NOTE ON PROTEIN CONTENTS AND AMINO ACID COMPOSITION OF DARK HARD AND YELLOW HARD KERNELS SEPARATED FROM RED WINTER WHEAT[1]

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Cereal Chem. 54(4): 778–783

A study of functional properties (in milling and baking) of dark, hard, and vitreous (DHV) and yellow hard winter wheats was reported recently by Pomeranz *et al.* (1). Dikeman and Pomeranz (2) separated six samples of hard winter wheat (two cultivars from three locations) into DHV and yellow hard

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

kernels. The DHV kernels contained, on the average, 19.7% more protein and 6.3% more total ash than the yellow hard kernels.

Fortini *et al.* (3) found that vitreous kernels contained more protein and organic S than yellow hard kernels. We report our study to determine whether the amino acid compositions of DHV and yellow hard kernels differ.

MATERIALS AND METHODS

Wheat Samples

Two subsamples from each of two hard red winter wheat cultivars Centurk and Buckskin, grown at three locations in Kansas (Hays, Newton, and Mineola), were separated by hand into DHV and yellow hard kernels. The DHV samples comprised 12.8 to 78.5% of the kernels in the six wheat samples.

Analytical Methods

The separated wheat samples were ground on a Weber pulverizer to pass a screen with 0.040-in. round openings. Moisture and protein (N × 5.7) were determined by AACC Approved Methods (4). Amino acids of acid hydrolysates were analyzed with a Beckman 121 automatic analyzer, basically, as described elsewhere (5,6). Methionine and cystine were determined after performic acid oxidation (7). All hydrolyses were under nitrogen. All analyses were made in

TABLE I
Per Cent Protein and Amino Acid Composition[a] of Dark, Hard, and Vitreous (DHV) and Yellow Hard Wheat Kernels

Protein (%) or Amino Acid[a]	DHV Kernels				Yellow Hard Kernels			
	Max.	Min.	Mean	cv.[b]	Max.	Min.	Mean	cv.
Protein	16.63	13.50	14.54	8.78	14.17	10.81	12.14	10.57
Lysine	2.81	2.48	2.69**	5.16	3.21	2.69	3.00	6.78
Histidine	2.29	2.10	2.19	3.23	2.37	2.08	2.26	4.29
NH_3	4.23	3.77	3.98	3.94	4.33	3.95	4.08	3.88
Arginine	4.81	4.48	4.58	2.74	5.01	4.41	4.82	4.47
Aspartic acid	5.06	4.87	4.98**	1.40	5.39	5.01	5.18	2.68
Threonine	2.75	2.61	2.69	1.73	2.86	2.60	2.78	3.58
Serine	4.30	4.15	4.23	1.53	4.35	4.19	4.29	1.54
Glutamic acid	34.57	32.42	33.43**	2.55	32.62	30.66	31.34	2.21
Proline	9.98	9.50	9.66	2.06	10.81	9.11	9.47	6.97
Cystine	2.24	2.10	2.15**	2.61	2.43	2.17	2.28	4.43
Glycine	2.65	2.53	2.59	1.52	2.53	2.59	2.66	2.05
Alanine	3.31	3.10	3.24**	2.51	3.53	3.25	3.44	3.15
Valine	4.18	4.03	4.10**	1.55	4.33	4.15	4.24	1.67
Methionine	2.49	2.07	2.27**	8.09	3.21	2.53	2.91	8.78
Isoleucine	3.29	3.22	3.26*	0.88	3.33	3.26	3.31	0.89
Leucine	6.74	6.58	6.65*	1.06	6.82	6.62	6.75	1.22
Tyrosine	1.98	1.65	1.84	7.33	1.99	1.69	1.85	7.24
Phenylalanine	4.82	4.33	4.44*	4.19	4.33	4.21	4.28	1.19
Tryptophan	1.22	0.85	1.03	15.04	1.21	0.89	1.07	10.52

[a]g/100 g recovered.
[b]Coefficient of variation. Per cent protein is on dry matter basis.

TABLE II

Significant Correlation Coefficients between Protein and Amino Acid Composition of the Protein and among Amino Acids in DHV[a] and Yellow Hard Wheat[b] Kernels

Simple Correlation Coefficients

Parameter	LYS	HIS	NH_3	ARG	ASP	THR	SER	GLU
Protein (PCP)	*-0.98* -0.89				*-0.98*	*-0.91*	*-0.92* -0.89	*0.82* 0.82
Lysine (LYS)		*0.87* 0.83			*0.92* 0.87	*0.86* 0.94	*0.96* 0.99	*-0.83*
Histidine (HIS)	0.89			0.87		0.82	*0.94* 0.81	*-0.89*
NH_3								
Arginine (ARG)	0.91	*0.91*				0.81		
Aspartic Acid (ASP)			1.00			*0.85* 0.88	*0.89* 0.93	*-0.85*
Threonine (THR)				0.91			0.96	
Serine (SER)	0.96	*0.92*		0.98		0.95		*-0.85*
Glutamic acid (GLU)						*0.91*		
Proline (PRO)				-0.91		-0.99	-0.92	
Cystine (CYS)								
Glycine (GLY)								
Alanine (ALA)	*0.88*							-0.89
Valine (VAL)					*-0.99*			
Methionine (MET)								
Isoleucine (ILE)	*0.94* 0.90			*-0.91* 0.96				
Leucine (LEU)	*0.88*			*-0.98* 0.92		1.00	0.89	
Tyrosine (TYR)								
Phenylalanine (PHE)					*0.99*			
Tryptophan (TRY)	*0.88*							

Partial Correlation Coefficients—Protein Constant

[a]Top line - italicized
[b]Bottom line - standard type

TABLE II

Significant Correlation Coefficients between Protein and Amino Acid Composition of the Protein and among Amino Acids in DHV[a] and Yellow Hard Wheat[b] Kernels

Simple Correlation Coefficients

PRO	CYS	GLY	ALA	VAL	MET	ILE	LEU	TYR	PHE	TRY
0.88			*-0.97*							
		-0.82	-0.95	-0.85		-0.82	-0.88			
-0.91			*0.99*	*0.82*						*0.87*
			0.82	0.82		0.95	0.96			
-0.86			*0.84*							*0.86*
-0.83						0.88				0.83
-0.92										
-0.84			*0.91*							
		0.90	0.82	0.89		0.87	0.90			
		0.97	*0.87*							
-0.89						0.92	0.98			
-0.95			*0.93*							*0.81*
			0.84	0.87		0.96	0.98			
			-0.83							
			-0.95	-0.89						
			-0.84							*0.81*
	0.83									
										0.84
					0.97	*0.94*				*0.85*
				0.93		0.83	0.81			
										0.96
						0.91	0.86			
	0.89									
				0.98						*0.94*
							0.94			
				0.89						*0.85*
-0.99	-0.91									
										-0.84
						-0.93				
				-0.88						
	0.89			*0.92*	*0.96*					

Partial Correlation Coefficients—Protein Constant

[a]Top line - italicized
[b]Bottom line - standard type

triplicate. Tryptophan was measured according to Hernandez and Bates (8). A computer program was used to calculate original output in nine forms; values are reported in grams amino acid/100 g recovered.

RESULTS AND DISCUSSION

Protein contents and their amino acid compositions in DHV and in yellow hard wheat kernels are summarized in Table I. The proteins in the DHV kernels contained less lysine, aspartic acid, cystine, alanine, valine, and methionine, and more glutamic acid than those in the yellow hard wheat kernels. The differences were significant at the 1% level. The correlations between protein content and amino acid composition and those among the amino acids were tested. The results are summarized in Table II. Both simple and partial (constant protein) correlations are given for DHV and yellow hard wheats. Simple correlation coefficients of at least 0.81 were significant at the 5% level and of at least 0.92 at the 1% level; partial correlation coefficients were significant, respectively, at the 0.88 and 0.96 levels. In no instance were both simple and partial correlations significant for the DHV and yellow hard wheats.

The total number of significant correlation coefficients (128) was distributed almost randomly for the DHV (59) and yellow hard (69) kernels. However, there were far more positive associations (89) than negative correlations (39). Tyrosine and phenylalanine were the only two amino acids which were not correlated with either protein content or any of the amino acids.

For both wheat types, protein was correlated negatively with lysine, serine, and alanine and positively with glutamic acid. Thirteen correlation coefficients depended on (or were affected by) the protein content, and were not consistently significant if the protein content were held constant. They included *lysine* and histidine, aspartic acid, threonine, serine, alanine, or valine; *alanine* and aspartic acid, serine, isoleucine, or glutamic acid (negative); *aspartic acid* and threonine or serine; and *tryptophan* and histidine.

The great number of highly significant correlations between protein contents and amino acid composition and the dependence of correlations among amino acids on protein contents indicate that protein content rather than grain type (wheat vitreousness in this study) governs amino acid composition. Similar results were previously reported for two- and six-rowed barleys (9) and barley kernels from different parts of the spike (10).

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[Received November 15, 1976. Accepted January 4, 1977]