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The Essential Amino Acid Content of Cottonseed, Peanut and Soybean Products

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Preface

Amino acids are the chemical structural units from which various kinds of proteins are built. The requirement of animals for protein is, in fact, a composite requirement for a number of different amino acids. This report gives the content of 10 different amino acids in meals, flours and commercial protein preparations made from cottonseed, peanuts and soybeans. The following 10 amino acids: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophane and valine were selected for study on the basis of their proven importance in nutrition.

When expressed on an equal protein content basis, meals of the same kind were quite uniform with respect to their amino acid composition.

Meals and flours made from cottonseed, peanuts and soybeans are good sources of amino acids. The protein of cottonseed and soybean products was found to be definitely superior to the protein of peanut products with respect to lysine, methionine and tryptophane. These 3 amino acids are of particular importance because feeds and feed products are likely to be deficient in one or more of them.

With the exception of soybean protein and soybean feed, different types of commercial processing appeared to have little or no effect on the amino acid composition of the products.

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The nutritional requirement of animals for protein is in reality a requirement for certain amino acids which are present in the protein. Although there are over 20 recognized amino acids, only 10 are generally regarded as essential in animal nutrition. These 10 amino acids are: arginine, histidine, lysine, valine, leucine, isoleucine, methionine, phenylalanine, threonine and tryptophane. Complete information on the amino acid content of feeds is needed as a guide in compounding rations for farm animals, if amino acid deficiencies are to be avoided.

Data to be found in the literature on the amino acid composition of cottonseed, peanut and soybean products are rather scattered and limited. Most of the older chemical methods for the determination of amino acids are more applicable and more reliable when applied to purified proteins than when applied to foodstuffs containing carbohydrates and other substances besides proteins. Comprehensive studies on the amino acid composition of natural and manufactured food products have been made practical by the development of microbiological assay methods during the last few years. In the present investigation microbiological procedures have been applied to the study of various products made from cottonseed, peanuts and soybeans.

Materials and Methods

Description of Samples

With the exception of 2 samples of solvent extracted cottonseed meal all of the materials were commercial products. Only materials of first quality were included. Cottonseed meal samples graded prime, according to the rules of the National Cottonseed Products Association. The process used for the preparation of 2 samples of solvent extracted cottonseed meal (A&M process) has been described by Harris, Bishop, Lyman and Helpert (1).

Table 1. Arginine, histidine and lysine content of cottonseed, peanut and soybean products

Product	Crude protein (N x 6.25)	Arginine		Histidine		Lysine	
		in the sample	in crude protein	in the sample	in crude protein	in the sample	in crude protein
	percent	percent	percent	percent	percent	percent	percent
Cottonseed							
Flour (Proflo)	54.07	6.11	11.30	1.39	2.57	2.25	4.16
Meal (solvent extracted, A&M process)	54.10	6.03	11.14	1.39	2.57	2.39	4.42
Meal (solvent extracted, A&M process)	55.18	5.39	9.77	1.49	2.70	.....	.....
Meal (solvent extracted, commercial product)	48.46	5.18	10.69	1.25	2.58	2.25	4.64
Meal (hydraulic)	40.26	4.66	11.58	1.13	2.81	1.73	4.30
Meal (hydraulic)	39.27	4.34	10.97	1.05	2.65	1.67	4.22
Meal (hydraulic)	39.29	4.13	10.51	1.04	2.65	1.60	4.07
Meal (hydraulic)	36.18	3.41	9.42	0.95	2.62	1.53	4.23
Meal (hydraulic)	33.15	3.09	9.32	0.83	2.50	1.33	4.01
Average for cottonseed products	.....	.....	10.52	.....	2.63	.....	4.26
Peanut							
Flour	61.00	6.87	11.26	1.32	2.16	1.95	3.20
Meal (hydraulic)	39.21	3.79	9.66	0.82	2.09	1.45	3.70
Meal (hydraulic)	38.69	4.25	10.99	0.86	2.22	1.30	3.36
Average for peanut products	.....	.....	10.64	.....	2.16	.....	3.42
Soybean							
Meal (hydraulic)	45.70	3.26	7.13	1.12	2.45	2.73	5.97
Meal (hydraulic)	42.34	3.26	7.70	1.10	2.60	2.73	6.45
Meal (hydraulic)	43.32	3.20	7.38	1.10	2.54	2.66	6.14
Meal (solvent)	48.52	3.50	7.21	1.12	2.31	2.83	5.83
Meal (solvent)	46.59	3.67	7.88	1.18	2.53	3.00	6.44
Protein (commercial)	79.50	5.72	7.20	1.85	2.33	4.59	5.77
Feed	37.19	2.51	6.75	0.95	2.55	2.55	6.86
Average for soybean products	.....	.....	7.32	.....	2.47	.....	6.21

Methods of Analysis

The amino acid analyses reported here were all carried out by the use of microbiological procedures developed at the Texas Agricultural Experiment Station. Valine, leucine and isoleucine were determined by the use of *Lactobacillus arabinosus* 17-5 as described by Kuiken, Norman, Lyman, Hale and Blotter (2). Histidine and threonine were determined with *Streptococcus faecalis* R. Details of the procedures are given in a report by Lyman, Kuiken and Hale (3). Methionine was determined with *Leuconostoc mesenteroides* P60 (see Lyman, Moseley, Butler, Wood and Hale (4)). Tryptophane was determined with *Streptococcus faecalis* R (see Kuiken, Lyman and Hale (5)). Description of the methods for the determination of the remaining amino acids will be given in a later publication.

Results and Discussion

There are several ways in which the amino acid composition of foodstuffs can be expressed. The data presented in this report are given in 2 ways; first, as the percent of the individual amino acid in the sample, and second, as the percent of the amino acid in the protein. The first of these 2 ways has the advantage that it gives a direct measure of the total amount of a given amino acid contained in the sample. Since amino acids are the constituents from which proteins are made, it is to be expected that differences in the protein content of different samples of the same kind of foodstuff will be reflected in corresponding differences in amino acid content. By dividing the percentage of a given amino acid in a sample by the protein content of the sample and multiplying by 100 we obtain the percentage of the amino acid contained in the protein. It is this latter value which is the more useful in evaluating the nutritional qualities of the protein in different kinds of foodstuffs.

It will be seen from the 3 tables that the content of the individual amino acids in the cottonseed meal samples decreased rather consistently with decreased protein content. The data also show that the protein in the cottonseed products of different protein content, and made by different commercial processes, all had practically the same amino acid composition. It follows that the content of any 1 of these 10 amino acids in other samples of cottonseed meal can be satisfactorily predicted on the basis of the average values given in the tables and the protein content of the sample. This is probably true for peanut meal and soybean meal as well, although a smaller number of samples of these products were included in this investigation. The data given in the tables indicate that this generaliza-

Table 2. Valine, leucine and isoleucine content of cottonseed, peanut and soybean products

Product	Crude protein (N x 6.25)	Valine		Leucine		Isoleucine	
		in the sample	in crude protein	in the sample	in crude protein	in the sample	in crude protein
	percent	percent	percent	percent	percent	percent	percent
Cottonseed							
Flour (Proflo)	54.07	2.62	4.84	3.37	6.23	2.13	3.94
Meal (solvent extracted, A&M process)	54.10	2.72	5.03	3.21	5.93	2.15	3.98
Meal (solvent extracted, A&M process)	55.18	2.83	5.13	3.33	6.03	2.29	4.15
Meal (solvent extracted, commercial product)	48.46	2.38	4.91	2.78	5.74	1.90	3.92
Meal (hydraulic)	40.26	2.08	5.17	2.54	6.31	1.64	4.07
Meal (hydraulic)	39.57	1.93	4.88	2.47	6.24	1.54	3.89
Meal (hydraulic)	39.29	1.92	4.89	2.38	6.06	1.60	4.07
Meal (hydraulic)	36.18	1.71	4.73	2.26	6.25	1.26	3.48
Meal (hydraulic)	33.15	1.59	4.80	2.05	6.18	1.23	3.71
Average for cottonseed products	.....	.....	4.93	.....	6.11	.....	3.91
Peanut							
Flour	61.00	2.83	4.64	4.11	6.74	2.64	4.33
Meal (hydraulic)	39.21	1.87	4.77	2.54	6.48	1.74	4.44
Meal (hydraulic)	38.69	1.88	4.86	2.66	6.88	1.63	4.21
Average for peanut products	.....	.....	4.76	.....	6.70	.....	4.33
Soybean							
Meal (hydraulic)	45.70	2.49	5.45	3.54	7.75	2.50	5.47
Meal (hydraulic)	42.34	2.27	5.36	3.30	7.79	2.37	5.60
Meal (hydraulic)	43.32	2.35	5.42	3.41	7.87	2.39	5.52
Meal (solvent)	48.52	2.59	5.34	3.65	7.52	2.68	5.52
Meal (solvent)	46.59	2.54	5.45	3.51	7.53	2.51	5.39
Protein (commercial)	79.50	4.09	5.14	6.18	7.77	4.65	5.85
Feed	37.19	2.38	6.40	3.28	8.82	2.28	6.13
Average for soybean products	.....	.....	5.51	.....	7.86	.....	5.64

tion is less applicable to soybean protein and soybean feed. The explanation of this finding is as follows: Products of high protein content, such as commercial soybean protein, are made from the oil seed meals by extraction of the protein with dilute salt or alkaline solution. The protein is then recovered from solution by precipitation. The residue left after the extraction of the protein is sold for feed. The net result is a partial separation of the different kinds of protein contained in the original meal. It is, therefore, logical to expect some differences between the amino acid composition of the protein in the product of high protein content and in the feed.

The data given in the tables show that cottonseed, peanut and soybean products are good sources of amino acids. Of the 10 amino acids studied in this investigation, lysine, methionine and tryptophane are perhaps the most important from the nutritional standpoint. Feeds and feed products are more likely to be deficient in one or more of these 3 amino acids than in any of the other amino acids studied. The amounts of these 3 amino acids contained in the protein of cottonseed and soybean products were significantly higher than the amounts found in peanut products.

The older chemical data on the amino acids contained in cottonseed, peanut and soybean proteins have been summarized by Block and Bolling (6). Microbiological methods have been applied to the determination of tryptophane in some of the products studied in the present investigation, by Greene and Black (7), Stokes, Gunnes, Dwyer and Caswell (8), Wooley and Sebrell (9), Baumgarten, Mather and Stone (10), and by Greenhut, Schweigert and Elvehjem (11). The value of 1.73 given in the last mentioned report, for the tryptophane content of the protein of soybean meal, is in excellent agreement with the results reported here. In all other cases the tryptophane values obtained in the present investigation are substantially higher than those to be found in the above mentioned reports. It is unlikely that differences in the samples studied are responsible for these discrepancies. The more probable explanation is to be found in the methods used for the hydrolysis of the materials. Preliminary tests in the present investigation likewise gave lower results. The higher values reported here were obtained only after an extended study of the factors which influence the stability of tryptophane during the alkaline hydrolysis of proteins and foodstuffs. The details of these studies have been published elsewhere (5).

Values for the content of one or more of the other essential amino acids in some of the products studied here are to be found in the

Table 3. Methionine, phenylalanine, threonine and tryptophane content of cottonseed, peanut and soybean products

Product	Crude protein (N x 6.25)	Methionine		Phenylalanine		Threonine		Tryptophane	
		in the sample	in crude protein	in the sample	in crude protein	in the sample	in crude protein	in the sample	in crude protein
	percent	percent	percent	percent	percent	percent	percent	percent	percent
Cottonseed									
Flour (Proflo)	54.07	0.87	1.61	2.81	5.20	1.82	3.36	0.84	1.55
Meal (solvent extracted, A&M process)	54.10	0.79	1.46	2.89	5.34	1.88	3.47	0.83	1.53
Meal (solvent extracted, A&M process)	55.18	0.79	1.43	2.95	5.35	1.80	3.36	0.85	1.54
Meal (solvent extracted, commercial product)	48.46	0.71	1.46	2.51	5.18	1.63	3.36	0.75	1.55
Meal (hydraulic)	40.26	0.64	1.59	2.18	5.41	1.47	3.65	0.66	1.64
Meal (hydraulic)	39.57	0.58	1.46	2.08	5.26	1.34	3.39	0.62	1.57
Meal (hydraulic)	39.29	0.56	1.42	2.00	5.09	1.33	3.39	0.61	1.55
Meal (hydraulic)	36.18	0.56	1.55	1.86	5.14	1.24	3.43	0.58	1.60
Meal (hydraulic)	33.15	0.49	1.48	1.69	5.10	1.12	3.38	0.52	1.57
Average for cottonseed products	.....	.....	1.50	.....	5.23	.....	3.42	.....	1.57
Peanut									
Flour	61.00	0.62	1.02	3.10	5.08	1.63	2.67	0.78	1.28
Meal (hydraulic)	39.21	0.35	0.89	1.94	4.95	1.20	3.06	0.49	1.25
Meal (hydraulic)	38.69	0.46	1.19	1.93	4.99	1.12	2.90	0.46	1.19
Average for peanut products	.....	.....	1.03	.....	5.01	.....	2.88	.....	1.24
Soybean									
Meal (hydraulic)	45.70	0.66	1.44	2.26	4.94	1.79	3.92	0.73	1.60
Meal (hydraulic)	42.34	0.60	1.42	2.00	4.72	1.79	4.23	0.75	1.77
Meal (hydraulic)	43.32	0.58	1.34	2.15	4.96	1.73	3.99	0.76	1.75
Meal (solvent)	48.52	0.65	1.34	2.32	4.78	1.95	4.02	0.82	1.69
Meal (solvent)	46.59	0.66	1.42	2.28	4.89	1.85	3.97	0.76	1.63
Protein (commercial)	79.50	0.93	1.17	4.40	5.53	2.83	3.56	1.16	1.46
Feed	37.19	0.66	1.77	1.92	5.16	1.89	5.08	0.61	1.64
Average for soybean products	.....	.....	1.41	.....	5.00	.....	4.11	.....	1.65

following publications: Kuiken, *et al.*, (2), Stokes (8), Baumgarten (10), Greenhut, Schweigert and Elvehjem (12), Riesen, Schweigert and Elvehjem (13), Schweigert (14), Horn, Jones and Blum (15). In some cases there is good agreement between the values given in these reports and those obtained in the present investigation. Marked discrepancies occur in the case of methionine. This problem has been extensively studied and evidence for the validity of the method used here has been reported (4).

The values for the valine, leucine and isoleucine content of cottonseed, peanut and soybean meal given in a previous report (2) from the authors' laboratory are lower than those given here. In this case the cause of the discrepancies was definitely found to be due to the inadequacy of the method used in the previous investigation for the hydrolysis of the samples.

Summary

The content of 10 different amino acids in 19 samples of cottonseed, peanut and soybean products is given. The products include cottonseed flour, both hydraulic and solvent extracted cottonseed meals, peanut flour, peanut meal, both hydraulic and solvent extracted soybean meals, soybean protein and soybean feed.

With respect to 3 amino acids which are of particular significance in nutrition, lysine, methionine and tryptophane, the proteins of cottonseed and soybean meals were found to be definitely superior to the protein of peanut meal.

With the exception of soybean protein and soybean feed, the type of commercial processing appeared to have little or no effect on the amino acid composition of the products.

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Bibliography

1. Harris, W. D., F. F. Bishop, C. M. Lyman and R. Helpert, 1947. Report on Isopropanol as a Solvent for Extraction of Cottonseed. J. Am. Oil Chem. Soc., Vol. 24, p. 370.

2. Kuiken, K. A., W. H. Norman, C. M. Lyman, F. Hale and L. Blotter, 1943. The Microbiological Determination of Amino Acids, I Valine, Leucine, and Isoleucine. J. Biol. Chem. Vol. 151, p. 615.

3. Lyman, C. M., K. A. Kuiken and F. Hale, 1947. The Histidine Content of Meat. J. Biol. Chem. Vol. 171, p. 233.

4. Lyman, C. M., O. Moseley, B. Butler, S. Wood and F. Hale, 1946. The Microbiological Determination of Amino Acids, III Methionine. J. Biol. Chem. Vol. 166, p. 161.

5. Kuiken, K. A., C. M. Lyman and F. Hale, 1947. Factors which Influence the Stability of Tryptophane During Hydrolysis of Protein in Alkaline Solution. J. Biol. Chem. Vol. 171, p. 551.

6. Block, R. J. and D. Bolling, 1945. The Amino Acid Composition of Proteins and Foods. Pp. 76, 136, 182, 214, 237, and 238, Springfield.

7. Greene, R. D. and A. Black, 1944. The Microbiological Assay of Tryptophane in Proteins and Foods. J. Biol. Chem. Vol. 155, p. 1.

8. Stokes, J. L., M. Gunness, I. M. Dwyer and M. C. Caswell, 1945. Microbiological Methods for the Determination of Amino Acids, II A Uniform Assay for the Ten Essential Amino Acids. J. Biol. Chem. Vol. 160, p. 35.

9. Wooley, J. G. and W. H. Sebrell, 1945. Two Microbiological Methods for the Determination of L(-) Tryptophane in Proteins and other Complex Substances. J. Biol. Chem. Vol. 157, p. 141.

10. Baumgarten, W., A. N. Mather and L. Stone, 1946. Essential Amino Acid Composition of Feed Materials. Cereal Chem. Vol. 23, p. 135.

11. Greenhut, I. T., B. S. Schweigert and C. A. Elvehjem, 1946. Hydrolysis Procedures for the Determination of Tryptophane in Proteins and Foodstuffs by the Microbiological Procedure. J. Biol. Chem. Vol. 165, p. 325.

12. Greenhut, I. T., B. S. Schweigert and C. A. Elvehjem, 1946. The Amino Acid Requirements of Streptococcus Faecalis and the Use of this Organism for the Determination of Threonine in Natural Products. J. Biol. Chem. Vol. 162, p. 69.

13. Riesen, W. H., B. S. Schweigert and C. A. Elvehjem, 1946. Microbiological Determination of Methionine in Proteins and Foodstuffs. J. Biol. Chem. Vol. 165, p. 347.

14. Schweigert, B. S., 1947. Amino Acid Content of Feeds, I. Leucine, Valine, Isoleucine, and Phenylalanine. J. Nutrition. Vol. 33, p. 553.

15. Horn, M. J., D. B. Jones and A. E. Blum, 1947. Microbiological Determination of Threonine in Proteins and Foods. J. Biol. Chem. Vol. 169, p. 739.