guinea.

The results show an uneven distribution of age groups among the children in the study, with a predominance of 30 - 39 months (32.3%) and 20 - 29 months (29%). This distribution could be influenced by local demographic factors, as suggested by [28], who highlighted heterogeneities in nutritional surveys in sub-Saharan Africa. Another study conducted by [29] in Senegal showed a comparable proportion of children in these age groups, often linked to more frequent nutritional monitoring in young children.

Anthropometric data showed that the majority of children were between 80 and 89 cm (51.6%), while 29% were less than 80 cm, suggesting a diversity of linear growth patterns. Weight-for-height (W/H) Z-score indicated mild underweight

for 64.5% of children (Z-score of −2) and a moderate risk of malnutrition for 35.5% (Z-score of −3). These observations are consistent with those of Black *et al.* [1] [2], who highlighted that stunting and underweight are persistent problems in low-income countries.

At baseline, 87.5% of children had a MUAC between 11.5 and 12.4 cm, and 12.5% had slightly higher values (>12.6 cm), confirming that all participants met WHO's definition of moderate acute malnutrition. This relatively low prevalence of moderate malnutrition is encouraging, although it highlights the need to target children at risk to prevent worsening of their nutritional status, in accordance with WHO diagnostic thresholds for moderate malnutrition.

The results also demonstrated a significant increase in weight over a period of 13 weeks (Friedman test, $p < 0.001$). This observed weight gain attests to the nutritional effectiveness of the preparation used. This result corroborates the research of Bationo *et al.* [2] [8], which documented the richness in protein (27%), lipids, and micronutrients of *P. biglobosa*, thus highlighting its potential in the prevention of malnutrition in children in West Africa. Other studies have also shown the effectiveness of incorporating *Parkia biglobosa* pulp into local infant flours to improve nutritional value and acceptability, thus contributing to the recovery of malnourished children Kayalto *et al.* [30].

The lack of significant correlation between the adherence score and weight gain ($p = 0.563$) can be explained by overall high and homogeneous adherence within the sample. This observation is similar to that made by Roschnik *et al.* [31], who studied the adherence and acceptability of micronutrient powders distributed in the community in Mali, where good acceptance was reported despite challenges. These results also support the findings of Bhutta *et al.* [32], which demonstrated that targeted nutritional interventions can lead to significant weight gains in young children.

One limitation of this study is the relatively small sample size ($N = 31$), which may limit the generalizability of the results, as may the absence of a control group, which makes it difficult to assess the precise effect of the interventions. These limitations are consistent with the challenges generally encountered in community-based studies, as noted by Victora *et al.* [33].

The absence of a control group constitutes a major limitation of this study. Without a comparative arm, it is difficult to attribute the observed weight gain exclusively to the intervention. Other factors, such as natural recovery, improved clinical attention, or seasonal dietary variation, may also have contributed to the observed improvements. Future randomized controlled trials are therefore needed to confirm causality.

5. Conclusions

This study demonstrated a significant improvement in the weight of children (12 to 59 months) monitored at INSE HN Donka over a 13-week period. The socio-demographic characteristics of the children and their mothers are consistent with

the profile of an urban population. Analyses revealed that the children's origin and the mothers' marital status were not associated with weight gain. However, there was a significant association between children's height and weight gain, suggesting a recovery effect in the smallest children.

This study demonstrates that a nutritional supplement made from locally available ingredients—*P. biglobosa flour*, honey, and powdered milk—can effectively support the recovery of children with moderate acute malnutrition. Given its accessibility and cultural acceptability, this approach could be integrated into community-based nutrition programs and scaled up within Guinea's public health strategy. In the future, studies with larger samples, extended follow-up periods, and the integration of variables concerning feeding practices would be useful to better understand the factors influencing weight gain in young children.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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