

EVALUATION OF PLANTAIN AND COWPEA BLENDS FOR COMPLEMENTARY FOODS

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Abstract

Complementary foods were produced from plantain and cowpea flours using ratios 70/30, 60/40, 50/50, 40/60 and 30/70. The samples were evaluated for chemical composition, functional and pasting properties. Moreover, the nutritional evaluation of the diets was done through rat feeding. Protein efficiency ratio (PER), Net protein retention (NPR), True digestibility (TD) were estimated. Blood samples were also collected for hematological analysis. The blends were prepared for sensory evaluation by cooking with addition of sucrose and vegetable oil. A commercial proprietary weaning food was used as control. The protein content ranged from 13.60 to 22.67% and it increased with increase in cowpea inclusion. The energy content ranged from 351 to 355.03kcal/100g and it was highest in 70/30 blend. There were significant differences ($p < 0.05$) in the dispersibility, water absorption capacity, loose and packed bulk densities and pasting characteristics evaluated. Highest mean weight gain (73.36g) was obtained from rats fed the skimmed milk diet followed by rat fed 30/70 (28.04g) and the least (13.07g) was obtained from 50/50 blend. The net protein utilization (NPU) ranged from 43.6 to 75.4% while the true digestibility was highest for rats fed 30/70 blend followed by rats fed the control diet. No significant differences ($P > 0.05$) were obtained from hematological parameters measured. The 60/40 plantain-cowpea complementary food was next to the control in terms of aroma with the score 5.70, while 50/50 plantain-cowpea complementary food was scored best in terms of texture with 5.70.

Keywords: plantain, cowpea, complementary foods. nutritive value, consumer acceptance

1. INTRODUCTION

Childhood malnutrition is a major public health problem throughout the developing world, and is one of the principal underlying causes of death for many of the world's children (Murray and Lopez, 1997). Grantham-McGregor et al. (2007) suggested that poor nutrition during infancy is likely to lead to poor academic achievement, low incomes in adulthood and inadequate care for the children of subsequent generations. Commercially available complementary foods in the developing countries are too expensive for average family (Onweluzo and Nwabugwu, 2009). Consequently, nursing mothers often depend on traditional complementary foods, which are often inadequate in energy density, protein and micronutrient. These traditional weaning foods are often prepared, stored or fed to the children in ways that increase risk of illness (Caulfield et al., 1999). Although there are many indigenous and unexploited grain legumes, which can be processed and when properly complemented with commonly available carbohydrate sources will provide relatively affordable weaning foods that will help to alleviate protein-energy malnutrition (PEM) and improve infant nutrition.

Plantain (*Musa paradisiaca*) is an important staple crop that contributes to the calories and subsistence economies in Africa (Adeniji and Tenkouano, 2008). It is a fruit that is rich in iron and other nutrients (Aremu and Udoessien, 1990). Plantains have high carbohydrate content (31g/100g) and low fat content (0.4g/100g). They are good sources of vitamins and minerals (Adeniji et al., 2006). It is also rich in non-dietary polysaccharides including cellulose, pectic substances, hemicelluloses and other polysaccharides. Unripe plantain pulp has a total of 3.5% dry matter as cellulose and hemicelluloses, hence a good source of dietary fibre (Kirk and Sawyer, 1991). The amino acid components of plantain include histidine, arginine and leucine. The ascorbic acid content is high compared to that of banana. In comparison with other starchy staples; vitamin C content is similar to those of sweet potato, cassava and potato. It provides a better source of vitamin A than most other staples (USDA, 2009).

Cowpeas (*Vigna unguiculata*) are probably the most popular grain legume in West Africa. Unlike other legumes such as soybeans and groundnut which is oil-protein seeds, cowpeas are starch-protein

seeds offering a wider pattern of utilization than any other legume (Henshaw et al., 1996). Dry cowpea seeds are important source of protein, B-vitamins and minerals in the predominantly carbohydrate based diet of people in rural community of Southern Africa (Mwangwela, 2006). Cowpea protein is rich in essential amino acids such as leucine, isoleucine, and lysine, phenylalanine and as such high in both protein quality and quantity (Ihekoronye and Ngoddy, 1985). It also contains some phenolic compounds (Mokgope, 2006). These anti-nutritional factors form complexes with food nutrients such as minerals and protein thus rendering them less available for absorption (Towo et al., 2003). Processing such as dehulling, soaking, heating and fermentation are known to reduce the presence of the anti-nutritional factors in cowpeas (Vijayakumari et al., 1998; Egounlety and Aworh, 2003).

The aim of this work was to produce and evaluate the quality attributes and acceptability of complementary food using plantain and cowpea blends.

2. MATERIALS AND METHODS

2.1 Material preparation

Matured green plantain fruits were obtained from research farm of Federal University of Agriculture, Abeokuta, Nigeria. Cowpea grains (Oloyin variety) were purchased at a retail Market in Ibadan, Oyo State, Nigeria. The plantain fruits were processed to flour following the method described by Kure et al. (1998) with slight modification (Figure 1). The cowpea grains were also processed to cowpea flour following the method described by Egounlety et al. (2002) with slight modification (Figure 2). The formulation of plantain-cowpea complementary food was based on the specification of a joint FAO/WHO/UNU (1985) Committee that stipulated a minimum level of 16.7% for protein. Five different blends consisted of plantain/cowpea flours in ratios 70/30, 60/40, 50/50, 40/60 and 30/70 (w/w) were produced. The samples were packed in moisture-proof low density Polyethylene and kept in refrigeration (10°C) for further use.

2.2 Determination of functional properties

Bulk density was determined by the method described by Eltayeb et al. (2011). Dispersibility was determined by the method described by Kulkarni et al. (1991). Water absorption capacity was determined using the method of Sathe and Salunkhe (1981). The least gelation concentration was determined as the concentration when the suspension from inverted test tube did not slip (Adebowale et al., 2005).

2.3 Determination of proximate composition

Proximate composition of the samples including crude protein, crude fat, crude fibre, ash and moisture contents were determined by standard methods of AOAC (2005). Carbohydrate was expressed as the difference between aforementioned constituents and 100%.

2.4 Analysis of pasting characteristics of the blends.

Pasting properties for each of the samples were determined using Rapid Visco Analyzer (New-port Scientific 1998). The sample (3.5g) and 25mL of distilled water were dispensed into a canister. Paddle was placed inside the canister this was placed centrally onto the paddle coupling and then inserted into the RVA machine. The slurry was heated from 50 to 90°C over a period of 3 min 45 seconds held at 95°C for 2 min and then cooled to 50°C over a period of 3 min 45 seconds. Peak viscosity, trough, breakdown viscosity, final viscosity, setback viscosity, peak time and pasting temperature were read from the pasting profile with the aid of a window's software connected to the computer.

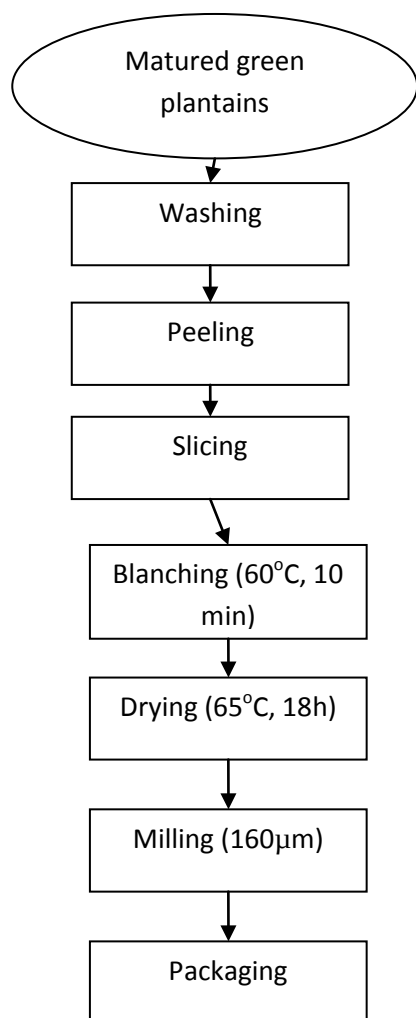


Figure 1: Production of plantain flour

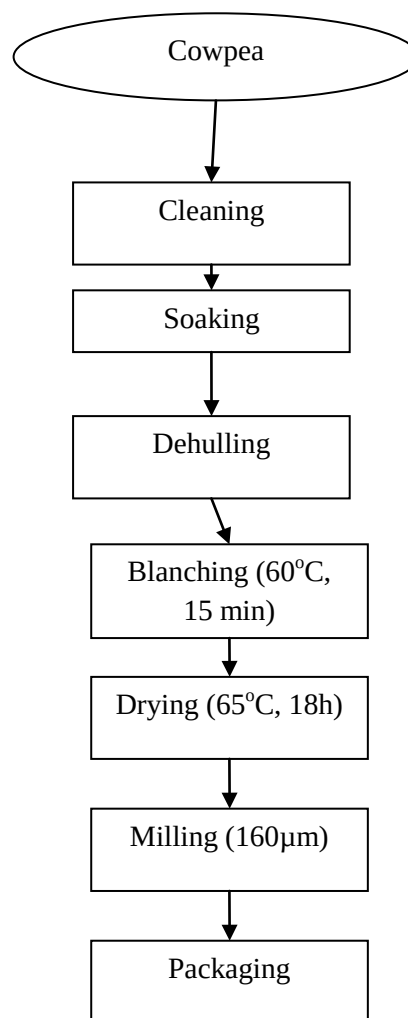


Figure 2: Production of cowpea flour

2.5 Nutritional evaluation of the complementary foods

A basal diet was prepared according to Fanimó (1991). Experimental and control diets were made by incorporating the complementary blends and skimmed milk (control) into the basal diet (protein free diet) to achieve an isonitrogenous diet at 10% protein as reported by Egounlety et al. (2002). Thirty-five albino rats (male and female) of 22-26 days old were randomly distributed into seven groups, placed in cages and fed stabilizing diet containing 4% skimmed milk for a period of five days after which they were re-weighed and re-grouped into seven groups having one group for control diet, five groups for experimental diets and the last for the protein-free diet. The animals were housed in cages and food and water were supplied ad libitum. The diets were fed to the animals for a period of 28 days. This period is nutritionally acceptable to be long enough to observe biological and chemical changes in animal tissues (Egounlety et al., 2002). Both dietary intake and live weights of the animals were recorded twice a week throughout the experimental period. Faeces were collected during the experimental period. The faeces were first air dried and finally at 105°C for 24h. At the end of the test period, the rats were sacrificed with chloroform after a starving period of 18h. The organs like liver, pancreas, kidney and adrenal gland were removed and weighed. The carcasses were dried in oven at 105°C for 3 days and digested for nitrogen determination by macro-Kjeldahl method. The protein efficiency ratio (PER), the net protein retention (NPR), the true digestibility (TD), the biological value (BV) and the net protein utilization (NPU) were calculated as reported by Egounlety et al. (2002).

2.6 Hematological analysis

The rats were slaughtered after 28 days feeding with the experimental diets and the blood samples were collected into anticoagulant coated sodium salt of ethylene diamine tetraacetic acid (EDTA) Bijou bottle at the end of the test period through ocular bleeding using capillary tube insertion. The blood collected was mixed thoroughly by gentle rotation of the bottle to enable the dried salt to be rapidly dissolved thereby preventing blood clotting (MAFF, 1984). The Packed Cell Volume (PCV) of the blood sample collected was determined using Haematocrit method. The blood sample was mixed by inverting about 20 times after which capillary tube was filled with blood by capillary action to the 10mark ensuring that there is no bubble. The vacant end of the tube was then sealed in the flame of a burner. It was then centrifuged at 209.8g (3000rpm) for 30 minutes after which the height of the red cell column was noted. This was repeated until two consecutive equal readings were obtained. The height of the column of red cells was read off and expressed as percentage of the total blood volume (MAFF, 1984). Red Blood Cell counting was done through the use of Neubauer haemocytometer. The equipment was cleaned and about 4ml of red blood cell dilution fluid was placed in bijou bottle and blood sample added. The sample was mixed properly by inverting for about 20 times avoiding vigorous agitation and 20 μ l pipette with disposable tip was used to draw up the blood and this was emptied in the bijou bottle containing the dilution fluid, and then mixed thoroughly using mechanical shaker. The red blood cell dilution was then taken in a capillary tube and then filled into counting chamber of haemocytometer by holding the tube at 45° and lightly touching the tip against the edge of the chamber and coverglass avoiding overflow into the channels. The counting chamber was then placed on the microscope stage and allowed to stand for 2 minutes before commencing the count in order to allow the cells to settle. Using a high dry objective, total red blood cells that are contained in 80 small squares were counted i.e. cells in five groups of 16 small squares including cells in the four corner squares and the centre square. Red blood cells present was calculated (MAFF, 1984).

2.7 Determination of white blood cell (WBC)

White blood cell diluting fluid was measured (0.95ml) into a bijou bottle. 50 μ L pipette was used to draw blood sample after thorough mixing by inversion for 20 times and then expelled into the dilution fluid. The fluid was used to wash out the content of the pipette by alternately drawing the fluid and expelling it into the bottle three times. The content of the bottle was mixed properly using mechanical shaker after which the neubauer counting chamber was filled in the same way as it was done for RBC except that the squares counted on the chamber were the four corner 1mm squares. White Blood Cells were calculated as shown below (MAFF, 1984).

$$\text{WBC} = \text{Average number of cells counted per square mm} \times \text{Depth} \times \text{Dilution} \dots\dots\dots (1)$$

2.8 Differential white blood cell (Leucocyte) count

A drop of blood sample was placed at one end of a clean grease free slide and allowed to spread along its edge using a beveled piece of glass that was a little narrower than the slide. The smear was slightly thicker at the start than at the tail end. The film was dried rapidly in air by vigorous shaking and then stained with Romanowsky stain. The counting was done starting from the outer margin of the smear for about 3 fields moving inward a short distance then paralleling the margin. The procedure was repeated as many times as necessary until about 200 cells have been enumerated. The leucocyte count was recorded for each 100 cells counted and the gross total was also recorded and the differential count was arrived at by finding the respective percentages of each set of the cells in the total count (MAFF, 1984).

2.9 Determination of haemoglobin concentration

The blood sample was mixed by inversion 20 times and 0.02ml was pipette into a bottle containing 5ml of Drabkin's solution of 1/251 dilution. This was mixed thoroughly and allowed to stand for 10 minutes after which the optical density of the solution was read in a colorimeter at 540nm using the tube of Drabkin's solution as a blank. The corresponding haemoglobin concentration was read on a standard calibration curve and recorded (MAFF, 1984).

2.10 Blood indices determination

Blood indices such as Mean Cell Volume (MCV), Mean Cell Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC) were determined from the values of Red Blood Cell (RBC), Packed Cell Volume (PCV) and Haemoglobin (Hb) counts using the equations below (MAFF, 1984).

$$MCV = \frac{PCV (\%)}{RBC (/ \mu l)} \times 100 fl \quad \text{----- (2)}$$

$$MCH = \frac{Hb (g/100ml)}{RBC (/ \mu l)} \times 10pg \quad \text{----- (3)}$$

$$MCHC = \frac{Hb (g/100ml)}{PCV (\%)} \quad \text{----- (4)}$$

2.11 Total protein

The blood sample collected was centrifuged and the plasma separated into a bijoux bottle. The total protein was determined using the biuret method which involved mixing 0.1ml of serum with 2.9ml of distilled water and the addition of 3ml of biuret reagent. The blank was prepared by adding 3ml of biuret reagent to 3ml of distilled water. The optical density of the sample was read in a spectrophotometer at 540nm. The instrument was standardized using standards of known optical density and zeroed with the blank. The corresponding total protein concentration in g/100ml was read off a calibration curve (MAFF, 1984).

2.12 Sensory evaluation of plantain-cowpea complementary foods

The complementary food was prepared by cooking each of the plantain-cowpea blends for 15 minutes, thereafter cooled with incorporation of granulated table sugar (6%, w/w) and refined vegetable oil (5%, w/w). The vegetable oil was added to increase the fat content of the food to the stipulated minimum level of 6% in a complementary food (FAO/WHO/UNU, 1985). The samples were evaluated by a panel consisting of twenty-five nursing mothers attending the Polytechnic Ibadan Health centre and their children of ages between 6 months and 2 years using multiple comparison tests. A porridge made from commercial complementary food was used as a reference against which the assessors were asked to compare the colour, flavour, texture, aroma and overall acceptability of plantain-cowpea based complementary food on a nine point hedonic scale where 9 = extremely better and 1= extremely inferior to the reference.

2.13 Statistical analysis

The procedure was replicated and data obtained were subjected to analysis of variance (ANOVA) at the significance level of 5%. Duncan Multiple Range Test was used to separate the means using SPSS version 19.0.

3. RESULTS AND DISCUSSION

3.1 Functional properties of plantain-cowpea based complementary foods

The functional properties of plantain/cowpea based complementary foods are presented in Table 1. There were significant differences in both the loose and packed bulk densities ($p < 0.05$) for all the formulations. The loose bulk density ($0.486\text{--}0.514\text{ g/cm}^3$) and packed bulk density ($0.835\text{--}0.886\text{ gcm}^{-3}$) values increased with increase in the amount of cowpea flour in the blends. The values were similar to the values reported by Egounlety et al. (2002) for tempeh-fortified maize based complementary foods. The water absorption capacity of the samples decreased with increase in cowpea flour inclusion and ranged from 150 to 170g/g. The values recorded were significantly higher than the values (120–140g/g) reported for sorghum-toasted soyabean flour blends (Onimawo and Onofua, 2003). The high water absorption capacity had been attributed to loose structure of starch polymers, while low value indicated the compactness of molecular structure (Sanni et al., 2006). There were no significant differences ($p > 0.05$) in the least gelation concentration (5.4–5.8%) for all the plantain/cowpea samples. The dispersibility of the plantain/cowpea samples ranged from 89 to 90%. There were no significant differences in the dispersibility for all the samples. The dispersibility indicates the ease with which the flour can be distributed as a single particle throughout the bulk of reconstituting water. It measures the reconstitution ability of the flour; hence high dispersibility values obtained indicate their stability in reconstituted food products (Sanni et al., 2006).

3.2 Proximate composition of plantain-cowpea based complementary foods

The proximate compositions of plantain-cowpea complementary foods are presented in Table 2. There were significant differences ($p < 0.05$) in protein, fat, ash, carbohydrate as well as energy content of all the blended samples but no significant differences ($p > 0.05$) were observed in their moisture and crude fibre contents. The moisture content values observed (9.67–9.53%) were similar to the values reported by Egounlety et al. (2002) for legume fortified weaning foods which ranged from 8.5 % to 9.20%, and within the range of the values reported by Abasiekong et al. (2010) for maize–bambara nut complementary foods (9.84–11.2%). The protein content for plantain flour alone was 2.10%, while that for the blends increased with increase in the amount of cowpea flour in the blends (13.6–22.7%), showing the practical significance of adding cowpea flour to the blend. Except for 70/30 plantain-cowpea complementary sample, the protein content was higher than that reported by Ezeocha and Onwuka (2010) for maize-soyabean based complementary blends which ranged from 14.9 to 15.9% and those reported by Abasiekong et al. (2010) for maize-bambara nut complementary food which ranged from 13.8 to 16.1%. The crude fat content of the complementary foods ranged from 1.83 to 2.20%. The values were in the same range with the fat content of defatted soy-fortified pupuru (1.10% to 2.75% for 10 to 25% soy inclusion) reported by Lasekan et al. (2004). The crude fibre content of the complementary foods ranged from 1.60 to 1.73%. These values were significantly higher than the value of 1.43% obtained for plantain flour alone. The carbohydrate content decreased with increase in cowpea flour inclusion. It ranged from 59.73% in 100% cowpea flour to 64.57% in 50/50 plantain-cowpea formulation to 82.47% in 100% plantain flour. The energy content of plantain-cowpea complementary formulation ranges from 351 to 355kcal/100g. These values are slightly lower than the recommended level of 375kcal/100g for complementary food (Egounlety et al., 2002).

Table 1: Mean* value of functional properties of plantain-cowpea based complementary foods

Sample (plantain/cowpea ratio)	Least gelation concentration (%)	Water absorption capacity (%)	Dispersibility (%)	Bulk density (loose)	Bulk density (packed)
100/0	6.0 ^a	150 ^c	85 ^b	0.449 ^f	0.835 ^e
70/30	5.8 ^b	170 ^{ab}	89 ^a	0.486 ^e	0.842 ^d
60/40	5.4 ^b	160 ^{bc}	90 ^a	0.496 ^{cd}	0.864 ^c
50/50	5.4 ^b	160 ^{bc}	89 ^a	0.494 ^d	0.876 ^b
40/60	5.6 ^b	160 ^{bc}	89 ^a	0.502 ^b	0.886 ^a
30/70	5.4 ^b	150 ^c	89 ^a	0.514 ^a	0.882 ^a
0/100	4.8 ^a	180 ^a	89 ^a	0.499 ^c	0.882 ^a

*Means of three replicates analysis.

Means not followed by the same superscripts along the column are significantly ($p < 0.05$) different

Table 2: Mean* proximate composition of plantain-cowpea based complementary foods

Sample (plantain/cowpea)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Energy kcal/100g
100/0	9.10 ^b	2.10 ^g	1.63 ^e	3.27 ^{cd}	1.43 ^b	82.5 ^a	353 ^{bc}
70/30	9.67 ^a	13.6 ^f	1.83 ^d	3.30 ^{bc}	1.60 ^a	71.0 ^b	355 ^a
60/40	9.53 ^a	15.7 ^e	1.90 ^d	3.07 ^d	1.60 ^a	68.2 ^c	353 ^{bc}
50/50	9.53 ^a	18.9 ^d	2.03 ^c	3.20 ^{cd}	1.70 ^a	64.6 ^d	352 ^{bc}
40/60	9.53 ^a	21.5 ^c	2.13 ^{bc}	3.60 ^a	1.63 ^a	61.6 ^e	352 ^c
30/70	9.53 ^a	22.7 ^b	2.20 ^b	3.67 ^a	1.73 ^a	60.2 ^f	351 ^c
0/100	9.47 ^a	23.4 ^a	2.37 ^a	3.47 ^{ab}	1.60 ^a	59.7 ^g	354 ^{ab}

*Means of three replicates analysis

Means within the same column not followed by the same superscripts are significantly ($p < 0.05$) different

3.3 Pasting properties of plantain-cowpea complementary foods

The results obtained for the pasting properties of plantain-cowpea blends are shown in the Table 3. There were significant ($p < 0.05$) differences in peak viscosity, trough, breakdown viscosity, final viscosity as well as setback viscosity, while no significant ($p > 0.05$) differences were observed in both the peak time and pasting temperature. The pasting temperature of the plantain/cowpea samples ranged from 84.4 to 85.2°C. The observed values were within the range of values reported by Henshaw and Adebawale (2004) for six varieties of cowpea starches (69 to 86°C). The pasting temperature gave an indication of the minimum temperature to cook a sample. It was observed that the peak viscosity decreases with increase in cowpea level. The value of peak viscosity ranged from 1881 to 3987RVU for the samples. The observed decrease in peak viscosity as cowpea flour increased in the blends can be attributed the lowering starch content of the product (Adeyemi and Beckley, 1986). The peak time values ranged from 5.40 to 5.77 minutes. The trough, breakdown viscosity, final viscosity

and setback viscosity decreased with increase in cowpea level. Pasting characteristics of the flour was reported to be affected by interactions such as hydration rate of starch granules by binding water in competition with starch and other factors such as the components of the starch granules i.e. amylose and amylopectin ratio, starch granules size and other physical and chemical properties (Henshaw et al., 1996).

Table 3: *Mean values of pasting properties of plantain-cowpea blends

Sample	Peak viscosity (RVU)	Trough (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (minutes)	Pasting temperature (°C)
70/30	3987 ^a	3147 ^a	840 ^a	5072 ^a	1925 ^a	5.40 ^b	84.4 ^a
60/40	3378 ^b	2792 ^b	586 ^b	4389 ^b	1597 ^b	5.63 ^a	85.2 ^a
50/50	2880 ^c	2465 ^c	415 ^c	3742 ^c	1276 ^c	5.67 ^a	85.2 ^a
40/60	2332 ^d	2036 ^d	295 ^d	2988 ^d	952 ^d	5.77 ^a	84.8 ^a
30/70	1881 ^e	1672 ^e	209 ^e	2378 ^e	706 ^e	5.77 ^a	85.2 ^a

*Means of three replicates analysis

Means within the same column not followed by the same superscripts are significantly ($p < 0.05$) different

3.4 Nutritional evaluation of plantain-cowpea based complementary foods

Table 4 shows the result of nutritional evaluation of plantain-cowpea based complementary foods and skimmed milk diet (control). Skimmed milk powder was used because of difficulty in getting skimmed milk. There were significant differences ($p < 0.05$) in mean weight gain, protein efficiency ratio (PER), net protein retention (NPR), net protein utilization (NPU) and feed efficiency ratio (FER), between rats fed skimmed milk diet and plantain-cowpea based complementary diets. The mean weight gain was highest for rats fed skimmed milk diet (73.36g) followed by rat fed 30/70 plantain-cowpea diet (28.04g) and rat fed 50/50 plantain-cowpea diet had the lowest weight gain of 13.07g. The weight gain by the experimental rats were lower than that reported by Egounlety et al. (2002) for rats fed tempeh fortified maize based weaning foods but are comparable with that reported by Oluwamukomi et al., (2003) for rats fed sorghum-cowpea based weaning foods. The PER ranged from 0.66 in rats fed 50/50 plantain-cowpea diet to 1.226 in rats fed 30/70 plantain cowpea diet, these values are lower than that obtained for rats fed skimmed milk diet and are comparable with that reported by Oluwamukomi et al., (2003) for rats fed sorghum-cowpea based weaning food but lower than that reported by Osundahunsi and Aworh (2003) for rats fed maize based complementary foods enriched with soyabean and cowpea tempeh which range from 2.30 in ogi-soy tempeh to 2.42 ogi-cowpea tempeh. The NPR values for the plantain-cowpea complementary diets were lower than that of skimmed milk diet (2.65) and ranged from 0.98 for 50/50 to 1.526 for 30/70 plantain-cowpea complementary diets. These values were higher than those reported by Oluwamukomi et al. (2003) for rats fed sorghum-cowpea based complementary diet (0.75 to 0.98). The NPU ranged from 43.56% for 30/70 to 75.38% for 40/60 plantain-cowpea complementary diets, they were comparable with that reported by Egounlety et al., (2002) for tempeh fortified maize based weaning foods, which ranged from 65.02% for ogi-cowpea tempeh to 72.42% for maize-cowpea tempeh diets. The true digestibility ranged from 47.18% in 60/40 to 93.70% in 30/70 plantain-cowpea diets, there was no significant difference ($p > 0.05$) between the true digestibility of rat fed 70/30, 50/50 and 40/60 plantain/cowpea complementary diets and that of rats fed skimmed milk diet. The values are comparable with that reported by Egounlety et al., (2002) for rats fed tempeh fortified maize-based weaning foods. The lowest value for FER of 0.07 was obtained for rats fed 50/50 plantain-cowpea complementary diet while the highest value of 0.75 was obtained for rats fed 70/30 plantain-cowpea complementary diet.

The values obtained for rats fed 60/40, 40/60 and 30/70 plantain-cowpea complementary diets (0.12) are comparable with that reported by Edem (2009) for rats fed palm oil containing diets which ranged from 0.11 for 20% red palm oil containing diet to 0.19 for 10% red palm oil and 10% corn oil containing diets.

Table 4: *Mean values of Nutritional evaluation of plantain-cowpea based complementary foods

Diets sample	Protein efficiency ratio	Net protein retention	Net protein utilization	True digestibility	Feed efficiency ratio
Skimmed milk	2.426 ^a	2.65 ^a	30.37 ^c	80.63 ^b	0.242 ^a
70/30	0.75 ^{cd}	1.084 ^{bc}	57.72 ^{ab}	71.40 ^{bc}	0.750 ^{bc}
60/40	1.152 ^{bc}	1.512 ^b	67.00 ^{ab}	47.18 ^d	0.115 ^b
50/50	0.66 ^d	0.984 ^c	68.77 ^{ab}	66.37 ^c	0.066 ^c
40/60	1.224 ^b	1.522 ^b	75.38 ^a	71.35 ^{bc}	0.122 ^b
30/70	1.226 ^b	1.526 ^b	43.56 ^{bc}	93.70 ^a	0.123 ^b

*Means of three replicates analysis

Means within the same row not followed by the same superscripts are significantly ($p < 0.05$) different

3.5 Haematological analysis of rats fed plantain-cowpea complementary foods

The results of haematological changes were presented in Table 5. Packed cell volume (PCV) of rats fed experimental diets varied from 41.33% in 60/40 formulation to 43.67% in skimmed milk diet. There was no significant difference ($p > 0.05$) between the PCV of rats fed experimental diets and those fed control diet i.e. skimmed milk diet. The PCV of rats fed basal diet was significantly lower ($p < 0.05$) than that of rats fed both the experimental diets and control diet (skimmed milk diet). The PCV was higher than that reported Osundahunsi and Aworh (2003) and are in the same range with that reported by Kumar et al., (2011). A decrease in haematocrit (PCV) value may show the extent of the shrinking cell size due to chemical intoxication (Atamanalp and Yanik, 2003), the significant increase in the study indicates the normal functioning of bone marrow (Kumar et al., 2011).

The haemoglobin concentration of rats fed experimental diets ranged from 13.07g/100ml in 50/50 formulation to 14.03g/100ml in 40/60 formulation while that of rats fed skimmed milk diet was 14.37g/100ml. The haemoglobin concentrations were in the same range with that reported by Kumar et al., (2011) but slightly higher than that reported by Osundahunsi and Aworh (2003) in rats fed maize based complementary diets enriched with soya and cowpea tempeh. Red blood cell (RBC) counts varied from 6.62 in 60/40 plantain/cowpea complementary diet to 7.33 in 70/30 plantain/cowpea complementary diet. There were no significant differences ($p > 0.05$) between the RBC of rats fed experimental diets and the control diet (skimmed milk diet) but they significantly differed from those fed basal diet. The RBC counts were higher than that reported by Osundahunsi and Aworh (2003) 5.77 in maize cowpea tempeh to 5.96 in ogi-cowpea tempeh and are in the same range with that reported by Kumar et al. (2011) for rats administered with Lantana aculeate weed extract ranging from 7.89 in control to 8.37 in rats administered 100mg/kg body weight. There were no significant differences ($p > 0.05$) in the values of mean corpuscular volume (MCV) and white blood cell (WBC) counts, for both the rats fed experimental diets and the control diets the MCV values ranging from 58.50fl in 50/50 to 62.44fl in 60/40 formulation diets and the (WBC) counts for the rats fed with experimental diets ranged from 5.73 in 70/30 to 8.05 in 60/40 plantain/cowpea complementary diets, the values obtained were comparable with that reported by Kolawole and Alemika (1996) for rats administered with halofantrine. Mean corpuscular haemoglobin (MCH) ranged from 18.16pg in 50/50 to 19.88pg

in 60/40 formulation diets, there were significant differences ($p < 0.05$) between the MCH of the rats fed with the experimental diets and those fed protein free (basal) diet. The mean corpuscular haemoglobin concentration (MCHC) values of the rats fed with the experimental diets and the skimmed milk diet were not significantly different from one another and the value ranged from 31.09% to 32.08% in rats fed with 50/50 and 40/60 formulation respectively. These values are comparable with that reported by Edem (2009) for rats fed with diets containing palm oil.

Table 5: *Mean values of Haematological analysis of rats fed plantain-cowpea complementary foods

Diet sample	PCV (%)	Hb (g/100ml)	RBC ($\times 10^6 / \mu\text{l}$)	MCV (fl)	MCH (pg)	MCHC (%)	WBC ($\times 10^3 / \mu\text{l}$)
Skimmed milk	43.67 ^a	14.37 ^a	7.31 ^a	59.72 ^a	19.65 ^{ab}	32.90 ^a	8.53 ^a
70/30	43.33 ^a	13.87 ^a	7.33 ^a	59.23 ^a	18.95 ^{abc}	32.00 ^{ab}	5.73 ^a
60/40	41.33 ^a	13.17 ^a	6.62 ^{bc}	62.44 ^a	19.88 ^a	31.14 ^{ab}	8.05 ^a
50/50	42.00 ^a	13.07 ^a	7.20 ^{ab}	58.50 ^a	18.16 ^c	31.09 ^{ab}	7.38 ^a
40/60	43.67 ^a	14.03 ^a	7.23 ^{ab}	60.44 ^a	19.38 ^{abc}	32.08 ^{ab}	6.77 ^a
30/70	42.67 ^a	13.33 ^a	7.27 ^{ab}	58.72 ^a	18.34 ^{bc}	31.25 ^{ab}	6.92 ^a
Basal	38.67 ^b	11.73 ^b	6.49 ^c	59.59 ^a	18.08 ^c	30.34 ^b	8.17 ^a

*Means of three replicates analysis

Means within the same column not followed by the same superscripts are significantly ($p < 0.05$) different

3.6 Differential white blood cell count of rats fed plantain-cowpea based complementary foods

The results of differential leucocyte counts were presented in Table 6. There is no significant difference ($p > 0.05$) in differential leucocyte counts between rats fed basal diet, skimmed milk diet and plantain-cowpea complementary diets. The lymphocyte counts varied from 70.33% in rats fed 60/40 plantain-cowpea complementary diet to 78.67% in rats fed 30/70 plantain-cowpea complementary diet and these values are lower than the lymphocyte count for rats fed with basal diet (81.67%). The values obtained are higher than those reported by Kolawole and Alemika (1996) for rats administered with various dosage of halofantrine which range from 38% in control to between 50 and 57% in the experimental rats.

Total serum protein varied from 6.53g/100ml in rats fed 70/30 plantain-cowpea complementary diet to 6.80g/ml in rats fed 40/60 plantain-cowpea complementary diets. These values are lower than that obtained in rats fed either skimmed milk diet or basal diet.

Table 6: *Mean differential white blood cell count of rats fed plantain-cowpea complementary foods

Sample diets	Neutrophils (%)	Lymphocyte (%)	Monocytes (%)	Eosinophils (%)	Total protein (g/100ml)
Skimmed milk	29.67 ^a	68.33 ^a	0.67 ^a	1.00 ^a	7.20 ^a
70/30	22.67 ^a	75.00 ^a	1.00 ^a	1.33 ^a	6.53 ^a
60/40	26.33 ^a	70.33 ^a	1.33 ^a	2.00 ^a	6.53 ^a
50/50	25.00 ^a	71.67 ^a	1.67 ^a	1.67 ^a	6.80 ^a
40/60	18.33 ^a	79.33 ^a	1.00 ^a	1.33 ^a	6.80 ^a
30/70	19.00 ^a	78.67 ^a	1.00 ^a	1.33 ^a	6.70 ^a
Basal	16.67 ^a	81.67 ^a	1.33 ^a	0.67 ^a	6.90 ^a

Means of three replicates analysis

Means within the same column not followed by the same superscripts are significantly ($p < 0.05$) different

3.7 Sensory evaluation of plantain-cowpea based complementary foods

The results obtained for multiple comparison test is as presented in Table 7. There were significant differences ($p < 0.05$) between the colour, taste and overall acceptability of the control (cerelac) and the plantain-cowpea based complementary foods whereas no significant difference ($p > 0.05$) was observed in aroma and texture of the porridges except for porridges made from 40/60 and 30/70 plantain-cowpea based complementary foods. The colour of the control was most preferred by the panelists having the highest score of 7.45 followed by 50/50 formulation (5.55) while 40/06 formulation was the least preferred with the score 4.75. Plantain-cowpea based complementary food containing 30% plantain and 70% cowpea was the least preferred in terms of taste and overall acceptability with the score 3.35 and 3.5 respectively. 50/50 plantain-cowpea formulation was the least preferred in terms of aroma (4.80) whereas it is second to the control in taste having the score of 5.80.

Table 7: Mean* scores of sensory evaluation of plantain-cowpea based complementary foods

Sample (plantain/cowpea ratio)	Colour	Aroma	Texture	Taste	Overall acceptability
Control	7.45 ^a	6.45 ^a	5.05 ^{ab}	6.80 ^a	7.60 ^a
70/30	5.15 ^b	4.90 ^b	4.25 ^{ab}	5.10 ^{bc}	4.10 ^b
60/40	5.50 ^b	5.70 ^{ab}	4.35 ^{ab}	4.50 ^c	4.10 ^b
50/50	5.55 ^b	4.80 ^b	5.70 ^a	5.80 ^{ab}	4.50 ^b
40/60	4.75 ^b	5.30 ^{ab}	3.45 ^b	5.25 ^{bc}	3.65 ^b
30/70	5.10 ^b	4.95 ^b	3.95 ^b	3.35 ^d	3.50 ^b

*Means within the same column not followed by the same superscripts are significantly ($p < 0.05$) different

CONCLUSION

Blends of plantain and cowpea flours give complementary foods of improved nutritional quality. The protein content of 50/50 and above plantain-cowpea complementary foods were within the recommended level of greater than 16.70% for complementary diet. The 40/60 plantain-cowpea complementary food supports the growth of the animals more than any other diets. The 50/50 plantain-cowpea complementary food was most preferred in terms of colour as well as taste among all the complementary foods evaluated hence compounding a diet with this ratio will produce a diet that will help to prevent protein-energy malnutrition in weanling children as revealed by the proximate results.

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