Determination of Mineral Contents, Proximate Composition and Functional Properties of Complementary Diets Prepared From Maize, Soybean and Pigeon Pea

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Abstract - The purpose of this study is to determine the mineral contents, proximate composition and functional properties of complementary dietary prepared from maize, soybean and pigeon pea. The legumes were made into flour and composed into Dietary Basal (A): Fermented maize-soybean-pigeon pea 70: 15: 15(B): Fermented maize-soybean 70:30(C): Fermented maize-pigeon pea70:30(D): Nutrend (E) a commercial dietary was used as control. The mineral contents including Calcium; Phosphorus, Potassium, Sodium, Magnesium, Iron, and Zinc of the dietary were ranged from 17.41 to 48.70; 260.10-948.45; 76.30-210.50; 184.60-324.7; 444.15 – 725.70; 4.815-10.22; and 2.75-6.77mg/100g respectively. The crude protein%, ash%, crude fibre%, ether extract%, moisture (dry basis) %, nitrogen free extract% and energy kcal/100g were ranged from 12.61 -20.75; 2.40 -3.01; 5.31- 7.05; 4.90 -9.05; 2.55 - 3.29; 56.96 -68.63 and 366.94 -545.42 kcal/100g respectively. The functional properties such as gelation power; swelling capacity; water absorption capacity; and bulk density of the dietary ranged from 12.61% – 16.41%; 23.67%- 38.74%; 1.202 – 1.487g/g; and 0.461 g/ml – 0.741g/ml. The result shows that the dietary, maize-soybean-pigeon pea mixture is an appropriate formula that can be prepared from a plant origin, compared favourably with control, and may be use as an alternative to exiting complementary diet that will be suitable for infants.

Keywords - Protein energy malnutrition, Proximate analysis, Functional analysis, Weaning

1. Introduction

PEM, "the silent emergency of the world" which may have hunted mankind since the dawn of history, is by far the most lethal form of malnutrition. It is an imbalance between the supply of energy and protein, and the body's demand for them to ensure optimal growth and function. It is currently the most widespread and serious health problem of children in the world being the moderate or severe forms, (FAO/WHO, 1998, USAID 2002). Protein energy malnutrition is associated with poverty and poor nutrition knowledge, resulting in early weaning, delayed introduction of complementary foods, a low-protein diet and severe or frequent infections, (Rice,*et al*,2000, Müller *et al* 2003). The weaning period is crucial stage of development, increasing metabolic demands; they require higher energy and quality proteins for the maintenance and continued growth and mental development of the child. Poor quality of weaning foods and improper weaning practices predispose infants to malnutrition, growth retardation, infection, diseases, and high mortality, (Onofiok, *et al* 2005, Prentice, *et al* 2005): Most authors have indicated

that early and severe malnutrition is an important factor in deficiencies in late mental development apart from social and hereditary influences, (Wang, *et al* 1976). According to the Protein Advisory Group, guidelines for weaning foods, protein content should be 20%, fat levels up to 10%, moisture 5% to 10%, total ash not more than 5%, (FAO/WHO/UNICEF, PAG, 2007). Several studies have reported that most of the weaning foods consumed by the children in many parts of developing nations are deficient in essential macronutrients and micronutrients, (PAG,2007, Fashakin, *et al* 1989, Millward, *et al* 2004). In view of this nutritional problem, several strategies have been used to formulate weaning food, through a combination of locally available foods that complement each other in such a way as to create a new pattern of amino acids that provide the recommended daily allowance for infants, (Lalude, *et al* 2006, Kulkarni, *et al* 1990 Ijarotimi, *et al* 2006). For instance, cereals were deficient in lysine but have sufficient sulphur-containing amino acids which are the limiting factors in legumes. Several types of commercial weaning foods are marketed in Nigeria, even though these foods are available and nutritious, most of them are expensive and only available for the rich. Rural mothers therefore depend on available

low-cost food mixtures to wean their infants who could not supply the needed nutrition; these consist mainly of un-supplemented cereal porridges made from maize, sorghum or millet, fruits like banana, and roots/tubers like cocoyam, yam or cassava, which are later replaced by foods eaten by older family members. This study is therefore aimed at producing a complementary diet from locally available, underutilized grains which will produce the required nutritional requirement for infants and it will be affordable and available for the mother.

2. Materials and Method

Maize, soybean and pigeon pea were purchased at Sekona market in Osun State, while the Nutrend, vitamins and minerals, were bought from Orisunmibare Central market,Osogbo, Osun State, Nigeria.

Maize, Soybean and Pigeon pea were sorted, cleaned and all grains with holes removed. The soybean and pigeon pea were soaked for 24hr, blanched for 20 mins, dehulled, solar dried, dry milled and sieved into fine flour, while the maize was soaked, wet milled, fermented, solar dried, milled and sieved into fine flour. The flours were mixed together with the mineral and vitamin mix using Hobart mixer, packaged in air tight polythene bags and stored in the freezer until needed. The basal diet was mixed with individual protein source as recommended to achieve an iso-nitrogenous diet at 10% protein level. The protein content of the experimental diets was adjusted to the desired 10% level by mixing of each of the diets with basal diet lacking protein. This standardisation facilitates the subsequent studies with regards to growth, nitrogen and tissues changes in protein content, (FAO/WHO/UNICEF PAG, 2007, Ibironke, et al 2012).

2.1. Chemical Analysis

The proximate analyses were carried out according to A.O.A.C. methods. Carbohydrate content was determined by difference and energy by Atwater factors, the mineral contents of the formulated diets were determined by atomic absorption spectrophotometer for calcium, magnesium, iron and zinc, sodium and potassium by flame photometry and phosphorus using a colorimeter,(AOAC, 1990).

2.1.1. Bulk Density Determination

10g of the samples were filled into a 25ml graduated cylinder and packed by gentle tapping of the cylinder on a bench top ten times. The final volume of the samples was recorded and expressed in g/ml.

2.1.2. Swelling Capacity Determination

20g of each formulated diets and control was weighed into a washed, dried and weighed graduated measuring cylinder. The cylinder was tapped on the table for some few minutes; then 80ml of distilled water was poured into the cylinder. The cylinder was allowed to stand for 1hour after which the final volume of the flour was noted. The ratio of the final gave the swelling capacity on volume basis. The supernatant was then decanted and the cylinder with its content weighed to obtain the weight of the net sample. The ratio of the final to initial weight of the sample gave the swelling capacity on the weight basis, (Akubor et al 1999).

2.1.3. Determination of Gelation Capacity

Test tubes containing 20% (w/v) dispersion of each diet was prepared with 5ml distilled water. The dispersion was heated for 1hr in a boiling water bath, cooled rapidly under water and subsequently at 4^0C for 2hrs. The test tubes were inverted to determine the concentration at which the sample would not slip, (Kulkarni, et al 1990)

2.1.4. Water Absorption Capacity Determination

1g of the sample was mixed with 10ml of distilled water for 5 minutes on a magnetic stirrer. The mixture was centrifuged at 3500rpm for 30minutes and the volume of the supernatant was measured by using 10ml measuring cylinder on each of the sample. The density of water was assumed to be 1g/ml, (Sathe, et al 1982).

$$WAC = \frac{volume\ of\ distilled\ water\ absorbed}{weight\ of\ sample\ used} \times \frac{100}{1}$$

2.1.5. Determination of Viscosity

Cold water slurries containing 10% sample solids were heated in a boiling water bath with constant stirring until boiled which was continued for three more minutes. They were cooled to room temperature and their viscosities were measured with NDJ.8S digital viscometer using spindle No 3 at 30rpm, (Hansen, et al 1989).

2.2. Statistical Analysis

Statistical analysis of the data was carried out using the one-way Analysis of Variance (ANOVA) technique (SPSS 17.0 for windows), and the differences were separated using Duncan's Multiple Range Test (DMRT) at a level considered to be significant at $p < 0.05$.

Table 1. Composition of Dietary Groups at 10% protein level

Dietary Group	Test Material	Corn Starch	Sugar	Vegetable Oil	Vitamin Mix	Cod Liver Oil
Diet B	611.62	193.38	60.00	100.00	30.00	5.00
Diet C	617.28	187.72	60.00	100.00	30.00	5.00
Diet D	636.53	168.47	60.00	100.00	30.00	5.00
Diet E	625.00	180.00	60.00	100.00	30.00	5.00

3. Results and Discussion

Composition of vitamin mix:

Vit. A 2250IU, Vit B_1 1.0mg, Vit B_2 1.0mg, Vit B_6 0.5mg,Vit B_{12} 0.75mcg, Vit E 5IU, Vit C 25.0mg, Nicotinamide 15mg, Vit D_3 150IU, Calcium 75.0mg, Folic Acid 125.0mcg, Phosphorus 58.0mg, Iodine 0.075mg, Potassium 2.0mg, Iron 14.0mg, Copper 1.00mg, Magnesium 3.0mg, Manganese 1.0mg, Molybdenum 0.1mg, Zinc 15.0mg.

Table 2. Proximate composition of dietary samples in g/100g of the diet

Dietary Sample	Crude Protein%	Ash%	Crude Fibre%	Ether Extract%	Moisture (dry basis)%	Nitrogen Free Extract%	Energy kcal/100g
Diet A	$12.61^a \pm 04$	$2.61^b \pm 03$	$5.31^a \pm 01$	$4.90^a \pm 01$	$2.75^b \pm 02$	$68.63^e \pm 03$	$545.42^e \pm 02$
Diet B	$20.75^e \pm 02$	$3.01^e \pm 01$	$6.25^d \pm 02$	$6.74^d \pm 03$	$3.11^d \pm 03$	$56.96^a \pm 02$	$371.40^c \pm 01$
Diet C	$19.60^d \pm 03$	$2.86^d \pm 01$	$5.95^c \pm 04$	$6.13^c \pm 01$	$3.29^e \pm 02$	$58.56^b \pm 01$	$367.83^b \pm 02$
Diet D	$16.71^c \pm 01$	$2.76^c \pm 04$	$5.86^b \pm 02$	$5.24^b \pm 03$	$3.01^c \pm 02$	$63.24^c \pm 03$	$366.94^a \pm 02$
Diet E	$15.00^b \pm 02$	$2.40^a \pm 02$	$7.05^e \pm 04$	$9.05^e \pm 02$	$2.55^a \pm 04$	$64.05^d \pm 02$	$397.65^d \pm 03$

Values with different superscript in a column are significantly different ($P < 0.05$)

Table 2 shows the proximate composition and Energy kcal/100g of the dietary A-E; the crude protein, ash, crude fibre, ether extract, moisture (dry basis), nitrogen free extract and energy kcal/100g were ranged from 12.61 -20.75; 2.40 -3.01; 5.31- 7.05; 4.90 -9.05; 2.55 - 3.29; 56.96 -68.63 and 366.94 -545.42 kcal/100g respectively. The dietary were nutritional adequate to prepare a complementary food and meet the estimated daily nutrient requirements for complementary (FAO/WHO, 1998, Akubor, *et al* 1999, Ibironke, *et al* 2012).

Table 3. Mineral composition of dietary samples in mg/100g of diet

Dietary Sample	Calcium (mg/100g)	Phosphorus (mg/100g)	Sodium (mg/100g)	Magnesim (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
Diet A	$17.41^a \pm 01$	$529.75^b \pm 02$	$76.30^a \pm 01$	$184.60^a \pm 03$	$444.15^a \pm 02$	$4.815^a \pm 01$	$2.75^a \pm 01$
Diet B	$48.70^e \pm 03$	$948.45^e \pm 04$	$112.65^d \pm 03$	$324.72^e \pm 02$	$725.70^e \pm 01$	$10.115^d \pm 01$	$6.55^d \pm 03$
Diet C	$34.78^c \pm 00$	$775.90^d \pm 01$	$97.805^c \pm 02$	$214.70^c \pm 04$	$654.80^d \pm 01$	$8.605^c \pm 02$	$4.75^c \pm 02$
Diet D	$22.82^b \pm 04$	$661.10^c \pm 01$	$86.76^b \pm 03$	$192.60^b \pm 01$	$531.15^b \pm 02$	$6.71^b \pm 04$	$3.60^b \pm 03$
Diet E	$39.60^d \pm 01$	$260.10^a \pm 01$	$210.50^e \pm 01$	240.20^d	$570.20^c \pm 03$	$10.22^e \pm 03$	$6.77^d \pm 01$

Values with different superscript in a column are significantly different ($P < 0.05$)

The mineral composition of the dietary samples is shown in Table 3. The values for calcium, phosphorus, potassium, iron, zinc, sodium, magnesium, of all the diets were significantly different from one another compared with the control. Nutrend has the lowest in phosphorus while it has the highest content of iron, sodium, and zinc. Diet B (fermented maize, soybean and pigeon pea) had the highest value in calcium, phosphorus, potassium, and magnesium compared with the others. It was discovered that some of the minerals were lowered in values compared to the requirement for weaning diet, such as iron level of diets A and D, while some of the mineral values were lower compared with recommended daily allowance for weaning diets such as in calcium with low values in Diets A, C, D, E but Diet B had a higher value.

Table 4. Functional Properties of Dietary Samples

Dietary Samples	Bulk Density (g/ml)	Water Absorption Capacity (g/g)	Swelling Power %	Gelation Capacity % w/c
Diet A	$0.461^a \pm 01$	$1.202^a \pm 01$	$23.67^a \pm 01$	$12.61^a \pm 01$
Diet B	$0.741^e \pm 04$	$1.485^e \pm 03$	$38.74^e \pm 00$	$16.30^d \pm 03$
Diet C	$0.640^d \pm 03$	$1.375^c \pm 01$	$33.80^c \pm 04$	$14.86^c \pm 02$
Diet D	$0.574^c \pm 01$	$1.265^b \pm 02$	$30.71^b \pm 01$	$13.74^b \pm 03$
Diet E	$0.535^b \pm 02$	$1.437^d \pm 03$	$34.81^d \pm 03$	$16.41^e \pm 01$

Values with different superscript in a column are significantly different ($P < 0.05$

Table 4 shows the functional characteristics composition of the formulated diets, (FAO/WHO 1998).

3.1. Bulk Density

The values of the dietary samples were significantly different from one another with Diet B having the highest value of 0.741g/ml while the basal diet had the lowest value of 0.461g/ml because it has the highest amount of flour particles that can stay together. Fermentation is discovered to reduce the bulk of food by reducing the viscosity. The bulk density is a reflection of the load the sample can carry if allowed to rest directly on one another. High bulk density of powdered food

is desirable for packing, since it allows more weight to be contained in a limited volume, (Hansen, *et al* 1989).

3.2. Water Absorption Capacity

The water absorption capacity gives an indication of the amount of water available for gelatinization, (Kulkarni, *et al,*1990). There were significant differences in the formulated samples compared to the control, the values ranging between 1.202 – 1.487g/g. This may be as a result of production of liquid gruel due to breakdown of starch by the enzymes, which leads to reduction in water absorption capacity and the release in the water trapped in the gel, (Hansen, *et al,* 1989, AOAC, 1990).

3.3. Swelling Capacity

The following values were recorded for diets A – E 23.67, 38.74, 33.80, 30.71, and 34.81 respectively. There were significant differences in the diets. Diet D was having the lowest value compared to diet B having the highest value. There was reduction in swelling of the fermented diets, this could be as a result of enzymes (amylase) released to breakdown the starch into dextrin-maltose which does not swell so well when cooked into gruel, (Hansen, *et al* 1989, AOAC, 1990).

3.4. Gelation Power

The values of the dietary samples were significantly different from one another. Diet A has the lowest value while diet B had the highest value. The values ranged from 12.61-16.41, the control diet had the highest gelation power. Diets that form gel at low concentrations are not ideal for weaning foods because they would require a lot of dilution in an attempt to improve digestibility in relation to volume, (Hansen, *et al* 1989, AOAC, 1990).

4. Conclusion

Functional properties has shown that formulated diets was highly digestibility, optimum in water uptake, desirable for packing, enable mothers at home to quantify diets (1g/ml) during preparation. However, from the study, the diet B which is maize- soybean – pigeon pea produced the best result of all the formulated diet when compared to the control (Nutrend), it can be used in ameliorating protein energy malnutrition in infants that are weaned.

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