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Evaluation of Proximate, Mineral and Antinutritional Factor of Home Processed Complementary Diet from Locally Available Food Materials (Sorghum Bicolor and Sphenostylis Stenocarpa)

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Abstract: A potential weaning diet was developed from locally available least expensive food items, using local processing methods. The supplement mixtures were sorghum bicolor and fermented African yam bean. The ingredients were mixed in different ratio of 90:10, 80:20, 70:30 and 60:40 and 50:50% of sorghum bicolor and African yam bean flour respectively. The results of proximate analysis of the formulated diet showed that energy value ranges between 372-432 kcal, moisture content 6.45-9.71 g, ash content 4.25-5.81 g, fat 6.19-8.75 g, protein 10.15-23.10 g, fiber content 1.06-1.70 g and carbohydrate 55.08-70.77 g. iron 135-180 mg, zinc 4.9-5.4 mg, copper 1.91-2.1 mg, sodium 760-2360 mg, phosphorous 1134.1-9144.3 mg, magnesium 144-136 mg, calcium 480-720 mg and potassium 1580-4560 mg; while others lead and aluminum were not detected in the samples. Results also show that 80% sorghum and 20% fermented African yam bean blend could meet satisfactorily the Recommended Dietary Allowances (RDA) for children of 1 to 3 years of age and it has tolerably low antinutrients level

Key words: Chemical composition, antinutritional factor, sorghum-african yam bean flour

INTRODUCTION

Cereals provide a major food resource for man. In developing countries, sorghum and maize are the most popular cereals consumed by both adults and infants. They are eaten in large quantities and are the main sources of both major and minor nutrients. They are prepared as gruel and used in feeding infants. Due to their high viscosity on cooking, a large amount of water is used during preparation to obtain the right consistence. The high viscosity characteristic of cereal gruel is obviously responsible for the low nutrient density and this is responsible for young children inability to fulfill their energy/nutrient requirement, which eventually contributed to high rate of malnutrition among the children in the areas where cereal form the major weaning diets. Study has reported that sorghum and maize form the major complementary food for infants among the low-income families, who cannot have access to commercial infant formulas[1]. Sorghum and maize pap (ogi or *koko)* have been implicated in the aetiology of protein-energy malnutrition in children during the weaning period[2,3]. Cereal-based diets have lower nutritional value than animal-based ones. Cereals form the primary basis for most of the traditional weaning foods in West Africa.

In an attempt to improve the nutritional status of cereal based complementary diet various forms of economical protein-rich plant mixtures are used for different areas in African countries. For instance, evidences have shown that vegetable proteins, particularly soybean have been used to improve the nutrient content of sorghum and maize in the preparation of local weaning food in many parts of West African countries[4-6]. People from low-income groups seldom feed meat, eggs, or fish to their infants, because of socio-economic factors, taboos and ignorance[7-9].

The high cost of commercial foods coupled with the expensive and scarce source of animal proteins as well as the dwindling family income, has made utilization of cereal and legumes a very important source of weaning food among low-income nursing mothers[10,11]. The formulation and development of nutritious weaning foods from local and readily available raw materials has received a lot of attention in many developing countries. The widespread problem of infant malnutrition in the developing world has stimulated efforts in research, development and extension by both local and international organizations. Legumes are largely replacing milk and other sources of animal protein, which are expensive and not readily available, as suitable substitutes for high-quality protein. Over 70% of

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dietary protein in developing countries is supplied by cereals that are relatively poor sources of protein[12]. The high lysine content of legumes improves the nutritional quality of cereals by complementing their limiting amino acids, for instant, sulphur containing amino acids are limiting in legumes and relatively high in cereals, whereas lysine is limiting in cereals and high in legumes. These two amino acids are indispensable to the growth of the young child[13]. Several blends using legumes singly or in combination cereals have been evaluated[14-17].

The purpose of this study was to develop low cost food formulations, using local foods to explore the feasibility of producing the supplementary foods using household technology and an attempt was made to evaluate them nutritionally.

MATERIALS AND METHODS

Sample collection: The sorghum biocolour ((L) moench) and African yam beans (Sphenostylis Stenocarpa) were obtained from the local market in Akure, Ondo State. From the bulk collection of the seeds under study, about 10 kg of each were thoroughly rinsed with distilled water before subjecting them to the different processing methods.

Processing methods

African yam beans: The African yam beans were sorted by removing extraneous materials, broken and unhealthy seed. The cleaned seeds were boiled for 30 min and then dehulled manually. The seeds were washed thoroughly, then boiled for 2 h, after which it was then poured into strainer to remove the water. The boiled samples were wrapped thoroughly with plantain leaves and allowed to ferment at room temperature (29-32) for seven days. The fermented seeds were then sun-dried and finely ground using a laboratory hammer mill (DIETZ-7311 Dettingen-Teck, West Germany). After milling, it was sieved through a 0.4 mm mesh screen to give the finished African yam bean flour. The African yam flour was then kept in airtight container prior to chemical analysis and protein quality evaluation Fig. 1.

Sorghum bicolor: The sorghum bicolor was sorted to remove impurities. Afterwards, it was washed with clean water and soaked in water for 5 days. After soaking, it was properly washed with clean water and drained. The clean samples were then sun-dried. The dried seed were then milled and sieved through a 0.4 mm mesh screen to give sorghum bicolor flour and then kept in airtight container.

Food formulation: The sorghum bicolor and fermented African yam beans were mixed in five different ratios and designated as A, B, C, D and E. The processing flow chart and the formulation of sorghum bicolor and fermented African yam beans are shown in Fig. 1 and Table 1, respectively.

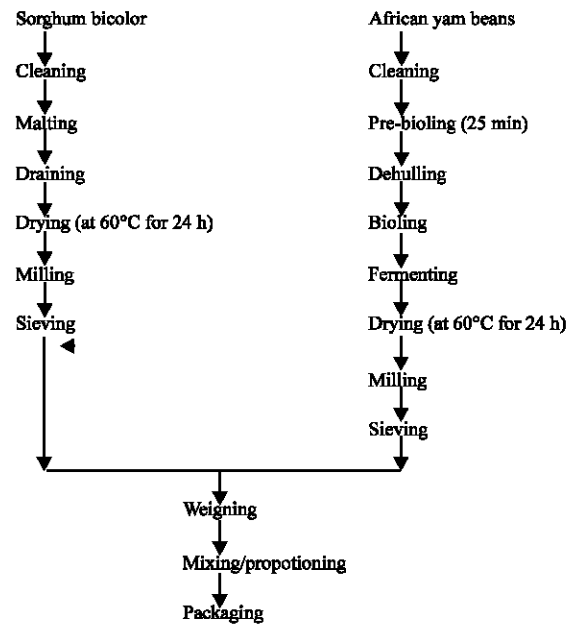

Fig. 1: Flowcharts for the preparation of formulated diet from sorghum bicolor and African yam beans

Table 1: Formulation of sorghum bicolor and African yam beans

Samples	Sorghum (%)	African yam beans (%)
A	90	10
B	80	20
C	70	30
D	60	40
E	50	50
F	-	100

Chemical analyses:

Proximate analysis: Triplicate samples of each blend were analysed for moisture, fat, protein (N×6.25), crude fiber and ash in accordance with the procedures of[18]. Total lipids were estimated by petroleum ether extraction. Carbohydrate content was estimated by difference. The gross energy was determined using a Gallenkamp Ballistic bomb calorimeter (Cam Metric Ltd. Cambridge, K). The total ash was estimated after ashing for 12 h at 550°C.

Minerals determination: The sodium and potassium contents were determined by flame photometry (Jenway Ltd. Dunmow, Essex, UK) and phosphorous by Vanado-molybdate method[18]. Calcium, magnesium zinc copper, lead aluminum and iron contents were determined after wet digestion with a mixture of nitric acid, sulphuric and hydrochloric acids, using atomic absorption on ash sample using a Buck Model 200A flame atomic absorption spectrophotometer.

ANALYSIS OF ANTINUTRITIONAL FACTORS

Phytic acid: Phytate was determined accordingly to[19]. Eight gram finely grounded samples were soaked in 200 cm^3 of 2% HCl for 3 h. This was then filtered through 2-layers of hardened filter paper 50 cm^3 of the filtrate were taken into 400 mL beaker and 10 cm^3 of 0.3% ammonium thiocyanate (NH_4SCN) solution was added as an indicator and 107 mL distilled water was then added to obtain the proper acidity (pH 4.5). The solution was then titrated with a standard iron chloride solution containing 0.00195 g Fe mL until a brownish yellow colour persists for 5 min. Phytin-phosphorus was determined and phytin content was calculated by multiplying the value of phytin-phosphorus by 3.55[19]. Each miligramme of iron is equivalent to 1.19 mg of phytin-phosphorus. Duplicate samples of each food sample type were analysed.

Tannin: About 200 mg of finely ground sample was weighed (200 mg in 10 mL of 70% aqueous acetone) were extracted for 2 h at 30oc in water bath using Gallenkamp orbital shaker (Surrey, UK) at 120 revolutions per minute. Pigment and fat were first removed from the samples by extracting with diethyl ether containing 1% acetic acid. Thereafter, the total polyphenols (as tannic equivalent) was determined in 0.05ml aliquot in test tubes by addition of distilled water to make it to 1.0 mL, followed by the addition 0.5 mL of the Folin Ciocalteuu reagent (Sigma) and then 2.5 mL of the sodium carbonate solution. The tubes were vortexed and the absorbance recorded at 725 nm after 40 min as described[20]. The amount of total polyphenols (as tannic equivalent) was calculated from the standard curve. Duplicate samples of each seed type were analyzed.

Oxalate: One gram of the sample was weighed into 100 mL conical flask and thereafter 75 mL of 1.5 N H_2SO_4 was added and the solution was carefully stirred intermittently with a magnetic stirrer for about 1 h and then filtered using whatman No. 1 filter paper. From the sample filtrate 25 mL of (extract) was taken and titrated hot (80-90°C) against 0.1 N $KMnO_4$ solution to the point when a faint peak colour appeared that persisted for at least 30 sec.

Lectin (hemagglutinin): The lectins in raw or processed seeds were extracted from the defatted seed flours by the method of[20]. The lectin titres of the extract were subsequently determined using 0.25% saline-washed trypsinated rabbit red blood cells in a two-fold serial dilution technique of[22] while the nitrogen content of the extract was determined by micro-Kjeldhahl method[22]. Duplicate samples of each formulated diet were analysed.

Trypsin inhibitor activity (TIA): The TIA was assayed in terms of the extent to which an extract of the defatted flour inhibited the action of Bovine Trypsin (EC 3.4.21.4) on the substrate benzoyl-DL-arginine-p-nitroanilide (BAPNA) hydrochloric[23] as modified by[24]. The samples (1 g each) were extracted continuously at ambient temperature for 3 h with 50 mL, 10 mM NaOH using a mechanical shaker (Gallenkamp orbital shaken Surrey, UK). The pH of the resulting slurry was adjusted to 9.4-9.6 with 1 M NaOH. After extraction, the suspension was shaken and diluted with distilled water such that 1 cm^3 of the extract produced trypsin inhibition of 40-60% at 37°C. The respective dilutions were noted. Consequently, TIA was calculated in terms of mg pure trypsin (Sigma type lll, lot 20H0868)

$$TIA = \frac{2.632DA^t}{S} \text{ mg pure trysin inhibited g-1 sample,}$$

Where D is the dilution factor, A^t is the change in absorbance at 410mm due to trypsin inhibition per cm^3 diluted sample extract and S is the weight of the sample. Duplicate samples of each seed type were analysed.

Statistical analysis: The statistical significance of the observed differences among the means of triplicate readings of experimental results were evaluated by analysis of variance (ANOVA), while means were separated using Duncan's Range Test. These analyses were carried out using GenStat 6.1 [2002] computer program.

RESULTS

The proximate composition of the formulated diet from sorghum bicolor and fermented African yam bean is shown in Table 2. The energy values of the formulated diets ranges between 372-432 kcal, moisture content 6.45-9.71 g, ash content 4.25-5.81 g, fat 6.19-8.75 g, protein 10.15-23.10 g, fiber content 1.06-1.70 g and carbohydrate 55.08-70.77 g. The values for the mineral composition of the diets are shown in Table 3. These values range as follows: iron 135-180 mg, zinc 4.9-5.4 mg, copper 1.91-2.1 mg, sodium 760-2360 mg, phosphorous 1134.1-9144.3 mg, magnesium 144-136 mg, calcium 480-720 mg and potassium 1580-4560 mg; while others lead and aluminum were not detected in the samples.

Table 2: Proximate composition of sorghum bicolor and fermented African yam beans mix, 100% fermented African yam bean (F) and control (H)

Parameters	A	B	C	D	E	F	H
Energy Kcal	384.00	379.00	397.00	380.00	372.00	432.00	412.60
Moisture (g)	6.45	6.76	7.82	8.12	8.14	9.71	2.50
Ash (g)	4.83	5.58	4.90	5.81	5.39	4.25	3.30
Fat (g)	6.74	6.42	8.75	8.51	6.19	6.60	9.00
Protein (g)	10.15	11.91	12.60	14.70	15.40	23.10	15.00
Fibre (g)	1.06	1.66	1.18	1.70	1.13	1.26	2.30
Carbohydrate	70.77	68.41	64.75	61.16	63.75	55.08	67.90

Table 3: Mineral composition of sorghum bicolor and fermented African yam beans mix and 100% fermented African yam bean (F)

Parameters	A	B	C	D	E	F
Iron	135^{f}	145^{e}	180^{a}	165^{b}	150^{d}	155^{c}
Zinc	5.0^{b}	10^{a}	5.0^{b}	5.0^{b}	5.0^{b}	5.0^{b}
Copper	1.96^{a}	1.96^{a}	1.96^{a}	1.96^{a}	1.96^{a}	1.96^{a}
Sodium	760^{f}	1420^{d}	1600^{b}	2000^{e}	2080^{c}	2360^{a}
Phosphorus	1134.1^{f}	3241.6^{d}	4076.1^{c}	6947.0^{e}	7144.0^{b}	9144.3^{a}
Magnesium	144^{c}	144^{c}	144^{c}	192c	336^{a}	336^{b}
Calcium	480^{a}	560^{c}	560^{a}	640^{c}	720^{b}	640^{b}
Potassium	1580^{f}	2560^{d}	3200^{c}	4300^{e}	4460^{b}	4560^{a}
Lead	ND	ND	ND	ND	ND	ND
Aluminum	ND	ND	ND	ND	ND	ND

ND = Not detected

Table 4: Anti-nutrient composition of sorghum bicolor and fermented African yam beans infant mixes and raw African yam beans

Samples	PhyticAcid (mcg 100 g^{-1})	Tannin (%)	Oxalate (%)	Trypsin (mg g)	Lectin
A	0.98	0.03	0.21	1.91	0.00
B	1.97	0.05	0.41	3.14	0.00
C	2.29	0.07	0.62	5.70	0.00
D	3.95	0.10	0.83	7.91	0.00
E	4.94	0.12	1.04	11.3	0.00

The results of anti-nutritional factors are shown in Table 4. It was observed that the phytic acid content of the sample increases as the percentage of the fermented African yam beans increases from 0.98 in 10% beans to 4.94 in 50% African yam beans. The tannin content varies from 0.03 in 10% beans to 0.12 in 50% African yam beans. Also, the oxalate varies from 0.21 in 10% beans to 1.04 in 50% African yam beans. The trypsin varies from 1.91-11.30 mg g^{-1}. The lectin content of the food sample was reduced to zero by the processing method.

DISCUSSION

The purpose of this study was to develop weaning food from locally available food materials. Sorghum bicolor and African yam bean that were used for this study were locally available and affordable by many nursing mothers, particularly those that belong to low-income group.

The result of proximate analysis of the blended samples established that the moisture content of the blended food samples increases as the percentage of African Yam Bean Flour (AYBF) increases, that is, 10% AYBF composition had the least moisture content while the 50% AYBF composition had the highest moisture content. This observation was similar to other findings[25], which reported that sorghum bicolor has lower moisture content when compared with legume and that the increase in moisture content of the blends was as a result of increased in AYBF. It was observed that there was no significant difference between the moisture content of the 10, 20 and 30% of the blended samples. However, the observed low moisture content level of the blended food samples can be used as an index of their storage stability.

The protein content of the food samples increases as the percentage of African yam bean flour increases. This finding was similar to other researchers' findings who reported that legume seeds are good sources of protein and other nutrients for humans and animals consumption and that their utilization in infant formula and other food products has been significantly solving nutrition problems in the community[1,6,26,27]. The blending of sorghum and African yam bean in the formulation of weaning diet would go a long way in solving nutrition problems, particularly protein-energy malnutrition, which is very common among the children that fed with local weaning food (ogi). The protein-energy malnutrition is now becoming a public health problem among the low-income families as a result of poor feeding practices and low purchasing power.

The mineral composition of the formulated food sample was appreciably high to meet the RDA of the children, particularly the infant. The result showed that heavy metals like lead (Pb) and Aluminum (Al) that are toxic to the body tissue were not detected in any of the samples. While the micronutrient like iron (Fe), Zinc (Zn) and Copper (Cu) were appreciably present in the required proportion needed for the body growth and development of infants. These proportions of minerals in the formulated diet were able to conform to the laid down standard for infant formula by the codex alimentarius standard[25]. This could be attributed to the fact that an African yam bean is a good source of minerals needed for the body growth and development of young children. This finding was similar to the report of[28].

The values of antinutritional factors obtained in this study are comparable low when compared with the raw values and this could be attributed to the processing methods (boiling and fermentation) that were employed during the product development, however, these values are within the tolerable range for animal consumption. These results agreed with the report of other researchers[29-31].

CONCLUSION

Increasing the fermented African yam bean flour content in sorghum flour thus results in a nutritionally dense product capable of improving the nutritional status of consuming children. However, before a definitive conclusion can be reached on the suitability of these blends for weaning diet, their biological value (part 2 of this study) has to be known and reconciled with their respective chemical composition.

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