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Efficacy of ready-to-use food supplement for treatment of moderate acute malnutrition among children aged 6 to 59 months

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Abstract

Moderate acute malnutrition (MAM) is a persistent public health problem in Tanzania. The current approach for its management is nutrition counselling. However, there has been no commercial production of ready-to-use supplementary foods for the management of MAM in the country but rather imported from companies outside the country. The objective of the study was to determine the ability of a ready-to-use food supplementation versus corn soya blend (CSB+) to manage MAM. The randomised controlled trial employed three parallel arm approach. The first arm received CSB+ and infant and young child feeding (IYCF) counselling, the second arm received ready-to-use food (RUF) and IYCF counselling and the third arm, a control group, received IYCF as standard care for three consecutive months. Results indicated that the overall proportion of children who recovered from MAM was 65.6%. There was a significant difference ($p < 0.001$) in the proportion of children who recovered from MAM between the three arms (CSB+, RUF and standard care). Results revealed further a high recovery rate of 83.7% in the RUF arm, followed by 71.9% in the CSB+ arm and 41% in the standard care arm. The risk differences for RUF compared with CSB+ and standard care were 11.8% and 42.7%, respectively. RUFs can be used as an alternative supplement to conventional CSB+ for the management of MAM in children and, thus, has the potential to scale up its use to address the problem of MAM among 6 to 59 months' children.

KEYWORDS

children aged 6 to 59 months, food supplement, moderate acute malnutrition, RUF, undernutrition

1 | INTRODUCTION

Malnutrition is a significant global public health burden, particularly for under-fives. It is also a barrier to worldwide poverty eradication, productivity and economic expansion (Alaba et al., 2023). Undernutrition is a leading cause of morbidity and mortality in children, particularly in tropical regions where children frequently suffer from a combination of pre-natal and post-natal malnutrition (Makori et al., 2018). Undernutrition occurs in three different forms, namely, stunting, underweight and wasting, and it could be either severe or moderate. Children with acute malnutrition are more likely to suffer delays in their physical growth and cognitive development and are at greater risk of death than well-nourished children (LaGrone et al., 2012). It occurs when there is severe weight loss, possibly caused by inadequate energy and protein intake or chronic health conditions (Tut & Tsegaye, 2020; Dipasquale et al., 2020). Children with moderate acute malnutrition (MAM) have an increased risk of infections and mortality, higher chances of suffering the consequence of suboptimal adult work capacity, and an increased risk of disease in adulthood (Saleem et al., 2021; Cichon et al., 2016).

Nutritional requirements for children with MAM differ from those of non-malnourished children, who require nutrient-dense foods to meet extra needs for weight and height gain and functional recovery. If children with MAM are not adequately managed, MAM can progress to severe acute malnutrition (SAM), which is a life-threatening condition (Isanaka et al., 2019). Treatment of MAM requires a high energy intake and essential nutrients to recover the existing deficiencies and support normal growth (Amegovu et al., 2013; Roche et al., 2021). A variety of food supplements are presently used to treat MAM (Isanaka et al., 2019). These consist of the corn-soy blend (CSB+) and lipid-based nutrient products (Isanaka et al., 2019; De Pee et al., 2015). The most commonly used is fortified blended flour, mainly CSB+ prepared as porridge. In the nutritional management of MAM, optimal feeding of locally accessible nutrient-dense foods has been effective at the household level (Ashworth & Ferguson, 2009). Local food ingredients are cheap and can provide key nutrients needed for the effective recovery of children with MAM (Amegovu et al., 2013). Therefore, ready-to-use supplementary food made from locally available, nutritionally dense foods might have a positive effect on treating MAM children.

In Tanzania, there has been no commercial production of ready-to-use supplementary foods but rather imported from different processing companies around the world. Due to that, the Tanzania Food and Nutrition Center, in collaboration with the Sokoine University of Agriculture through technical and financial support from the World Food Program (WFP), developed ready-to-use food supplements (RUFs) for the treatment of MAM children. Therefore, the objective of this study was to determine the ability of a 3-month RUF supplementation of 100 g versus the conventional CSB+ to improve weight-for-height, mid upper arm circumference (MUAC) status and linear growth among children aged 6 to 59 months in Tanzania. The findings obtained through this study provide evidence of the efficacy of developed local food supplements on the management of MAM children and recommendations to improve the nutritional status of children aged 6 to 59 months in Tanzania.

Key messages

- Moderate acute malnutrition can progress to the severe form, which is a life-threatening condition if not well managed.
- Chronic undernutrition, in turn, can have an impact on the nutritional status of future generations, tending to result in 'intergenerational growth failure', a cycle of poor diet that continues throughout generations with lifelong implications.
- Supplementary foods can be formulated from locally available ingredients that are accessible, cheap and can deliver the required amounts of nutrients essential for the effective recovery of children with MAM.
- Supplementation of RUFs is more effective in treating MAM when compared to other conventional supplementation methods.

2 | MATERIALS AND METHODS

2.1 | Subject and setting

The study was conducted in Chamwino and Ikungi Districts located in the Central Zone of Tanzania. The districts were purposely selected based on the criteria of receiving support from WFP, with high prevalence of malnutrition in the country. The study recruited mother-child pairs from selected 12 health facilities (six health facilities in Chamwino District and six health facilities in Ikungi), children had an age range of 6 to 59 months.

2.2 | Sample size

The sample size was calculated to investigate whether RUF was not inferior to CSB+ in terms of the recovery rate among children with MAM aged 6 to 59 months. The sample size was calculated based on the 80% power of the test, 7% margin of non-inferiority and an assumed recovery rate with CSB+ of 67%. Considering the above assumptions, a total of 524 children, allowing for a 20% withdrawal rate, were required to be sure that the lower limit of a two-sided 95% confidence interval (CI) was above the −7% margin of non-inferiority. The anticipated 20% dropout rate was used based on the observed dropout rate reported in two studies (United Nations High Commissioner for Refugees, 2011; World Health Organization, 2012). The non-inferiority margin (−7%) was set depending on the previous studies that showed the compared group (children who received CSB) had a recovery rate of 67% (11) and the recovery rate without any treatment was 54% (James et al., 2016), hence the difference of 13%. The non-inferiority margin was specified considering that the standard care arm (with no supplementary food) has at least a 7% (the average of the difference of two proportions) higher recovery rate than the RUF arm group. This was based on the recommendations for selecting a non-inferiority margin (Piaggio et al., 2012).

2.3 | Recruitment of study participants

Recruitment of mother–child pairs was done at the health facility level, with the help of village leaders who informed households with children aged 6 to 59 months to attend screening sessions at the health facility. Field teams screened all children for assessment of eligibility to participate in the study based on set criteria. Those who met inclusion criteria were selected by using random numbers based on recruitment target per each health facility. Inclusion criteria were weight-for-height z-score (WHZ) < −2, MUAC < 12.5 cm, age of 6 to 59 months, resident in the catchment area, signed informed consent form, not receiving ready-to-use type of foods at the time of recruitment and availability of the mother–child pair for the next 3 months. Recruited children were identified as MAM according to MUAC values and weight-for-height/length z-scores.

2.4 | Study design and intervention

This study was an open-label, randomised, controlled trial that assessed the efficacy of 100 g/day of RUF compared with conventional treatment, which is CSB+ in the amount of 100 g of CSB+/day in treating MAM for 3 months (12 weeks). The randomised controlled trial had three parallel arms for the intervention of ready-to-use type of foods (CSB+, RUFs and standard care). The first arm was regarded as an intervention group, obtained CSB+ and routine infant and young child feeding (IYCF) counselling by the health cadres, while the second arm was similar to the first intervention group but received RUF and was given IYCF counselling by the health cadres. The third arm was the control group, which received IYCF counselling only without any treatment. In the first, second and third arms, the intervention was administered for 3 months according to the recommended duration by the WHO for an intervention study. Randomization was done to allocate 12 health facilities into respective arms, whereby four health facilities were randomly assigned to each arm. The recruitment of mother–child pairs was done through health facilities. Mothers/caregivers of children allocated under RUFs and the CSB+ arms received specific recommendations based on the type of product provided for supplementation.

2.5 | Description of intervention

Subjects in the intervention arms (CSB+ and RUF) received a daily ration of equal proportion that contained 100 g of flour for 12 weeks. Distribution of RUF and CSB+ flour was done every 2 weeks; mother/caregiver received a package of 14 packets to be used by the child for 14 days. The child was required to use one packet of 100 g every day for the period of 3 months of the intervention. IYCF counselling session was conducted for all mothers/caregivers recruited in the study; the content of nutrition education sessions was based on national guidelines and validated available materials in the country. The counselling session was intended to equip mothers with adequate knowledge to ensure optimal feeding for their infants to promote child growth. Sessions were scheduled to be timely for recommended changes in diet over the period of intervention and onward. Also, the caregivers attended session of 10–20 min before the distribution of products (CSB+ or RUF) and were reminded of the appropriate usage of the product based on frequency, preparation and cooking method of flour provided. Caregivers were required to bring back the empty RUFs and CSB+ packs at the next visit to monitor flour consumption.

2.6 | Blinding

The study was an open trial since participants were not blinded with respect to the main type of food (RUFs or CSBs+). However, within the arms either CSB+ or RUFs, participants were blinded to the content of the food. The investigators measuring the primary outcome (lean body-mass) were kept unaware of the allocation group and therefore were blinded with respect to the main type of food. In addition, the investigators measuring other biological factors were blinded with respect to the main type of food.

2.7 | Data collection and follow-up

The study questionnaires were subjected to pilot testing and were refined for clarity and correctness; the interviews were conducted with selected caregivers of children with MAM aged 6 to 59 months. The child's weight was measured using a Seca weight scale to the nearest 0.1 kg. Data collectors ensured appropriate position of scale, on a flat, firm surface, and weighing was done with no/light clothing. The weight of a child was measured after every 2 weeks using the same equipment.

The length was measured to the nearest 0.1 cm using height/length board. Before height measurement, data collectors ensured that the height board was on level ground and the child was barefoot; the data collector kneeled to get to the level of the child and encouraged the caregiver to help. For length, data collectors measured the child lying down, being sure that the length board was placed on a flat and stable surface. Length of a child was measured after every 2 weeks with identical equipment as used at baseline.

MUAC was assessed by non-stretchable standard United Nations Children's Fund plastic tape measures. The measurement was taken halfway between the acromion and olecranon processes, with the measuring tape fitting comfortably, but without making a depression on the left upper arm. This was done twice for every child and was recorded to the nearest 0.1 cm. MUAC was measured twice, at the baseline and at the end of the study.

Data collectors conducted different types of surveys for the period of 12 weeks; data were collected in seven phases throughout the intervention period. A baseline questionnaire was administered once to collect information such as general information, demographic and household information, antenatal care, infant health, health-seeking behaviour, infant feeding, household WASH facilities, exposure to education sessions and household food security. The porridge feeding questionnaire was administered every 2 weeks (fifth time); the tool was intended to capture the consumption and adherence to porridge feeding both in two arms (RUFs and CSB+). An end-line questionnaire was administered at the end of the study.

2.8 | Data analysis

Data were analysed using a statistical software package SPSS version 20.0. Kruskal–Wallis non-parametric test was used to check the differences in distributions of gains of anthropometric variables (weight, length and MUAC) across intervention. The test was performed due to the non-normal nature of anthropometric variables. Emergency Nutrition Assessment for SMART version 20.0 was used to analyse data obtained from the anthropometric measurement. Z-scores and the prevalence of wasting were calculated according to the child growth standards of the WHO. Recovery rate was based on WHZ (wasting). Weight gain (in g/kg), relative to the enrolment weight, was calculated for study groups over the 3-month period (or less if the children recovered earlier). Mean difference in weight gain, MUAC increase and height/length gain were computed to describe the magnitude of the difference between the three groups. Rates of weight gain through the whole period of follow-up were estimated in g/kg body weight and compared between the study groups. Comparison of outcomes in the three study arms was assessed using Fisher's exact test for dichotomous variables. Multivariable logistic regression modelling was used to assess predictors for recovery from MAM. The procedure used was backward stepwise selection with removal testing that was based on the likelihood ratio statistic. The significant value to enter the regression model was $p < 0.05$, and the hypotheses were tested by a two-tailed test of significance. The generalised linear model, Poisson family with log link function for unbiased parameter estimates, was employed to model the effect of interventions CSB and RUF against standard care.

2.9 | Ethics approval and consent to participate

Ethical approval for conducting this study was obtained from the National Health Research Ethics Sub-Committee of the National Institute of Medical Research of Tanzania. Permission to conduct research in the respective districts was sought from the President's Office—Regional Administration and Local Government. The purpose of the study and methods of data collection, confidentiality and voluntary participation were explained to mothers/caregivers of children who were invited to sign an informed consent form. Written informed consent was obtained from all mothers and caregivers of children who met inclusion criteria before the recruitment. All interviews and intervention procedures were conducted in privacy.

3 | RESULTS

3.1 | The enrolment process and trial profile for the study participants

The study assessed the eligibility of 3355 children through screening, of whom 524 met inclusion criteria. The enrolment procedure, allocation of participants into study groups and lost to follow-ups information are illustrated in Figure 1. A total of 480 (92%) mother–child pairs completed the study, with 44 lost to follow-up. Reported reasons for lost to follow-ups were moving outside the study site (due to divorce, holidays and livelihood activities) and the mother's voluntary withdrawal from the study.

3.2 | Baseline characteristic of the study participants

Baseline characteristics were compared between the CSB+, RUFs and standard care arms (Table 1). The mean age of the caregivers was 30.22 ± 8.59 years in all three arms. The mean (standard deviation [SD]) age of the mothers in the CSB+ arm was 30.3 (8.64) years, RUF arm was 30.9 (8.66) years and standard care was 29.5 (8.5) years. The mean (SD) age of the children recruited under CSB+, RUFs and standard care arm was 21.6 (12.14), 24.2 (14.63) and 19.6 (13.03), respectively. The overall mean age of children in all three arms was 22 months, and the median and mode were 18 and 9 months, respectively. A slightly higher number of girls (54.2%) were recruited in the study than boys (45.8%). The majority of children were from households involved in agricultural activities (67.2%), with a range of one to twelve (12) number of children in the household.

3.3 | Outcome in the three intervention arms over 12 weeks

Fisher's exact test showed that the overall proportion of children who recovered from MAM was 65.6%, whereas 25.8% remained in MAM and 8.5% deteriorated to SAM. There was a significance difference $p = 0.001$ in the proportion of children who recovered from MAM between arms (CSB+, RUFs and standard care). Analysis showed a recovery rate of 71.9% for CSB+, 83.7% for RUFs and 41% for standard care. The risk differences for RUFs compared with CSB+ were 11.8% and RUFs compared with standard care was 42.7%. The odds ratio of MAM children developed into SAM was six times

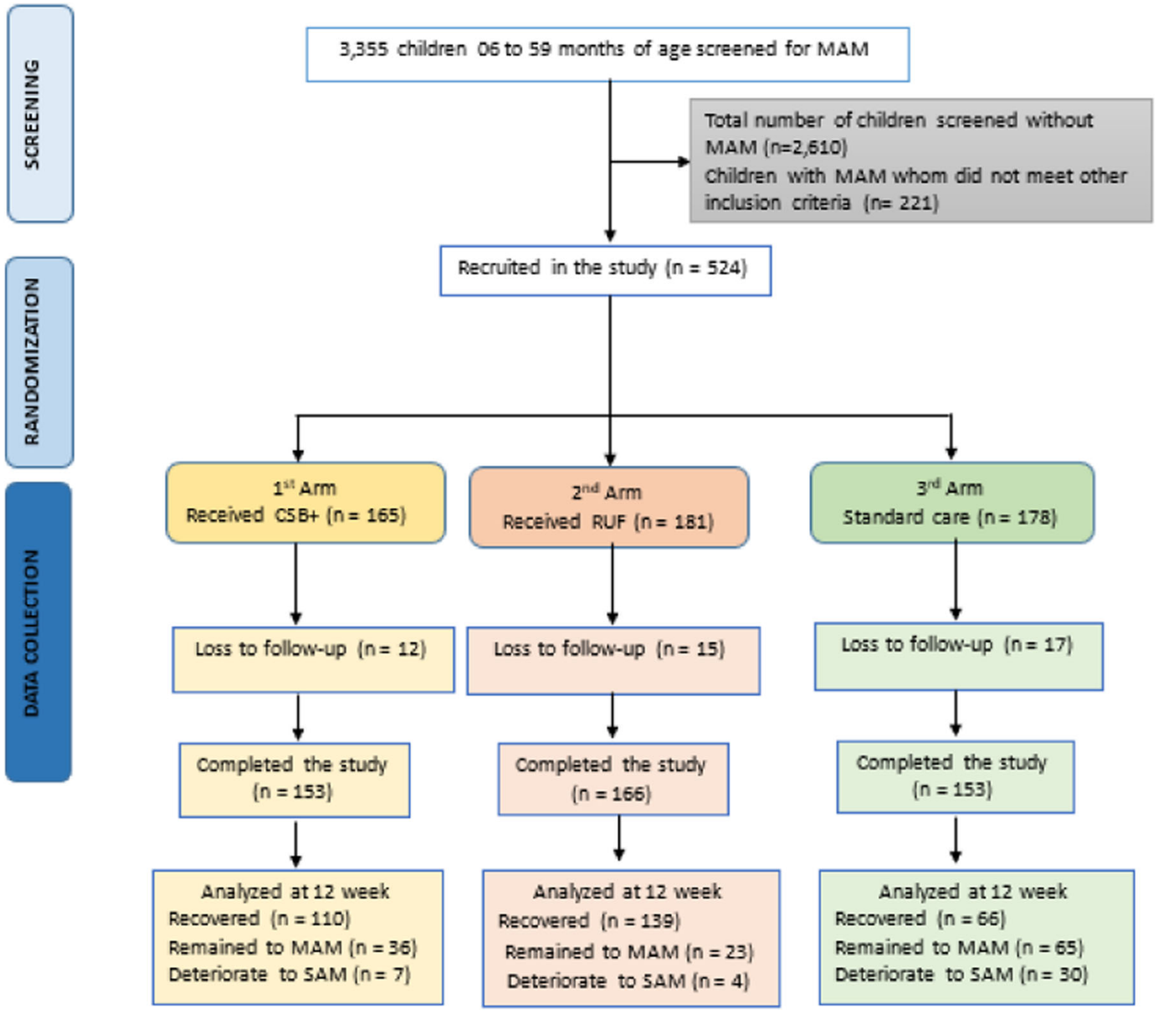

FIGURE 1 Flowchart of subjects' enrolment and conduction of the RCT. CSB+, corn soya blend; MAM, moderate acute malnutrition; RCT, randomized controlled trial; SAM, severe acute malnutrition.

greater among children who were in the standard care arm compared to other arms at 95% CI: 3.12, 13.18. Additionally, recovery was more likely to occur in intervention groups (CSB+ and RUFs arms). Both analyses showed that RUFs were non-inferior compared with CSB+ and standard care in terms of the recovery rate, as the difference between the two groups was above the predefined non-inferiority margin of risk difference (−7%).

The weight gain was not similar between arms after 3 months of intervention; maximum weight gain was observed in RUFs 3.20 kg, followed by CSB+ 2.20 kg and standard care arm 1.20 kg. The mean weight gain (SD) among children recruited under CSB+, RUFs and standard care arm was 0.68 ± 0.47 g/kg, 1.37 ± 1.38 kg and 0.23 ± 0.34 g/kg, respectively. The mean differences are presented in Table 3 below. Both analyses showed that RUFs and CSB+ arms were non-inferior compared with the standard care arm (predefined non-inferiority margin of risk difference = −1.3 g/kg/d). Based on the multiple comparisons analysis, the mean differences in weight gain between arms were significant ($p < 0.001$), as shown in Table 2.

The model results indicate that children exposed to CSB treatment (adjusted prevalence ratio [APR]: 0.58, 95% CI: 0.43–0.79) were less likely to be moderately malnourished as compared to those who received standard-of-care treatment. Likewise, children administered under RUF intervention (APR: 0.29, 95% CI: 0.19–0.43) were even more less likely to become moderately malnourished after 12 weeks of intervention as compared to standard care arm, indicating a 71% decrease in MAM children as compared to standard care arm. However, children administered to CSB intervention arm had a higher (APR: 2.01, 95% CI: 1.27–0.43) risk of retaining to MAM status after 12 weeks compared to the RUF intervention arm, indicating that after the intervention the number of MAM children were two times more likely to remain in MAM as compared to RUF as shown in Table 3.

3.4 | Recovery time between arms

Results indicated further that overall recovery time was 42 days (after 6 weeks of intervention), whereby a total of 53.5% of children in all arms recovered from MAM, though few children (13.9%) were reported to recover at the second week (14 days) of the intervention.

TABLE 1 Baseline characteristics of mother–child pairs in each arm.

Characteristics (*N* = 524)	CSB++ (*n* = 165)	RUF (*n* = 181)	STD (*n* = 178)
Age of the child in months, mean (SD)	21.6 (12.14)	24.2 (14.63)	19.6 (13.03)
Sex of child, *n* (%)			
Male	81 (49.1)	81 (44.8)	78 (43.8)
Female	84 (50.9)	100 (55.2)	100 (56.2)
Education level of mothers, *n* (%)			
Non-formal education	26 (15.8)	39 (21.5)	72 (40.4)
Did not complete primary school	18 (10.9)	15 (8.3)	28 (15.7)
Completed primary school	106 (64.2)	108 (59.7)	68 (38.2)
Secondary and above	15 (9)	19 (10.5)	10 (5.6)
Social-economic activities of the mother, *n* (%)			
Farmer	106 (64.2)	129 (71.3)	118 (66.3)
Business owner/ Employed	33 (20.0)	19 (10.5)	21 (11.8)
Housewife	23 (13.9)	33 (18.2)	39 (21.9)
Marital status of mother, *n* (%)			
Married/cohabitating with partner	146 (88.5)	151 (83.4)	148 (83.1)
Divorced/separated/ widowed/never married	19 (11.5)	13 (16.6)	30 (16.6)
Number of children in the household, *n* (%)			
1–3	81 (49.1)	86 (47.5)	87 (48.8)
4–6	65 (39.3)	75 (41.4)	60 (33.7)
≥7	19 (16.6)	20 (11.1)	31 (17.5)
Relationship to the child, *n* (%)			
Biological mother	159 (96.4)	166 (91.7)	169 (94.9)
Relative	9 (3.6)	11 (8.3)	7 (5.1)
Breastfeed child, *n* (%)			
Yes	156 (94.5)	173 (95.6)	172 (96.6)
No	9 (5.5)	8 (4.4)	6 (3.4)
Still breastfeed, *n* (%)			
Yes	90 (54.5)	98 (54.1)	101 (56.7)
No	75 (45.5)	83 (45.9)	77 (43.3)
Had fever in the last 2 weeks, *n* (%)			
Yes	60 (36.4)	67 (37)	71 (39.9)
No	105 (63.6)	114 (63)	107 (60.1)
Had diarrhoea in the last 2 weeks, *n* (%)			
Yes	65 (39.4)	67 (37)	53 (29.8)
No	100 (60.6)	114 (63)	125 (70.2)
Had an illness with a cough in the last 2 weeks, *n* (%)			
Yes	72 (43.6)	91 (50.3)	89 (50.0)
No	63 (56.4)	90 (49.7)	89 (50.0)
Anthropometry, mean (SD)			
Child weight in kg	8.7 (1.8)	8.7 (2.0)	8.3 (2.0)
Child length/height in cm	78.0 (9.5)	79.0 (10.3)	75.9 (10.4)
Child MUAC in cm	12.8 (0.7)	13.0 (0.9)	12.9 (0.9)

Abbreviations: CSB++, corn soya blend; MUAC, mid upper arm circumference; RUF, ready-to-use food; SD, standard deviation; STD, standandard care.

In the sixth week of the intervention, the CSB+ and RUFs arms had recovery rates of 49.2% and 56.5%, respectively. However, children in the standard care arm had a notably slow recovery rate compared to other arms, 35.1% and 41% recovery rates at eighth and 12th week, respectively.

3.5 | MUAC increase

The findings revealed that the mean MUAC increase (SD) after the 3-month intervention period was 0.76 (0.58) cm, 0.75 (0.40) cm and 0.22 (0.36) cm for the RUF, CSB+ and standard care arm. The maximum MUAC gain for CSB+, RUFs and standard care arm was 2.00 cm, 2.90 cm and 1.40 cm, respectively. Based on multiple comparisons analysis of mean difference, there was no significant mean difference on MUAC between RUFs and CSB+ arms $p = 0.934$ (95% CI: −0.104 to 0.14). A significant mean difference was observed between RUFs and standard care arms $p < 0.001$ (95% CI: 0.41–0.66) as well as CSB+ and standard care arms $p < 0.001$ (95% CI: 0.39–0.63). The anthropometric indices are presented in Table 4.

3.6 | Porridge feeding in the follow-up period

There was a significant difference ($p < 0.05$) in the amount of porridge consumed between the two arms. The mean intake of porridge was 371.86 ± 172 mL and 409.05 ± 134 mL in the CSB and RUF arms, respectively. During the tenth week, there was no significant difference ($p = 0.334$) in the amount of porridge consumed between both arms. However, there was an increase in the mean intake of CSB+ porridge. On the other hand, during the entire period of intervention starting from the second week up to the 10th week, the frequency of porridge consumption differed significantly between CSB+ and RUFs arms ($p < 0.001$). Consumption pattern of porridge during the period of intervention is presented in Table 5.

TABLE 2 Multiple comparison of mean weight gain between arms.

					95% confidence interval	
Arm (a)	Arm (b)	Mean difference (a – b)	Std. error	Sig	Lower bound	Upper bound
RUF	CSB+	0.6919*	.05450	.000	.5638	0.8201
	STD	1.1418*	.05379	.000	1.0154	1.2683
CSB	RUF	−0.69195*	.05450	.000	−0.8201	−0.5638
	STD	.44990*	.05490	.000	0.3208	0.5790
STD	RUF	−1.14186*	.05379	.000	−1.2683	−1.0154
	CSB	−0.44990*	.05490	.000	−0.5790	−0.3208

Abbreviations: CSB+, corn soya blend; RUF, ready-to-use food, STD, standard care.
*Significant at $p \leq 0.05$.

4 | DISCUSSION

A randomised control trial indicated that locally produced RUFs and CSB+ were more effective in treating MAM than IYCF counselling alone. This is the first study to evaluate the efficacy of RUFs in terms of their ability to treat MAM in infants and young children. The study provides evidence that RUF had a higher recovery rate than conventional food (CSB+) in treating MAM, and both food supplements were relatively successful in treating MAM in children aged 6 to 59 months. In the present trial, the recovery rate of children treated with MAM in RUFs and CSB+ arms were very high at a rate of 83.7% and 71.9%, respectively, compared to 41% in the standard care arm who received IYCF counselling only. This suggests that both food supplements were relatively successful in the treatment of MAM in children, based on the proportion of children who recovered from MAM. The recovery rates observed in the current study were comparable with the recovery rates observed in supplementary feeding reported in other studies (67% to 82.3%) (Amegovu et al., 2013; Isanaka et al., 2019; Roche et al., 2021). Children's age was found to be a predictor of recovery rate; younger children recovered faster than older children. Growth rates are directly related to age; younger children normally grow at faster rates. The comparability of recovery rates between RUFs and the CSB+ arm indicates that locally produced RUFs are an excellent alternative to CSB+ in treating MAM in Tanzania. Additionally, the findings of this study are in line with other previous studies that compared the effectiveness of RUTF and CSB+ for the treatment of MAM, suggesting that RUTF may be more effective (Medoua et al., 2016; Nane et al., 2021; Roche et al., 2021).

The relatively high recovery rates achieved with the RUFs supplementation could be attributed to adequate energy content and protein, coupled with appropriate complementary feeding practices. Levels of carbohydrates in the RUFs formula were adequate to provide sufficient energy for a child to recover from moderate malnutrition. Energy density is vital for the recovery of moderately malnourished children (Michaelsen et al., 2009). Energy is needed for catch-up growth and maintenance. Wasted children experience loss of both lean and fat tissues and need to be replaced; a food supplement with a high energy density directly relates to increased recovery rates (Golden, 2009). Also, ready-to-use foods require no cooking, which could be a reason for encouraging mothers to adhere to the feeding regime. These characteristics may contribute to the efficacy of RUFs product in attaining a higher recovery rate.

Moreover, it was speculated that high recovery rate in this study may be due to increased compliance and care for mothers, prompted by health professionals delivering the care at the health facility level. Also, this could be contributed by limiting the tendency to share at the household level; the supplementation of RUFs and CSB+ rations were packed in a package of 100 g required to be used per day. The provision of products was accompanied by specific instructions, should be used for feeding identified MAM children only and not either. It was portrayed as a medicine and therefore not to be shared with other children in the household.

In addition, the trend of weight gain in the RUFs arm was significantly higher than that in the CSB+ arm despite the fact that the total energy provided by the supplement in both arms (RUFs and CSB+) was quite similar. A higher consumption rate of RUFs product would result in a faster and greater recovery rate in terms of weight gain among infants compared to CSB+. However, the weight gain obtained in the present study was higher than the one reported in previous studies for children receiving regular CSB+ (Thakwalakwa et al., 2010).

The finding form this study was in contrast with the study found out length gain was comparable between two intervention groups (Nane et al., 2021). The current study found out higher mean length gain 2.72 ± 0.82 in CSB+ arm as compared to RUF and standard care arm. Higher consumption of porridge (in quantity) might have attributed to increase in length gain. CBS+ has been used as a standard therapeutic food for the management of MAM for an extended period of time and has proven to be effective in improving the nutritional status of children. Its protein and zinc content is adequate enough to promote growth and development (Uauy et al., 2015).

Furthermore, about 7% of children enrolled in the study under the treatment arms [RUFs (2.4%) and CSB+ (4.6%) did not respond to supplementary feeding and developed SAM. Therefore, mothers/caregivers whose children developed SAM were counselled and referred to the nearby health centres for further management.

TABLE 3 Generalised linear model adjusted prevalence ratio estimates for the effect of intervention arms compared to standard of care.

	MAM vs. normal, APR95% CI	*p* Value	MAM vs. normal, APR95% CI	*p* Value	MAM vs normal, APR95% CI	*p* Value
Intervention arm	CSB vs. STD		RUF vs. STD		CSB vs. RUF	
CSB	0.58 (0.43–0.79)	0.000*				
STD	1.00					
RUF			0.29 (0.19–0.43)	0.000*		
STD			1.00			
CSB					2.01 (1.27–3.17)	0.003*
RUF					1.00	
Sex of a child						
Male	1.00		1.00		1.00	
Female	0.84 (0.65–1.10)	0.209	0.93 (0.69–1.26)	0.647	0.69 (0.45–1.06)	0.088
Social-economic activities of the mother						
Farming	1.00		1.00		1.00	
Small business/trade	1.36 (0.96–1.92)	0.083	1.39 (0.92–2.08)	0.114	0.91 (0.55–1.52)	0.720
Housewife	1.26 (0.91–1.74)	0.162	1.35 (0.98–1.87)	0.069	0.45 (0.18–1.09)	0.075
Number of children						
1–3	1.00		1.00		1.00	
4–6	1.15 (0.87–1.53)	0.327	1.30 (0.96–1.76)	0.093	1.38 (0.88–2.16)	0.159
7+	1.19 (0.79 1.80)	0.407	0.97 (0.61–1.56)	0.907	1.29 (0.73–2.29)	0.379
Marital status						
Single parent	1.00		1.00		1.00	
Married/cohabit	0.79 (0.56–1.10)	0.167	0.80 (0.55–1.17)	0.243	0.58 (0.33–1.01)	0.054
Breastfeed child						
Yes	1.00		1.00		1.00	
No	0.89 (0.47–1.68)	0.716	1.06 (0.45–2.51)	0.892	0.85 (0.34–2.13)	0.725
Had diarrhoea in the last 2 weeks						
Yes	1.00		1.00		1.00	
No	1.10 (0.82–1.49)	0.521	0.97 (0.69–1.35)	0.849	2.12 (1.27–3.54)	0.004*
Had an illness with a cough in the last 2 weeks						
Yes	1.00		1.00		1.00	
No	1.01 (0.77–1.32)	0.960	1.04 (0.77–1.42)	0.786	0.89 (0.58–1.37)	0.612

Abbreviations: APR, adjusted prevalence ratio; CI, confidence interval; CSB+, corn soya blend; MAM, moderate acute malnutrition; RUF, ready-to-use food; STD, standard care.

*$p < 0.05$, significant.

TABLE 4 Anthropometric outcome indicators in the three intervention arms over 12 weeks.

Outcomes	RUF ($n = 181$)	CSB+ ($n = 165$)	STD ($n = 178$)	*p* Value
Recovery rate, *n* (%)	83.7%	71.9%	41%	$p = 0.000$*
Mean weight gain, g ± SD	1.260 ± 1.38	0.69 ± 0.45	0.24 ± 0.34	$p < 0.000$*
Mean height gain, cm ± SD	2.08 ± 2.69	2.72 ± 0.82	1.95 ± 2.5	$p = 0.000$*
Mean MUAC increase, cm ± SD	0.75 ± 0.58	0.74 ± 0.40	0.23 ± 0.36	$p < 0.000$*

Abbreviations: CSB+, corn soya blend; MUAC, mid upper arm circumference; RUF, ready-to-use food; SD, standard deviation; STD, standard care.

*Significant at $p \le 0.05$.

TABLE 5 Food consumption at the beginning and the end of feeding intervention.

Description	Type of Porridge	Mean ± SD	Std. Error	Significance	95% confidence interval	
					Lower bound	Upper bound
Amount of porridge (mL)	2nd week					
	CSB+	371.86 ± 172	14.280	0.039*	343.64	400.09
	RUF	409.05 ± 134	10.947		387.42	430.69
Frequency of porridge consumption	CSB+	1.76 ± 0.6	0.053	0.000*	1.65	1.86
	RUF	2.37 ± 06	0.047		2.28	2.46
Amount of porridge consumed (mL)	10th week					
	CSB+	420.14 ± 146	12.005	0.334	396.41	443.86
	RUF	405.87 ± 101	8.422		389.22	422.52
Frequency of porridge consumption	CSB+	1.72 ± 0.6	0.049	0.000*	1.63	1.82
	RUF	2.24 ± 0.5	0.043		2.15	2.32

Abbreviations: CSB+, corn soya blend; RUF, ready-to-use food; SD, standard deviation.
*Significant at $p \leq 0.05$.

5 | CONCLUSION

The findings from this study provide an experimental indication that RUFs can be used as an alternative to CSB+ in the management of MAM among children aged 6 to 59 months in Tanzania. Thus, the potential for scaling up the use of RUFs should be promoted in different geographical zones including in refugee's camps to assess its potential on reducing the rates of malnutrition. Further studies should be extended to examine cost-effectiveness of RUFs product to inform the policymakers and potential stakeholders on decision-making, especially on directing resources towards such interventions. The evidence drawn from this study will be shared with the public and policymakers as RUFs have the potential to increase the recovery rate and decrease the burden of malnutrition among children below 5 years of age.

AUTHOR CONTRIBUTIONS

Nyabasi Makori implemented the study, performed data analysis and interpretation and developed the first draft. Germana Lyena designed the study, interpreted data and critically reviewed the manuscript. Hope Masanja implemented the study, performed data analysis and interpretation and reviewed the manuscript. Geofrey Mchau implemented the study and reviewed the manuscript. Meshack Tegeye implemented the study. Juliana Muiruri designed and implemented the study. Debora Esau implemented the study and reviewed the manuscript. Neema Shosho implemented the study. Vera Kwara implemented the study and reviewed the manuscript. Suleman Rashid implemented the study and reviewed the manuscript. Theresia Jumbe implemented the study and reviewed the manuscript. Cypriana Moshi implemented the study and reviewed the manuscript. Hoyce Mshida participated in data analysis and review of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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