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Original Research Article

Formulation of Ready-To-Use Therapeutic Food (RUTF) from Food Waste for the Management of Severe Acute Malnutrition

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ABSRTACT

The state of malnutrition in Nigeria is alarming, with the country standing as the second-highest prevalence of stunted children in the world. Ready-to-Use Therapeutic Foods (RUTFs) are critical for managing severe acute malnutrition (SAM). However, the effectiveness of RUTF in preventing malnutrition is undermined by its periodic unavailability in Nigeria due to shipping costs, delays, and donor fatigue. This study aims to formulate RUTFs from food waste for the management of SAM. Nutritional composition of the formulated RUTFs was conducted using proximate analysis methods, and sensory evaluation was done using a 5-point rating scale. Findings show that the proximate composition of formulated RUTFs is comparable to that of standard RUTF, with total energy of 507.30 and 492.35 kcal/100g, respectively, for RUTF-AP and RUTF-AV, both slightly higher than 433.70 kcal/100g in RUTF-SD, used as a control in the study, with all samples rated good for all the sensory attributes assessed. It can be concluded that the RUTFs formulated from food wastes had good macronutrients comparable to the standard RUTF. The protein, carbohydrate and lipid needs of children with SAM can be fulfilled by the intake of the formulated RUFTs. It also demonstrated that production of RUTF from locally sourced novel ingredients would meet recommended standards, as well as meet the culinary requirements of the local community.

Keywords: Proximate Analysis, Malnutrition, Micronutrient Analysis, Sensory Evaluation, Ready-To-Use Therapeutic Food.

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Introduction

Malnutrition is the degree of inadequacy or abundance of one or more nutrients consumed by an individual.[1] Malnutrition could also be referred to as undernutrition which is characterized by stunting, underweight, and wasting,[1] affecting more children under 5 years of age. Worldwide, malnutrition contributes significantly to nearly half (45%) of all childhood deaths,[2] representing greater than 3 million children each year. In Nigeria, the state of malnutrition is horrifying. Forty percent (40%) of children (≤ 5 years) suffer stunting, 27% are underweight, 8% are wasted, and 1% are overweight.[3] Several decades ago, enriched cereals and legumes with or without milk, oil, sugar, and eggs had made a small impact on the treatment of severe acute malnutrition (SAM).[4,5] Hence, the invention of ready-to-use therapeutic food (RUTF) which has been proven significantly useful in the last two decades.

RUTF is a packaged food, high-energy-dense, enriched with minerals and vitamins, requiring zero preparation and used to treat SAM.[6] RUTF is easily consumed by children between 6 months and 5 years because it is soft and it is most appropriate in areas with poor hygiene conditions.[6] Peculiarities of RUTF are its high calorie density (between 500 and 540 kcal/100g), complete nutrient composition with adequate vitamins and minerals, and low moisture content.[7] This product (RUTF) is either produced commercially and locally (e.g., research center or clinic) with similar or varying ingredients.[8] The peanuts may be partially replaced with cereals or other legumes based on local availability, acceptability, and cost, while maintaining compliance with the recommended nutritional composition.[9] However, the world is currently faced with an insufficient and inconsistent supply of RUTF, which has hampered the treatment of SAM, resulting in low coverage and poor treatment outcomes.[10,11,12]

In addition, the high cost of RUTF, delays, donor fatigue,[13] coupled with inadequate funding, has been identified as the biggest challenge limiting the availability of RUTF to affected children.[10] A lot of efforts have been made to tackle the high cost and increase the availability of RUTF, including expansion of the supply base and formulation of plant-based products, excluding the expensive animal ingredients like milk.[10,14,15,16] Many nations have included RUTF on their essential drugs lists in order to increase funding and commitment by government and stakeholders.[17] These efforts, though, have shown some improvements; they seem not to be significantly addressing the challenge of insufficient supply and availability of RUTF. As such, development partners, especially WHO and UNICEF, are supporting developing countries to commence local production of RUTF for local use;18 but this has been partly hindered by the high cost of setting up processing plants and sourcing raw materials,10,19 leading to continued shortages, thereby affecting many patients who fail to receive the right treatment. Therefore, this study aims to formulate RUTF from food waste for the management of severe acute malnutrition. By food waste, we mean food fit for human ingestion being discarded or otherwise lost uneaten, whether after it is kept beyond its expiry date or left to spoil .[20] Food waste, such as unripe plantain peels, avocado and African pear seeds, was employed in this study to produce RUTF for the management of SAM, and the sensory evaluation, proximate, mineral and vitamin analysis of the formulated RUTF was determined. This study is significant because it helps reduce dependence on expensive, imported RUTF ingredients and promotes the use of locally available resources. It supports the reduction of food waste and its negative environmental effects, aligning with global sustainability goals.

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Materials and Methods

Equipment and Chemicals
Soxhlet extractor (Drawell international Technology Ltd, China, Model: SOX406), centrifuge (Jactermac, model-LXJ-2, China), analytical balance, weighing balance (Viraze, ASIN: BOCXQ3K11G, China), drying oven (Medifield equipment & Scientific Ltd, model: No DNP-9022A), acetic acid (Merck KGaA Germany, CAS-64-19-7), nitric acid (Loba Chemie, India), 50% ammonium hydroxide (Redel-deHaen, Germany), hydrochloric acid (Guangdand Guanghua Chemical factory Ltd China), potassium permanganate (Merck Schuchardt OHG, Germany), conical flasks, beakers, volumetric set, centrifuge tubes, porcelain crucibles, extraction thimbles, glass funnel, aluminium dishes, spatula, desiccator, filter papers, and 2mm mesh size of muslin clothe.

Collection and Identification of Plant Material
Avocado seed, African pear seed, groundnut, Unripe plantain peel, sugar, and palm kernel seed were all purchased from the Masaka local market (9.0046° N, 7.6753° E) in Karu L.G.A, Nasarawa State, Nigeria. All the plants were collected on 17 November 2024. The unripe plantain peel (*Musa paradisiaca*), African pear (*Dacryodes edulis*), palm kernel seed (*Elaeis guineensis*), avocado seed (*Persea americana*), and groundnut (*Arachis hypogeae*) were taken to the National Institute for Pharmaceutical Research and Development (NIPRD), Abuja, for plant identification, and voucher numbers were allocated as NIPRD/H/7114, NIPRD/H/7115, NIPRD/H/7113, NIPRD/H/7116, and NIPRD/H/7112, respectively.

Preparation of plant material
The seeds of African pear and avocado were separated from the pulp, washed diligently with water, sliced into smaller pieces, and oven-dried to a constant weight at 100 °C after 3 hours. The dried seeds were milled to coarse powder using milling machine and stored in an airtight container. The plantain peel was sorted, cleaned, blanched and dried at a temperature of 75 °C for 6 hours, after which it was milled into flour, sifted and packaged. The palm kernel was deshelled to obtain the seeds, it was then sorted, cleaned and milled using a heavy-duty electric blender.

Preparation of groundnut paste
The raw groundnuts were carefully sorted to eliminate debris, stones, and unwanted foreign materials. Then washed thoroughly with clean water, drained, and air-dried for 60 minutes. The dried groundnuts were carefully roasted in batches in a pan over medium heat for approximately 40 minutes, then spread on a clean tray for about 20 minutes to return to room temperature. The seed coats were removed and separated through manual winnowing. The dehulled groundnuts were ground using a mechanical grinder into a fine paste.

Composition of Locally Formulated RUTF
Two RUTFs, were formulated from African pear seed (RUTF-AP) and Avocado seed (RUTF-AV). RUTF-AP comprises 100g of palm kernel,100g of unripe plantain peel, 210g of African pear seed, 100g of groundnut, 28g of sugar and 173.6 g of vegetable oil (Power oil, which is from palm olein). While RUTF-AV is composed of 100g of palm kernel,100g of unripe plantain peel, 140g of Avocado seed, 100g of groundnut, 21.2g of sugar, 148.7g of vegetable oil. All the ground ingredients were weighed and mixed using an electric mixer.

Proximate Analysis
The crude fat content was analyzed according to the AOAC methods.[21] The Soxhlet Extraction Method was applied to measure crude fat. Samples were extracted using petroleum ether inside a Soxhlet extractor. After extraction, the solvent is evaporated, and the leftover residue is weighed to calculate the fat content. The method employed for determining the moisture content of the plant material anchored on measuring the loss of weight due to drying at 100 °C, as described by AOAC.[22]

For ash content determination, the samples were burned in a muffle furnace at 600°C until all organic matter was completely oxidised. The remaining residue represents the ash content, consisting of all inorganic minerals. The crude fibre content was analyzed according to the AOAC methods.[21] The crude fibre was determined by the method where samples were treated with acid and alkali to eliminate soluble components. The remaining residue was then dried, weighed, and incinerated, and the weight was re-recorded. The difference in weight before and after incineration represents the crude fibre content. Results were calculated and expressed in percentage (gram/100g of sample).
The Kjeldahl Method was used to find the protein amount.[21] Samples were treated with sulfuric acid to change nitrogen into ammonium sulfate. Then, a base was added, and the mixture was heated to release ammonia. The ammonia was measured to find how much nitrogen is in the sample. The percentage of crude protein was ascertained by the percentage of Nitrogen multiplied by a factor of 6.25. Results were calculated and expressed as a percentage (gram/100g of sample). The percentage carbohydrate was obtained by AOAC methods,[23] based on equation 1:

$$\text{Percentage carbohydrate} = 100 - (\%\,ash + \%\,fibre + \%\,fat + \%\,protein + \%\,moisture)$$

Determination of vitamins and minerals
Some selected vitamins (E, C, A, and niacin) were quantified using high-performance liquid chromatography (HPLC: 1260 Infinity, Agilent Technology, USA) according to AOAC.[22] Determination of mineral elements such as iron, phosphorus, calcium, zinc, manganese, and copper was done using atomic absorption spectroscopy (AAS: 280FS AA, Agilent Technology, USA) according to AOAC.[22]

Sensory evaluation
A hedonic sensory evaluation of the formulated RUTF was carried out with 20 untrained panelists drawn from Bingham University. The panelist assessed six sensory attributes: taste, texture, aroma, colour, appearance, and overall acceptability, using a 5-point hedonic scale (Scale: 5-like extremely; 4-like slightly; 3-neither like nor dislike; 2-dislike slightly; 1-dislike extremely) was used to rate the sensory attribute.[24]

Statistical Analysis
Data gotten in this study were analyzed by One-Way analysis of variance (ANOVA) using IBM SPSS Statistics data editor version 22 for personal computers, and results were presented as mean ± standard deviation, except if stated otherwise. The post-hoc test used was the Duncan multiple range test at $p<0.05$ level of significance.
Results and Discussion

Proximate composition of food waste
The results indicated that the percentages of carbohydrate, protein, lipid, fiber and ash of unripe plantain peel and palm kernel seed are 60.90, 6.50, 4.10, 14.10, 6.80 and 0.55, 10.95, 40.05, 40.10, 1.70 respectively (Table 1), while that of African pear seed and Avocado seed are 71.03, 10.07, 3.35, 5.00, 2.30 and 64.00, 9.20, 9.50, 8.20, 1.65 respectively. The results indicated that the percentages for carbohydrate, protein, lipid, fiber and ash of groundnut are 16.75, 19.27, 54.55, 5.20, and 2.75.
The proximate composition of unripe plantain peel revealed CHO (60.90%), CP (6.5%) CL (4.10%), CF (14.10%), AC (6.8%) and MC (7.60%) (Table 1). This study revealed lower values of protein and fat content compared to those reported by Aderolu et al.,[25] which was 11.02% and 4.10%, respectively. The Ash content of the food waste ranged from 1.70% to 6.80%, with unripe plantain peel having the highest ash content at 6.80%.
In Table 1, this study finding shows that the palm kernel seed has lower protein (10.95%) and carbohydrate (0.55%) values, which is in contrast to 18% protein and 50% carbohydrate reported by Zarei et al.[26] Also, the palm kernel contained higher crude lipid (40.05%) and

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crude fiber (40.10%) than those reported by Zarei et al.,[26] with 5.5% and 11.5%, respectively. In contrast, African pear seed has a lower protein (10.07%) and crude fiber (5.00%) but higher carbohydrate (71.03%) than the values obtained by Onuegbu et al.,[27] which was 18% protein, 19% fibre, and 39% carbohydrate. However, the crude lipid of the African pear seed had similar values; the ash and moisture contents were 2.30% and 8.25%, respectively.

Table 1: Proximate results of plant materials after processing

Parameters	Plantain Peel	Palm kernel	African Pear Seed	Avocado Seed	Groundnut
N.F.E (%)	60.90 ± 2.70	0.55 ± 0.150	71.03 ± 2.03	64.00 ± 2.00	16.75 ± 1.25
CP (%)	6.50 ± 0.50	10.95 ± 0.75	10.07 ± 0.57	9.20 ± 0.70	19.27 ± 1.17
CL (%)	4.10 ± 0.30	40.05 ± 1.55	3.35 ± 0.35	9.50 ± 1.00	54.55 ± 1.55
CF (%)	14.10 ± 1.10	40.10 ± 2.10	5.00 ± 1.00	8.20 ± 0.70	5.20 ± 0.40
AC (%)	6.80 ± 0.60	1.70 ± 0.20	2.30 ± 0.30	1.65 ± 0.25	2.75 ± 0.50
MC (%)	7.60 ± 0.70	6.65 ± 0.45	8.25 ± 0.75	7.45 ± 0.55	1.40 ± 0.30
M.E (Kcal)	306.5 ± 6.50	406.15 ± 6.01	357.07± 7.07	378.30 ± 8.30	635.15 ± 15.15

Data presented as mean ± standard deviation (n = 3). M.E = Metabolizable Energy, N.F.E = Nitrogen Free Extract, A= Ash Content, CL= Crude Lipid, CF= Crude Fiber, CP= Crude Protein, MC= Moisture Content

The avocado seed in this finding has higher crude protein, crude lipid, CHO, crude fiber, ash content, and moisture content, with values of 9.20%, 9.50%, 64.00%, 8.20%, 16.5%, and 7.45%, respectively (Table 1). This finding shows that roasted groundnut has lower values of CHO (16.7%), crude protein (19.27%), crude fiber (5.20%), and moisture content (1.40%) compared to the values reported by Ishaq et al.,[28] which had 25.9%, 29.30%, 11.57% and 1.40%, respectively. While ash content (2.75%) and crude lipid (54.55%) of the groundnut are higher than those reported by Ishaq et al.,[28] who have 1.57% and 29.30%, respectively. The variations in the proximate values of groundnut and other seeds reported by different authors are primarily due to genetic diversity among cultivars, environmental and cultivation conditions, processing techniques, and storage duration.[29]

Proximate analysis of formulated RUTFs

The present study has investigated the novel approach of producing RUTFs from food waste, aiming to address the dual global challenges of malnutrition and food waste. The study successfully demonstrated that it is technically feasible to process African pear seeds, avocado seeds, unripe plantain peels, palm kernel seeds, groundnuts, as well as table sugar, into safe and palatable RUTF samples. The proximate results in percentages for carbohydrate, crude fiber, crude lipid, and crude protein of RUTF-AP are 39.10, 10.10, 34.90, and 9.20, respectively, while those of RUTF-AV are 47.86, 5.10, 29.15, and 9.64, respectively (Table 2).

Table 2: Proximate composition of standard and formulated RUTFs

Parameters	RUTF – SD	RUTF – AP	RUTF – AV
N.F.E (%)	46.70 ± 1.70[a]	39.10 ±1.60[b]	47.86 ± 1.66[a]
CP (%)	12.40 ± 1.40[a]	9.20 ± 0.70[b]	9.64 ± 1.07[b]
CL (%)	28.20 ± 2.03[b]	34.90 ± 1.40[a]	29.15 ± 1.05[b]
CF (%)	5.45 ± 0.55[b]	10.10 ± 0.60[a]	5.10 ± 0.60[b]
AC (%)	2.25 ± 0.35[a]	2.60 ± 0.50[a]	2.50 ± 0.50[a]
MC (%)	2.40 ± 0.05[c]	4.10 ± 0.10[b]	5.75 ± 1.25[a]
M.E (kcal)	433.70 ± 10.00[c]	507.30 ± 5.20[a]	492.35 ± 4.15[b]

Data presented as mean ± standard deviation (n = 3). Means having different alphabets in the same row are significantly different at $P < 0.05$. M.E = Metabolizable energy, N.F.E = Nitrogen Free Extract, AC = Ash Content, C.L = Crude Lipid, C.F = Crude Fibre, C.P = Crude Protein, M.C = Moisture Content.

The nutritional analysis of the developed formulations indicated that caloric values of the RUTF-AP (507.30 kcal) and RUTF-AV (492.35 kcal) were found to be slightly decreased than the caloric requirement (2176-2301kJ or 520 – 550 kcal/100g) of the RUTF formulation.[6] In Table 2, the caloric values of the produced RUTF were also lower than the RUTF formulations produced in Malawi having caloric values of above 500 Kcal.[30] However, the energy contents of developed RUTFs were above the caloric value of 478 kcal attained in a locally formulated RUTF in Nigeria by Edafioghor et al.[31] These lower energy values can be credited to the decreased energy contribution from protein, which contributes only about 9.20 and 9.64 g/100g, respectively, below the recommended requirement of 13–17 g/100g.[32] A locally made alternative to RUFT, 'Balamrutham plus (+)', developed in India for the treatment of SAM,[33] had an energy composition of 460 kcal below what was observed in this study.

The CHO content of RUTF-AP (39.10%) was significantly decreased (P<0.05) than that of RUTF-SD (46.70%) and RUTF (47.86%) (Table 2). Carbohydrate content (39.10 and 47.86 g/100g) was below 45g in a commercial peanut-based RUTF product (Plumpy Nut), which also contributed to the lower energy density observed, which is critical for the rehabilitation of malnourished children. That can be associated with a lack of carbohydrate-rich ingredients (cereals) in the formulations.

Both RUTF-AP (9.20%) and RUTF-AV (9.64%) were significantly lower (P<0.05) than RUTF- SD (12.40%) in the crude protein content (Table 2). Protein content of the formulations was 9.20 and 9.64 g/100g, respectively, for RUTF-AP and RUTF-AV, which falls below the recommended range of 10 – 12% protein for RUTF as stipulated by the UNICEF guidelines,[32,34] and below the 14 g/sachet in NutriFeedo RUTF, a commercial RUTF. Although the protein is lower than the requirement for standard RUTF, the observed values were almost similar to 9.41 and 9.75 g/100g reported by Edafioghor *et al*.,[31] 9.5 g/100g reported by Sandeep and Mona,[35] and 13.0, 11.15, and 14.37 g/100g of locally formulated RUTFs reported by Bumba.[36] The

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low protein values observed in this study can be accredited to the low protein contents of the food wastes and other ingredients used in the formulations.

The crude lipid content of RUTF-SD (28.20%) and RUTF-AV (29.15%) is significantly lower (P<0.05) than that of RUTF-AP (34.90%) (Table 2). Lipid contents of 34.90 and 29.15 g/100g, respectively for RUTF-AP and RUTF-AV, were contributed largely by vegetable oil, groundnut, palm kernel seeds and residual oils from other ingredients. The lipid content of the formulated RUFTs is between 27 and 37 g/100g of total energy as required by UNICEF.[6]

The crude fiber content of RUTF-AP (10.10%) is significantly higher (P<0.05) than RUTF-SD (5.45%) and RUTF-AV (5.10%). There was no significant difference (P<0.05) in the ash content of the formulated RUTFs (RUTFS-AP 2.60% and RUTF-AV 2.50%) compared to the RUTF-SD (2.25%)

The moisture content of the RUTF-SD (2.40%) was significantly lower (P<0,05) than RUTF-AP (4.10%) and RUTF-AV (5.75%), which has the highest moisture content (Table 2). The moisture content (4.10-5.75 g/100g) reported in this formulated RUTF was observed to be slightly higher than the 2.5% benchmark by UNICEF,[32] and the moisture content (2.73%) reported in RUTF AOB produced in Bauchi, Nigeria by Sosanya et al.[30] Lowering moisture content allows locally produced RUTF to be preserved without spoilage at room temperature for up to 4 months.[30] However, the observed moisture levels in this study are lower than 11.11, 9.89, and 9.26% attained by Edafioghor et al.,[31] in different locally formulated RUTFs or the 9.89% moisture content in METU-2, a formulated RUTF in Uganda by Amegovu et al.[37]

Vitamins and minerals composition of the formulated RUTFs

Vitamins and minerals are micronutrients inherent in foods that are needed in minute amounts by the body for biological functions. The micronutrient contents of the formulated RUTF in this study were significantly lesser than the UNICEF-recommended values[6] as seen in Figures 1-6 and Tables 3 and 4. The current findings were comparable with what Jibril[38] observed in Zaria, but the RUTFs produced by Edafioghor et al.[31], also in Nigeria, had significantly decreased mineral contents than those of this study (Table 4). The low mineral contents in this study reflect the poor micronutrient content of the food waste ingredients used in the formulation and the lack of mineral/vitamin fortification in the formulations. The inadequacy of vitamins/minerals in a diet hinders the growth and proper development of children, leading to deficiency diseases such as anemia and night blindness.[20]

Table 3: Vitamin contents of formulated RUTFs

Parameters	RUTF-SD	RUTF-AP	RUTF- AV
Vitamin A (μg/ml)	800 (μg)	6.17 ± 0.73[a]	4.63 ± 0.50[b]
Vitamin E (μg/ml)	20 (mg)	49.66 ± 1.44[a]	11.77 ± 0.64[b]
Vitamin C (μg/ml)	50 (mg)	80.06 ± 1.54[a]	1.27 ± 0.13[b]
Vitamin B3 (μg/ml)	5.0 (mg)	ND	ND

ND: Not Detected, NI: Not Indicated; Data presented as mean ± standard deviation (n = 3). Mean values having different alphabet in the same row are significantly different at P<0.05.

Table 4: Mineral composition of the formulated RUTFs

Parameters	RUTF-SD	RUTF-AP	RUTF-AV
CU (ppm)	1.4 (mg)	0.039 ± 0.0006[a]	0.033 ± 0.0004[b]
Fe (ppm)	10 (mg)	ND	ND
Zn (ppm)	11 (mg)	0.023 ± 0.0014[b]	0.125 ± 0.0013[a]
Mn (ppm)	NI	0.076 ± 0.0003[b]	0.124 ± 0.0025[a]
Ca (g)	300 (mg)	0.500 ± 0.1000[b]	0.800 ± 0.1000[a]
P (g)	300 (mg)	0.700 ± 0.0200[a]	0.040 ± 0.0100[b]

ND: Not Detected, NI: Not Indicated; Data presented as mean ± standard deviation (n = 3). Mean values having different alphabet in the same row are significantly different at P<0.05.

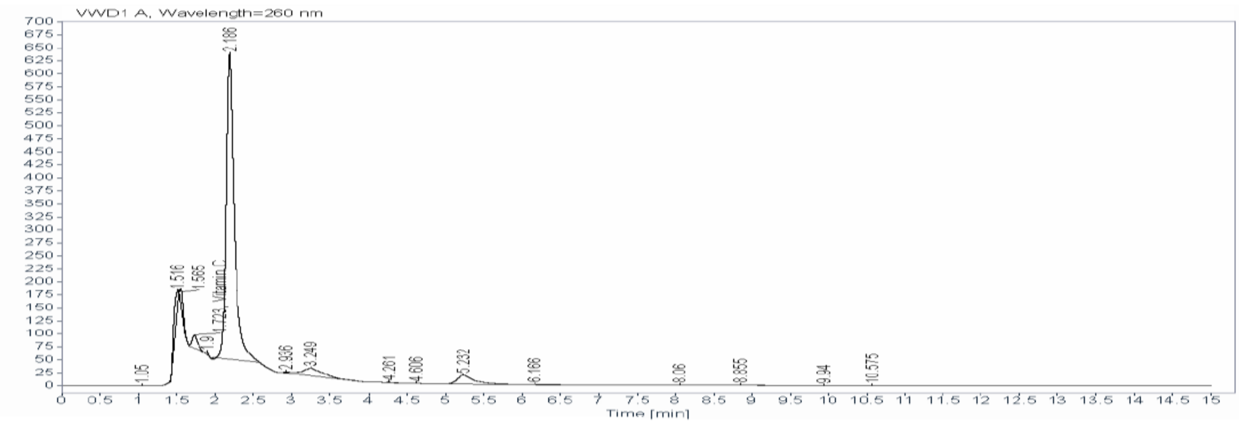

Figure 1: Chromatogram of Vitamin C and Vitamin B3 for RUTF- AP

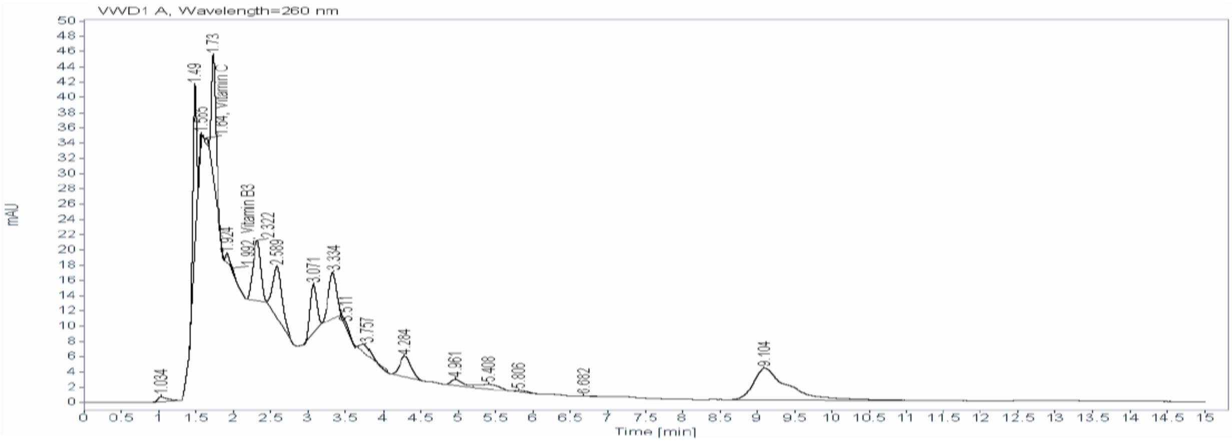

Figure 2: Chromatogram of Vitamin C and Vitamin B3 for RUTF- AV

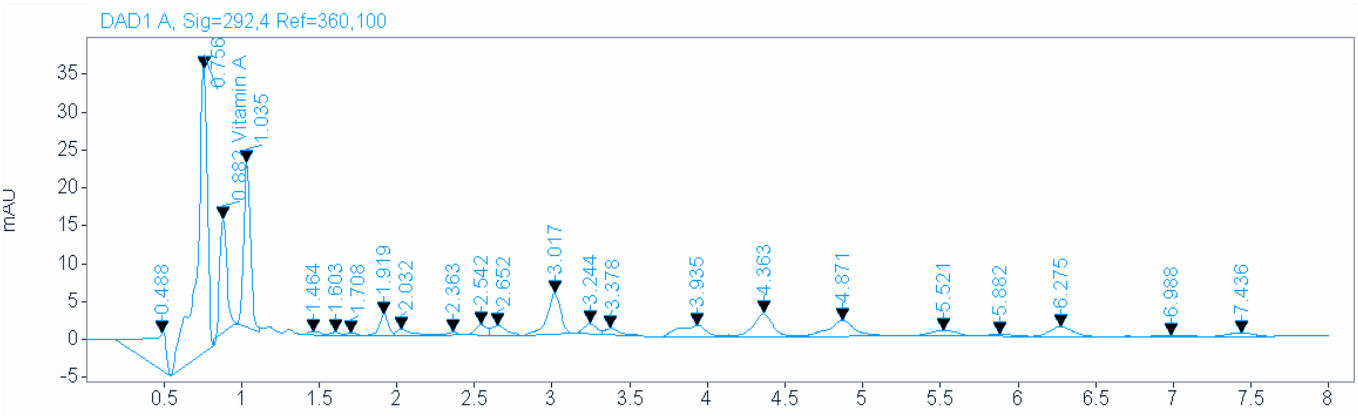

Figure 3: Chromatogram of Vitamin A for RUTF- AP

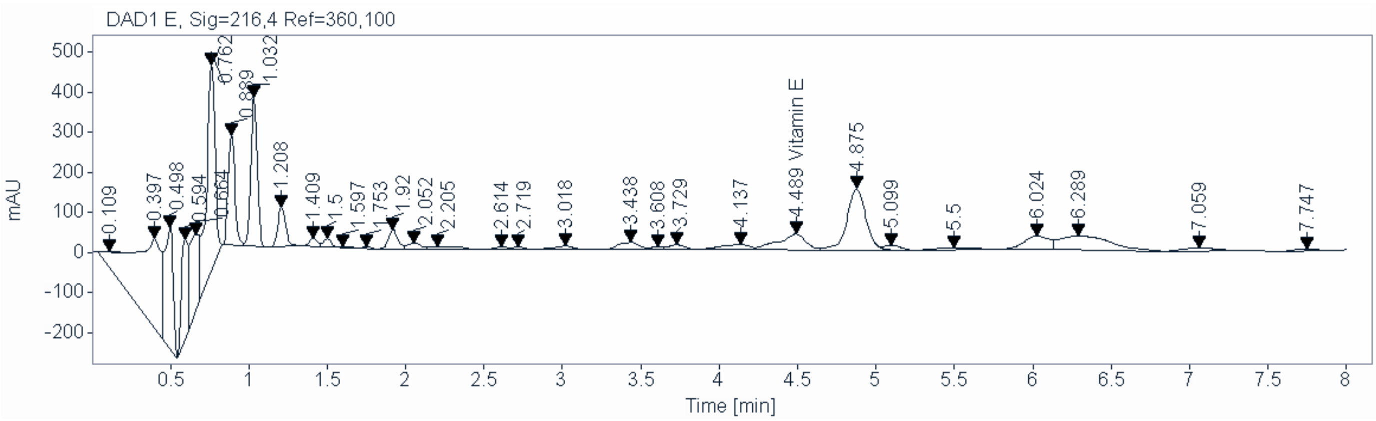

Figure 4: Chromatogram of Vitamin E for RUTF- AP

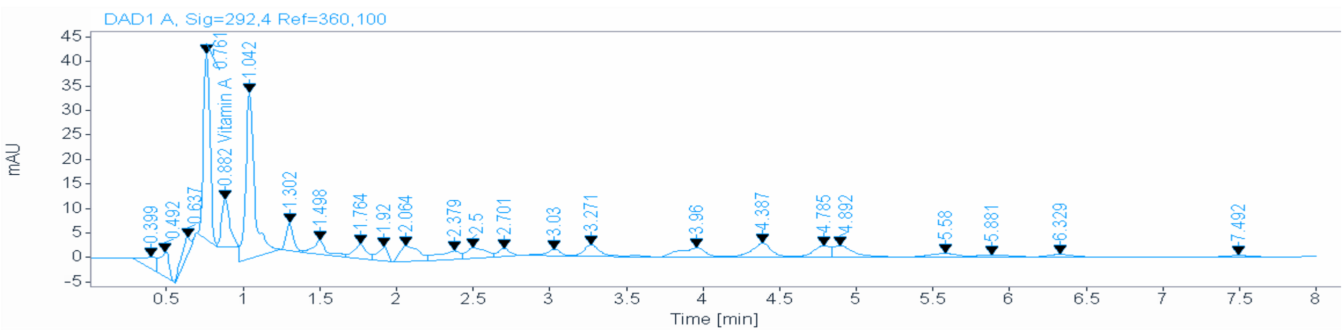

Figure 5: Chromatogram of Vitamin A for RUTF- AV

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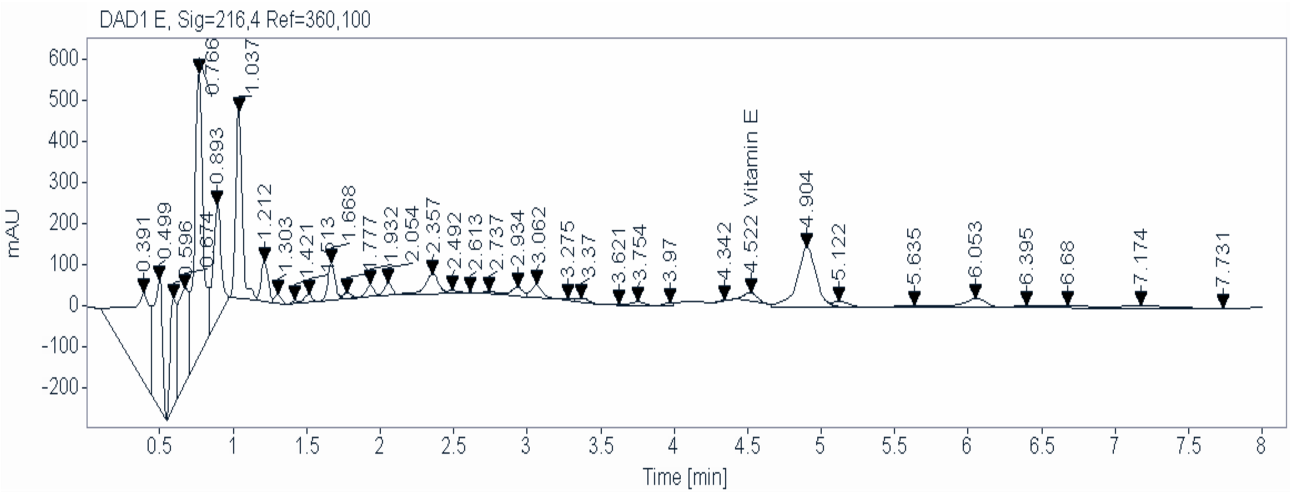

Figure 6: Chromatogram of Vitamin E for RUTF- AV

Sensory evaluation of the formulated RUTF

This sensory evaluation in this study utilizes adult respondents for an objective assessment of the formulations. The results revealed that the standard RUTF was rated highest in all attributes, suggesting better acceptability, while the formulated RUTF samples from food wastes showed moderate acceptability (Table 5). There was no significant difference in the colour between the standard RUTF and the formulated RUTFs (RUTF-AP and RUTF-AV). Overall acceptability of the formulated RUTFs (RUTF-AP and RUTF-AV) was lower than that of the standard RUTF. According to Briend et al.,[39] a good balance between taste, texture, and aroma will increase the overall acceptability scores of formulated RUFTs. Thus, it is recommended that minor modifications in formulation be introduced to improve the acceptability of the formulated RUTFs.

Table 5: Sensory Evaluation of Control and Formulated (RUTF-AP and RUTF-AV)

Sensory properties	RUTF-SD	RUTF-AP	RUTF-AV
Taste	4.30 ± 0.48[a]	2.50 ± 0.71[b]	2.20 ± 1.14[b]
Texture	4.00 ± 0.67[a]	2.30 ± 1.06[b]	2.40 ± 1.12[b]
Aroma	3.70 ± 0.67[a]	2.60 ± 0.70[b]	3.00 ± 1.05[ab]
Appearance	3.95 ± 0.76[a]	3.10 ± 1.45[ab]	2.80 ± 0.99[b]
Colour	4.00 ± 0.82[a]	3.00 ± 1.33[a]	3.20 ± 1.32[a]
Overall acceptability	4.08 ± 0.54[a]	3.20 ± 1.14[b]	3.30 ± 0.67[b]

Data presented as mean ± standard deviation (n=20). Mean values having different alphabet in the same row are significantly different at P<0.05. 5 = Like Extremely, 4 = Like Moderately, 3= Neither like nor dislike, 2 = Dislike moderately, 1 = Extremely dislike

Conclusion

This study holds that food waste products such as avocado seed, African pear seed, plantain peel, and palm kernel seed can be successfully utilized in the formulation of Ready-to-Use Therapeutic Food. The resulting formulations exhibited appreciable energy, lipids and carbohydrate values, and moderate sensory acceptability. However, inadequacies were observed in protein and micronutrient composition relative to UNICEF/WHO benchmarks. The study provides evidence that food waste products can be harnessed and contribute to addressing both malnutrition and food insecurity. Finally, the formulated RUTFs should be optimized for energy and overall acceptability, and randomized controlled trials should be conducted to ensure safety, effectiveness, and acceptability for treating SAM.

Conflict of Interest

The authors declare no conflicts of interest

Author's Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them

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