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Development and Evaluation of Weaning Foods from Pigeon Pea and Millet

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Abstract: Weaning foods were formulated by complementing millet with pigeon-pea after sprouting and fermentation pre-treatments. Products were evaluated for composition and functional properties. Nutritional quality was evaluated by animal feeding experiment using 36 weanling male Wister rats (45-55g). Untreated composite, commercial weaning food (Cerelac) and casein diet served as controls. Sprouted pigeon pea and sprouted millet (SPSM) composite had high crude and true proteins which compared with protein of casein diet but differed ($p \leq 0.05$) from the protein content of other diets. Calcium and iron in all formulated diets except SPSM compared with the levels in commercial diet. Viscosity was lower ($p \leq 0.05$) in formulated diets (200-209cps) than in commercial control (303cps). Fermented pigeon-pea and fermented millet (SPFM) and sprouted pigeon-pea and fermented millet (SPFM) diets gave highest ($p \leq 0.05$) weight gain (113.51g and 123.42g), PER (2.15 and 2.02), BV (70.7 and 76.2) and NPU (70.13 and 74.57), respectively thus suggesting their superiority over other diets. Diets FPSM and SPFM promoted growth better than other formulated diets.

Key words: Weaning food, high energy density food, protein-energy malnutrition, unexploited legume and cereal, fermentation and sprouting

INTRODUCTION

Weaning is a period of transition for the infant during which its diet changes in terms of consistency and source. From a liquid milk-based diet, the child is gradually introduced to semi-solid food (Draper, 1994). Such semi-solid or generally called weaning food should ideally be easily digestible, have high energy density and low bulk (Ezeji and Ojimelukwe, 1993). Incidentally in Nigeria and many developing countries, commercially available weaning foods are too expensive for the average family so, nursing mothers often depend on traditional weaning foods which often are of low nutritive value (Okeiyi and Futrell, 1983). Meanwhile there are many indigenous and unexploited legumes which can be processed and when properly complemented with commonly available carbohydrate sources will provide relatively affordable weaning foods that will help alleviate protein-energy malnutrition and improve infant nutrition.

Millet and pigeon pea are among the commonly available grains and legumes. They are good protein and carbohydrate sources yet they are unexploited. Millet (*Pennisetum americanum*) is one of the cereals produced extensively in Nigeria. According to FAO (2002), Nigeria produces 21% of the world's total millet. Millet contains about 67% carbohydrate and 12% protein. The seed is high in ash, iron, phosphorus and is an important source of the B group of vitamins (FAO, 1995). The essential amino acid profile of millet indicate that it contains more lysine, threonine, methionine and cysteine than sorghum (FAO, 1995). Despite the rich nutrient content of millet, its use in Nigeria is limited to the production of household porridge-type breakfast gruel (akamu "dawa") and dough (fura).

Pigeon pea (*Cajanus cajan*) is a legume reported to contain 20-22% protein, 1.2% fat, 65% carbohydrate and 3.8% ash (FAO, 1982). The mineral content and amino acid profile of pigeon pea compares closely with those of soybean except in methionine content (Apata and Ologhobo, 1994; Osegie, 1998). Pigeon pea is not a very popular food in Nigeria, it is mainly resorted to during the hunger periods (before harvest season). At such periods, mature dry pigeon pea is eaten in combination with starchy staples after several hours of boiling to soften the hard seed (Obizoba, 1983).

Although pigeon pea and millet have potentials as good sources of the much needed protein, they are under-utilized in Nigeria (Eneche, 1999). It is evident that the use of such readily available staples like the unexploited legumes and cereals, processed by simple house-hold adaptable methods into weaning foods hold promise to the alleviation of protein-energy malnutrition, given the prohibitive cost of industrially produced commercial weaning foods. This study therefore is aimed at formulating weaning foods from unexploited legume and cereal sources and evaluating the composition, selected functional properties and nutritional quality of the formulated weaning food. Result of the study will highlight or otherwise the latent potentials of millet and pigeon pea composite, as a source of nutritious weaning food.

MATERIALS AND METHODS

Mature dried seeds of pigeon pea (*Cajanus cajan*) and millet (*Pennisetum americanum)* were bought from Nsukka market in Enugu state, Nigeria. Corn starch, sucrose and casein were bought from a chemical store in Nsukka. Vitamin and mineral pre-mixes were bought from Bio-organics Nigeria PLC, Lagos.

Preparation of samples: Based on the results of a preliminary study, cleaned whole seeds of pigeon pea (500g) and millet (500g) were soaked for 24h, drained and allowed to ferment naturally for 72h at 28°C±2°C. The fermented seeds were washed, steamed for 30min and dried at 100°C for 8h. Dried seeds were dehulled, milled and sieved through 1mm pore sieve. Another batch of cleaned pigeon pea (500g) and millet (500g) seeds was soaked in excess water for 24h, spread on moist jute bags and allowed to sprout at room temperature (28°C±2°C) for 24h. The seeds were moistened at 8h interval and turned once to enable aeration. After sprouting, the seeds were steamed for 30min and dried in the oven at 100°C for 8h. The dried seeds were cleaned to remove the rootlets and hulls before milling and sieving through 1mm pore sieve. The flours obtained from the fermentation and sprouting treatments were packed and sealed in polythene bags stored at 4°C until used for the weaning food formulation and analyses. Unfermented and unsprouted millet and pigeon pea flours served as the negative control.

Diet formulation: Four diets were formulated by blending the fermented and sprouted flours such that pigeon pea flour contributed 70% of the total dietary protein while millet flour contributed 30% in all the diet formulations as shown in Table 1. Composite of untreated pigeon pea and untreated millet served as the negative control, a commercial weaning food (Cerelac, Nestles Nig. Plc) served as the commercial control while casein based diet served as the positive control.

Chemical analyses: Proximate analysis was carried out for moisture, fat, protein (N x 6.25) and ash on the diet blends according to the procedures outlined by AOAC (1990). Minerals calcium, iron, and zinc were determined after wet digestion of the samples using an Atomic Absorption Spectrophotometer. Energy was estimated from Atwater factors.

Evaluation of functional properties

Apparent viscosity: Apparent viscosity was determined by the method of sathe and salunkhe (1981) using a torson viscometer (Gallenkamp, England). Water dispersions containing 10% (w/v) of each diet formulation was heated for 10min at 100°C to form a gruel. Each gruel was cooled to 28°C±2°C before viscosity measurements was taken.

Water absorption capacity: Water absorption capacity (WAC) was determined by a modification of the method of Lin *et al.* (1974). One gram of each diet was weighted into 3 centrifuge tubes and mixed with 10ml of distilled water. Each sample was vortexed for 5 min and allowed to stand for 15 min at room temperature (28°C±2°C) before centrifuging (10,000 x G) for 5min. Excess water was decanted and each sample was allowed to drain by inverting the tube over absorbent paper. Water absorption capacity was expressed as weight of water absorbed by 1g of diet.

Least gelation concentration: Test tubes containing 2,4,6..20%(w/v) dispersions of each diet were prepared with 5ml distilled water. The dispersions were heated for 1h in a boiling water bath, cooled rapidly under running tap water and subsequently at 4°C for 2h. The test tubes were inverted to determine the concentration at which the sample would not slip.

Animal feeding experiment: Thirty six male weanly rats of the wistar strain with average initial weight of 45g-50g obtained from the Department of Veterinary Pathology, University of Nigeria, Nsukka were divided into six groups of six rats each based on body weight. The rats were housed in individual metabolic wire-mesh-bottomed cages in a room with 28°C±2°C temperature. Drinking water provided with nipple drinkers and feed (test diets) supplied in troughs were fed to the animals *ad libitum*. Each group of 6 replicates was fed a different experimental diet for 28 days including the period of acclimatization. The feed intake was measured individually twice weekly and body weight weekly for 28 days. The Protein Efficiency Ratio (PER) value was also estimated. A 7 day Nitrogen balance study was conducted after the 28 days feeding experiment. Carmine red (0.2%) was used as a faecal marker at the beginning and end of the 7 day balance period. Urine samples were collected in sample bottles containing 0.INHCl to prevent loss of ammonia and stored in a refrigerator until analyzed for urinary Nitrogen. Faeces of individual rats were pooled, dried at 85°C for 3h, weighed, before being ground into fine powder and stored for faecal N determination. Biological value (BV) and Net protein utilization (NPU) were estimated.

Data analysis: Data were analyzed by analysis of variance (ANOVA). Mean separation was done by LSD, using Genstat Release 4.23 DE (Pc/window 98).

RESULTS AND DISCUSSION

Composition of the formulated diets is given in Table 2. The protein content ranged from 8.7-10.5%, crude fat ranged from 9.7-11.7% and ash content ranged from 2.6-4.8%. Diets made from composite of fermented pigeon pea and sprouted millet (FPSM) and composite of sprouted pigeon pea and fermented millet (SPFM) had lower ($P \leq 0.05$) protein content than other diets except the commercial control (cerelac). There was an

Table 1: Formulation of pigeon pea-millet weaning food and casein based diets fed to rats (dry weight basis g/100g)

Ingredients	UPUM	FPFM	FPSM	SPFM	SPSM	CASN
UP	800.35					
UM	823.54					
FP		751.97	751.97			
SP				707.11	707.11	
FM		799.09		799.09		
SM			959.36		959.36	
Casein						302.88
Oil	126	126	126	126	126	126
Mineral	88.2	88.2	88.2	88.2	88.2	88.2
Vitamin	25.2	25.2	25.2	25.2	25.2	25.2
Fibre	25.2	25.2	25.2	25.2	25.2	25.2
Cornstarch	315.755	352.17	272.035	374.6	294.465	976.26
Sucrose	315.755	352.17	272.035	374.6	294.465	976.26
Total	2520	2520	2520	2520	2520	2520

UP-untreated pigeon pea, FM-fermented millet, UM-untreated millet, SM-sprouted millet, FP-fermented pigeon pea, SP-sprouted pigeon, Casein-casein (control)

Table 2: Composition of Pigeon pea- millet based Weaning Food, Cerelac and Casein diets

Components (% Dry weight basis)	Diet Blends							
Proximate	UPUM	FPFM	FPSM	SPFM	SPSM	COCD	CASN	LSD
Protein(Nx6.25)	9.43	9.43	8.80	8.70	10.50	19.53	9.83	0.443
Ether extract	11.13	9.80	9.67	11.33	11.73	8.40	11.43	0.463
Crude fibre	2.47	2.40	2.47	2.50	2.70	2.47	2.70	0.064
Moisture	7.27	1.50	4.35	1.50	1.50	7.63	1.50	0.645
Total ash	4.10	2.60	2.60	4.80	3.40	5.0	3.07	0.449
Nitrogen free extract	65.60	74.27	72.11	71.17	70.17	56.97	71.77	1.697
Energy Kcal/g	400.29	423.0	410.67	421.45	428.25	381.6	428.07	4.282
True Protein	6.70	5.10	5.37	4.98	7.07	10.40	7.30	0.572
Mineral (mg/100g)								
Calcium	6.63	4.80	5.07	4.97	1.03	4.58	4.63	0.189
Iron	7.66	6.74	6.98	5.00	4.68	6.98	4.76	0.316
Zinc	46.30	39.47	43.67	43.33	44.0	40.00	41.33	1.610

Values are means of triplicate determinations. UPUM = untreated pigeon pea, untreated millet (negative control), FPFM = fermented pigeon pea fermented millet, FPSM = ferment pigeon pea sprouted millet, SPFM = sprouted pigeon pea fermented millet, SPSM = sprouted pigeon pea sprouted millet, COCD = commercial diet (Cerelac control), CASN = casein based diet (control)

apparent decrease in crude protein content of diets FPSM and SPFM when compared with the negative control diet made from untreated pigeon pea and untreated millet (UPUM). The decrease was attributed to the fermentation and sprouting treatment. Odibo *et al.* (1990) and Youssef *et al.* (1987) observed similar decreases in crude protein content of fermented telferia seeds and sprouted faba beans respectively. Diet SPSM showed a crude protein content that differed significantly from other diets and conformed to the FAO/WHO minimum recommended protein of 10% (FAO/WHO, 1994). Commercial control (Cerelac) had significantly ($P \leq 0.05$) higher protein content (19.53%) than all the formulated diets and showed appreciably higher protein than the 15% FAO/WHO recommended requirement for commercial weaning diet (FAO/WHO, 1994). The percent protein derived kilo calories of the formulated diets which ranged from 8.4-10.0% did not differ appreciably from that of the casein based diet. Casein based diet and commercial diets had 9.1% and 18.6% protein derived kilo calories, respectively. True protein content of the diets showed a similar pattern as the crude protein content with diet SPFM showing the lowest value that did not differ significantly from that of FPFM and FPSM diets. The true protein content of diet SPSM compared with that of casein based diet.

Crude fat was lower ($P \leq 0.05$) in diets FPFM and FPSM than in other formulated diets. The commercial control had the lowest ($P \leq 0.05$) crude fat content, highest total ash and lowest energy. Among the formulated diets, diet SPFM showed the highest ($P \leq 0.05$) total ash content which was comparable to the ash content of the commercial control. Diet SPSM had comparable ash content with the casein based diet while diets FPSM and FPFM had the lowest ($P \leq 0.05$) ash content. Energy content of the formulated diets was within the recommended value (Hofvander and Underwood, 1987). There were variations in the mineral content of the diets (Table 2). Higher levels of minerals were observed in the negative control diet due probably to the fact that substantial amounts of minerals especially calcium, Zinc and Iron are located in seed coats of legumes and

Table 3: Functional properties of pigeon pea-millet based weaning food, cerelac and casein diet

Property Apparent	UPUM	FPFM	FPSM	SPFM	SPSM	COCD	CASN	LSD
Viscosity (CPs (10% gruel concentration at 28°C±2°C)	220	209	205	207	200	3030	190	9.15
Water absorption capacity (g/g)	1.83	1.57	1.56	1.58	1.54	1.40	1.57	0.14
Least gelation concentration (%)	4.0	10.0	9.0	9.0	10.0	12.0	20.0	2.29

Values are means of triplicate determinations. UPUM = untreated pigeon pea, untreated millet (negative control), FPFM = fermented pigeon pea fermented millet, FPSM = ferment pigeon pea sprouted millet, SPFM = sprouted pigeon pea fermented millet, SPSM = sprouted pigeon pea sprouted millet, COCD = commercial diet (Cerelac control), CASN = casein based diet (control)

Table 4: Food intake, protein efficiency ratio (PER) and Nitrogen balance of rats fed pigeon pea-millet based weaning food, cerelac and casein diet

Parameter	UPUM	FPFM	FPSM	SPFM	SPSM	COCD	CASN	LSD
Food intake(g)	90.89	111.34	113.51	123.42	102.08	173.54	130.79	16.49
Weight gain(g)	6.98	10.41	12.10	12.25	10.00	46.82	23.96	1.69
PER	1.14	1.83	2.15	2.02	1.39	2.59	0.2.50	0.23
Nitrogen intake(g)	0.322	0.364	0.372	0.471	0.364	0.756	0.514	0.051
Feacal Nitrogen(g)	0.018	0.119	0.0098	0.0101	0.0182	0.0289	0.0209	0.008
Digested Nitrogen(g)	0.304	0.3525	0.3689	0.4609	0.3458	0.7271	0.4931	0.05
Urinary Nitrogen(g)	0.108	0.1066	0.1080	0.1094	0.1083	0.1383	0.0785	0.005
Retained Nitrogen(g)	0.196	0.2455	0.2609	0.3512	0.2375	0.5888	0.4146	0.052
BV	64.42	69.73	70.72	76.20	68.68	80.98	84.08	4.46
NPU	60.77	67.45	70.13	74.57	65.25	77.88	80.66	4.60

UPUM = untreated pigeon pea, untreated millet (negative control), FPFM = fermented pigeon pea fermented millet, FPSM = ferment pigeon pea sprouted millet, SPFM = sprouted pigeon pea fermented millet, SPSM = sprouted pigeon pea sprouted millet, COCD = commercial diet (Cerelac control), CASN = casein based diet (control)

grains (Ene-Obong and Obizoba, 1996). Singh *et al.* (1989) earlier reported appreciable losses in protein, Ca, Fe and Zn associated with the dehulling of pigeon pea. Diets SPSM showed the lowest ($P \leq 0.05$) level of Ca while all other formulated diets showed comparable level of Ca with the commercial control (cerelac) and casein based diet. Calcium is one of the nutrients limiting in the diets of Nigerians due probably to non consumption of milk and milk products (Ene-Obong 1993; Ene-Obong and Akosa, 1993). It may therefore be logical to advocate that legumes and cereals which constitute the major sources of calcium in Nigerian diet should not be dehulled before use except when it is absolutely necessary, as in the production of weaning food. However Lost calcium due to processing can be replaced from other sources or by fortification.

Diets SPSM showed comparable Fe content with the casein based diet while diets FPFM and FPSM showed comparable Fe content with the commercial diet. Considering the fact that dietary intake of heme Fe in many developing countries is negligible due to cost and cultural constraints and that dairy and human milk are deficient in Fe, (Passmore and Eastwood, 1986), these formulations can serve as good sources of non heme Fe which constitutes the main source of dietary Fe for most people including children in developing countries. The negative control diet (UPUM) had higher ($P \leq 0.05$) level of Zn than all the formulated diets due probably to contributions from the hulls and peripheral aleurone cells of the grains (Singh *et al.*, 1989). Except diet FPFM all other formulated diets showed higher levels of Zn than the casein based and commercial control diets. Based on the National Research Council (NRC, 1989) recommendations of a dietary allowance of 5mg Zn/day for infant, these formulations can contribute appreciable amount of dietary zinc for infants.

Functional properties

Apparent Viscosity: apparent viscosity values (measured at 10% w/v gruel) of the formulations ranged from 200-220cps. Apparent viscosity of the formulated diets was higher ($P \leq 0.05$) than that of the casein based diet but lower ($P \leq 0.05$) than that of commercial control (303.0cps). Expectedly, formulations containing malted flour had lower apparent ($P \leq 0.05$) viscosities than those containing only fermented flour due probably to the thinning effect of amylases activated during the malting process (Uvere *et al.*, 2000). Decrease in apparent viscosity indicates increase in nutrient density. Nkama *et al.* (2001) made similar observations. Low viscosity weaning diet with a high nutrient content is a desirable characteristic in weaning foods (Ariahu *et al.*, 1999). Draper (1994) noted that low energy density has been one of the factors implicated in infant and young children malnutrition. The pre-formulation treatments (fermentation and sprouting) evidently modified the rheological properties of the raw materials because low energy density is usually associated with weaning formulations from unmodified starchy staples (Nout *et al.*, 1988).

Water absorption capacity: All the diet formulations showed comparable water absorption capacity (WAC) with the casein based diet except the negative control (UPUM) which had very ($P \leq 0.05$) high WAC. The commercial control unexpectedly had low (1.4g/g) WAC.

However Mahgoub (1999) also reported low WAC for cerelac in comparison to weaning diets formulated with sorghum and legumes. WAC indicates the volume of water required to form a gruel with suitable consistency for infant feeding.

The least gelation concentration: The least gelation concentration (LGC) of the formulated diets ranged from 4.0-10g/g. All the formulated diets showed comparable LGC except the negative control (UPUM). The LGC of diets FPFM and SPSM did not differ significantly ($P > 0.05$) from that of the commercial control. The casein based diet had the highest LGC which differed ($P \leq 0.05$) from other diets. LGC is the concentration of the diet required for gel formation. 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 (Ezeji and Ojimelukwe, 1993; Draper, 1994).

Nutritional evaluation: Table 4 shows result of the nutritional evaluation of the test diets. All the rats fed the formulated diet except those fed diet SPFM had low ($P \leq 0.05$) food intake relative to those fed the casein based diet. Since food intake can be influenced by palatability among other factors, it could be that the rats found the casein based diet more palatable. Rats fed the commercial diet, had higher ($P \leq 0.05$) food intake and weight gain than rats fed casein based diet and other formulated diets. The weight gain of rats fed diets FPSM and SPFM was significantly ($P \leq 0.05$) higher than that of rats fed the other formulated diets implying that these diets (FPSM and SPFM) promoted growth better than other diet formulations. Diets FPSM and SPFM also had comparable protein efficiency ratio (PER) values apparently indicating that they have comparable nutritive value. The PER of diets FPSM and SPFM was higher ($P \leq 0.05$) when compared to that of the other formulated diets, suggesting their superiority over the other diets. The PER value of FPSM and SPFM agrees with the recommendations of FAO/WHO (1970) for weaning foods.

The groups of rats fed commercial and casein diets, had higher nitrogen (N) intake and digested N relative to the rats fed the formulated diets. Faecal N affects digestibility consequently, rats fed FPFM and SPSM diets which had relatively high faecal N losses had low N digestibility and utilization when compared to those fed FPSM and SPFM diets. Diet SPFM had digested N value (0.4609g) that compared ($P > 0.05$) with the digested N value (0.493g) of the casein diet.

Casein diet had high digested N but low urinary N which apparently led to the observed high retiained N, biological value (BV) and net protein utilization (NPU). Diet SPFM had higher ($P \leq 0.05$) retained N (0.351g), BV and NPU than other formulated diets. The higher NPU for rats fed FPSM and SPFM diets relative to other formulated diets suggests that these two diets were better quality protein sources than other formulated diets. The observed superiority of diets FPSM and SPFM over other formulated diets may be due to the combined effects of fermentation and sprouting treatments.

Conclusion: It is evident from the study that nutritious weaning diets can be formulated by complementing unexploited legume and cereal like pigeon pea and millet. Such composite can serve as a potential source of the much needed protein that can be used to check protein-energy malnutrition which is prevalent especially in rural communities in developing countries like Nigeria. The formulation will also be a good source of dietary Ca, Fe and Zn.

Fermentation and sprouting as pretreatments, modified the functional properties of the composites. Combination of fermentation and sprouting was found to improve nutritional qualities of the diets better than either fermentation or sprouting alone. Weaning diets formulated from composites of sprouted and fermented flours supported growth better than other formulated diets.

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