Acta Scientific NUTRITIONAL HEALTH (ISSN:2582-1423)

Volume 6 Issue 11 November 2022

Research Article

Development of Food Formulation Based on Local Products for Children Suffering from Severe Acute Malnutrition without Complications at the National Institute of Public Health ABIDJAN

Adelaide Gnonde, N' Guessan Anon Franck-Donald, M-Digbe, H Yepie Al, Egnon V Kouakou*, Anin Atchibri, O S Ake-Tano A and M Ake

Nutrition service, National Institute of Public Health of Ivory Coast , Abidjan, Côte d'Ivoire

***Corresponding Author:** N' Guessan Anon Franck-donald, Medical researcher in nutrition service at the National Institute of Public Health of Ivory Coast. BP47 Abidjan 01.

DOI: 10.31080/ASNH.2022.06.1140

Received: August 30, 2022

Published: October 17, 2022

Abstract

Ready-to-use therapeutic foods (RUTF) play a fundamental part in the protocol for the management of severe acute malnutrition in children aged 6 to 59 months. Their availability is therefore a major issue in the fight against infant morbidity and mortality in developing countries. In Côte d'Ivoire, frequent shortages of RUTF are observed in the majority of health structures with repercussions on the level of performance of nutritional programs. Faced with this situation, an Ivorian research team offered to compose food formulas based on local products. The objective is to develop formulas that meet the recommended nutritional and microbiological requirements in order to use them as substitutes for reference products. To this end, a nutritional formulation based on local food products was made using the linear programming technique and then produced using traditional methods. Nutritional and microbiological qualities were determined using standard laboratory methods. This work was carried out at the National Institute of Public Health and made it possible to obtain a corn and cowpea-based formula that meets the nutritional and microbiological requirements recommended for malnourished children. It could be used in the management of cases of severe acute malnutrition without complications. They must be subjected to the clinical trial processes in force in order to use them with complete peace of mind.

Keywords: Therapeutic Food; Severe Acute Malnutrition; Local Product

Introduction

Acute malnutrition in children aged 0 to 5 is a real public health problem in developing countries and Côte d'Ivoire is not spared. It is the result of an insufficiency in quantity and/or quality of food intake in relation to the needs of the individual. This state can appear in the event of food shortage, recent acute illness, inappropriate infant care or feeding practices or a combination of some of these factors [2]. It is assessed by the weight-for-height (W/T) ratio. This takes into account the difference between the observed measurement and the median value established for the reference population. Acute malnutrition can be moderate, severe without complication or severe with complication [3,9].

In its management, ready-to-use therapeutic foods (RUTF) are effective means [1]. They include all therapeutic food compounds ready to be consumed, without the need for cooking, dilution or any preparation [10,14]. RUTFs can come in the form of cookies or bars (BP-100) or drinks, made up of ingredients such as cereals, vegetable oil, sugar and vitamin and mineral complexes [10].

In Côte d'Ivoire, their unavailability is becoming very frequent and constitutes a major problem in the management of malnutrition. Faced with this deficit, a research team proposed to set up an RUTF based on local ingredients. The aim was to formulate a nutritional complex based on local foods, meeting the recommended nutritional and microbiological requirements, with a view to use them as substitutes for reference products in the management of uncomplicated severe acute malnutrition.

Material and Methods

Type, duration and location of the study

This is an experimental study carried out over a period of 4 months in the nutritional rehabilitation service of the National Institute of Public Health (INSP) and in the laboratory of the University of Nangui Abrogoua (UNA).

Formulation steps

Ingredients were selected based on recommendations from Collins., *et al*. (2006) [14]. These are maize, egg white, cowpea, palm oil and cane sugar. Spirulina and vitamin C have been used as micronutrient supplements. Soy lecithin served as emulsifiers. The quantity per food ingredient was defined by linear programming [26].

Ingredients treatment

Corn flour was obtained from corn kernels grown in Ivory Coast. After cleaning (sorting, winnowing and washing with water 3 times), these beans were moistened with water (5% by eight) then roasted in a pan between 120 and 130°C for 30 to 40 min. The roasted beans were then cooled, pulverized in a mill (PHILIPS®, HR 2056) and finally sieved using a 300 µm mesh sieve. Cowpea flour was obtained using the same process. The cane sugar has been ground using a mill and then sieved to obtain a finer powder (150 µm in diameter) with a particle size close to 1000 µm. This process made it possible to obtain icing sugar.

Preparation of RUTF from ingredients

The RUTF formula based on local ingredients was prepared by combining the ingredients. The formulated recipe has been standardized as follows steps.

- Palm oil (19g/100g) was first mixed with soy lecithin powder (950mg) in a multifunction blender (SOKANY®, KF-103S) and then heated to a temperature between 50 and 56° C. using a SEVERIN® brand dryer, HT0104 for 15 min. Temperature monitoring was carried out via the infrared thermometer. The icing sugar was then added to the previous mixture followed by the addition of corn flour previously roasted over low heat for 2 to 5 minutes until a homogeneous paste was obtained, mixture 1.
- To the mixture1 was added cowpea flour (27g/100g) previously roasted, egg white powder (5g/100g), olive oil (10g/100g) then heated to 50°C for 5 min to obtain mixture 2. To this mixture 2, spirulina (5g/100g) and vitamin C (50g/100g) were added then homogenized at different speeds (2 to 8) for 3 min/degree of speed in order to simulate the conditions of the silos in the reference RUTF production plants.
- The final mixture is the local ready-to-use food called MANl. It was stored between 45 and 50°C in 100 ml polypropylene plastic containers.

Biochemical analyzes of ready-to-use therapeutic food

The determination of moisture and dry matter content of the samples was carried out by the AOAC method (2000) [7]. The ash content was determined by incineration in a muffle furnace at 550°C according to the AOAC method (2000) [7]. The samples obtained were used to produce the mineral profile of the samples using the Scanning Electron Microscope (SEM). The protein content was determined according to the Kjeldahl method [5,9]. The total lipid content was determined according to the method using the SOXHLET AOAC (2000) [7]. The fiber content was determined according to the AOAC method (2000) [7]. The calculation of the available carbohydrate content in the samples was obtained by difference and expressed as a percentage according to the relationship given by FAO (2015) [18]. The calculation of the energy value (EV) (kcal/100g) was carried out according to the relationship given by the conversion coefficient of metabolized energy also called general Atwater factors [13,17,18].

Microbiological analyzes

The microbiological analysis of total Mesophilic Aerobic Germs (GAMT), Yeasts and Molds, Total and Faecal Coliforms, Escherichia coli, and Staphylococci was carried out according to standard procedures for the preparation of culture media and the enumeration of germs [17]. The determination of each microorganism, 10g of each formula were withdrawn aseptically and added to 90 ml of Buffered Peptone Water (EPT) prepared according to the manufacturer's recommendations (SCHARLAB S. L®, Spain).

Statistical analyzes

The data collected was processed with GraphPad Prism software version 7.00. The experimental results are expressed as arithmetic means and accompanied by the standard error (m ± SEM). An analysis of variance (ANOVA) followed by a Newman-Keuls test at the 5% threshold was then performed.

Result and Discussion

The nutritional elements of local RUTF

The nutritional compositions of MANI are presented in tables 1,2. The energy value of the formula is 524.53 kcal per 100g of ma-

terial. The lipid content is 30.61 ± 0.20g/100g. The protein composition of the formula is 16.37 ± 0.35g/100g. The carbohydrate content is 46 ± 0.8g per 100g. The moisture content is 2.67 ± 0.12 per 100grams of material. The MANI formula has a high dry matter content of 99.33 ± 0.12. The fiber content (4.47 ± 0.30g/100g for MANI) is less than 5g/100g. The mineral composition of the food is made of Potassium Calcium Phosphorus Magnesium, Zinc and Copper.

Each value represents the mean ± standard error (n = 3 replicates). After a one-factor analysis of variance (ANOVA), the comparison of the means is carried out by the Newman-Keuls test at the 5% threshold. The means on the same line, assigned different superscript letters are significantly different ($p < 0.05$) depending on the parameter studied. DM: Dry matter; GD: Available Carbohydrates; EV: Energy Value; MANI: Local formula based on maize/cowpea

Settings	Mani	Recommendation*	
		Min	Max
Humidity (%)	2,67 ± 0,12 ^{c}	2,5	5
MS (%)	99,33 ± 0,12 ^{a}	_	_
Protein (G/100G)	16,37 ± 0,35 ^{a}	13	16,5
Lipids (G/100G)	30,61 ± 0,20 ^{c}	28	36
Ashes (G/100G)	2,1 ± 0,16 ^{b}	_	_
Fibers (G/100G)	4,47 ± 0,30 ^{a}	_	5
GD (%)	46,54 ± 0,81 ^{a}	_	_
VE (KCAL/100G)	520,32 ± 1,13 ^{b}	520	550

Table 1: Macronutrients of the local formula.

Minérals (MG/100G)		MANI	Recommendation	
			Min	Max
Micro-elements	Na	_	290	210,5 ± 2,99 ^{b}
	K	1110	1400	1234,71 ± 9,06 ^{c}
	Ca	300	600	329,03 ± 2,47 ^{b}
	P	300	600	380,6 ± 3,34 ^{c}
	Mg	80	140	120,43± 1,69 ^{b}
Trace elements	Fe	10	14	11,59 ± 0,11 ^{b}
	Zn	11	14	12,89 ± 0,09 ^{c}
	Cu	1,4	1,8	1,02 ± 0,01 ^{b}
Ratio	Na/K		1	0,18
	Ca/P	0,5	1,3	1,03
	Zn/Fe	0,8	3,5	1,48
	Zn/Cu	5	20	19,95
	Vit C/Fe	3	16	6,39

Table 2: Minéral profile of the local formula.

Each value represents the mean ± standard error (n = 3 replicates). After a one-factor analysis of variance (ANOVA), the comparison of the means is carried out by the Newman-Keuls test at the 5% threshold. The means on the same column, assigned different superscript letters are significantly different ($p < 0.05$) depending on the parameter studied.

Microbiological quality of "MANI".

The value obtained for the total mesophilic aerobic germs of local formula is lower than the standard (2.45.102 CFU/g). Yeasts were observed but, in a quantity, lower than the pre-established standards. On the other hand, total and faecal coliforms, molds, salmonella, Escherichia coli and staphylococci were not detected in this study. Thus, the fungal and bacteriological loads detected in the local formula are lower than the microbiological criteria applicable to ready-to-use therapeutic foods intended for malnourished children under five years of age [29]. The microbiological analyzes are presented in table 3.

Discussion

The objective of this study is to formulate a ready-to-use therapeutic food with local nutritional products for the management of severe uncomplicated cases of acute malnutrition. Ingredients were selected based on recommendations from Collins., *et al.* (2006) [14]. These are maize, egg white, cowpea, palm oil and cane sugar. Spiru-

Microorganisms	MANI	Standards*
Total mesophilic aerobic germs	$2,45.10^2$	< 104 CFU/g
Total coliforms	Abs	< 10 CFU/g
Faecal coliforms	Abs	
Molds	Abs	< 50 CFU/g
Enterobacteriaceae	Abs	< 10 CFU/g
Escherichia coli	Abs	Abs/g
salmonella	Abs	Abs/g
Staphylococci	Abs	Abs/g

Table 3: Microbiological quality of the local formula produced.

Abs: Absent; UFC: Colony Forming Unit; MANI: Local formula based on maize/cowpea.

lina and vitamin C have been used as micronutrient supplements. Soy lecithin served as an emulsifier. The quantity per food ingredient was defined by linear programming. Formulation work made it possible to obtain a ready-to-use therapeutic food called "MANI".

Its nutritional composition has been researched and compared to international standards. In terms of macronutrients, the energy density of MANI is 524.53 Kcal per 100g of material. This constitutes an important quality of RUTF intended for the rehabilitation of severe acute malnourished children without complications because of their high energy requirement. This result is the same than Amegovu study en 2013 [6]. According to international experts, malnourished children need a high-fat diet [15,30]. The local MANI formula (30.61 ± 0.20g/100g) has a statistically adequate lipid level because its value remains within the fixed limits of 28 to 36g/100g [16,31]. These lipids are necessary for the absorption of vitamins A and E according to Michaelsen in 2009 [31]. These vitamins are important for rapid recovery and a reduction in the incidences associated with acute malnutrition. Also, the protein content of the formula (16.37 ± 0.35g/100g) is superimposable to the recommended standards [17,19,28]. These proteins are essential for the rehabilitation of the lean mass of the malnourished. Indeed, they are involved in many biological functions such as the formation of muscle tissue, the production of enzymes and hormones as well as growth [25]. Regarding carbohydrates, the carbohydrate content of MANI is adequate according to the work of Amegovu (2013) [6]. These carbohydrates help in protein synthesis and are involved in thermoregulation in the malnourished [22].

The mineral profile of MANI was also studied. It is satisfactory according to the work of Adjou., *et al.* (2012) [4]. These minerals play an important role in restoring intracellular and extracellular fluids. They are involved in many biological functions including enzymatic activities as well as the electrolyte balance of blood flow where certain minerals (Na, K and Mg) must have a perfect match for the proper functioning of the organization [31].

Sodium and Potassium are minerals necessary for maintaining the osmotic balance of body fluids as well as body pH by regulating nervous and muscular irritability [20,21]. They also help control glucose uptake and improve normal protein retention during growth [23]. The body's Na/K ratio is of great interest in the prevention of cardiovascular disorders. A Na/K ratio of less than 1 is therefore recommended [8,22,24,25]. The Na/K ratios of the formula obtained are less than 1. The results of the "MANI" mineral profile have values that globally represent 80% of the minimum recommended requirements [5]. At the end of this analysis, it appears that the nutritional composition of Mani is superimposable on that suggested by the experts for the care of children with severe acute malnutrition without complications [31].

The study of the microbiological quality of the local formula indicates that the load of total mesophilic aerobic germs is lower than the microbiological criteria (< 104 CFU/g) indicated by the various agencies involved in the management of acute malnutrition [11,12,29] The moisture content of the formula is statistically included in the levels set in ready-to-use foods according to the work of Santini., *et al*. (2013) [27]. This moisture content is due to the various cooking, drying and roasting treatments applied to the various inputs including cowpea, maize and eggs. The cooking/drying and drying/roasting couplings allowed a significant reduction in the load of mesophilic aerobic germs. This low humidity level of the

local formula is beneficial for a better and long conservation [23]. Other authors such as Tarhouni., *et al.* (2015) [28], have also shown that the pre-cooking and drying of flours reduce total mesophilic aerobic germs. The absence of hygiene control germs (Faecal coliforms) and pathogenic germs (S. aureus, Salmonella) in the local formula proves the effectiveness of the cooking conditions (temperature/time). These results could also reflect compliance with good hygiene practices (GHP) and manufacturing practices (GMP) during the production of local RUTF.

Conclusion

The fight against malnutrition in children under five years of age is one of the major areas of intervention in public health worldwide. The availability of ready-to-use therapeutic foods plays an important part in this process. In Ivory Coast, the frequent shortage of these therapeutic food products motivated the realization of the present study in order to formulate an RUTF based on local ingredients. The work has shown its nutritional and microbiological qualities which are superimposable with international standards. The "MANI" could for this purpose be used for the management of cases of severe acute malnutrition without complications. It will follow the current clinical trial process in order to be safely prescribed to children.

Bibliography

1. ACF. "Inventory of definitions commonly used for prevention, diagnosis and treatment of undernutrition". Département Scientifique et Technique, ACF – France. International (2011a).

2. ACF. "L'essentiel des clés pour comprendre la nutrition-santé et le positioningnement d'ACF. Département Scientifique et Technique, Secteur Nutrition - Santé, ACF - International. International (2011b).

3. ACF. "Mettre fin à la malnutrition d'ici à 2030. Faire de la deuxième conférence internationale sur la nutrition une étape décisive. ACF - International (2014).

4. Adjou ES., *et al.* "Investigations on the mycoflora and processing effects on the nutritional quality of peanut (*Arachis hypogea* L. Var. Ts 32-1)". *Journal of Microbiology, Biotechnology and Food Sciences* 2.3 (2012): 1025-1039.

5. Ahmed T., *et al.* "Development and acceptability testing of ready-to-use supplementary food made from locally available food ingredients in Bangladesh". *BMC Pediatrics* 14.164 (2014): 1.

6. Amegovu AK., *et al.* "Sensory acceptability of sorghum peanut blend (SPB) and corn soy blend plus by young chilfrenwith moderate Acute malnutrition in karamoja Uganda". *Journal of Food research* 3 (2013): 17-26.

7. AOAC. "Official Methods of Analysis of Association of Official Analytical Chemists. 17th Edition, Gaithersburg, Maryland, USA". Methods 925.10 (2000): 65.17, 974.24, 992.16.

8. Audu SS and Aremu MO. "Effect of processing on chemical composition of red kidney bean (*Phaseolus vulgaris* L.) flour". *Pakistan Journal of Nutrition* 10.11 (2011): 1069-1075.

9. Brixi G. "Innovative optimization of ready to use food for treatment of acute malnutrition". *Maternal and Child Nutrition* e12599 (2018): 1-9.

10. Brou K., *et al.* "Effects of processing method and blend on some physicochemical properties and digestibility of flours made from selected cereals and legumes". *International Journal of Biological and Chemical Sciences* 3.5 (2009): 1151-1211.

11. CAC. "Programme mixte FAO/OMS sur les normes alimentaires". Comité du codex sur la nutrition et les aliments diététiques ou de régime. Document de travail sur une norme pour les aliments prêts à l'emploi. Trente-sixième session. Bali, Indonésie 24-28. CX/NFSDU 14/36/2 Add (2014): 1.

12. CAC. "Programme mixte FAO/OMS sur les normes alimentaires". Comité du codex sur la nutrition et les aliments diététiques ou de régime. Avant-projet de ligne directrice pour les aliments thérapeutiques prêts à l'emploi (RUTF). Trente-huitième session. Hambourg, Allemagne 5-9 (2016).

13. Callaghan-Gillespie M and Mui M. "Useful Tools for Food Aid: Linear Programming and Protein Quality Tools". *Food and Nutrition Bulletin* 39.S2 (2018): S80-S88.

14. Collins S., *et al.* "Management of severe acute malnutrition in children". *Lancet* 368 (9551): 1992-2000.

15. Dibari F. "Design and pre-testing of lipid-based, ready-to-use foods for the prevention and treatment of malnutrition in low-resource settings". Doctoral thesis Institute of Global Health, University of College London, England (2015): 353.

16. Duclercq MP. "Production des aliments prêts à l'emploi (APE) : un aperçu des étapes de leur production « locale » et des défis à relever". Dossier technique du Forum PCMA (2014).

17. FAO. "Individual food intake survey methods". Keynote paper, National Institute of Food and Nutrition Research, Rome (2003).

18. FAO/INFOODS. "Directives FAO/INFOODS relatives à la vérification des données sur la composition des aliments avant la publication d'une table/base de données utilisateur-Version 1.0. FAO, Rome (2015b).

19. Ikujenlola AV. "Quality and *in vivo* assessment of precooked weaning food from quality protein maize, soybean and cashew nut flour blends". *Croatian Journal of Food Technology, Biotechnology and Nutrition* 11.1-2 (2016): 49-57.

20. Kosoko SB., *et al.* "Comparative Quality Evaluation of Roasted Cashew Nut Kernel: Effect of Roasting Methods". *Advance Journal of Food Science and Technology* 6.12 (2014): 1362-1371.

21. Michaelsen KM and Clausen T. "Inadequate supplies of potassium and magnesium in relief food - Implications and countermeasures". *Lancet* 2 (2009): 1421-1423.

22. Nieman DC., *et al.* "Nutrition". WmC. Brown, Dbugye, USA (1992): 237-312.

23. NRC. "Recommended Dietary Allowances. 10th Edition"., Washington DC, National Academy Press, 24 (1989).

24. OMS. "Note technique : Suppléments alimentaires pour la prise en charge de la malnutrition aiguë aigue chez les nourrissons et les enfants âgés de 6 à 59 mois" (2012).

25. Ponka R., *et al.* "Composition nutritionnelle de quelques farines infantiles artisanales du Cameroun". *International Journal of Innovation and Applied Studies* 16.2 (2016): 280-292.

26. Ryan KN., *et al.* "A comprehensive linear programming tool to optimize formulations of ready-to-use therapeutic foods: an application to Ethiopia". *The American Journal of Clinical Nutrition* 100 (2014): 1551-1558.

27. Santini A., *et al.* "State of the art of Ready-to-Use Therapeutic Food: A tool for nutraceuticals addition to foodstuff". *Food Chemistry* 140 (2013): 843-849.

28. Tarhouni A., *et al.* "Mise au point d'un procédé intégré de valorisation des coproduits de la sardinelle aquadocs" (2015).

29. USDA (United States Department of Agriculture), 2013. "National School Lunch Program Fact Sheet". Food and Nutrition Service of the United States Department of Agriculture (2015).

30. WFP. "Technical Specifications for-Ready-to-Use Supplementary Food-RUSF". WFP, Specification reference: MIXRSF000 (2016).

31. FAO/IFAD/UNICEF/WFP/WHO. "The State of Food Insecurity in the World 2017. Building resilience for peace and food security". Rome (2017).