JASEM ISSN 1119-8362

Full-text Available Online at www.bioline.org.br/ja

J. Appl. Sci. Environ. Mgt. *March*, 2006
Vol. 10 (1) 55 - 61

Evaluation of Processed Sweet Potato-Crayfish – Soya Bean and Sweet Potato-Crayfish-Bambara Groundnut Weaning Mixtures

***AKANINWOR, J O; OKECHUKWU, P N**

ABSTRACT: Feeding studies with 21 – day albino rats (Wistar strain) fed ad libitum for twenty – eight days with Nutrend (a commercial weaning food used as reference diet) and processed sweet potato-crayfish-soyabean/bambara groundnut mixtures were carried out to assess the suitability of the mixtures as substitutes for Nutrend. Result showed feed consumption of rats on Nutrend to be highest (244.92±45.56g) followed by rats on Diet 3; sweet potato + bambara groundnut mixtures (236.59±34.70g). The same trend was observed for weight gain. The organ weight measurements showed liver weight range of 1.33 – 4.80g, kidney 0.41-1.80g, pancreas 0.16-0.49g, and heart 0.17-0.42g. The result also showed that the PER of diets ranged between 0.64 – 1.90, NPU 86.60 – 91.40% BV87.92 – 92.86%, NPR 1.17 – 1.82, FCR 0.05 – 0.32 and T.D 98.51 – 99.49%. The results obtained with diet 3 (sweat potato – bambara groundnut mixture) and diet 5 (sweat potato – soya bean mixture) compared favourably with the reference diet (Nutrend) in all the parameters examined except for corn starch (diet 7), which recorded lowest values although it contained higher carbohydrate and energy values. Diets 3 and 5 are therefore recommended as substitute diets to the expensive commercial weaning food. @JASEM

The need to provide infants weaning food rich in protein and adequate calories, which are affordable, has become increasingly necessary especially in rural communities of developing countries. (Abbey and Nkanga, 1988). Consequently during the last 20 years, great efforts have been made to develop, produce and distribute protein – rich foods that are able to alleviate the problem of protein – energy malnutrition in these developing countries (Gopaldas et al 1988 and Gosh 1986). The energy and nutrient needs of infants and young children are relatively high. This is because they are undergoing rapid growth. FAO/WHO Expert Groups have recommended what are considered adequate energy and nutrient in take, (Table 1) for infants, which are intended to serve as guide for planning diets or assessing the adequacy of what is being consumed (FAO/WHO Report 1973). These recommendations though are for healthy children and may not be adequate for children exposed to repeated infections (FAO/WHO Report 1979). Make a new pattern with a quality much better than that of either food alone (Edman, 1986). Although most proteins of animal origin have a satisfactory amino acid pattern than vegetable proteins and therefore, have a higher biological value, in recent years, animal sources have become scarce and very expensive. This scarcity is most common in developing countries where population growth is very high (Graham et al). Vegetable sources are however abundantly available and if properly utilizes can contribute remarkably in solving the problem of protein malnutrition which is common in the tropics. Furthermore vegetable proteins have economic advantage over animal protein since the cost of raw materials needed to make vegetable protein mixtures are lower.

Most cereals and legumes often used for weaning food preparation are limited in essential amino acids (e.g lysine and methionine) and this makes their protein poorer compared with animal proteins (Graham et al 1986). However, the low levels of methionone and cytosine are usually corrected by complementation with cereals, tubers of roots (Rachie, 1973). Also heat treatment effectively eliminates the undesiarable antinutritional factors and excessive heat treatment does little or no damage to legume protein (Elias et al, 1979 and Kon et al, 1981 and Kon and Sanhuk 1981). Worldwide, legumes as green vegetables are readily accepted and in Africa, the most important leguminous crops in terms of production and consumption are groundnut, cowpea, soyabean and bambara groundnut. The legumes are generally of high nutritional value and make a larger contribution to the energy and protein available to the population than any other food (Sellscop, 1962). In keeping with the need to explore and document other sources of affordable and nutritionally adequate alternatives to the existing commercial weaning food, the aim of this present study was to evaluate the nutritional adequacy of processed sweet potato – crayfish – soyabean and sweet potato – crayfish bambara groundnut mixtures.

*Corresponding author

TABLE 1: Recommended Daily Nutrient Intake for Infants (Fao/Who Report, 1973)

		Age Range (Months)			
Nutrients	Unit	0-3	4-6	7-9	10-12
Energy	Kcal	120.kg	115/kg	110kg	105/kg
Protein	g	9.8	11.8	17.8	19.0
Vitamin A	μg	300	300	300	300
Vitamin D*	μg	10	10	10	10
Vitamin C	μg	20	20	20	20
Vitamin B12	μg	+	+	0.3	0.3
Thiamine	μg	+	+	0.3	0.4
Riboflavin	mg	+	+	0.5	0.5
Folic acid	mg	+	+	60	60
Niacin	mg	+	+	5.6	6.6
Iron II	mg	+	+	7.0	7.0
Calcium	mg	+	+	500	500

The values given assume that the sources of protein are (i) milk from 0-6 months (2) milk and mixed plant proteins from 7-12 months (score 70). * Dietary intakes may be partially replaced by exposure of the skin to sunlight.
+ No values are given as these nutrients are provided by well nourished mother. II Intake is for a diet in which most of the protein is from plant sources.

MATERIALS AND METHODS

Sweet Potato processing: The red skinned variety of sweet potato purchased in Port Harcourt was used. The fresh tubers were peeled washed, cut into thin slices and dehydrated in a hot air over at 70°C for 18 hours. The chips were then ground into flour using a hand mill, sieved through 710 mm sieve and packed in plastic bags which were stored at 4°C until required for analysis.

Bambara Groundnut Processing: The seeds were purchased from Nsukka, freed from broken seeds, dust and stones and then washed with tap water after which they were soaked for 24 hours at room temperature.

Table 2: Percent Composition Of The Experimental And Control Diets.

Ingredients	Diets							
(g100g Diet)	1	2	3	4	5	6	7	8
Sweet potato	54.50	43.50	33.00	68.50	53.50	59.00	-	-
Corn starch	10.00	10.00	10.00	10.00	10.00	10.00	98.00	-
Crayfish	8.00	8.00	8.00	8.00	8.00	8.00	-	-
Vegetable oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00	-
Bambara groundnut	25.50	36.50	47.00	-	-	-	-	-
Soya bean	-	-	-	11.50	16.50	21.00	-	-
Nutrend								100
Total	100	100	100	100	100	100	100	100

Corn Starch Processing: A local white maize (Zea mays) was purchased from Port Harcourt was used. The traditional method of "Ogi" preparation was used for the isolation of the starch (Akinrele, 1970; Umoh and Fields, 1981). The flour produced was packed in plastic bags and stored at 4°C.

Dehulling was by hand rubbing and dried in hot air oven at 70°C for hours. The dried seed were then ground with a hand mill, sieved through a 710 mm sieve and stored at 4°C in plastic bags until required.

Soya Beans Processing: The soya beans were purchased in Port Harcourt and the same method for processing bambara groundnut was applied except that the soaking time, dry temperature and drying time were 12 hours, 70*C and 24 hours respectively.

Crayfish Processing: Dry crayfish was bought in Port Harcourt dried further in the oven and ground into powder. The powder was then used for analysis and diet formulation.

Diet Formulation: The various flour preparations were autoclaved for 15 minutes at 121°C before being used for diet formulation. Combinations were tested until the following criteria were met; total calories 353 – 391 Kcal/100kg and NdpCal% 6.5 – 8.19%. High values of NdpCal% were avoided in order to keep the cost of the protein supplements low. Commercial maize – soya bean weaning formula (Nutrend) was usedas the positive control diet while corn starch flour was used as the protein free or negative control diet. Table 2 shows the percentage composition of Experimental and control diets.

Chemical Evaluation: As described in an earlier paper (Akaninwor & Okechukwu 2002).

Energy Calculation: Standard procedures were used the for calculation of protein energy, lipid energy, carbohydrate energy, protein percent (P %), Lipid (fat) energy percent (F %) and Net dietary protein calorie percent (NDp Cal %) as described previously standard (Akaninwor and Okechukwu, 2002). The Atwater factors 4,4 and 9 for protein, carbohydrate and lipid (fat) respectively expressed in kilocalories were used. The values for protein, carbohydrate and lipid obtained in proximate analysis were multiplied by their respective Atwater factor to give their corresponding energy values in Kcal.

TABLE 3. Calculated Energy Values of Processed Flour Samples

Sample	Protein Energy (Kcal/100)	Lipid Energy (Kcal/100g)	Carbohydrate Energy (Kcal/100g)	Gross Energy (Kcal/100g)
Sweet Potatoe	13.12	3.32	328.12	344.56
Corn starch	26.24	69.39	281.24	376.87
Crayfish	266.88	41.22	9.36	317.46
B/Groundnut	89.68	71.73	246.88	408.29
Soya Bean	184.64	198.27	64.08	445.67
BSB	184.64	156.24	65.64	406.52
CSB	184.64	202.77	60.92	448.33

Key: B/Groundnut = Bambara; BSB = Blessed Soyabean; CSB = Chima Soyabean;

*Biological Evaluation: Animal Assay***:** The method of Umoh and Oke (1974) was adopted. Thirty-two weanling albino rats (Wistar strain) aged 21 days, obtained from Animal & Environmental Department, University of Port Harcourt were used for this study. They were divided into eight groups, four per group, in such as way that the group mean weight did not differ by more than ± 2.00/mean rat weight. The rats were all acclimatized with a commercial stock diet to their new environment for three days, during which no records of food consumption, etc were kept. Their initial weight (17.40 – 33.90g) were however, taken at the end of this period and the groups of four rats were randomly assigned to test and control diets. They were housed one per wire cage with facilities for faeces and spilled food collection. Water was provided from plastic water bottles and food contained in specially designed metallic containers. They were fed ad libitum for 28 days on the diets. The weights of rats were recorded after two weeks and at the end of experiment the faeces of each rat were pooled, dried at 105°C for 24 hours and then ground into powder for faecal nitrogen determination. Data on feed consumption and spilled feed were collected by recording the amount of feed measured out for each rate at the beginning and the quantity remaining at the end of the experiment.The rats were euthanized with chloroform and sacrificed after 28 days on the diets. The liver, kidney, pancreas and heart were excised from each rat, weighed and returned to the carcass. The entire animal carcasses were then dried to a constant weight in an oven at 105°C for 48 hours. The dry weight of each rat carcass was taken, and the carcass ground thoroughly with laboratory mortar and pestle for Carcass and Faecal Nitrogen

Table 4: Calculated energy values of Diets

Sample	Protein Energy (Kcal/100)	Lipid Energy (Kcal/100g)	Carbohydrate Energy (Kcal/100g)	Gross Energy (Kcal/100g)
Diet 1	48.12	45.45	273.44	367.01
Diet 2	60.36	53.64	262.52	376.52
Diet 3	70.00	58.41	243.76	372.17
Diet 4	50.76	51.39	250.00	352.15
Diet 5	64.76	58.23	263.76	386.75
Diet 6	70.88	76.41	243.76	391.05
Diet 7	31.52	53.98	278.12	363.62
Nutriend	66.52	20.34	273.44	360.30

Determination: Ig of each ground sample was used for the analysis by the Kjeldahl method for both carcass and faeces. The nitrogen retained in the carcass was measured by comparison with the group given the protein free diet (corn starch).

RESULTS AND DISCUSSIONS

*Energy Value***:** The gross energy values of the processed ingredients calculated using the Atwater factors are shown in Table 3 Cornstarch was found to have a higher energy values 376.87 Kcal/100g than sweet potato flour (344.56Kcal/100g). This is the agreement with the reports of Louis and Sidik (1988), that on a dry matter basis, sweet potato is lower in energy than corn grain. The high energy values of ingredients show that they are potentially capable of supplying infants with their energy requirements.

TABLE 5: Protein Energy Percent (P%), Fat Energy Percent (F%) and Net Dietary P rotein Calorie Percent (NdpCal%) of Diets

Sample	P*%	F%	NdpCal%	AA Score*
Diet 1	13.11	12.38	6.54	60
Diet 2	16.03	14.25	7.44	60
Diet 3	18.18	15.69	8.19	60
Diet 4	14.41	14.69	6.96	60
Diet 5	16.74	15.07	7.64	60
Diet 6	18.67	19.54	8.02	60
Diet 7	8.67	14.85	5.46	70
Nutrend	18.46	5.65	8.84	70

* = Amino Acid Score (FAO/WHO)

The gross energy values of the diets are shown in table 4 while the protein energy percent (P^e%), fat energy percent (F^e%) and net dietary protein calorie percent (NdpCal%) are shown in Table 5. Except for diet 4, Nutrend was found to be lower in energy value than all the test diets. The energy values of the diets (352.15 – 391.05) are similar to the 355Kcal/100g value calculated for home – made weaning food mixtures by Pellet and Marmabachi (1978). The high energy content of the diets is noteworthy as protein utilization and energy intake are closely interrelated since where energy intake is seriously inadequate, it is unlikely that protein would be effectively utilized by the body (Isichei and Achinewhu, 1988). Protein energy percent (P^e%) expresses the protein content of foods in energy terms, and estimates their potential to satisfy protein needs. There was an appreciable difference in the P^e% values obtained in table 5. Beaton and Swiss, (1974) recommended a lower limit of 11 – 2% for protein utilization of about 60% (amino acid score) as safe values. All the test diets and Nutrend recorded values higher than this range, indicating their high potential in meeting protein needs of a child. Diets 3, 6 and Nutrend had similar P^e% values (Table 5). The protein free diet (corn starch), as expected had P^e% value lower than the recommended range. This shows that corn starch is incapable of satisfying protein needs of a child who depends on corn starch for his/her protein source. The P^e% of diets 1 (13.11%) and 4 (14.41%), are thought to be higher than that Beaton and Swiss recommended lower limit (11 – 12%) safe value. However, P^e% values as high as 29.30 and 29.40 have been reported by Isichei and Achinewhu (1988) for unfermented and fermented oil been seed diets respectively. Fat energy percent (F^e%) expresses the fat content of foods in energy terms and estimates the potential of the diet to satisfy fat needs. The F^e% of Nutrend was found to be significantly lower than values for all the test diets. Though most of the test diets did not met the FAO/WHO (1997) recommended F^e% value 20 – 30, diet 6 however, had the highest value of 19.54% which is very close to the FAO/WHO recommended value.

Table 6: Quantities(g) of Diets expected to meet an infants daily need for protein and energy

Diets	Age Range (Months)			
	0 – 3	4 – 6	7 – 9	10 – 12
Diet 1	81.64	98.09	147.96	157.94
Diet 2	64.94	.20	118.00	125.91
Diet 3	56.00	67.43	101.71	108.57
Diet 4	77.23	92.99	140.27	149.72
Diet 5	60.53	72.88	109.94	117.37
Diet 6	55.30	66.59	100.45	107.22
Diet 7	124.37	149.75	225.89	241.12
Nutred	58.93	70.96	107.04	114.20

The Net Dietary Protein Calorie Percent (NdpCal%) of Diets 1, 2 and 4 (Table 6) are within the 6.50 – 7.00% range calculated for home – made weaning food from local staples by pellet and Mamaebachi (1978). Diets 3, 5, 6 and Nutrend met the Araya (1980) recommended NdpCal% value of 8 which is the equivalent of the human breast milk, and considered optimal for the human infant (Isichei & Achinewhu 1988). Bodwell et al (1981) have shown that individuals with high protein requirement and young children recovering from protein energy malnutrition (PEM) would benefit from levels significantly above the recommended NdpCal% level of 8. The protein – free diet (corn starch) scored value (5.46%) lower than recommended value and so demonstrates that corn starch cannot meet the protein needs of a child. Table 6, however, shows the quantities of the different diets expected to provide the recommended daily requirements for protein and energy of infants.

Feed and Nitrogen intakes: The feed intake and feed conversion ratio of rats fed with Nutrend were highest throughout the study period though not significant. This could be due to non palatability of the test diets relative to the more palatable Nutrend which contain sucrose and vanillin. The nitrogen intakes of groups on 1 and 4 were significantly lower than values for lower protein content of the two diets (Akaninwor and Okechukwu, 2002). However, nitrogen intakes of rats on other test diets were similar to values for those on Nutrend (Table 7).

Table 7: Performance of rats on the diets during the 28 days

Diet	No. of Rat	Total feed intake (g)	Total N intake (g)	Total protein intake (g)	Weight gain (g)	Carcass nitrogen (g)	Carcass protein (g)	Faecal nitrogen (g)
1	4	221.57 ±28.91	4.27 ±0.56	26.67 ±3.47	53.50 ±5.43	4.54 ±0.04	28.38 ±0.25	0.06 ±0.03
2	4	208.86 ±28.91	5.04 ±0.24	31.52 ±1.48	64.34 ±6.99	5.30 ±0.12	33.13 ±0.12	0.09 ±0.02
3	4	236.59 ±34.74	6.63 ±0.97	41.42 ±6.06	73.33 ±11.05	6.86 ±0.25	43.06 ±0.12	0.08 ±0.02
4	4	193.07 ±38.05	3.92 ±0.77	24.88 ±4.84	42.33 ±10.84	4.18 ±0.21	43.06 ±0.52	0.08 ±0.02
5	4	202.02 ±29.05	32.71 ±4.71	32.71 ±4.71	48.88 ±12.00	5.50 ±0.26	26.13 ±0.02	0.08 ±0.01
6	4	219.62 ±45.50	6.23 ±1.29	38.92 ±8.06	52.31 ±18.28	6.49 ±0.32	40.56 ±0.17	0.11 ±0.06
7	4	136.56 ±35.11	1.73 ±0.54	10.81 ±2.75	6.92 ±4.95	2.50 ±0.01	15.63 ±0.46	0.02 ±0.01
Nutred	4	244.92 ±45.56	6.52 ±1.21	40.72 +7.58	77.35 +7.24	6.78 ±0.04	42.38 ±0.08	0.05 ±0.03

Weight Gain and Carcass Nitrogen: The weight gain and carcass nitrogen of rats on all the test diets, with exception of Diet 3, were significantly lower than values of rats on Nutrend (Table 7). However, weight gain of all the rats on the test diets and Nutrend increased as protein intake increased. These results are similar to earlier work on beef steers and fermented fluted pumpkin (Louis and Sidik 1988, Isichei and Achinewhu, 1988).

*Organ Weights***:** Changes in organ weights are shown in Table 8. Rats maintained on Nutrend had the highest liver weight although it is similar to the liver weight for rats on all the diets, except Diet 4 which had the lowest value. There were no significant differences between the pancreas and heart weights of rats on the test diets and Nutrend. The Diet 3 group had the highest mean pancreas weight (0.62g), while Diet 7 group differed significantly in heart weight. Nutrend also induced the highest kidney weight and this was not significantly (P>0.05) higher than of the groups on Diet 2, 3 and 6. Those on the protein free diet however, had the lowest organ weights. Earlier reports have shown that the sensitivities of muscle (e.g. heart muscle) and liver tissues to the quality and effects of dietary protein are higher than of the kidneys (Allison, 1955) and that 100% and 20% protein level incorporations of amino acids into the muscle was higher when casein was the protein source and lowest with gluten respectively (Von der Deckon and Onistedt, 1972). It is therefore, imperative that the similarity in organ weights could indicate that the proteins from the test diets were also similar to the protein in Nutrend.

Table 8: Organ Weights of Rats (Mean Values ± SD)

Samples	No. of Rat/Diet	Liver (g)	Kidneys (g)	Pancreas (g)	Heart (g)
1	4	3.94 ±0.50	0.82 ±0.14	0.38 ±0.22	0.38 ±0.05
2	4	4.16 ±0.27	1.04 ±0.32	0.52 ±0.06	0.33 ±0.22
3	4	4.20 ±0.85	0.86 ±0.16	0.62 ±0.29	0.36 ±0.04
4	4	2.77 ±0.79	0.69 ±0.13	0.42 ±0.51	0.29 ±0.07
5	4	3.42 ±0.62	0.70 ±0.10	0.38 ±0.04	0.30 ±0.05
6	4	3.39 ±1.07	0.79 ±0.29	0.38 ±0.04	0.30 ±0.09
7	4	1.33 ±0.26	0.41 ±0.07	0.49 ±0.23	0.17 ±0.03
Nutred	4	4.82 ±0.98	1.08 ±0.15	0.44 ±0.15	0.42 ±0.07

The effect of diets on the protein utilization of rats is shown in Table 9. Protein Efficiency Ratio (PER), Net Protein Utilization (NPU), Biological Value (BV)*, etc***:** The PER and Net Protein Ratio (NPU) of Diets 5 and 6 were significantly higher than values for Nutrend (Table 9). The BV and NPU of Diets 1 and 4 were all found to be significantly lower ($P < 0.05$) than values for Nutrend; however, values for these parameters in other diets were not remarkably different from that on Nutrend. The protein – free diet (corn starch) in contrast had inferior quality in all the characteristics investigated. These results proved that pap (a gruel made purely from corn starch), which serves as a major weaning food in Nigeria is incapable of sustaining the rapid growth that occurs in infancy. Unless supplemented with legumes, milk or other high proteinous food, pap will normally lead to severe malnutrition (Achinewhu, 1987). This might explain the death of one of the rats on the protein – free diet seven days after the start of the experiment. It has been demonstrated that supplementing pap with 30% soybeans raised the PER three fold. The PER of the soya beans and bambara groundnut supplemented diets in this study were 1.73, 1.49. 1.34 and 2.01, 2.04. 1.77 respectively compared to 0.64 corn starch (diet 7) (Table 9). This is in agreement with the finding of Akinrele et al (1966). Millet – soyabeans weaning porridge have also been prepared and reported to be capable of increasing the PER, NPU and BV by 80%, 40% and 46% respectively after fortification with soya beans (Eka, 1978). The results obtained also showed that in spite of the higher weight gain, the PER of Nutrend was similar to that of the test diets. This similarity could be an indication that all proteins from these different sources were adequately utilized for growth etc; it was not surprising therefore that the faecal nitrogen excretion of rats on the test diets did not differ significantly (Table 7) from that of those on Nutrend. There was also significance between the digestibility of Nutrend and test diets (Table 7). This could be a consequence of the effectiveness of the processing methods employed in detoxifying the antinutrients. The true digestibility obtained (98.51 – 99. 31%) were similar to 87% for pumpkin – pap weaning mixture, 92.61% for unfermented pumpkin and 92.49% for fermented pumpkin diets using rats reported by earlier workers. Other workers have used children for study and reported 73% for lactic acid fermentation whole grain sorghum flour (Graham et al, 1986). Maclean (1979), used children and obtained 81% digestibility for refined wheat flour. The digestibility of proteins in heat-treated beans for humans, however, has been reported as 55% (Nnayelugo and Nwaegbute, 1987b; Bressani, and Elias 1980).

Table 9: Effect of the diets on the protein utilization of rats

Diets	FCR	NPR	PER	NPU	TD	BV
1	0.24 ±0.02	0.75 ±0.11	2.01 ±0.13	87.87 ±1.94	98.86 ±0.74	88.89 ±0.20
2	0.31 ±0.02	0.82 ±0.16	2.04 ±0.13	89.87 ±0.98	98.86 ±0.51	90.81 ±1.90
3	0.31 ±0.19	1.60 ±0.12	1.77 ±0.12	92.18 ±0.83	99.31 ±0.68	92.82 ±1.23
4	0.22 ±0.18	1.73 ±0.22	1.73 ±0.22	86.60 ±0.96	98.51 ±0.38	87.92 ±1.99
5	0.24 ±0.03	1.49 ±0.18	1.49 ±0.88	90.12 ±1.85	98.86 ±0.16	91.16 ±0.87
6	0.23 ±0.05	1.34 ±0.28	91.47 ±0.52	91.47 ±0.52	98.51 ±0.42	91.16 ±0.87
7	0.05 ±0.04	1.64 ±0.29	0.64 ±0,29	-	-	-
Nutrend	0.32 ±0.06	1.90 ±0.37	0.90 ±0.37	91.11 ±0.58	99.49 ±0.26	91.57 ±0.41

FCR - Feed Conversion Ratio; NPR - Net Protein Ratio; PER - Protein Efficiency Ratio; NPU - Net Protein Utilization; TD - True Digestibility; BV - Biological Value

REFERENCES

Abbey, B. W and Nkanga, U. E (1988); Production of high quality weaning products form Maize – Cowpea – Crayfish mixture. Nutr. Rept. Int. 37 (5): 951 – 957.

Achinewhu, S. C. (1987): Protein quality evaluation of weaning food mixtures from indigenous fermented foods. Nig. J. Nutr. Sci. 8 (1): 23 – 31.

Akaniwor J. O. and Okechukwu P. N (2004): Nutrient and Antinutrient levels in processed potato-crayfish-soyabean and sweet potato – crayfish – Bambara groundnut mixtures: (In Press).

Allison, J. B. (1995): Biological evaluation of protein; Physiol. Rev. 35: 664 – 670.

Araya, H. (1980): Examining the nutritive value of basic foods as a tool for the study of Diets in poor countries.

Beaton, G. H. and Swiss, L. D (1974): Evaluation of the nutritional quality of food supplies: Prediction of 'desirable' or 'safe' protein caloric ratio. Am J. Clin. Nutr. 27: 485 – 504.

Bodwell, C. E; Adkins, J. S and Hopkins, D. T (1981): Protein quality in human. Avi. Pub. Co. Inc. Westport. Conn.

Bressani, R. and Elias (1980): Protein quality and nutritional value of beans.

Research highlights. Michigan State University. Bean/Cowpea CRSP. Vol. 2(6): 49 – 59.

Eka, O. U. (1978): Chemical evaluation of nutritive value of 'soya-papa and porridges'. The Nigeria Weaning Food. Food. Chem. 3: 199 – 202.

FAO/WHO (1973): Expert Consultation, Energy and Protein requirements. Tech. Report Series No. 52. Rome. WHO Tech. Report Series No. 522. Geneva.

FAO/WHO (1979): Food Standards Programme. Codex alimentarius commission recommended energy and protein requirements for infants and children.

Graham, G. G; Maclean, W. C. Jr. Morales, E: Hamaker, R. R; Kirleis, A. W; Mertz, E. R and Axtell, J. D (1986): Digestibility and utilization of protein and energy from Nasha, a traditional Sudanese fermented sorghum weaning food. J. Nutr. 116: 978 – 984.

Ghost, S. (1986): Constraints to improved child feeding. In "proceedings of the 14th international congress of nutrition". Edinburgh. 1: 608 – 61.

Isichei, M. O. and Achinewhu, S. C. (1988): The nutritive value of African Oil Bean seed (Pentactthra Macrophylla). Food Chem. 30: 118 – 123.

Kon, S. and Sanshuck, D. W. (1981): Phutate Content and its effect on cooking quality of beans. J. Food process. Presser. 5: 169 – 176.

Louis, S. L. and Sidik, A. (1988): A comparison of Corn and Sweet potata meal in finishing rations for beef steers. Nutr. Rept. Int. 37 (5): 938 – 950.

Malcean, W. C. Jr. Lopez de Roana, G; Klein, G. L ; Massa, E : Mellitis, E. D. and Graham, G. g. (1979) : Digestibility and utilization of the energy and protein of wheat by infants. J. Nutr. 109: 1290 – 1298.

Nnayelugo, D. O. and Uwaegbute, A. C. (1987) (b): Nutritive value and biological evaluation of processed cowpea diets compared with local weaning foods in Nigeria. Nutr. Rept. Int. 22:81 – 92.

Pellet, P. L. and Manmarbachi, D. (1978): Recommended proportions of foods in Home-made weaning mixtures. Ecol. Food Nutr. 7: 219 – 228.

Rachie, K. O. (1973): Improvement of food legumes by breeding. Milliner M. (Ed.) PAG United Nations, New York. p 83 – 92.

Sellschop, J. F. P. (1962): Cowpeas (Vigna Unigiaculata L. Walp). Fied Crop Abt. 15: 259 – 266.

Umoh, I. B and Oke, O. L. (1974); Nutritive value of some leser known oil seeds in rats. Nutr. Rept. 9: 453 – 459.

Von der Decken, A. and Onistedt, P. T. (1972): Dietary protein quality measured by in vitro protein synthesis in rat skeletal muscle ribosome J. Nutr. 102: 1555 – 1562.