OPEN ACCESS
Saudi Journal of Biomedical Research
Abbreviated Key Title: Saudi J Biomed Res
ISSN 2518-3214 (Print) |ISSN 2518-3222 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Formulation and Evaluation of Supplementary Food from Tigernut, Date Palm, Moringa, Groundnut and Milk

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DOI: 10.36348/sjbr.2023.v08i08.004 | **Received:** 05.07.2023 | **Accepted:** 09.08.2023 | **Published:** 26.08.2023

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Abstract

Globally, undernutrition is the single biggest contributor to disease. Undernutrition is of particular concern in young children as it can compromise their physical and intellectual development. Current study formulated and evaluation of supplementary food from tiger nut (*Cyperus esculentus*), date palm (*Phoenix dactylifera)*, moringa (*Moringa oleifera*), groundnut (*Arachis hypogaea)* and milk. The formulated supplementary food were designated S1, S2 and S3. Nutritional composition, selected minerals and anti-nutritional factors were investigated using standard analytical methods of Association of Official Analytical Chemist. Data was analyzed by ANOVA and results expressed as mean and standard deviation. Result of proximate composition indicates that ash ranged from (4.0 - 7.5), moisture (2.5 - 5.5) and protein (9.3 - 15.0). The result also revealed that the formulations contain appreciable amount of all essential amino acids. Anti-nutritional factor indicate that oxalate ranged from (7.0 - 14.0) and phytate (6.5 - 7.0). Selected micro-nutrient estimated suggested that the composite blends are good sources of minerals like Zn, Ca and Fe which are of public health importance. Based on the results of this study, it can be concluded that with proper blending of local foodstuff, it is possible to prepare nutritionally adequate supplementary food.

Keywords: Undernutrition, Supplementary food, Micro-nutrient, Blend, Foodstuff and Public health.

INTRODUCTION

Malnutrition is 'a state of nutrition in which a deficiency or excess (or imbalance) of energy, protein and other nutrients causes measurable adverse effect on tissue and body form (body shape, size and composition) and function and clinical outcome' (Hickson and Smith, 2018). Majority of the studies use the term 'Malnutrition' to refer to undernutrition. However, the use of malnutrition instead of undernutrition prevents distinguishing between the issues of undernutrition and overnutrition (Hickson and Smith, 2018).

Overnutrition is a less acknowledged form of malnutrition (Ngaruiya *et al.*, 2017). The Lancet Commission report suggested an all-encompassing definition for malnutrition indicating that all dietary risks including obesity and undernutrition that lead to poor health (Swinburn *et al.*, 2019). World Health Organisation identified the double burden of malnutrition as the coexistence of undernutrition along with obesity or non-communicable diseases (NCD) from overnutrition (Min *et al.*, 2017).

Undernutrition is defined as a physical state that results from the lack of intake of nutrition, causing changes in body composition and body cell mass (Cederholm *et al.*, 2015). A diet that does not supply a healthy amount of one or more nutrients including protein, carbohydrates, fat, vitamins or miner als causes undernutrition (WHO, 2021). It adversely affects the physical and mental functional status of the affected person (*Safiri et al., 2021*). Undernutrition is a major health problem causing the highest mortality rate in children and is responsible for long-lasting physiologic effects (*Safiri et al., 2021*).

The different forms of undernutrition include stunting, wasting, and underweight. While a surplus of nutrients causes overnutrition, including overweight and obesity (*Young, 2012*; WHO, 2021). Undernutrition occurs when an individual is not getting enough calories, protein, or micronutrients (*Young, 2012)*. If undernutrition occurs during pregnancy, or before two years of age, it may result in permanent problems with physical and mental development (*WHO, 2013*).

Extreme undernutrition, known as starvation, chronic hunger, severe acute malnutrition (SAM) or moderate acute malnutrition (MAM) may have symptoms that include: a short height, thin body, very poor energy levels, and swollen legs and abdomen (edema) (*Young, 2012*; *WHO, 2013*). Those who are undernourished often get infections and are frequently cold (*Young, 2012)*. The symptoms of micronutrient deficiencies depend on the micro-nutrient that is lacking (*Young, 2012)*.

Reducing malnutrition is key part of Sustainable Development Goal 2 (SDG2) "Zero hunger" with a malnutrition target alongside reducing under nutrition and stunted child growth. According to the World Food Programme (WFP) 135 million suffer from acute hunger, largely due to manmade conflicts, climate changes, and economic downturns (GRFC, 2020). Therefore, the current study is aimed at formulating and evaluating the supplementary food from tiger nut, date palm, moringa, ground nut and milk.

MATERIALS AND METHODS

Procurement and Processing of Food Materials

The tiger nut, ground nut, Date palm and milk were purchased in Kalgo market, Kalgo Local Government, Kebbi State. While the moringa was obtained in a home garden at borehole area Kalgo, and authenticated in Department of Biology Federal University, Birnin Kebbi. The groundnut, date palm and tiger nut was manually sorted to remove stones and dirt. When followed by roasting for about 10 to 15min and then dehulling. Then the ground nut and tiger nut were grinded separately. The moringa leaves was sorted manually to remove damaged and diseased ones. The leaves was washed to remove dirt and soaked in 1% saline solution (NaC1) for 5mins. to get rid of microbes. The leaves was drained of excess water and dried in a shade indoors to avoid loss of nutrients. The Tiger nut, Groundnut, Moring and Milk was grinded in to powder separately, then were been mixed thoroughly.

Chemicals and reagents

All chemicals and reagents used were of analytical grade and manufactured by British Drug House (BDH) Limited, England and Randox Laboratories, Northern Ireland.

Optimization and Formulation of the Supplementary Foods

Nutrisurvey software (2007) was used to optimize the composite blends by varying the amounts of the various ingredients so as to enhance nutritional quality. The formulated samples were designated S1, S2 and S3. The proportion of various ingredients is indicated in Table 1.

Table 1: Composition of the Formulations per 100g dry weight

INGREDIENTS	S1(g)	S2(g)	S3(g)
Tiger nut	25	10	25
Ground nut	_	50	_
Moringa	50	15	_
Milk	_	_	50
Date palm	25	25	25

Nutrient Analysis

Proximate composition was determined in triplicate using standard procedures of Association of Official Analytical Chemists (AOAC, 2012). The moisture content was determined by oven drying method. Crude protein was determined by Micro-Kjeldahl Method. Fat was determined by soxhlet extraction utilizing hexane as solvent. Crude fibre was determined by neutralization method (Method 962.09). Ash content was determined by dry ashing method of AOAC (Method 923.03) (AOAC, 2012).

Carbohydrate Estimation

Carbohydrate content was determined by difference (%Carbohydrate) = [100-(%Protein + %Moisture+ %Ash+% Fibre% + %Crude Lipid)] (Mathew *et al*., 2015).

Determination of amino acid profile of the supplementary food blends

The amino acid profile was determined with Technicon Amino Acid Analyzer (TSM-1) using Norleucine as internal standard (Adeyeye and Afolabi, 2004; AOAC, 2005).

Determination of Phytate

Phytic acid was determined as described by Wheeler and Ferrel (1971). Phytic acid was extracted from 3g of sample with 3% trichloroacetic acid by shaking at room temperature followed by high speed centrifugation. The phytic acid was estimated by multiplying the amount of phytate phosphorus by 3.55 based on the empirical formula $C_6P_6O_{24}H_{18}$.

Determination of Oxalate

Oxalate content was determined according to AOAC (2005). 1g of sample was weighed into 100 ml conical flask. Then, 75 ml of 3mol/l H2SO4 was added. The solution was stirred intermittently for 1hour on magnetic stirrer and then filtered using Whatman No. 1 filter paper. 25 ml of the sample filtrate was collected and titrated against hot (80-90˚C) 0.1 N KMnO4 to point where a faint pink color appear that persist for 30 seconds. Oxalate was calculated using 1ml 0.1 permanganate = 0.006303 g oxalate.

Determination of Selected Micronutrient Content

Selected mineral content (Iron, Zinc, Magnesium, Copper, Phosphorus, Potassium and Calcium) were determined by means of atomic absorption spectrophotometer (AAS) (Shimadzu AA-6200 Tokyo, Japan) according to AOAC method (AOAC, 1996).

Statistical Analysis

Data were reported as means ± standard error of mean of triplicate determination. Analysis of variance (ANOVA) was used to establish significant difference (P<0.05). Values were analyzed statistically using Graph Pad PRISM version 6.05 software (Statcon, Witzenhausen, Germany).

RESULTS

The results of proximate composition of the formulated supplementary food at different blending ratio are given in Table 2. Proximate composition generally represents the nutritional quality of the product. Ash and crude fiber is highest in S1 while carbohydrate, moisture and crude lipid is highest in S3 and crude protein is highest in S2. It is necessary to determine the proximate composition of the formulated blend of the food product to judge its effect on final product after utilization as a novel ingredient.

Table 2: Percentage proximate composition of the formulated supplementary foods

PARAMETERS	S1 (%)	S2 (%)	S3 (%)
Moisture	2.5^a±0.5	3.5^a±0.4	5.5^a±0.3
Ash	7.5^b±0.5	4.0^b±0.4	5.0^b±0.3
Crude lipid	2.0^C±0.3	4.0^C±0.2	5.0^C±0.3
Crude fiber	15.5^a±3.0	13.0^a±2.0	2.5^a± 0.1
Crude proteins	9.3^b±3.0	15.0.^{b}±4.0	13.8^b±2.0
Carbohydrate	62.7^b±5.0	60.5^b± 4.0	71.7^b± 5.0

Values are mean ± standard deviation of triplicate determination, Values with the same superscript in the same row differ significantly at (P <0.05).

Table 3. Represent the result for the selected mineral analysis of the supplementary food. Mineral content of the formulated blend is essential in justifying the foods value. Phosphorous, calcium, iron, magnesium and potassium are the minerals of interest in current study. The result revealed Fe and K is the highest in both samples while P and Cu is the lowest. Minerals play a key role in various physiological functions of the body especially in the building and regulation processes.

Table 3: Selected mineral content of the formulated supplementary foods

PARAMETERS	S1(mg/100g)	S2(mg/100g)	S3(mg/100g)
Na	150^a±0.80	120^a±0.70	237.5^a±0.60
K	175.021^m±5.0	150.0^m±5.0	190.0^m±5.0
Ca	40^C±0.80	36^c±0.70	36^c±0.60
Mg	36^c±0.60	48.0^c+3.0	51.^{c}±40
P	5^b±0.80	4.7^b±0.70	5.0^b+0.6
Fe	183.925^a±5.0	180.746^a±5.50	183.328^a±7.0
Zn	181.7^b±0.80	181.7^b±80	180.0^b±0.80
Cu	6.71.^{c}±0.80	10.13.^{c}±0.70	0.44.^{c}±0.60

Values are mean ± standard deviation of triplicate determination, Values with the same superscript in the same row differ significantly at (P <0.05).

The result of the amino acid contents of the composite blends is presented in Table 4. The test formulations were found to contain all the 20 naturally occurring amino acids, they are therefore sources of both essential and non essential amino acids. The most abundant essential amino acid was arginine and leucine; while the least abundant was Tryptophan. The values of amino acid arginine and histidine are slightly higher than the recommended values of FAO/WHO (FAO/WHO, 2004). These amino acids are referred to as growth promoting factors since they are not synthesised in sufficient amounts during growth, hence they are essential in growing children (Oibiokpa *et al*., 2018).

Table 4: Essential Amino acid Profile of the Optimized supplementary Foods

PARAMETERS	S1(mg/100g)	S2(mg/100g)	S3(mg/100g)
Leucine	6.01^a±0.8	5.14^a±0.7	5.60^a±0.6
Lysine	3.82^b±0.4	3.02^b±0.3	4.35^b10.2
Isoleucine	3.01^c±0.7	2.29^c±10.6	2.62^c±0.5
Phenylalanine	3.72^a±0.7	3.19^a±0.6	2.48^a+0.5
Tryptophan	0.87.^{c}±0.4	0.79.^{c}±0.3	0.81^c±0.2

PARAMETERS	S1(mg/100g)	S2(mg/100g)	S3(mg/100g)
Threonine	4.21^{a}±0.7	2.05^{a}±0.6	2.83^{a}±0.5
Valine	3.45^{b}±0.8	2.89^{b}±10.7	2.98^{b}±0.6
Methionine	1.20^{a}±0.5	0.85^{a}±0.4	0.91^{a}±0.3
Histidine	2.36^{a}±105	1.92^{a}±0.4	2.40^{a}±0.3
Arginine	6.80^{c}±0.8	6.80^{c}±0.8	3.97^{c}±0.8

Values are mean ± standard deviation of triplicate determination, Values with the same superscript in the same row differ significantly at (P <0.05).

Table 5. Represent the result of the anti-nutritional profile of formulated supplementary food. The results for phytate and oxalate content are presented in table 5. The anti-nutritional factors found to have effect on gastrointestinal tract and affect the micro flora count of the intestine by promoting the growth of beneficial bacteria's.

Table 5: Anti-nutrient Composition of the formulated supplementary foods

PARAMETERS	**S1**(mg/g)	**S2**(mg/g)	**S3**(mg/g)
Oxalate	14.0^{a}-±0.5	7.7^{a}-±0.4	7.0^{a}±0.3
Phytate	6.5 1^{b}±0.4	7.3^{b}±0.3	6.5^{b}±0.2

Values are mean ± standard deviation of triplicate determination, Values with the same superscript in the same row differ significantly at (P <0.05).

Table 6: Ranking of formulated supplementary foods to determine the most optimal nutritional profile

PARAMETERS	S1	S2	S3
Moisture	1	2	3
Fiber	1	2	3
Carbohydrate	2	3	1
Oxalate	3	2	1
Minerals	1	3	2
Ash	1	3	2
Amino Acid	1	3	2
Crude proteins	3	1	2
TOTAL	**13**	**19**	**16**

Most desirable (1) to least desirable (3)

DISCUSSION

Problem of malnutrition in children continues to be critical in most underdeveloped and developing countries like Nigeria. This problem associated with inadequate protein and amino acids supply to the growing child (Salve *et al.*, 2011). Therefore, supplementation has to be implemented after four to six months to overcome malnutrition and related complications. These supplementary foods are worked as balanced diet for pre-school children. When the child is 1 to 1.5 years old, breast milk may not be available to it or milk is no longer sufficient to meet its nutritional requirements. It needs some more calories and other nutrients as supplement to milk till he/she is ready to eat adult's food. This is the post weaning stage of a child. In this stage proper nutritional care of the child is essential to ensure normal growth. It helps to avoid malnutrition in pre-school children (Salve *et al.*, 2011).

Proximate composition

It is evident from Table 2 that moisture content was higher in S3 followed by S2 then S1 is the lowest. The proximate composition of the supplementary foods under investigation indicates that moisture content of the formulations was within standard recommended by International Organization for Standardization (ISO). These values of moisture contents translate good storage stability and shelf life; as higher moisture contents may encourage microbial growth and spoilage (Sanni and Oladapo, 2008).

The result revealed highest in S1 followed by S3 then S2. The values recorded for ash content may be attributed to inclusion of moringa in the ingredients which is a good reservoir of micro-nutrients (Singh, 2019). Ash content of food substances could be used as an index of mineral constituent of the food. Minerals play a vital role in many biochemical processes such as in optimal functioning of the nervous system, water, and electrolyte balance (Sanni and Oladapo, 2008; Singh, 2019).

The crude fibre content obtained from this study suggests that this supplementary foods is a potential source of dietary fibre (roughages). High level of fibre is known as anti-tumorigenic and hypocholestrolaemic agent (Okoro and Achuba, 2012). This implies that this supplementary foods may be recommended for people with cholesterol related problems (Peter and Tolulope, 2015).

Low crude fat recorded from both samples, this study in comparison to protein suggests that this supplementary food could be recommended as good source of food supplement for patient with cardiac problems or at risk with lipid induced disorders (Peter and Tolulope, 2015).

The protein content of the formulated supplementary foods is similar to values reported by Peter and Tolulope (2015). The protein content may be attributed to Milk and moringa in the ingredients. The quantity and quality of protein is playing a crucial role in the diet. Proteins are essential constituents of all body tissues (Sanni and Oladapo, 2008). Similarly, both samples had high carbohydrate content which is essential for energy provision and prevention of depletion of body tissues.

Selected Minerals

The values of selected minerals indicate amount of potassium, sodium, calcium, and magnesium. These elements play a significant in electrolyte homeostasis and participate in biochemical reactions. Calcium and magnesium levels reported in the current study were higher than values reported by Richard *et al*., (2004). However, Richard *et al*., (2004) reported higher values of iron, zinc and copper. Earlier studies on humans have shown that optimal intakes of minerals can reduce individual's risk for several health problems and diseases (Mohammed and Sulaiman, 2009).

Amino acids composition

The amino acids composition of the supplementary food blends is presented in Table 4. Amino acid content of supplementary foods is very important in infant and young child nutrition, particularly in low-income countries where PEM has remained a serious public health problem. The current study reveals that all the essential amino acids are present in the three supplementary Food formulations and they met the FAO/WHO reference values. Similar findings were reported by (Hussein, 2000). The improvement in the amino acid profile of the supplementary food formulations is as a result of inclusion of milk and ground nut in the blends.

Anti nutritional factors

Plant based food contain numerous antinutrients which are secondary metabolites essential for their survival. These antinutrients can hinder the bioavailability of nutrients in the gastro-intestinal tract by binding chelating them. Phytic acid and oxalic acid are two prominent antinutrients found in plant based foods (Dahouenon-Ahoussi *et al*., 2012). The result revealed that amount of Phytate is higher in S2, Oxalate was higher in S1.

Phytic acid binds to mineral elements such as calcium, zinc, manganese, iron and magnesium to form complexes that are indigestible, thereby decreasing the bioavailability of these elements (Dahouenon-Ahoussi *et al*., 2012). Oxalate is a salt formed from oxalic acid. A typical example is calcium oxalate which is widely distributed in plants.

Oxalate is an anti-nutrient which can bind minerals, such as calcium, magnesium, sodium, and potassium. This chemical combination results in the formation of oxalate salts. Oxalate is an anti-nutrient which under normal conditions is confined to separate compartments. However, when it is processed and/or digested, it comes in contact with the nutrients in the gastrointestinal tract. When released, oxalic acid binds with nutrients, rendering them inaccessible to the body. If food with excessive amounts of oxalic acid is consumed regularly, nutritional deficiencies are likely to occur, as well as severe irritation to the lining of the gut (Dahouenon-Ahoussi *et al*., 2012).

CONCLUSION

In conclusion, the quality of supplementary foods is among the major drivers; if infants and young children nutrition is to be improved. In Nigeria and other developing countries, because of the persistent problem of poverty, so many families cannot afford nutritionally-adequate commercial complementary foods. Thus, they prepare porridge from only cereals which are grossly inadequate when compared to estimated needs.

The bio assay profile for all the experimental diets is of interest but diet S1 happen to be the most effective due to its outstanding performance in the protein utilization, biological value and digestibility. Diet S1 also recorded the highest score for parameters of growth performance. Therefore, the results of the current study provide a basis for the development of acceptable supplementary foods that can provide the required protein and energy levels to support growth, physical activity and prevent PEM.

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