EAS Journal of Nutrition and Food Sciences
Abbreviated Key Title: EAS J Nutr Food Sci
ISSN: 2663-1873 (Print) & ISSN: 2663-7308 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-7 | Issue-5 | Sep-Oct; 2025 | DOI: https://doi.org/10.36349/easjnfs.2025.v07i05.002

Original Research Article

Effects of Honey Bee Brood and Pearl Millet supplement on moderate Wasting

Kinanu Grace Safari[1]*, Dasel Wambua Mulwa Kaindi[1], Wambui Kogi-Makau[1], Diana Mwendwa Marangu[2]

[1]Department of Food Science, Nutrition and Technology, University of Nairobi
[2]Department of Pediatrics and Child Health, University of Nairobi

Article History
Received: 18.07.2025
Accepted: 08.10.2025
Published: 15.10.2025

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: ***Background:*** Poor nutritional status is a global prevailing crisis due to associated short term and long-term negative impact on individual health, social-economic development and reduced per capita productivity potential. In Kenya, childhood under-nutrition is concentrated in the Arid and semi-Arid Lands (ASALs), where it is associated with food insecurity, environmental conditions and poor child care practices. ***Objective:*** The objective of this randomized efficacy trial was to determine the effects of honey bee brood and pearl millet based supplement (PeMH+), on weight, height, MUAC, hemoglobin and wasting, as compared to Corn Soy Blend (CSB+). ***Methods:*** A total of 38 children (12-36 months) were randomized to two arms of study (with 19 children in each group) for 12 weeks, in Meru County, Kenya. Group A was fed on PeMH+ (Novel Supplement), and Group B was fed on Corn Soy Blend (CSB+) which is the conventional treatment for moderate wasting. Changes in Weight, Height, and Mid-Upper Arm Circumference (MUAC), weight for height Z-score (WHZ), Height for Age (WFH) Z-score were monitored two weekly while Hemoglobin was monitored at baseline and at the end of study so as to determine their changes and recovery rates for wasting, stunting. Pearson Chi-Square tests were employed to evaluate statistical significance of the effects of PeMH+ on weight, Height, MUAC, Weight Height Z-Score (WHZ), Height for Age Z-Score (HFA), and hemoglobin as compared to the Control (CSB+ group). ***Results****:* Cumulatively, there was an average weight, Height, and MUAC and hemoglobin change of 0.8kg, 2.1 cm, 1.1 cm and 1.9g/dl respectively for PeMH+ group A). This marked a whooping majority recovery rate (>-1 Z-score) of 94.6% from moderate wasting. No statistical difference was identified between pattern of recovery and change in weight, MUAC, WHZ between the two groups except for HFA Z-score where children were shown to gain height faster in the group A. PeMH+ significantly improved nutritional status in children by causing increase in weight, height, MUAC and hemoglobin and causing 94.6% cure of acute wasting compared with Control – CSB+. ***Conclusion:*** This pilot study suggests that a pearl millet and honey bee brood-based supplement (PeMH+) may be a promising and efficacious approach for improving nutritional status and treating moderate wasting in children aged 12–36 months. Further research with larger sample sizes is warranted to confirm these findings and assess the supplement's effectiveness in broader populations.

Keywords: Moderate Wasting, Honey Bee Brood, Pearl Millet, Wasting.

1.1 INTRODUCTION

Malnutrition remains an urgent crisis as it is coupled with Short term and long-term negative impact on individual health, social-economic development and reduced per capita productivity potential (United Nations (UN), 2010; Lloyd, 2016; United Nations Children's Emergency Fund (UNICEF), 2017; FAO, 2019a). According to the KDHS 2022, 17.6% of children under five are stunted, 5% are wasted, 10% are underweight. In comparison, Meru North (ASAL region in Meru County) registered 26%, 6% and 11% in stunting, wasting and underweight respectively (KDHS, 2022). Previous studies indicate that wasting is mainly concentrated in the Arid and Semi-arid Lands (ASALs), and the poor urban settings in Kenya (Kirogo, 2019; FAO, 2019; World Bank,

***Corresponding Author:** Kinanu Grace Safari
Department of Food Science, Nutrition and Technology, University of Nairobi

2018). While the immediate causes include inadequate dietary intake and disease, the underlying causes include food insecurity, feeding practices, and access to health services (WHO, 2010). Specifically, aggressive treatment of moderate wasting is key in prevention of deterioration to severe forms of malnutrition, relapse and alleviation of immediate and long-term consequences.

While treatment of children suffering moderate acute malnutrition (Moderate wasting) is such an urgent agenda, access to care is limited due to erratic supply of the supplements (Ministry of Health, Republic of Kenya, 2018; Ministry of Health, Republic of Kenya, 2023). Furthermore, malnutrition management strategies in ASALs must be coupled with innovations that radically cause sustainable livelihood improvement by embracing livelihood diversification, strengthening food security systems and enhancing access to nutrition interventions among other strategies. In this regard, measures to support alternative income-generating activities, promote profitable, diverse, productive and sustainable food systems, and consistent supply of supplementary foods have previously been proposed (Ministry of Health, Republic of Kenya, 2018; Ministry of Health, Republic of Kenya, 2023).

From this background, it is hypothesized that development of a food supplement from locally available foods may improve production and consumption of such foods, as well as provide an alternative income from supply of the ingredients to the supplement. This wills in-turn improves the economic status of the ASALs residents and hence nutritional status of residents.

1.2 RATIONALE AND METHODOLOGY

1.2.1: Study Participants

This study was conducted from February to June 2024 among children (12–36 months), in Meru North ASALs region of Meru County, Kenya, who were attending routine Maternal Child Health Clinic (MCH), in Igembe South and Igembe Central Sub-County hospitals. The population in these facilities was selected based on the reported high case load of acute malnutrition and location in the ASALS where pearl millet and Bee farming have consistently been emphasized for income diversification and consumption is typical.

1.2.2: Study Design

Efficacy of PeMH+ was monitored in a double blind, randomized control trial where results of children fed to this product were compared to those of children supplemented with corn Soy Blend (CSB+) which is a standard treatment for MAM. A total of 38 children (12-36 months) were randomized to two arms of study (19 in each group) for 12 weeks in Kangeta sub-County Hospital and Nyambene Sub-County Hospital in Meru, Kenya. Group A was fed on PeMH+ (Novel Supplement), and Group B was fed on Corn Soy Blend (CSB+), which is the conventional treatment for moderate wasting. Changes in Weight, Height, and Mid-Upper Arm Circumference (MUAC) were monitored two weekly while Hemoglobin was monitored at baseline and at the end of study so as to determine their changes and recovery rates for wasting. Pearson Chi-Square tests were employed to evaluate statistical significance of the effects of PeMH+ on weight, Height, MUAC, Weight Height Z-Score (WHZ), Height for Age Z-Score (HFA), and hemoglobin as compared to the Control (CSB group).

1.2.3: Intervention Supplements

PeMH+ supplement was developed by combining processed honey bee brood, pearl millet, and sugar at a ratio of 61%: 26% and 13% respectively. Pearl millet was processed through cleaning, germination, drying and milling. Honey bee brood was carefully removed from the combs, fried until crunchy, and then milled into a fine powder. The quality checks of concern included; quality and safety of raw materials, nutrient composition analysis, microbial, quality and safety of the raw materials, accelerated shelf-life evaluation, method of cooking and sensory evaluation. From the processes, the product was safe for consumption, consisting of 368 kcal, with 20.9% protein, 5.9% fat, 6.3% fiber which was comparable to CSB+ (consists of Corn, Soy and sugar to provide 380 kcal with14% protein, 6% fat, and 5% fiber). To provide an equivalent energy intake of 950 kcal (same as 250g of CSB+), participants were given 258g of PeMH+ per day. PeMH+ was packaged to 258g daily rations labeled Group A, which was distributed to the participants 2 weekly just as CSB+. Enough Corn Soy Blend was acquired from the manufacturers, repackaged to a daily ration of 250g hygienically and labeled Group B, a day prior to distribution.

1.2.3: Randomization, Monitoring and Evaluation

This was a double-blind, randomized efficacy trial of PeMH+ (Novel supplement developed from pearl millet and Honey Bee brood supplement) and CSB (conventional supplement for management moderate wasting). A total of 79 children aged 12-36 months were initially screened from the two sites (34 at Kangeta and 45 at Nyambene sub-County Hospitals). Children were assessed at the two sites consecutively as they reported at the two health facility for a period of one month. A total of 41 children were not eligible (15 at Kangeta and 26 at Nyambene) because they suffered severe anemia (hemoglobin <9.0 g/dl), taking any supplement or unwilling to participate in the study. All children at Nyambene and Kangeta hospital (19 in each), were assigned to Group A and B respectively. Baseline weight, Height, and MUAC, WHZ and HFA were computed while capillary blood was taken for hemoglobin analysis

At the beginning of the study, all participants received Antihelminthic treatment (Albendazole) and necessary information was provided to the child care givers involved in the study. The children returned to the clinic every 2 weeks for collection of food supplement rations, monitoring of anthropometric measurements and clinical assessment. Study personnel (Study nutritionists, Clinical officer, health records, and Community Health Promoters (CHPs) and participants were initially (during selection of participants) blinded on which group would consume PeMH+ or CSB+. However, due to differences in taste, color smell and preparation methods, the health care workers could not be blinded further. Each child was assigned a trained CHP who visited them daily to enable prevention of loss to follow-up, early detection of illness, mortality or feeding problems. All baseline tests and measurements were completed before the first batches of food rations were issued. In case of any illness, the participants were assessed and treated by a study clinician at the study site. Weight, height and MUAC were monitored 2 weekly, while hemoglobin was assessed at baseline and at the end of 12 weeks (end-line). The supplements were inspected by the assigned study nutritionist before issuing them out, and daily by the caregiver before use.

1.2.4: Ethics Approval

The study was approved by the Ethics and Research Committee (ERC) of the University of Nairobi and registered with National Commission for Science, technology and innovation (NACOSTI). Meru County health department, and participating health facilities research and training committees approved the study and all participants' caregivers provided their written consent to the study.

1.2.5: Quality Assurance and Data Analysis

Qualified nutritionists, laboratory technologists, one health records officer and CHPs were recruited, trained and involved in the study. They also enrolled and completed Good Clinical practices (GCP) Course and file their Curriculum Vitae to authenticate their qualifications. Three indexes of each measure (Weight, height and MUAC) were taken and an average was recorded at each visit. Weight was measured using an electronic tearing scale while length was measured using to the nearest 0.5 cm using weight/length board, and MUAC was measured with a standard MUAC tape to the nearest 0.1 cm.

Anthropometric indexes were based on the WHO's 2009 Child Growth Standards (WHO, 2009). Weight gain (nearest 0.1kg), while Change in height and MUAC were measured to the nearest 0.1cm every 2 weeks relative to enrollment parameters. Duration of recovery was computed by considering day of supplementation to the nearest 2 weeks when the child achieved WHZ>-1 Z-Score and/ MUAC >12.5cm. Comparisons of outcomes between types of supplementary foods were made using Pearson Chi-square and Fisher's exact test and likelihood ratio.

1.3 RESULTS

1.3.1 Change in Weight

At Baseline, the mean weight of children randomized to group A and B was 7.4kg and 7.8kg respectively. All children in both groups had Weight for Age (WFH) Z-Score of <-2 Z-Score.

A positive weight gain recorded at 6 weeks was an average of 7.8kg and 8.4kg for group A and B respectively with a range of 0.1 to 1 kg in A and 0.1kg to 1.3kg in B. This is an average of 0.4kg for both groups. There was no incidence of weight deterioration in both groups when evaluated by weight.

The Average weight at 12 weeks was 8.2kg for group A as compared to and 8.7kg. This is an average of for 0.4kg and 0.3kg for group A and B respectively in the feeding period of 6 to 12 weeks. Cumulatively, the average weight change for the period of 0 to 12 weeks was averagely 0.8 cm in A and 0.9kg in B.

1.3.2 Change in Height

The mean height for children randomized to group A and B at baseline was 74.3cm and 71.2cm respectively which increased to 75.3cm in group A as compared to and 72.4cm in group B at 6 weeks and to 76.4cm for A and 73.3cm for B at 12 weeks. This is an average change of 2.1cm for group A and 2.2cm for group B in the 12 weeks.

1.3.3 Change in MUAC

The mean MUAC for both groups was 12.0cm at baseline. Gradually MUAC changed to 12.6cm in A and 12.4cm in B at 6 weeks and 13.0cm and 12.8 cm at 12 weeks for A and B respectively. This is a change by 1.0cm in group A and 0.8cm in group B.

1.3.4 Change Hemoglobin (Hb)

At baseline, the average hemoglobin levels were 10.9g/dl for group A and 11.0g/dl for B. The mean Hb at 12 weeks was 12.3g/dl and 11.6g/dl for group A and B respectively. This shows that there was an increase by a mean from 10.6g/dl to 12.3g/dl and 11.0 to 11.6g/dl for Group A and B respectively. By the end of 12 weeks, there was a Cumulative average change of 1.7g/dl and 0.6g/dl in group A and B respectively.

Table 1: Changes in Weight, Height, MUAC and Hemoglobin

	Group A			Group B		
	Baseline	**At 6 weeks**	**At 12 weeks**	**Baseline**	**At 6 weeks**	**At 12 weeks**
Weight	7.4kg	7.8kg	8.2kg	7.8 kg	8.4kg	8.7kg
Height	74.3 cm	75.3	76.4cm	71.1 Cm	72.4cm	73.3cm
MUAC	12.0cm	12.6cm	13.0cm	12.0cm	12.4cm	12.8cm
Hemoglobin	10.9g/dl	-	10.3g/dl	11.0g/dl	-	11.6 g/dl
Height	74.3 cm	75.3cm	76.4cm	71.1 cm	72.4cm	73.3cm

1.3.5: Recovery

1.3.5.1: Stunting/ HFA Z-Score

At baseline, 26.3% were at <-3, 21.1% at <-2 and 52.6% at >1 HFA Z-Score in group A, while 26.3% were at -<3, 42.1% at -2 and 31.6% at ->1 Z-Score for group B. This means that 47.4% in group A and 68.4%in B had stunting. Assessment at 6 weeks showed that there was a significant change of HFA where 73.6% achieved >-1, and 26.4% were at <-2 Z-Score for group A. On the other hand, 73.6% achieved >-1, 15.8% at <-2 and while 10.5% <-3 Z-Score in group B. A drastic shift was observed at end-line with all participants converting to normal and mild stunting with a distribution of 84.2% at normal and 15.7% at >-1Z-score for group A. Comparatively, 63.2% of the children achieved the normal HFA, 26.3% were at >-1 and 10.5% remained at -3 Z-Score for children in group B. In other words, all children in Group A achieved the acceptable WFH Z-Score (-1 Z-Score), while 10.5% in group B lagged at -3 Z-score at 12 weeks in group B.

1.3.5.2: Wasting

1.3.5.2.1: Assessment by Weight Height Z-Score (WHZ)

At baseline, all children in both groups were classified as having MAM when graded by WHZ. Only 10.5% of the participants in group B did not achieve the desired WHZ of >-1 Z-Score at the end line with none at -2 and -3 Z-Score respectively. This status changed gradually especially after 6 weeks where 84.3% in Group B and 73.7% in A achieved normal status at 12 weeks.

1.3.5.2.2: Assessment by MUAC

Baseline assessment by MUAC revealed that all participants in group B had MAM (11.5 to 12.5 cm), while 89.5% and 10.5% had MAM and Normal status respectively for group A. All children exhibited MUAC increase during randomization, where 36.8% in A and 42.1% in B achieved normal status at 6 weeks and 100% in both groups at 12 weeks.

1.3.6: Anemia

Distribution of children along recovery lines revealed that pearl millet and honey bee brood supplement was able to improve hemoglobin (Hb) level in the majority of children just as in CSB+. Although there was a higher average change in Hb level in group A (1.7 g/dl) than in group B (0.6 g/dl), a greater proportion of children (81.3%) in group B attained Hb greater than 11.5g/dl than in group A (73.4%)

Table 2: Recovery by WHZ, MUAC, HFA, and Hemoglobin (Hb)

	Group A			Group B		
	Baseline	**At 6 weeks**	**At 12 weeks**	**Baseline**	**At 6 weeks**	**At 12 weeks**
			Distribution by WHZ			
<-3 Z-score	26.3%	0	0	26.3%	10.8%	10.5%
<-2 Z-score	21.1%	15.8%	0	42.1%	15.8%	0
>-1 Z-score	52.6%	84.2%	100%	31.6%	73.5%	89.5%
			Distribution by HFA Z-Score			
>-1 Z-Score	52.6	73.6%	100%	31.6	73.6%	89.5%
<-2 Z-score	21.1	26.4%	0	15.8%	15.8%	0%
_<-3 Z-score	26.3	0	0	26.6	10.5%	10.5%
			Distribution by MUAC			
>12.5 cm	0	42.6%	100%	0	42.1%	100%
11.5-12.5cm	89.9%	57.9%	0	100%	47.4	0
<11.5 cm	10.5%	0	0	0	0	0
			Distribution by Hemoglobin			
>11.5mmol/dl	21.1%	-	78.9%	15.7%	-	89.6%
<11.5mmol/dl	78.9%	-	10.5%	84.2%	-	10.5%

1.3.7.1: Height for Age Z-Score Statistics

Significantly, Children randomized to Group A (PHEM+) were shown to recover more than those in Group B (CSB+) on height basis. At least 10.5% of the children who had stunting and randomized to CSB+ group failed to achieve <-1 HFA Z-score while all children in group A converted to normal status. The p-value from Pearson Chi-Square of 0.010 was less than 0.05 which indicates a statistically significant between the recovery rates in the two groups at 12 weeks. The recovery rate for HFA in Group A was significantly higher than in B.

1.3.7.2: Wasting Statistics

No statistical difference was identified between weight changes for the 2 groups at 12 weeks as represented by the Chi-square p-value is 1.000 which is above the significance p<0.05. This means there is no statistically significant difference in recovery outcomes between Group A and Group B. Both groups had identical recovery outcomes (18 recovered, 1 not recovered in CSB group). This means that children randomized to PHEM+ and CSB+ recovered equally at 12 weeks.

All children in both groups achieved 100% recovery at 12 weeks which translates to no statistical difference between the two groups.

1.3.7.3: Hemoglobin Statistics

However, when subjected to statistical tests for significance, results on recovery from anemia showed a p-value of 0.683 in Pearson Chi-Square which was greater than 0.05. Therefore, there is no statistically significant difference in recovery from anemia between Group A and Group B. Both groups had similar recovery outcomes. This confirms that the PHEM+ supplement is effective in treatment of anemia just as CSB+.

1.3.8: Safety of the Supplement

1.3.8.1 Completion of Feeds

Table 3: Statistical Significance for HFA Z-Score, WHZ and Hemoglobin

Test	Value	df	Asymp. Sig. (2-sided)
Recovery HFA Z-Score			
Pearson Chi-Square	6.692	1	0.010
Likelihood Ratio	9.114	1	0.003
Fisher's Exact Test	—	—	0.020 (2-sided)
Recovery in wasting (WHZ)			
Pearson Chi-Square	0.000	1	1.000
Likelihood Ratio	0.000	1	1.000
Fisher's Exact Test	—	—	1.000 (2-sided)
Recovery by Hemoglobin			
Pearson Chi-Square	0.167	1	0.683
Likelihood Ratio	0.168	1	0.682
Fisher's Exact Test	—	—	0.699

Majority (78.9%) in group A and 63% in B completed their feed assigned for the day by second week while the remaining proportion in both groups consumed 75-80 percent and all participants could complete the daily ration by sixth week. Reasons given for the child not consuming whole amount of feeds included the following: low appetite for both groups and Wrong measurements and Family having shared with the patient, as compared to Amount being too much for the baby and that the Child not liking it.

Table 4: Feed Completion rates

Group		Completed >75%	Completed 75-80%	Completed 81-100%	Reasons for not completing the feeds
GROUP A (PeMH+)	At 2 weeks	0	21.1%	78.9%	-Wrong measurements -Family had consumed it together with the patient -Low appetite
	At 4 weeks	0	10.5	89.5%	
	At 6 weeks	0	0	1	
GROUP B (CSB+)	At 2 weeks	21.1%	15,7%	63.2%	-Low appetite -Amount too much for the baby -Child did not like it

During the period of study, 5.3% of participants in group A were reported ill with diarrhea and vomiting while 10.6% in group B were ill where the first child developed fever, constipation and vomiting and the second had diarrhea, and vomiting. The illness was not related to the feeds, and the children were treated with usual medication, recovered and continued with the study. No adverse effects or allergic reaction was identified. No adverse effects or allergic reaction were identified. The sick children were seen, examined and treated effectively at the study site by the study clinician. Children continued with the intervention while on medication and under close monitoring.

1.3.8.2 Stay and Exit from Study

Each child exited the study when they achieved weight for height -1 Z-score and MUAC

>12.5cm. Cumulatively, days of stay in program for both arms of study were 135 and136 for group A and B respectively. This translates to an average of 7.5 weeks for group A and 8 weeks for B. Patients who were registered as non-recovered at the end of 12 weeks of study were one in Group A and two in group B. No child deteriorated by achieving MUAC or WHZ parameters less than the measurements on admission any visit.

Table 5: Length of stay in Program

	Cumulative days of Stay	Average length of stay (weeks)	Range in Weeks	Discharge Non Recovered
Group A	**135**	**7.5**	**4-12**	**5.3%**
Group B	**136**	**8**	**4-12**	**10.5%**

1.3.8.3 Overall Satisfaction with the Supplement

At the exit of the study, participants were asked to rate how happy they were with the product that the child consumed. In group A, a whooping majority 66.4%, reported to be very happy, while 26.3% and 5.3% were happy and neutral (neither happy nor unhappy). In Group B, 63.2% were very happy, 31.6% were happy and 5.3% were neither happy nor unhappy. No participants reported to be unhappy with the product.

Similarly, most caregivers were willing to refer other caregivers to consume both supplements. In CSB+ (Group B), majority (57.9%) were very likely to refer patients to be supplemented while 42.1% were likely to refer others. In group A, 63. 1% was willing to refer while 36.9% were likely to refer others for supplementation.

The participants were allowed to give their best reason for their degree of satisfaction. The positive rating (happy and very happy), was attributed to ability of the child to gain wait, child liking it and easy cooking. The negative rating (neither happy nor unhappy), was associated with the child disliking it and the high volume of feed.

Table 6: Feed Completion rates

Group	Degree of Satisfaction			Willing to refer others	
	Very Happy	Happy	Neither happy nor unhappy	Likely	Very likely
GROUP A (PeMH+)	64.4%	26.3%	5.3%	42.1%	36.9%
GROUP B (CSB+)	61.1%	31.6%	5.3%	57.9%	63.1%

1.4: DISCUSSION

In this study, PeHM+ significantly increase in weights, Height, MUAC and hemoglobin comparable to CSB+ and hence effectively managed moderate wasting, stunting and anemia. The study identified no statistical difference between weights, MUAC and hemoglobin changes in PeMH+ and CSB+ at 6 weeks and at 8 weeks. This implies that PeMH+ treats malnutrition just like CSB+. However, there was a statistical difference between height changes between the two groups where children fed on PeMH+ were shown to acquire greater height increase than in CSB+ group.

Although data of previous studies on such a supplement are limited, the results of this study are in line with results achieved previously from studies aimed at determining efficacy of pearl millet in management of iron deficiency anemia, weight and height changes. In a study carried out among adolescents in Karnataka state, India it was demonstrated that pearl millet is efficacious in treatment and prevention of malnutrition (Anitha, 2019). Other studies reported reduction in iron deficiency anemia among children fed on pearl millet-based meals (Finkelstein, 2015; Rati, 2014; Anitha, 2021), while in another showed that children fed on pearl millet gained more height (79.2 +3.5) as compared to children fed on maize (Rati, 2014). Besides, pearl millet has pro-biotic potential hence its ability for modulating gut microbiota which alleviates malnutrition (Blanton, 2016). No previous studies aimed at testing efficacy of honey bee brood on treatment of acute malnutrition were identified.

Previous studies show that for a supplement to cause the desired change, it must provide high energy, protein and balanced fatty acids and micro-nutrients so as to meet the increased nutritional demands for growth, facilitate lean tissue recovery and replenish depleted micro-nutrients (WHO, 2012; Michaelsen, 2009; Golden, 2029).According to WHO (2023), supplementation of children with acute malnutrition should include 100-130 Kcal/kg/day. Since children included in this study consisted of children weighing 7.4 for group A and 7.8 for group B, the required energy in a supplement was estimated at 950 Kcal/day (250g) of Corn-Soy-Blended (CSB) which is conventionally used in treatment of moderate acute malnutrition (WHO, 2012, Chisti, 2014).

Previous studies highlight exemplary nutritional characteristics in honey bee brood and pearl millet indicating that they are energy dense with high protein, fats and micronutrients (*Hocking & Matsumura, 1960;* (Yadav, 2011; Saleh, 2013; Amadou, 2016; Kumara, 2016; Guiné, 2022; Safari, 2025; Gosh, 2025). Specifically, pearl millet require little rainfall to thrive with rainfall below 300 mm as compared to 600 mm for maize (Léder, 2004; Vadez 2012; Yadav 2013), has low cultivation costs, is drought resistant, has shorter harvesting days, and low vulnerability to pests and diseases (Mgonja 2012; Mweu, 2017). It is also gluten free and hence can be consumed by majority of population without causing intolerance (Singh, 2018). Studies show that simple processing will cause localize the minerals and reduce the antinutrient components in pearl millet significantly (Nithya 2007; Hassan 2006; Sade 2009; Arora, 2011; Pushparaj and Urooj 2011; Kindiki 2016).

Another nutritional aspect of advantage in PeMH is the high protein content. By combining honey bee brood and pearl millet and sugar, PeMH+ was shown to contain 20.9% as compared to 14% in CSB. Considerably, previous studies show that honey bee brood contains 35-57% protein (dry weight) (Omizek, 1985; Finke, 2005; Kim, 2018; Ghosh, 2020; Gahukar, 2011; Rumpold & Schlüter, 2013) which is higher than 18.2% - 44.4% in soybean (Sharma, 2014). Additionally, about 17 amino acids (AA) have previously been identified in Honey bee brood with a distribution where 40-45.9% and 54.1 -59,7% of the total proteins are essential and non-essential AAs respectively (Ozimek 1985; Finke, 2005; Ghosh 2016; Gosh, 2020; Kim, 2018; Gosh, 2021), as compared to 59 and 41in soybean. This is also observed in pearl millet which contains 8 to 21 percent protein (Gopalan 2003; Sade, 2003), as compared to 4.7 in maize (Gopalan 2003; Abdalla, 1998). The high constituents of essential amino acids such as leucine at 9.99µg, Phenylalanine at 7.65 µg, isoleucine 4.59 µg, and lysine 4.02 µg (per 100g) among others qualify pearl millet for classification to high chemical score foods (Mibithimwikya, 2000, Olaleye 2017) (which is not a case in maize). Specifically, Essential amino acids are beneficial for muscle growth, and repair, replenishing protein stores, restoration of immune function and growth. For instance; administration of Leucin at a rate above 150mg/kg per day is evidenced to activate protein synthesis in the muscle induces protein synthesis (Glynn, 2010; Rieu, 2006; Blomstrand, 2oo6) and also reduces muscle wasting (Wamiti, 2018; De Bandt, 2006).

Supplementation with the correct fatty acid profile is essential to supports healthy growth, weight gain, and normal metabolic function for malnourished children. Previously, studies show that wasting presents with depleted essential fatty acids which is characterized by dry skin, impaired growth, and poor immune function (Desci 1998). Pearl millet and Honey bee brood are rich sources of balanced fatty acids. Honey bee brood consists of 14.5-20.3% fatty acids (Ghosh 2016; Finke, 2005; Gosh, 2020), with Monounsaturated fatty acids (MUFAs) and saturated fatty acids at a ratio of 54%: 41% respectively. On the other hand, pearl millet predominantly consists of 75% Polyunsaturated fatty acids (Goswami, 2020), primarily linoleic acid (40-52%), followed by oleic acid (20-31%) although saturated fatty acids like palmitic acid (17-25%) and stearic acid (1.8-8%) are also present, though in lower proportions (Sharma 2015; Ragaee, 2006, Nani, 2015; Sharma, 2015, Goswami, 2020).

Micro-nutrient deficiencies are often coupled with wasting. Pearl millet consists of ash value of 1.6 to 5.9 (Sade, 2009; Adeola 1995; Abdalla, 1998; Gopalan, 2003) with iron levels of 70–180 (Abdalla, 1998; Gopalan 2003; Sade, 2009), while honey bee brood contains 2.160 ± 0.202% (Chakravorty 2011), with Iron at 4.7 to 6.0. A combination of the two can reasonably result to iron to meet the recommended 18-30mg in a supplement. Pearl millet is a rich source of vitamin A, niacin, zinc, iron, magnesium, manganese, copper, phosphorous, and potassium (Gopalan, 2003). This confirms the results of the efficacy of PeMH+ in treatment of iron deficiency Anemia. These results are also consistent with previous studies where pearl millet has been shown to improve blood hemoglobin (Finkelstein, 2015; Rati, 2014; Anitha, 2021).

In this study, PeMH+ flour was prepared so as to mimic CSB in relation to total energy. PeMH_ was determined to be safe for use among children 12-36 months who have MAM. When tested, it was determined that it was free from harmful micro-organisms, with storability length of 6 months before being fed to the children. Additionally, it produced a high level of satisfaction among participants. Secondly, there was weight, height and MUAC gain, no adverse reactions, mortality, deterioration, clinical indications or unpleasant observations on the product indicating safety threats from PeMH+ is safe for use as a supplement. Besides, all children were able to complete feeds, caregivers were satisfied with the product, were willing to refer others to the feeding program and all participants completed the study in good health. These desirable effects could have been boosted by some characteristics in pearl millet and honey bee brood. For example, pearl millet is specifically gluten free (Singh, 2018) hence child with celiac disease did not exhibit intolerance.

According to Vadez, (2012) pearl millet requires little rainfall to thrive. It thrives and yields with rainfall below 300 mm as compared to 600 mm for maize (Léder, 2004; Vadez 2012). Other studies show that cultivation costs for pearl millet is low cost, is drought resistant, has shorter harvesting days, and low vulnerability to pests and diseases (Rathi, Kawtra, & Sehgal, 2005; World Bank, 2006). Studies show that simple processing will cause localization of the minerals, reduce the anti-nutrients and the gastorgenic components in pearl millet significantly (Nithya 2007; Hassan 2006; Sade 2009; Arora, 2011; Pushparaj and Urooj 2011; Kindiki 2016).

On the other hand, beekeeping requires little input, labour, land and does not rely on nature of soil. In Kenya, it can be carried out successfully in 80% of the country, including ASALS where crop agriculture is difficult (Government of Kenya (GoK), 2008; Hussein, 2001). Since removal of brood combs is a considerable way to enhance maintenance of the hive, and control of bee hive pest (*Varroa destructor* mite), (Anderson, 2000), honey bee brood is a product on increase and is readily available. With careful removal of the honey bee brood from the comb and immediate drying, the production and storage is made possible.

Owing to the excellent nutritional and biophysical characteristics of pearl millet and honey bee brood, the to be effectively produced in the ASALs, and evidence of ability to effectively treat malnutrition, embracing PeMH+ in treatment of malnutrition will not only provide a solution to treatment of the cases but would also solve the problem of erratic supply, providing an alternative source of income, livelihood support and hence alleviating the vicious cycle of malnutrition. This is because, increased demand for pearl millet and honey bee brood will possibly cause adoption of better variety, attract more research, and the potentially transform the economic situation of the ASALs regions. This would mean more honey bee farming and research and job opportunities which can be customized to include women and persons living with disability and hence increased per capita production in the ASALs.

1.5: CONCLUSION

In conclusion, consumption of PHEM+ (nutritional supplement developed from Pearl millet and Honey bee brood) causes positive weight, height, MUAC and hemoglobin changes and satisfactorily cures wasting, stunting and iron deficiency anemia. It is safe for treatment of MAM and adoption for commercialization will not only treat malnutrition cases but also provide a lasting solution for erratic supply of supplementary feeds in ASALs, and transform the economy of ASAL livelihoods by providing an additional income.

1.6: Recommendations for Further Research

The following further research is suggested:

1. To conduct similar randomization studies to strengthen this evidence
2. Genomics and Bio-informatics of honey bee brood with focus to improve breeding programs for healthier and more productive bees.
3. Effects of Consumption of PeMH on gut microbiota

REFERENCES

- Amadou I., Gounga M., Le G., (2013). Millets: nutritional composition, some health benefits and processing-A review. Emir J Food Agric; 1: 501-508.
- Anderson, D. L., & Trueman, J. W. H. (2000). Varroa jacobsoni (Acari: Varroidae) is more than one species. Experimental & applied acarology, 24, 165-189.
- Anitha, S., Kane-Potaka, J., Botha, R., Givens, D. I., Sulaiman, N. L. B., Upadhyay, S., ... & Bhandari, R. K. (2021). Millet can have a major impact on improving iron status, hemoglobin level, and in reducing iron deficiency anemia–a systematic review and meta-analysis. *Frontiers in nutrition*, *8*, 725529.
- Anitha, S., Kane-Potaka, J., Tsusaka, T. W., Tripathi, D., Upadhyay, S., Kavishwar, A., ... & Nedumaran, S. (2019). Acceptance and impact of millet-based mid-day meal on the nutritional status of adolescent school going children in a peri urban region of Karnataka State in India. *Nutrients*, *11*(9), 2077.
- Arora S, Jood S., & Khetarpaul N., (2011). Effect of germination and probiotic fermentation on nutrient profile of pearl millet-based food blends. Br. Food J; 113(4): 470-81.
- Blanton L.V., Charbonneau M. R., Salih T., Barratt M. J., Venkatesh S., Ilkaveya O., *et al.,* (2016). Gut bacteria that prevent growth impairments transmitted by microbiota from malnourished children. Science. 351: aad3311.
- Decsi T, Molnár D, Koletzko B. (1998). The effect of under- and overnutrition on essential fatty acid metabolism in childhood. Eur J Clin Nutr. 1998 Aug; 52(8):541-8. doi: 10.1038/sj.ejcn.1600607. PMID: 9725653.
- FAO (2019a). FAO and the 2030 agenda for sustainable development goals: Accessed at: https://www.fao.org/sustainable-development-goals/overview/fao-and-the-2030-agenda-for-sustainable-development/food-security-and-the-right-to-food/en/
- FAO, IFAD, UNICEF, WFP and WHO (2018). The State of Food Security and Nutrition in the World 2018. Building climate resilience for food security and nutrition. Rome, FAO.ISBN 978-92-5-130571-3
- Finkelstein J.L., Mehta S., Udipi S.A., Ghugre P.S., Luna S.V., Wenger M.J., Murray-Kolb L.E., Przybyszewski E.M., Haas J.D. A., (2015). Randomized Trial of Iron-Biofortified Pearl Millet in School Children in India. *J. Nutr.* 145:1576–1581.
- Ghosh S., (2025). Honey bees and their brood: a potentially valuable resource of food, worthy of greater appreciation and scientific attention. World Journal of Ecology; 1(1)

- Goswami, S., Asrani, P., Ali, T.P.A., Kumar, R.D., Vinutha, T., Veda, K., Kumari, S., Sachdev, A., Singh, S.P., Satyavathi, C.T., Kumar, R.R. and Praveen, S. (2020). Rancidity matrix: Development of biochemical indicators for analysing the keeping quality of pearl millet. *Food Analytical Methods.* 13(11): 2147-2164.
- Government of Kenya (GoK). (2008). Economic Survey. Nairobi: Government Printer.
- Guiné, R.P.F.; Florença, S.G.; Correia, P.M.R.; Anjos, O.; Coelho, C.; Costa, C.A (2022). Honey Bee (Apis mellifera L.) Broods. Composition, Technology and Gastronomic Applicability. Foods; 11, 2750.
- Hassan A.B., Ahmed I.A.M, Osman N.M., Eltayeb M.M., Osman G.A., Babiker E.E., (2006). Effect of processing treatments followed by fermentation on protein content and digestibility of pearl millet (Pennisetum typhoideum) cultivars. Pakistan J Nutr; 5(1): 86–9
- Hocking B, Matsumura F.(1960). Bee brood as food. Bee World;41(5):113–20.
- Hussein, M. H. (2001). Beekeeping in Africa: INorth, East, North-East and West African countries. Proceedings of the 37th International Apicultural Congress, 28 October – 1 November 2001, Durban, South Africa
- KDHIS (Kenya District Health information system), (2020). Kenya District Health information system data. accessed at: https://hiskenya.org on 15/10/2020
- Kenya National Bureau of Statistics (KNBS) (2010b). Kenya National Bureau of Statistics. 2009 population and housing census highlights. http://www.knbs.or.ke/CensusResults/KNBS Brochure.pdf
- Kinanu G. S., Dasel Wambua M. K., Wambui K.M., Diana M. M., (2024). Insects for Food: A Review of Potential Characteristics in Honey Bee Brood and Pearl Millet for Malnutrition Prevention and Resolution. *EAS J Nutr Food Sci, 6*(6), 147-154.
- Kindiki M., (2016). Development of a nutritious composite flour from pearl millet (pennisetum glaucum) and pumpkin fruit (cucurbita pepo-variety styriaca). Accessed on 15/12/2020 At: https://ir.jkuat.ac.ke.
- Kirogo V., (2019), Kenya Nutrition Situation Overview Arid and Semi-Arid Areas. Kenya Food and Nutrition Security Seasonal Assessments; Accessed at: http://www.nutritionhealth.or.ke/wpcontent/uploads/infographics/Infographic%20Kenya%20Nutrition%20Situation%20Arid%20and%20SemiArid%20Areas%20%E2%80%93%20July%202019.pdf
- KNBS (2015). Ministry of Health/Kenya, National AIDS Control Council/Kenya, Kenya Medical Research Institute, and National Council for Population and Development/Kenya (2015)
- Kumara C., Moses S., Bantilan C., Borikar S., Gupta S., Rai K., (2016). Pearl Millet Technology Adoption and Impact Study in Maharashtra. Research Report 71.
- Léder I., (2004). Sorghum and millets. Cultivated plants, primarily as food sources, 1, 66
- Lloyd-Still J.D., Hurwitz I., Wolff P.H., Scwachman H. (1974). Intellectual development after severe malnutrition in infancy. *Pediatrics.* 54: 306
- Mgonja M., Shiferaw B., Mitaru, B., & Obare, G. (2012). An assessment of the sorghum and millet sub-sector in ECA: Towards better integration and exploitation of productivity enhancement and market opportunities. International Crops Research Institute for the Semi-arid Tropics (ICRISAT), Eastern and Southern Africa, Nairobi, Kenya.
- Ministry of Health, Republic of Kenya (2018). Kenya National Nutrition Action Plan (KNAP) 2018–2022: Popular Version. Nairobi, Kenya.
- Ministry of Health, Republic of Kenya (2023). Kenya National Nutrition Action Plan (KNAP) 2018–2022: Popular Version. Nairobi, Kenya.
- Mweu B., (2017). Adaptability of Pearl Millet Varieties in the Semi-Arid Kitui County of Kenya [Dissertation]; South Eastern Kenya University.
- Nithya, K. S., Ramachandramurty, B., & Krishnamoorthy, V. V. (2007). Effect of processing methods on nutritional and anti-nutritional qualities of hybrid (COHCU-8) and traditional (CO7) pearl millet varieties of India. *J. of Bio. Sci, 7*(4), 643-647.
- Pushparaj F.S, Urooj A (2011). Influence of processing on dietary fibre, tannin and in vitro protein digestibility of pearl millet. Food and Nutrition Sciences; 2(8):895-900
- Rati S.A., Jawadagi S., (2014). Prevalence of anemia among adolescent girls studying in selected schools. Int. J. Sci. Res. 3:1237–1242.
- Sade F.O., (2009). Proximate, antinutritional factors and functional properties of processed pearl millet. *J Food Technol*; 7:92–97.
- Saleh A., Zhang Q., Chen J., Shen Q., (2013) Millet grains: nutritional quality, processing, and potential health benefits. Compr Rev Food Sci Food Saf 12: 281-295.
- Sharma, M., Yadav, D.N., Singh, A.K. and Tomar, S.K.(2015). Rheological and functional properties of heat moisture treated pearl millet starch. *Journal of Food Science and Technology* 52: 6502- 6510.
- Singh, N., Singh, S.P., Kumar, M., Kanhiya, K. and Kumar, A. (2018). Nutri cereal pearl millet: Way forward. *International Journal of Current Microbiology and Applied Sciences* 7(6): 578-581.
- UNICEF-WHO-World Bank Group (WBG) (2017). Levels and Trends in Child Malnutrition, UNICEF-WHO-World Bank Group Joint Child

Malnutrition Estimates. (Key Findings of the 2017 edition) (Available at: website) http://www.who.int/nutgrowthdb/jme_brochoure2017.pdf?ua=1

- United Nations (UN) (2010), World Population Monitoring: Focusing on Health, Morbidity, Mortality and Development - A Concise Report. United Nations, Department of Economic and Social Affairs
- Vadez V, Hash T, Bidinger F R, Kholova J. (2012). Phenotyping pearl millet for adaptation to drought. Frontiers in Physiology, 3, 386.
- WHO (2010). WHO, Global Recommendations for Physical Activity for Health, 2010
- WHO (2017). WHO: Double-duty actions for nutrition. Policy Brief WHO/NMH/NHD/17.2
- WHO (2012). Technical note: supplementary foods for the management of moderate acute malnutrition in infants and children 6–59 months of age. Geneva, World Health Organization.
- WHO, (2023). WHO guideline on the prevention and management of wasting and nutritional oedema (acute malnutrition) in infants and children under 5 years. Geneva: World Health Organization; 2023. Web Annex H, Optimal dietary management for moderate wasting: quantity and duration. Available from: https://www.ncbi.nlm.nih.gov/books/NBK601639/
- Yadav, R., Sehgal D., and Vadez V., (2011). Using genetic mapping and genomics approaches in understanding and improving drought tolerance in pearl millet. J. Exp. Bot. 62, 397–408. doi: 10.1093/jxb/erq265

Cite This Article: Kinanu Grace Safari, Dasel Wambua Mulwa Kaindi, Wambui Kogi-Makau, Diana Mwendwa Marangu (2025). Effects of Honey Bee Brood and Pearl Millet supplement on moderate Wasting. *EAS J Nutr Food Sci, 7*(5), 146-155.