Amino Acid Composition of Grain Dusts

J. D. HUBBARD, F. S. LAI, C. R. MARTIN, B. S. MILLER, and Y. POMERANZ, U.S. Grain Marketing Research Laboratory, Science and Education Administration, U.S. Department of Agriculture,[1] Manhattan, KS 66502

ABSTRACT

Cereal Chem. 59(1):20–22

The amino acid compositions of wheat, corn, grain sorghum, soybeans, a wheat-corn mixture, and rice and of dusts from those grains were determined by automated ion-exchange chromatography. Protein content was 2–3% (dry basis) less in dust than in the corresponding grains, except for soybeans, in which the protein content of dust was about 13% compared to about 41% in whole seeds. However, the concentration of lysine, the most limiting amino acid in most grains, was higher in each type of dust than in the parent grains, except soybean dust.

In a detailed study of the chemical composition and physical characteristics of grain dust, Martin (1978) determined fat, fiber, ash, protein, starch, and trace element contents in corn, grain sorghum, soybean, and wheat dust. However, no data on amino acid compositions were reported. Such data are important if grain dust is to be included in livestock feed. The amino acid composition of protein in grain dust depends on the composition of the grain, the part of the kernel from which the dust is obtained, and the composition of amino acids in the grain. In this study, we determined the amino acid composition of grain dust from wheat, corn, grain sorghum, soybeans, a wheat-corn mixture, and rice.

MATERIALS AND METHODS

Samples of grain and dust were collected from corn, grain sorghum, soybeans, and wheat at four commercial elevators in central and eastern Kansas. One elevator did not handle soybeans, and one elevator included a sample of mixed corn and wheat dust (the proportion of each component could not be determined). The manager of each elevator supplied about 2 L of dust discharged from the dust control system on the bucket elevator. A 1-L sample of grain was collected at the same time as the dust. All elevators had cyclone air cleaners on their bucket elevator dust control systems.

Two-liter samples of dust were collected during the cleaning and milling of rice at four locations in Texas, Louisiana, and Arkansas. One location included a sample of mixed dust collected from several locations in the same facility.

Each 2-L sample of dust was placed in a 4-L can and blended by hand for 2 min. After blending, approximately 10 g of dust were removed for analysis.

[1]Mention of firm names or trade products does not constitute endorsement by the USDA over others of a similar nature not mentioned.

Dust samples were ground on a Weber pulverizer to pass a screen with round openings 0.61-mm (0.024-in.) in diameter. Moisture and protein (N × 6.25) were determined by AACC approved methods.

Samples were prepared for hydrolysis by placing a sample of ground dust equivalent to 5 mg of protein in a 19 × 100-mm vacuum hydrolysis tube (Kontes No. 896860-8910) and adding 6*N* HCl acid containing 10%, v/v, 0.1*M* phenol, previously purged with pure nitrogen (Kistler et al 1975), in the proportion of 10 mg of sample to 1 ml of acid (Sanger and Thompson 1963, Savoy et al 1975). The samples were frozen (methyl cellosolve dry ice at approximately −40° C), alternately evacuated and flushed with nitrogen three times while they gradually warmed, and finally sealed under vacuum. The samples were then hydrolyzed in a Lab-Line model 2093 multi-block heater adjusted so that the temperature in the hydrolysis tube was 110 ± 1° C. After hydrolysis, the samples were cooled, filtered, evaporated to dryness (Hubbard and Finney 1976), and diluted to 10 ml with sodium citrate buffer (pH 2.2). An aliquot of the hydrolysate was filtered through a membrane (0.22-nm pore size) and analyzed on a Beckman model 121 amino acid analyzer as described by Robbins et al (1971). Areas under peaks were determined with a Columbia Scientific Supergrator-3 programmable computing integrator. Methionine and cystine were determined after performic acid oxidation (Moore 1963) on separate samples. All analyses were performed in duplicate.

RESULTS AND DISCUSSION

Table I contains results of moisture, protein, and ash analyses of the dust samples. The dusts varied widely in protein and, especially, in ash contents.

Wetting of samples during hydrolysis proved a problem, which was overcome by vortex mixing of the dry sample and acid during evacuation and sealing.

Selected grain and dust samples were hydrolyzed for varying lengths of time ranging from 16 to 24 hr; the amino acid content and the recovered nitrogen were determined. Optimum hydrolysis conditions were determined to be 22 hr at 110° C.

TABLE I
Moisture, Protein, and Ash Contents (%) of Dust Samples[a]

	Moisture		Protein[b]		Ash	
	Mean	Range	Mean	Range	Mean	Range
Dust						
Wheat	8.2	6.3–10.2	11.3	8.2–14.4	21.2	7.9–53.5
Corn	10.4	7.7–13.0	7.9	5.8– 9.9	4.9	2.9– 8.8
Wheat-corn mix	11.2	7.7–14.5	8.6	6.7–12.0	8.2	6.8– 9.6
Grain sorghum	9.7	6.0–12.2	8.3	6.2–11.1	13.4	7.0–32.2
Soybean	7.4	6.1–10.3	12.4	7.7–15.6	20.0	10.9–40.5
Rice	7.2	6.8– 8.0	8.3	5.0– 9.9	30.4	16.3–74.8
Grain						
Wheat	8.3	...[c]	12.7	...	1.72	...
Corn	9.5	...	10.4	...	1.31	...
Grain sorghum	9.5	...	10.8	...	1.48	...
Soybean	6.3	...	37.7	...	4.85	...
Rice	8.4	...	10.0	...	1.26	...

[a] As is basis.
[b] N × 6.25.
[c] Only one sample from each grain.

TABLE II
Amino Acid Composition of Grains and Dusts[a]

	Amino Acid (g/16 g of N)			
	Dust			
	Max	Min	Mean	Grain
Wheat and Wheat Dusts				
Lysine	3.90	2.63	3.43	2.77
Histidine	1.98	1.49	1.72	2.36
Ammonia	4.10	3.23	3.67	5.98
Arginine	5.02	3.97	4.34	4.81
Aspartic acid	6.53	4.43	5.91	4.61
Threonine	3.19	2.15	2.90	2.68
Serine	3.84	2.54	3.39	4.29
Glutamic acid	11.08	8.39	9.73	23.98
Proline	3.61	2.72	3.11	8.40
Half-cystine	1.87	1.45	1.70	1.61
Glycine	4.11	3.34	3.75	3.71
Alanine	4.19	2.70	3.65	3.18
Valine	3.48	2.60	3.13	4.28
Methionine	2.29	0.91	1.65	1.65
Isoleucine	2.41	1.66	2.16	3.34
Leucine	5.41	3.17	4.48	6.04
Tyrosine	2.67	1.97	2.39	2.65
Phenylalanine	3.21	2.09	2.84	4.09
Corn and Corn Dust				
Lysine	3.65	2.91	3.34	3.09
Histidine	2.68	1.96	2.31	2.91
Ammonia	3.83	3.30	3.58	4.01
Arginine	4.42	3.72	4.22	5.20
Aspartic acid	6.90	5.68	6.28	6.64
Threonine	3.64	3.00	3.39	3.52
Serine	4.25	3.39	3.92	4.84
Glutamic acid	13.76	10.87	12.67	17.90
Proline	6.89	5.13	6.35	8.43
Half-cystine	3.07	1.75	2.30	2.27
Glycine	4.07	3.60	3.86	3.80
Alanine	5.89	4.60	5.46	7.07
Valine	4.81	3.54	4.15	4.62
Methionine	5.15	2.02	3.45	2.77
Isoleucine	2.95	2.39	2.75	3.52
Leucine	8.85	6.89	8.19	11.25
Tyrosine	3.41	2.63	3.10	3.87
Phenylalanine	3.87	2.89	3.58	4.75

(continued in column 2)

TABLE II
Amino Acid Composition of Grains and Dusts (continued)

	Amino Acid (g/16 g of N)			
	Dust			
	Max	Min	Mean	Grain
Mixed Wheat-Corn Dusts				
Lysine	3.77	3.23	3.40	...
Histidine	2.24	1.91	2.04	...
Ammonia	3.64	3.23	3.43	...
Arginine	4.38	3.75	4.04	...
Aspartic acid	6.97	6.51	6.68	...
Threonine	3.53	3.28	3.43	...
Serine	4.50	4.04	4.24	...
Glutamic acid	14.01	12.17	12.97	...
Proline	6.61	5.61	6.01	...
Half-cystine	2.28	1.28	1.86	...
Glycine	4.21	3.79	3.95	...
Alanine	6.23	5.43	5.77	...
Valine	3.92	3.81	3.87	...
Methionine	2.30	1.29	1.88	...
Isoleucine	2.66	2.57	2.62	...
Leucine	8.37	7.22	7.78	...
Tyrosine	3.25	2.88	3.08	...
Phenylalanine	3.72	3.39	3.54	...
Grain Sorghum Grain and Dust				
Lysine	3.79	3.29	3.46	2.06
Histidine	1.95	1.34	1.71	2.17
Ammonia	3.64	2.86	3.29	4.59
Arginine	4.39	3.50	3.88	3.49
Aspartic acid	7.02	6.34	6.65	6.28
Threonine	3.50	3.03	3.27	3.04
Serine	4.42	3.16	3.75	4.44
Glutamic acid	13.98	8.44	11.03	18.97
Proline	5.64	4.24	5.11	7.50
Half-cystine	2.04	1.62	1.81	1.75
Glycine	4.35	3.60	3.94	3.05
Alanine	6.21	4.30	5.32	8.30
Valine	4.34	3.72	4.03	4.71
Methionine	2.59	1.61	2.11	2.37
Isoleucine	2.91	2.28	2.62	3.76
Leucine	8.07	5.24	6.71	11.56
Tyrosine	3.12	2.26	2.69	3.61
Phenylalanine	3.88	2.68	3.26	4.58
Soybean and Soybean Dust				
Lysine	5.68	3.80	4.59	6.19
Histidine	2.27	1.67	1.93	2.72
Ammonia	3.42	2.70	3.03	3.18
Arginine	5.74	4.00	4.94	6.95
Aspartic acid	10.07	7.74	9.07	11.45
Threonine	3.79	3.21	3.50	4.09
Serine	5.21	4.42	4.81	5.43
Glutamic acid	13.71	9.46	11.67	17.39
Proline	5.86	4.73	5.09	5.79
Half-cystine	2.65	1.73	2.06	1.54
Glycine	5.82	4.33	4.72	4.29
Alanine	5.31	4.09	4.49	4.50
Valine	4.11	3.61	3.86	5.09
Methionine	2.05	1.16	1.72	1.63
Isoleucine	3.93	2.95	3.36	4.44
Leucine	7.71	6.26	6.91	7.73
Tyrosine	4.85	3.33	3.84	3.56
Phenylalanine	3.76	2.82	3.36	4.86

(continued on p. 22)

TABLE II
Amino Acid Composition of Grains and Dusts (continued)

	Amino Acid (g/16 g of N)			
	Dust			
	Max	Min	Mean	Grain
	Rice and Rice Dust			
Lysine	3.69	3.02	3.36	3.24
Histidine	2.11	1.26	1.58	2.06
Ammonia	3.90	2.37	2.81	3.34
Arginine	8.01	4.38	5.75	7.94
Aspartic acid	8.27	6.61	7.39	6.79
Threonine	3.57	2.92	3.23	2.77
Serine	4.75	3.52	4.05	3.69
Glutamic acid	14.54	8.59	10.13	13.37
Proline	4.32	3.40	3.84	3.57
Half-cystine	1.93	1.49	1.72	1.88
Glycine	5.11	4.08	4.46	3.33
Alanine	5.50	4.48	4.98	4.64
Valine	4.25	3.70	3.94	4.54
Methionine	1.93	1.47	1.62	2.15
Isoleucine	2.71	2.13	2.43	3.05
Leucine	6.77	4.80	5.76	6.25
Tyrosine	3.88	2.39	2.85	3.21
Phenylalanine	4.23	2.98	3.46	4.03

[a] Recovery of nitrogen from whole grains: wheat, 89.3%; corn, 91.9%; sorghum, 92.5%; soybean, 92.4%; rice, data not available. Number of dust samples and average nitrogen recovery: wheat, 9, 61.2%; corn, 8, 70.2%; mixed wheat and corn, 4, 70.5%; sorghum, 7, 62.8%; soybean, 6, 75.1%; rice, 9, 66.3%.

Nitrogen recoveries, calculated as percent of amino acids recovered, averaged 91.5% (range 89.3–92.5%) for the grains but only 67.7% (range 61.2–75.1%) for the dusts. The highest nitrogen recovery was for soybean dust (75.1%). Initial analysis of dusts resulted in what appeared to be very low recoveries based on nitrogen content. In subsequent analyses, the tyrosine peak disappeared completely. Sanger and Thompson (1963) have suggested that phenol can be added to the hydrolyzing acid as a scavenger. When we added phenol to dusts, it protected tyrosine and dramatically improved its recovery. Because phenol has an insignificant effect on the recovery of the other amino acids, however, the addition of phenol did not have a profound effect on the total recovery of amino acids in dust.

The amino acid compositions of proteins in grain dust and the parent grains are given in Table II. Of particular interest are the values for lysine, the limiting amino acid in most grains. Only grain sorghum dust was significantly higher in lysine than its parent grain. However, the concentration of lysine was actually higher in the protein of each dust, except soybean dust, than in the protein of the parent grain, probably because the protein in the outer portion of the kernel is richer in basic amino acids than is the whole grain.

For each amino acid, we calculated the coefficients of correlation of protein and amino acid content (not shown) and found that the amino acid composition in each type of dust was essentially independent of the level of protein content. However, as in most cereal grains (Kasarda et al 1971), lysine was inversely correlated with protein content for all types of grain dust. Only corn dust exhibited a positive correlation with aspartic acid and dust protein (significant at the 5% level). The relatively low concentrations of glutamic acid and proline indicate that the protein of grain dust, except corn dust, is essentially devoid of storage protein.

CONCLUSIONS

The protein in grain dust, except corn dust, is essentially devoid of storage protein.

The reasonably uniform amino acid composition of the dusts from various grains indicates that mixing dusts would not adversely affect the amino acid balance of the proteins. However, the probable presence of substantial amounts of nonprotein N in grain dust, as demonstrated by the low nitrogen recovery from amino acid analysis, reduces the reliability of Kjeldahl-N determination as an index of protein content.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1976. Approved Methods of the AACC. Method 44-15A, approved April 1967, and Method 46-11, approved April 1961. The Association: St. Paul, MN.

HUBBARD, J. D., and FINNEY, K. F. 1976. Quick evaporation of protein hydrolysates for amino acid assay. J. Food Sci. 41:1229.

KASARDA, D. D., NIMMO, C. C., and KOHLER, G. O. 1971. Proteins and the amino acid composition of wheat fractions. Page 227 in: Pomeranz, Y., ed. Wheat, Chemistry and Technology. Am. Assoc. Cereal Chem.: St. Paul, MN.

KISTLER, W. S., NOYES, R., HSU, R., and HEINRIKSON, R. L. 1975. The amino acid sequence of a testis-specific basic protein that is associated with spermatogenesis. J. Biol. Chem. 250:1847.

MARTIN, C. R. 1978. Characterization of grain dust properties. ASAE Paper No. 78-3020. Am. Soc. Agric. Eng.: St. Joseph, MI.

MOORE, S. 1963. On the determination of cystine as cysteic acid. J. Biol. Chem. 238:235.

ROBBINS, G. S., POMERANZ, Y., and BRIGGLE, L. W. 1971. Amino acid composition of oat groats. J. Agric. Food Chem. 19:536.

SANGER, F., and THOMPSON, E. O. P. 1963. Halogenation of tyrosine during acid hydrolysis. Biochim. Biophys. Acta 71:468.

SAVOY, C. F., HEINIS, J. L., and SEALS, R. G. 1975. Improved methodology for rapid and reproducible acid hydrolysis of food and purified proteins. Anal. Biochem. 68:562.

[Received September 2, 1980. Accepted March 20, 1981]