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<td>NNAM, N. M.</td>
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Comparison of the protein nutritional value of food blends based on sorghum, bambara groundnut and sweet potatoes

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The protein quality of four blends based on sprouted sorghum, bambara groundnuts and fermented sweet potatoes had been evaluated by rat feeding experiments; casein served as a reference protein. The test proteins were incorporated to make up 1.6% total nitrogen. There was an inverse relationship between % nitrogen digestibility and the proportion of sorghum protein in the blend; being highest (89.7%) in the diets based on sorghum: bambara groundnut: sweet potatoes with protein ratios of 52:46:2. This blend proved to be optimum when the biological value (93.6%) and the net protein utilization (84%) were used as protein indices. The findings imply that foods with good protein quality could be formulated from a blend of sorghum, bambara groundnut and sweet potatoes, provided appropriate processing and blending are taken into consideration.

Introduction

Protein deficiency, particularly in the diets of young children, is one of the major nutritional problems facing the developing countries. Poor food quality has been identified as one of the causative factors (WHO, 1997). In Nigeria, the traditional complementary foods consist mainly of unsupplemented starchy staples like sorghum, maize, millet, yams, cassavas, cocoa yams and sweet potatoes. They are poor in protein and limited in food value due to the presence of antinutrients which chelate or complex with essential nutrients. Adequate processing is necessary to improve their utilization.

Germination and fermentation are two household-level food technologies which have been extensively reviewed as means by which the nutritive value of plant food could be improved (Obizoba, 1998). They increase amino acid and mineral availability, protein and carbohydrate digestibility, nutrient and energy densities of gruels, levels of the B-complex vitamins and decrease toxic and antinutritional factors like phytates, tannins and alpha-galactosides (Obizoba & Nnam, 1992; FAO, 1995; Obizoba, 1998).

In Nigeria, there exist 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 complementary foods. This will help alleviate the protein gap experienced in the country particularly among young children. Sorghum is a popular cereal in Nigeria, particularly in the...
northern part of the country where it is pro-
duced. It constitutes a major source of energy
and protein in areas where it is a staple. The
protein varies from 7.5 to 9.0% and like other
cereal proteins, it is limited in the amino acids,
lysine, threonine, tryptophan and methionine
(Ihekwerere & Ngo daddy, 1985). Supplemen-
tation with other foods whose protein would
complement the amino acid composition is
necessary.

Bambara groundnut is an important legume
produced extensively in northern Nigeria. The
legume is sweet and pleasant to eat either as dry
or immature seeds. The protein content in the
forage range from 12-15% and in grains from
20-25% (dry matter basis) (Arora, 1995). It has
more methionine than is found in other grain
legumes and would serve as a good supplement
to sorghum protein.

Sweet potato is a root crop that provides
significant amounts of energy and protein. The
tuber is rich in carotene (particularly the yellow
variety), minerals and the B-complex vitamins.
It has a fair quantity of ascorbic acid. The
protein is rich in the amino acids lysine and
tryptophan (LFJE, 1994) which are low in
sorghum. The vegetative parts were carefully removed in
sorghum. Bambara groundnut grains were
dehulled mechanically using PRL mini-roller
dehuller (Nutana Machine Co., Saskatoon, Can-
ad). All the sprouted samples were milled
separately in a laboratory hammermill (Thomas
Wiley Mill, Model E3-S) to a fine powder
(70 mm mesh screen).

One kg of sweet potatoes were hand-peeled,
then milled using a Gallenkamp mixer Ken-
wood-MPR201 and fermented in a bell jar for
48 h by the microflora present in the paste. The
fermented sweet potato (FSP) sample was dried
and remilled using the same procedure as for
sorghum and bambara groundnuts.

Animal feeding experiments
The composition of the diets is presented in
Table 1. The diets were formulated based on the
protein quality of blends of processed sorghum,
bambara groundnuts and sweet potatoes. The
effect of this study was to evaluate the
protein quality of various combinations of
sprouted sorghum, bambara groundnuts and
fermented sweet potatoes in rats. The criteria
used for the evaluation were: nitrogen (N)
digestibility and utilization.

Materials and methods

Materials
White sorghum (Sorghum bicolor) (S), cream
bambara groundnuts (Vigna subterranea (L)
Veide) (BG) and reddish-purple sweet potatoes
(Ipomoea batatas) (SP) were used as source of
protein for the study. They were all purchased
from the Nsukka market in Enugu State of
Nigeria.

Preparation of materials
Five kg of sorghum and 2 kg of bambara
groundnuts were soaked separately in cold
denitized water for 8 h in a ratio of 1:3 (w/v) of
grain to water. The soaked grains were drained
at the end of the soaking period. They were
separately spread on wet jute bags and covered
with moistened muslin cloth to sprout for 48 h
at an average room temperature of 28.0 ± 2°C.
The grains were washed twice daily to avoid the
growth of mold. The sprouted grains, (sprouted
sorghum, SS and sprouted bambara groundnuts,
SBG) were dried separately in a convection air
oven (Gallenkaup and Co. Ltd, London, Eng-
land) at 50°C for 12 h to 96% dry matter. The
vegetative parts were carefully removed in
sorghum. Bambara groundnut grains were
dehulled mechanically using PRL mini-roller
dehuller (Nutana Machine Co., Saskatoon, Can-
ad). All the sprouted samples were milled
separately in a laboratory hammermill (Thomas
Wiley Mill, Model E3-S) to a fine powder
(70 mm mesh screen).

One kg of sweet potatoes were hand-peeled,
then milled using a Gallenkamp mixer Ken-
wood-MPR201 and fermented in a bell jar for
48 h by the microflora present in the paste. The
fermented sweet potato (FSP) sample was dried
and remilled using the same procedure as for
sorghum and bambara groundnuts.

Animal housing and feeding
Thirty male adult rats weighing from 80-150 g
were obtained from the Department of Veteri-
nary Pathology, University of Nigeria, Nsukka.
The wide range in the weight of the rats was
because of a scarcity of rat feed in the country, which led to
lack of rats. The animals were divided into five groups of 6 rats each on the basis of body
weight. They were housed individually in stainless steel metabolic cages equipped to
separate urine and feces. The rats were fed the
diets and deionized water ad libitum for 12
days, which included a 5-day adaptation period followed by a 7-day N balance period. The animals were weighed prior to access to the test diets and at the end of the study period to estimate the maintenance body weight. Daily food intake was recorded for the 7-day study period and the data were used for calculation of N intake of each animal during the N balance study.

Collection of urine and feces
Carmine red was used as a marker substance to mark the beginning and end of the fecal collection. It was fed on the mornings of days 5 and 12; coloured feces appeared, beginning on days 6 and 13; the coloured feces excreted on day 6 were included in the pooled fecal sample, while those excreted on day 13 (7 days) were excluded. Urine was collected from 7.00 a.m. of day 6 through the morning of day 13 (7 days). Hydrochloric acid (0.1 N) was added as a preservative to prevent loss of ammonia and the samples were stored in a refrigerator until analyzed for urinary N. Feces of individual rats were pooled, dried at 85°C for 3 h and weighed before being ground into fine powder and stored for fecal N determination.

Laboratory analysis
The nitrogen content of the diets, feces and urine was analyzed using approved methods of AOAC (1995).

Protein quality indices
Three protein quality indices, namely the apparent nitrogen digestibility (%D); the biological value (%BV) and the net protein utilization (%NPU) were assessed according to the following equations:

\[
\text{Nitrogen Balance (NB)} = I - (F + U)
\]

\[
(\% D) = \frac{I - F}{I} \times 100
\]

\[
(\% BV) = \frac{\text{I} - (\text{I} - \text{F} - \text{U})}{\text{I} - \text{F}} \times 100
\]

\[
(\% NPU) = \% D \times \% BV
\]

whereby I = nitrogen intake; F = fecal nitrogen; U = urinary nitrogen.

Statistical analysis
The means and standard error of the means were calculated. Analysis of variance and Duncan’s new multiple range test (DNMRT) was used to separate the means. Significance was accepted at \( P < 0.05 \).

Results and discussion
Table 2 presents the results of the rat feeding experiment. The average gain in body weight was highest \( (P < 0.05) \) among the rats consuming diet 4 based on SS: BG: FSP with the protein ratios (55: 46: 2) compared to the three other experimental diets. On the other hand, mean food intake was highest (99.83 g) among the rats consuming diet 1 based on the above

<table>
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<tr>
<th>Protein content</th>
<th>Reference</th>
<th>Experimental diet</th>
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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>Casein</td>
<td>90.80</td>
<td>11.01</td>
</tr>
<tr>
<td>S普roted sorghum (SS)</td>
<td>8.76</td>
<td>0.49</td>
</tr>
<tr>
<td>Sprouted groundnut (SSG)</td>
<td>19.44</td>
<td>20.38</td>
</tr>
<tr>
<td>Fermented sweet potatoes (FSP)</td>
<td>2.08</td>
<td>0.00</td>
</tr>
<tr>
<td>Vitamin mix C</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Mineral mix C</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Oil b</td>
<td>79.49</td>
<td>0.00</td>
</tr>
<tr>
<td>Nitrogen %</td>
<td>3.60</td>
<td>1.60</td>
</tr>
</tbody>
</table>

*Purchased from local retailers.
**Purchased from Teklad Harlan Sprague Dawley Inc., USA.
1 SS = sprouted sorghum; SGG = sprouted bambara groundnuts; FSP = fermented sweet potatoes.
2 Protein = N x 6.25.

### Table 1. Composition of the four experimental diets (g%)
Table 2. Indices of protein quality of four food blends based on different combinations of sprouted sorghum, barnbara groundnuts and fermented sweet potatoes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference casein diet</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tr>
<td>Gain in body weight (g/16 rats)</td>
<td>20.00 ± 1.57</td>
<td>16.67 ± 0.66</td>
<td>33.33 ± 1.07</td>
<td>1.50 ± 0.30</td>
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<tr>
<td>Food intake (g/16 rats)</td>
<td>99.03 ± 5.70</td>
<td>94.03 ± 7.60</td>
<td>97.42 ± 5.62</td>
<td>97.42 ± 5.62</td>
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<tr>
<td>Nitrogen intake (g/6 rats)</td>
<td>1.56 ± 0.36</td>
<td>1.51 ± 0.24</td>
<td>1.98 ± 0.31</td>
<td>2.03 ± 0.31</td>
<td></td>
</tr>
<tr>
<td>Fecal nitrogen (g/6 rats)</td>
<td>0.07 ± 0.01</td>
<td>0.06 ± 0.01</td>
<td>0.06 ± 0.01</td>
<td>0.06 ± 0.01</td>
<td></td>
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<tr>
<td>Apparent digestibility (%)</td>
<td>64.00 ± 0.01</td>
<td>67.98 ± 0.01</td>
<td>98.94 ± 0.01</td>
<td>98.94 ± 0.01</td>
<td></td>
</tr>
<tr>
<td>Urinary Nitrogen (g/6 rats)</td>
<td>0.13 ± 0.01</td>
<td>0.07 ± 0.01</td>
<td>0.06 ± 0.01</td>
<td>0.06 ± 0.01</td>
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<tr>
<td>Nitrogen balance (g/10 rats)</td>
<td>87.11 ± 0.24</td>
<td>80.07 ± 0.21</td>
<td>95.97 ± 0.42</td>
<td>95.97 ± 0.42</td>
<td></td>
</tr>
<tr>
<td>Net protein utilization (%)</td>
<td>85.71 ± 0.09</td>
<td>85.94 ± 0.36</td>
<td>85.94 ± 0.36</td>
<td>85.94 ± 0.36</td>
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Mean values are significantly different (P < 0.05) if they do not share the same superscript within the same row (Student’s t-test).

SS = sprouted sorghum; SBG = sprouted barnbara groundnut; FSP = fermented sweet potatoes.

The highest food intake among the group consuming diet 1 was associated with a lower mean N intake. However, the differences in the N intake did not attain statistical significance (P > 0.05). The mean N excretion with the rats consuming the casein diet, which had an apparent N digestibility (D) of 92.2%, was significantly lower than the respective mean figure obtained with the other experimental diets. This might be attributed to the presence of tannin in sorghum. Tannins are known to bind both exogenous and endogenous proteins including enzymes of the digestive tract, thus affecting the utilization of protein (Griffiths, 1985). Eggum et al. (1983) reported higher true protein digestibility in decorticated sorghum grain (low tannin) than in whole grain with higher tannin level. The nitrogen excretion of the group of rats differed. The group consuming diet 4 had comparably (P > 0.05) lower (P < 0.05) figures than the groups that consumed the other three experimental diets. The urinary N excretion showed a trend similar to that of the D and was highest and of the same magnitude among the group of animals consuming the reference casein diet or the experimental diet 4. Both figures were significantly higher (P < 0.05) when they were compared with the respective figures obtained after consuming diets 1, 2 and 3. This appears to indicate that the essential amino acid patterns of both diets were equally utilized by the animals for the synthesis of body protein. The higher (P > 0.05) N retention of the animals on diet 4 than the other experimental diets suggests that the ratios of the protein sources (52: 46: 2) gave a better protein quality and amino acid pattern than the other combinations. This result showed that whey sorghum is supplemented with barnbara groundnut and sweet potatoes at 52: 46: 2 ratio (protein basis), the mixture gives a protein quality equal to or comparable with casein.

The mean biological value and the net protein utilization reveal that diets 1, 2 and 3 were significantly (P < 0.05) inferior to diet 4 or the reference casein diet. This result supports the reported higher true protein digestibility in decorticated sorghum grain (low tannin) than in whole grain with higher tannin level. The nitrogen excretion of the group of rats differed. The group consuming diet 4 had comparably (P > 0.05) lower (P < 0.05) figures than the groups that consumed the other three experimental diets. The urinary N excretion showed a trend similar to that of the D and was highest and of the same magnitude among the group of animals consuming the reference casein diet or the experimental diet 4. Both figures were significantly higher (P < 0.05) when they were compared with the respective figures obtained after consuming diets 1, 2 and 3. This appears to indicate that the essential amino acid patterns of both diets were equally utilized by the animals for the synthesis of body protein. The higher (P > 0.05) N retention of the animals on diet 4 than the other experimental diets suggests that the ratios of the protein sources (52: 46: 2) gave a better protein quality and amino acid pattern than the other combinations. This result showed that whey sorghum is supplemented with barnbara groundnut and sweet potatoes at 52: 46: 2 ratio (protein basis), the mixture gives a protein quality equal to or comparable with casein.
Okeke and Obizoba (1986) whose findings suggested that substituting cereal and legume protein with tuber at low levels (2%) produced good-quality protein comparable to casein. The result is also in accordance with Obizoba (1990) who observed that when plant proteins are carefully selected and judiciously combined, the protein so produced could be equal to or better than animal protein.

Conclusion

The results of the study were revealing. Diet 4 showed superiority in protein quality over the other experimental diets in all the parameters tested and compared favorably with the reference casein diet. This has serious implications particularly with the current trend in dietary diversification to combat protein and other nutrient deficiencies in Nigeria. The use of the experimental diet based on 52:46:2 protein ratios of processed sorghum, bambara groundnuts and sweet potatoes should be encouraged both in infant and young child feeding programs because of its good protein quality.

References