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Production, Formulation, Proximate Composition and Sensorial Attributes of Complementary Food from Pearl Millet (Pennisetum glaucum), African Yam Beam (Sphenostylis stenocarpa Hoechst ex. A. Rich) and Tiger Nut (Cyperus esculentus)

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Abstract

Feeding infants with foods that are grossly inadequate in protein and micronutrients as practiced in developing countries can lead to malnutrition. After two years of the life of a child, it may be impossible to reverse stunting that may have occurred earlier in life. Protein-energy malnutrition is one of the major threats to child development globally. Complementary foods are therefore introduced to infants from 6 months to 24 months. This study examined the possibility of pearl millet, African yam bean and tiger nut flours to serve as low cost, energy dense complementary foods. The pearl millet, African yam bean and tiger nuts were prepared into flours using standard procedures. Ten blends of these flours were formulated at specified ratios. The formulated flour blends were analyzed for proximate compositions. The blends were then made into gruels according standard method and were subjected to sensory evaluation. Analysis of variance (ANOVA) was used to establish if there were significant differences in the analytical data obtained. The results showed that the protein contents ranged from 12.79 to 14.63%, energy contents ranged between 616.60 Kcal and 696.90 Kcal and the moisture contents ranged from 4.60 to 5.29%. For the sensory attributes the sample with 70% pearl millet, 20% African yam bean and 10% tiger nut was rated highest compared with the control sample (Nutrend) in terms of the overall acceptability. It can therefore be concluded that this sample had better nutritional quality based on the overall ranking in terms of protein, energy and sensory attributes.

Keywords: Millet, African yam bean, tiger-nut, complementary, food, proximate, composition, sensory, attributes.

Introduction

Malnutrition is often most associated with under-nutrition; in which a person is not receiving enough energy, protein and micronutrient. Malnutrition is a condition which occurs due to the consumption of diets which will not produce healthy amounts of one or more nutrients. If undernourishment occurs before two years of age, it can result in permanent impairments of physical and mental development [1]. Malnutrition is often defined differently in various countries of the world and by different organizations; hence, the exact prevalence of malnutrition varies according to the population studied and the methods used to identify malnutrition. Malnutrition is associated with serious consequences that include growth stunting, increased complications during hospitalization, increased costs of care, loss of physical and mental function, lower life quality and higher risk of death. Malnutrition continues to be a public health challenge which has broad impact on health outcomes, death rates and financial costs of health care around the globe. It is generally agreed that persons in low-, middle- and high-income countries are all vulnerable to grave tolls of malnutrition. Malnutrition broadly speaking covers both under- and over-nutrition, as well as specific nutrient deficiencies [2]. Malnutrition in children is a major nutritional challenge in developing countries that leads to high morbidity and mortality, retardation in physical growth and mental development, working capacity and increased risk of adult disease [3]. Malnutrition is a major drain on the prospects for development of the affected countries in that malnourished children requires more intense care from their parents and are less physically and intellectually productive like adults [4].

Every year in Nigeria, over two and a half million children under the age of five are affected by severe acute malnutrition (SAM) or extremely wasting (weight-for-height), and it is a health condition when left unattended would lead to nearly half a million deaths [5]. Despite its progress economically, educationally and technologically, India has failed to fight malnutrition which adversely affects its socio-economic progress. Over one-third of the global malnourished children are located in India. Half of the global malnourished children lives in three countries; India, Pakistan and Bangladesh [6]. India ranked 100 out of 119 countries according to the Global Hunger Index of 2017. The prevalence of malnourished children in India is almost double that of Sub-Saharan Africa and it affects the mortality rate, productivity and economic growth. Every year, almost half of children in India are malnourished and about one million die before attaining one month of age. About 43% of children under the age of five in India are underweight while 48% are stunted due to severe malnutrition [7].

The entire global population is in need of alternative food sources whether from the perspective of developing or developed nations. Persons living in developing countries are often found to be dangerously malnourished [8]. The growth of infants and children in their first two years is so rapid that only breast feeding will not be sufficient for the infant's nutritional needs [9]. Good nutrition within the first 1000 days has been reported to be very essential for healthy growth and development of children for their full potential [10]. After six months of age infants requires complementary foods especially that of adequate nutrient density, consistency, and good texture; they need to be fed regularly more often [11]. The materials utilized in food blends for complementary feeding are normally food commodities composed of high levels of one or more essential nutrients normally available at comparatively lower cost and underutilized [12]. Traditional complementary foods often fail to meet the nutritional need of infant due to poor nutritive quality [9]. In Nigeria, millet is the third most important and readily available cereal, ranking behind maize and the fourth most important cereal crop in the world. It is relatively rich in some minerals and B-vitamins particularly thiamin [13]. Tiger nut is a well known food plant which is very common in West Africa and highly underutilized. The nuts are valued for their starch contents; dietary fiber and carbohydrate [14].They also contain essential minerals as well as B-vitamins. African yam bean is one of the underutilized tropical legume with high nutritional value. Its protein content is reported to range from about 20.20 to 21.20% [15]. Its lysine and methionine levels in the protein are about equal or better than those of soybean. Moreover, it has been reported to also have high crude fiber content [16]. Judging from the nutritional challenges associated with traditional complementary foods, this present study aims at formulating low cost and nutritionally adequate complementary foods from pearl millet, African yam bean and tiger nut.

Materials and Methods

Materials

African yam beans were obtained from Genetic Resources Centre, International Institute for Tropical Agriculture (IITA), Ibadan. While pearl millets and tiger nuts were purchased from a local dealer at Bodija market, Ibadan.

Methods

Production of millet flour

The malted millet flour was prepared according to the method of [17]. One kilogramme (1kg) of millet grains were sorted to remove dirt and other extraneous materials. The grains were thoroughly cleaned and steeped in 3.5 litres of potable water in a plastic bowl at room temperature (29±2°C) for 24 h with a change of water at every 8 h to prevent fermentation. The steeped grains were drained, rinsed and immersed in 2% sodium hypochlorite solution for 10min to sterilize the grains. The grains were rinsed for five consecutive times with excess water and cast on a damped jute bag, covered with a polyethylene bag and left for 24 h to fasten sprouting. The grains were carefully spread on the jute bag and allowed to germinate in the germinating chamber at ambient temperature (29±2°C) and relative humidity of 95% for 120 h. During this period, the grains were sprinkled with water at intervals of 10 h to facilitate germination. Non- germinated grains were handpicked and discarded. The germinated grains were spread on the trays and dried in a cabinet dryer (Model HR 6200, UK) at 60°C for 20 h with occasional stirring of the grains at intervals of 30 min to ensure uniform drying. The dried malted grains were cleaned, rubbed in –between palms and winnowed to remove the roots and the sprouts. The millet malts were milled in an attrition mill (Franky DM-WP 200 Electric Cereal mill). The flours were packaged in high density polyethylene (0.08mm thick) and stored in a deep freezer (-10^{0}C)

Production of tiger nut flour

The method described by Akande and Oladokun [18] was used to prepare tiger nut flour. Dry tiger nut were sorted to remove extraneous materials and washed with portable water. The clean nuts were dried at 105^{0}C for 3hrs.The dried nuts were milled, sieved and packaged in high density polyethylene and stored in deep freezer.

Production of African yam beans flour

The method of Eka [19] was used for the preparation of African yam bean flour. The seeds were handpicked, carefully sorted and winnowed to remove immature and unwholesome seeds and other extraneous materials. The cleaned seeds were steeped in warm water (45^{0}C; 10hrs) in a thermostatic water bath. The seeds were manually dehulled and washed and then decanted to remove the seed coats. The seeds were then dried in a cabinet drier (60^{0}C; 8hrs) and milled in an attrition mill through a 210µm sieve and packaged in a high density polyethylene and stored in a deep freezer.

Formulation of complementary food blends

Ten (10) complementary food blends were formulated in the specified ratio to make 100% as shown in Table 1.0

Table 1: Formulation of complementary food blends (%)

S/N	Sample code	PMF	AYBF	TNF
1	ITS	70	20	10
2	OTO	75	10	15
3	BSA	80	10	10
4	OAB	70	15	15
5	OAK	71.67	11.67	16.67
6	BUI	70	10	20
7	CUO	73.33	13.33	13.33
8	BEL	76.67	11.67	11.67
9	LAC	71.67	16.67	11.67
10	OPE	75	15	10

PMF = Pearl millet flour, AYBF = African yam bean flour, TNF = Tiger nut flour

Analysis

Proximate composition

The official methods of the Association of Official Analytical Chemists [20] were used to determine the proximate composition of all the complementary food blends. All analysis were carried out in triplicates. The carbohydrate contents was estimated by difference as

% CHO = 100% - (moisture + ash + fat + protein +fiber)

Energy content

The energy contents of the complementary food blends were determined using the Atwater general factor system as follows: Energy values for protein, fat and carbohydrates are 16.74, 37.66 and 16.74 KJ/g respectively.

Sensory evaluation of the complementary foods

The method of Bello et al. [21] was used to prepare the gruels. The complementary flour blends and the control sample (Nutrend) were prepared into gruel by reconstituting portions of the blends with boiling water. In preparing the gruels, 60g each of all samples including the control sample was suspended in 100ml portable water in a small stainless bowl. Then 60ml of boiling water was added to each of the suspended samples to produce hot gruels. Sensorial attributes of the coded gruels were evaluated for different sensory characteristics by a panel of twenty five (25) nursing mothers attending the Ajibode Community Health Centre, Ibadan.The panelists were asked to compare the color, flavor, texture, aroma and overall acceptability of the complementary foods on a nine point hedonic scale where 9 = like extremely and 1 = dislike extremely.

Statistical analysis

All data obtained were statistically analyzed and subjected to one-way Analysis of Variance (ANOVA) using Statistical Packages for Social Sciences (SPSS) version 20, 2013 software. The means were then separated using Duncan's Multiple Range Test (DMRT) and LSD at ($p \leq 0.05$).

Results and Discussion

Proximate composition

The results of the proximate composition of the complementary food blends are presented in Table 2.0. There were significant differences ($p \leq 0.05$) in moisture, ash, protein, fat, crude fiber and carbohydrate contents of the samples. Moisture content ranged between 4.60% and 5.30%. This range is far lower than 15.5% maximum specified for wheat flour and lower than 10% suitable for suppressing the growth of microorganisms favorable for storability. According to Iwe et al. [22] flours and flour products with less than 14% are highly stable from moisture-dependent deterioration during storage and will be more resistant to microbial proliferation. In a research study a range of 4.10% to 7.06% was reported by Mengistu et al. [9] for complementary foods from fermented cereals and soybean. Moisture range of 3.93% and 5.03% was reported by Bello et al. [21], 3.32% and 6.74% reported by Adesanmi et al. [23], 8.15% and 9.58% reported by Olaleye et al. [24], 2.50% and 10.48% reported by Akinbode and Origbemisoye [25] and a range of 9.23% to 9.73% reported by Olaniran et al. [26] for complementary flour blends from various indigenous cereals and legumes.

There were significant differences ($p \leq 0.05$) in the ash contents of all samples and ranged between 0.51 to 4.88% with sample OAK having the lowest value and sample OPE having the highest value. This range is similar to the range 0.55 to 3.38 reported by [23] for complementary diet from defatted almond seed, yellow maize and quality protein maize flours. Olaleye [24] reported a range of 1.86% to 2.52% for weaning foods from sorghum, mung bean and orange fleshed sweet potato blends. Ash content of a food is a measure of the amount of mineral composition present in the food. They are necessary in combating infections and for other metabolic activities in infants and children.

The protein contents ranged from 12.79% to 14.63%. Significant differences exist in the protein contents of all samples with ITS having the highest value of 14.63% and OTO having the lowest value of 12.79%. The range is similar to that of 9.00% - 14.57% reported by Mengistu et al. [9] and the range 4.47% - 15.44% reported by Akinbode and Origbemisoye [25]. The range reported in this study is far higher than the range 4.39% - 14.83% reported by Bello et al. [21]. Olaleye [24] reported higher range between 14.00% and 18.04% for sorghum, mung beans and orange fleshed sweet potato blend weaning foods while Olapade *et al*. [27] reported a range 13.60 – 22.70% for plantain-cowpea based complementary foods.

Table 2: Proximate composition of complementary food blends of millet, African yam bean and tiger nut flours.

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)	Energy (Kcal)
ITS	5.01 ± 0.02^{d}	1.34 ± 0.08^{fg}	14.63 ± 0.00^{a}	5.07 ± 0.26^{cd}	0.95 ± 0.72^{b}	72.99 ± 0.22^{a}	657.70^{a}
OTO	4.62 ± 0.0	1.66 ± 0.08	12.79 ± 0.12	6.18 ± 0.07^{a}	0.81 ± 0.12	73.93 ± 0.01	683.4

	7^{f}	^{ef}	^{h}	^{b}	^{bc}	^{a}	4^{a}
BSA	5.21±0.02^{b}	2.05±0.11^{de}	13.49±0.00^{f}	4.94±0.09^{d}	0.59±0.06^{d}	73.71±0.10^{a}	645.77^{a}
OAB	5.29±0.01^{a}	1.88±0.18^{e}	13.75±0.00^{e}	5.79±0.27^{abc}	0.65±0.06^{cd}	72.62±0.15^{a}	663.89^{a}
OAK	5.09±0.01^{c}	0.51±0.14^{h}	13.79±0.06^{de}	2.86±0.28^{e}	0.60±0.11^{d}	77.14±0.18^{a}	639.88^{a}
BUI	4.75±0.04^{e}	1.06±0.07^{g}	13.14±0.12^{g}	6.56±0.16^{a}	1.02±0.11^{ab}	73.47±0.04^{a}	696.90^{a}
CUO	4.60±0.05^{f}	3.98±0.57^{b}	13.86±0.03^{de}	6.31±0.59^{a}	1.19±0.76^{a}	70.04±1.16^{a}	642.13^{a}
BEL	4.79±0.01^{e}	2.81±0.14^{cd}	13.93±0.00^{d}	5.39±0.80^{cd}	0.83±0.09^{bc}	72.25±0.55^{a}	645.65^{a}
LAC	5.11±0.01^{c}	2.45±0.11^{c}	14.32±0.06^{b}	5.35±0.17^{cd}	0.99±0.08^{ab}	71.81±0.01^{a}	643.30^{a}
OPE	4.65±0.01^{f}	4.88±0.36^{a}	14.15±0.06^{c}	5.45±0.15^{bcd}	0.71±0.01^{cd}	70.16±0.27^{a}	616.60^{a}

Values within a column with different superscripts are significantly different ($p \leq 0.05$)

There were significant differences (p $p \leq 0.05$) in the crude fat contents of the complementary food blends where sample BSA has the lowest value of 4.94% and sample BUI having the highest value of 6.57%. This indicates that fat contents of the blends increased with increased addition of tiger nut flour. The fat contents observed in this study are within the range (4.63 – 7.71%) reported by Awolu *et al* [28] for rice, soybean, tiger nut and millet composite flour. The range reported in this study is far higher than the range (1.26 – 2.81%) reported by Olaniran *et al* [26] for cassava-cowpea-orange fleshed sweet potato blends and the range (1.55 – 2.76%) reported by Olaleye *et al* [24] for sorghum, mung beans and orange fleshed sweet potato blends. Adesanmi *et al* [23] reported a range of 4.49 – 9.82% for defatted almond seed, yellow maize and quality protein maize flour blends; while Akinbode and Origbemisoye [25] reported a range of 1.34 – 9.00% for complementary food blends from orange fleshed sweet potato, cowpea and groundnut flours. In this study only samples OTO, BUI and CUO are in agreement with the recommended fat content of not less than 6% for complementary diets [29] and should not be more than 10% [30]. The fat content of food contributes immensely to the energy value of the food as well as providing the essential fatty acids for optimal neurological, immunological and functional developments in infants and children [31].

The crude fiber content of the complementary food blends ranged from 0.60 to 1.20% with sample BSA having the lowest value and sample CUO having the highest value. Significant differences exist ($p \leq 0.05$) among the samples. Crude fiber is a measure of the quantity of indigestible cellulose, pentosans, lignin and other food components. Low fiber contents of the complementary food blends in this study are of importance since it helps in encouraging good appetite to eat more food to get satisfaction in other to meet their daily energy requirement [32]. The low crude fiber contents obtained in this study is also nutritionally appreciated as it traps less protein and carbohydrates [33]. Foods with high fiber contents tends to cause indigestion in infants, therefore samples with low fiber contents as obtained in this experiment are good potentials for complementary food production. The range obtained in this study is closely in agreement with the range 0.62 – 0.97% reported by Adesanmi *et al* [23] for complementary diet made from deffated almond seed, yellow maize and quality protein maize flours. Akinbode and Origbemisoye [25] reported higher range (2.63 – 7.00%) for orange fleshed-cowpea-groundnut complementary food blends.

The carbohydrate contents of the complementary food blends in this study ranged from 70.04 to 73.94%. The carbohydrate content was highest in sample OTO and lowest in sample CUO. There were no significant differences ($p \leq 0.05$) among the samples. Carbohydrates are the most important and readily available sources of metabolizable energy. They are known to be important in brain, heart, nervous, digestive function and immune system [34]. The range obtained in this study is far higher than that (51.68 – 61.07%) reported by Olaniran *et al* [26] for complementary food blends made from cassava-cowpea-orange fleshed sweet potato flours. Akinbode and Origbemisoye [25] reported a range 61.98 – 79.78% for complementary food blends made from orange fleshed sweet potato-cowpea- groundnut flours.

The energy values obtained in this study ranged from 616.60 to 696.90 Kcal/ 100g. There were no significant differences ($p \leq 0.05$) among all samples. The minimum desirable amount of energy expected from complementary foods was suggested to be 370 Kcal/ 100g [34] and 344 Kcal/ 100g [35]. Thus the energy levels obtained in this study could sufficiently meet the energy requirement of growing infants. The energy contents obtained in this study is far higher than the range 377.70 – 388.00 Kcal/ 100g reported by Bello *et al* [21] for sorghum-African yam bean-soybean complementary food blends and the range 349.12 – 383.61 Kcal/ 100g reported by Akinbode and Origbemisoye [25] for orange fleshed sweet potato-cowpea-groundnut complementary food blends.

Sensory properties of complementary foods made from blends

The results of the sensory characteristics of the formulated complementary foods and the control (Nutrend) for color, taste, aroma, consistency, mouth feel and overall acceptability are presented in Table 3.0. There were significant differences ($p \leq 0.05$) between the control and all the samples. But significant difference did not exist between the control sample and samples ITS in terms of color, aroma, taste, consistency texture and overall acceptability. There was also no significant difference between the control sample and sample OTO in terms of aroma, texture and overall acceptability. There were no significant differences between samples BEL, LAC and OPE and the control sample in terms of consistency, texture and overall acceptability. Significant differences exist between samples ITS and all other samples in all the parameters evaluated. There were no significant differences between the control sample and all other samples in terms of texture and overall acceptability. Texture is generally described as one of the most important quality characteristics that affects consumer acceptance of manufactured food products.

The color of the control sample was most preferred by the panelists, followed by sample BSA while sample LAC was least preferred. The preference for the control sample in terms of color may be attributed to its appealing creamy color.

Significant differences ($p \leq 0.05$) were observed in the taste between the control sample and all other test samples with the exception of sample ITS. Tasters preferred the taste of the control sample followed by samples BEL, ITS, and lastly by sample BUI.

Table 3: Sensory properties of complementary foods made from millet, African yam bean and tiger nut flours.

Sample	Color	Aroma	Taste	Consistency	Texture	Overall acceptability
Nutrend	8.45 ± 0.02^{d}	7.21 ± 0.08^{fg}	8.63 ± 0.00^{a}	7.07 ± 0.26^{cd}	8.95 ± 0.72^{b}	8.99 ± 0.22^{a}
ITS	7.32 ± 0.02^{d}	6.21 ± 0.08^{fg}	6.63 ± 0.00^{a}	6.97 ± 0.26^{cd}	7.95 ± 0.72^{b}	6.99 ± 0.22^{a}
OTO	6.12 ± 0.07^{f}	6.31 ± 0.08^{ef}	5.79 ± 0.12^{h}	6.18 ± 0.12^{ab}	6.81 ± 0.12^{bc}	6.93 ± 0.01^{a}
BSA	7.45 ± 0.02^{d}	6.65 ± 0.11^{fg}	6.49 ± 0.00^{f}	6.94 ± 0.09^{d}	6.59 ± 0.06^{d}	5.71 ± 0.10^{a}
OAB	6.12 ± 0.01^{a}	5.74 ± 0.18^{e}	5.75 ± 0.00^{e}	5.79 ± 0.27^{abc}	5.65 ± 0.06^{cd}	6.62 ± 0.15^{a}
OAK	5.86 ± 0.01^{c}	6.21 ± 0.14^{h}	5.79 ± 0.06^{de}	4.86 ± 0.28^{e}	4.60 ± 0.11^{d}	5.14 ± 0.18^{a}
BUI	5.45 ± 0.04^{e}	6.54 ± 0.07^{g}	5.14 ± 0.12^{g}	6.56 ± 0.16^{a}	5.02 ± 0.11^{ab}	5.47 ± 0.04^{a}
CUO	7.38 ± 0.05^{d}	6.37 ± 0.57^{b}	5.86 ± 0.03^{de}	6.31 ± 0.59^{a}	5.19 ± 0.76^{a}	6.04 ± 1.16^{a}
BEL	6.11 ± 0.01^{e}	5.33 ± 0.14^{cd}	6.93 ± 0.00^{d}	4.39 ± 0.80^{f}	6.83 ± 0.09^{bc}	5.25 ± 0.55^{a}
LAC	5.10 ± 0.01^{c}	5.24 ± 0.11^{c}	5.32 ± 0.06^{b}	5.35 ± 0.17^{bc}	4.99 ± 0.08^{ab}	6.81 ± 0.01^{a}
OPE	6.31 ± 0.01^{f}	5.66 ± 0.36^{a}	5.15 ± 0.06^{g}	5.45 ± 0.15^{bc}	5.71 ± 0.01^{cd}	5.16 ± 0.27^{a}

Values within a column with different superscripts are significantly different ($p\leq0.05$).

Significant differences were not observed in the ratings of the aroma of the control sample and samples ITS, OTO, BSA and BUI but significant differences exist between these samples and all other samples.

The mean scores for overall acceptability which ranged from 5.14 to 8.99 gave a general idea of the tasters total impression towards the complementary foods. It was observed that the texture, taste and color had the greatest effect on the overall acceptability of the complementary foods. It can be observed that the control sample was the most acceptable by the panelists with a mean score of 8.99 while sample OAK had the lowest overall acceptability.

Conclusion

This experiment has shown that acceptable complementary food of good nutritional quality can be produced from blend of fermented pearl millet, African yam bean and tiger nut flours. The complementary food produced from 70% millet, 20% African yam bean and 10% tiger nut flours was most preferred and acceptable in terms of all the sensory attributes evaluated. It has the highest protein content among all the samples tested. Therefore the blend could be used for infant feeding most especially in developing nations.

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