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Review Paper

Recent Advances in Ready-To-Use Therapeutic Foods (Rutf) For the Management of Severe Acute Malnutrition

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ABSTRACT

Current guidelines for managing severe malnutrition focus on the body's physiological needs rather than the outdated belief that protein deficiency is the main cause. Severely malnourished children cannot tolerate high protein, iron, or sodium early in treatment. Instead, specially formulated milk-based diets with added vitamins and minerals are used during initial and rehabilitation phases. New therapeutic foods—low in protein and high in fat—have been developed to improve recovery and prevent relapse. While current dietary recommendations do not yet distinguish between different types of malnutrition or between adults and children, more specific guidance may be needed.Severe acute malnutrition (SAM) is identified by a weight-for-height measurement that is 70% or more below the median, or three standard deviations below the mean National Centre for Health Statistics reference values. It can also be indicated by the presence of bilateral pitting edema of nutritional origin or a mid-upper-arm circumference of less than 110 mm in children aged 1 to 5 years. Currently, around 13 million children under the age of 5 are affected by SAM, leading to an estimated 1 to 2 million preventable child deaths annually. Despite its significance, child-survival initiatives have largely overlooked SAM, and the World Health Organization does not officially recognize the term "acute malnutrition." Treating SAM in a hospital setting is resource-intensive and requires a skilled and dedicated workforce. In areas where SAM is prevalent, the number of cases often exceeds the available inpatient facilities, limiting treatment effectiveness; case-fatality rates can reach 20-30%, and coverage is typically below 10%. Community-based therapeutic care programs have been shown to significantly lower case-fatality rates and improve coverage. These programs utilize new, ready-to-use therapeutic foods and aim to enhance access to services, reduce opportunity costs, promote early treatment, and improve compliance, which in turn boosts coverage and recovery rates. In this model, all patients with uncomplicated SAM

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are treated as outpatients, making it a promising and cost-effective treatment approach

INTRODUCTION

- SAM can be defined by a weight-for-height Z-score < -3 compared to the median WHO growth standards; by visible severe wasting; or by the presence of nutritional oedema [1]. Children with SAM face a risk of morbidity and mortality nine-to-eleven times greater than their healthy counterparts.[i]
- [1]Malnutrition was defined as "a subacute or chronic state of nutrition, in which a combination of varying degrees of under- or overnutrition and inflammatory activity has led to changes in body composition and diminished function".
- [2]In acute malnutrition, the body does not have enough of one or more macronutrients to function properly. This deficiency can happen due to a poor diet, issues with absorbing nutrients, or a long-term inflammatory condition that raises the need for nutrients while causing the body to lose them.[ii]
- [3]The goal here is to check out the effects of home based RUTF. You know, when its used at home. On recovery and relapse and mortality rates too. All that in kids dealing with severe acute malnutrition.[iii]
- [4]Based on information from the UNICEF, WHO, and World Bank Joint Child Malnutrition Estimate (2020) covering the years 2000–2019, the prevalence of stunting in children under five worldwide [iv]
- [5]Decreased from 199.5 million (32.4%) to 144 million (21.3%), but in West and Central Africa, the numbers have gone up (from 22.4 to 29.0 million).[v]
- [6]The WHO threw out some honestly staggering numbers—around 149 million kids were stunted (like, not growing right), 45 million were wasted (which, yeah, means way too skinny), and almost 39 million were either overweight or straight up obese.[vi]
- [7]According to the latest joint estimates on child malnutrition, 16.9 million children under 5 years old globally, which is 2.5%, are experiencing severe acute malnutrition (SAM; United Nations Children's Fund [UNICEF], World Health Organization [WHO], and World Bank [WB], 2017). Children with SAM are more than nine times as likely to die compared to well-nourished children (Black et al., 2008). As part of the global nutrition goals, the world aims to reduce or keep the level of wasting below 5% by 2025 (WHO, UNICEF, and World Food Programme).[vii]
- [1]In Western Europe and North America prevalence of wasting and stunting in under 5 children is low More than half, and about a quarter of total wasted children in the world live in South Asia and Saharan Africa, respectively. On the other extreme of malnutrition, globally 38.3 million of the under-5 children were over-weight as per the data published in the year 2019. In a study showing the data on burden and indicators of malnutrition in under-five children during 1990 to 2017 in India, it was concluded that malnutrition was cause of 68.2% of total deaths and 17.3% of total Disability-Adjusted Life Years.
- [7]As per WHO and UNICEF, Severe Acute Malnutrition (SAM) in 6-59 months of age is defined as Weight for Height/Length (WFH/WFL) less than -3 Standard Deviation (SD) and/or Mid-Upper Arm Circumference (MUAC) less than 11.5 cm and/or clinical sign of bilateral pedal oedema (sign of Kwashiorkor) and/or visible severe wasting.
- [5]SAM may represent an increasing portion of the childhood nutritional disease burden. This

burden might also be focused in the most disadvantaged societies. To tackle these issues, this study outlines an effort to create better estimates of SAM incidence, examine the statistical links to SAM, and project the possible future burden of SAM using a combined forecasting model.

- [2]Some earlier studies provided disease data for specific populations, but no research has looked at the global impact of protein-energy malnutrition and its changes. This study aimed to assess the risk of protein-energy malnutrition using global burden data. It also described the geographical location, age, gender, and socio-demographic index (SDI) of protein-energy malnutrition in 204 countries and territories from 1990 to 2019. We calculated the age-standardized prevalence rate (ASPR), disability-adjusted life year (DALY), estimated annual percentage change (EAPC), and other indicators that have been used in fields like cardiovascular diseases and pulmonary diseases. This helps to clarify the causes and trends of protein-energy malnutrition.
- [1]During the early 2000s, ready-to-use therapeutic foods (RUTFs) were introduced. These products have a nutritional makeup similar to therapeutic milk formulas but do not require water, which greatly lowers the risk of bacterial contamination and removes the need for refrigeration (UNICEF, 2013a). Around the same time, the community-based management of acute malnutrition (CMAM) model was introduced. This model lets local providers diagnose children with uncomplicated severe acute malnutrition (SAM) and refer them to an outpatient therapeutic feeding program (OTP) at health carecenters.
- [4]This review tries to help figure out how much it matters when we let community health workers diagnose and treat severe acute malnutrition. It pulls together what happened in past real-world efforts. That way it spots the good chances ahead. It also calls out the tough spots with this fresh kind of method.

Evaluation of RUTF

Historical BackgroundofPlumpy'nutsTo F-100

Malnutrition is a major world concern that impacts children the most. As of 2020, almost 150 million children are suffering from stunting (low height for age) and 45.4 million from wasting (low weight for height[1].Every 10 seconds a child dies from malnutrition[2]The side effects of malnutrition can be devastating and can lead to lower IQs, premature mortality, and weaker immune systems. It is estimated that malnutrition costs the global economy US$3.5 trillion[3].The COVID-19 pandemic has impacted the already existing malnutrition crisis. Worldwide school feeding instances through history that put him on his journey to revolutionize how severe acute malnutrition (SAM) was treated[4].Some arresting events include the worst humanitarian crisis since World War II faced by the former Yugoslavia in 1992, leading to thousands of Europeans without food. Additionally, in 1994, mass genocide was happening in Rwanda, leading to millions of Rwandans fleeing to other countries and experiencing lack of nutrition[5].During these hunger emergencies, there were not enough TFCs to manage all the children that needed aid, nor were the centers close enough to many of the communities they were meant to serve. Dr.Andre Briend goal was to provide a solution to malnutrition that could be administered at home. In 1996 Dr.Andre Briend partnered with food engineer, Michel Lescanne, and met his objective by developing a RUTF (the first of which was known as Plumpy'Nut)[6]. Plumpy'Nut consists of peanut paste, sugar, vegetable oil, dairy powders, and twentythree vitamins and minerals. It provides 500 calories, 45g of carbohydrates, 30g of fat, and 13g of protein. Severely malnourished children are treated with 1-3 sachets per day for 6-10 weeks. Response Initially, Plumpy'Nut was only produced by the company Nutriset, which is based in France. They sold Plumpy'Nut to UNICEF who would distribute the product as needed. Given the success of Plumpy'Nut, demand increased dramatically. In programs temporally closed to prevent the spread of the virus forcing a shift towards household feeding, which put additional challenges on families already dealing with reduced income due to work absences.The financial struggles on families led them to opt for unhealthy and cheaper food options.

Before the advent of RUTF, in acute nutrition emergencies the best means of treating malnutrition required children to be taken to therapeutic feeding centers (TFCs) for around the clock treatment with therapeutic milks. French pediatrician Dr. André Briend saw several2005, Nutriset set up a franchising plan enabling the local production and distribution of Plumpy'Nut in developing countries. Part of the benefit of a franchise system is that franchisees have access to Nutriset's technical support. It also provides advantages to local communities by contributing to their economy and industrial development as well as cutting the cost of transportation. The first network has expanded to nine countries (Ethiopia, Niger, Nigeria, Burkina Faso, Guinea, Sudan, Madagascar, India, and Haiti)[7],[8].

●Before Plumpy'Nut, therapeutic milks (F-75 and F-100) were used, which consisted of a liquid diet recommended by the WHO[9]. Dr. Briend and his team modified the formulation creating what we now know as Plumpy'Nut. The synergism between a pediatrician and a food scientist made Plumpy'Nut the product that we know today.

● Ready-to-use therapeutic foods (RUTF) provide one of the best solutions to tackle malnutrition among children because they are nutritious and convenient. Plumpy'Nut was the original RUTF developed. RUTFs like Plumpy'Nut can be locally produced in or near the countries where they are needed. RUTF production uses local materials when possible, though some ingredients may be imported[10].New products can be developed according to ingredient availability; however, those need to meet standards established by the main purchasing agencies such as UNICEF, USAID, and WFP. Standards include: does not contain anti-nutritional factors, heavy metals, or pesticides that may represent a hazard to health[11].

● Edesia's production facility is in Rhode Island, USA, but they are part of Nutriset's network which includes producers in 9 countries in the developing world, and they assist with technology transfer so countries can produce their own Plumpy'Nut. The Edesia team also provides R&D support if the countries want to launch their own RUTF based on access to ingredients specific to their country. R&D support comes in the form of finding ingredient suppliers and equipment for production and starting up factories.

● Currently, the main buyers of RUTF are nonprofit agencies like UNICEF, USAID, and WFP. When RUTF started, 8 weeks of treatment was around US$50. Today, Plumpy'Nut cost has been impacted by the COVID-19 pandemic and the Ukraine war. The cost to produce Plumpy'Nut has dramatically increased as ingredient prices have increased, as well as the cost in transportation. Additionally, some production facilities have limited personnel. In May 2021, prices of Plumpy'Nut increased by 23%, and UNICEF is expecting another 16% increase[12].

● In 2022, there was a major funding announcement by USAID of an additional US$250M to go to UNICEF for RUTF. In September, USAID announced an additional

US$280M in matching funds. With these additional half a billion dollars dedicated to RUTF in 2022 and 2023, the world will be able to reach about 50% of children with SAM (instead of the historical 25%). Due to this increase, factories around the world are adding shifts and scaling up their production. Nonprofit organizations are concerned about how to maintain/sustain this higher level of funding to have an impact in the longer term (at least the next 5 years)[13]

WHO Guidelinesfor RUTF use

1. Standard RUTF (for outpatient use) should contain at least 50% protein from dairy products, according to the 2021 WHO guideline, which updates the previous Joint Statement. It is conditionally advised to use RUTFs with less than 50% dairy protein only in research or evaluation settings (i.e., not routine)[14].
2. According to the WHO's 2023 "prevention and management of wasting and nutritional oedema" guideline, children aged 6 to 59 months who require outpatient care and have severe wasting or oedema are conditionally advised to:
   • 150–185 kcal/kg/day until anthropometric recovery and resolution of oedema
   • Or: continue to consume 150–185 kcal/kg until there is no more significant wasting or oedema, then cut back to 100–130 kcal/kg per day until you recover[15].
3. Additional information and tables on the "optimal quantity of RUTF" (i.e., caloric targets, durations) for various clinical contexts can be found in the WHO "web annexe F" for the wasting guideline[16].
4. The World Health Organization (WHO) brought together a guideline development group to assess if less dairy (or dairy-free) ready-to-use therapeutic foods (RUTFs) containing less than 50% dairy protein have the same efficacy/safety as the standard RUTF[17].
5. According to the WHO recommendations for the treatment of wasting and oedema, RUTF is the main therapeutic food (particularly for outpatient/community care) combined with medical treatment, infection control, micronutrient supplementation, monitoring, etc. for severe acute malnutrition (SAM). The usage of RUTF is emphasized[16]

Composition and Characteristics of RUTF

1. Standard Composition of RUTF (per 100g)

Component	Typical range per 100g	Function
Energy	520-550kcal	Provides high caloric density for weight gain
Protein	10-12g	Promotes tissue repair and growth
Carbohydrates	40-45g	Serves as quick energy source
Fats	30-35g	Provides essential fatty acids and improves palatability
Moisture	<2.5%	Ensures long self life and microbial stabitlity
Iron	10-14mg	Prevents anemia
Zinc	11-14mg	Supports immune functions
Calcium	300-600mg	Essential for bone growth
Sodium	<290mg	Control to prevent edema

Potassim	1100-1400mg	Maintains cellular function
Viamin A	0.8-1.1mg	Supports vision and immunity
Vitamin C	50-90mg	Aids iron absorption
Vitamin E	20mg	Acts as an antioxidant
B-complex vitamins	Variable	Support energy metabolism

2. Ingredients Used in RUTF

1.Roasted peanut paste:-Use as main energy and protein source.

2.sugar:-Palatability and readily available energy provides.

3.Skimmed milk powder:-protein and calcium provide.

4.Vegetable Oil:-increases caloric density and supplies essential fatty acids.

5.Vitamin-mineral premix:-adequate micronutrient intake.

Characteristics of RUTF

1. High energy density: Children recovering from SAM can meet their energy needs without consuming large amounts of food because RUTF is designed to provide a lot of calories per unit weight (approximately 520–550 kcal per 100 g).[1]
2. High lipid content, with special focus on the composition of fatty acids (fat types: saturated, monounsaturated, and polyunsaturated), particularly the ratios of n-6 to n-3 polyunsaturated fatty acids. These have an impact on immunological response, inflammation, and neurodevelopment in addition to energy.[2]
3. Protein quality is important. Digestibility (e.g. PDCAAS, DIAAS), amino acid profile, and source (dairy vs. non-dairy) are important considerations. According to reviews, RUTFs with less dairy may not be as beneficial for weight gain or recovery.[3]
4. Thing is, micronutrient completeness covers vitamins like A, D, E, K, the B-complex group, and C. It also includes minerals such as iron, zinc, magnesium, calcium, phosphorus, and others. All these need to reach recommended levels. Recovery then can restore those micronutrient stores properly. You know, some studies point out deficiencies in certain RUTFs. Especially with lipophilic vitamins. That shows up under storage conditions or in altered formulations.[2]
5. Stability matters a lot for RUTF. You see, it gets used in all kinds of field settings. So low moisture and low water activity help keep microbial growth away. Fats need to resist oxidation pretty well. Packaging and storage conditions have to be adequate too.[4]
6. Palatability and acceptability matter a lot. Especially for kids. You know, the taste, the smell, the texture. All that stuff affects how well they stick with it. Local RUTFs go for ingredients that fit the culture. They keep costs down too. But they have to hold onto that sensory side. Make sure it stays okay to eat.[5]

Recent Advances in Ready-to-Use Therapeutic Foods (RUTF)

Ready-to-use therapeutic food (RUTF) has revolutionized the management of severe acute malnutrition (SAM) in children, particularly in low-resource settings. RUTFs are energy-dense, micronutrient-enriched pastes that can be consumed directly without the need for water, cooking, or refrigeration. Recent years have seen significant innovation in RUTF composition, formulation, and delivery strategies aimed at improving nutritional quality, reducing costs, enhancing sustainability, and expanding access.

This review highlights recent advancements in ingredient diversification, formulation efficiency, technological improvements, and clinical applications.

Severe acute malnutrition remains a major contributor to childhood mortality, particularly in developing regions of Africa and South Asia. The introduction of ready-to-use therapeutic food (RUTF) has significantly improved recovery rates and reduced hospital dependency by enabling community-based management of acute malnutrition (Ashworth, 2006; Ciliberto et al., 2005). Traditionally, RUTF formulations contain peanut paste, milk powder, vegetable oil, sugar, and a vitamin-mineral premix. However, the high cost of milk-based proteins and the reliance on imported ingredients have prompted innovations to make RUTF more affordable, accessible, and sustainable. Research now focuses on alternative protein sources, improved formulations, packaging innovations, and enhanced clinical implementation to optimize outcomes.

Ingredient Innovations

The nutritional and functional composition of RUTF continues to evolve as researchers explore more cost-effective and nutritionally adequate alternatives. A key focus has been replacing milk-based proteins with plant-based sources that are locally available and culturally acceptable.

Plant-Based Proteins

Traditional RUTFs use skimmed milk powder as a protein source due to its high digestibility and amino acid quality. However, milk powder contributes substantially to the overall cost of production. Plant-based proteins, such as soy, chickpea, lentils, and mung bean, have been increasingly incorporated as partial or full substitutes for milk. Studies indicate that well-balanced plant-based formulations can achieve comparable recovery rates and growth outcomes to conventional milk-based RUTFs (Dube et al., 2009). Moreover, the use of plant proteins reduces dependence on imported dairy products, supporting local agriculture and improving sustainability.

Local and Culturally Acceptable Ingredients

The use of locally available crops such as millets, sorghum, and groundnuts aligns RUTF production with regional food preferences and agricultural practices. Locally sourced ingredients lower transportation costs and enhance community ownership of nutrition programs. For example, sorghum and millet-based RUTFs are increasingly tested in African regions where these grains are dietary staples. Incorporating culturally familiar ingredients enhances acceptance and adherence among children and caregivers.

Nutritional Fortification and Functional Additives

Recent advances focus on functional fortification to enhance the nutritional impact of RUTF. Supplementation with omega-3 fatty acids supports brain development and immune function, while probiotics and prebiotics improve gut health and nutrient absorption. These bioactive components can restore gut microbiota balance disrupted by malnutrition, thereby improving recovery outcomes. Although these enriched formulations are still under evaluation, they represent a promising frontier in therapeutic food innovation.

Formulation Advances

Low-Cost and Locally Produced RUTF

Cost reduction remains a primary objective in scaling up RUTF availability. Locally produced RUTFs utilize regional raw materials and small-scale manufacturing facilities to reduce costs and improve supply chain resilience (Prudhon et al., 2006). This approach also fosters economic empowerment within communities and ensures consistent product availability during emergencies.

Ready-to-Use Supplementary Foods (RUSF)

For children with moderate acute malnutrition (MAM), Ready-to-Use Supplementary Foods (RUSF) provide a preventive and therapeutic option. RUSF formulations are similar to RUTF but have lower energy density and micronutrient levels. They can be integrated into preventive feeding programs to avert progression to severe malnutrition (Isanaka et al., 2009).

Reduced-Milk and Milk-Free RUTF

To address cost and lactose intolerance challenges, researchers are developing reduced-milk or milk-free formulations. Blends of plant proteins and locally sourced ingredients are used to replace milk without compromising protein quality. These products have demonstrated similar efficacy in promoting weight gain and recovery when compared with traditional milk-based RUTF (Dube et al., 2009).

Alternative Lipid Bases

Peanut oil, while nutritionally valuable, may not always be available or suitable in all settings. Alternative lipid sources such as sunflower, canola, and palm oils are now being tested. These oils improve fatty acid profiles and reduce oxidative degradation, thus enhancing the shelf life and stability of the final product.

Technological Advances

Powdered and Semi-Solid Formulations

Traditional RUTF is a thick paste packaged in individual sachets. New developments include powdered or semi-solid versions that can be reconstituted with safe water. These variants enhance flexibility, reduce packaging waste, and are particularly beneficial for older children and adults requiring therapeutic feeding.

Improved Packaging and Storage

Innovations in RUTF packaging aim to improve both usability and environmental sustainability. Eco-friendly, biodegradable, and moisture-resistant packaging materials are being explored. Single-use sachets ensure portion control, minimize contamination, and simplify distribution. Improved sealing techniques also enhance protection against humidity and pests in tropical climates.

Shelf Stability in Humid Environments

Maintaining product stability in hot and humid conditions remains a challenge. Advances in formulation chemistry, such as the use of antioxidants and improved lipid matrices, have enhanced oxidative stability. These innovations ensure product safety and efficacy over extended storage periods, even in high-temperature environments.

Clinical and Programmatic Advances

Efficacy and Mortality Reduction

RUTF-based interventions have consistently demonstrated effectiveness in reducing mortality and promoting rapid nutritional recovery among severely malnourished children. Studies in Malawi and Niger have shown recovery rates exceeding 80% with RUTF compared to traditional inpatient feeding programs (Ciliberto et al., 2005; Ashworth, 2006).

Comparative and Reduced-Dose Studies

Recent trials have compared standard and modified formulations, including milk-free versions, finding comparable recovery outcomes. Research on reduced-dose RUTF regimens has also gained traction, suggesting that lower daily quantities may achieve similar therapeutic benefits, thus improving cost efficiency and scalability.

Integration into CMAM Programs

The integration of RUTF into Community-Based Management of Acute Malnutrition (CMAM) programs has revolutionized the delivery of care. These programs allow for home-based treatment under minimal supervision, increasing coverage and reducing hospitalization rates (Prudhon et al., 2006). This approach empowers communities to actively participate in malnutrition management and enhances sustainability.

Challenges and Limitations

High Cost and Dependency on Imported Ingredients

The production of RUTFs can be expensive, particularly because of ingredients like milk powder. The cost of raw ingredients for certain milk-free, soy-based RUTFs was found to be significantly lower than a standard RUTF like Plumpy'Nut. The cost of a 10% milk RUTF was also found to be about 23% cheaper than a 25% milk RUTF. This highlights that a major cost factor is the milk content, which can be 11 times more expensive than ingredients like soy flour. Additionally, some countries do not have indigenously made RUTF that meets the necessary criteria and thus must rely on imports.

Acceptability in Different Cultural Contexts

While RUTFs are generally well-accepted, there can be a preference for the standard peanut-based product over alternative formulations. For example, one study found that children preferred the taste of the standard RUTF over an almond, lentil, and maize-based RUTF. Another study noted that an initial version of a mung bean-based RUTF was perceived as less palatable, but acceptability improved after it was reformulated to be less dry. These findings highlight the need for formulations that are not only nutritious but also culturally acceptable and palatable.

Logistical and Administrative Issues

India's porous administrative system raises concerns about the potential for commercial exploitation of malnutrition by vested interests. These groups might try to delay the development of indigenous RUTF to ensure that high-cost imports continue. Global and national food corporations might also try to influence government policies to promote their imported products, turning childhood malnutrition into a source of profit.

Peanut Allergy Concerns

Although not explicitly mentioned as a major challenge in the documents, a peanutbased RUTF could pose a risk to children with peanut allergies. Some studies on alternative RUTFs noted that children with known allergies to the formulation's ingredients were excluded from the trials. Research is needed to assess the potential for adverse events like allergic reactions from formulations with particular ingredients of interest, such as soy and chickpeas.

Research and Nutritional Limitations

Despite decades of research, the evidence on alternative RUTFs remains limited. Most studies focus on basic anthropometric outcomes like weight and height, with limited information on other crucial factors such as the effects on the gut microbiome, cognitive development, or iron status. Another significant limitation is the challenge of achieving the recommended protein quality, especially in milk-free formulations. Many studies are also not designed with enough statistical power to detect differences in adverse events between alternative and standard RUTFs.

FUTURE PERSPECTIVE:

The future may hold a **nutrigenomics approach** to RUTFs, where the food is personalized based on a child's unique genetic makeup. This is a concept similar to **personalized medicine**, which is already gaining traction. It involves studying how nutrients and genes interact and how an individual's genetic profile might affect their response to a specific diet. This could lead to RUTFs that are even more effective at preventing and treating diseases by tailoring the diet to a child's specific needs.

Integration with Sustainable Agriculture and Local Food Systems

Current RUTF production often relies on imported, high-cost ingredients like milk powder. Future efforts aim to integrate RUTF development with local, sustainable agriculture. This means using locally available and culturally acceptable ingredients to create new formulations, which could make RUTFs more affordable, increase their availability, and reduce transportation costs. Local production would also create jobs and support local economies in the communities that need it most.

Innovations for Infants Under 6 Months

Most current RUTFs are designed for children aged 6 to 59 months. There is a need for innovation to create effective therapeutic foods for **infants under 6 months** who are suffering from severe acute malnutrition. For this age group, RUTFs must be specifically formulated to be safe and effective, ensuring they don't displace breastmilk, which is the ideal food for young infants.

Digital Health Tools for Monitoring RUTF Programs

Technology is playing an increasingly important role in healthcare, and this extends to malnutrition programs. **Digital health tools**, such as mobile apps, are being developed to help frontline health workers monitor RUTF programs more effectively. These apps can provide step-by-step guidance for assessing a child's nutritional status, calculating the correct dosage of RUTF, and tracking a child's progress. They can also provide real-time data to program managers, which helps them ensure that RUTF is consistently available and used correctly by the children who need it. This digital monitoring can improve the quality and efficiency of malnutrition treatment programs.

- higher moisture content than the UNICEF product. Low moisture is essential for preventing microbial activity and extending shelf life.

Bulk Density: The bulk density of the formulated pearl millet RUTFs was higher than the 100% pearl millet flour but lower than the UNICEF product. While the formulated foods and the control are within the recommended range for infant food, bulk density is an important factor in packaging

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