The Nutritive Value of Mixtures of Two Varieties of Bambarra Groundnut and Sorghum

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ABSTRACT

Thirty albino rats were used to investigate the nutritive value of mixtures of two bambarra groundnut varieties (cream and brown) with sorghum. The bambarra groundnuts were dehulled and soaked and mixed in a 70:30 ratio with sorghum soaked for 18 or 24 hr. The 12-day balance study consisted of a five-day adjustment and a seven-day nitrogen and mineral balance period. The four all-vegetable mixed test diets and casein, which served as the control, provided 1.6 g of nitrogen per 100 g of diet daily during the study. Casein caused decreases in food and N intakes, weight gain, and dietary and retained phosphorus and increased other parameters tested. Dehulling improved the nutritive value of the cream variety better than the brown except for dietary and retained iron. Soaking improved the nutritive value of the brown variety much more than the cream. The results of this study indicate that blends of bambarra groundnut and sorghum could provide cheap and nutritious dishes for the populations that use them as staple foods.

Bambarra groundnut (*Voandzeia subterranea* (L.) Thouars.) is among the currently little-known and under utilized legumes that could improve the well-being of people in developing countries. It produces a nutritious food and is cultivated throughout Nigeria, but as one of the two most drought-resistant legumes, its commercial use is increasing despite scientific appraisal of its value (NAS 1979). Legume proteins have high lysine contents and have a beneficial complementary effect when consumed with cereal proteins, which are low in lysine. Cereal proteins contribute methionine and cysteine, the limiting amino acids of legume proteins.

Sorghum bicolor (L.) Moench. is the major cereal grain consumed in West Africa, especially in northern Nigeria. Sorghum is used for preparing various dishes for children and adults, mostly as pap (sorghum gruel) with added sugar to taste. The storage protein of sorghum seeds is of poor nutritional quality for humans. Any procedure that would improve the nutritional value of sorghum and thus spare use of other food stores could be of value in Nigeria. Soaking and germination have been proposed as means by which the nutritional quality of cereal and legume seeds might be improved (Dalby and Tsai 1975, Lemar and Swanson 1976, Ranhotra et al 1977, King and Puwastein 1987, Koehler et al 1987).

Legumes and cereals constitute the staple diet in Nigerian homes and public institutions, but the nutritive values of mixtures of flours from bambarra groundnut and sorghum and fractions extracted from them have not been investigated as ready-to-serve, low-cost foods for weaned infants and small children or as supplements for adults. It is necessary to show by feeding trials that the higher levels of lysine, tryptophan, and minerals accompanying soaking, dehulling, or germination (Koehler et al 1987) do lead to improved nutritive value. The objective of this study was to determine the effect of dehulling and soaking on the nutritive value of two varieties of bambarra groundnuts supplemented with soaked sorghum in four blends as ready-to-serve, low-cost, and all-vegetable foods.

Although a study of this nature calls for the use of young rats, we used adults because a scarcity of rat feed for more than five months in this country caused a lack of young ones. The protein that supports growth in young animals has been reported to maintain body weight in adult animals (Pineda et al 1981). Whole bambarra groundnut was excluded from the study because previous work in this laboratory showed it to be of poor nutritional value.

MATERIALS AND METHODS

A 12-day balance study in rats included a five-day adjustment and a seven-day N and mineral balance period. The mean N and mineral balances were estimated from the seven-day food and N intakes, feces, and urine of the rats.

Animals and Housing

Thirty adult albino rats supplied by the Deparment of Veterinary Pathology, University of Nigeria, Nsukka, were divided into five groups of six each on the basis of body weight. The rats were weighed before access to the test diets and at the end of the study to determine changes in body weight. The rats were housed in individual stainless steel, screened-bottom metabolism cages equipped to separate the animals' urine and feces. Both the test and control diets and deionized water were provided to the rats ad libitum for 12 days.

Each test group and the control received its respective diet throughout the study period. Food intakes were recorded daily and the data were used for calculation of N and mineral intakes of each rat.

Diets

The two varieties of bambarra groundnut, cream and brown (CBG, BBG), and sorghum used as sources of protein were purchased from local retailers. The bambarra groundnut seeds, which have a hard seed coat, were first split in two by machine. Half of the split seeds were soaked for an hour in warm water for easier seed coat removal; the other half were soaked for 8 hr before cooking. The sorghum grains were divided into two equal portions and soaked for 18 and 24 hr (S_{18}, S_{24}). They were cooked separately until tender. The cooked grains were dried to 96% dry matter according to an AOAC procedure (AOAC 1980) before being ground into a fine powder in a laboratory hammer mill (70 mesh screen). The flours from the grains were stored in a refrigerator until analysis for various nutrient levels.

Table I presents the composition of the diets. Casein served as the control. The four test diets obtained 70% of their dietary N from the two varieties of bambarra groundnut and the remaining 30% from sorghum.

Laboratory Analysis

All the procedures for collection and treatment of feces and urine, analysis of N, and determination of mineral contents of diets, feces, and urine have been cited previously (Ranjiham and Gopal 1980, Okeke and Obizoba 1986). At the end of the study, the rats were sacrificed by decapitation. The livers were removed and weighed. The liver composition (dry weight basis) and the method for statistical analysis of the data have been described elsewhere (Obizoba 1985, Okeke and Obizoba 1986).

RESULTS AND DISCUSSION

The crude protein contents of the dietary foods were as follows: dehulled CBG 18.9%, dehulled BBG 23.3%, soaked CBG 19.35%,

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soaked BBG 21.98%, and S_{18} and S_{24} 8.98 and 9.42%, respectively.

Table II shows the food and N intakes, maintenance weight, digested and retained N, and liver weight and composition of the rats. The casein group had a lower food intake than other groups ($P < 0.05$). The dehulled CBG:S_{18} group had higher food intake than the dehulled BBG:S_{18} group. The differences were due to varietal differences and treatment. The lower food intake for the casein group might result from rats preferring the bambarra groundnut-sorghum mixtures to the casein and eating more of them.

The maintenance weight for all groups varied, and the variations were attributed to treatment, food intake, and source of N. The control group had lower weight gain than the test groups because it ate less and gained less. The group fed dehulled CBG:S_{18} gained more than those fed dehulled BBG:S_{18}, and those fed soaked BBG:S_{24} gained more than the soaked CBG:S_{24} group. These differences might be due to food intake, treatment, and varietal differences.

The N intake of the casein group was the least and significantly lower than the groups fed dehulled CBG:S_{18} or soaked BBG:S_{24} ($P < 0.05$). This might be as a result of lower food intake.

As one would expect, the casein group had the least fecal N output. The group fed soaked BBG:S_{24} had the highest output. The variations were influenced by N intake and treatment. Dehulling lowered fecal N output of the dehulled BBG:S_{18} group. Soaking increased it in the soaked BBG:S_{24} group.

The digested N value for all groups differed. The differences were influenced by treatment, source of N, N intake, and fecal N output. The digested N for the dehulled CBG:S_{18} was higher than for both the control and the test groups. The digested N for the SCGB:S_{24} diet was lower than for the soaked BBG:S_{24} diet. The casein group had high digested N relative to the N intake. The higher digested N of the dehulled CGB:S_{18} diet indicates that the dehulled BBG had a lower protein quality. This might be due to lower N intake and high fecal output. The higher value for the soaked BBG:S_{24} group than for the soaked CBG:S_{24} group might be attributed to variety.

The urinary N values for all groups of rats differed. The casein and the soaked BBG:S_{24} groups had equal values that were higher than for the other groups. Regardless of treatment and intake, the brown variety produced higher urinary output than the cream type.

The N balance values for all groups were positive. The dehulled CBG:S_{18} group had the highest value. The control and the SCBG:S_{24} groups had comparable values that were lower than for the other groups. Varietal differences might be the cause of higher N balance of the dehulled CBG:S_{18} group than for the dehulled BBG:S_{18} diet. The higher value for the soaked BBG:S_{24} than for the soaked CBG:S_{24} group might also be attributed to varietal differences. Soaking caused more exposure of the protein of the brown bambarra groundnut to enzymatic action than that of the cream variety.

The liver weight of the group fed soaked BBG:S_{24} was the highest and that of the group fed dehulled BBG:S_{18} was lowest. The slightly lower liver weight for the dehulled BBG:S_{18} than for the dehulled CBG:S_{18} group suggests the superiority of the cream variety. The liver weight for the soaked BBG:S_{24} was higher than for the soaked CBG:S_{24} group ($P < 0.05$), and this could be attributed to treatment and food intake.

The liver N for all groups of rats was influenced by liver weight, treatment, intake, and varietal differences. The liver N for the dehulled CBG:S_{18} group was the highest. The dehulled BBG:S_{18} group had much lower value than the other groups ($P < 0.05$). The casein group value was comparable to that of the soaked CBG:S_{18}

TABLE I
Composition of Diets (g) Containing Cream (CBG) or Brown (BBG) Varieties of Bambarra Groundnuts and Sorghum (S)

Diet Components	Casein Control (100%)	Dehulled CBG:S_{18}[a] (70:30)	Dehulled BBG:S_{18} (70:30)	Soaked CBG:S_{24}[a] (70:30)	Soaked BBG:S_{24} (70:30)
Dehulled CBG[b]	···	355.36	···	···	···
Dehulled BBG[b]	···	···	288.41	···	···
Soaked CBG[b]	···	···	···	347.29	···
Soaked BBG[b]	···	···	···	···	305.73
Soaked sorghum (18,24 hr)[b]	···	320.7	320.7	305.73	305.73
Oil	48.0	48.0	48.0	48.0	48.0
Casein[c]	222.0	···	···	···	···
Vitamin[c]	9.6	9.6	9.6	9.6	9.6
Mineral[c]	33.6	33.6	33.6	33.6	33.6
Sucrose[b]	324.4	96.37	129.85	107.89	128.67
Corn starch[c]	324.4	96.37	129.85	107.89	128.6
Total	960.0	960.0	960.0	960.0	960.0

[a] S_{18} = Sorghum soaked for 18 hr; S_{24} = sorghum soaked for 24 hr.
[b] Purchased from local retailers.
[c] AIN 76 mineral mix; cornstarch; AIN 76A vitamin and NRC casein; purchased from Teklad; A Harlan Sprague Dawley Inc., Madison, WI.

TABLE II
Food and N Intake, Maintenance Body Weight, N Balance and Liver Composition and Weight of Rats Fed Mixtures of Cream (CBG) or Brown (BBG) Bambarra Groundnuts and Sorghum (S)

Parameter	Casein Control (100%)	Dehulled CBG:S_{18}[a] (70:30)	Dehulled BBG:S_{18} (70:30)	Soaked CBG:S_{24}[a] (70:30)	Soaked BBG:S_{24} (70:30)
Food intake, g	54.8 ± 3.3	73.4 ± 1.9	65.7 ± 4.7	65.7 ± 5.3	72.8 ± 5.5
Maintenance wt, g	17.8 ± 1.8	36.3 ± 4.2	20.8 ± 5.2	21.4 ± 3.7	31.2 ± 5.2
N intake,[b] g	0.96 ± 0.1	1.24 ± 0.03	1.11 ± 0.08	1.04 ± 0.09	1.23 ± 0.09
Fecal N, g	0.05 ± 0.007	0.19 ± 0.012	0.15 ± 0.01	0.19 ± 0.015	0.22 ± 0.019
Digested N,[c] g	0.91 ± 0.05	1.05 ± 0.02	0.96 ± 0.07	0.85 ± 0.08	1.01 ± 0.08
Urinary N, g	0.11 ± 0.03	0.05 ± 0.02	0.08 ± 0.04	0.05 ± 0.02	0.11 ± 0.04
N balance,[c] g	0.80 ± 0.06	1.00 ± 0.02	0.88 ± 0.1	0.80 ± 0.07	0.90 ± 0.08
Liver wt, g	5.0 ± 0.1	5.8 ± 0.7	4.5 ± 0.2	4.7 ± 0.3	6.2 ± 0.5
Liver, N,[d] mg	121.6 ± 3.7	187.2 ± 18.4	70.0 ± 2.9	126.6 ± 8.3	161.2 ± 21.4
Liver moisture,[d] %	35.0 ± 1.0	38.8 ± 2.7	36.9 ± 1.7	37.7 ± 2.4	36.8 ± 1.8
Liver lipids,[d] %	9.3 ± 0.3	6.5 ± 0.6	5.9 ± 0.2	8.1 ± 0.5	13.6 ± 1.0

[a] S_{18} = Sorghum soaked 18 hr; S_{24} = sorghum soaked 24 hr.
[b] Intake for seven days.
[c] Apparent.
[d] Dry weight basis.

TABLE III
Iron and Phosphorus Balances[a] of Rats Fed Mixtures of Cream (CBG) or Brown (BBG) Bambarra Groundnuts and Sorghum (S)

Parameter	Casein Control (100%)	Dehulled CBG:S_{18}[b] (70:30)	Dehulled BBG:S_{18} (70:30)	Soaked CBG:S_{24}[b] (70:30)	Soaked BBG:S_{24} (70:30)
Iron intake, mg	1.05 ± 0.06	0.80 ± 0.02	3.71 ± 0.29	1.24 ± 0.10	0.79 ± 0.06
Fecal Fe, mg	0.03 ± 0.003	0.08 ± 0.005	0.05 ± 0.003	0.09 ± 0.007	0.05 ± 0.009
Urinary Fe, mg	0.01 ± 0.004	*[c]	0.01 ± 0.008	0.002 ± 0.0006	0.009 ± 0.003
Retained Fe, % intake	96.2 ± 6.0	90.0 ± 2.0	98.4 ± 2.9	92.7 ± 9.0	92.4 ± 9.0
Phosphorus intake, mg	2.3 ± 0.14	3.7 ± 0.09	3.0 ± 0.21	2.6 ± 0.21	3.8 ± 0.29
Fecal P, mg	0.09 ± 0.001	0.21 ± 0.001	0.14 ± 0.001	0.20 ± 0.02	0.26 ± 0.03
Urinary P, mg	0.23 ± 0.07	0.03 ± 0.004	0.02 ± 0.007	0.03 ± 0.008	0.07 ± 0.02
Retained P, % intake	86.1 ± 12.0	93.5 ± 9.0	94.7 ± 21.0	91.2 ± 19.0	91.3 ± 20

[a] Mean ± SEM (six rats).
[b] S_{18} = Sorghum soaked 18 hr; S_{24} = sorghum soaked 24 hr.
[c] * = Trace.

group ($P < 0.05$). The liver N level for the soaked BBG:S_{24} group was higher than for the soaked CBG:S_{24} group. The observed variations could be a result of either intake or liver weight, varietal differences, or a combination of these factors.

There were no significant differences in liver moisture among all groups of rats. The slightly higher but similar moisture values for the four test groups suggests that the liver moisture was solely influenced by varietal differences.

The liver lipids differed for all rats. The differences were a function of both individual variation between rats and the test diets. The soaked BBG:S_{24} diet induced higher liver lipids than the other groups ($P < 0.05$). Varietal differences, food intake, liver weight, and N possibly were the causes of variation in liver lipid levels between the soaked BBG:S_{24} and the soaked CBG:S_{24} groups.

Table III presents the iron (Fe) and phosphorus (P) balances of the rats. Fe intake value for all groups of rats varied and was influenced by treatment. The intake from the dehulled BBG:S_{18} diet was similar to the dehulled CBG:S_{18} group ($P < 0.05$). The dehulled BBG:S_{18} group had a higher Fe intake than the dehulled CBG:S_{18} group, which indicates that the brown bambarra groundnut had more Fe than the cream variety, and that the dehulled BBG:S_{18} blend might be more palatable than the dehulled CBG:S_{18} mixture. The higher Fe intake for the soaked CBG:S_{24} group than for the soaked BBG:S_{24} group might be due to the nutrient in question and the treatment.

The fecal Fe output was influenced by food intake, source of N, treatments, and varietal differences. The fecal Fe output of the soaked BBG:S_{24} and dehulled BBG:S_{18} groups was similar ($P > 0.05$). The fecal Fe output of the control was lowest. Values for the cream variety regardless of treatment and intake were similar to those of the brown.

The urinary Fe output for all groups was generally low.

The Fe retention was expressed as a percentage of intake. The Fe retention was positive for all groups and was influenced by treatment, source of N, intake, fecal and urinary output, and varietal differences. The dehulled BBG:S_{18} group ate more and retained more than other groups except for the control. The DCBG:S_{18} group had lower value than the casein and the dehulled BBG:S_{18} groups.

Individual variation between rats, intake, and varietal differences influenced Fe retention of the rats fed the dehulled bambarra groundnuts (90.0 ± 2.0 vs. 98.4 ± 2.9%).

The P intake of the casein group was lower than for those fed the test diets. This might be because the bambarra groundnut-sorghum blends were more palatable, and the rats ate more of them. The slight differences in Fe intake between test groups could be attributed to treatments and varietal differences.

The fecal P output for the control group was the least. Dehulling and soaking had equal effect on the fecal P output of the cream variety. The high values for the cream variety showed that some of the anti-nutritional factors remained despite the treatments. Soaking, however, increased the output of the soaked BBG:S_{24} group.

The casein group excreted more urinary P than any other group. This might be attributed to individual variation between rats. The P retention was based on a percentage of the food phosphorus intake. The P retention value for the control was the least. There were no differences between test groups.

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