EISSN: 2707-0425

*East African Journal of Science, Technology and Innovation, Vol. 4 (Special Issue): August 2023*



# Physiochemical and sensory characteristics of a supplementary food for malnourished underfive children, *a case of maize, millet and peanut*

*[1*]MWANGI J.,[1]OKOTH M., [1]ABONG G*

[1]Department of Food Science, Nutrition and Technology, University of Nairobi, P.O. Box 29053-00625, Nairobi, Kenya.

***Corresponding Author**: jokim8947@yahoo.com

**Abstract**

Malnutrition in children remains a major public health challenge in developing countries. The local un-availability of the necessary ingredients and lack of knowledge on how to prepare food for malnourished children are among the primary causes of child malnutrition. The study sought to determine the use of locally available food material (maize, millet and peanut) in formulating a food product to address the rampant protein- energy malnutrition of children in Kenya. The linear programming model of the nutrisurvey computer software was used in generating six treatments of a supplementary food as follows: Sample A=27%millet, 36%maize, 28% peanut and 9% oil, B=30%millet, 33%maize, 30% peanut and 7% oil, C=32%millet, 19%maize, 38% peanut and 11% oil, D=35%millet, 11%maize, 42% peanut and 12% oil, E= 35%millet, 30%maize, 26% peanut and 9% oil and F=40%millet, 20%maize, 30% peanut and 10% oil. Physico-chemical and sensory attributes of the supplementary food were determined using standard procedures. The moisture, energy, protein, fat, carbohydrate, dietary fiber, total ash, iron, calcium and zinc of 100 g of the products A,B,C,D,E and F were found to have ranges from: 3.9 ±0.3g to 5.2 ±0.3g, 424.0kcal 485.0kcal, 9 ±1.1 to 14.1 ±1.1g, 23.9 ±0.2 to 35.9 ±0.1g, 28.7 ±0.7 to 52.4 ±1.4g, 7.9 ±1.8 to 18.0 ±1.0g, 1.6 ±0.01 to 2.1 ±0.02g, 2.0 ±0.7 to 7.0 ±0.1g, 14.47 ±0.3 to 33.4 ±0.3g, 2.6.0 ±0.0 to 4.4 ±0.1g respectively. The formulations chemical attributes were in the range that meets the RDA's requirements for children under five in 2 to 3 serving of 100g of the products and thus, it's supplementation to other foods given to the child could be effective in the treatment of malnourished children after the clinical trial.

**Keywords:** *Maize, Malnutrition, Millet, Physico-chemical, Sensory, Supplementary,*

**Cite as:** *Mwangi et al., (2023)* Physiochemical and sensory characteristics of a supplementary food for malnourished underfive children (a case of maize, millet and peanut). *East African Journal of Science, Technology and Innovation 4(special issue).*

Received: 27/06/23
Accepted: 06/07/23
Published: 09/08/23

## Introduction

Globally, it is estimated that 165 million children under 5 years of age are stunted, most of them being in Africa, South and Central Asia. Under nutrition in childhood causes 3.1 million child deaths annually; it is associated with 35% of deaths in children less than 5 years' old (De Vita *et al*., 2019). Childhood under nutrition (low weight for age, low height for age, low weight for height, or micronutrient deficiencies) contributes up to 45% of deaths globally in children under 5 years (Mogaka *et al*., 2022).

Food security status in sub-Saharan African countries face increasing risks of deterioration fueled by the changing climate that has resulted in low agricultural production, with the ever-growing population exerting increasing pressure to feed. A reduction in agricultural products affects not only supply of food but also impact the major sources of income of most households negatively (Kasomo and Gayawan 2021). Malnutrition is a major global challenge and one of the prominent Sustainable Development Goals (SDGs). SDG 2.2 aims to "end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under 5 years of age" (Bailey *et al*., 2020).

The main attributing factors for malnutrition is consumption of less nutrient dense diets coupled with other factors such as poverty, illiteracy and large families (Younis, 2015). Children are mainly exposed to risk of under-nutrition during complementary feeding as some nutritional requirements may not be adequately met in the meals provided (Jackson *et al*., 2016). According to KDHS (2014), just over 25 percent of children below five years are malnourished in Kenya. In this number, 26 percent of the children are stunted, while 7% are wasted and 11% are underweight. Stunting is prevalent in rural setting than urban setting (29% versus 20%) and ranges from 15% in Nyeri to 46% in Kitui and West Pokot Counties.

The high rate of malnutrition witnessed in the world and Kenya in general is highly expensive to treat and the affected children can be rehabilitated by administering a supplementary diet from locally available food material. The World Health Organization (WHO) currently recommends the provision of nutrient--dense supplementary food to children with moderate under--nutrition in order to meet the child's extra needs for weight and height gain and functional recovery (Grobler *et al*., 2015). Malnourished children have nutritional requirements that differ from non-malnourished children, that is, they require increased intake of energy and essential nutrients over and above those required by non-malnourished children and, when necessary, treatment for any associated medical conditions (Grobler *et al*., 2015). Nowadays, supplementary feeding programs have been established in some African countries such as Congo, Ethiopia, Malawi and Niger to treat malnutrition. Fortified blended flours, such as corn-soya blend (CSB), prepared as a porridge, are the most widely used foods in supplementary feeding programs (Ntsama *et al*., 2020). In Kenya supplementary feeding programs for the treatment of the malnourished children has not been fully exploited by the companies like Insta in Kenya and importation of ready to use therapeutic food. WHO, 2013 recommends the use of locally available foods in the production of ready to eat supplementary food for the treatment of malnourished children.

This study was therefore set to established whether incorporation of locally available materials: maize, millet and peanut can be used in production of ready to eat foods for malnourished children. The study also sought to determine the acceptability of the formulations in terms of color, taste, flavor and texture and meet the energy, protein, zinc, calcium and iron content of ready to eat foods for malnourished children. Maize is locally available and a staple food in the country that is high in carbohydrates but low in minerals and protein to meet the nutritional requirements of malnourished children (Ignjatovic-Micic *et al*., 2015). Finger millet on the other hand has a good amounts of minerals with the highest calcium level among other grains (Singh, 2012). Peanuts (groundnuts) are good sources of healthy fats, protein, and fiber. Other components of groundnuts are potassium, phosphorous, magnesium, and B vitamins. Peanut are rich in nutrients and high in calories but low in carbohydrates (Savage, 1994). It is against this background that this study was designed to establish the physical chemical characteristics and sensory profile of ready to eat food made from maize, millet and peanut for malnourished children.

## Materials and methods

### *Study design*

The linear programming model of the nutrisurvey computer software (Briend *et al*., 2001) was used in generating the formulations. The constrain in this study was cost the limiting factors. zinc, calcium, iron and protein were optimized.

*Acquisition of raw materials*

Dried maize grain, millet and peanut were procured from Gikomba market in Nairobi City, Kenya. Vegetable cooking oil was bought from local supermarket in Nairobi town.

*Cleaning and sorting of raw materials*

Maize grains and millet were sorted to remove impurities such as stones, rotten seed other grains, and broken kernels. Sorted maize grains and millet were washed to remove dust and preservative chemicals, drained and immediately sun dried. Groundnuts were sorted by removal of broken kernels as they are susceptible to contamination by aflatoxin. The clean remnant kernels were tested of contamination with aflatoxin.

*Malting of finger millet*

The cleaned millet was steeped into water at room temperature (25-27 °C). Surplus water was drained off and the grains were spread on metallic trays at room temperature (25-27 °C) by covering with wet muslin cloth to germinate. To prevent drying out, the grain was sprinkled with water at the interval of every 12 hours and the grain was turned and mixed from time to time to equalize the moisture and for aeration. The germination was done for 72 hours. Malting was done to lower the anti-nutrients (phytic acid) in millet. The malted seeds were then dried in oven for 60$^{o}$c for 8 hours to moisture level of 4-6% and put into airtight plastic bags and stored at ambient temperatures (Hiremath *et al.*, 2019).

*Pre-cooking of maize and finger millet*

The dry malted millet and clean dry maize were milled by use of a commercial hammer (Powerline®, BM-35, Kirloskar, India) in Nairobi, fitted with a 2.0 mm opening screen. The maize and millet were pre-cooked using drum dryer in the pilot plant at the department of food science nutrition and technology, university of Nairobi to obtain pre-cooked products. A single drum dyier from (APV-Mitchell (Dryers) Ltd., Carlisle, England) with Diameter 12 in. (0.3048 m) Total surface area = 0.2797 m$^2$, Length 11.5 in. (0.2921 m) and Effective drying surface - 79.3% (0.2217 m$^2$) was used (See table 1. typical operational data on preparation of maize and finger millet).

***Table 1. Typical operational data on preparation of maize and finger millet***

| | |
|---|---|
| Drum drier speed | 1.43 rpm |
| Steam pressure (gauge pressure) | 4.08 kg/cm$^2$ (4.0 bar) |
| Steam temperature | 144°C |
| Drying time | 33.3 s |

*Blanching of peanuts*

Blanching was done to facilitate further manual sorting of aflatoxin-contaminated kernels after deskinning (Horn, 2005). The kernels were placed in a bucket of water and all the kernels that did float were discarded as molds infected kernels are lighter in weight (Study, 2017). The peanut seeds that did not float were lightly blanched at 140 $^0$C for 25 min in preheated roaster which facilitated the manual removal of stained (suspected of aflatoxin contamination) kernels by splitting the seed and checking of stained surface. The clean and non-stained peanut were further roasted in an oven at 130$^{o}$c to remove moisture and to improve on aroma, cooled and stored in airtight container (Galvez *et al.*, 2003).

*Milling of raw materials*

The clean peanut kennels and the precooked maize and millet (flakes) and oil were mixed as per ratios in table 1, ground and using an electric mixer (Kenwood® Chef, KMC200, Kenwood Co. Ltd., and UK) at medium speed for 2.5 minutes The resulting products were immediately transferred in to air tight plastic container and stored at ambient temperatures awaiting physical chemical and sensory analysis.

*Formulation of supplementary food from maize, millet and peanut with improved mineral and protein*

The linear programming model of the nutrisurvey computer software (Briend *et al.*, 2001) was used in formulating the ingredient ratios. Six formulas were developed with different ratios of the ingredients and the recommended daily allowance for children aged between 6 to 59 months. See table 2 on ingredient percentages of the product formulations.

*Table 2: Ingredient percentages in the food formulations*

| Ingredients | Food formulations (%) | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| **Millet** | 27 | 30 | 32 | 35 | 35 | 40 |
| **Maize** | 36 | 33 | 19 | 11 | 30 | 20 |
| **Peanut** | 28 | 30 | 38 | 42 | 26 | 30 |
| **Vegetable oil** | 9 | 7 | 11 | 12 | 9 | 10 |
| **Total** | 100 | 100 | 100 | 100 | 100 | 100 |

***Analytical methods***

***Determination of aflatoxin content***

Peanut flour samples (sorted and non- sorted peanuts) were analyzed for aflatoxin levels using VICAM fluorimeter S/N: EX03150 (Washington, USA) as per the manufacturer's manual (Dorner, 2008). The analysis of the samples was done in duplicate and the levels of aflatoxin expressed as ppb (µg/kg). The aflatoxin level of the unsorted and sorted peanuts had a mean of 12.8 to 8.7 ppb respectively. The end product had a mean of 9.12 ppb which agrees with KEBS recommendations of not more than 10ppb (Samarajeewa *et al.*, 1990).

***Proximate analysis***

The six parameters of proximate composition in the treatment were determined as per AOAC (2012) method. Specific methods that were employed for each measurement were moisture content (method 925.10), crude protein (method 920.87), crude fiber (method 920.86), crude fat (method 922.06), crude ash (method 923.03) and carbohydrate content by difference method.

***Mineral analysis***

Mineral content was analyzed using an atomic absorption spectrophotometer (210 VGP, Buck Scientific, East Norwalk) as described by AOAC (2000) method number 923.03. Samples (5 g) were digested with 10ml of 20% HCl on a hot plate. Calcium (Ca), iron (Fe) and zinc (Zn). Standard solutions of zinc oxide (ZnO), calcium carbonate (CaCO3) and ferrous ammonium sulphate (Fe (NH4)2(SO4)2) were used for determining concentrations of Zn, Ca and Fe.

***Phytic acid determination***

Malted and non- malted millet were tested for the levels of phytic acid as per AOAC (2000) method Number 986.11. Approximately 1 gram of each sample was weighed into a centrifuging tube and added 10ml of petroleum ether and the two mixed. The mixture was left 10 minutes to settle the solid particles before decanting. The tube was turned upside down and left to dry. 10 ml of 2.4% HCl was added and topped up with distilled water. The mixture was then mixed for 10 minutes and three times for three minutes after which it was centrifuged. The filtrate was collected 4 times during centrifugation and toped up to 100 ml in volumetric flask. About 2ml of the 100 ml of the solution in the volumetric flask was drawn into a test tube and added 2ml mixture of 1ml 0.03% $FeCl_3$. $6H_2O$ and 1ml of 0.3% sulfosalicylic and 6mls of distilled water, shaken and absorbance readings taken by use of Atomic Absorption spectrophotometer (210 VGP, Buck Scientific, East Norwalk).

***Sensory analysis***

Acceptance sensory analysis of the six formulations was done at the University of Nairobi, in the department of Food Science Nutrition and Technology by use of semi- trained panelists. The panelist consisted of 40 adults (male and female) aged 20 to 50 years. Verbal consent was sought from the participants after which they were trained on how to conduct the sensory analysis. A 7-point hedonic scale was used to test the intensity that each attribute scored on the appearance (color), smell (flavor), taste, texture and general acceptability of the products. The 7- point scale used were: 1-dislike very much, 2- dislike moderately, 3- dislike slightly, 4- neither like nor dislike, 5- like slightly, 6-like moderately, 7- like very much. Products were assigned random numbers representing the different treatments where single blinding was used in the study. Clean water was provided to the panelists to rinse their palate in between successive assessment of the products (Sharif *et al.*, 2017).

***Statistical analysis***

The data was analyzed in Genstat version 15. Descriptive statistics such as mean and standard deviation of aflatoxin, phytic acid levels of millet, proximate characteristics, physical attributes, and sensory scores was determined. The proximate composition was analyzed using one-way analysis of variance (ANOVA). Least significance difference (LSD) was used to separate means that were significantly different at p <0.05.

**Results**

***Physiochemical characteristics and sensory attributes of the formulated food product from maize, millet and peanut***

The phytate content of millet before and after malting gave a mean of 26.53 and 21.67mg/100g, respectively. The energy in this study were 464.7±8.3g/100g, 469.2±1.4g/100g, 481.6±8.1g/100g, 485.0±2.8g/100g, 483.1±3.6g/100 and 424.0±1.4g/100g in the products A, B, C, D, E and F respectively. The moisture contents of formulation A, B, C, D, E and F were 4.6 ±0.5g/100g, 5.2g/100 g,4.3 ±0.3g/100 g, 3.9 ±0.3g/100 g, 5.0±0.1g/100 and 5.2 ±0.3g/100g respectively.

**Table3 Proximate composition (g/100 g dry weight) of supplementary food formulated from maize, millet and peanut**

| Parameter | A | B | C | D | E | F | LSD |
|---|---|---|---|---|---|---|---|
| **Moisture(wet weight)** | 4.6±0.5$^{ab}$ | 5.2±0.00$^{b}$ | 4.3±0.3$^{ab}$ | 3.9±0.3$^{a}$ | 5.0±0.1$^{ab}$ | 5.2±0.3$^{b}$ | 0.636 |
| **Fat** | 24.2±0.2$^{c}$ | 28.1±0.1$^{c}$ | 33.4±0.4$^{d}$ | 35.9±0.1$^{e}$ | 25.9±0.1$^{b}$ | 23.9±0.2$^{a}$ | 0.5249 |
| **Fibre** | 7.9±1.8$^{a,}$ | 10.8±0.5$^{b}$ | 15.5±1.0$^{b}$ | 18.0±1.0$^{b}$ | 15.8±1.0$^{b}$ | 17.0±0.4$^{b}$ | 2.546 |
| **Ash** | 1.6±0.04$^{ab}$ | 1.8±0.1$^{c}$ | 2.0±0.01$^{d}$ | 1.7±0.04$^{bc}$ | 2.1±0.02$^{e}$ | 1.6±0.01$^{a}$ | 0.0595 |
| **Protein** | 9.4±1.1$^{a}$ | 12.3±1.7$^{a}$ | 14.1±1.1$^{a}$ | 11.9±0.4$^{a}$ | 12.1±3.0$^{a}$ | 12.2±1.6$^{a}$ | 4.178 |
| **CHO** | 52..4±1.4$^{d}$ | 41.9±1.2$^{c}$ | 31.2±2.3$^{ab}$ | 28.7±0.4$^{a}$ | 39.1±4.2$^{bc}$ | 41.1±0.8$^{c}$ | 5.186 |
| **Energy(kcal/100 g)** | 464.7±8.3$^{b}$ | 469.2±1.4$^{b}$ | 481.6±8.1$^{b}$ | 485.0±2.8$^{b}$ | 438.1±3.6$^{a}$ | 424.0±1.4$^{a}$ | 12.61 |

All values are in a wet weight basis. Means with the same superscript in the same row are not significantly different (p<0.05). A=27%millet, 36%maize, 28% peanut and 9% oil, B had 30%millet, 33%maize, 30% peanut and 7% oil, C=32%millet, 19%maize, 38% peanut and 11% oil, D=35%millet, 11%maize, 42% peanut and 12% oil, E=35%millet, 30%maize, 26% peanut and 9% oil and F=40%millet, 20%maize, 30% peanut and 10% oil.

Approximately 9.4±0.1g/100g, 12.3±1.7g/100g, 14.1±1.1g/100g, and 11.9±0.4g/100g, 12.1±3.0g/100g and 12.2±1.6g/100g of protein content accounted for A, B, C, D, E and F respectively. The fat content of 24.2±0.2g/100g, 28.1±0.1g/100g, 33.4±0.4g/100g, 35.9±0.1g/100g, 25.9±0.1g/100g and 24.2±0.2g/100g, 23.9±0.2g/100g was recorded in formulation A, B, C, D, E and F.

**Table 4: Mineral composition (mg/100 g dry weight) of supplementary food formulated from maize, millet and peanut**

| | A | B | C | D | E | F | LSD |
|---|---|---|---|---|---|---|---|
| **Zinc** | **4.2±0.3$^{cd}$** | **4.0±0.1$^{c}$** | **3.0±0.1$^{b}$** | **2.6±0$^{a}$** | **4.4±0.1$^{d}$** | **3.2±0.1$^{b}$** | **0.2519** |
| **iron** | **2.0±0.7$^{a}$** | **5.9±0.2$^{bc}$** | **5.3±0.6$^{b}$** | **6.2±0.2$^{bc}$** | **5.7±0.1$^{b}$** | **7.0±0.1$^{c}$** | **0.7420** |
| **Calcium** | **18.4±0.6$^{b}$** | **29.4±0.4$^{c}$** | **14.47±0.3$^{a}$** | **17.52±0.3$^{d}$** | **32.2±0.3$^{d}$** | **33.4±0.3$^{e}$** | **0.6683** |

All values are in a wet weight basis. Means with the same superscript in the same row are not significantly different (p<0.05). A had 27%millet, 36%maize, 28% peanut and 9% oil, B had 30%millet, 33%maize, 30% peanut and 7% oil, C=32%millet, 19%maize, 38% peanut and 11% oil, D= 35%millet, 11%maize, 42% peanut and 12% oil, E=35%millet, 30%maize, 26% peanut and 9% oil and F=40% millet, 20%maize, 30%peanut and 10%oil.

Fiber content of the formulated products were 7.9±1.8 g/100 g,10.8. ±0.5 g/100 g, 15.5±1.0 g/100 g, 15.8±1.0 g/100 g,17.0±0.4 g/100 g, and 18±1.0 g/100 g respectively.

There was a significance difference among the various products in (p<0.001) in the amount of calcium, zinc and iron. The amount of calcium was 18.4±0.6mg/100g, 29.4±0.4mg/100g, 14.47±0.3mg/100g, 17.52±0.3mg/100g, 32.2±0.3mg/100g and 33.4±0.3mg/100g in formulations A, B, C, D, E and F respectively. The iron content of formulations A, B, C, D, E and F were 2.0±0.7mg/100g, 5.9±0.2mg/100g, 5.3±0.6mg/100g, 6.2±0.2mg/100g, 5.7±0.1mg/100g, and 7.0±0.1mg/100g respectively. The zinc content of the formulated product A, B, C, D, E and F were 4.2±0.3mg/100g, 4.0±0.1mg/100g, 3.0±0.1mg/100g, 2.6±0mg/100g, 4.4±0.1mg/100g and 3.2±0.1mg/100g respectively.

***Table5: Recommended dietary allowance coverage by the food formulation A with 27%millet, 36%maize, 28% peanut and 9%***

| Parameter | Recommended dietary allowance (RDA) | Effected by: |
|---|---|---|
| Energy | 0 to 6 months- 490kcal/day | Single serving of 100g<br>2 or more serving of 100g |
| | 7- 36months 989.7kcal/day | |
| Protein | 6-59months -12.57% | 2 serving of 100g |
| fibre | 1-3yeras- 19g | 1 serving of 100g |
| Iron | 1-3 years- 7mg | 3 or more serving of 100g |
| Zinc | 0-6months -2mg per day | Single serving of 100g |
| | 8- 36months -3mg/day | Single serving of 100g |

***Sensory analysis***

The score on the overall averages' acceptability based on attributes such as color, texture odor, and taste of formulations A, B, C, D, E and F were 6.2±1.5, 4.7±1.5, 4.7±1.5, 5.6±1.2, 4.1±1.6, 4.1±1.8 respectively. Formulation A had the highest score in acceptability of 6.2±1.5.

*Table 6. Sensory scores of supplementary foods formulated from maize, millet and peanut as perceived by panelists*

| Attribute | Food Formulation | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | LSD |
| **Color** | $5.0±1.6^{b}$ | $5.1±1.5^{b}$ | $5.1±1.5^{b}$ | $5.2±1.4^{b}$ | $4.1±1.8^{a}$ | $4.2±1.8^{a}$ | 0.5349 |
| **Odor** | $5.7±1.2^{c}$ | $5.0±1.5^{ab}$ | $5.0±1.5^{ab}$ | $5.4±1.5^{bc}$ | $4.3±1.7^{a}$ | $4.7±1.3^{a}$ | 0.4884 |
| **Texture** | $4.3±1.7^{a}$ | $4.5±1.6^{ab}$ | $4.5±1.6^{ab}$ | $5.2±1.3^{b}$ | $3.9±1.7^{a}$ | $4.2±2.0^{a}$ | 0.5170 |
| **Taste** | $4.3±1.6^{a}$ | $4.2±2.0^{a}$ | $4.2±2.0^{a}$ | $5.2±1.5^{b}$ | $4.2±1.5^{a}$ | $4.0±1.7^{a}$ | 0.5615 |
| **Overall acceptability** | $6.2±1.5^{a}$ | $4.7±1.5^{a}$ | $4.7±1.5^{a}$ | $5.6±1.2^{a}$ | $4.1±1.6^{a}$ | $4.1±1.8^{a}$ | 1.747 |

means with the same superscript in the same raw are not significantly different ($p<0.05$). A had 27%millet, 36%maize, 28% peanut and 9% oil, B had 30%millet, 33%maize, 30% peanut and 7% oil, C=32%millet, 19%maize, 38% peanut and 11% oil, D=35%millet, 11%maize, 42% peanut and 12% oil, E=35%millet, 30%maize, 26% peanut and 9% oil and F=40%millet, 20%maize, 30% peanut and 10% oil,

**Discussion**

***Physiochemical characteristics and sensory attributes of the formulated food product from maize, millet and peanut***

The moisture content of the formulations was slightly higher than the standard moisture level of 2.5% in accordance to world health organization (WHO) in ready to eat foods for malnourished children. However, the moisture content in this study was lower than that reported in a previous study conducted in Ethiopia which had 13.48g/100g, 9.6g/100g, and 6.7g/100g (Yazew, 2022) among the formulations. Similarly, another study on ready to eat food for malnourished children had moisture levels equal to formulation B which had 5.2±0.00g/100g (Mezgebo *et al.,* 2018). High moisture content in supplementary food for malnourished children creates a conducive environment for spoilage and pathogenic bacteria that reduce the storage time, quality and at same time exposes the child to risk of gastrointestinal infections (Mahmood-Aljamali *et al.*, 2021).

In this study the energy contents of the six developed products were slightly lower than what is recommended in RUTF which is 530 kcal/100g. Similarly, a study done on complementary food in Nigeria recorded higher energy which ranged from 520 to 550kcal/ 100g (Awuchi *et al.*, 2020). However, these finding were higher than the previous studies reported in Ethiopia, which showed that the complementary food gross energy varied from 376.30 to 385.56 kcal/100 g (Mezgebo *et al.,* 2018). According to WHO (2003), the RDA energy for children aged 6 months (6kgs of weight) and 1-3 years is about 490kcal and 989.7kcal/day respectively. Approximately 100g of the developed food products provides 42.84%-49.04% of daily allowance energy.

The products had protein content in the range of that meets the RDA requirements, given that other foods will be given to the child which will compensate for the missing nutrient requirement. The protein content of this study was lower than a study done in Ethiopia where formulations involved sorghum and millet giving 36% and 54% protein respectively (Forsido *et al.,* 2020). However, in another study done in the same country, the protein content of one of the formulations with 12.26% was almost similar with that of formulation B(2.3±1.7g/100g), E(12.1±3.0g/100g) and F(12.2±1.6g/100g) in the current study while the other one had 0.88% (Mezgebo *et al.,* 2018).

Protein recommended for children 6-59 months is 12.57% with 0-6 months and 7-12 months requiring 12.5g/day and 13.7g/day, respectively. Protein help the body repair cells and make new ones and is thus important in replenishing cells of malnourished children (Sudhakararao *et al*., 2019). Treatment of malnourished children requires high quality dietary protein for recovery (Manary *et al*., 2016a). Too much protein might lower the appetite of the malnourished child which is especially harmful to them (Michaelsen, 2009).

The recommended daily allowance for fiber for children aged 1-3years is 19g (WHO, 2003). Regardless of the benefit of fiber in aiding bowel movements, high levels in foods for malnourished children will dispel high energy food leaving the malnourished child inadequately replenished (Andrew *et al*., 2018) and thus 100 g serving of the food has adequate fiber for malnourished child. In case of fat, 2 serving of 100 g of the food products will attain 40-60% to the energy value for food which is in line WHO (2003) standard that state that fat should contribute 40-60% of the energy value for foods for SAM (Manary & Callaghan, 2016). A similar study recorded lower levels of zinc 1.2 mg/100g (Affonfere *et al*., 2021) than in the current study. However, zinc content in this formulations were lower than that reported in a previous study conducted in Bangladesh which had zinc in the range of 12.2 to13.8mg/100g of the products (Choudhury *et al*., 2018) In another study done in Nigeria, the zinc content varied from4.05–5.58 mg/100g (Mezgebo *et al*., 2018) The recommended dietary allowance (RDA) for infants aged 0-6 month(s) is 2.0mg, and 3.0mg per day for young children aged 7-36 months (Larson *et al*., 2008). Single to two serving of 100g of the formulated products would complement the zinc requirement for these children for children aged 7-36 months.

Calcium content in this study was lower when compared with another study which ranged from 279.7 to 301.3mg/100g (Choudhury *et al*., 2018). Similarly, another study done in Ethiopia had higher calcium levels of 300mg/100g of the product (Phuong *et al*., 2011). A similar study done in Nigeria recorded calcium level ranging from 300–600 mg/100 g (Awuchi *et al*., 2020).

The concentration of calcium in F100 (a "catch-up" formula to rebuild wasted tissues) is about 1000 mg Ca/1000 kcal. This translates to 424 mg Ca/100 kcal of the food product (Diop *et al*., 2003). The RDA for children aged 6 months,6-12 months and 1- 3 years is 200 mg, 250 mg and 700 mg (2-3) serving per day respectively (Gibson *et al*., 2016).

The iron content of the formulations was lower than those of a study on ready to eat supplementary food done in Nepal which had 12.27% (Niraula *et al*., 2018). Another study done in Ethiopia had iron content ranging from 0.94 to 38.00 mg/100g (Mezgebo *et al*., 2018). In the current study, a single serving of 100g of formulation F(7.0±0.1mg/100g) meets the RDA for iron for 1-3 years per day. Other formulations apart from formulation A with (2.0±0.7) would require 2 serving per day to meet the recommended dietary allowance (RDA).

***Sensory analysis.***

The scores in color were almost equal. The different sets of attributes that lead to the most preferred highest and least liked products may be due to different cultural backgrounds, experiences, attitudes, and habits of respondents (Yazew, 2022). However, the following remarks can be made on the respondents' decision based on the individual constituents of the formulation.

Food Sample D scoring highest on the mouth feel might have been due to the effect of high percentage of peanut in the sample mixture that imparted a smoother texture to the product. The smooth texture of peanut is believed to improve the texture of the product (Tehrani *et al*., 2009) (Riveros *et al*., 2009).

**Conclusion**

Ready-to-use supplementary food that can be used for the treatment of malnourished children under 5 years of age was formulated using pre-cooked finger millet, pre-cooked maize flour, peanut paste and vegetable cooking oil. The products chemical attribute was in the range that meets the RDA requirements, given that other foods will be given to the child which will compensate for the missing nutrient requirement. In terms of sensory analysis, formulation A (27%millet, 36%maize, 28% peanut and 9% oil) was found to be the best among the six product and use of this product would be effective in rehabilitating malnourished children after clinical trials.

## References


Abeshu, M. A., Lelisa, A., & Geleta, B. (2016). Complementary Feeding: Review of Recommendations, Feeding Practices, and Adequacy of Homemade Complementary Food Preparations in Developing Countries – Lessons from Ethiopia. *Frontiers in Nutrition*, *3*(October), 1–9. https://doi.org/10.3389/fnut.2016.00041.

Affonfere, M., Chadare, F. J., Fassinou, F. T. K., Talsma, E. F., Linnemann, A. R., & Azokpota, P. (2021). A complementary food supplement from local food ingredients to enhance iron intake among children aged 6–59 months in Benin. *Food Science and Nutrition*, *9*(7), 3824–3835. https://doi.org/10.1002/fsn3.2358

Alquaiz, A. M. (1962). Iron Deficiency Anemia. *Nutrition Reviews*, *20*(6), 164–166. https://doi.org/10.1111/j.1753-4887.1962.tb04605.x

Andrew, A. K., Yiga, P., Kuorwel, K. K., & Chewere, T. (2018). Nutrient and Anti-nutrient Profile of a Local Formula from Sorghum, Peanut, Honey and Ghee (Metu2) for Treatment of Severe Acute Malnutrition. *Journal of Food Research*, *7*(2), 25. https://doi.org/10.5539/jfr.v7n2p25

Awuchi, C. G., Igwe, V. S., & Amagwula, I. O. (2020). Ready-to-use therapeutic foods (RUTFs) for remedying malnutrition and preventable nutritional diseases. *International Journal of Advanced Academic Research*, *6*(1), 47-81.

Bailey, J., Opondo, C., Lelijveld, N., Marron, B., Onyo, P., Musyoki, E.N., Adongo, S.W., Manary, M., Briend, A. & Kerac, M., (2020). A simplified, combined protocol versus standard treatment for acute malnutrition in children 6–59 months (ComPAS trial): A cluster-randomized controlled non-inferiority trial in Kenya and South Sudan. *PLoS medicine*, *17*(7), p.e1003192. https://doi.org/10.1371/journal.pmed.1003192

Beck, K. L., Conlon, C. A., Kruger, R., & Coad, J. (2014). Dietary determinants of and possible solutions to iron deficiency for young women living in industrialized countries: A review. *Nutrients*, *6*(9), 3747–3776. https://doi.org/10.3390/nu6093747

Briend, A., Ferguson, E., & Darmon, N. (2001). Local food price analysis by linear programming: A new approach to assess the economic value of fortified food supplements. *Food and Nutrition Bulletin*, *22*(2), 184–189. https://doi.org/10.1177/156482650102200210

Borel, P., & Desmarchelier, C. (2018). Bioavailability of Fat-Soluble Vitamins and Phytochemicals in Humans: Effects of Genetic Variation. *Annual Review of Nutrition*, *38*(1), 69–96. https://doi.org/10.1146/annurev-nutr-082117-051628

Choudhury, N., Ahmed, T., Hossain, M. I., Islam, M. M., Sarker, S. A., Zeilani, M., & Clemens, J. D. (2018). Ready-to-Use Therapeutic Food Made from Locally Available Food Ingredients Is Well Accepted by Children Having Severe Acute Malnutrition in Bangladesh. *Food and Nutrition Bulletin,* 39(1), 116–126. https://doi.org/10.1177/0379572117743929

De Vita, M.V., Scolfaro, C., Santini, B., Lezo, A., Gobbi, F., Buonfrate, D., Kimani-Murage, E.W., Macharia, T., Wanjohi, M., Rovarini, J.M. & Morino, G., (2019). Malnutrition, morbidity and infection in the informal settlements of Nairobi, Kenya: An epidemiological study. *Italian journal of pediatrics*, *45*(1), pp.1-11.

Deshpande, J., Joshi, M., & Giri, P. (2013). Zinc: The trace element of major importance in human nutrition and health. *International Journal of Medical Science and Public Health*, *2*(1), 1. https://doi.org/10.5455/ijmsph.2013.2.1-6

Di Pasquale, M. G. (2009). The essentials of essential fatty acids. *Journal of Dietary Supplements*, *6*(2), 143–161. https://doi.org/10.1080/19390210902861841

Diop, E. H. I., Dossou, N. I., Ndour, M. M., Briend, A., & Wade, S. (2003). Comparison of the efficacy of a solid ready-to-use food and a liquid, milk-based diet for the rehabilitation of severely malnourished children: A randomized trial. *American Journal of Clinical Nutrition*, *78*(2), 302–307.

https://doi.org/10.1093/ajcn/78.2.302

Dorner, J. W. (2008). Management and prevention of mycotoxins in peanuts. *Food Additives and Contaminants - Part A Chemistry, Analysis, Control, Exposure and Risk Assessment*, *25*(2), 203–208. https://doi.org/10.1080/02652030701658357

Forsido, S. F., Hordofa, A. A., Ayelign, A., Belachew, T., & Hensel, O. (2020). Effects of fermentation and malt addition on the physicochemical properties of cereal based complementary foods in Ethiopia. *Heliyon*, *6*(7). Article ID e04606, 2020.

Galvez, F.C.F., Francisco, M.L.D.L., Villarino, B.J., Lustre, A.O., & Resurreccion, A.V.A. (2003). Manual Sorting to Eliminate Aflatoxin from Peanuts. *J. of Food Prot*. Vol. 66 (10), p 1879-1884.

Hiremath, S. P., & Geetha, K. (2019). *Nutritional Composition of Raw, Malted and Popped Finger Millet (Eleusine coracana) Varieties*. *8*(02), 966–974.

Gibson, R. S., King, J. C., & Lowe, N. (2016). A Review of Dietary Zinc Recommendations. *Food and Nutrition Bulletin*, *37*(4), 443–460. https://doi.org/10.1177/0379572116652252

Grobler, L., Visser, M., Young, T., Schoonees, A., & Siegfried, N. (2015). Benefits and harms of supplementary food in moderately under-nourished children. *Cape Town, South Africa*.

Guidelines, P. F. D., & Africa, S. (2013). Paediatric Food-Based Dietary Guidelines for South Africa: Oral health and nutrition for children under five years of age. *S150Supplement) S Afr J Clin Nutr*, *26*(3), 150–155.

Gupta, D. C. P. (2014). Role of Iron (Fe) in Body. *IOSR Journal of Applied Chemistry*, *7*(11), 38–46. https://doi.org/10.9790/5736-071123846

Horn, B. W. (2005). Colonization of wounded peanut seeds by soil fungi*: selectivity for species from Aspergillus section Flavi*. *97*(1), 202–217.

Ignjatovic-Micic, D., Vancetovic, J., Trbovic, D., Dumanovic, Z., Kostadinovic, M., & Bozinovic, S. (2015). Grain nutrient composition of maize (Zea mays L.) drought-tolerant populations. *Journal of Agricultural and Food Chemistry*, *63*(4), 1251–1260. https://doi.org/10.1021/jf504301u

Jackson, N. N., & Cumber, S. N. (2016). Eradicating malnutrition in cameroon. *South African Journal of Clinical Nutrition*, *29*(4), 172–173. https://doi.org/10.1080/16070658.2016.1217649

Kasomo, J.M. & Gayawan, E., (2021). Spatial location, temperature and rainfall diversity affect the double burden of malnutrition among women in Kenya. *SSM-Population Health*, *16*, p.100939.

Mahmood-Aljamali, N., Mohammed Al Najim, M., & Jawad-Alabbasy, A. (2021). Global Academic Journal of Pharmacy and Drug Research Review on Food poisoning (Types, Causes, Symptoms, Diagnosis, Treatment). *Glob Acad J Pharm Drug Res*, *3*(November), 54–61. https://doi.org/10.36348/gajpdr.2021.v03i04.001

Manary, M., Callaghan, M., Singh, L., & Briend, A. (2016). Protein Quality and Growth in Malnourished Children. *Food and Nutrition Bulletin*, *37*(May), S29–S36. https://doi.org/10.1177/0379572116629023 https://doi.org/10.1177/0379572116629023

Mezgebo, K., Belachew, T., & Satheesh, N. (2018). Optimization of red teff flour, malted soybean flour, and papaya fruit powder blending ratios for better nutritional quality and sensory acceptability of porridge. *Food Science & Nutrition*, *6*(4), 891-903.

Michaelsen, K. F. (2009). *S344*. *30*(3). https://www.who.int/nutrition/publications/moderate_malnutrition/FNBv30n3_suppl_paper2.pdf

Misra, V., Ansari, M. I., Shrivastava, A. K., & Shukla, S. P. (2016). Effect of sugar intake towards human health Role of GABA-transaminase during leaf senescence process in Arabidopsis thaliana View project Developing Sugarbeet Varieties for Indian Agro-climates View project Effect of sugar intake towards human health. *Review Article Saudi Journal of Medicine*, *July*, 28–36. https://doi.org/10.21276/sjm.2016.1.2.2

Mogaka, J.N., Owuor, P.M., Odhiambo, S., Waterman, C., McGuire, M.K., Fuchs, G.J. & Attia, S.L., (2022). Investigating the Impact of Moringa oleifera Supplemented to Kenyan Breastfeeding Mothers on Maternal and Infant Health: A Cluster Randomized Single-

Blinded Controlled Pilot Trial Protocol. *JPGN Reports*, *3*(3), p.e237.
Nadeem, M., Anjum, F., Amir, R., Khan, M., Hussain, S., & Javed, M. (2010). An overview of anti-nutritional factors in cereal grains with special reference to wheat-A review. *Pakistan Journal of Food Sciences*, *20*(1–4), 54–61.
Niraula, P. (2018). *Preparation of Ready to Use Supplementary Food (RUSF) for treating moderately acute malnutrition in children aged 6-24 months* (Doctoral dissertation).
Ngugi, V. W., Obwoge, R. O., Simba, J. M., Ngugi, S. W., & Nyabola, A. M. (2018). *Prevalence of Rickets forchildren aged less than Five years adimitted i n Murang ' a County Hospital in The Year 2014 / 2015*. *7*(3), 14–19. https://doi.org/10.9790/1959-0703101419
Ntsama, P. M., Tsafack, J. J. T., Medoua, G. N., & Mbofung, C. M. F. (2020). Preparation of Ready to Use Supplementary Food for Treating Moderate Acute Malnutrition in Children Aged 6 to 59 Months. *IRA-International Journal of Applied Sciences (ISSN 2455-4499)*, *14*(3), 22. https://doi.org/10.21013/jas.v14.n3.p1
Pathare, P. B., & Opara, U. L. (n.d.). *Colour Measurement and Analysis in Fresh and Processed Foods: A Review Colour Measurement and Analysis in Fresh and Processed Foods : A Review*. https://doi.org/10.1007/s11947-012-0867-9
Pee, S. De, & Bloem, M. W. (2009). *S435 Specially formulated foods and food supplements*. *30*(3), 434–463
Phuong, H., Nga, T. T., Mathisen, R., Nguyen, M., Hop, L. T., Hoa, D. T. B., ... & Wieringa, F. T. (2014). Development and implementation of a locally produced ready-to-use therapeutic food (RUTF) in Vietnam. *Food and Nutrition Bulletin*, *35*(2_suppl1), S52-S56.
Pragya, S., & Rita, S. R. (2012). Finger millet for food and nutritional security. *African Journal of Food Science*, *6*(4), 77-84. https://doi.org/10.5897/ajfsx10.010
Pravina, P., Sayaji, D., & Avinash, M. (2013). Calcium and its role in human body. *International Journal of Research in Pharmaceutical and Biomedical Sciences*, *4*(2), 659–668.
Ramashia, S. E., Anyasi, T. A., Gwata, E. T., Meddows-Taylor, S., & Jideani, A. I. O. (2019). Processing, nutritional composition and health benefits of finger millet in sub-saharan Africa. *Food Science and Technology*, *39*, 253-266.
Riveros, C. G., Mestrallet, M. G., Nepote, V., & Grosso, N. R. (2009). Chemical composition and sensory analysis of peanut pastes elaborated with high-oleic and regular peanuts from Argentina. *Grasas Y Aceites*, *60*(4), 388-395.
Ruottinen, S. (2011). Carbohydrate intake in children – associations with dietary intakes, growth, serum lipids, and dental health. *The STRIP Project.*
Samarajeewa, U., Sen, A. C., Cohen, M. D., & Wei, C. I. (1990). Detoxification of aflatoxins in foods and feeds by physical and chemical methods. *Journal of food protection*, 53(6), 489-501.
Sandstead, H. H. (1993). Zinc requirements, the recommended dietary allowance and the reference dose. *Scandinavian Journal of Work, Environment and Health*, *19*(SUPPL. 1), 128–131.
Savage, G. P. (1994). The Groundnut Crop. In *The Groundnut Crop* (Issue March 1994). https://doi.org/10.1007/978-94-011-0733-4
Schoonees, A., Lombard, M., Musekiwa, A., Nel, E., & Volmink, J. (2013). Ready-to-use therapeutic food for home-based treatment of severe acute malnutrition in children from six months to five years of age (Review) Summary of Findings for the Main Comparison. *Cochrane*, *6*. https://doi.org/10.1002/14651858.CD009000.pub2.www.cochranelibrary.com
Sharif, M. K., Butt, M. S., Sharif, H. R., & Nasir, M. (2017). Sensory Evaluation and Consumer Acceptability. *Handbook of Food Science and Technology*, *October*, 362–386. https://www.researchgate.net/publication/320466080
Sharif, M. K., Butt, M. S., Sharif, H. R., & Nasir, M. (2017). Sensory Evaluation and Consumer Acceptability. *Handbook of Food Science and Technology*, *October*, 362–386. https://www.researchgate.net/publication/3204660.
Smith, K., & Peterson, D. G. (2020). Identification of Aroma Differences in Refined and Whole Grain Extruded Maize Pu ff s. 1–9,40–48.

Spence, C. (2015). On the psychological impact of food colour. *Flavour*, *4*(1), 1–16. https://doi.org/10.1186/s13411-015-0031-3.

Stephen, A., Alles, M., De Graaf, C., Fleith, M., Hadjilucas, E., Isaacs, E., Maffeis, C., Zeinstra, G., Matthys, C., & Gil, A. (2012). The role and requirements of digestible dietary carbohydrates in infants and toddlers. *European Journal of Clinical Nutrition*, *66*(7), 765–779. https://doi.org/10.1038/ejcn.2012.27

Study, Y. Y. (2017). Study of an Educational Hand Sorting Intervention for Reducing Aflatoxin B1 in Groundnuts in Rural Gambia Study of an Educational Hand Sorting Intervention for Reducing Aflatoxin B 1 in Groundnuts in Rural Gambia. *80*, 44–49. https://doi.org/10.4315/0362-028X.JFP-16-152

Sudhakararao, G., priyadarsini, K. A., Kiran, G., Karunakar, P., & Chegu, K. (2019). Physiological Role of Proteins and their Functions in Human Body. *International Journal of Pharma Research and Health Sciences*, *7*(1), 2874–2878. https://doi.org/10.21276/ijprhs.2019.01.02

Tehrani, M. M., Yeganehzad, S., & Razmkhah, S. (2009). Physicochemical and Sensory Properties of Peanut Spreads Fortified with Soy Flour. January.

Tette, E. M. A., Sifah, E. K., & Nartey, E. T. (2015). Factors affecting malnutrition in children and the uptake of interventions to prevent the condition. *BMC Pediatrics*, *15*(1). https://doi.org/10.1186/s12887-015-0496-3

Thorne, C. J., Roberts, L. M., Edwards, D. R., Haque, M. S., Cumbassa, A., & Last, A. R. (2013). Anaemia and malnutrition in children aged 0-59 months on the Bijagós Archipelago, Guinea-Bissau, West Africa: A cross-sectional, population-based study. *Paediatrics and International Child Health*, *33*(3), 151–160. https://doi.org/10.1179/2046905513Y.0000000060.

Usselman, C. W. N. S. S. J. R. B. (2017). HHS Public Access. *Physiology & Behavior*, *176*(3), 139–148. https://doi.org/10.1016/j.physbeh.2017.03.040

Wagh, V. D., & Deore, B. R. (2018). Ready to Use Therapeutic Food [RUTF] formulation and packaging for malnutrition: an Overview. *Advances in Colloid and Interface Science*, *2*(1), 1–15. https://doi.org/10.19080/NFSIJ.2018.04.555648

Wamunga, F. W., & Wamunga, B. J. (2017). Locally Developed Ready-To-Use-Therapeutic-Food (RUTF) for Management of Malnutrition Using Animal Models. *Journal of Clinical Nutrition & Dietetics*, *03*(01), 1–6. https://doi.org/10.4172/2472-1921.100044

Weisstaub, G., Medina, M., Pizarro, F., & Araya, M. (2008). Copper, iron, and zinc status in children with moderate and severe acute malnutrition recovered following WHO protocols. *Biological Trace Element Research*, *124*(1), 1–11. https://doi.org/10.1007/s12011-008-8090-2

Whaley, S. E., Sigman, M., Neumann, C., Bwibo, N., Guthrie, D., Weiss, R. E., Alber, S., & Murphy, S. P. (2003). Animal Source Foods to Improve Micronutrient Nutrition and Human Function in Developing Countries. *J. Nutr*, *133*, 3965–3971.

WHO. (2013). Guideline: Updates on the management of severe acute malnutrition in infants and children. Report. World Health Organization. Geneva.

WHO (2012). Technical note: supplementary foods for the management of moderate acute malnutrition in infants and children 6–59 months of age. Geneva, World Health Organization.

Yazew, T. (2022). Therapeutic Food Development from Maize Grains, Pulses, and Cooking Banana Fruits for the Prevention of Severe Acute Malnutrition. *Scientific World Journal*, *2022*. https://doi.org/10.1155/2022/3547266

Younis, K., Ahmad, S., & Badpa, A. (2015). Malnutrition: causes and strategies. *J Food Process Technol*, *6*(434), 2. https://doi.org/10.4172/2157-7110.1000434