Effect of Wheat Processing on the Tryptophan Content of the Resulting Product

L. HUSSEIN, M. ABBASSY, A. ARAFAH, and S. R. MORCOS, Department of Food Science and Nutrition, National Research Center, Dokki, Giza, Egypt

ABSTRACT

The tryptophan content of whole wheat and eight other wheat products was assessed by chemical analysis. It was found to be highest in wheat (70 mg. per g. N); lowest in short-extracted white flour (55 mg. per g. N), baladi (58 mg. per g. N), and French bread (62 mg. per g. N) prepared from it. When the tryptophan content of whole wheat was set as 100, the following relative values were obtained for tryptophan in the following wheat products: 78.7 in white flour; 82.1 and 88.8 in the corresponding baladi and French bread prepared from it; 96.9 in the high-protein dietetic bread; 97.1 in belila (parboiled whole wheat); and 119.1 in biscuits. Under the experimental conditions, neither the baking process nor the boiling process had a destroying effect on the tryptophan content of the resulting product. Biscuit is poor in total nitrogen (1.182%) and its high content of tryptophan is attributed to the incorporation of milk and eggs in the dough.

In Egypt, wheat in the form of bread is the daily staple (1). The most popular type of bread is a flat, circular loaf composed of two layers with almost no crumb. This type of bread is usually prepared from long-extracted flour (80 to 90% extraction). White bread from white flour (first clear, short-extracted, 70% extraction) is also becoming more popular. Belila, which is prepared by boiling the whole wheat, is now available in the domestic food channels throughout the country and is served hot after being suspended in milk and sweetened.

There are no systematic studies available on the changes in the amino acid contents upon processing of the wheat under local conditions. However, numerous reports have been published on amino acid content of wheat products (2,3). Availability of the tryptophan in some wheat products has been reported (4,5) and was found to be close to 100% in bread (5).

Technological advance in the food industry has stimulated considerable interest in the upgrading and conversion of wheat kernels into products of higher acceptability and greater market stability (6,7,8); however, the industry has displayed little interest in studying changes in the nutritional value of new food products.

It is the aim of the present work to study the changes in one of the essential amino acids, tryptophan, caused by different methods of wheat processing. This can be measured by determining the amino acid of the product before and after treatment.

MATERIALS AND METHODS

The wheat used in the course of this work was a soft white winter variety (*Triticum vulgaris,* Giza 155) obtained from the Cereal Department, Ministry of Agriculture, Egypt. The wheat was commercially milled at 16% moisture content, whereby white (first-clear) flour was obtained at short extraction of 72% and low-grade (second class) flour was obtained at long extraction of 87.5%. Four different types of bread were analyzed: baladi bread, prepared either from white flour or from low grade flour; French bread, prepared from white flour; and dietetic bread, a high-protein product manufactured by Bisco Misr Co., in which the flour was mixed with gluten before dough-making. Sweetened biscuits were obtained commercially (Bisco Misr Co.) and were prepared from white flour, in which milk, eggs, and sugars were incorporated during the preparation of the dough. Belila was prepared in the laboratory according to the traditional batch procedure using the open-pot method. The wheat kernels were cooked in water (1:5) until they cracked and an expanded structure was created.

Samples were prepared for analysis by drying in a slow stream of unheated air. They were then ground in an electric mill and kept in airtight containers until analyzed. Nitrogen content was determined by the Kjeldahl method (9). Moisture and ash were determined by standard methods of the AOAC. Tryptophan was determined in triplicate by Procedure O of Spies and Chambers (10).

Analyses of variance were carried out for the tryptophan data in whole wheat and in wheat products (excluding the data for tryptophan content in dietetic sliced bread and in biscuits, whereby the flour was mixed with other ingredients—gluten in the first and skim milk and eggs in the second—during preparation of dough). A multiple F-range test of Duncan (11) was also carried out to determine the least significant differences.

TABLE I. THE TRYPTOPHAN CONTENT OF WHOLE WHEAT AND WHEAT PRODUCTS[a]

Material	Nitrogen % in the Dry Matter	Tryptophan in mg./g. Nitrogen			
		Mean	Max.	Min.	$S_{\bar{x}}$
Whole wheat, Giza	2.07	70 a	75	67	1.19
White flour	1.81	55d	61	47	4.37
Baladi bread, prepared from white flour	1.67	58d	59	55	1.33
French bread	1.70	62b,d	63	61	0.65
Second-clear flour	1.71	68a,b	71	63	2.38
Baladi bread, prepared from second-clear flour	1.78	67a,b	68	66	0.70
Belila, whole wheat	2.09	66a,b	70	64	2.00
Dietetic sliced toast[b]	5.01	68	68	68	0.00
Biscuits[b]	1.18	85	90	74	5.35
Casein[b]	13.48	81	85	74	3.51

[a] $S_{\bar{x}}$ = Standard error of the mean. Values are significantly different (P = 0.05) if they do not share a common letter Duncan's test.
[b] Excluded from the analysis of variance.

RESULTS AND DISCUSSION

Nitrogen and tryptophan values of the wheat and wheat products are given in Table I. Except for biscuits, which had relatively low nitrogen content (1.18%), nitrogen content was quite comparable among the different wheat products. Dietetic sliced toast supplemented with gluten had a level of 5.01% nitrogen.

Tryptophan content in the wheat was 70.2 ± 1.19 mg. per g. nitrogen, corresponding to 1.12 g. per 16 g. nitrogen. Low-grade flour obtained at long extraction of 87.5% approaches, in its tryptophan content, the values obtained in the whole wheat; white flour has, however, lower tryptophan content, which is statistically lower when compared with either one of the forementioned products (P=0.05). The baking process apparently had negligible effects on the tryptophan content of the resulting bread. White baladi bread and French bread had almost the same tryptophan content present in white flour, whereas, the tryptophan content of low-grade flour (second class) and bread made from it was practically the same (68 and 67 mg. per g. nitrogen, respectively). When the wheat was converted into belila under the laboratory conditions used in the present study, which minimized leaching losses of soluble protein from outer bran tissues, there was essentially no change in the total protein content of the product. Tryptophan content, however, is lower in the belila than in its parent wheat, yet not to a statistically significant level. Indeed, the values for belila are still in the range of low-grade flour and baladi bread.

The high tryptophan content in biscuits is attributed to the incorporation of eggs and milk in the dough mixture prior to baking. Both ingredients are rich sources of tryptophan, with a content of 1.536 (12) and 1.78 (13) g. per 16 g. nitrogen for the eggs and milk, respectively.

Generally good agreement was found between the tryptophan level in the whole wheat variety Giza 155 and those levels published for American (5), English (14), and Dutch (15) varieties. It appears from these data that tryptophan is a more constant amino acid in the wheat protein, compared to other amino acids, particularly lysine (16).

A loss of 20% was demonstrated for tryptophan in the process of converting whole wheat into white flour. The reason for this discrepancy is associated with the anatomy of the wheat kernel and the mechanical properties of the various tissues of wheat during milling. White flour is contributed largely by the endosperm, a poor source of this amino acid. Bran, which is obtained in a separate form from the white flour, has been known to be the richest source of tryptophan in the wheat kernel, as was indicated by Pence et al. (2) and Kohler and Palter (3).

The baking process apparently has a negligible effect on tryptophan content of the resulting bread. It is noteworthy that the baladi bread is baked at 400°C., compared to the lower temperature of 220°C., sufficient for the baking of French bread. The tryptophan level of baladi bread obtained in this study is higher than values reported by Jamalian and Pellett (12) from Lebanon.

The FAO provisional pattern (17) recommends a level of 90 mg. tryptophan per g. nitrogen as the minimum daily requirements for optimum growth, although some argue that this level is too high (18,19). The best pattern for rat growth, according to Allison (20), is 1% in the protein.

From previous published data, it can be concluded that the tryptophan content of whole wheat (1.12 g. per 100 g. protein) as well as that of bread prepared from second clear flour (1.08 g. per 100 g. protein) is present in amounts sufficient to cover the minimum daily requirements–if wheat is the sole source of protein in the diet, and assuming that availability of the tryptophan in the bread is close to 100, as found by Hepburn et al. (5).

That tryptophan is not limiting in baladi bread has been confirmed by experimental data from this laboratory (21), since lysine is known to be the first limiting amino acid in bread made from wheat. Supplementation of the bread protein with three essential amino acids (lysine, threonine, and methionine) in adequate amounts raised its protein efficiency ratio (PER) in a 3-week rat-feeding experiment from 1.28 in unsupplemented bread to 3.30 in supplemented bread. The latter value exceeded the PER values obtained with reference casein supplemented with methionine.

In conclusion, the data obtained made it clear that the consumption of products prepared from long-extracted (second-clear) flour are to be favored. In formulation of food-protein mixtures of plant sources based on bean-bread protein mixtures (21), bread proteins are in general higher in their tryptophan content.

Literature Cited

1. MORCOS, S. R. A review on the nutritional status in the United Arab Republic. J. Egypt. Pub. Health Ass. 41:151 (1966).
2. PENCE, J. W., MECHAM, D. K., ELDER, A. H., LEWIS, J. C., SNELL, N. S., and OLCOTT, H. S. Characterization of wheat gluten. II. Amino acid composition. Cereal Chem. 27: 335 (1950).
3. KOHLER, J. O., and PALTER, R. Studies on methods for amino acid analysis of wheat products. Cereal Chem. 44: 512 (1967).
4. KUIKEN, K. A., and LYMAN, C. M. Availability of amino acids in some foods. J. Nutr. 36: 359 (1948).
5. HEPBURN, F. N., CALHOUN, W. K., and BRADLEY, W. B. The biological availability of essential amino acids in wheat, flour, bread, and gluten. Cereal Chem. 43: 271 (1966).
6. MORGAN, A. I., BARTA, E. J., and GRAHAM, R. P. Wurld wheat—a product of chemical peeling. Northwest. Miller 40 (June 1966).
7. FELLERS, D. A., SHEPHERD, A. D., and PENCE, J. W. From wheat by-products low cost

protein for new products. Food Process. Mkt. (Oct. 1966).
8. KOHLER, G. O. Effect of processing on the biological value of wheat proteins. Cereal Sci. Today 9: 173 (1964).
9. ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. Official methods of analysis. 11th ed. 14.100, p. 227, and Method 42.016, p. 858. The Association: Washington, D. C. (1970).
10. SPIES, J. R., and CHAMBERS, D. C. Chemical determination of tryptophan in proteins. Anal. Chem. 21:1249 (1949).
11. DUNCAN, D. B. Multiple range and multiple F-test. Biometrics 1: 1 (1955).
12. JAMALIAN, J., and PELLETT, P. L. Nutritional value of Middle Eastern foodstuffs. IV. Amino acid composition. J. Sci. Food Agr. 19: 378 (1968).
13. NAGUIB, Kh., and HUSSEIN, L. The effect of hydrogen peroxide treatments on the bacteriological quality and nutritive value of milk. Milchwissenschaft 27: 758 (1972).
14. MILLER, E. L. Determination of the tryptophan content of feedingstuffs with particular reference to cereals. J. Sci. Food Agr. 18: 381 (1967).
15. CENTRAAL VEEVOEDERBUREAU IN NEDERLAND. Table on the amino acid composition of feedstuffs. CVB: Geleen (1968).
16. BOND, D. A. The development of field beans as a crop in Britain. Proc. Nutr. Soc. 29: 74 (1970).
17. FAO/WHO EXPERT GROUP. Protein requirements. FAO nutrition meetings report series No. 37: Rome (1965).
18. BRESSANI, R. WILSON, D. L., BEHAR, M., and SCRIMSHAW, N. S. Supplementation of cereal proteins. III. Effect of amino acid supplementation of wheat flour as measured by nitrogen retention of young children. J. Nutr. 70: 176 (1960).
19. SCRIMSHAW, N. S., and BRESSANI, R. Possible modifications in the amino acid pattern of the FAO reference protein. National Research Council Conference on Evaluation of Protein Quality, Washington D. C. (1963).
20. ALLISON, J. B. In: Mammalian protein metabolism, ed. by Munro and Allison; Vol. II, p. 79. Academic Press: New York (1964).
21. HUSSEIN, L., GABRIEL, G. N., and MORCOS, S. R. Studies on the nutritional values of broad bean proteins. I. Supplementation of rat diets based on baladi bread. J. Sci. Food Agr. In Press.

[Received November 8, 1972. Accepted January 4, 1974]