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Nutritional Composition, Sensory and Biological Evaluation of A Potential Weaning Diet from Low Cost Food Materials *(Sorghum bicolor* and *Cajanus cajan)*

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Abstract: The chemical composition of the food samples ranged between 6.4-7.9% moisture contents, 12.7-28.0% crude protein, 2.3-3.2% fat, 1.4-2.2% crude fiber, 5.2-6.5% ash and 53.7-71.8% carbohydrate, calcium 252-268mg kg^{-1}, sodium 151.2-172.3 mg kg^{-1}, potassium 2247-2645 mg kg^{-1} and magnesium 152.6-260.2 mg kg^{-1} while others iron 18.2-42.4 mg kg^{-1}, Zinc 6.2-8.2 mg kg^{-1}, copper 0.215-0.815 mg kg^{-1}, aluminum 0.821-1.80 mg kg^{-1}, phosphorous 231.6-264.3 mg kg^{-1} and lead was not detected in the food samples. The result of sensory evaluation of the formulated weaning food samples. The result showed that there was significant a difference between the control food sample and the experimental food samples in term of taste, color and aroma. The overall acceptability result showed that SP1 was rated 92% of the control, SP2 59.6%, SP3 59.6, SP4 65.4 and SP5 51.9%. The biological evaluation result showed PER ranged between 55.4% of SP5 and 92.8% of SP3, NPU ranged between 109.9% of SP1 and 116.1% of SP5, BV ranged between 71.7% of SP5 and 111.3% of SP1 and TND ranged between 94.9% of SP4 and 117.5% of SP1. Findings show that at 20% pigeon peas flour supplementation, the meal could meet satisfactorily the Recommended Dietary Allowances (RDA) for children of 1 to 3 years of age and has tolerably low antinutrients level.

Key words: Nutritional composition, sensory and biological evaluation

INTRODUCTION

Protein-energy malnutrition is a nutrition problem among infants and children in the poor socio-economic groups of developing countries[1]. Findings have shown that the high cost of commercial weaning foods, animal proteins and faulty feeding practices are mostly responsible for this nutrition problem, that is, protein-energy malnutrition among the children from low-income group[2].

Protein-energy malnutrition generally occurs during the crucial transitional phase when children are introduced family diet. During this period, because of their rapid growth, children need nutritionally balanced diet of high protein quality and energy dense complementary foods in addition to mothers' milk[3-4]. The poor physical growth (or stunting) and development produced as s result of poor dietary intake is best described as hidden malnutrition. This is because the child may appear healthy while severely malnourished.

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[5-7]. 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. Study has shown that over 70% of dietary protein in developing countries is supplied by cereals that are relatively poor sources of protein[8]. The high lysine content of legumes improves the nutritional quality of cereals by complementing their limiting amino acids.

Traditional weaning foods in developing countries are known to be of low nutritive value[9-10] and are characterized by low protein, low energy density and high bulk. Among the poor in Nigeria the usual first weaning food is called pap, *akamu or ogi* and is made from maize (*Zea mays*), millet (*Pennisetum americanum*), or guinea corn (*Sorghum* sp.)[11-14]. Maize pap or ogi has been implicated in the aetiology of protein-energy malnutrition in children during the weaning period[15-16]. Cereal-based diets have lower nutritional value than animal-based ones. Cereals form the major weaning food for children from most of the low-income family. The protein content of maize and sorghum corn is of poor quality, low in lysine

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and tryptophan. Evidence has shown that the traditional weaning foods could be improved by combining locally available foods that complement each other in such a way that the new pattern of amino acids created by this combination is similar to that recommended for infants[17]. Therefore, the purpose of this study was to develop low cost weaning food, using the combination of cereals and legumes.

MATERIALS AND METHODS

Sample collection: The sorghum biocolour ((L) moench) and Pigeon peas (*Cajanus cajan)* were obtained from the local in Akure, Ondo state. From the bulk collection of the seeds under study, about 10kg of each were thoroughly rinsed with distilled water before subjecting the peas to different processing methods.

Processing methods: Pigeon peas: The extraneous materials, broken and unhealthy seed were removed from the Pigeon peas. 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°C) 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 0.4mm mesh screen to give the finished pigeon peas flour. The pigeon peas flour was then kept in airtight container prior to chemical analysis and protein quality evaluation.

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 pigeon peas were mixed in five different ratios and designated as SP1, SP2, SP3, SP4 and SP5. The processing flow chart and the formulation of sorghum bicolor and pigeon peas are shown in Fig. 1 and Table 1, respectively.

Chemical analysis: 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 AOAC[18]. Total lipids were estimated by petroleum ether extraction. Carbohydrate content was estimated by difference. The gross energy was determined

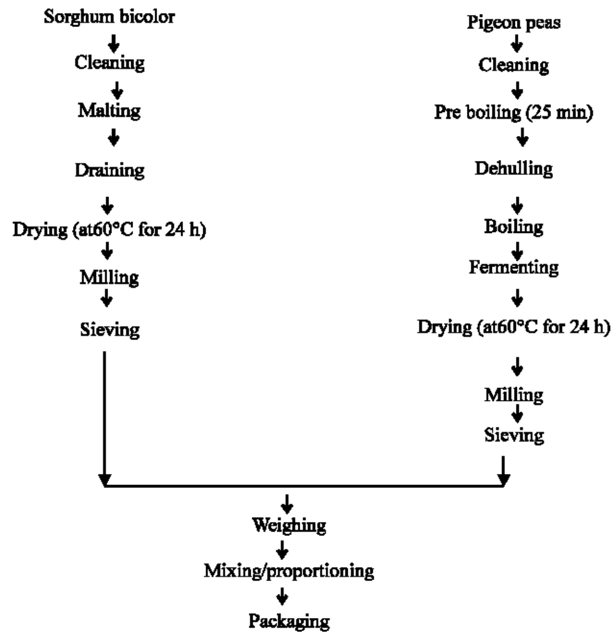

Fig. 1: Flowcharts for the preparation of formulated diet from sorghum bicolor and Pigeon peas Sorghum bicolor Pigeon peas

Table 1: Formulation of sorghum bicolor and African yam beans

Samples	Sorghum (%)	Pigeon peas (%)
SP1	90	10
SP2	80	20
SP3	70	30
SP4	60	40
SP5	50	50
PP	-	100

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 Young and Greave[19]. The finely grounded samples (5 g) 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^{-1} 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 (200mg in 10ml 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 0.05 mL 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 by Makkar and Goodchild[20]. The amount of total polyphenols (as tannic equivalent) was calculated from the standard curve. Duplicate samples of each seed type were analyzed.

Lectin (hemagglutinin): The lectins in raw or processed seeds were extracted from the defatted seed flours by the method of Huprikar and Sohonie[21]. 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 Kabat and Mayer[22] while the nitrogen content of the extract was determined by micro-Kjeldhahl method[18]. 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 Smith *et al.*[24]. The samples (1g each) were extracted continuously at ambient temperature for 3 hours 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 1M 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)

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

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 analyzed.

Biological evaluation of protein quality: The experimental animal for the bioassay test were clinically healthy weaning albino rats of Wister strain (age 21days old) and they were obtained from the animal unit of Drug research and production unit of faculty of pharmacy, Obafemi Awolowo University (OAU), Ile-Ife, Osun state. The rats were randomly selected and divided into seven groups of four rats in each group and two of the groups were control and nitrogen free basal diet group respectively, while others were experimental groups. The rats were individually housed in separate cubicles in a metabolic cage with adequate facilities for separate feacal and urinary collection. The nutritional composition of the diet was sorghum bicolor and fermented African yam beans in the ratio shown in Table 1 for the experimental rat groups, cerelac (a commercial weaning food) for the control group and N-free basal diet. The rats were offered water and diets ad libitum for 35 days. Records were kept of the weight changes and total food intake. The last seven days of the experimental periods were used to collect urine and faece of the rats from each group. The urine from each cage was collected in small urine cups containing 1cm^3 of 0.1M H_2SO_4 acids as preservative and each day collection was stored in screw-capped bottles and stored at-18°C. Faecal samples were collected from each group daily, dried and stored. Duplicate samples of urine, faeces and diets were taken for nitrogen determination and the obtained values were used to determine the Protein Efficiency Ratio (PER), Net Protein Utilization (NPU), Biological Balue (BV) and True Nitrogen Digestibility (TND) parameters.

Sensory and economic evaluation: The sensory evaluation was carried out on the following attributes: taste, appearance, aroma, mouth (texture), colour and overall acceptability by a panel of ten members using a 9-point hedonic scale. The rating of the samples ranged from 1 (Dislike extremely) to 9 (Like extremely). The costs of the diets were estimated using the prevailing prices of the component food materials and the commercial infant foods at the time of the experiment.

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 results of proximate chemical composition of the food samples ranged between 6.4-7.9% moisture contents, 12.7-28.0% crude protein, 2.3-3.2% fat, 1.4-2.2% crude fiber, 5.2-6.5% ash and 53.7-71.8% carbohydrate. The mineral composition were calcium 252-268 mg kg^{-1}, sodium 151.2-172.3 mg kg^{-1}, potassium 2247-2645 mg kg^{+} and magnesium 152.6-260.2 mg kg^{-1} while others iron 18.2-42.4 mg kg^{-1}, Zinc 6.2-8.2 mg kg^{-1}, copper 0.215-0.815 mg kg^{-1}, aluminum 0.821-1.80 mg kg^{-1}, phosphorous 231.6-264.3 mg kg^{-1} and lead was not detected in the food samples (Table 2). The anti-nutritional level of the food samples were phytic acid ranged between 0.10 mcg/100 g in sample SP1 and 0.49 mcg g^{-1} in sample SP5, tannin ranged between 0.21% in sample SP1 and 1.07% in sample SP5, trypsin ranged between 0.22 mg g^{-1} in Sp1 sample and 1.0mg/g in Sp5 sample and lectin was between 0.09 in sample SP1 and 0.48 in sample SP5 (Table 3).

Table 4 shows the result of sensory evaluation of the formulated weaning food samples. The result showed that there was significant a difference between the control food sample and the experimental food samples in term of taste, but SP1 sample was rated next to the control while SP5 was rated least. In term of color, it was observed that there was significant difference between the control food sample and experimental food samples, but Sp1 was also rated next to the control and in term of aroma the result showed that there was a significant difference between the control food sample and the experimental food samples and also, SP1 was rated next to the control and SP5 was rated least. The overall acceptability result showed that SP1 was rated 92% of the control, SP2 59.6, SP3 59.6, SP4 65.4 and SP5 51.9%.

The formulated food samples were subjected to biological evaluation and rated relatively to the control food sample (Cerelac). The result showed that Protein Efficiency Ratio (PER) ranged between 55.4% of SP5 and 92.8% of SP3, Net Protein Utilization (NPU) ranged between 109.9% of SP1 and 116.1% of SP5, Biological Values (BV) of the samples was ranged between 71.7% of SP5 and 111.3% of SP1 and True Nitrogen Digestibility (TND) was ranged between 94.9% of SP4 and 117.5% of SP1 (Table 5).

DISCUSSION

Protein-energy malnutrition is the commonest nutrition problem among children from low-income families in developing countries, particularly in Nigeria. Some of the factors responsible for this are low economic status of many families, which limit their purchasing powers and also, lack of nutritional knowledge particularly among the rural nursing mothers. Several studies have attributed the high prevalence rate of malnutrition among the children in rural communities to their low socio-economic status and knowledge of nutrition in utilizing their immediate food materials for their benefits[25-28]. This present study is therefore aimed at developing weaning food from locally available food materials (sorghum bicolor and pigeon peas) and also affordable to many nursing mothers, particularly those those belong to low-income group.

Table 2: Proximate composition of d formulated diet (Sorghum bicolor and Pigeon pea) and reference (Cerelac)

Nutrients	SP1	SP2	SP3	SP4	SP5	PP
Moisture %	6.4±0.2	6.7±0.4	7.3±0.2	7.5±0.4	7.9±0.8	7.5±0.2
Crude protein %	12.7±0.4	14.4±0.4	15.8±0.0	19.7±0.4	21.9±0.9	28.0±0.0
Fat	2.3±0.20	3.6±0.20	3.2±0.10	3.2±0.10	3.2±0.15	3.4±0.05
Crude fiber (%)	1.4±0.07	1.6±0.09	1.5±0.04	2.0±0.05	2.2±0.16	2.2±0.11
Ash (%)	5.4±0.4	5.8±0.1	5.6±0.4	6.4±0.2	6.5±0.2	5.2±0.04
Carbohydrate(%)	71.8±0.2	67.9±0.2	66.7±0.08	61.9±0.36	58.3±0.3	53.7±0.03
Calcium	252.7±0.24	265.3±0.32	261.8±0.15	263.2±0.09	268.5±0.10	271.7±0.23
Sodium	151.2±0.30	169.2±0.50	173.2±0.09	171.3±0.42	172.3±0.32	191.5±0.35
Magnesium	152.6±0.32	185.7±0.41	179.9±0.32	210.2±0.25	260.2±0.11	262.8±0.27
Iron	18.2±0.07	22.8±0.05	34.2±0.08	40.2±0.09	42.4±0.10	42.2±0.08
Zinc	6.2±0.02	6.4±0.03	7.2±0.02	8.1±0.05	8.2±0.07	9.5±0.06
Copper	0.222±0.02	0.215±0.02	0.601±0.01	0.789±0.02	0.815±0.03	0.722±0.02
Potassium	2247±2.20	2846±2.75	2572±2.40	2623±2.61	2345±2.72	2269±2.50
Phosphorous	261.3±0.25	253.3±0.36	249.8±0.45	255.9±0.4	231.6±0.31	264.3±0.58
Aluminum	1.80±0.02	1.70±0.03	1.50±0.01	1.35±0.01	0.914±0.03	0.821±0.02
Lead	ND	N.D	N.D	N.D	N.D	N.D

Table 3: Anti-nutrient composition of formulated weaning diet (sorghum bicolor and pigeon pea)

Samples	Phytic acid (mcg/100g)	Tannin (%)	Trypsin mg g^{-1}	Lectin
SP1	0.10	0.21	0.22	0.09
SP2	0.20	0.43	0.44	0.19
SP3	0.29	0.64	0.66	0.28
SP4	0.39	0.86	0.88	0.38
SP5	0.49	1.07	1.10	0.48

Table 4: Sensory evaluation of the formulated diet (sorghum bicolor and pigeon pea)

Samples	Taste	Colour	Aroma	Overall acceptability
Control	7.00^{a}	7.10^{a}	7.10^{a}	5.20^{a} (100%)
SP1	4.80^{b}	4.80^{b}	4.60^{b}	4.80^{b} (92%)
SP2	4.10^{c}	3.50^{c}	3.60^{c}	3.10^{c} (59.6%)
SP3	3.40^{c}	3.70^{b}	4.00^{b}	3.10^{c} (59.6%)
SP4	3.80^{c}	4.00^{b}	3.50^{b}	3.40^{c} (65.4%)
SP5	2.80^{cd}	3.20^{b}	3.20^{b}	2.70^{c} (51.9%)

Subscript with the same alphabet are not significant different while values with different subscript are significantly different.

Table 5: Biological performances of the mice fed with a mix of sorghum bicolor and pigeon pea

Parameters	Control	SP1	SP2	SP3	SP4	SP5
Mean weight gain						
PER	100	74.3^{c}	83.7^{b}	92.8^{a}	82.6^{b}	55.4^{bc}
NPU	100	109.9^{c}	113.9^{b}	110.2^{b}	111.8^{b}	116.1^{a}
BV	100	110.3^{a}	110.7^{a}	110.3^{a}	69.1^{b}	71.7^{b}
TND	100	117.5^{b}	121.2^{a}	117.1^{b}	94.9^{c}	95.9^{c}

Subscripts with the same alphabet are not significant different while values with different subscripts are significantly different. Key: PER-Protein Efficiency Ratio; NPU-Net Protein Utilization; BV-Biological Value; TND-True Nitrogen Digestibility

Table 6: Amount of formulated diet (reference to sample SP1) required by the weaning child to meet RDA

Nutrients	RDA (1-3years)	Sample SP1 (100g)	Amount needed to meet RDA (g)
Energy (MJ)	5.5	0.15	3667
Crude protein (g)	16	12.7	125.9
Fat (g d^{-1})	30	2.3	1304
Crude fibre (g)	19	1.4	1357
Carbohydrate (g)	130	71.8	181.1
Calcium (mg)	500	252.7	197.9
Sodium (mg)	1.0	151.2	0.66
Phosphorous (mg)	460	261.3	176.0
Magnesium (mg)	80.0	152.6	52.4
Iron (mg)	15	18.2	82.4
Zinc (mg)	3.0	8.2	36.6
Copper mg)	0.5	0.32	156.3
Potassium (mg)	3.0	2247	0.134
Aluminum (mg)	NR	1.80	-
Lead(mg)	NR	ND	-

Table 7: Comparative cost of developed supplement and some commercial formulae

		Cost of production	
Weaning foods	Weight (g)	Naira	Kobo
Developed diet	500	160	00
Commercial weaning foods			
Nutrend	400	400	00
Cerelac	450	450	00
Nan	450	650	00
SMA Gold	450	1500	00
SMA	450	800	00
123 Peak Milk	500	450	00

N= Naira, K= Kobo (=N=150: 00=$1)

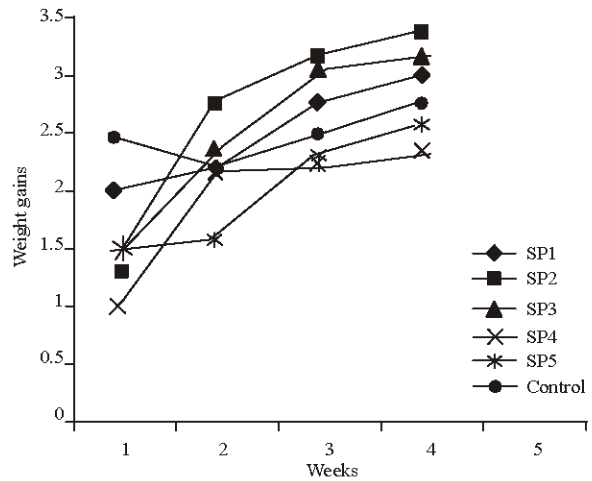

Fig. 2: Average weight changes of experimental rats

The chemical composition of the blended food sample showed that the nutritional quality of sorghum was improved and it was observed that as the percentage concentration of pigeon peas increases in the mix so also the protein contents and some other vital nutrients. This finding was in support of other investigators that early reported that cereal was deficient in many vital nutrients and therefore could not supply the necessary nutrient requirement for the rapid growth and development in children and that there is a need to complement cereal with legume in order to improve its nutritional values[5-29]. Findings also showed 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 among low income group[6, 7, 30-32]. The formulated diet (sorghum and pigeon pea mix) would go a long way in solving nutrition problems, particularly protein-energy malnutrition, 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 developed weaning food was appreciably high to meet the RDA of the weaning children. The analysis of the food sample showed that heavy metals like lead (Pb) and Aluminum (Al) that are toxic to the body tissue were not detected in the formulated diet sample. While the micronutrient like calcium, phosphorous, iron (Fe), Zinc (Zn) and Copper (Cu) were appreciably present in the required proportion needed for the body growth and cognitive development of infants.

The values of antinutritional factors of the food sample were comparatively 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 human consumption. These values agreed with the report of other researchers[33-35].

The sensory and biological values of the sorghum-pigeon peas mixed were assessed and it was observed that there was a significant difference between the control food sample and developed food samples in term of taste, colour, aroma and over all acceptability. This could be attributed to the fact that people have been used to these attributes in the control food sample, which has a similar characteristic of local ogi (Maize gel). The SP1 sample was highly accepted more than others and this could be attributed to the fact that it contained less pigeon peas flour than other food samples. In case of biological evaluation, the animals in SP2 group gained more weight than other groups (Fig. 2). Also, it was observed that the percentage values of SP2 relatively to the control food sample was higher than others in terms of BV and TND, but rated second to SP3 and SP5 in PER and NPU parameters respectively. This suggests that supplementation above 20% Pigeon peas protein only causes minimal alteration in the nutritive value of sorghum-pigeon peas. Therefore, the higher biological performances of samples SP1, SP2 and SP3 than SP4 and SP5 could be attributed to the low quantity of Pigeon peas, hence low anti-nutritional factors. Similar finding has been reported by other investigator[36].

In respect to sample SP2 (20% Pigeon peas flour and 80% sorghum flour), the amount of sorghum-Pigeon peas flour that could adequately meet the RDAs of children (1-3 years) were minimal and also the cost of production was low compared to the control food sample (Table 6 and 7). Evidence has showed that one of the factors limiting the use of commercial weaning foods is their cost, which are above the purchasing power of many low-income families[37] and or such people an alternative low cost weaning formula is warranted.

CONCLUSION

This study showed that the biological performance of complementary diet formulated from 80% sorghum and 20% Pigeon peas was compared favourably with the control diet in term of overall acceptability, nutritional composition and biological performance. Therefore, it could be inferred that it would support the growth and development of young children. Thus, this would serve as alternative diet supplying adequate protein from cheap and locally available vegetable sources.

REFERENCES

1. Agu, V.C., 1976. Feeding and weaning practices in Enugu, urban and rural. Bachelor of Science Thesis. University of Nigeria, Nsukka.
2. Dutra-de-Oliveira, J.E., 1991. Malnutrition in developing countries: The challenges to the responsibilities of the experts, Proc Nutr. Soc India, 37: 29-38.
3. Berggren, G.G., 1982. Questions and answers about weaning food. Nutrition bulletin, 4: 20-4.
4. Cameroon, M. and Y. Hofvander, 1971. Manual on Feeding infants and young children. PAG Document, 14: 25-26.
5. Malleshi, N.G., M.A. Daodu and A. Chandrasekhar, 1999. Development of weaning food formulatioin based on malting and roller drying of sorghum and cowpea Int J. Food Sci. Tech., 24: 511-519.
6. Ijarotimi, S.O. and F. Ashipa 2005, Chemical composition, sensory and physical property of home processed weaning food based on low cost locally available food materials, Intl. J. Mol. Med. Adv. Sci., 1: 213-219.
7. Ijarotimi, S.O. and F. Aroge, 2005. Evaluation of the nutritional composition, sensory and physical properties of a potential weaning food from locally available food materials-breadfruit (*artocarpus altilis*) and soybean (*glycine max*). Pol. J. Food Nutr. Sci., 14/55: 411-415.
8. Glover, D.V., 1976. Improvement of Protein Quality in Maize. In: Wilke HL, Ed. Improving the Nutrient Quality of Cereals. Washington, DC: AID, pp: 69-97.
9. Guiro, A.T., M.G. Sail, O. Kane, A.M. Ndiaye, D. Diarra and M.T.A. Sy, 1987. Protein-calorie malnutrition in Senegalese children. Effects of rehabilitation with a pearl millet weaning food. Nutr Rep. Intl., 36: 1071-9.
10. Akinrele, I.A. and O. Bassir, 1967. Nutritional value of ogi. A Nigerian Infant food. J. Trop Med. Hyg., 70: 279-281.
11. King, J. and A. Ashworth, 1987. Changes in infant feeding practices in Nigeria: An historical review. Occasional Study No. 9. London: Centre for Human Nutrition, London School of Hygiene and Tropical Medicine.
12. Longhurst, R., 1984. The energy trap. Work, nutrition and childhood malnutrition in Northern Nigeria. International Monograph Series 13. Ithaca, NY, USA: Cornell University.

13. Cherian, A., 1981. Attitudes and practices of infant feeding in Zaria. Ecol. Food Nutr., 11: 75-80.
14. Osuhor, P.C., 1980. Weaning practices amongst the Hausas. J. Hum. Nutr., 34: 273-80.
15. Naismith, D.J., 1973. Kwashiorkor in Western Nigeria: A study of traditional weaning foods with particular respect to energy and linoleic acid. Br. J. Nutr., 80: 567-576.
16. Fashakin, J.B. and F. Ogunsoola, 1982. The utilization of local foods in fermentation of weaning foods. Trop. Paediatr (Lond) 28: 93-96.
17. Uwaegbute, A.C. and D.O. Nnanyelugo, 1989. Towards Improving the Nutritional Value of Straditional Weaning Foods. In: Fashakin JB, Ed. Proceedings of the Workshop on Present Knowledge on Weaning Foods in Nigeria, Held in Lagos. Oshodi-Lagos: Federal Institute for Res., pp: 63-85.
18. A.O.A.C., 1995. Official Methods of Analysis, 16th Edn., Arlington VA. Association of official Analytical Chemists.
19. Young, S.M. and J.S. Greaves, 1940. Influence of variety and treatment on phytin content of wheat. Food Res., 5: 103-105.
20. Makkar, A.O.S. and A.V. Goodchild, 1996. Qualification of tannins. A Laboratory Manual. International Center for Agriculture Research in the Dry areas (ICARDA). Alepo, Syria, pp: 4-25.
21. Huprikar, S.V. and K. Sohonie, 1965.Heamaglutinins in Indian pulses. II:L purifications and properties of heamaglutinins (Lectins) from white pea (Pisum sp). Enzymologia, 28: 333-340.
22. Kabat, E.A. and M.M. Mayer, 1961. Qualitative and Semi-qualitative method of measuring agglutinins. Wxperimental Immuno Chem., 3: 3-10.
23. Kakade, M.L., J.J. Rachis, J.E. Macghee and G. Puskin, 1974. Determination of trypsin inhibitor activity of soy products: A Laborative analysis of an improve procedure. Cereal Chem., 51: 376-382.
24. Smith, C., Win, Van. Megen., T. Leendert and C. Hitchcock, 1980. The determination of trypsin levels in food stuffs. J. Sci. Food Agric., 31: 341-350.
25. Nnanyelugo, D.O., 1985. Nutritional Status of Children in Anambra State: A Comprehensive Treatise. Nsukka: University of Nigeria Press.
26. Uwaegbute, A.C., 1982. Infant feeding patterns and comparative assessment of formulated weaning foods based on vegetable proteins. Doctoral Thesis, University of Nigeria, Nsukka.
27. Onofiok, N. and D.O. Nnanyelugo, 1992. Nutrient intake of infants of high and low socio-economic groups in Nsukka, Nigeria. Occasional Study. Nsukka: Department of Home Science and Nutrition, University of Nigeria.
28. Brown, L. and E. Pollitt, 1996. Malnutrition, poverty and intellectual development. Scientific American, 274: 38-43.
29. Uwaegbute, A.C. and D.O. Nnanyelugo, 1987. Usage Patterns of Cow-Peas (*Vigna unguiculata*) for Infant Feeding in Nigeria. In: Kwik Whei L, Kiang Ai K, Eds. Trends in Nutrition and Food Policy. Proceedings of the 7th World Congress of Food Science and Technology. Singapore: Institute of Food Sci. Technol., pp: 201-205.
30. Torun, B., F.E. Viteri and V.R. Young, 1981. Nutritional role of soya protein for humans. J. AOCS, 58: 400-406.
31. Fageria, N.K., V.C. Baligar and C.A. Jones, 1990. Common Bean and Cowpea. In: Growth and Mineral Nutrition of Field Crops, Eds. Fageria, NK, Baligar, VC, Jones, CA., pp: 281-381.
32. Ikujenlola, V.A. and J.B. Fashakin, 2005. The physico-chemical properties of a complementary diet prepared from vegetable proteins. J. Food Agric. Environ., 3: 23-26.
33. Krogdhal, A., T.B. Lee and J.J. Olli, 1994. Soybean protease inhibitors affect intestinal trypsin activities and amino acids digestibilities in rainbow trout (*Oncorhyncus mykiss)*. Comp. Biochem. Physiol., 107A: 215-219.
34. Astrat, I. and G.M. Ngappa, 2000. Development of weaning food based on malted popped and roller dried barley and chick pea. J. Food Sci., pp: 2-6.
35. Olli, J.J., K. Hjelmeland and A. Kroghahl, 1994. Soybean trypsin inhibitors in diets for Atlantic salmon (*Salmo salar, L.*): effects on nutrient digestibilities and trypsin in pyloric ceasa homogenate and intestinal content. Comp. Biochem. Physiol., 109A: 923-928.
36. Rackis, J.J., 1974. Biological and physiological factors in soybeans. J. Am. Oil Chem. Soc., 51: 161A-174A.
37. Adeyemi, I.A., 1989. Prospect for Upgrading Traditional Technology for Weaning Food Manufacture in the 1990s. Proceeding of the 13th Annual Conference of the Nigerian Institute of Food Science and Technology (E. Balogh, Edn.), pp: 85-94.