AMINO ACIDS IN THE CORN KERNEL [1]

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INTRODUCTION

A knowledge of the amino acid composition of individual staple foods used in human and animal dietary is of value to the nutritional worker as well as to the agriculturist. The classification of amino acids as dispensable and indispensable emphasizes the protein quality rather than the quantity requirement of protein in the daily diet. We do not eat or feed purified proteins of known amino acid composition. From the nutritional standpoint, staple foods are generally consumed in combinations in order to correct or supplement certain deficiencies in amino acids, vitamins, minerals, etc., and thus avoid the use of concentrates. The present study in the series of amino acids in staple foods is a further attempt to furnish data on corn (*Zea mays* L.).

Pellagra has been found to occur in sections where the population is poorly nourished and lives chiefly on corn. This observation suggested the nutritional origin of the disease, and the low quality of corn proteins was suspected as a contributing factor to the malnourished state of pellagrins. Osborne and Clapp (*5*) [2] analyzed zein, the alcohol-soluble corn protein, and noted the absence of tryptophane and lysine, both of which are nutritionally indispensable amino acids. In the corn glutelin, the author has found 0.516 percent of tryptophane (*1*); thus the absence of tryptophane in the zein is largely, if not wholly, corrected when whole corn is eaten.

EXPERIMENTAL METHODS

The method for determining amino acids has been described in two previous publications (*2*, *3*). Certain changes have been introduced, which are given in the following paragraph, to suit the analytical procedure to the property of the protein material present in the corn kernel.

A white corn and a yellow corn [3] were selected for analysis. The cleaned and selected whole corn kernels were ground to a fine meal and stored at a temperature slightly below freezing. Duplicate samples (air-dry) of 25 gm. each were used for analysis. Ether extraction to remove fatty substances was omitted, because it lowers the solubility of protein in a 1-percent salt solution (*2*). The finely ground corn meal was, therefore, extracted with 100 cc. of precooled 1-percent NaCl solution. Three of these salt extractions of 1-hour duration at 6°–8° C. were applied for removal of the water- and salt-

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[2] Italic numbers in parentheses refer to Literature Cited, p. 768.

[3] The author is indebted to M. T. Jenkins, of the Bureau of Plant Industry, and to H. C. Fellows, of the Bureau of Agricultural Economics, U. S. Department of Agriculture, for supplying and grinding the corn samples.

soluble proteins. Then the residue was extracted twice with 80-percent alcohol in 100-cc. portions at room temperature. One of these alcoholic extractions was of 3 hours' duration, and another lasted overnight. The third alcoholic extraction was carried out at 56°–58° C. for only one-half hour. The residue was cooled in a refrigerator, and the starch removed by the addition of a 21-percent HCl solution, using 200 cc. the first time at refrigeration temperature for 1 hour and stirring occasionally to facilitate the dispersion of starch. The acid extract separates well from residue "R" by centrigutation. By the addition of an equal volume of 95-percent alcohol to the acid extract the starch precipitates. The extract was then centrifuged and the supernatant liquid was decanted. The decanted liquid was then evaporated to a small volume and added to the 1-percent NaCl and 80-percent alcohol extracts. The residue "R" was extracted twice more with 21-percent HCl to remove all starch, 50 to 100 cc. of acid being used each time. These acid extracts do not separate clearly by centrifugation and the slightly turbid supernatant liquid has to be filtered, preferably in the refrigerator. Since the second and third acid extracts contained only starch and an insignificant quantity of nitrogen, the filtrate was discarded. The precipitate from the filtrate, however, was removed and added to the starch-freed residue and hydrolyzed for 24 hours in 20-percent HCl. This hydrolysate, together with the hydrolysate of the combined salt, alcohol, and acid-alcohol extracts, was analyzed for the amino acids as described in previous publications (*2*, *3*).

The distribution of nitrogen in the extracts already referred to was approximately the same in the white and yellow corn samples and together represented from 90 to 92 percent of the total nitrogen.

The salt- and alcohol-insoluble type of protein constituted the largest percentage (48 percent); the 80-percent alcohol-soluble protein, 27 percent; and the 1-percent NaCl solution, 16 percent. It should be noted that the distribution of nitrogen in the different extracts is comparable only when the several factors, such as fineness of ground particles of meal, the concentration of salt or alcoholic solution, the order of the extraction by the different solvents, and the varieties under investigation, are identical. An 80-percent alcoholic solution, for example, invariably removed more nitrogen than an 85-percent solution in the procedure just described.

In regard to the determinations of tryptophane [4] and histidine, a few remarks are needed. By using a Bürker colorimeter, which is equipped with color compensation chambers, a decided improvement was observed in color matching by the May and Rose tryptophane method as modified by the author (*1*). The Ehrlich reagent was omitted from the samples used for color compensation, otherwise the technique was similar to that used for the standard and for the unknown samples. The color compensation for both standard and unknown solutions results in a more accurate color match. In regard to the histidine determination, it was found advantageous to decolorize the solution with Carboraffin before it was precipitated by Hopkin's mercuric sulfate reagent.

[4] An error in calculation was discovered in the tryptophane percentages in the earlier papers (*3*, *6*). To obtain correct values those given for wheat, bran, and shorts should be doubled.

EXPERIMENTAL DATA

Showalter and Carr (*7*) state that the proportion between zein and the other proteins varies according to the nitrogen content of the corn.

The nitrogen content of the two types of corn selected for this investigation differed little, as is shown in table 1; therefore a difference found in the amino acid composition might be significant in selecting one or the other on the basis of protein quality. The analytical results as shown in table 1, however, do not reveal any justification for preferring white corn to yellow corn with respect to amino acid composition. On a dietary regimen where the protein requirement is covered only by the corn proteins unsatisfactory growth of animals has been reported (*4*), not because of lack of any specific amino acid, but rather because of insufficient quantities of some of those indispensable ones considered herein. This conclusion is reached on the basis of Rose's figures representing the minimum quantities of indispensable amino acids required to support growth (*6*). Furthermore, in table 2, where the amino acids are expressed in quantities as obtained from 1 gm. of nitrogen of the whole corn kernel, the inferior quality of the corn protein as compared to casein is clearly demonstrated in respect to tryptophane and lysine. A judiciously selected mixed diet, however, should correct a poor nutritional state brought about by a diet in which corn is the chief source of protein.

TABLE 1.—*Amino acid content and total nitrogen of two varieties of moisture-free corn grown in 1937*

Place grown and variety of corn	Cystine	Trypto-phane	Tyrosine	Arginine	Histi-dine	Lysine	Total nitrogen
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Virginia: Boone County White	0.096	0.047	0.703	0.212	0.089	0.107	1.71
Iowa: Black Yellow Dent	.095	.053	.700	.226	.109	.108	1.78

TABLE 2.—*Protein quality of indicated amino acid obtained from 1 gm. of staple food nitrogen with casein for comparison*

Staple food	Cystine	Trypto-phane	Tyrosine	Arginine	Histidine	Lysine
	Milligrams	*Milligrams*	*Milligrams*	*Milligrams*	*Mulligrams*	*Milligrams*
White corn	56	28	441	124	52	63
Yellow corn	53	30	393	127	61	61
Casein	20	130	405	236	156	475

SUMMARY

The present study shows definitely that none of the indispensable amino acids considered herein are missing from the whole corn flour and that they are equally distributed in white and yellow corn. The amino acid composition of the whole corn kernel as found and as described in this paper when compared with that of casein shows that tryptophane and lysine are present at a lower level. The deficiency of tryptophane and lysine, which are absent in zein, apparently is not corrected sufficiently by the rest of the corn proteins. This conclusion, based on analytical findings, supports the general feeding practice of supplementation.

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