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Effect of Processing on the Protein Quality of African Yambean and Bambara Groundnut Supplemented with Sorghum or Crayfish in Rats

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Abstract: Forty-eight adult Wistar albino male rats (75-128 g) of age 8 weeks were used to study the effect of processing on the protein quality of African Yam Bean (AYB) and Bambara Groundnut (BG) supplemented with sorghum or crayfish. The rats were fed for 10 days. Three out of the ten days were adjustment and the rest for the balance period. Eight diets were formulated and fed to the rats. The mixed protein diets provided 10% protein daily for the entire study period. Casein (CA) was served as a reference protein. The N content of the food, urine and feces were analyzed using AOAC (1980) procedure. As judged by protein quality, rats fed the control diet had significant decreases ($p<0.05$) in all the parameters tested except for digested N (0.91 g) urinary N (0.11 g) and apparent digestibility (94.79%). Addition of an equal amount of Crayfish (CR) to sorghum (S) as a supplement decreased food intake, N intake and Nitrogen Balance (NB) in both Dehulled African Yam Bean (DAYB) and Soaked Brown Bambara Groundnut (SBBG). Dehulling of White Bambara Groundnut (DWGB) resulted to increases in all the parameters tested except for urinary N (0.05 g) and apparent digestibility (84.68%) as compared to the brown variety. Soaking of White Bambara Groundnut (SWBG) decreased protein quality in all the parameters tested as compared with the brown variety except for Biological Value (BV) (94.12%) and Net Protein Utilization (NPU) (76.92%). As judged by N intakes (1.24 g) digested N (1.05 g) and biological value (95.24%) the DWGB:S_{18} diet appears to contain much more desirable pattern of Essential Amino Acid (EAA) than the other test diets. The result showed that it could be of great importance to people living in areas where these foods are staple.

Key words: Sorghum, bambara groundnut, African yam bean, rats

INTRODUCTION

The fight against protein malnutrition all over the world is based on bridging the gap between protein needs and supplies. As a result, it has become a special task of nutrition research to develop and test nutritionally adequate diets from commonly consumed foodstuffs, locally and readily available, cheap and acceptable to the population groups (Ganapathy *et al.*, 1980; Nzomiwu and Obizoba, 1987).

In Nigeria, there exists a lot of cheap, nutritious and readily available indigenous foods which when adequately processed and judiciously combined could serve as an improvement of the existing traditional foods. This will help alleviate the protein gap experienced among young children (Nnam, 2001). From the list of staple food stuffs available in developing countries like Nigeria, legumes provide the highest amount of good protein. However, they are deficient in methionine. It is possible, however, to supplement the protein of cereals with that of legumes to improve the protein quality (Oke, 1975).

Legume foods are ideal complement to sorghum food. They are rich in lysine, threonine, valine and other Essential Amino Acids (EAA). Legumes are also good sources of thiamin, riboflavin, iron and calcium. Thus, the simultaneous ingestion of cereals with legumes and cheap animal protein like crayfish has a complementary effect and offers a technique for improving protein nutrition within the economic and cultural patterns of families. The practice of eating cereals in conjunction with legumes is very common in Nigeria; however, the methods of preparation, particularly legumes are inadequate. This may have some important nutritional consequences for the vulnerable groups, mostly children (Nzomiwu and Obizoba, 1987).

Greevani and Theophilus (1981) reported that the utilization of legume proteins depend both on the kind of legume and the method of processing. Dehulling and soaking improves *in vitro* protein digestibility in both cereals and legumes (Deshpande *et al.*, 1982). The objective of the study was to evaluate the effect of processing on the protein quality of Dehulled African Yam Bean (DAYB) dehulled and soaked bambara groundnut supplemented with sorghum or Crayfish (CR) in rats.

MATERIALS AND METHODS

A 10 day N balance study was conducted; the study involved a 3-day adjustment and a 7-day balance period.

Animals and housing: Forty eight adult Wistar albino male rats (75-128 g) of age 8 weeks (supplied by the Department of Veterinary Pathology, University of Nigeria, Nsukka) were divided into 8 groups of six rats each on the basis of body weight. The rats were weighed prior to access to the experimental diets and at the end of the study. The rats were housed in individual metabolism cages, fed both the test and control diets, de-ionized water *ad libitum* for 10 days. The cages were of stainless steel and screen bottom type, equipped to separate urine and feces of the animals.

Each test group received its respective diet throughout the entire study period. Food intakes were recorded daily and were used for calculation of N intakes and N balances of each animal.

Diets: The legumes, cereal and crayfish used as sources of dietary protein were purchased locally from Obukpa market-a small town market near Nsukka, Enugu state of Nigeria. The Bambara Groundnut (BG) (*Voandzeia subterranean*) were of two varieties: Brown (BBG) and White (WBG). The African yam bean (*Sphenostylis stenocarpa*) was Dehulled (DAYB) after purchase. The cereal grain used was sorghum (*Sorghum bicolor* Linn Moench).

The African Yam Bean (AYB) was soaked in warm water ratio of seed to water 1:3 w/v for 4 h to loosen the seed coats which were then removed manually using the traditional method. However, Bambara Groundnut (BG) with a much harder seed coat was first carefully split into two halves with a machine locally designed by Engineer P.O. Ngoddy of the Department of Food Science and Technology, University of Nigeria, Nsukka. The split seeds were then soaked for about $1^1/_2$ h in the warm water (35±0.2°C) for easier seed coat removal before dehulling. The AYB and other halves of both varieties of BG were soaked for 5 h before cooking.

Sorghum grains were soaked for 18 and 24 h (S_{18} and S_{24}). The grains, after treatment were cooked separately in 1:3 w/v deionized water at 100±0.2°C for 45 min until they were judged soft enough for human consumption. They were removed from the fire and were found to have little or no cooking water left in the cooking utensil. The cooked grains were dried separately to 96% dry matter in Gallenkamp, size one, BS oven at 85°C for 8 h before being ground to a fine powder in a Wiley laboratory hammer mill (70 mm mesh screen). The Crayfish (CR) (*Astacus spp.*) was also dried in the Gallenkamp, size one, BS oven at 85°C for 30 min and ground into a fine powder using the same machine and screen size as the grains. The flours from the grains and CR were stored in polythene bags and frozen in a Thermocool refrigerator at -7°C until used for the formulation of the diets.

Table 1 data indicate the ingredient composition of the experimental diets. The control diet contained only casein as the sole source of protein. The seven diets derived 70% of their nutrients from Dehulled African Yam Bean (DAYB) Dehulled White Bambara Groundnut (DWBG) Dehulled Brown Bambara Groundnut (DBBG) Soaked White Bambara Groundnut (SWBG) and Soaked Brown Bambara Groundnut (SBBG). Five diets had 30% of their remaining dietary protein either from sorghum soaked for 18 h (S_{18}) or 24 h (S_{24}). Two diets had 30% of their dietary protein from 15% CR. Food intakes were recorded (7 days) and the data were used to know the protein quality of each diet.

Laboratory analysis: A pitch of carmine red (0.625 g) was fed on the morning of days 4 and 11. Coloured feces excreted on day 5 were included in the pooled fecal samples. Those excreted on day 12 were excluded. Individual fecal collections were dried at 85°C for 3 h and weighed before being ground manually into a fine powder that can pass through a 70 mm mesh screen

Table 1: Composition of the eight experimental diets (g)

N sources and ratios (%)	DAYB:S_{18} 70:30	DAYB:S_{18}:CR 70:15:15	DWBG:S_{18} 70:30	DBBG:S_{18} 70:30	SWBG:S_{24} 70:30	SBBG:S_{24} 70:30	SBBG:S_{24}:CR 70:15:15	Casein
Casein[1]	-	-	-	-	-	-	-	300.0
Dehulled AYB[2]	306.42	306.42	-	-	-	-	-	-
Dehulled WBG[2]	-	-	355.36	-	-		-	-
Dehulled BBG[2]	-	-	-	288.41	-	-	-	-
Soaked WBG[2]	-	-	-	-	347.28	-	-	-
Soaked BBG[2]	-	-	-	-	-	305.73	305.73	-
Crayfish[2]	-	25.99	-	-	-	-	25.99	-
Sorghum soaked (18 and 24 h)[2]	320.7	160.36	320.7	320.7	305.73	305.73	152.87	-
Oil[2]	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
Vitamin[1]	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Mineral[1]	33.6	33.6	33.6	33.6	33.6	33.6	33.6	33.6
Sucrose[1]	120.84	188.0	96.37	129.85	107.89	128.67	192.2	284.4
Corn starch	120.84	188.0	96.37	129.84	107.89	128.67	192.1	284.4
	960.0	960.0	960.0	960.0	960.0	960.0	960.0	960.0

[1]Purchased from Tekland Dawley Inc., Box 8156, Madison, Wisconsin, 53708, USA;
[2]Purchased from local retailers: AYB = African Yam Bean; WBG = White Bambara Groundnut; BBG = Brown Bambara Groundnut; D = Dehulled; S = Soaked (18 or 24 h) CR = Crayfish

using a mortar and pestle. The urine from each rat was collected from 7.00 am on day 4 through the morning of day 10 (7 days) in bottles containing 1 ml of 0.1N Hydrochloric acid (HCl) as preservative. They were refrigerated until analyzed for N. The food, feces and urine samples were wet digested with concentrated nitric acid and perchlorate for N content according to the AOAC (1980) procedure.

Protein quality indices: Nnam (2001) and Ihekoronye and Ngoddy (1985) reported that protein quality indices namely the apparent N digestibility (% D) the biological value (% BV) and the net protein utilization (% NPU) could be assessed according to the following equations:

N Balance (NB)

$$NB = I-(F + U)$$

$$\text{Digested N} = I-F$$

$$\%\ D=\frac{(I\text{-}F)}{I}x100 \text{ or } \frac{\text{DigestedN}}{\text{NIntake}}x\frac{100}{1}$$

$$\%BV=\frac{(I-F-U)}{(I-F)}x100 \text{ or } \frac{\text{NRetained}}{\text{NAbsorbed}}x\frac{100}{1}$$

$$\%NPU=\%Dx\%BV \text{ or } \frac{(I-F-U)}{I}x\frac{100}{1} \text{ or } \frac{\text{NRetained}}{\text{NIntake}}x\frac{100}{1}$$

Where
I = Nitrogen intake
F = Fecal nitrogen
U = Urinary nitrogen
These were the indices used in this study.

Statistical analysis: One way analysis of variance and Duncan's New Multiple Range Test (DNMRT) (Steel and Torrie, 1990) were used to determine significant differences of protein quality of diets at $p\leq 0.05$.

RESULTS AND DISCUSSION

Table 2 presents the Nitrogen (N) balance of rats fed dehulled African yam bean and bambara groundnut supplemented with sorghum or crayfish. The food intake of the animals differed. The group fed the DAYB:S_{18} diet had the highest while the casein group had the least (78.01 vs 54.80 g). The casein group had lower food intake which was significantly different from that of the other groups ($p<0.05$).

The slightly higher but comparable food intake of SWBG:S_{24} and DBBG:S_{18} groups suggest that treatment and varietal differences had influence on food intake ($p>0.05$). On the other hand, the higher but significant food intake between SBBG:S_{24} and SWBG:S_{24} groups show that varietal differences had influence on food intake of the animals. As judged by food intake, CR was inferior to S_{24} as a supplement to SBBG. The lower food intake of the animals fed casein tends to show that adult animals need less food for maintenance of body weight. Food intake can be influenced by palatability, source of N and EAA profile. The higher food intake of the experimental diets might be due to a combination of these factors (Ene-Obong and Obizoba, 1995). Animals are known to eat more food when it has good organoleptic appeal (Ihekoronye and Ngoddy, 1985; Nnam, 2001).

The N intake of the casein group was the least and differed significantly from the rest of the experimental diets ($p<0.05$). The higher but similar N intake of the groups fed DWBG:S_{18} and SBBG:S_{24} diets appear to indicate that N intake was influenced by varietal differences and treatment (soaking) (1.24 vs 1.23 g) ($p>0.05$). The lower N intake of the control group could be due to low food intake, as well as biological variation (adult vs young rats) and could also be that as adult rats, they need only N for maintaining growth rather than for promoting growth which would be otherwise higher. Nnam (2001) observed that the highest food intake among the group fed the experimental diet was associated with higher mean nitrogen intake which was not statistically significant ($p>0.05$). In the present study, the association between the groups fed the experimental diet and the control diet were statistically significant ($p<0.05$).

The fecal N value for all groups varied. The variations were influenced by N intake and treatments. The control group had the lowest fecal N output which was significantly lower than for all groups ($p<0.05$). The replacement of S_{18} with equal amount of CR as a supplement to DAYB significantly decreased fecal N output ($p<0.05$). On the other hand, the replacement of S_{24} with an equal amount of CR as a supplement to SBBG increased fecal N output and the difference was significantly different for both the control and the test groups ($p<0.05$). The fecal N output of DBBG: S_{18} was lower than but comparable to that of the DWBG: S_{18} group ($p>0.05$). On the other hand, the fecal N output of the SBBG:S_{24} group was significantly higher than that of the SWBG:S_{24} group ($p<0.05$).

The significantly lower fecal N output for the control group as compared with the test groups show the superiority of the protein quality of casein. The lower fecal N of the casein group indicates that the protein was highly digested as compared with others. The significantly lower fecal N output of the DAYB:S_{18}:CR than the DAYB:S_{18} diets appears to indicate that the addition of CR as a supplement of DAYB was beneficial, probably, it furnished a much more desirable pattern of EAA which increased the digestibility and absorption of its protein (N). On the other hand, the higher fecal N

Table 2: Nitrogen balance of rats fed dehulled African yam bean and bambara groundnut supplemented with sorghum and crayfish[1]

Protein sources and ratio	CA 100	DAYB:S_{18} 70:30	DAYB:S_{18}:CR 70:15:15	DWBG:S_{18} 70:30
7-day food intake (g)	54.80±3.31^{e}	78.01±5.02^{a}	69.32±4.50^{d}	73.41±1.90^{b}
N intake* (g)	0.96±0.14^{d}	1.21±0.08^{a}	1.17±0.08^{b}	1.24±0.03^{a}
Fecal N (g)	0.05±0.01^{d}	0.27±0.09^{b}	0.18±0.02^{c}	0.19±0.01^{c}
Digested N (g)	0.91±0.01^{b}	0.94±0.03^{b}	0.99±0.02^{b}	1.05±0.03^{a}
Urinary N (g)	0.11±0.03^{b}	0.08±0.02^{c}	0.05±0.02^{d}	0.05±0.02^{d}
N balance (g)	54.64±0.01^{e}	77.66±0.02^{a}	69.09±0.04^{c}	73.17±0.01^{b}
BV (%)	97.91±0.02^{c}	91.49±0.04^{b}	94.95±0.01^{a}	95.24±0.02^{a}
NPU (%)	83.33±0.02^{a}	71.04±0.04^{c}	80.34±0.01^{b}	80.65±0.02^{b}
Apparent digestibility (%)	94.79	77.69	84.62	84.68
Protein sources and ratio	**DBBG:S_{18} 70:30**	**SWBG:S_{24} 70:30**	**SBBG:S_{24} 70:30**	**SBBG:S_{24}:CR 70:15:15**
7-day food intake (g)	65.71±4.72^{c}	65.73±5.33^{c}	72.80±5.50^{b}	71.62±5.91^{b}
N intake* (g)	1.11±0.08^{b}	1.04±0.09^{c}	1.23±0.09^{a}	1.11±0.09^{b}
Fecal N (g)	0.15±0.01^{c}	0.19±0.02^{c}	0.22±0.02^{b}	0.42±0.06^{a}
Digested N (g)	0.96±0.01^{b}	0.85±0.02^{c}	1.01±0.04^{a}	0.69±0.04^{d}
Urinary N (g)	0.08±0.04^{c}	0.05±0.02^{d}	0.11±0.04^{b}	0.16±0.04^{a}
N balance (g)	65.48±0.03^{d}	65.49±0.03^{d}	72.47±0.02^{b}	71.04±0.03^{b}
BV (%)	91.67±0.04^{b}	94.12±0.02^{a}	89.11±0.01^{c}	76.04±0.03^{b}
NPU (%)	79.28±0.04^{b}	76.92±0.02^{c}	73.17±0.01^{c}	47.75±0.03^{d}
Apparent digestibility (%)	86.49	81.73	82.11	62.16

[1]Mean±SEM (6 rats); *7 day N intake; CA = Casein, DAYB = Dehulled African Yam Bean; DWBG = Dehulled White Bambara Groundnut; DBBG = Dehulled Brown Bambara Groundnut; SBBG = Soaked Brown Bambara Groundnut; SWBG = Soaked White Bambara Groundnut; CR = Crayfish; S = Sorghum Soaked (18 or 24 h) $^{a-e}$Values of means with different superscript letters in a row differ significantly ($p<0.05$)

output of the SBBG:S_{24}:CR group as compared to the SBBG:S_{24} group shows a lack of mutual supplementation effect between the SBBG, S_{24} and CR. The significantly higher fecal N value for the SBBG:S_{24}:CR group as compared with that of the DAYB:S_{18}:CR group could be attributed to treatment and the type of legume. DAYB produced a better protein quality when blended with sorghum and CR as compared with the combination of BG, sorghum and CR. It could possibly be due to longer soaking of the sorghum which might have leached out most of the nutrients and destroyed them during thermal treatment (denaturation). The significantly higher fecal N output of the SBBG:S_{24} group and lower output of DBBG as compared with those of DWBG group shows specie differences as well as treatments. Dehulling lowered fecal N output in brown specie while soaking of brown BG increased fecal N output.

The digested N value for all groups varied and the variations were influenced by (a) type of legume (b) source of N (c) treatment (d) N intake and (f) fecal N output. The digested N for the DWBG:S_{18} diet was the highest while that of the SBBG:S_{24}:CR diet was the least. There was an increase in the digested N value when CR replaced S_{18} as a supplement of DAYB (0.94 vs 0.99 g). However, addition of an equal amount of CR to replace S_{24} as a supplement to SBBG caused decreases in digested N (0.01 vs 0.69 g). The digested N value of the control was high relative to the intake.

The slightly higher but similar digested N for the DAYB:S_{18}:CR and the DAYB:S_{18} groups could be attributed to lower fecal N output of the DAYB:S_{18}:CR relative to intake ($p>0.05$). The lower digested N of the DBBG as compared with that of the DWBG showed that the protein of the white BG was better than that of the brown BG. This could be attributed to lower N intake and higher fecal N output relative to intake. On the other hand, the higher digested N of the SBBG as compared with that of the SWBG could be due to treatment. It could be that soaking leached out protein from the white variety faster than that of the brown. One would expect that the SBBG:S_{24} group that had higher fecal N output than the SWBG group should have lower digested N. However, this could not be surprising because the SBBG:S_{24} had higher N intake. The significantly lower digested N value for the SBBG:S_{24}:CR diet as compared with the SBBG:S_{24} diet ($p<0.05$) tends to indicate that the mixture contained a poor pattern of EAA as compared with the SBBG:S_{24} group. This led to higher fecal N output and decreased N digestibility. The higher digested N for the DAYB:S_{18}:CR group when compared with that of the SBBG:S_{24}:CR group indicates differences in legume variety and treatment. It appears that protein from AYB can blend much more fairly well with that of CR and sorghum than those from SBBG and S_{24}.

The urinary N value for the SBBG:S_{24}:CR group was significantly higher than all the experimental diets and control ($p<0.05$). The urinary N for the DAYB:S_{18}:CR; DWBG:S_{18} and SWBG:S_{24} groups were comparable ($p>0.05$). Replacement of equal amounts of S_{18} with CR as a supplement to DAYB significantly lowered urinary N output (0.08 vs 0.05 g) ($p<0.05$). On the other hand, replacement of S_{24} with equal amounts of CR as a supplement to SBBG significantly increased urinary N output (0.11 vs 0.16 g) ($p<0.05$). The differences in the response of rats fed the diets containing CR might be attributed to type of legume and treatment. The significantly higher urinary N outputs for the DBBG:S_{18} as compared to the DWBG:S_{18} diets ($p<0.05$) indicates that DWBG had better protein quality than the DBBG diet. The same trend was observed with the SBBG:S_{24} and SWBG:S_{24} groups.

The similarities in urinary N output for the DAYB:S_{18}:CR; DWBG:S_{18} and SWBG:S_{24} groups suggests that the mixtures furnished high protein quality which was better than that of the other experimental diets and control. As a result, less was used for catabolic purposes.

When brown BG was soaked and mixed withS_{24}, the N retention was significantly higher than that of the SWBG mixed with the same amount of S_{24} ($p<0.05$). The control group had significantly lower NB value than all the test groups ($p<0.05$). The N balance of all groups was positive and varied. The DAYB:S_{18} group had the highest NB (77.66 g) while the control diet had the least (54.64 g). The SBBG:S_{24}:CR group had lower but comparable NB than the SBBG:S_{24} and DWBG:S_{18} groups ($p>0.05$). The NB of the DAYB:S_{18}:CR group was significantly lower than that of the DAYB:S_{18} group ($p<0.05$). The DWBG:S_{18} group significantly retained more N than the DBBG:S_{18} group ($p<0.05$). When brown BG was soaked and mixed with the same amount of S_{24}, the N retention was significantly higher than that of the SWBG mixed with the same amount of S_{24} ($p<0.05$).

The higher values of NB in the test groups as compared to the control group confirms the results of many workers who observed that plant proteins when carefully selected and mixed such that the amino acid deficient in one can compensate for the surplus in the other, could be equal to or better than animal protein (casein) (Bressani and Elias, 1974; Souza and Dutra de Oliveira, 1959; Ene-Obong and Obizoba, 1995; Obizoba and Egbuna, 1992; Obizoba, 1990). The increases in N retention for the SBBG:S_{24}:CR and the decrease in NB for the DAYB:S_{18}:CR group suggests that the difference could be due to type of legume. Soaked brown BG appears to establish a much better mutual supplementation effect with sorghum and CR as compared with DAYB. The increase in NB for the DAYB:S_{18} group as compared with that of the DAYB:S_{18}:CR group was an indication of the superiority of S_{18} to CR as a supplement to DAYB. It could be possible that the former had a better pattern of EAA. This is also the case when the SBBG:S_{24} group was compared with the SBBG:S_{24}:CR group (72.47 vs 71.04 g). The lower NB for the DBBG:S_{18} group as compared with the DWBG:S_{18} group indicates that the brown variety had poor protein quality as compared with the white. On the other hand, when SBBG was mixed with S_{24}, it produced high NB value when compared with that of the white variety treated as the brown. The higher NB value for the SBBG group could be that soaking caused more exposure of its protein to enzymatic action than that of the SWBG group.

The Biological Value (BV) of all groups regardless of treatment was high. However, the BV of the SBBG:S_{24}:CR group was lower than for all groups ($p<0.05$) but comparable to the control and SBBG:S_{24} group ($p>0.05$). The BV of the DWBG:S_{18} group was significantly higher ($p<0.05$) but comparable to those of DAYB:S_{18}:CR and SWBG:S_{24} groups.

The increase in the BV of the DAYB:S_{18}:CR group as compared with the DAYB:S_{18} group shows that CR was a better supplement to DAYB than sorghum. On the other hand, the lower BV for the SBBG:S_{24}:CR diet as compared with the SBBG:S_{24} diet indicates the inferiority of CR to S_{24}. This could be attributed to the type and treatment of the legume. Based on this result, it appears that CR was inferior to sorghum as a supplement to DAYB-a phenomenon already observed in other parameters tested. The lower but significant BV for the DBBG:S_{18} group as compared to that of the DWBG:S_{18} group ($p<0.05$) suggests that the DWBG had better protein quality than the DBBG. Similarly, the higher BV for the SWBG:S_{24} as compared with that of the SBBG:S_{24} suggests that varietal differences were the cause of the apparent high protein quality of the SWBG.

The Net Protein Utilization (NPU) was influenced by various factors such as source of N, varietal differences of the legumes and treatments. The NPU for the control group was the highest and that of the SBBG:S_{24}:CR the least which was significantly lower than for all the groups ($p<0.05$). The addition of CR to DAYB increased NPU value as compared with that of the DAYB:S_{18} group alone. The addition of CR to SBBG:S_{24} group significantly decreased NPU ($p<0.05$).

Net Protein Utilization (NPU) is a measure of both digestibility and BV of the amino acid mixture absorbed from food (Scrimshaw and Young, 1972; Ene-Obong and Obizoba, 1995). The decrease in NPU as a result of the replacement of S_{18} with CR in the DAYB and the decrease in NPU as a result of the replacement of S_{24} in the SBBG could be attributed to type of legume and the length of time for soaking of sorghum used as a supplement to either of the legumes. The lower NPU for the dehulled and soaked brown BG as compared with the white BG appears to establish a trend. This trend was clearly shown in BV values for these groups. This could be due to N intake except for the SBBG group which had higher food intake, fecal and urinary N output. The casein diet had the highest apparent digestibility value (94.79%) as compared with that obtained from the test diets (Table 2). This tends to show that although the N intake for the casein diet was low, little was excreted in the feces. As judged by N intake, digested N and BV, the DWBG:S_{18} diet appears to contain much more desirable pattern of EAA than the other test diets. The results showed that it could be of great importance to people living in areas where these foods are staple.

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