Production of Extruded Cereal – Legume based Ready-to – Use Therapeutic Foods (RUTFS) for Management of Severe Acute Malnutrition (SAM) in Nigeria

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ABSTRACT

Background: *Management of severe acute malnutrition (SAM) in Nigeria has out of stock of imported peanut milk-based ready- to - use therapeutic foods (RUTFs) as its major challenge.*

Objective: *The study aimed at the production of extruded cereal – legume based RUTFs for management of SAM in Nigeria.*

Methods: *Five test cereal - legume based RUTF blends (eRUTF1 – 5) were formulated using a modified linear programming tool according to WHO guidelines and produced by extrusion cooking. Standard methods were employed to determine the proximate compositions, cost and organoleptic characteristics of the eRUTFs. Data obtained were analyzed using the Statistical Package for Scientists and Engineers' Statistix 9.2, 2012 software.*

Results: *The energy in the eRUTFs ranged from 522.10 to 527.33kcal / 100g. Proximate composition of the eRUTFs showed moisture levels of (0.10 - 0.57%); protein (14.03 – 15.19 %), fat (27.82 – 29.09%); ash (2.75 – 4.56%); crude fibre (0.41 – 1.69%) and carbohydrate (50.18–53.96%) per 100g. The cost of the eRUTFs (N 54.17- N 56.57) per 100g satchet were comparable ($p > 0.05$) and significantly ($p<0.05$) lower than the cost of the imported RUTF (N146 / sachet) in Nigeria. Acceptance levels of the eRUTFs were comparable ($p>0.05$).*

Conclusion: *Extruded cereal- legume based RUTFs for management of SAM made from local staples met the recommendations for energy, protein, and fat for RUTF and were cheaper than the peanut milk based imported RUTFs.*

Keywords: composition, extrusion, cereal – legume, RUTF, SAM.

Received: 07-07-2022
Accepted: 02-09-2022
doi: https://dx.doi.org/10.4314/njns.v44i1.15

INTRODUCTION

Malnutrition (under nutrition, over nutrition and micronutrient deficiency) is a major source of global disease problem with under nutrition accounting for more than one-third of child deaths world wild[1]. In developing countries like Nigeria, severe acute malnutrition (SAM) affects children in the range of 0 to 5 years heavily and is associated with a great number of preventable child deaths every year [1, 2]. Severe acute malnourished children have severely low weight for their height and are at risk of dying unless provided with urgent attention. Children with SAM without medical complications can be treated without being hospitalized using Ready-

To-Use Therapeutic Foods (RUTFs). This creates an urgent need to scale up the programme coverage for the treatment of severe acute malnutrition, thereby generating a greater increase in demand for RUTF. RUTFs are energy-dense micronutrient enhanced foods that are crushable or drinkable, given directly to patients without cooking [3]. RUTFs are designed primarily for the management of severe acute malnutrition without complications, providing energy equivalent to the World Health Organization (WHO) requirement of 520 – 550 Kcal / 100gm [4]. RUTFs used in Nigeria are peanut-based with milk solids, imported, and expensive. It was also reported that RUTF has greatly improved the recovery rate of children with SAM in sub-Saharan Africa [4]. However, periodical unavailability of RUTF caused by shipping costs, delays, and donor fatigue has greatly undermined the effectiveness of RUTF in combating malnutrition in Nigeria [5]. Local production of RUTF is necessary and is recommended by UNICEF to increase availability and efficiency in the supply of RUTF, which is a major problem in the management of SAM in Nigeria.

Extrusion cooking is a high-temperature short-time process in which moistened, expansive, starchy, and proteinaceous food materials are prepared in a tube by a combination of moisture, pressure, temperature, and mechanical shear [6]. Extrusion cooking offers high productivity and significant nutrients retention owing to the high temperature and short time required [6].

Cereals, legumes and nuts are the most widely grown crops in Northern Nigeria and in Adamawa State in particular where this research was conducted [7]. The three different crops contain high energy, protein and fat and processing them in an adequate proportion could yield quality nutrients and produce high energy protein foods required in RUTFs using the principle of complementation and linear programming tool (8, 9). Based on these facts the aim of this research work was to produce extruded cereal - legume based RUTF for management of SAM using local staples.

MATERIALS AND METHODS

Materials Identification of locally available grains in the State

Based on the agricultural database of grains locally available (grains produced in the tune of ≥ 500 metric tons per annum consistently from 2005 - 2015) in Adamawa State, Nigeria, four each, of the locally available cereals and legumes were identified along with the quantities produced. The identified and selected grains were cereals, maize (MZ), millet (ML), rice (RC), sorghum (SG) and legumes – bambaranut (BB), groundnut (used as defatted groundnut cake {DGNC}), sesame seed (SS) and soybeans (SB).

Procurement of grains and other ingredients.

The identified wholesome grains were purchased from Mubi daily market Adamawa State Nigeria and were used for the study. Other components of RUTFs as recommended by WHO - salt and vegetable oil (palm olein) were bought from Mubi daily market. The mineral and vitamin premix were purchased from Bio-organics Nutrient Systems Ltd, Ogun State, Nigeria.

Preparation of Samples / Processing of grain flours

Sorghum

Five (5) kilogrammes of sorghum was purchased, sorted, washed, steeped for 12hours, dried, decorticated, toasted at low heat for ten minutes, dry- milled into flour in a laboratory hammer mill (70 mesh screens) and packaged in cellophane bag and kept under room temperature on a table as described by [9].

Millet

Five (5) kilogrammes of millet was sorted, washed and dried, decorticated, toasted and dry milled into flour according to [10]; packaged in cellophane bag and kept under room temperature on a table.

Maize

Five(5) kilogrammes of maize was sorted, washed, steeped for 24hours, sun dried, decorticated and dry- milled into flour in a laboratory hammer mill (70 mesh screens), and packaged in cellophane bag and kept under room temperature on a table .

White Rice

Five (5) kilogrammes of white rice was bought, sorted, washed, sun dried and dry- milled into flour in a laboratory hammer mill (70 mesh screens) and packaged in cellophane bag and kept under room temperature on a table.

Groundnut cake

Ten (10) kilogrammes of groundnuts (Espanola) was purchased and prepared by sorting the groundnuts, washed, and sun-dried, then toasted for 10 minutes at 100^{0}c, decorticated, and milled into paste, defatted, fried into cakes until golden brown as described by [11] milled and packaged in cellophane bag and kept under room temperature on a table.

Soybean

Ten (10) kilograms of soybean was purchased and cleaned by sorting, washing, soaking for 6 hours, dried, toasted, decorticated and dry-milled into flour in a laboratory hammer mill (70 mesh screen) [12] packaged in cellophane bag and kept under room temperature on a table.

Bambaranut

Ten (10) kilogrammes of bambaranut was sorted, washed, sun dried, toasted for ten minutes at 100° and decorticated and dry milled into flour and packaged and kept under room temperature on a table.

Sesame seed

Ten (10) kilogrammes of sesame seed were sorted, washed, sun dried, slightly toasted for five minutes at low heat and dry-milled into flour in a laboratory hammer mill (70 mesh screens) and packaged and kept under room temperature on a table.

Proximate analysis of the grains and extruded RUTF blends

The proximate composition of the samples was determined using the official methods of [13]. The samples were analyzed for moisture, crude protein, ash, crude fat, and crude fibre. Carbohydrate was obtained by difference. The sum of the percentage of crude protein, moisture, ash, crude fibre and fat were determined, and the values were subtracted from 100% to get the carbohydrate content.100% - % (protein + fat + ash + fiber + moisture) = carbohydrate. Energy densities were calculated using the Atwater factors (4, 9, and 4) kcal for protein, fat, and carbohydrates respectively.

Formulation of R3TF blends.

Modified linear programming tool was used for blends formulation as described by [3,6]. The WHO recommendation of 15 % protein per 100g product was used at the level of blends formulation using Pearson square method. The energy supplements (sugar and vegetable oil), salt and premix for RUTF were carefully combined into the blends to meet the nutrient requirements of RUTF which is (total energy of 520 - 550Kcal; protein 10 - 12 % and fat 45 - 60% of total energy) per 100g of RUTF. The calculated ingredient composition of the experimental RUTF formulations per 100g is shown in Table 1.

Mixing of the blends and moisture adjustments

The formulated blends (3kg each for each batch production) were measured out and all ingredients mixed in an electric mixer (Hobart mixer model A 200 ML No 25265) to obtain a uniform blend (unextruded RUTF). The moisture content of different blends (feed moisture content) was adjusted to meet the extrusion condition according to the method of Zasupkin& Tung-chigh as described by [9]. Thorough mixtures obtained were packaged in cellophane bags kept under room temperature on a stainless table ready for extrusion.

Extrusion cooking of the blends

Extrusion cooking of the formulated blends was done in the wet processing laboratory of the Department of Food Science and Technology, Federal Polytechnic Mubi using SLG65 Twin Screw Extruder, Jinansaibainuo technology Development co; LMD China. Three independent heating zones (95,100, 120)^{0}C were applied for feeding zone, transition or metering zone and the final cooking zone respectively. The length to diameter of the extruder was 20:1. The diameter of the hole die was 4 mm with die length of 27mm. Basic quantity for batch extrusion cooking was used i.e. 3000g of each formulated RUTF blend (manufacturers design). The extruder was fed manually through a screw operated conical hopper. The experimental RUTFs were collected when steady state (constant temperature and torque) was achieved.

Quality Control

Quality control was achieved by adopting operating procedures that are internationally accepted as standards for food production [14]. The Codex Alimentarius and the Hazard Analysis and Critical Control Point Program [15] were adhered to.

Packaging of the products

The extruded RUTFs were packaged in 100g portions in cellophane packages and sealed, kept in cartons of 150 pieces each.

Sensory evaluation

Fifty young mothers from Mubi and Yola towns, who knew and have used the imported RUTF before on their children were used for the sensory evaluation according to [9]. Attributes rated were texture, colour, flavour, taste, and general acceptability using a nine point hedonic scale ranging from 'like extremely' (9) to 'dislike extremely' (1). The products were ranked according to the mean score of all the attributes.

Cost Analysis.

The cost of raw ingredients and cost of processing of grains as well as the cost of extrusion and packaging were calculated to determine the cheapest formulated blend of extruded RUTF produced, and Cost of the imported RUTF (Diva RUTF) as used in Nigeria was used as a control

Data and Statistical Analysis

Data collected were analysed with statistical package for scientists and engineers STATISTIX 9.1 version 2012. One-way analyses of variances were used to separate and compare differences between means. Data from the sensory evaluation was analysed using a nine-point hedonic scale ranging from 'like extremely' (9) to 'dislike extremely' (1) according to (10).

RESULTS

Food Availability and Consumption

Table 2 shows the locally available cereals and legumes in Adamawa State identified with their annual production values in metric tons from 2005 - 2015. Identified cereals include maize, millet, rice, sorghum. Legumes were bambaranut, groundnut (used as defatted groundnut cake (DGNC), sesame seed and soybeans. Annual production values (metric tons) from 2005 - 2015 were maize (525,250 - 20,841,583), millet (569,613 - 9,301,400), rice (1,259,216 - 24,543,059), sorghum (5,696,130 – 16,119,792), bambaranut (698,487 - 118,687,878), groundnut (7,214,976 - 20,604,203), sesame seed (560,490 - 5,155,442, and soybeans (1,012,300 – 17,201,142) metric

Table 3 presents the proximate composition of the eRUTFs per 100g. The moisture content of the eRUTFs were similar and ranged from 0.10% in eRUTF1 to 0.57% in eRUTF 4; Crude protein content ranged from 14.03% in eRUTF5 to 15.83% in eRUTF2 and the values were comparable; fat contents ranged from 27.82% in eRUTF1 to 29.09% in eRUTF4 and were not much different from one another. Ash contents were different from one another ranging from 2.75% in eRUTF3 to 4.56% in eRUTF4, While the carbohydrates contents in were similar and ranged from 50.18% in eRUTF4 to 53.96 % in eRUTF3.

Table 4 presents the total cost **of** ingredients, processing, extrusion and packaging of 100g of the eRUTFs. eRUTF 1 had a total cost of ₦ 54.79, eRUTF2 (₦ 55.18), eRUTF3 (N 54 .17), eRUTF4 (N56.53) and eRUTF5 had N56.57. There were no significant (p >0.05) differences on the total costs between the eRUTFs. However the costs of eRUTF1 (N54.79) and eRUTF3 (N 54.17) were comparable and lower than the cost of the other eRUTFs (eRUTF2 N 55.18, eRUTF4, N56.53, and eRUTF5 N56.57).

Table 5: shows the mean score values of organoleptic properties and acceptability evaluation of the eRUTFs. In texture eRUTF2 (8.3) was significantly higher than the values of all other eRUTFs (8.0 to 8.2) at $p<0.05$). In colour, eRUTF4 scored a significantly higher value (8.3) than other eRUTFs (7.3 -7.8) while eRUTF5 scored the lowest (7.3) at ($p < 0.05$). eRUTF1 scored significantly $p<0.05$) higher value (8.1) in terms of flavour while eRUTF5 had the least score of 7.1 in flavour. For general acceptability eRUTF 1 and eRUTF3 had equal values of 8.2 ($p > 0.05$) which were significantly higher than other eRUTFs at $p < 0.05$ while eRUTF5 scored the least value (7.2).

DISCUSSION

Food availability and composition

High annual production values of the identified cereals and legumes showed that the grains were locally available and using such grains in the formulation and production of RUTF would be sustainable and acceptable since the raw materials (grains) will be always available and is commonly consumed, as reported by [3, 5] that availability of raw material is a very important factor for sustainability of RUTF production in a place.

Proximate composition of the eRUTFs

Lower moisture content of the eRUTFs was in line with the work of [7] who reported low moisture values in the extruded products. High extrusion temperature100^{0}C to 150^{0}C reduced moisture level in extrudates, due to rise in starch degradation –[14,15], and determines the shelf life and microbiological safety –[16]. The protein content of the eRUTFs provided 10.72 – 12.13% contribution to total energy required for rapid catch-up growth in severe acute malnourished children as recommended by '[17,18].The high fat content of the eRUTFs met the recommendation of fat contribution to total energy by [17].This positively affects structure formation and texture of the extruded products–[19,20,21]. The high ash content of the extruded RUTFs showed that the eRUTFs were high in inorganic nutrients, an indicator of its mineral content and also a quality parameter for contamination especially with foreign matter from the process of extrusion [9]. The processes involved in preparation of grains for extrusion- dehulling, decortications, roasting, milling, as well as the shear and pressure of extrusion cooking contributed to the low crude fibre content of the eRUTFs [22], which is necessary for children with SAM [13]. High carbohydrates content of the eRUTFs could be due to low moisture content of the eRUTFs, which was an advantage because of the high energy level required in the eRUTFs '[17]. The effects of extrusion cooking on carbohydrates is primarily on starch gelatinization, enhancing its digestibility which is an advantage in RUTFs production [22,23] The high energy density and contribution of macronutrients to the total energy of the eRUTFs showed that the linear programming tool used in the formulation of the extruded RUTFs in the current study was appropriate and agrees with that reported by [3]. The energy densities of the eRUTFs were comparable to the energy densities of the imported RUTFs used in Nigeria and other countries for treating SAM [24, 25, and 26].

Sensory evaluation and acceptability of extruded RUTFs (eRUTFs)

Texture

The higher the mean score of eRUTF2 (8.3) for texture (mouth feel), may be attributed to its fibre content since eRUTF2 contains sesame seed known for its high fibre and oil content—[27].

TABLE 1: Calculated Ingredient composition of the experimental RUTF formulations (per 100g)

RUTF 1		RUTF 2		RUTF 3		RUTF 4		RUTF 5	
SGML/DGNCSB		MZML/SBSS		SGMZ/SBDGNC		MZSG/SBBB		RCML/DGNCSB	
Ingredients	%	**Ingredients**	%	**Ingredients**	%	**Ingredients**	%	**Ingredients**	%
Sorghum	13.28	Maize	5.26	Sorghum	25.72	Maize	13.36	Rice	12.75
Millet	26.56	Millet	10.52	Maize	12.86	Sorghum	6.68	Millet	25.50
DGNC	8.06	Soybean	32.14	Soybean	15.68	Soybean	28.64	DGNC	8.58
Soybean	16.12	Sesame	16.07	DGNC	7.84	Bambaranut	14.32	Soybean	17.16
Sugar	14.00	Sugar	20.00	Sugar	15.00	Sugar	13.00	Sugar	15.00
Veg. oil	21.00	Veg. oil	15.00	Veg. oil	22.00	Veg. Oil	23.00	Veg. oil	20.00
Salt	00.25	Salt	0.25	Salt	0.25	Salt	0.25	Salt	0.25
Premix	00.75	Premix	0.75	Premix	0.75	Premix	0.75	Premix	0.75

Keys:

RUTF 1 SGML/DGNCSB = sorghum, millet, defatted groundnut cake, soya beans, sugar, vegetable oil, salt, premix.
RUTF 2 MZML/SBSS = maize, millet, soybean, sesame, sugar, vegetable oil, salt, premix
RUTF 3 SGMZ/SBDGNC = sorghum, maize, soybean, defatted groundnut cake, sugar, vegetable oil, salt, premix
RUTF 4 MZSG/SBBB = maize, sorghum, soybean, bambaranut sugar, vegetable oil, salt, premix
RUTF 5 RCML/DGNCSB = rice, millet, defatted groundnut cake, soybeans, sugar, vegetable oil, salt, premix
Premix = mineral and vitamin mixture

Table 2: Locally Available cereal and legumes in Adamawa state for 2005 - 2015

Grains (Metric tons)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Maize	18,117,189	20,603,780	20,841,583	12,733,675	9,961,121	4,773,200	525,250	9,473,085	9,800,768	9,055,026	3,696,130
Millet	1,452,392	1,478,264	1,512,081	1,300,210	1,038,843	4,652,300	9,301,400	1,165, 597	821,614	644,497	569,613
Rice	19,631,178	17,751,132	17,850,761	24,543,059	5,893,440	3,519,680	2,219,350	1,784,957	1,910,193	1,756,440	1,259,216
Sorghum	15,524,920	15,792,621	16,119,792	12,003,904	10,488,535	10,960,029	9,401,600	11,655,972	8,216,139	6,444,790	5,696,130
Legumes											
Bambaranut	4,967,459	8,641,119	9,200,546	11,868,787	6,924,332	5,189,628	2,934,805	1,485,063	1,066,790	765,087	698,487
Groundnut	18,683,544	19,750,000	19,826,769	20,604,203	19,747,650	17,025,045	15,275,605	10,301,235	9,099,062	7,613,760	7,214,976
Sesame seed	4,388,275	5,155,442	4,962,419	3,448,438	1,678,000	1,021,280	892,780	1,065,000	1,215,455	889,390	560,490
SoyBeans	11,289,680	12,523,362	13,334,124	17,201,142	10,035,264	7,521,200	4,253,340	2,152,265	1,546,073	1,108,822	1,012,300

Source: Adamawa State Agricultural development programme (AADP) 2019

Table 3: Proximate composition of the eRUTFs per 100g

	Variables (%)					
RUTF blends	Moisture	Protein	Fat	Ash	Crude fibre	Carbohydrate
eRUTF 1	0.10 ± 0.01	14.90 ± 0.10	27.82± 1.00	3.20± 0.01	0.76± 0.01	53.22± 11.00
eRUTF 2	0.32 ± 5.75	15.83±1.00	28.30 ±1.00	3.84± 0.01	1.69 ± 5.75	51.02± 0.01
eRUTF 3	0.25± 5.77	14.40 ±5.75	28 .21 ±1.00	2.75 ± 1.00	1.43± 1.00	53.96± 0.01
eRUTF 4	0.57± 1.00	15.19±1.00	29.09±1.19	4.56± 1.00	0.41 ± 1.00	50.18±5.17
eRUTF 5	0.25± 0.01	14.03± 1.00	28.00±5.77	3.24± 0.02	1.67± 0.03	53.81± 0.01

Values are means ± standard deviation of three determinations

RUTF 1 SGML/DGNCSB= sorghum, millet, defatted groundnut cake, soya beans, sugar, vegetable oil, salt, premix

RUTF 2 MZML/SBSS = maize, millet, soybean, sesame, sugar, vegetable oil, salt, premix

RUTF 3 SGMZ/SBDGNC= sorghum, maize, soybean, defatted groundnut cake, sugar, vegetable oil, salt, premix

RUTF 4 MZSG/SBBB= maize, sorghum, soybean, bambara nut sugar, vegetable oil, salt, premix

RUTF 5 RCML/DGNCSB = rice, millet, defatted groundnut cake, soybeans, sugar, vegetable oil, salt, premix

Colour

Significantly different higher value recorded for eRUTF4 (8.3) for colour, might be because of the slight cream colour imparted on eRUTF4 by mixture of soyabean and bambaranut as reported by [28] that the type of ingredients significantly affected the colour of extruded products. UNICEF organoleptic requirement as per specification for colour indicated that RUTF paste should have cream to light brown colour [29].

Flavour

Higher value for flavour detected for eRUTF1 (8.1) might be connected to the toasted sorghum, millet and groundnuts used in the formulation of eRUTF1; Toasting has been reported by to enhance the flavour of cereal products [5].

Taste

Comparable taste score ($p>0.05$) of eRUTF1 (8.00) and eRUTF3 (8.0) could be related to the similarity in their components. All the products contained soybean, but the similarity is more in eRUTF1 and eRUTF3 (Table 2) and they ranked slightly higher than other eRUTFs.

General acceptability and overall ranking

Similarity in the general acceptability and ranking of eRUTF1 and eRUTF3 which were higher than other eRUTFs could be because of their similarity ($p > 0.05$) in texture, flavour and taste (Table 5). Consumer acceptability is often determined by sensory evaluation [24].

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Costing of the eRUTFs

The higher ($p < 0.05$) cost of eRUTF4 and eRUTF5 than other eRUTFs may be attributed to the higher cost of the main cereal and legumes used in their formulations. White Rice used in eRUTF5 was costlier than all other cereals and bambaranut in eRUTF4 was more expensive than soybeans used in the study. The costs of all the eRUTFs [N 54.17 -N 56.57] were significantly lower than the cost of the imported RUTF (N 146.00 / satchet) used in the study. Economics and sustainability of any wide use of any RUTF to prevent or treat severe acute malnutrition is very important [5]. The eRUTFs in this study costing N 54.17 (14 cents) - N 56.57 (16 cents) per 100g though expensive were still much cheaper than the imported RUTFs N 146.00 / sachet (41cents) RUTFs in this study.

Table 4: The total cost **of** ingredients, processing, extrusion and packaging of 100g of the eRUTFs.

eRUTF 1 SGML/DGNCSB			eRUTF 2 MZML/SBSS			eRUTF 3 SGMZ/SBDGNC			eRUTF 4 MZSG/SBBB			eRUTF 5 RCML/DGNCSB		
Ingredients	Quantity (g)	Cost (#)	Ingredients	Quant (g)	Cost (#)	Ingredients	Quantity (g)	Cost (#)	Ingredients	Quan (g)	Cost (#)	Ingredient	Quantity	Cost (#)
Sorghum	13.28	1.77	Maize	5.26	0.66	Sorghum	25.72	3.42	Maize	13.36	1.67	Rice	12.75	3.49
Millet	26.50	4.81	Millet	10.52	1.90	Maize	12.86	1.61	Sorghum	6.68	0.89	Millet	25.50	4.82
DGNC	8.06	4.51	Soybean	32.14	6.88	Soybeans	15.00	5.00	Soybeans	28.64	6.13	DGNC	8.59	4.80
Soybean	16.12	3.45	Sesame	16.07	8.29	DANC	7.84	4.39	Bambaranut	14.32	6.32	Soybeans	17.16	3.67
Sugar	14.00	4.66	Sugar	20.00	6.66	Sugar	15.00	5.00	Sugar	13.00	4.33	Sugar	15.00	5.00
Veg. oil	21.0	16.89	Veg. Oil	15.00	12.00	Veg. Oil	22.00	17.6	Veg. Oil	23.00	18.40	Veg. Oil	20.00	16.00
Salt	0.25	0.04	Salt	0.25	0.04	Salt	0.25	0.05	Salt	0.25	0.04	Salt	0.25	0.04
Premix	0.75	3.75	Premix	0.75	3.75	Premix	0.75	3.75	Premix	0.75	3.75	Premix	0.75	3.75
Processing*		2.00	Processing*		2.00	Processing*		2.00	Processing*		2.00	Processing*		2.00
Extrusion &packaging**		13.00	Extrusion &packaging**		13.00	Extrusion& packaging**		13.00	Extrusion &packaging**		13.00	Extrusion& packaging**		13.00
Total		**54.79c**	Total		**55.18bc**	Total		**54.17c**	TOTAL		**56.53b**	Total		**56.37b**

Values in a row with different superscripts are significantly different at $p < 0.05$

eRUTF 1 SGML/DGNCSB = sorghum, millet, defatted groundnut cake, soya beans, sugar, vegetable oil, salt, and premix

eRUTF 2 MZML/SBSS = maize, millet, soybean, sesame, sugar, vegetable oil, salt and premix

eRUTF 3 SGMZ/SBDGN = sorghum, maize, soybean, defatted groundnut cake, sugar, vegetable oil, salt and premix

eRUTF 4 MZSG/SBBB = maize, sorghum, soybean, bambaranut sugar, vegetable oil, salt and premix

eRUTF 5 RCML/DGNCSB = rice, millet, , defatted groundnut cake, soybeans, sugar, vegetable oil , salt and premix

* = cost of processing and milling of grains into flour at #20/kg

* * = charges on extrusion cooking in the departmental extruder machine and packaging at #133/kg

Table 5: Mean score values of the organoleptic properties and acceptability of the eRUTFs

eRUTFs	Texture	Colour Table	Flavour	Taste	General Acceptability	Overall Ranking
eRUTF1	8.0±0.90[c]	7.8±1.21[b]	8.1±1.46[a]	8.0±0.90[a]	8.2±17.27[a]	8.20±0.15,1st[a]
eRUTF2	8.3±17.25[a]	7.7±1.20[c]	7.6±0.67[c]	7.6±1.89[b]	8.0±0.65[b]	7.84±0.30,3rd[bc]
eRUTF3	8.0±0.78[c]	7.5±1.04[d]	7.9±1.15[b]	8.0±0.78[a]	8.2±1.09[a]	7.92±0.26,2nd[b]
eRUTF4	8.2±0.88[b]	8.3±0.65[a]	7.6±0.49[c]	6.6±1.70[c]	8.0±0.45[b]	7.74±0.69,4th[c]
eRUTF5	8.2±0.61[b]	7.3±0.9 [e]	7.1±1.92[d]	6.3±10.04[d]	7.2±0.76[c]	7.22±0.68,5th [d]

Values are Means ± standard deviation of three determinations. For each column values with different superscripts are significantly different at $p < 0.05$

eRUTF 1 SGML/DGNCSB = sorghum, millet, defatted groundnut cake, soya beans, sugar, vegetable oil, salt and premix

eRUTF 2 MZML/SBSS= maize, millet, soybean, sesame, sugar, vegetable oil, salt and premix

eRUTF 3 SGMZ/SBDGNC = sorghum, maize, soybean, defatted groundnut cake, sugar, vegetable oil, salt and premix

eRUTF 4 MZSG/SBBB = maize, sorghum, soybean, Bambara nut sugar, vegetable oil, salt and premix

eRUTF 5 RCML/DGNCSB = rice, millet, , defatted groundnut cake, soybeans, sugar, vegetable oil, salt and premix

Conclusion

Cereals and legumes grown in abundant quantities in Nigeria contain high nutrient values. Formulated RUTFs based on these cereals and legumes using modified linear programming tool and extrusion cooking method produced cereal – legume based RUTFs that met WHO recommendations for RUTFs. The RUTFs were cheaper than the imported peanut based RUTFs, generally accepted by the people. Therefore, extruded cereal – legume based RUTFs made from the local staples could be used to manage SAM in Nigeria.

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