Nutritive Value of Malted, Dry- or Wet-Milled Sorghum and Corn

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ABSTRACT

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A 12-day study consisting of five-day adjustment and seven-day nitrogen-balance periods was conducted to evaluate the protein quality of malted sorghum and corn, dry- or wet-milled and supplemented with crayfish to provide 1.6 g of nitrogen per 100 g of the daily diet of adult rats. Wet milling produced high-quality protein that blended well with crayfish to effect increases in most of the parameters tested. The processes of malting and wet milling seem to offer methods for improving the nutritional value of the proteins of sorghum and corn by increasing the total protein content and quality.

Sorghum and corn are the major cereal grains consumed in West Africa, especially in Nigeria. These two grains are used for preparing various dishes for both children and adults, mostly as pap for children (sorghum and corn gruels) with added sugar to taste. Cereals are generally low in lysine. It is generally thought but little documented that malting improves overall nutritive value of cereals, wheat in particular (Lemar and Swanson 1976), and protein quality especially because of an increase in lysine (Dalby and Tsai 1976). Thus, malting sorghum and corn would be expected to improve their nutritive value. Crayfish is one of the cheapest sources of animal protein in Nigeria and a good source of both lysine and methionine. The investigation reported herein was undertaken to determine the protein quality of malted and unmalted sorghum or corn mixed with crayfish.

Protein quality of the mixtures was assessed by the standard AOAC method (1975) except for the selection of the rats and use of casein as reference protein. Adult male rats were chosen because long periods (over six months) of a scarcity of rat feed in the country led to a lack of young rats. Although young rats are called for in the standard AOAC method, it is known that protein that could promote growth in young animals would maintain body weight of adult animals.

MATERIALS AND METHODS

The 12-day study included a five-day adjustment period followed by a seven-day N balance period.

Animals and Housing

Forty male adult rats supplied by the Department of Veterinary Pathology, University of Nigeria, Nsukka, were divided into eight groups of five rats each on the basis of body weight. The rats were weighed on day 1 of the experiment, housed in individual metabolism cages, and fed diets and tap water ad libitum for 12 days, at the end of which the final weight was recorded. The cages have been described elsewhere (Obizoba 1985).

Diets

The sorghum (*Sorghum bicolor*), corn (*Zea mays*), and crayfish (*Astacus fluviatilis*) used as sources of protein in this study were purchased from local retailers. The grains were each divided into two equal portions. One portion (malted) was soaked overnight in cold water in a ratio of 1:3; the soaking water was completely drained the following morning. The soaked grains were spread on wet jute bags and covered with moist muslin cloth to germinate. The grains were washed with cold water every 12 hr at an average room temperature of 29.0 ± 2°C. After malting, the grains were dried at 55°C for 48 hr to 96% dry matter. The sprouts were carefully removed. The malted and unmalted sorghum and corn samples were further divided into two equal portions for milling. Portions of each grain were dry or wet milled into a fine powder in a laboratory hammer mill (70-mesh screen). The dry-milled flours were sieved, mixed with cold water (1:3), and allowed to ferment for 24 hr, after which they were drained and dried in an air oven at 50°C to 96% dry matter.

The flours were then remilled into a fine powder. The malted and unmalted grains were separately wet milled after soaking for 24 hr in cold water (1:1) to ferment. At the end of fermentation they were sieved separately with cheese cloth, dried at 50°C to 96% dry matter, and remilled to a fine powder. Both flours were then stored in separate polyethylene bags and frozen until used for the formulation of test diets. The crayfish was milled also into fine powder and stored like the flours. Table I presents the ingredient composition of the diets.

The eight diets derived 70% of their dietary protein from malted or unmalted corn or sorghum either dry or wet milled. The remaining 30% came from crayfish. Regardless of the N source, the mixtures provided 1.6 g of N per 100 g of diet daily during the study period. Food intakes were recorded (seven days), and the data were used for calculating N intakes for each rat.

Laboratory Analysis

All the procedures for the collection, treatment, and storage of feces, urine, and liver, the estimation of N in diets, feces, urine, and liver, the moisture and lipid content of the liver, and all statistical techniques applied in this study have been described elsewhere (Obizoba 1984).

RESULTS AND DISCUSSION

The crude protein contents of protein foods were as follows: crayfish (CR) 55.62%; malted dry-milled corn (MDC) 12.3%; malted wet-milled corn (MWC) 13.07%; malted dry-milled sorghum (MDS) 12.3%; malted wet-milled sorghum (MWS) 14.07%; unmalted dry-milled corn (UDC) 11.4%; unmalted wet-milled corn (UWC) 12.3%; unmalted dry-milled sorghum (UDS) 11.4%; and unmalted wet-milled sorghum (UWS) 12.3%. Regardless of treatment, wet milling caused increases in total crude protein levels.

Table II presents food and N intakes, fecal and urinary N, digested and retained N, biological value, net protein utilization, maintenance body weight, and liver composition of the rats. Food intakes of all groups of rats were influenced by treatments including dry or wet milling. Dry milling decreased food intake for the group given the unmalted corn but resulted in increases for the group given the unmalted sorghum. Wet milling had the opposite effect; it increased intake of the unmalted corn diet and decreased the sorghum. In either case the difference was insignificant ($P > 0.05$). Malting and dry milling resulted in increases in food intake, but the increase was much higher for corn. The lower values for the UDC, UWS, MWC, and MWS groups might be due to lack of palatability or flavor or both.

The N intakes for all groups varied and were influenced by food intake, treatment, and grain type. The groups that consumed the UDC and UDS diets had lower intake than those that consumed diets containing wet-milled unmalted grains (UWC, UWS), but the

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TABLE I
Composition of Corn- and Sorghum-Crayfish Diets Fed to Rats (g)

	Grain-Crayfish (70:30) Mixtures							
Diet Component[a]	UDC:CR	UWC:CR	UDS:CR	UWS:CR	MDC:CR	MWC:CR	MDS:CR	MWS:CR
UDC	551.1	...	...	...	...	...	...	...
UWC	...	511.8	...	...	...	...	...	...
UDS	...	...	551.1	...	...	...	...	...
UWS	...	...	...	511.8	...	...	...	...
MDC	...	...	...	...	511.8	...	...	...
MWC	...	...	...	...	...	483.5	...	...
MDS	...	...	...	...	...	...	551.1	...
MWS	...	...	...	...	...	...	...	447.76
CR	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4
Vitamin mix[b]	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Mineral mix[b]	31.5	31.5	31.5	35.5	31.5	31.5	35.5	35.5
Corn starch[b]	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5
Oil	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Sucrose	107.5	107.5	107.5	107.5	107.5	107.5	107.5	107.5

[a]UDC = Unmalted dry-milled corn (11.4% protein); UWC = unmalted wet-milled corn (12.3% protein); UDS = unmalted dry-milled sorghum (11.4% protein); UWS = unmalted wet-milled sorghum (12.3% protein); MDC = malted dry-milled corn (12.3% protein); MWC = malted wet-milled corn (13.07% protein); MDS = malted dry-milled sorghum (12.3% protein); MWS = malted wet-milled sorghum (14.07% protein); and CR = dry-milled crayfish (55.67% protein). All protein values were based on 6.25 × N.

[b]Purchased from Teklad Harland Sprague Dawley Inc., Madison, WI.

TABLE II
Food and N Intake, Fecal and Urinary N, Digested and Retained N, Biological Value, Net Protein Utilization, Maintenance Body Weight, and Liver Composition of Rats Fed Corn- or Sorghum-Crayfish Diets[a]

	Grain-Crayfish (70:30) Mixtures[b]							
Diet Component	UDC:CR	UWC:CR	UDS:CR	UWS:CR	MDC:CR	MWC:CR	MDS:CR	MWS:CR
Food intake, g	86.6 ± 7.9	91.0 ± 3.2	79.7 ± 4.2	75.7 ± 13.7	92.5 ± 7.2	78.6 ± 7.6	70.1 ± 5.1	65.6 ± 7.2
N intake, g[c]	0.98 ± 0.09	1.16 ± 0.04	1.18 ± 0.06	1.30 ± 0.24	1.17 ± 0.09	0.61 ± 0 .06	1.11 ± 0.08	1.06 ± 0.12
Fecal N, g	0.21 ± 0.02	0.13 ± 0.01	0.18 ± 0.01	0.13 ± 0.02	0.21 ± 0.02	0.14 ± 0.01	0.25 ± 0.01	0.16 ± 0.01
Digested N, g	0.77 ± 0.07	1.03 ± 0.04	0.99 ± 0.06	1.17 ± 0.21	0.96 ± 0.07	0.46 ± 0.05	0.85 ± 0.07	091 ± 0.11
Urinary N, g	0.21 ± 0.03	0.15 ± 0.02	0.14 ± 0.04	0.09 ± 0.02	0.22 ± 0.05	0.14 ± 0.03	0.11 ± 0.02	0.08 ± 0.02
Retained N, g	0.56 ± 0.1	0.88 ± 0.1	0.86 ± 0.1	0.86 ± 0.2	0.74 ± 0.1	0.32 ± 0.1	0.75 ± 0.1	0.83 ± 0.1
Biological value	72.7 ± 3.6	85.28 ± 2.6	85.16 ± 5.2	92.1 ± 1.4	75.9 ± 6.9	67.6 ± 8.6	87.5 ± 2.8	91.4 ± 2.4
Net protein utilization	57.3 ± 2.8	75.8 ± 1.6	72.2 ± 4.8	82.5 ± 1.5	62.3 ± 5.9	51.8 ± 6.6	67.4 ± 2.3	77.9 ± 2.5
Maintenance body wt, g	35.2 ± 6.5	18.2 ± 6.1	33.2 ± 2.9	26.6 ± 4.6	26.6 ± 3.7	19.8 ± 6.9	21.1 ± 3.6	19.8 ± 3.7
Liver wt, g	7.4 ± 0.62	8.1 ± 0.89	6.0 ± 0.32	5.8 ± 0.72	6.7 ± 0.37	6.6 ± 0.66	4.8 ± 0.20	5.7 ± 0.97
Liver moisture, %	66.1 ± 0.56	63.1 ± 3.37	64.7 ± 2.27	68.5 ± 1.46	66.23 ± 0.65	66.2 ± 0.31	68.2 ± 1.23	61.9 ± 2.80
Liver N, mg[d]	81.5 ± 5.1	78.5 ± 12.1	91.3 ± 9.7	77.3 ± 10.9	86.2 ± 2.7	84.4 ± 7.0	67.2 ± 5.7	76.2 ± 16.4
Liver lipid, %[d]	22.1 ± 1.4	38.1 ± 5.9	5.5 ± 0.6	25.7 ± 3.6	11.2 ± 0.4	15.5 ± 1.3	7.0 ± 0.6	37.2 ± 8.0

[a]Means ± SEM (5 rats).

[b]UCD = Unmalted dry-milled corn; CR = crayfish; UWC = unmalted wet-milled corn; UDS = unmalted dry-milled sorghum; UWS = unmalted wet-milled sorghum; MDC = malted dry-milled corn; MWC = malted wet-milled corn; MDS = malted dry-milled sorghum; MWS = malted wet-milled sorghum.

[c]Seven-day food and N intakes.

[d]Dry weight basis.

differences were not significant ($P > 0.05$). On the other hand, malting and dry milling increased N intake for both grains, but the increase was much higher for corn. Wet milling significantly lowered N intake only for corn ($P < 0.05$) (1.17 vs. 0.61 g).

The fecal N excretion levels for all groups were a function of treatment and intake. Dry milling caused increases. Lower N intake led to higher fecal N levels except for the MDC and MWS groups. The lower fecal N levels for the wet-milled groups appear to indicate that wet milling produced high-quality protein that combined with CR to form highly digestible mixtures. It increased protein content and probably exposed the protein to more enzymatic action.

The digested N differed in all groups. The groups that ate the UWC and UWS diets had higher digested N than the MWC group ($P < 0.05$) (1.03 and 1.17 vs. 0.46 g). The lower digested N values for the UDC, UDS, MDC, MWC, and MDS groups were caused by low intake and high fecal N excretion levels. Wet milling had an advantage over dry milling only for the MWC group. Urinary N levels for the groups fed the diets containing dry-milled grains were higher than for the wet-milled diet groups regardless of malting. The higher urinary N levels for these groups were indicative of poor utilization, possibly due to an undesirable pattern of essential amino acids of the mixtures. The retained N values were generally low for the groups consuming the diets containing dry-milled grains irrespective of treatment, except for the MWC group (0.32 g). The higher N retention levels for the wet-milled groups (except for the MWC group) suggest that wet milling produced high-quality protein that established a mutual supplementation effect with CR. Dry milling was not as beneficial, except for the MDC group (0.74 g). The increases in retained N were higher for the sorghum groups.

The biological and net protein utilization values for all groups of rats tended to increase as did the retained N values and appeared to have been influenced by the same factors. Dry milling, low food and N intakes, and high fecal and urinary N output adversely affected these values. The corn groups were much more affected than the sorghum groups.

The body weight (maintenance) of the rats varied. The UDC:CR diet maintained more body weight than any other diet (35.3 g), whereas the UWC:CR diet had the lowest value. There was a general trend towards increased maintenance body weight when the rats were given diets containing dry-milled grains. Although the increases were more pronounced in those fed the UDC and UDS diets, they were not significant ($P > 0.05$). The lower body weight for the groups given the wet-milled grains and CR might be attributed to lower quality protein of the blends.

The liver weight of the animals differed, and these differences were due to low food and N intakes and to low values of digested and retained N. Dry milling lowered liver weight of rats consuming the UDC:CR diet but caused increases in the UDS:CR group. This difference might be due to physical properties of the grains. Malting and dry milling slightly increased liver weight in rats fed the MDC but not MDS, and this might be due to grain type. The liver moisture levels for the UWS and MDS groups were highest, and those of the UWC and MWS groups were lowest. The MWS group had lower moisture than the UWS and the MDS groups ($P < 0.05$). There were no other differences between groups. The similarities in liver moisture for all groups except for the MWS group showed that treatment and milling processes had no effects on moisture levels.

The liver N levels for the UDC, UDS, and MDC groups were higher than for the UWC, UWS, MWC, and MDS groups. Dry milling appears to be the cause except for the MDS group, however the increases were not significant ($P > 0.05$). Liver lipids varied, and the variations were influenced by source of N and treatment. Dry milling produced lower values than wet milling. These lower values were much higher for the groups fed corn diets irrespective of treatment (malting). On the other hand, wet milling caused increases, and the increases also were more pronounced for the corn group.

LITERATURE CITED

LEMAR, L. E., and SWANSON, B. G. 1976. Nutritive value of sprouted wheat flour. J. Food Sc. 41:719-20.

DALBY, A., and TSAI, Y. 1976. Lysine and tryptophan increases during germination of cereal grains. Cereal Chem. 53:222-26.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. 1975. Official Methods of Analysis, 12th ed. The Association: Washington, DC.

OBIZOBA, I. C. 1984. Comparative nutritional value of legume proteins supplemented with rice fed at equal intake. Ecol. Food Nutr. 14:71-75.

OBIZOBA, I. C. 1985. Evaluation of the protein quality of rice supplemented with bean or crayfish in rats. Qual. Plant Plant Food Hum. Nutr. 35:43-49.

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