Nutritional Evaluation of Some Varieties of Sorghums (*Sorghum bicolor* (L.) Moench)

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Cereal Chem. 64(6):413–417

ABSTRACT

Sorghums grown in the 1980 and 1981 seasons were analyzed for dry matter, crude protein, indigestible residue, ether extract, ash, free sugars, starch, tannins, apparent metabolizable energy, and in vitro crude protein digestibility. Varietal as well as seasonal differences were observed in all the determined parameters. Tannin values depended upon the method used for their determination. Varietal differences were also found when these samples were incorporated in the diets of flour beetle (*Tribolium castaneum*) larvae to support their growth. Isonitrogenous diets containing sorghums and soybean meal as the main ingredients supported the growth of chicks to different extent depending upon the variety of sorghum. Apparent metabolizable energy and apparent nitrogen retention of these diets for chicks also had varietal differences.

Sorghums (*Sorghum bicolor* (L.) Moench) may be classified as low- or high-tannin (bird-resistant) varieties according to their tannin content. Information on the composition and utilization of sorghums has been compiled (Rooney 1973, Hulse et al 1980).

Varietal differences exist for sorghums in chemical composition (Neucere and Sumrell 1980), protein content (Miller et al 1964), amino acid profiles (Waggle et al 1967, Breuer and Dohm 1972, Briley et al 1979, Neucere and Sumrell 1979, Sikka and Johari 1979), and nutritive value (Breuer and Dohm 1972). The protein content and amino acids are influenced by the agronomic factors (Rooney 1973).

The nutritional value of sorghums has been evaluated using chickens (Waggle et al 1967; Armstrong et al 1973, 1974a,b; Luis et al 1982). This study evaluated the composition of some varieties of sorghums and their nutritional value for flour beetle (*Tribolium castaneum*) larvae and for chickens.

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MATERIALS AND METHODS

Ten selected varieties of sorghum were grown at Davis, CA, during the 1980 and 1981 seasons. These varieties (abbreviated names in parentheses) were DeKalb DD 50T (DD 50T), O'Gold EXP 9520 (EXP 9520), Northrup King NK 1580 (NK 1580), Northrup King NK 129 (NK 129), P.A.G. 4432 (PAG 4432), Pioneer 8790 (P 8790), Asgrow Corral (Corral), DeKalb A 28+ (A 28+), P.OIL P01652G (P 1652G), and O'SG M 0505 (M 0505). The high-tannin varieties NK 300, Savanna S-91906 (S-91906), Savanna 3174-63836 (X-63836), and BRY 936 (Y 936) were donated by Northrup King Co., Minneapolis, MN.

Three replicates of each sample were used for analysis. Dry matter (DM), crude protein (%CP = % Kjeldahl N × 6.25), ether extract (EE), and ash were determined according to AOAC (1979) procedures. The method of Hellendoorn et al (1975) was used for estimating indigestible residue (IDR). Starch was determined by the method of Southgate (1969). Free sugars were estimated as glucose by the glucose oxidase method (glucose diagnostic kit 115, Sigma Chemical Co., St. Louis, MO).

Tannins (polyphenols) were measured as catechin equivalent by the procedures of Price et al (1978), Earp et al (1981), and Price and Butler (1977) and as tannic acid equivalent by Folin-Denis method (Burns 1971).

Apparent metabolizable energy (AME) of the samples was determined by a fast method using adult roosters (Vohra et al 1982). In vitro crude protein digestibility was determined using pepsin (AOAC 1979).

Tribolium castaneum larvae were used for the bioassay of sorghums (Vohra et al 1981). The test samples were ground finely to pass through a 100-mesh screen. The test diets contained 90% sorghum flour and 10% brewer's yeast. Six-day old larvae

TABLE I
The Composition of Isonitrogenous Diets for Chickens Containing Different Varieties of Sorghum and a Control Diet Containing Corn (g/kg diet)

Ingredient	Control Diet	Sorghum Variety										
		DD 50T	EXP 9520	NK 1580	NK 129	PAG 4432	P 8790	Corral	A 28+	PO 1652	M 0505	NK 300
Corn	505	···	···	···	···	···	···	···	···	···	···	···
Sorghum	···	540	635	516	532	530	523	555	545	537	833	530
Soybean meal, (48% CP)	405	370	375	394	378	380	387	355	365	373	377	380
Supplement[a]	90	90	90	90	90	90	90	90	90	90	90	90

[a] Supplement supplied (g/kg of diet): DL-methionine, 4.5; $CaCO_3$, 10; $CaHPO_4 \cdot 2H_2O$, 28.5; soybean oil, 17.4; KCl, 2.97; KH_2PO_4, 4.95; $MgSO_4 \cdot 7H_2O$, 3.97; NaCl, 5.5; $MnSO_4 \cdot H_2O$, 0.297; $CuSO_4 \cdot 5H_2O$, 0.097; ZnO, 0.12; $Co(C_2H_3O_2)_2 \cdot 4H_2O$, 0.02; $Na_2MoO_4 \cdot 2H_2O$, 0.009; KIO_3, 0.009; $Na_2SeO_3 \cdot 5H_2O$, 0.00066; $FeSO_4 \cdot 7H_2O$, 0.664; vitamin mix, 10. Vitamin mix contained (in mg): menadione, 10; thiamine HCl, 10; riboflavin, 10; niacin, 120; calcium pantothenate, 30; folic acid, 5; biotin, 0.4; pyridoxine HCl, 10; vitamin B_{12}, 0.01; choline chloride, 2,400; BHT, 100; vitamin A, 4,000 IU; vitamin D_3, 500 ICU; vitamin E, 40 IU; balance, starch.

TABLE II
Composition[a] of 10 Varieties of 1980-Season Sorghum (dry matter basis)

Variety	DM (%)	CP (%)	IDR (%)	EE (%)	Ash (%)	ACHO (%)	Starch (%)	Sugar (%)	Tannin (%)	AME (kcal/kg)	CP Dig (%)
DD 50T	88.1	12.2	9.7	2.8	1.7	73.9	72.6	1.3	0.28	3,734	66.5
EXP 9520	92.8	11.3	12.6	3.1	1.5	67.4	66.4	1.0	0.2	3,550	65.3
NK 1580	90.9	10.8	12.3	3.5	1.7	71.7	69.1	2.6	0.24	3,662	67.8
NK 129	92.3	11.2	15.4	4.8	1.7	63.1	61.1	2.0	0.23	3,716	73.3
PAG 4432	89.6	12.3	12.2	2.7	1.7	66.4	65.0	1.5	0.32	3,494	63.0
P 8790	93.4	11.3	12.9	2.6	1.8	71.7	70.4	1.8	0.26	3,698	60.2
Corral	88.8	13.9	14.9	3.1	1.6	72.2	70.9	1.3	0.13	3,600	51.2
A 28+	92.2	12.1	11.7	5.7	1.9	64.4	62.9	1.5	0.26	3,764	55.7
PO 1652G	88.5	13.0	13.1	3.0	1.9	70.0	68.4	1.6	0.13	3,568	67.8
M 0505	90.7	12.5	12.5	4.2	1.9	68.4	66.8	1.6	0.18	3,017	55.8
Mean	90.7	12.3	12.5	3.5	1.7	68.8	67.4	1.6	0.23	3,569	62.7
± SD	1.7	0.3	0.3	0.2	0.1	4	4	0.2	0.03	10	1.7
Corn	90.0	···	···	···	···	···	···	···	···	3,788	···
Statistical analysis, ANOVA											
df error	20	20	20	20	20	20	20	20	20	22	20
Mean square	14.49	2.58	6.98	2.84	0.36	38.03	39.38	0.81	0.81	134,684	141.12
MS error	1.55	0.09	0.06	0.04	0.01	1.69	1.75	0.01	0.01	544.4	2.8
F ratio	9.35	28.4	116.4	71.1	35.5	22.7	22.5	80.5	121.1	247.4	50.4
LSD ($P < 0.01$)	1.5	0.4	0.3	0.3	0.2	1.6	0.6	0.1	0.1	2	2.1

[a] DM = Dry matter; CP = crude protein; IDR = indigestible residue; EE = ether extract; ACHO = available carbohydrate (starch + sugar); tannin = catechin equivalent; AME = apparent metabolizable energy; CP Dig = apparent crude protein digestibility in vitro.

TABLE III
Composition[a] of 11 Varieties of 1981-Season Sorghum (dry matter basis)

Variety	DM (%)	CP (%)	IDR (%)	EE (%)	Ash (%)	ACHO (%)	Starch (%)	Sugar (%)	Tannin (%)
DD 50T	92.2	10.3	9.9	5.0	1.9	70.2	69.7	1.2	0.35
EXP 9520	91.0	10.1	9.8	4.1	2.1	72.2	71.1	1.1	0.27
NK 1580	90.1	10.9	8.8	4.6	1.8	72.3	71.2	1.1	0.31
NK 129	91.5	11.2	10.0	3.0	2.0	73.2	72.2	1.1	0.35
PAG 4432	90.5	10.9	10.0	3.6	2.1	73.0	72.0	1.0	0.35
P 8790	88.9	9.8	8.9	4.6	1.7	76.4	75.5	0.9	0.27
Corral	87.9	10.7	11.8	4.0	1.9	77.9	77.1	0.8	0.36
A 28+	90.4	9.3	15.3	2.9	2.8	74.5	73.4	1.1	0.36
PO 1652G	86.6	10.5	10.1	5.3	1.8	81.9	80.7	1.2	0.25
M 0505	88.5	10.9	10.9	5.5	2.0	74.5	73.4	1.1	0.29
NK 300	91.2	11.6	12.7	3.6	1.8	73.5	72.3	1.2	1.15
Mean	89.9	10.5	10.6	4.3	2.0	74.5	73.6	1.0	0.39
± SD	1.1	0.3	0.7	0.1	0.3	3.4	3.4	0.14	0.03
Statistical Analysis									
df error	22	22	22	22	22	22	22	22	22
Mean square	5.38	1.28	10.61	2.38	0.29	0.06	31.84	30.41	0.19
MS error	1.12	0.104	0.46	0.012	0.005	6.73	6.73	0.0053	0.0012
F ratio	4.8	12.3	23.0	201.0	64.4	4.6	4.7	11.8	164.5
LSD ($P < 0.01$)	1.5	0.4	0.8	0.1	0.1	3.1	3.1	0.1	0.04

[a] DM = Dry matter; CP = crude protein; IDR = indigestible residue; EE = ether extract: ACHO = available carbohydrate (starch + sugar); tannin = catechin equivalent.

maintained on a diet containing 90% unbleached whole wheat flour and 10% brewer's yeast were separated and acclimatized to the test diets for two days before three groups of 10 larvae each were fed each of the test diets. The larval weights were determined after another six days. Samples of the 1980 crop were assayed once and of the 1981 crop three times, once every six months to study the effect of storage on their nutritive value for the tribolium larvae.

Day-old broiler chicks (obtained from A. M. Hatchery, Santa Rosa, CA) were weighed, wing-banded, and distributed randomly, eight birds per cage, in a Petersime battery. A replicate of the experiment was set up on each side of the battery with test diets (Table I). The usual system of husbandry was followed. Food and water were available ad libitum. The chicks were weighed individually twice a week. Total collection of excreta were made every 12 hr over a 48-hr period during the third week of the experiment. The corresponding feed intake was also measured over this period. The excreta were dried in a forced-air oven at 60° C. From the gross energy of the diets and the corresponding excreta, AME of the diets was calculated. Also, apparent nitrogen retention (ANR) was calculated from the Kjeldahl nitrogen of the diet and the corresponding excreta.

The data were subjected to analysis of variance, and the values for least significant difference (LSD) were calculated to compare any two means. Some data were compared by *t* test (Steel and Torrie 1960).

TABLE IV
Differences in the Composition of 10 Varieties of Sorghum Grown in 1980 and 11 in 1981 (mean ± SD)

Constituent	Growing Season 1980	Growing Season 1981	Mean
Dry matter, %	90.7 ± 1.9**[a]	89.9 ± 1.1	90.3 ± 1.3
Crude protein, %	12.3 ± 0.3 **	10.5 ± 0.3	11.4 ± 0.3
Indigestible residue, %	12.5 ± 0.3**	10.6 ± 0.7	11.5 ± 0.5
Ether extract, %	3.5 ± 0.2	4.3 ± 0.1**	3.9 ± 0.2
Ash, %	1.7 ± 0.1	2.0 ± 0.3**	1.9 ± 0.1
Tannin, %	0.23 ± 0.03	0.39 ± 0.03**	0.31 ± 0.0
Starch, %	67.4 ± 4.0	73.7 ± 3.4**	70.5 ± 2.1
Free sugar, %	1.63 ± 0.2**	1.05 ± 0.14	1.34 ± 0.08

[a]** Significantly different ($P < 0.01$) by *t* test.

TABLE V
A Comparison of Methods[a] of Determining Percent Tannin Content of Sorghum Samples (dry matter basis)

Variety	Vanillin-HCl (1)	Vanillin-HCl (2)	Prussian Blue (3)	Folin-Denis (4)	Mean
DD 50T	0.35	0.41	0.12	0.71	0.40
EXP 9520	0.27	0.37	0.10	0.79	0.38
NK 1580	0.31	0.33	0.12	0.56	0.33
NK 129	0.35	0.48	0.11	0.74	0.42
PAG 4432	0.35	0.41	0.12	0.83	0.43
P 8790	0.27	0.29	0.11	0.63	0.33
Corral	0.36	0.49	0.13	1.06	0.51
A 28+	0.36	0.80	0.12	0.03	0.33
PO 1652G	0.29	0.35	0.12	0.07	0.21
M 0505	0.29	0.46	0.13	0.11	0.25
NK 300	1.15	1.96	0.38	2.45	1.49
S-91906	1.10	1.97	0.31	1.72	1.28
X-3174	0.84	1.44	0.25	1.55	1.02
Y-936	1.04	1.82	0.24	1.79	1.22
Mean	0.52	0.83	0.17	0.93	

[a] 1, Price et al 1978; 2, Earp et al 1981; 3, Price and Butler 1977; 4, Burns 1971. Catechin standard (1), (2), and (3). Tannic acid standard (4). Statistical analyses gave the following results: varieties (13 df) 2.308 MS, 851.9 *F* ratio; methods (3 df) 4.996 MS, 1,844.2 *F* ratio; interaction (39 df) 0.314 MS, 115.9 *F* ratio; and error (112 df) 2.709^{-3}.

RESULTS AND DISCUSSION

In the proximate analysis, DM, CP, EE, ash, and crude fiber (CF) are determined to estimate nitrogen-free extract (NFE) as a measure of available carbohydrate. As CF and NFE are not reliable parameters for any nutritive constituent, we determined IDR and available carbohydrates (ACHO) instead of CF and NFE. ACHO is the sum of starch and free sugar.

The data on the composition of sorghums indicate significant ($P < 0.01$) varietal (Tables II and III) and seasonal differences (Table IV) in all the measured parameters.

A significant ($P < 0.01$) difference was also observed in the mean values for the same parameters for sorghums grown in the 1980 and 1981 seasons (Table IV). The grains from the 1980 crop were smaller and less plump than the 1981 crop and might have encountered some unfavorable agronomic factor that reduced their starch content and yield but increased CP, IDR, and free sugar. This was expected, because starch in the seed is synthesized at the cost of free sugars.

The total protein content of cereals is controlled by the genetic makeup of the plant and agronomic factors including nitrogen fertilization. The main increase in protein level is caused by an increase in kafirinlike (prolamines) storage proteins and not in the structural proteins, such as glutelins, that form matrices for the starch granules. Unless the granules get plumped with starch, the protein content of the grain is relatively high. The storage proteins are deposited along with starch (Rooney 1973).

The data on varietal and seasonal differences in the composition of sorghums are also reported by Hulse et al (1980) and Chavan et al (1981).

Tannins or polyphenolic compounds are concentrated in pericarp. Their estimation is still a problem as different methods do not measure the same entity (Maxson and Rooney 1972). The most commonly used method for their determination relies on the development of color with a solution of vanillin in HCl; the color is compared against a color produced by a known amount of catechin (Price et al 1978). However, vanillin gives no color with tannic acid and gallic acid. The data on the determination of tannins in fourteen varieties of sorghums (10 low- and four high-tannin) by four methods are presented in Table V. The Prussian blue method of Price and Butler (1977) gave lower and the Folin-Denis method (Burns 1971) higher values for tannins than the vanillin-HCl method. These data indicate varietal differences in tannin contents, significant differences in results obtained by different methods, and a significant interaction between methods of determining tannins and the varieties of sorghums. Earp et al

TABLE VI
Correlation Matrix for the Chemical Composition of 11 Varieties of 1981-Season Sorghum

Parameter[a]	DM	CP	IDR	EE	Ash	Tannin	Starch	Sugar
DM	1.000							
CP	0.096	1.000						
IDR	0.046	−0.226	1.000					
EE	−0.488**[b]	0.002	−0.526**	1.000				
Ash	−0.104	−0.647**	0.070	−0.057	1.000			
Tannin	0.328	0.517**	0.405	−0.328	−0.852**	1.000		
Starch	−0.916**	−0.113	0.087	0.241	0.021	−0.182	1.000	
Sugar	0.351	0.134	0.117	0.102	−0.304	0.384	−0.294	1.000
ACHO	−0.912**	−0.109	0.094	0.249	0.007	−0.167	0.999	−0.253

[a] DM = Dry matter; CP = crude protein; IDR = indigestible residue; EE = ether extract; ACHO = available carbohydrate (starch + sugar).
[b]** Significant at $P < 0.01$.

TABLE VII
Amino Acid Profiles of 10 Varieties of 1980-Season Sorghum (% protein on a dry matter basis)

	Sorghum Variety										
	DD 50T	EXP 9520	NK 1580	NK 129	PAG 4432	P 8790	Corral	A 28+	PO 16552G	M 0505	Mean
Crude protein, %	10.3	10.1	10.9	11.2	10.9	9.8	10.7	9.3	10.5	10.8	
Ammonia	15.2	11.0	17.8	16.4	14.5	13.9	10.8	12.4	12.0	14.4	13.8
Nonessential amino acids											
Alanine	8.8	7.9	9.6	11.3	8.3	7.9	6.2	7.3	6.0	7.0	8.1
Aspartic acid	6.1	5.7	6.4	7.0	5.2	4.9	4.2	4.8	4.8	5.1	5.4
Glutamic acid	16.4	14.7	22.1	25.6	18.4	17.2	11.1	13.0	14.9	17.0	17.0
Glycine	3.2	3.3	3.9	3.5	3.2	4.0	2.5	3.0	2.6	2.7	3.2
Proline	7.5	7.9	10.3	8.1	7.0	6.3	5.9	5.8	5.8	6.2	7.1
Serine	2.9	2.9	3.8	3.3	2.9	2.7	2.1	2.6	2.4	2.3	2.8
Tyrosine	3.7	3.5	5.1	4.1	3.5	3.3	3.0	2.8	2.7	2.9	3.5
Essential amino acids											
Arginine	2.6	3.3	4.2	3.7	2.9	2.9	2.6	2.9	2.5	2.9	3.0
Cystine	0.9	1.1	1.3	1.0	0.9	0.9	0.7	0.9	0.8	0.8	0.9
Histidine	1.6	1.7	2.2	1.9	1.7	1.6	1.4	1.5	1.4	1.4	1.6
Isoleucine	2.6	2.7	3.8	3.2	2.7	2.5	2.2	2.5	2.4	2.7	2.7
Leucine	11.7	10.4	15.2	13.3	10.9	10.3	8.4	9.4	9.1	10.2	10.9
Lysine	2.2	2.2	2.6	2.4	2.1	1.9	1.5	2.0	1.7	1.8	2.0
Methionine	0.5	0.7	1.2	0.8	0.7	0.6	0.6	0.5	0.5	0.7	0.7
Phenylalanine	4.4	4.2	6.1	5.0	4.1	4.0	3.7	3.7	3.5	3.8	4.2
Threonine	5.2	5.1	6.8	5.8	4.9	4.7	3.6	4.4	4.2	4.5	4.9
Valine	3.4	3.6	5.0	4.2	3.6	3.3	2.8	3.0	3.0	3.5	3.6
Tryptophan[a]	0.9	0.9	0.7	0.9	0.8	0.9	0.7	0.9	0.9	1.2	0.8
Leucine/isoleucine ratio	4.5	3.9	4.0	4.2	4.0	4.2	3.8	3.8	3.8	3.8	4.0

[a]Determined by method of DeVries et al 1980.

TABLE VIII
Average Larval Weight (mg) of *Tribolium castaneum* (at 14 days of age) Fed Various Varieties of 1980- and 1981-Season Sorghum[a]

Sorghum Variety in Diet	1980	1981[b] Test 1	Test 2	Test 3	Varietal Mean
DD 50T	3.10 ± 0.05	3.01 ± 0.04	2.69 ± 0.2	3.10 ± 0.27	2.98 ± 0.12
EXP 9520	2.80 ± 0.3	3.01 ± 0.01	2.16 ± 0.08	2.97 ± 0.18	2.73 ± 0.2
NK 1580	1.50 ± 0.3	3.10 ± 0.1	2.83 ± 0.2	3.10 ± 0.09	2.63 ± 0.4
NK 129	1.80 ± 0.09	2.93 ± 0.1	2.53 ± 0.1	2.68 ± 0.25	2.49 ± 0.1
PAG 4432	2.40 ± 0.14	2.82 ± 0.1	1.86 ± 0.27	2.49 ± 0.4	2.41 ± 0.1
P 8790	1.60 ± 0.07	2.73 ± 0.01	2.08 ± 0.3	2.49 ± 0.5	2.25 ± 0.2
Corral	3.30 ± 0.2	3.00 ± 0.04	2.77 ± 0.1	1.99 ± 0.1	2.77 ± 0.1
A 28+	0.94 ± 0.4	2.96 ± 0.05	2.21 ± 0.2	2.75 ± 0.3	2.21 ± 0.2
PO 1652G	2.70 ± 0.1	2.89 ± 0.3	2.92 ± 0.25	3.10 ± 0.03	2.89 ± 0.1
M 0505	1.40 ± 0.05	2.91 ± 0.09	2.91 ± 0.0	3.10 ± 0.27	2.56 ± 0.3
Control diet (corn)	3.20 ± 0.07	3.04 ± 0.08	3.12 ± 0.06	3.12 ± 0.37	3.11 ± 0.03
Mean	2.23	2.95	2.56	2.81	

[a]Statistical analysis: varieties (10 df) 1.039 MS, 16.99 *F* ratio; tests (3 df) 3.376 MS, 55.24 *F* ratio; interaction (30 df) 0.654 MS, 10.69 *F* ratio; error (88 df) 0.061 MS, LSD ($P < 0.01$) for varieties = 0.27; LSD ($P < 0.01$) for tests = 0.45.
[b]Test 1, 12/1981; test 2, 6/1982; test 3, 12/1982.

(1981) also found wide differences in the tannin content of sorghums depending upon the method used.

The correlation matrix for the various determined parameters is given in Table VI. Significant ($P < 0.01$) negative correlations were found between EE, starch, or available starch, and DM; EE and IDR; ash and tannins; CP and ash; and a positive correlation between CP and tannins. Aurora and Luthra (1974) had also observed a higher CP level in high-tannin sorghums.

AME of the sorghums varied from 3,017 to 3,764 kcal per kilogram of dry matter (mean, 3,569 kcal/kg DM). The corresponding value for maize was 3,788 kcal/kg DM or 3,370 kcal/kg for an air-dried sample containing 89% DM. The data confirmed varietal differences in sorghums for AME.

The following expression would predict the AME of sorghums from our data by multiple linear regression:

$$\text{AME (kcal/100 g sorghum DM)} = -148 + 1.726 \times \%\text{CP} + 7.370 \times \%\text{IDR} + 11.958 \times \%\text{EE} - 14.637 \times \%\text{Ash} + 4.532 \times \%\text{ACHO} + 267.48 \times \%\ \text{tannin}.$$

If the ash and tannin components are neglected, the prediction expression changes as follows:

$$\text{AME (kcal/100 g DM)} = 317.79 - 7.149 \times \%\text{CP} + 1.013 \times \%\text{IDR} + 3.033 \times \%\text{EE} + 1.491 \times \%\text{ACHO}$$

Statistically significant differences were also observed in the in vitro percent crude protein digestibility and values varied from 51 to 73% (mean, 62.7%). Armstrong et al (1974b) and Chibber et al (1980) also found differences in in vitro protein digestibility in high-tannin sorghum.

The amino acid profiles of a single sample of each of the 10 varieties of sorghums grown in 1980 are presented in Table VII. As only one sample from each variety was analyzed, no statistical analysis of the data could be carried out. The data do suggest wide varietal differences in amino acid contents, as has also been found by Sikka and Johari (1979) and Badi et al (1976).

The 1980 sorghum samples were assayed once and the 1981 samples three times (freshly ground and after storage) using tribolium larvae. Significant ($P < 0.01$) differences were observed in the growth response of the larvae to different varieties of sorghums (Table VIII). The varieties NK 1580, NK 129, P 8790, A

TABLE IX
The Growth of Chicks, Apparent Metabolizable Energy (AME) of the Diet, and Apparent Nitrogen Retention (ANR) as Affected by Different Varieties of Sorghum[a]

Sorghum Variety	Average Body wt at Three Weeks (g)	AME (kcal/kg diet)	ANR (%)
DD 50T	532 ± 19	3,352 ± 14	63.6 ± 0.1
EXP 9520	527 ± 15	3,405 ± 11	65.0 ± 0.3
NK 1580	552 ± 16	3,433 ± 14	60.6 ± 3.5
NK 129	525 ± 13	3,241 ± 14	63.2 ± 0.2
PAG 4432	544 ± 14	3,447 ± 18	65.8 ± 1.7
P 8790	531 ± 16	3,407 ± 26	66.2 ± 3.2
Corral	485 ± 11	3,427 ± 21	62.7 ± 2.3
A 28+	511 ± 16	3,086 ± 8	58.8 ± 1.6
PO 1652G	515 ± 14	3,396 ± 16	69.7 ± 2.6
M 0505	510 ± 41	3,160 ± 10	70.0 ± 1.9
NK 300	498 ± 10	3,487 ± 2	73.1 ± 1.1
Corn-soy	519 ± 12	3,645 ± 48	71.4 ± 2.2
Mean	521 ± 28	3,349 ± 20	65.3 ± 2.0
Statistical analysis			
df error	168	24	24
Mean square	9,545.4	67,438.6	56.69
MS error	794.2	403.8	4.18
F ratio	6.98	167.01	14.04
LSD ($P < 0.01$)	30	23	2.3

28+, and M 0505 were significantly inferior to the other varieties. These differences were not observed in the fresh samples in December 1981. The second and third tests were on stored samples in June and December 1982, when the variety P 8790 was still poorest and DD 50T the best variety in supporting larval growth. The relative ranking of other varieties was different in 1980 and 1981 sorghums for larval growth. Agronomic factors may have reduced the antinutrients in the 1981 crop. The effect of storage on nutritional quality of sorghums deserves further study. Pant and Susheela (1977) observed varietal differences to infestation by *T. castaneum* during storage of sorghum.

The data on growth of broilers, AME, and ANR of the sorghum-based diets are presented in Table IX. The levels of sorghums and of soybean meal could not be kept constant to obtain diets containing 24% CP. Significant differences ($P < 0.01$) were observed in the growth of broiler chicks on diets containing different varieties of sorghums. Chick growth was not a reflection of the level of soybean meal in the test diets but suggests varietal nutritional differences in sorghums for the chickens. The high-tannin sorghum variety (NK 300) was significantly better than the variety Corral but inferior to other varieties. The adverse effects of high-tannin sorghums on growth of chickens have been reported before (Armstrong et al 1974a). However, diets based on some low-tannin sorghum and soybean were superior to the corn-soybean control diet.

AME (kcal/kg diet) as well as ANR (%) of the diets differed significantly ($P < 0.01$). AME of sorghum-soybean diets was significantly less than that of the corn-soybean diet. ANR of the diet containing high-tannin sorghum was better than that of other sorghum diets and of the corn-soybean diet in this study.

ACKNOWLEDGMENT

The authors acknowledge with thanks the generous supply of high-tannin sorghums from Northrup King Co., Minneapolis, MN.

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[Received February 11, 1987. Revision received June 5, 1987. Accepted June 5, 1987.]