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Performance of Nutritionally Optimized Millet Porridges in the Rehabilitation of Severely Malnourished Children at Mulago National Referral Hospital, Uganda

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Authors' contributions

This work was carried out in collaboration between all authors. Author BEI designed, carried out the study, analyzed the data and wrote the final manuscript under the supervision and guidance of authors MKS, KGE and GWM. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aim: To evaluate the performance of nutritionally optimized millet porridges against F-100 which is a therapeutic food recommended by World Health Organisation for rehabilitating severely malnourished children.
Study Design: Controlled and longitudinal.
Place and Duration of Study: Mulago Hospital, Uganda from January to March 2014.
Methodology: Severely malnourished children in the rehabilitative stage of their treatment were randomly divided into three groups with 26 to moringa group, 25 to pumpkin group and 25 to F-100 group. In addition to the local diet, the experimental groups were fed on fermented millet porridges of either 7% *Moringa oleifera* leaf powder or 17% *Curcubita maxima* flesh powder while the control

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group was fed on F-100. The children were assessed for weight, haemoglobin, serum iron, zinc and vitamin A levels before and after the controlled feeding.
Results: Majority of the children were discharged after six days of rehabilitation. By the sixth day, weight gain/kg body weight for moringa and pumpkin groups were 97 and 79% respectively of weight gain/kg body weight achieved for F-100 group. The mean haemoglobin, serum iron, retinol and zinc levels for all groups remained below normal even at the point of discharge. Moringa group however had their mean haemoglobin and serum retinol levels increased significantly from 9.57±0.28 to 10.19±0.30 g/dl and 0.55±0.04 to 0.69±0.06 µmol/l at P =.02 and =.01 respectively, while pumpkin group had only their serum retinol levels significantly increased from 0.58±0.04 to 0.78±0.09 µmol/l at P =.01. F-100 group had neither their haemoglobin nor the other micronutrients levels significantly increased. By day six, all children in F-100 group were discharged while only 97 and 92% in moringa and pumpkin groups respectively were discharged.
Conclusion: Nutritionally optimized millet porridges performed well compared to F-100. They can therefore be relied upon to avoid relapses in malnutrition conditions after children are discharged.

Keywords: Performance; nutritionally optimized; rehabilitation; malnourished children and Uganda.

1. INTRODUCTION

Almost 10 million deaths occur annually among children below 5 years of age with malnutrition rates of underweight, stunting, and wasting at 19%, 15% and 15%, respectively [1]. Globally, more than 29 million suffer from severe acute malnutrition with Asia and Africa being the most affected regions contributing 71% and 28% respectively [2]. Severe acute malnutrition entails serious and often fatal complications if not properly treated. Therapeutic rations and micronutrient supplements are commonly being used for nutritional rehabilitation of malnourished children in Africa with positive results. Examples of such rations and foods include, Corn Soy Blend, (CSB), Unimix, Ready to Use therapeutic foods and F-100 [3]. These food rations have proved effective in nutritional rehabilitation of malnourished children. However, they are expensive, require donor agencies or government support, and are available only at nutritional rehabilitation centres or as food relief to communities. Once malnourished children are rehabilitated and discharged; or support by government or donor agencies discontinued, the children frequently experience relapse in their malnutrition conditions, and have to be taken back to the nutrition rehabilitation centres.

Persistently high malnutrition levels of over 40% have been reported among children below five years in the Western part Uganda where millet porridges are common complementary foods [4,5]. Fermentation and judicious blending of locally available foods has been encouraged as a measure of improving nutrient intake among children in areas with limited resources [6]. Millet (*Eleucine coracana*) porridge forms an abundant source of protein, iron, energy, calcium and zinc among households with low income in Africa [7]. *Moringa oleifera* is the best known of the 13 species of the genius moringacae. The leaves are eaten throughout West Africa and parts of Asia and have been used to combat malnutrition especially among infants and nursing mothers [8]. Pumpkin (*Curcubita maxima*) is a gourd-like squash of the genus cucurbita and family cucurbitaceae. It is a herbaceous running plant characterized by presence of large and bristly leaves that bear large, yellow and solitary flowers from which the fruit eventually develop [9]. Many disease-fighting nutrients such as potassium, pantothenic acid, magnesium, vitamin C and E, iron and zinc are found in large quantities in the pumpkin flesh [10]. This study formed part of a big study done in the rural areas of Western Uganda. Millet flours with either 7% *Moringa oleifera* leaf powder or 17% *Curcubita maxima* (pumpkin) flesh powder had been formulated so as to provide not less than 60% daily requirements of protein, iron, zinc and vitamin A for children aged 7-24 months in rural communities of Western Uganda [11]. The flours were fermented using lactic acid fermentation starter cultures prepared according to a method described by Mbugua [12]. They were each slurred with water (50% solids), inoculated with 5% starter culture and incubated at room temperature for up to 24 hours.

F-100 is composed of dry skimmed milk, sugar, vegetable oil, vitamin and mineral mix. It is specifically formulated to improve on the weight of severely malnourished children in inpatient care after they have recovered from medical complications and regained appetite [3]. Studies have demonstrated its effectiveness in the nutritional rehabilitation of severely malnourished children in many countries including Senegal [13] and Sierra Leone [14]. The study was done at Mwanamugimu Nutrition Unit of Mulago National Referral Hospital which is the largest rehabilitation centre with institutionalized undernourished children in Uganda. Majority of the children are admitted with severe acute malnutrition and clinical manifestations of edematous and non edematous kwashiorkor. They are first monitored in the stabilization ward and treated for all ailments before the nutrition rehabilitation phase.

This study therefore evaluated the therapeutic values of fermented millet porridges with either moringa leaf powder or pumpkin flesh powder against F-100, the hospital ration used for rehabilitating children with severe acute malnutrition.

2. MATERIALS AND METHODS

2.1 Materials

Moringa and pumpkin optimized millet porridges were used as experimental feeding rations while F-100, the therapeutic food used by Mulago national referral hospital was used as the control. The porridges were composed of water, millet flour, 5% sugar and either 7% moringa leaf powder or 17% pumpkin flesh flours. Two hundred millilitres of slurries made from 15% and 13% fermented millet flour solids of either moringa-millet or pumpkin-millet respectively were each mixed with 1 litre boiling water and brought to boil on a gas cooker. The porridges were allowed to simmer for 5-10 minutes and cooled to around 40℃ before being served to children. Table 1 shows the nutrient composition of the porridges.

The energy, protein, retinol and zinc content in F-100 were higher compared to the amounts in the porridges. Only the iron content in the porridges was higher than in F-100. Iron sulphate is usually added to F-100 for those children with clinical signs of anaemia after they have started gaining weight [3].

Nutritionally optimized millet porridges had inhibitory effect against test pathogens *E. coli, S. aureus, S. typhi* and *S. shiga* [11].

2.2 Methods

The study was controlled and longitudinal in design. This involved administering feeding trials among three groups of children randomly selected basing on the type of feed. They formed a total of 76 children and were randomly divided into 26 to moringa group, 25 to pumpkin group and 25 to F-100 group (the control).

2.2.1 Criteria for selecting study children

Children selected for the study were aged 7-36 months, severely malnourished (z-score of ≤ -3) and with no medical complications.

2.2.2 Baseline characteristics of study children

The study children had their baseline characteristics as shown in Table 2 and differences in the selected characteristics between the three children groups were not significant (*P* > .05).

2.2.3 Feeding regiment for the study children

The children's feeding regiment is shown in Table 3. All groups were provided with cornsoy blend, at 6.00 am and a traditional dish at 12.00 pm (midday) and 6.00 pm. The control group got F-100 four times within 24 hours at 9.00 am, 3.00 pm, 9.00 pm and 12.00 am (midnight), while experimental groups were given F-100 ration only at 12.00 am (midnight). The traditional dish was composed of either beans or peanut sauce enriched with silverfish powder, along side a starchy food like rice, maize meal, plantain, cassava (manioc) or potatoes. To determine feed intake by children, clear records of amounts served and amounts left were weighed and recorded.

Table 1. Composition of ready to feed porridges and F-100 per 100 mililitres

Food type	Energy (kcal)	Protein (g)	Retinol (µg)	Iron (mg)	Zinc (mg)
F-100	100	2.9	154.4	0.4	2.3
Moringa-millet	50.0	1.4	44.3	2.4	0.4
Pumpkin-millet	43.8	1.2	37.4	1.2	0.3

Table 2. Baseline characteristics of study children basing on rehabilitation group

Variable	F-100 group (n=25)	Moringa group (n=26)	Pumpkin group (n=25)	P- value
Age (Mean±se)	17.0±1.0	17.8±1.3	16.9±1.7	.54
Nutritional status (Mean±se)				
Weight-for-age z-score	-3.7±0.21	-3.7±0.38	-3.7±0.27	.69
Height-for-age z-score	-3.5±0.25	-3.5±0.40	-3.5±0.26	.19
Weight-for-height/length z-score	-3.2±0.46	-3.4±0.43	-3.4±0.69	.13
Sex				
Male	50.0%	53.8%	50.0%	
Female	50.0%	46.2%	50.0%	.95
Immunisation status				
Fully immunised	48%	49.2%	40%	
Partially immunised	52%	50.8%	60%	.18
Vitamin A supplementation				
Received	72%	70%	76%	
Not received	28%	30%	24%	.15
Breastfeeding status				
Still breastfeeding	12.0%	11.6%	12.0%	
Not breastfeeding	88.0%	88.4%	88.0%	.46

Table 3. Feeding regime for the children basing on rehabilitation group

Time	Control (F-100 group)	Pumpkin group	Moringa group
6.00 am	Cornsoy blend	Cornsoy blend	Cornsoy blend
9.00 am	F-100	Pumpkin-millet	Moringa-millet
12.00 pm	*Traditional dish	*Traditional dish	*Traditional dish
3.00 pm	F-100	Pumpkin-millet	Moringa-millet
6.00 pm	*Traditional dish	*Traditional dish	*Traditional dish
9.00 pm	F-100	Pumpkin-millet	Moringa-millet
12.00 am	F-100	F-100	F-100

**Traditional dish = Composed of either beans or peanut sauce enriched with silverfish powder alongside a starchy food like rice, maize meal, plantain, Cassava (manioc) or potatoes*

2.2.4 Measurement of children's nutritional status

This was done basing on WHO's guidelines [15]. Standing height/length was taken using Short's Height Measuring Board (Short Productions, Woonsocket, RI). Weight measurements were taken daily before the 9.00 am feed using light weight-SECA mother-infant scales with a digital screen that was designed and manufactured under the guidance of United Nations Children's Emergency Fund (UNICEF). Rate of weight gain was calculated as follows;

Rate of weight gain =

$$\frac{Final\ weight - Initial\ weight}{Initial\ weight \times study\ period\ in\ days}$$

Nutritional status indices were calculated using Emergency Nutrition Assessment (ENA) for SMART 2010 software [16] and interpreted using WHO 2006 reference standards.

2.2.5 Children's biochemical measurements

Biochemical measurements were done before and after the interventional feeding. Blood samples were drawn for analysis of haemoglobin, serum iron, zinc and retinol. This was done before the first meal in the morning by a qualified medical laboratory technologist. Haemoglobin levels were analyzed onsite using a portable battery powered HaemoCue machine (HaemoCue AB, Angelholm, Sweden). Prevalence of anaemia was determined using World Health Organization's cut off values of 11.0 g/dl haemoglobin [17]. Serum retinol was determined using high-performance liquid chromatography [18] and any child below 0.825 µmol/l was considered serum retinol deficient [19]. Serum zinc concentrations were analyzed with flame atomic absorption spectrophotometer

[20] and values less than 10.0 µmol/l were categorized as deficient [21]. Serum iron was determined using calorimetric method and a cut off of <9.0 µmol/l was used for iron deficiency [22].

2.2.6 Disease incidences during the rehabilitation period

Disease incidences during the rehabilitation period were documented after examination by medical doctors. Laboratory tests were frequently carried out for malaria and other infections. Clinical conditions were defined as the number of times a child developed a medical condition/disease.

2.2.7 Discharge criterion from the nutritional rehabilitation unit

Children were discharged by medical doctors if they persistently gained weight, were clinically healthy and had improved appetite which was measured by increment in daily feed intake.

2.3 Statistical Analysis

Data was entered, cleaned and analyzed using SPSS software (Statistical Package for Social Scientists) version 20.0 for windows (*SPSS*, *Inc., Chicago IL*). Analysis of Variance (ANOVA) and Chi-square tests were used to analyze data. Paired t-test was used to compare pre-intervention and post-intervention results, and the difference statistically tested for significance at $P < .05$.

2.4 Ethical Clearance

The design and ethics of the study was reviewed and cleared by The Aids Support Organisation (TASO) internal review board (TASOIRC/029/13-UG-IRC-009), and then approved by the Uganda National Council of Science and Technology (HS 1315). Informed consent from children's mothers/caregivers was given by signing a consent form.

3. RESULTS

3.1 Feed Intake by the Study Children

Fig. 1 shows the feed intakes for the children over the rehabilitation period. The feed intakes for children taking moringa-millet and pumpkin-millet porridges were higher than those feeding on F-100 and increased at a higher rate. Feeds for the pumpkin group increased slightly higher than for moringa group. It is therefore apparent that the porridges were more palatable than F-100 as demonstrated by their intake.

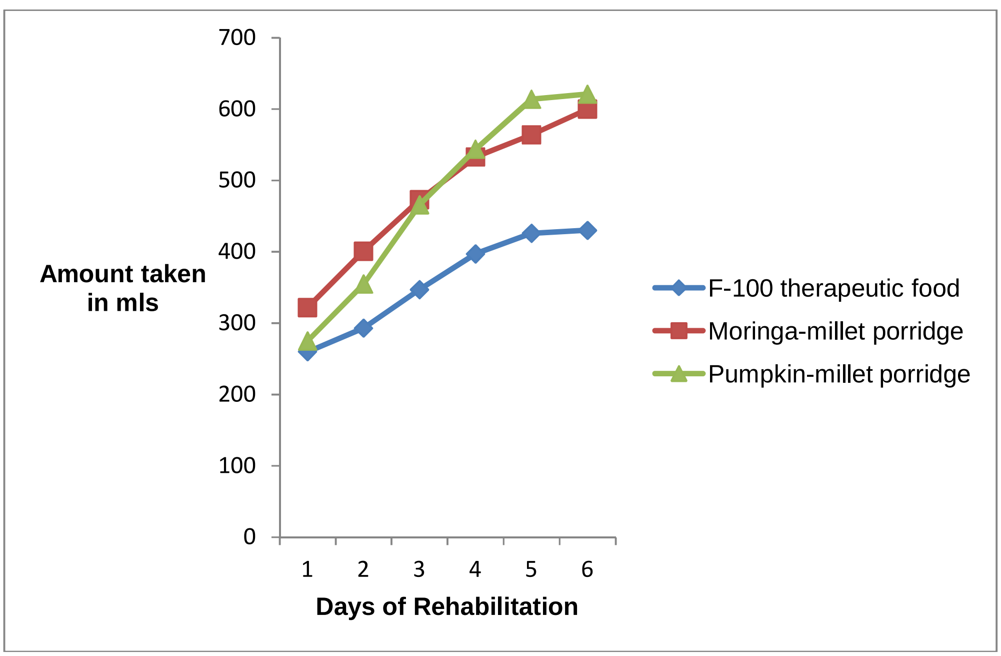

Fig. 1. Average feed intakes over the first six days of rehabilitation

3.2 Nutrient Intake from Optimized Millet Porridges Compared to F-100

Table 4 shows the average nutrient intake by the study children over the rehabilitation period. The calculated mean protein, vitamin A and zinc intakes from F-100 were significantly higher than from moringa and pumpkin optimized millet porridges at $p<0.01$. However mean iron intake for moringa-millet porridge fed children was significantly higher than for the other two groups at $p=0.02$. There was no significant difference in the energy intake per kg body weight/day among the three rehabilitation groups. Children feeding on F-100 therefore received significantly higher protein, vitamin A and zinc compared to those feeding on moringa and pumpkin optimized millet porridges while children feeding on moringa-millet porridge received significantly higher amounts of iron.

3.3 Weight Gain for the Study Children

The daily weight gain per kg body weight for the study children are shown in Fig. 2. Weight gain/kg body weight for children feeding on F-100 increased rapidly to a maximum of 97.2 g on the 5th day, while weight gain/kg body weight for children feeding on moringa and pumpkin optimized millet porridges continued to increase, even on day six when majority of children were discharged. By the sixth day, weight gain per kg body weight for children fed on moringa and pumpkin optimized millet porridges were 97 and 79% respectively of weight gain/kg body weight achieved for children fed on F-100.

3.4 Effect of Moringa and Pumpkin Optimized Millet Porridges on Haemoglobin, Serum Iron, Zinc and Vitamin A Status of the Study Children

Table 5 shows the effect of feeding children on optimized millet porridges and F-100 on their haemoglobin, serum iron, zinc and retinol levels. The haemoglobin and serum micronutrient levels in children were measured twice, at the baseline, before feeding them with the rations, and at the time of discharge, 5-7 days later. The mean baseline haemoglobin levels and the serum iron, zinc and vitamin A levels were below normal on admission. At the time of discharge, children fed on moringa-millet porridge had their mean haemoglobin and serum retinol levels significantly increased from 9.57±0.28 to 10.19±0.30 g/dl and 0.55±0.04 to 0.69±0.06 µmol/l at P=.02 and .01 respectively, but did not reach the normal. Children fed on pumpkin-millet porridge had only their mean serum retinol levels significantly increased from 0.58±0.04 to 0.78±0.09 µmol/l at P=.01, but still did not reach the normal. Children fed on F-100 had neither their haemoglobin nor the other micronutrients significantly increased.

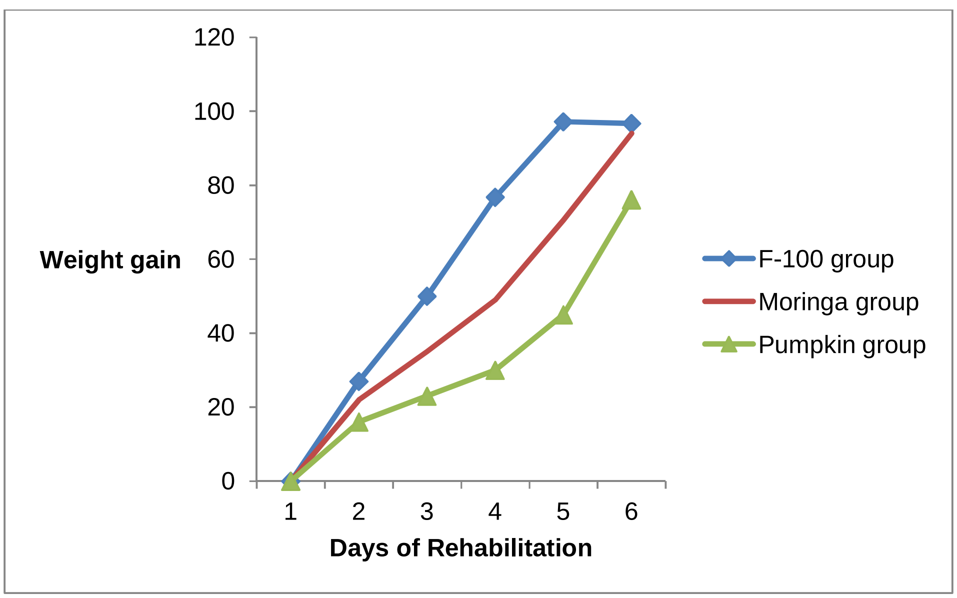

Fig. 2. Weight gain during the first six days per rehabilitation group

Table 4. Nutrient intake from optimized millet porridges compared to F-100

Study feeds	Kcal/kg body weight	Protein/kg body weight	Zinc	Iron	Vitamin A
Moringa-millet	178.6±16.9	4.7±0.3	1.6±0.1	9.1±0.8	99.9±6.6
Pumpkin-millet	157.9±12.9	4.0±0.2	1.1±0.1	3.8±0.4	78.3±7.7
F-100	188.3±13.7	5.3±0.4	1.9±0.1	0.5±004	130.8±10.8

Table 5. Effect of moringa and pumpkin optimised millet porridges on haemoglobin, serum iron, zinc and vitamin A levels of children

Micronutrient status	F-100 group (n=25)	Moringa group (n=26)	Pumpkin group (n=25)
Hb (normal=11 g/dl)			
Baseline	9.78±0.33	9.57±0.28	9.47±0.236
After feeding	10.0±0.29	10.19±0.30	9.68±0.26
P-value	0.37	**0.02**	0.37
Iron (Normal= 9 µmol/l)			
Baseline	8.36±1.38	7.31±0.85	8.91±1.27
After feeding	6.91±1.06	8.98±1.20	7.22±0.87
P-value	0.35	0.14	0.17
Zinc (Normal=10 µmol/l)			
Baseline	9.20±0.4	9.06±0.65	9.16±0.89
After feeding	9.52±1.3	9.16± 1.02	9.48±1.27
P-value	0.80	0.3	0.8
Retinol (Normal=0.8 µmol/l)			
Baseline	0.67±0.04	0.55±0.04	0.58±0.04
After feeding	0.77±0.06	0.69±0.06	0.78±0.09
P-value	0.14	**0.01**	**0.01**

Hb= Haemoglobin. P-value (Determined by paired t-test); Baseline = before feeding trials

3.5 Disease Incidences among Study Children during the Study Period

Table 6 shows the prevailing sicknesses among children during the rehabilitation period. Although fever was slightly more frequent than other sicknesses, there was no significant difference in morbidity experienced between children fed on F-100 and those fed on moringa and pumpkin optimized millet porridges. Children in all the three groups were free from unhealthy clinical conditions at the time of discharge.

3.6 Nutritional Status of Children at the End of Study Period

Table 7 shows the percentage children who improved from Severe Acute Malnutrition (SAM) to Moderate acute malnutrition (MAM) and normal states within the 5-7 days of rehabilitation. By the end of the rehabilitation period, 20.8% of the children in F-100 group had progressed from SAM to MAM state. Only 23.1% recovered while 56.1% still remained severely malnourished. The percentage improvement of children in the moringa and pumpkin groups compared to those in F-100 group was 81 and 80% respectively. Children who were still severely malnourished were given ready to Use Therapeutic Feeds (RUTF) at discharge and required to come after two weeks for follow up in the Outpatient clinic (OTC).

The mean weight-for-height/length z-scores improved from -3.2±0.46 to -2.28±0.26 for children fed on F-100 (*P*=.05) while for those fed on moringa-millet and pumpkin-millet porridge, it improved from -3.4±0.43 to -2.02±0.57 (*P*=.05) and from -3.4±0.69 to -2.0±0.28 (*P*=.06) respectively. It is therefore clear that at the end of the rehabilitation period, there was no significant improvement in the nutritional status of all children groups.

3.7 Discharge Rate for Children during Rehabilitation Period

Fig. 3 shows the rate of discharge of children during rehabilitation. Majority of the children were discharged after six days of rehabilitation. By day six, all children fed on F-100 were discharged while only 97 and 92% of children fed on moringa

Table 6. Disease incidences during the study period per rehabilitation group

Illness	F-100 group % (n)	Pumpkin group % (n)	Moringa group % (n)	*P*-value
Diarrhoea	8% (2)	4% (1)	3.8% (1)	.76
Respiratory infections	8% (2)	8% (2)	3.8% (1)	.79
Fever	12% (3)	12% (3)	7.6% (2)	.55

n = Number of children with the disease condition

Table 7. Nutritional status of children at the end of the study period per rehabilitation group

Nutritional status	F-100 N = 25	Moringa millet N = 26	Pumpkin millet N = 25
Baseline			
Severe (< -3 z-score)	100	100	100
End			
Moderate (≤ -2 z ≥ -3 z score)	20.8	24.0	24.0
Normal (≥ -2 z-scores)	23.1	11.6	11.5
Severe (< -3 z-score)	56.1	64.4	64.5

Baseline = before feeding trials; End = after feeding trials

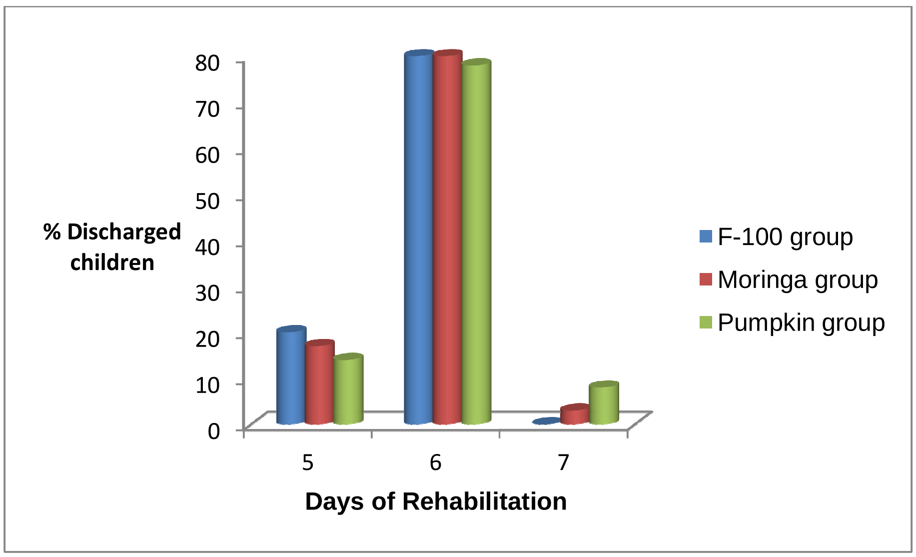

Fig. 3. Discharge rate per rehabilitation group

and pumpkin optimised millet porridges respectively were discharged. The rate of convalscence for the sick is critical and significant in assessing efficacy of a therapeutic treatment. Accordingly it can be deduced that moringa and pumpkin optimised millet porridges had 92-97% efficacy compared to F-100, the hospital therapeutic ration.

4. DISCUSSION

4.1 Feed Intake among Study Children

Intakes for pumpkin and moringa optimised millet porridges were significantly higher than for F-100, the therapeutic food. This can be attributed to familiarity with the products and palatability due to a sweet sour taste from lactic fermentation and the sweetening with sugar. Given the acceptability of the porridges by severely malnourished children, they can therefore be easily adopted as complementary food to avoid relapse of malnutrition conditions after children are discharged from rehabilitation units. This could help reduce on rehabilitation costs and the inconviniences experienced by families due to separation from their homes while attending to children during rehabilitation in nutrition units. Feed intake for children on pumpkin-millet porridge increased at a slightly higher rate than for other feeds and this promoted recovery.

4.2 Nutrient Intake among Study Children

All groups received adequate amounts of energy basing on WHO recommendations of a daily energy intake of 150-220 kcal /kg body weight. The daily protein intake of 4.7 g/kg body weight for children on moringa-millet porridge and 4 g/kg body weight for children fed on pumpkin-millet porridge were significantly lower than the 5.3 g/kg body weight for children fed on F-100 but met WHO's recommendations of 4-6 g of daily protein intake per kg body weight /day for severely malnourished children undergoing rehabilitation [23]. The daily protein intake derived from millet optimised porridges were also higher than for a study using tempeh-yellow maize porridge (yellow maize with traditionally fermented soy) and milk yellow maize porridge for rehabilitation of malnourished children, where the mean daily protein per kg/ body weight was 3.4 g and 3.9 respectively [24].

4.3 Effect of Moringa and Pumpkin Millet Porridges on Nutritional Status of Children

Monitoring of daily weight is required during nutritional rehabilitation and the weight gain/kg body weight/day in all groups was within World Health Organisation recommendations of 10-20 g/kg body weight [23]. Though the average daily feed intake for F-100 was lower compared to optimized millet porridges, the average weight gain /kg body weight increased drastically for children fed on F-100 compared to experimental groups. The high feed intakes for moringa and pumpkin groups did not translate to quick recovery as measured by weight gain when compared to F-100. Since F-100 is targetted towards promoting weight gain in severely malnourished children, it was more effective in recovering the body's deficit of energy and nutrients. Moringa-millet porridge performed better than pumpkin-millet porridge. This was because of increased solid matter in moringa-millet porridges compared to pumpkin-millet porridges and this occurred after the porridges were adjusted to the acceptable viscosity by the mothers/caretakers of children.

Apart from improved protein, vitamin A, iron and zinc content in moringa and pumpkin millet porridges, significant improvements in weight among these childen could also be attributed to the reported enhanced digestibility of starch and protein as a result of lactic acid fermentation [25,26]. Use of moringa powders in millet could also have promoted protein utilisation in the body system of these malnourished children since digestibility of proteins in moringa powder is reported to be close to 60% [27].

Fermented yellow maize and millet, supplemented with moringa powder have also been reported to improve on the nutritional status of preschool children [28]. An interventional study among severely malnourished children with moringa as a supplement in porridge registered a weight gain of 8.9±4.3 g/kg body weight /day in 36±16.54 days compared to the control with no moringa supplement, where the weight gain /kg body weight/day was 5.7±2.7 g [27]. These results support the use of moringa powders in the fight against malnutrition [29]. There was no significant improvement in the nutritional status of all children in the three rehabilitation groups because of the short time.

4.4 Effect of Moringa and Pumpkin Optimised Millet Porridges on Serum Zinc, Retinol, Iron and Haemoglobin Levels

Mean serum zinc, retinol, iron and haemoglobin levels for all children were below normal even at the end of the rehabilitation period. This was because of the short time frame. However children feeding on moringa and pumpkin optimised millet porridges significantly improved in their serum retinol levels while only children fed on moringa-millet improved in their haemoglobin levels. These results compare well with those where addition of moringa leaf powders combined with lactic acid fermentation in yellow maize (*Zea mays*) and soybean (*Glycine max*) blend, improved haemoglobin levels, minerals and vitamins in infants aged 6-12 months [30]. Moringa has also been reported to improve the vitamin A status in depleted rats [31]. Increased bioavailability of minerals and vitamins reported in lactic acid fermented foods could also have contributed to the increased haemoglobin levels [26]. Failure of children in F-100 group to significantly improve in their serum retinol levels can be attributed to the short rehabilitation period for this group compared to moringa and pumpkin groups.

4.5 Discharge Rate from the Rehabilitation Unit

The porridges were found to be 92-97% efficacous basing on 100% for F-100.This implicated both moringa and pumpkin optimised millet porridges as being comparatively effective in rehabilitating children with Severe Acute Malnutrition. Such progress is attributed to the palatability of the porridges that resulted in increased protein, vitamin A, iron and zinc intake by children feeding on optimised millet porridges. Adding 7% moringa leaf powder and 17% pumpkin flesh powder combined with lactic acid fermentation promoted good performance among rehabilitated children due to increased feed intake, enriched content of millet porridges and improved bioavailability. The children were able to be rehabilitated within an interval of 5-7 days since severe acute malnutrition is sensitive to rapid changes in food supply and nutrient intake [27]. After regaining the appetite, children who were still having severe acute malnutrition (SAM) were discharged, managed as outpatients and treated with Ready to use therapeutic foods as recommended. The decision to transfer children from inpatient care was determined by their clinical condition and not anthropometric measurements just as recommended by World Health Organization [3].

Children with severe acute malnutrition are first treated for medical complications before admission to the nutrition rehabilitation unit but because their immunity is low, infections normally reoccur. Although previous studies had indicated moringa and pumpkin optimised millet porridges to have antimicrobial properties, there was no significant difference in diseases incidences among the children in the three rehabilitation groups. This was perhaps because of the study being hospital based, where infections were carefully avoided.

5. CONCLUSIONS

Moringa and pumpkin optimised millet porridges were palatable even among malnourished children. They were able to rehabilitate children with severe acute malnutrition reasonably well when compared with the hospital ration in a cost effective manner.

6. LIMITATIONS OF THE STUDY

It was difficult to completely eliminate F-100 from the diet of children fed on optimized millet porridges for ethical reasons.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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