Effect of Variety, Location, and Years on the Protein and Amino Acid Content of Dried Beans

EDITH M. LANTZ, HELEN W. GOUGH[1], and ADA MARIE CAMPBELL[2]

New Mexico State Agricultural Experiment Station, State College, N. M.

As previous work had shown variety and environmental variations in the protein content of dried beans, nine amino acids were determined microbiologically in eight varieties of dried beans grown for 3 years in one location and for 1 year in three locations. Differences due to location and years were highly significant for all amino acids on milligram-per-gram basis and for seven and six amino acids, respectively, on a per-cent-of-protein basis. For some amino acids, variety differences, which were significant on a milligram-per-gram basis, were not significant when expressed as per cent of protein. The arginine content was affected much more than the other amino acids. The fact that the relative amounts of an amino acid affects its biological value may be significant in planning dietaries of population groups eating large amounts of dried beans.

SEVERAL YEARS AGO, this laboratory reported that the time required to cook dried beans was affected by variety and the location in which the beans were grown—with locality having the greater effect (*4*). When the chemical composition of the beans was determined, significant variety, locality, and year differences were found in protein, three B vitamins, calcium, and phosphorus—with locality again having the greatest effect (*5*, *6*).

The effect of protein was particularly marked, beans from one locality being approximately 50% higher in protein, on a dry-weight basis, than those from a second locality, while a third locality had intermediate values.

This is a report on the effect of variety and growing environment on the amino acid content of eight varieties of dried beans.

Review of Literature

The composition of plants can be altered in many ways. It is possible by breeding and selection to develop varieties high in certain nutrients. The development of high-niacin corn varieties is only one example of this (*8*).

The growing environment of a plant is made up of many factors. Some of these are soil, fertilizer treatments, altitude, climate, rainfall, length of growing season, light intensity, length of day, and temperature. These operate in different, but interrelated, ways to change the composition of plants.

Analyses of corn samples from different parts of the United States revealed statistically significant differences in food nutrients due to location (*9*). Zones of high or low protein were found. Moderate or large regional and state variations were found for copper, iron, niacin, potassium, and chlorine in corn.

The experiment stations of several southern states cooperated in a study of the effects of fertilizers and other factors on the composition of vegetables. They found marked location effects in

Table I. Effect of Variety and Location on Protein (N × 6.25) Content of Dried Beans[a]

Variety	Protein, %			
	Deming	Estancia	State College	Means[b]
295	20.0	30.8	22.8	24.53
641	20.9	32.1	24.8	25.93
Michelite	23.8	34.4	25.7	27.97
Red Mexican	19.9	29.0	22.5	23.80
2574	19.9	30.9	24.4	25.07
2534	20.0	29.9	26.2	25.37
Calico	19.8	30.1	24.3	24.73
Navy	19.2	30.1	23.9	24.40
Means[c]	20.44	30.91	24.33	25.23

[a] Values are expressed on moisture-free basis.
[b] Differences are significant at 5% level. Least significant difference equals 1.70.
[c] Differences are significant at 1% level. Least significant difference equals 14.5.

[1] Present address, Fort Wayne, Ind.
[2] Present address, University of California, Los Angeles, Calif.

Table II. Effect of Variety on Amino Acid Content of Dried Beans Grown in Deming Area for 3 Years[a]

Variety	Arginine		Histidine		Isoleucine		Leucine		Lysine		Methionine		Phenylalanine		Threonine		Valine	
	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein %	Mg./g.	Protein, %
295	11.1	5.3	5.7	2.7	13.2	6.4	17.3	8.4	14.8	7.1	5.6	2.7	11.6	5.6	10.6	5.1	11.9	5.8
641	10.5	4.9	5.8	2.7	13.2	6.1	17.7	8.2	15.1	7.0	5.9	2.8	12.2	5.7	10.2	4.8	12.5	5.8
Michelite	13.0	5.1	6.9	2.7	14.5	5.9	19.6	7.9	16.3	6.5	6.2	2.5	13.1	5.3	12.4	5.0	11.9	4.8
Red Mexican	10.6	4.9	5.8	2.7	13.2	6.1	17.5	8.1	15.0	6.9	5.7	2.6	12.3	5.7	10.1	4.7	12.1	5.6
2574	11.2	5.4	6.1	3.0	13.5	6.5	17.7	8.5	14.6	7.0	5.6	2.7	11.5	5.5	10.4	5.0	11.5	5.5
2534	11.5	5.3	6.1	2.8	13.4	6.2	18.4	8.5	15.2	7.2	6.3	2.9	12.6	5.8	9.5	4.4	12.2	5.6
Calico	12.2	5.9	6.2	3.0	13.3	6.4	19.3	9.3	15.6	7.5	6.5	3.1	12.6	6.1	10.1	4.9	12.3	5.9
Navy	11.4	5.2	6.0	2.7	12.9	5.9	18.7	8.5	15.4	7.0	6.0	2.8	12.6	5.8	11.4	5.2	12.7	5.8
Mean	11.4[b]	5.2	6.1[c]	2.8	13.4[b]	6.2	18.3[b]	8.4	15.2[b]	7.0	6.0[c]	2.8	12.3[b]	5.7	10.6[b]	4.9	12.1	5.6
L. S. D. 0.01			0.72								0.54				1.02			
L. S. D. 0.05	1.47				0.69		1.47		0.80				0.88					

[a] Values expressed on dry basis.
[b] Differences significant at 5% level.
[c] Differences significant at 1% level.

protein, mineral, and vitamin contents of a wide variety of vegetables. Their findings have been reported in a series of bulletins and journal articles which were reviewed recently (7).

Experimental Material

The beans were supplied by the Agronomy Department of New Mexico State College from the many strains and varieties being studied in their pinto-bean improvement project. Included were navy, Michelite, Red Mexican, calico, two strains of pinto (295 and 641), and two pinto-calico natural hybrids (2534 and 2574).

These beans were grown under field conditions at three locations which differed in soil and other growing conditions. Estancia, an important bean-growing area in central New Mexico, has an altitude of slightly over 6000 feet, and the beans were grown there under dry-farming conditions. State College, with an altitude of a little less than 4000 feet, and Deming, with an altitude of 4300 feet, are both approximately 170 miles south of Estancia. State College beans are irrigated by river water and Deming beans by water from deep wells. The entire area is semiarid with abundant sunshine. Differences in altitude and latitude affect temperature and the length of growing season.

The soil in the Estancia Valley is Witt loam; in the Deming area, Mimbres loam; and at State College, Gila clay loam. Information about available soil nutrients is meager though potassium is high in all, and phosphorus is high in the Deming area and low at Estancia.

The amino acids—arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and valine—were determined microbiologically by the method of Dunn and associates (7).

Values have been expressed as milligrams per gram (dry basis) or per cent of total protein as determined by the Kjeldahl method.

Results

The effect of variety and location on the total protein in the beans is shown in Table I. The data represent 3-year means of the eight varieties analyzed for amino acids. Mean differences between some varieties were significant while mean differences between all locations were highly significant. These data follow the same pattern as the many samples analyzed previously.

Table II summarizes the effect of variety on the amino acid contents of the beans. The data show means for 3 years at one location. When the values are expressed as milligrams per gram, the differences are significant for all acids except valine. These differences are not significant when the data are expressed as per cent of total protein.

The effect of location is shown in Table IV, which summarizes data for the same eight varieties for three locations for 1 year. Again, highly significant differences are found for all amino acids on a milligram-per-gram basis. When the values are expressed as per cent of total protein, there is a marked increase in the arginine content of beans from Estancia and decrease in the other amino acids.

When beans are grown in the same location for 3 years or planted on two dates in the same years, variations in soil and irrigation water are eliminated, but storage introduces another variable. Data on beans grown in the same location three different years and those from two planting dates are shown in Table IV. Differences due to years are highly significant for all amino acids on a milligram-per-gram basis, and for some of the amino acids when expressed as per cent of protein. Difference in planting dates affects only a few amino acids.

In field experiments it is not possible to separate the many interrelated factors that make up the growing environment of plants. Variation in a single factor may cause a shift in the effect on a plant or even on different parts of the same plant.

Data in Tables II and IV show that environmental factors due to location have more effect than those due to variety, years, or planting dates. Estancia beans are not only higher in the total amounts of the amino acids in the beans.

Table III. Relative Amounts of Amino Acids in Dried Beans from Three Localities

Amino Acids	Ratios[a]			
	Milligrams per Gram		Protein, %	
	Estancia	State College	Estancia	State College
Arginine	2.2	1.2	1.5	1.1
Histidine	1.4	1.2	0.9	1.0
Isoleucine	1.2	1.1	0.8	0.9
Leucine	1.3	1.1	0.9	1.0
Lysine	1.3	1.1	0.9	1.0
Methionine	1.3	1.2	0.9	1.0
Phenylalanine	1.3	1.1	0.9	1.0
Threonine	1.2	1.1	0.8	0.9
Valine	1.3	1.1	0.9	1.0

[a] Deming values considered unity.

Table IV. Effect of Locality, Years, and Planting Date on Amino Acid Content of Eight Varieties of Dried Beans[a]

	Arginine		Histidine		Isoleucine		Leucine		Lysine		Methionine		Phenylalanine		Threonine		Valine	
	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %	Mg./g.	Protein, %
Locality																		
Estancia	26.0	8.4	9.4	3.0	16.5	5.3	24.7	8.0	19.8	6.4	7.2	2.3	17.1	5.5	13.3	4.3	16.1	5.2
State College	14.8	6.1	7.8	3.2	14.6	6.0	20.8	8.6	17.2	7.1	6.4	2.6	14.3	5.9	12.2	5.0	13.8	5.6
Deming	12.1	5.7	6.8	3.2	13.6	6.4	18.4	8.6	15.4	7.2	5.5	2.6	13.0	6.1	11.3	5.3	12.5	5.9
Mean	17.6[b]	6.7[b]	8.0[b]	3.1	14.9[b]	5.9[b]	21.3[b]	8.4[b]	17.5[b]	6.9[b]	6.4[b]	2.5[b]	14.8[b]	5.8[b]	12.3[b]	4.9[b]	14.1[b]	5.5
L. S. D. 0.01	3.04	0.66	1.02		0.75	0.48	1.38	0.38	0.93	0.21	0.48	0.23	9.0	0.30	0.66	0.27	2.26	
Years																		
1948	9.5	4.6	4.8	2.4	12.2	6.0	16.6	8.2	13.9	6.8	5.9	2.9	11.2	3.5	9.2	4.5	10.9	5.4
1949	12.1	5.7	6.8	3.2	13.6	6.4	18.4	8.6	15.4	7.2	5.5	2.6	13.0	6.1	11.3	5.3	12.5	5.9
1950	12.7	5.4	6.6	2.8	14.4	6.2	19.8	8.5	16.5	7.1	6.6	2.8	12.8	5.4	11.2	4.8	13.0	5.5
Mean	11.4[b]	5.2[b]	6.1[b]	2.8[b]	13.4[b]	6.2	18.3[b]	8.4	15.3[b]	7.0	6.0[b]	2.8[b]	12.3[b]	5.7[c]	10.6[b]	4.9[b]	12.1[b]	5.6[c]
L. S. D. 0.01	1.26	0.13	0.45	0.30	0.60		1.23		0.66		0.33	0.27	0.75		0.63	0.48	1.17	
L. S. D. 0.05														0.45				0.39
Planting Date																		
Early	12.3	5.4	8.0	3.6	14.4	6.4	19.0	8.4	16.5	7.2	6.0	2.7	12.8	5.7	10.6	4.7	13.2	5.8
Late	12.7	5.4	6.6	2.8	14.4	6.2	19.8	8.5	16.5	7.1	6.6	2.8	12.8	5.4	11.2	4.8	13.0	5.5
Means	12.5	5.4	7.3[b]	3.2[b]	14.4	6.3	19.4	8.4	16.5	7.2	6.3[b]	2.8[c]	12.8	5.6	10.9[b]	4.8	13.1	5.7
L. S. D. 0.01			1.19	0.45							0.38				0.68			
L. S. D. 0.05												0.12						

[a] Values expressed on moisture-free basis.
[b] Differences significant at 1% level.
[c] Differences significant at 5% level.

but the relative amounts of the amino acids have changed. This is shown in Table III where the amounts of each amino acid in beans from Estancia and State College have been compared with the amounts in Deming beans. The ratios, on both the milligram-per-gram and per-cent-of-protein basis, are constant except for arginine, which is high.

The total protein of beans is a mixture of several proteins (*10*). Changes in environmental conditions possibly act in some way to cause a shift in the relative amounts of these different proteins.

The shift in the relative amounts of amino acids in beans grown under different environmental conditions may have nutritional significance. Many low-income families depend on dried beans for most of their protein. As with other plant foods, beans are unbalanced with respect to their content of amino acids and are particularly low in methionine.

Increasing the level at which an incomplete protein is fed or supplementing it with single amino acids may create such an imbalance with respect to other amino acids that the result is less desirable than if the deficient protein were fed at a low level (*2*).

Elvehjem points out that it is possible, by selection, to produce strains of corn as high as 19.45 or as low as 4.9% protein. But there are evidences that as the percentage of protein increases there is a decrease in lysine and an increase in leucine. This is a change in the wrong direction as corn is already overbalanced with respect to leucine, and presumably the high-protein corn would be inferior in biological value for nonruminants (*3*).

Literature Cited

(1) Dunn, M. S., Camien, M. N., Malin, R. B., Murphy, E. A., Reiner, P. J., *Univ. Calif. (Berkeley) Publs. Physiol.* **8**, 293 (1949).
(2) Elvehjem, C. A., *J. Am. Dietet. Assoc.* **32**, 305 (1956).
(3) Elvehjem, C. A., *Proc. 4th Ann. Meeting Agr. Research Inst.* **1955**, p. 82.
(4) Gough, H. W., Lantz, E. M., *Food Research* **5**, 308 (1950).
(5) New Mexico Agr. Expt. Sta. Ann. Rept. **57**, 35 (1945–46).
(6) *Ibid.*, **58**, 33 (1946–47).
(7) *Nutrition Rev.* **12**, 207 (1954).
(8) Richey, F. D., Davison, R. F., *Plant Physiol.* **23**, 238 (1948).
(9) Schneider, B. H., Lucas, H. L., Beeson, K. C., J. Agr. Food Chem. **1**, 172 (1953).
(10) Waterman, H. C., Johns, C. O., Jones, D. B., *J. Biol. Chem.* **55**, 93 (1923).

Received for review September 29, 1956. Accepted April 11, 1957. Published with permission of the director of the experiment station.