THE DISTRIBUTION OF THE AMINO ACIDS OF WHEAT IN COMMERCIAL MILL PRODUCTS[1]

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ABSTRACT

The eighteen commonly occurring amino acids were determined by microbiological analysis in two blends of hard red spring and hard red winter wheats and in each of the final products produced by commercial milling. The summation of amino acid values obtained for the separate products, weighted by the proportion of the whole wheat represented in each product, yielded total values in good agreement with the results determined for the wheat.

Changes in the relative proportions of the amino acids showed the same trends in both sets of samples. Less lysine, glycine, arginine, alanine, and aspartic acid was found in the flour fractions and more in the offals than in the wheat proteins. Conversely, more proline, glutamic acid, and phenylalanine was found in the flour proteins and less in the offals than was found in the wheats. The proportions of the remaining amino acids were much less affected by milling.

The uniformity of amino acid concentrations within the flour fractions explains the previous observation that the amino acid distribution of flour proteins was independent of the degree of separation of the flour. It is postulated that the consistency of amino acid distribution in bread flour protein may be related to the selection and blending of wheats.

Previous work from this laboratory (2) indicated that although the concentrations of amino acids in flour differed from those of the wheats from which they were milled, the relative proportions contained in the proteins of the flours tended to be constant even though the flours which were analyzed ranged from 98.5 to 80% patent. The observed consistency of amino acid proportions of flour proteins could not be explained by previously published data, because the few studies on the amino acids of mill products have been limited either in the number of amino acids or in the number and type of products investigated. This present study was undertaken to determine quantitatively the distribution of amino acids among the products resulting from the commercial milling of wheat.

Materials and Methods

Sample Description. Samples of cleaned wheat and the products milled from them were obtained from two flour mills. Both wheats were blends of hard red spring and hard red winter wheats, typical

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of the type used for the production of baker's flour. From mill A the final products were: farina, flour (80.1% patent), first-clear flour, low grade flour, red dog, shorts, bran, and germ. In addition, samples were collected of the best- and poorest-quality flour streams. The extraction rate was reported to be 75.75%. The yield of the products (percent of the cleaned wheat) was determined by measuring the weights obtained after processing a known amount of wheat. From mill B the final products were: flour (95% patent), second-clear flour, red dog, shorts, bran, and germ. The extraction rate was approximately 68%. Values for yield constitute estimates furnished by the mill.

The samples of wheat, bran, and germ were ground in a hammer mill to pass a 0.024-in. screen. Nitrogen was determined by the Kjeldahl-Gunning procedure and moisture by the vacuum-oven method. Values for yield and for nitrogen are shown in Table I.

TABLE I
DESCRIPTION OF MILL PRODUCTS
(14% moisture basis)

Mill Product	Mill A		Mill B	
	Nitrogen	Percent of Wheat	Nitrogen	Percent of Wheat
	%		%	
Farina	1.88	1.51	...	...
Best flour stream	1.96	[a]	...	...
Patent flour	2.05	60.68	2.06	64.5
First-clear flour	2.60	11.14	...	...
Second-clear flour	...	....	2.69	5.5
Low-grade flour	2.88	2.42	...	...
Poorest flour stream	3.02	[b]	...	...
Red dog	2.87	0.48	2.90	1.0
Shorts	2.86	9.13	2.82	15.0
Bran	2.54	14.57	2.79	12.0
Germ	3.98	0.07	3.78	2.0
Whole wheat	2.27	100.00	2.24	100.0

[a] Constituent of patent flour.
[b] Constituent of low-grade flour.

Analysis of Amino Acids. The 18 commonly occurring amino acids were determined by microbiological analysis in all mill products and in the original wheat samples using the procedures described previously by Hepburn *et al.* (2). The only modification was that *Leuconostoc citrovorum* 8081 was utilized for the analysis of cystine. This organism has been found to give a more consistent response with the short-term hydrolysates used for cystine than does *Leuconostoc mesenteroides*. Preliminary investigations showed that the removal of fat from germ and bran was not necessary for the determination of amino acids in these products. Analysis of solvent-extracted samples gave values identical to those obtained without such treatment.

Results and Discussion

All amino acids were determined at least twice in each of duplicate hydrolysates of each product. Average results of analysis of samples from mill A are given in Table II and those of mill B in Table III. Values have been calculated to the 16% nitrogen basis so that changes in protein composition can be followed.

Comparison of Results between Mills. Comparison of the data in Tables II and III reveals no pronounced differences between the two samples of wheat or between the two patent flours. Values for these products are in excellent agreement with those previously reported (2), except that the cystine content of each was found to be lower. It is not known whether this difference can be attributed to the samples or to the use of the different assay organism. In general, the data for the flours are also in agreement with those reported by McDermott and Pace (4).

Values for the offals may not be comparable between mills because of differences in milling procedures. Differences in amino acid contents may reflect the extent of separation of bran from germ and the relative amounts of fragments of these products which are contained in the red dog and shorts fractions.

Comparison of Products. Changes in the relative proportions of the amino acids showed the same trends in the samples from both mills. Less lysine, glycine, arginine, alanine, and aspartic acid was found in the flour fractions, and more in the offals than in the wheat proteins. Conversely, more proline, glutamic acid, and phenylalanine was found in the flour proteins and less in the offals than was found in the wheat. The proportions of the remaining amino acids were much less affected by milling. These findings for wheat and flour are in general agreement with those obtained by chromatographic analysis of Manitoba wheat and flour as reported by Nunnikhoven and Bigwood (6), but these workers did not investigate other milling products. Earlier values reported by Barton-Wright and Moran (1) on the distribution of amino acids in different fractions of wheat are difficult to compare with the data presented here because only 11 amino acids were studied, and of these, a number are at such wide variance with those cited above for wheat and flour as to suggest analytical differences rather than product differences.

Of greatest interest to the purpose of this paper is the distribution of amino acids in the proteins of the flour fractions. It can be noted

TABLE II

CONCENTRATION OF AMINO ACIDS IN PRODUCTS OF MILL A

(g. per 16 g. nitrogen)

	Alanine	Arginine	Aspartic Acid	Cystine	Glutamic Acid	Glycine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Proline	Serine	Threonine	Tryptophan	Tyrosine	Valine
Farina	2.73	3.77	4.01	1.76	33.4	3.03	1.92	4.01	6.72	2.01	1.73	4.91	11.68	5.36	2.70	1.04	3.35	4.31
Best flour stream	2.65	3.65	3.86	1.80	34.8	2.90	1.91	3.94	6.68	1.94	1.68	4.88	11.63	5.34	2.59	1.02	3.31	4.27
Patent flour	2.67	3.73	3.90	1.76	33.7	2.96	1.92	3.91	6.63	1.97	1.73	4.77	11.69	5.40	2.64	0.92	3.27	4.32
First-clear flour	2.75	3.87	3.86	1.85	34.7	3.25	2.06	4.02	6.59	1.94	1.71	5.04	11.75	5.32	2.73	1.01	3.35	4.44
Low-grade flour	3.10	4.68	4.50	1.67	29.6	3.70	2.14	3.72	6.33	2.54	1.67	4.64	10.16	5.12	2.76	1.01	3.20	4.45
Poorest flour stream	3.79	5.91	5.55	1.51	25.8	4.37	2.27	3.65	6.16	3.17	1.74	4.25	8.58	5.07	2.89	1.07	3.08	4.73
Red dog	4.70	6.84	6.76	1.40	17.9	4.98	2.22	3.42	5.77	4.13	1.70	3.55	6.30	4.85	3.11	1.25	2.85	4.91
Shorts	4.74	6.85	6.95	1.36	16.6	5.33	2.20	3.31	5.64	4.18	1.62	3.44	6.03	4.69	3.03	1.29	2.82	4.84
Bran	4.65	6.60	6.64	1.52	16.2	5.12	2.22	3.29	5.51	3.77	1.48	3.58	6.11	4.58	2.86	1.58	2.82	4.69
Germ	5.23	6.88	7.48	1.04	14.0	5.22	2.26	3.48	5.75	5.28	1.91	3.38	5.03	4.60	3.42	0.98	2.85	4.90
Whole wheat	3.37	4.71	4.85	1.80	29.3	3.94	2.12	3.78	6.52	2.67	1.74	4.43	9.94	5.22	2.76	1.13	3.19	4.69
Weighted sum of products[a]	3.18	4.48	4.61	1.70	29.6	3.56	2.01	3.77	6.34	2.46	1.69	4.49	10.31	5.19	2.72	1.07	3.16	4.43

[a] Sum of amino acid values of products multiplied by percent of product milled from whole wheat.

TABLE III
CONCENTRATION OF AMINO ACIDS IN PRODUCTS OF MILL B
(g. per 16 g. nitrogen)

	Alanine	Arginine	Aspartic Acid	Cystine	Glutamic Acid	Glycine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Proline	Serine	Threonine	Tryptophan	Tyrosine	Valine
Patent flour	2.72	3.97	4.06	1.70	35.5	3.19	1.80	4.05	6.90	2.02	1.70	5.17	11.70	5.52	2.86	1.03	3.38	4.64
Second-clear flour	2.95	4.43	4.43	1.69	35.1	3.41	1.87	4.04	6.84	2.32	1.71	5.00	11.53	5.54	2.90	1.04	3.41	4.65
Red dog	4.50	6.50	6.13	1.55	22.3	4.37	2.01	3.58	6.15	3.67	1.68	4.00	7.61	4.91	3.21	1.21	2.98	4.82
Shorts	4.92	6.91	6.59	1.44	18.6	4.90	2.04	3.36	5.86	4.04	1.56	3.70	6.66	4.83	3.22	1.33	2.85	4.82
Bran	4.55	6.64	6.15	1.45	19.7	4.74	1.94	3.41	5.78	3.84	1.51	3.76	6.92	4.66	3.05	1.36	2.82	4.70
Germ	5.08	7.04	7.19	1.19	17.3	4.94	2.08	3.28	5.72	4.78	1.73	3.68	6.09	4.60	3.44	1.10	2.84	4.91
Whole wheat	3.34	4.88	5.09	1.66	31.6	3.79	1.91	3.86	6.58	2.76	1.73	4.66	10.24	5.25	2.96	1.17	3.25	4.79
Weighted sum of products[a]	3.35	4.85	4.79	1.62	30.6	3.70	1.86	3.85	6.57	2.64	1.65	4.73	10.21	5.28	2.95	1.11	3.23	4.68

[a] Sum of amino acid values of products multiplied by percent of product milled from whole wheat.

in Table II that the amino acid concentrations are nearly constant for farina, patent flour, and the best-quality flour stream. Moreover, the values for the clear flour differ only slightly from those of patent flour. Because of the small differences in the amino acid composition of the flour fractions and because the low-quality fractions represent such a small proportion of the total flour, even extreme variations in the degree of separation would produce insignificant differences in the amino acid content of the patent flours produced. For example, from the lysine data (which show the greatest change in milling) and from the yield data it can be calculated that if the clear and low-grade flours were combined with the patent flour of mill A the lysine content would be increased to only 1.98% as compared to the value of 1.97% found for the patent flour. Similarly, inclusion of the second-clear flour with the 95% patent flour of mill B would yield a predicted lysine level of 2.04% as compared to the value of 2.02% found for the patent flour. This serves to explain the previous observation that the amino acid distribution of patent flours has been found to be nearly independent of the degree of separation of the flour.

This observation is at variance with the results of Nunnikhoven and Bigwood (6), which indicated greater loss of lysine in milling a 65% extraction flour than one of 75%. Calculations from their data yield protein values of 12.0, 11.9, and 11.5% (nitrogen × 5.7, 14% moisture basis) for the wheat, 75% extraction flour, and 65% extraction flour, respectively. It should be noted that these authors have confused the term "percent patent" with percent extraction in comparing their results with those previously published by this laboratory (2); but this does not invalidate their findings. It is possible that the disparity is related to the difference in wheat source, the method of milling, or a combination of these factors.

Lawrence *et al.* (3) reported that an inverse relationship exists between the protein content of wheat and the concentration of lysine in the protein. McDermott and Pace (5) recently published evidence indicating that lysine, arginine, and, to a lesser extent, histidine showed the same inverse relationship to protein in three flours of different protein content. The data of Lawrence *et al.* (3) and unpublished data of this laboratory suggest that the inverse relationship between lysine level and protein level is pronounced in samples of low protein content and tends to disappear at high levels of protein. Most of the samples studied by this laboratory represent commercial blends of wheat intended for the production of bread flour and hence are generally high in protein. It is possible that this alone accounts for the uniformity of the amino acid distribution in these samples; or it may be that the empirical blending of wheats to produce flour with desirable bread-baking qualities depends upon securing a blended protein having a fixed amino acid pattern.

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