



Nutrient evaluation and organoleptic properties of formulated cereals and legumes ready to use therapeutic foods (RUTF)

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Abstract

This research work evaluates the nutrients and organoleptic properties of cereals and legumes ready-to-use therapeutic foods (RUTF) F75 (finger millet, soya beans, groundnut and micro-minerals), and F100 (soybeans, Sesame, groundnut, milk, vegetable oil, and micro-minerals blends) formulated. Seven (7) samples were formulated in this study coded PNS, PNSY, F75, F100, PNC, F100C and F75C using different processing methods. The PNC, F100C and F75C are used as control samples for PNSY, PNS, F100 and F75 respectively. The samples were subjected to different evaluations, which includes; proximate composition, mineral elements and organoleptic properties of the samples. The moisture content of the samples shows that F75C (16.05±0.0) had the highest moisture content compared to F75 while the PNS and PNSY has (2.0±0.0) and (3.0 ± 00) moisture content which is lower than the control PNC. The fat content of the samples ranges between 1.0±0.0-20.75±0.4, F100C had the least fat content while PNS had the highest fat content. The highest ash value was observed in PNC (20±0.0) and the highest percentage protein (17.85±0.1) was found in PNSY. Furthermore, F75C, F100C and F100 had no crude fibre while the highest crude fibre was found in PNSY (8.0±0.0). The percentage carbohydrate content of the samples ranges between 53.15-78.09±0.2, with F75C having the highest carbohydrate content. The mineral composition of the formulated RUTF samples (per 100ml) shows that PNC had the highest calcium (114±0.02mg), magnesium (27±0.01mg), iron (0.06±0.0mg) zinc (3.1±0.0mg) copper (0.4±0.0mg) and selenium (7.0±0.0mg). The organoleptic properties of the samples reveal that PNS (7.80±1.23) and F75C (7.80±1.40) had the highest acceptability score. The RUTF formulated had nutrient density within the standard recommended for RUTF formulations. The results of this study reveal that all the samples investigated contain a high level of protein and are comparable with the standard. Therefore, the RUTF with this protein quality, energy and nutrient density could serve as an alternative to P-RUTF or It could be alternative food for an infant in place of commercially produced RUTF which is cost-effective.

Keywords: RUTF, nutrients and organoleptic properties

Introduction

Food and Nutrition insecurity and nutritionally related diseases are among the leading challenges facing the world, especially in developing and underdeveloped countries. Poor access to adequate health facilities, food shortage and the prevalence of nutritionally related diseases have taken Centre stage among the global challenges, especially in most developing and underdeveloped countries in Africa, Asia and Southern America (WHO, 2012).

Undernourishment is most usually due to not having enough high-quality food available to eat, often this is related to high food prices and poverty (United Nations Children's Fund, 2010). Lack of breastfeeding can contribute and other several infectious diseases such as; pneumonia, malaria, measles, and gastroenteritis which increase the requirements of nutrients. There are two major types of nutrition; dietary deficiencies and protein-energy malnutrition.

Protein-energy malnutrition has two severe forms; Kwashiorkor (a lack of just protein) and marasmus (a lack of protein and calories). Common micronutrient deficiencies include lack of iron, iodine, vitamin A (Young, 2012), vitamin B2, etc. Due to the body's increased need during pregnancy, deficiencies may become more common in pregnant women. In some developed and developing countries. Overnutrition in the form of obesity is beginning to present in the same communities as undernutrition.

Anorexia nervosa and Bariatric surgery are other causes of malnutrition.

The efforts to improve nutrition are part of the major effective forms of development aid. Exclusive breastfeeding can reduce the rates of malnutrition, infant morbidity, and mortality in children, and the efforts to promote the practice increase rate of breastfeeding (Bhutta *et al.*, 2013). In young children, giving food (along with breast milk) between 6 months and 2 years of age improves the outcomes. There is sufficient evidence supporting the supplementation of several micronutrients to pregnant women and among children in the developing world (Bhutta *et al.*, 2013). Management of severe acute malnutrition (SAM) within the individual's home with ready-to-use of therapeutic foods (RUTF) is likely much of the time (Bhutta, *et al.*, 2013).

For those with severe acute malnutrition complicated by other health issues, treatment in hospital settings is recommended, which usually involves managing body temperature and low blood sugar, gradual feeding and addressing dehydration (Bhutta, *et al.*, 2013). Routine antibiotics are often recommended because of the high risk of infection encountered.

Ready to use therapeutic foods are fortified, high-energy, ready-to-eat foods suitable for the treatment of children (and some other vulnerable groups) with severe acute malnutrition. At least, half of the protein food should come

from milk and/or milk products which should be crushable or soft, and easy for children to consume without any preparation.

Children; zero to five years old have a greater need for food, due to both greater energy and nutritional requirements for growth and development and due to developing immune systems. The nutrient's lack has a negative influence on all body functions, causing serious pathological conditions, such as edema and death (Vijay, 2018).

The 1000 days of the child's life between a woman's pregnancy and her child's second birthday after a brief but critical window of opportunity to shape a child's development. It is a time of both tremendous potential and enormous vulnerability. How well or how poorly a child fares during his first 1000 days can mean the difference between a thriving future and one characterized by struggle. They are the days when a child's brain is growing and lifelong health's are built.

Poor nutrition in the first 1000 days of life can cause irreversible damage to a child growing brain.

It can also set the stage for later obesity, diabetes and other chronic diseases which lead to lifetime health problems.

Several nutrients play important role in building the brain during pregnancy. These include iron, protein, copper, folate, zinc, iodine etc (National Institute of health, 2011)^[4].

Sources of materials

Materials used for this study include finger millet, soya beans, groundnut, sesame, milk, vegetable oil, and micro-minerals blends were purchased from Bakin – dogo market, Kaduna, Kaduna state and identified at the herbarium unit of the Department of Biological Sciences, Prince Abubakar Audu University, Anyigba, Kogi State.

Chemicals

All chemicals and reagents were of analytical grade and were purchase from a well-known and reputable chemical company and stored at the departmental laboratory.

Experimental Design

This involved the formulation and analysis of different cereals and legume-based ready to use therapeutic foods (RUTF) using staple foodstuff readily available in Kaduna State. This was to allow for the use of a wide range of foodstuff available to prepare diets inexpensively, and nutritious enough to meet the nutritional requirements of infants and children with malnutrition.

The foodstuffs to be used include sesame, groundnut, and finger millet were the main ingredient for the formulation.

Proximate analysis

The sample would be analyzed for moisture, ash, crude protein, fat, fibre and available carbohydrate according to the method recommended by the Association of Official Analytical Chemists (AOAC, 2000).

Determination of Mineral Analysis

Determination of Cations was carried out using A.A.S. All atomic absorption spectrophotometric measurements were

carried out with a Hitachi 180-80 spectrophotometer which is equipped with a data processing unit and a strip chart automatic recorder. This model of the atomic absorption spectrophotometer (AAS) has provisions for flame and flameless procedures of elemental concentration determinations. The flame technique was used for the determination of Na, Mg, Zn, Ca and Fe which were the cations of interest. The flameless method can be used for cations that are usually found in very low concentrations in biological fluids e.g Cd, Pb, Cu and Co.

In the two techniques, the flame and the graphite atomizer are subjected to a strong magnetic field during the atomization of the element of interest. This produces a Zeeman effect on the atomic vapour of the element. The energy emitted from a hollow cathode lamp is thus split into two arrays-one parallel (P//) and the other perpendicular (P[^]) to the magnetic field. The two beams are affected by the light scattering and broadband molecular absorption while the beam parallel is affected additionally by sample absorption. Electronic subtraction of P[^] from P// gives the true absorption of the sample.

A more detailed treatment of the principles of automatic absorption spectroscopy is given by Price (1972), Whiteside (1979), Wilson *et al.* (1995) and Williams *et al.*, (1979).

Determination of Anions was done by the ion Chromatographic Analyzer (Model IC 100-25), is a product of Yokogawa equipped with conductivity and a U.V detector. This equipment has a dual column system comprising a suppressor and a separator column (SAX-1, YEW, 250 x 4.6mm in diameter), which uses a strong base anion exchange resin and a concentrator (SAX -2, 100x 4.6mm in diameter).

Sensory Evaluation

Acceptability of the products was carried out by 20 semi-trained panellists (ANA, 2007). The panellists were selected among nursing mothers. A 9-point hedonic scale was used for sensory evaluation. All the above food products were present in small plates labelled with three-digit random codes. Panellists were provided with drinking water to rinse their mouths between samples. The samples were presented in random order and panellists were asked to rate the assessment of colour, taste, flavour, texture and overall acceptability on a 9-point hedonic scale (1 = dislike extremely, 2 = dislike moderately, 3 = dislike slightly, 4 = neither like nor a dislike, 5 = like slightly, 6 = like moderately, 7 = like extremely). A score of 5 or below was considered a limit of acceptability for all sensory attributes tested. Sensory evaluation was carried out according to Indrani, *et al.*, (2001).

Statistical Analysis

Results were presented as mean \pm standard deviation except if stated otherwise. The data were analyzed by ANOVA (for processing methods). Differences between means were separated by DMRT. The result with $P < 0.05$ was considered significant.

Table 1: Proximate composition of the formulated RUFT samples (per 100ml)

Samples	%Moisture	%Fat	%Ash	%Protein	%Crude Fiber	% Carbohydrate	Calorine value
PNS	2.0±0.0	20.75±0.4	2.0±0.0	14.45±0.1	7.55±0.1	53.25±0.35	457.55
PNSY	3.0±0.0	13.0±0.0	5.0±0.0	17.85±0.1	8.0±0.0	53.15±0.1	401
F75	7.0±0.0	8.05±0.1	14.0±0.0	5.2±0.14	2.0±0.0	63.75±0.21	348.25
F75C	16.05±0.1	0.21±0.01	3.0±0.0	2.65±0.1	0.0±0.0	78.09±0.2	324.85
PNSC	16.0±0.0	20.0±0.0	20.0±0.0	7.75±0.1	2.55±0.1	69.7±0.14	489.8
F100C	16.0±0.0	1.0±0.0	3.0±0.0	3.45±0.1	0.0±0.0	76.55±0.1	329
F100	11.0±0.0	13.0±0.0	12.0±0.0	9.45±0.1	0.0±0.0	54.55±0.1	373

PNS = Plumpy nut sesame sample, PNSY = Plumpy nut soybean sample, F75 = with finger millet base
 F75C = Control F75, F100 = Formulated F100, PNC = Control Plumpy nut, F100C = Control F100

Table 2: Mineral composition of the formulated RUFT samples (per 100ml)

Samples	Calcium (mg)	Magnesium (mg)	Potassium (mg)	Phosphorus (mg)	Manganese (mg)	Sodium (mg)	Iron (mg)	Zinc (mg)	Copper (mg)	Selenium (mcg)	Iodine (mcg)
PNS	101.0±0.1	20.1±0.01	258.0±0.35	77.0±0.3	19±0.0	51.5±0.33	0.01±0.0	2.10±0.01	0.23±0.0	5.1±0.01	19.0±0.0
PNSY	110.0±0.0	24.1±0.02	276.0±0.01	91.0±0.13	22.05±0.01	53.1±0.06	0.04±0.0	2.99±0.02	0.39±0.0	6.3±0.02	24.0±0.0
F75	74.0±0.01	8.2±0.02	122.0±0.01	72.0±0.01	9.2±0.0	16.0±0.01	0.033±0.0	1.8±0.01	0.24±0.0	5.1±0.01	16.7±0.03
F75C	80.0±0.1	9.0±0.02	150.0±0.01	95.0±0.0	10.5±0.03	17±0.0	0.05±0.0	3.0±0.01	0.26±0.01	6.1±0.01	22.5±0.04
PNSC	114.0±0.02	27.0±0.01	271.0±0.02	93.0±0.01	29±0.01	53±0.0	0.06±0.0	3.1±0.0	0.4±0.0	7.0±0.00	22.0±0.0
F100C	100.0±0.02	19.0±0.01	250.0±0.22	75.0±0.22	21±0.0	50±0.01	0.05±0.0	2.5±0.0	0.3±0.0	5.7±0.02	20.0±0.0
F100	111.0±0.01	22.0±0.01	268.0±0.01	88±0.025	25±0.0	51±0.0	0.04±0.0	2.91±0.0	0.36±0.0	6.2±0.02	18.0±0.0

PNS = Plumpy nut sesame sample, PNSY = Plumpy nut soybean sample, F75 = with finger millet base
 F75C = Control F75, F100 = Formulated F100, PNC = Control Plumpy nut, F100C = Control F100

Table 3: Sensory properties of the formulated RUFT samples (per 100ml)

Sample	Appearance	Taste	Texture	Overall acceptability
PNS	7.60±0.70 ^b	7.60±0.52 ^b	7.10±1.52 ^a	7.80±1.23 ^b
PNSY	7.10±1.60 ^a	7.40±1.35 ^a	7.20±1.35 ^a	7.40±1.07 ^a
F75	7.90±1.20 ^b	7.40±1.43 ^a	8.50±0.71 ^c	7.50±1.27 ^b
F75C	7.10±1.52 ^a	7.40±1.26 ^a	7.20±1.31 ^a	7.80±1.40 ^b
PNC	7.30±1.57 ^a	7.70±0.95 ^b	7.50±1.77 ^b	6.90±2.13 ^a
F100C	7.70±1.42 ^b	7.60±0.84 ^b	7.80±1.47 ^b	6.30±1.70 ^a
F100	8.00±1.05 ^b	7.80±1.23 ^b	7.60±1.43 ^b	7.30±0.95 ^a

Means of samples in the same column with the same superscript(s) are not significant (p.0.05) different
 PNS = Plumpy nut sesame sample, PNSY = Plumpy nut soybean sample, F75 = with finger millet base
 F75C = Control F75, F100 = Formulated F100, PNC = Control Plumpy nut, F100C = Control F100

Result and discussion

The basic requirement to reduce child malnutrition is the availability of nutritious food, improved hygiene, health services and adequate care. Poverty and food insecurity seriously affect the accessibility to nutritious diets, including high protein quality, adequate micronutrient content and bioavailability, low anti-nutrient content, and high nutrient density. These conditions predispose children to severe acute malnutrition. Guidelines provided by WHO to manage children with severe acute malnutrition without any medical complication (e.g., anorexia, diarrhea etc.), suggested the use of ready-to-use therapeutic food (RUFT). RUTF can be safely and easily produced in small or large quantities. The local availability of the necessary ingredients limits their use in some settings, and further investigation into alternative ingredients is needed to overcome the limitation (Manary, 2006) [1].

Table1 shows the proximate composition of the formulated RUTF samples, the moisture content of the samples shows that F75C (16.05±0.0) had the highest moisture content observed in this study while the least (2.0±0.0) moisture content was found in PNS. The fat content of the samples ranges between 1.0±0.0-20.75±0.4, F100C had the least fat content while PNS had the highest fat content. The highest ash value was observed in PNC (20±0.0) and the highest

percentage protein (17.85±0.1) was found in PNSY. Furthermore, F75C, F100C and F100 had no crude fibre while the highest crude fibre was found in PNSY (8.0±0.0). The percentage carbohydrate content of the samples ranges between 53.15-78.09±0.2, with F75C having the highest carbohydrate content.

The caloric values of the formulated and control samples in this study were found to be significantly lower than the minimum caloric requirement (520 – 550 kcal/100g) of RUTF formulation (Vijay and Bhawesh, 2014) [8]. This is attributed to lower calorie contribution from fats, which contribute only about 40% at maximum to the total calorie below the recommended requirement of 45% - 60% (UNICEF, 2010). Unlike the commercially produced samples that are F100C (329Kcal), and F75C (324.85Kcal), the locally formulated samples tend to have higher calories compared to the commercially produced RUTF, similar to a supplementary food having a caloric value of 380Kcal and 15g protein per 100g reported by Saskia and Martin, 2008. The commercial samples also have lower protein and fat content compared to the locally-produced ones, this is contrary to the report of Vijay and Bhawesh, (2014) [8], reporting significantly high amounts of protein which was above the recommended levels of 10 – 12% of total energy. This might be responsible for the low calorie observed. The locally formulated samples have higher nutrient content due

to the ingredient used in their formulation as millet which is best attributed to high carbohydrate content, while soybean and sesame are good sources of fat and protein (Martinchik and Vopr, 2011).

Table 2 shows the mineral composition of the formulated RUTF samples (per 100ml) it reveals that PNSC had the highest calcium ($114\pm 0.02\text{mg}$), magnesium ($27\pm 0.01\text{mg}$), iron ($0.06\pm 0.0\text{mg}$) zinc ($3.1\pm 0.0\text{mg}$) copper ($0.4\pm 0.0\text{mg}$) and selenium ($7.0\pm 0.0\text{mg}$). Compared to the formulated samples (PNSY and PNS). In this research, the control sample exhibit higher value of mineral elements exception of F100 exception of iron and Iodine.

Minerals are substances found in food that are required by the body for normal growth and function. The mineral contents of the formulated samples appeared to be within the recommended value (Caron, 2012; UNICEF, 2010). This was due to the micronutrient content of plant-based diets (Solomon, 2005) [5], and the type of mineral/vitamin premix used in the formulation which contains appreciable amounts of the micronutrients and is similar to Nutriset Mineral/vitamin premix recommended for RUTF formulations. Sufficient micronutrients in the diet affect the health and development of children and result in potentially life-threatening deficiency diseases such as anemia and vitamin A deficiency (FAO, 1990). This feature makes the samples suitable for the management of SAM.

The result of the sensory evaluation carried out on the formulated RUTF samples presented in table 3 shows that the samples were significantly ($p < 0.05$) different in all the parameters evaluated. F100 had highest score for appearance ($8.00\pm 1.05\text{b}$) and taste ($7.80\pm 1.23\text{b}$) compared to all other samples. For texture, F75 (8.50 ± 0.71) is significantly ($p < 0.05$) different from all other samples and had the highest sensory score. The overall acceptability score shows that PNS (7.80 ± 1.23) and F75C (7.80 ± 1.40) had the highest acceptability score.

The recent uses of affective analysis or hedonic tests in consumer preferences have been established to be a highly efficient tool in product development and production that will sell in substantial quantities or permit higher pricing (Meilgaard *et al.*, 2006).

The result of the sensory evaluation reveals that appearance ($8.00\pm 1.05\text{b}$) and taste ($7.80\pm 1.23\text{b}$) had more sensory scores compared to all other samples. For texture, F75 (8.50 ± 0.71) is significantly ($p < 0.05$) different from all other samples and had the highest sensory score. The overall acceptability score shows that PNS (7.80 ± 1.23) and F75C (7.80 ± 1.40) had the highest acceptability score. Although all samples had a good ranking in all parameters evaluated, however, locally formulated samples had higher sensory scores compared to the commercially produced samples. The varied choice of attributes resulting in the highest and least preferred product might be a result of the diverse cultural backgrounds, experiences, attitudes and habits of respondents (Svensson, 2012). A study showed that different cultures affected the acceptance of flavours and tastes of healthy juices (Koppel *et al.*, 2014).

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