Maturation Time and Some Seed Composition Characters Affecting Nutritive Value in Soybean Varieties

D. KRIVORUCHCO,[1] H. KABA, M. E. SAMBUCETTI, and J. C. SANAHUJA, Department of Nutrition and Food Science, School of Pharmacy and Biochemistry, University of Buenos Aires, Argentina

Cereal Chem. 56(4):217-219

ABSTRACT

Thirty varieties of soybeans grown on experimental plots were obtained from twice-yearly crops during three consecutive years. The results of determinations of soybean seed composition, methionine and cystine content, and trypsin inhibitor activity fell mainly within the range of U.S. commercial varieties. Protein and oil content were negatively correlated. Correlation between seed composition characteristics and seed size and maturation date was also studied. Maturation time correlated well with fat content: Fat content was higher in earlier varieties. Trypsin inhibitor activity changed according to flowering time, with a high correlation between maturation time and trypsin inhibitor concentration. Bioclimatic groups differ significantly. Late varieties had significantly lower fat content and trypsin inhibitor activity.

The increasing soybean production throughout the world makes it important to define the composition and nutritional characteristics of soybeans so they can be used efficiently as a protein supplement.

Like other pulse proteins, soybean protein has a high lysine content, a deficiency of sulfur amino acids, and low digestibility, which is partly due to antinutrients such as trypsin inhibitors (Jaffé 1973). Nutritive value is the result of both favorable and negative characteristics. The question then is the interrelation of these factors and the effects of genetic variation, environmental conditions, and cultural practices.

During the past few years soybean production has steadily increased in Argentina, and the use of soybeans for animal feeds and human foods also has increased. To study the protein value of the most commonly grown varieties of soybean in Argentina, we determined percent composition, sulfur amino acids content, and trypsin inhibitor activity. We also attempted to correlate fat content with protein content, sulfur amino acids content with trypsin inhibitor activity, and sulfur amino acids content with total protein, as was reviewed by Lam Sánchez (1975). We also investigated the possibility of correlation between composition characteristics and the plant cycle, which depends on the bioclimatic variety of soybean (Remussi and Gutiérrez 1968).

MATERIALS AND METHODS

Materials

The Department of Industrial Crops of the School of Agriculture of the University of Buenos Aires provided 30 varieties of *Glycine maxima*. The seeds were sown on experimental plots (34°35′ latitude, 58°29′ longitude, 25 m above sea level). The samples analyzed were from twice-yearly crops grown in three consecutive years and were classified in the bioclimatic groups (Table I) outlined by Remussi and Gutiérrez (1968).

Methods

The soybean seeds were ground to a meal of 100 mesh. Moisture, fat and protein content were determined according to AOAC methods (1960). Protein content was calculated as N × 6.25.

Sulfur amino acids, methionine, and cystine were determined by the microbiological method of Steele et al (1949), as modified by Cotelly and Basualdo (1969). The microorganism used was *Leuconostoc mesenteroides* P60 ATCC 8042.

Trypsin inhibitor activity was determined by the method of Kakade et al (1969) with a 2% casein solution as trypsin substrate and expressed as Trypsin Units Inhibited (TUI) per milligram of extracted protein. Protein content in the extracts was determined according to Lowry et al (1951).

Analysis of variance and correlation coefficients were calculated according to Snedecor and Cochran (1967).

[1]Research chemist of Instituto Nacional de Tecnologia Industrial (INTI).

0009-0352/79/000029$3.00/0

RESULTS AND DISCUSSION

Soybean seed composition is varied and is affected by genetic factors, agricultural methods, and environmental conditions such as climate and nutrition. Environmental conditions and agricultural methods were similar for all varieties studied so that differences in composition were attributed mainly to genotype.

Tables II and III show moisture, fat, and protein content for the 30 samples. Water content ranged from 7.80 to 10.20%. Fat content averaged 19.51 g per 100 g dry weight, with a range of 14.80–22.00%. Protein content on a dry weight basis averaged

TABLE I
Phenotypic Characteristics of Soybean Varieties

	Days of Emergence Until:	
Maturation	**Flowering Time**	**Fall of Leaves**
Early	25–34	80–109
Semiearly	35–59	110–144
Semilate	60–79	145–164
Late	80–115	165–185

TABLE II
Protein, Fat, and Moisture Content in Early and Semiearly Varieties of Soybean

Soybean Variety[a]	Water (g/100 g)	Fat[b] (g/100 g)	Protein[b,c] (g/100 g)	Flowering time[d] (days)
Early				
Hardome	9.9	20.0	40.85	29
Merit	8.8	21.4	39.19	29
Chipewa	9.4	20.6	36.69	30
Disoy	9.6	20.9	41.26	32
Harosoy	8.6	20.9	37.63	33
Hawkeye	9.6	21.7	38.61	35
Lindarin	7.8	20.5	38.62	35
Semiearly				
Calland	9.6	20.3	37.64	35
Clark 63	8.2	21.6	38.40	36
Scott	8.6	20.9	36.35	44
Shelby	8.4	21.3	37.87	36
Adelphia	8.4	22.0	37.93	37
Ford	10.2	21.1	42.10	37
Average	9.00 ± 0.72	21.03 ± 0.57	38.70 ± 1.74	

[a]In order of increasing time of maturation.
[b]Dry weight basis.
[c]N × 6.25.
[d]Days from emergence to first flowers.

39.41%, with a range of 35.97–43.41%. The figures of this study fall mainly within the range of U.S. commercial varieties (Hartwig 1973).

The average fat content of the late and semilate varieties (18.00 g/100 g) was significantly lower than the average of the early and semiearly varieties (21.03 g/100 g) of soybean ($P < 0.001$). The average protein content was slightly higher for the late and semilate varieties ($P < 0.10$).

The amount of sulfur amino acids limits nutritional value of soybean protein. Total sulfur amino acids content (Tables IV and V) ranged from 2.08 to 3.53 g/16 g N, with an average of 2.77 g/16 g N. Methionine content ranged from 0.93 to 1.52 g/16 g N with an average of 1.16 g/16 g N. Cystine ranged from 0.97 to 2.32 g/16 g N with an average of 1.62 g/16 g N. These figures are similar to those reported by Kakade et al (1972) for commercial varieties of soybean.

The different bioclimatic groups show no significant differences in sulfur amino acids content.

The correlation between the content of each nutrient and flowering time was studied to see if maturation time of the variety led to consistent changes in nutrients (Johnson et al 1955, Weiss et al 1952). Flowering time correlated well with fat content ($r = -0.83$; $P < 0.001$) (Table VI). Fat content was higher in the earlier varieties of soybean. The two late groups tended to have higher protein content, but the correlation coefficient between flowering time and protein content was very low ($r = 0.29$).

Although Johnson et al (1955) reported positive correlation between the strain characteristics of seed size and fat content of the seed, we found no correlation between seed size and nutrients content.

The most consistent relationship reported in the literature is negative correlation between fat and protein content (Lam Sánchez 1975). In our samples, the correlation coefficient was -0.59 ($P < 0.002$), which is similar to the range of -0.31 to -0.58 reported by Weiss et al (1952). The negative correlation was higher for late and semilate varieties ($r = -0.65$; $P < 0.01$) than for early and semiearly varieties ($r = -0.10$).

Krober and Carter reported a tendency toward positive correlation between methionine and protein content, although some of their studies show null correlation (1966). We found only a tendency toward positive correlation ($r = 0.21$) between total sulfur amino acids and protein content. Methionine and protein content were not correlated, but there was a tendency to higher cystine content with higher protein concentration ($r = 0.29$).

Trypsin inhibitor activity is shown in Table VII. The figures ranged from 72.7 to 210.7 TUI/mg of extracted protein. These values fell within the range reported by Kakade et al (1972) for 108 varieties of soybean. According to Kakade's classification, our TUI average (127.3 TUI/mg of protein) corresponds to medium trypsin inhibitor activity.

Because the sulfur amino acid content is high in trypsin inhibitor proteins, a possible correlation between increased sulfur amino acids content and high trypsin inhibitor activity has been suggested (Jaffé 1973). We found no correlation between sulfur amino acid content and trypsin inhibitor activity (Table VI).

Trypsin inhibitor activity changed according to flowering time of the variety: Late flowering varieties had lower trypsin inhibitor

TABLE III
Protein, Fat, and Moisture Content in Late and Semilate Varieties of Soybean

Soybean Varieties[a]	Water (g/100 g)	Fat (g/100 g)[b]	Protein (g/100 g)[b,c]	Flowering time[d] (days)
Semilate				
Haberland	9.0	17.2	42.77	58
Dorchsoy 2	9.4	19.8	40.04	71
Hill	8.6	19.3	40.53	64
Dare	7.9	20.4	39.31	66
Halesoy 321	9.8	17.6	41.56	68
Ogden	8.6	17.8	42.99	69
Hood	9.0	18.5	40.23	72
Hernon 49	9.0	20.1	35.97	78
Lee	8.4	18.6	41.00	76
Hale 7	9.0	18.8	38.62	78
Jackson	8.2	19.2	36.59	77
Bragg	9.9	19.8	36.53	80
Late				
Hampton 266	8.8	17.9	37.89	82
J.E.W.45	9.8	16.3	42.20	88
Boone	9.1	15.0	39.88	95
C.N.S.	10.1	14.8	43.41	90
Seminole	9.6	14.8	42.50	106
Average	9.70 ± 0.92	18.00 ± 1.83	40.12 ± 2.37	

[a]In order of increasing time of maturation.
[b]Dry weight basis.
[c]N × 6.25
[d]Days from emergence to first flowers.

TABLE IV
Methionine, Cystine, and Total Sulfur Amino Acids Content in Early and Semiearly Varieties of Soybeans

Soybean Varieties	Methionine (g/16 g N)	Cystine (g/16 g N)	Total Sulfur Amino Acids (g/16 g N)
Early			
Hardome	1.07 ± 0.18	1.59 ± 0.08	2.67 ± 0.10
Merit	0.97 ± 0.30	1.97 ± 0.04	2.95 ± 0.27
Chipewa	0.95 ± 0.01	1.59 ± 0.15	2.54 ± 0.13
Disoy	1.40 ± 0.01	1.52 ± 0.06	2.92 ± 0.06
Harosoy	1.11 ± 0.18	1.66 ± 0.10	2.77 ± 0.08
Hawkeye	0.93 ± 0.03	1.15 ± 0.18	2.08 ± 0.15
Lindarin	1.16 ± 0.27	1.73 ± 0.61	2.89 ± 0.35
Semiearly			
Calland	1.46 ± 0.34	1.41 ± 0.15	2.87 ± 0.49
Clark 63	1.13 ± 0.09	1.61 ± 0.04	2.74 ± 0.04
Scott	1.18 ± 0.02	1.10 ± 0.26	2.29 ± 0.24
Shelby	1.16 ± 0.35	1.71 ± 0.09	2.87 ± 0.26
Adelphia	1.13 ± 0.12	1.44 ± 0.15	2.57 ± 0.28
Ford	1.17 ± 0.32	1.86 ± 0.07	3.03 ± 0.25
Average	1.14 ± 0.16	1.57 ± 0.25	2.71 ± 0.28

TABLE V
Methionine, Cystine, and Total Sulfur Amino Acids Content in Late and Semilate Varieties of Soybeans

Soybean Varieties	Methionine (g/16 g N)	Cystine (g/16 g N)	Total Sulfur Amino Acids (g/16 g N)
Semilate			
Haberland	1.01 ± 0.03	1.10 ± 0.26	2.11 ± 0.29
Dorchsoy 2	0.96 ± 0.13	1.77 ± 0.06	2.73 ± 0.08
Hill	1.21 ± 0.18	2.32 ± 0.34	3.53 ± 0.53
Dare	1.42 ± 0.30	1.62 ± 0.10	3.05 ± 0.41
Halesoy 321	1.25 ± 0.32	2.20 ± 0.42	3.45 ± 0.11
Ogden	1.43 ± 0.09	1.79 ± 0.10	3.23 ± 0.20
Hood	0.93 ± 0.03	1.39 ± 0.08	2.32 ± 0.32
Hernon 49	1.12 ± 0.13	1.04 ± 0.05	2.16 ± 0.08
Lee	1.52 ± 0.29	1.25 ± 0.18	2.77 ± 0.11
Hale 7	1.35 ± 0.61	1.60 ± 0.08	2.95 ± 0.69
Jackson	1.42 ± 0.08	1.99 ± 0.50	3.42 ± 0.58
Bragg	1.31 ± 0.25	1.53 ± 0.15	2.84 ± 0.40
Late			
Hampton 266	0.93 ± 0.11	1.86 ± 0.16	2.80 ± 0.27
J.E.W. 45	1.02 ± 0.09	1.55 ± 0.08	2.57 ± 0.18
Boone	1.29 ± 0.41	0.97 ± 0.01	2.26 ± 0.42
C.N.S.	0.84 ± 0.20	1.97 ± 0.04	2.82 ± 0.17
Seminole	1.05 ± 0.05	2.22 ± 0.39	3.27 ± 0.44
Average	1.18 ± 0.21	1.66 ± 0.42	2.84 ± 0.45

TABLE VI
Correlations Between Nutrient Content, Trypsin Inhibitor Activity and Phenotypic Characters of 30 Varieties of Soybeans

	Varieties		
	Early and Semiearly (n = 13)	Late and Semilate (n = 17)	Total (n = 30)
FD[a]/fat	0.30	−0.66($P < 0.01$)	−0.83($P < 0.001$)
FD/protein	−0.33	0.04	0.29
FD/sulfur amino acids	−0.24	0.21	0.13
Protein/fat	−0.10	−0.65($P < 0.01$)	−0.59($P < 0.002$)
Protein/sulfur amino acids	0.48	0.08	0.21
Protein/methionine	0.16	−0.26	−0.09
Protein/cystine	0.43	0.21	0.29
FD/TUI[b]	−0.38	−0.15	−0.73($P < 0.001$)
Protein/TUI	0.38	−0.07	−0.15
Sulfur amino acids/TUI	0.16	0.18	−0.03
Methionine/TUI	−0.36	0.15	−0.15
Cystine/TUI	0.40	0.12	0.04

[a]FD = Flowering time (days)
[b]TUI = Trypsin Units Inhibited

TABLE VII
Trypsin Inhibitor Activity in Soybeans

Varieties	TUI[a]/mg of protein
Early	
Hardome	196.7 ± 24.7
Merit	161.3 ± 8.5
Chipewa	133.3 ± 11.6
Disoy	136.3 ± 15.0
Harosoy	210.7 ± 17.8
Hawkeye	171.7 ± 13.9
Lindarin	198.0 ± 11.1
Semiearly	
Calland	120.0 ± 10.0
Clark 63	158.7 ± 15.6
Scott	119.0 ± 10.6
Shelby	134.3 ± 6.0
Adelphia	127.0 ± 1.0
Ford	174.0 ± 14.4
Average	155.4 ± 30.4
Semilate	
Haberland	120.0 ± 10.0
Dorchsoy 2	72.7 ± 16.2
Hill	126.3 ± 7.6
Dare	126.0 ± 9.2
Halesoy 321	116.3 ± 10.9
Ogden	82.7 ± 16.2
Hood	73.7 ± 5.9
Hernon 49	115.0 ± 5.0
Lee	101.0 ± 11.5
Hale 7	111.3 ± 3.2
Jackson	106.3 ± 1.5
Bragg	99.3 ± 13.6
Late	
Hampton 266	109.0 ± 10.1
J.E.W. 45	113.7 ± 9.0
Boone	97.3 ± 14.3
C.N.S.	108.0 ± 7.0
Seminole	100.7 ± 6.7
Average	104.4 ± 16.1

[a]Trypsin units inhibited per milligram of extracted protein.

activity and the correlation coefficient between flowering time and TUI was −0.73 ($P < 0.001$). This was confirmed by comparing the average trypsin inhibitor activity in the two early groups (155.4 TUI) with the two late groups (104.4 TUI); the figures were significantly different ($P < 0.001$).

The results with these 30 soybean varieties show significant differences between the bioclimatic groups. Late and semilate varieties had lower fat content, greater protein content, and significantly lower trypsin inhibitor activity. Some samples, such as Dortchsoy 2, Ogden, and Hood, had all three favorable characteristics: high fat and protein contents, and low trypsin inhibitor activity.

Adequate cooking destroys most antinutrients in soybeans, but it would be worthwhile to investigate how these factors vary with the plant's life cycle because the use of varieties genetically deficient in antinutrients would simplify the processing of soybeans.

LITERATURE CITED

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. 1960. Official Methods of Analysis (9th ed.), p. 832. The Association: Washington, DC.

COTELLY, N, and BASUALDO, R. 1969. Microbiological analysis applied to amino acid determination in food proteins. Rev. Asoc. Argent. Microbiol. 1:243.

HARTWIG, E.I. 1973. Varietal development in soybeans: Improvement, production and uses, p. 187. CALDWELL, B.E. (ed.). Am. Soc. Agron.: Madison, WI.

JAFFÉ, W.G. 1973. Toxic factors in beans. Their practical importance. Proc. Meeting on the Nutritional Aspects of Common Beans and Other Legume Seeds as Animal and Human Foods, Riberao Preto (S.P.), Brazil. Jaffé, W. (ed.), p. 199.

JOHNSON, H.W., ROBINSON, H.F., and COMSTOCK, R.E. 1955. Genotypic and phenotypic correlations in soybeans and their implications in selection. Agron. J. 47:477.

KAKADE, M.L., SIMONS, N., and LIENER, I.E. 1969. An evaluation of natural vs. synthetic substrates for measuring the antitryptic activity of soybean samples. Cereal Chem. 46:518.

KAKADE, M.L., SIMONS, N.R., LIENER, I.E., and LAMBERT, J.W. 1972. Biochemical and nutritional assessment of different varieties of soybeans. J. Agric. Food Chem. 20:87.

KROBER, O.A., and CARTER, J.L. 1966. Relation of methionine content to protein levels in soybeans. Cereal Chem. 43:320.

LAM SÁNCHEZ, A. 1975. Soybean production and nutritive value. 10th Intern. Congr. Nutr., Kyoto, Japan.

LOWRY, O.H., ROSEBROUGH, N.J., FARR, A.L., and RANDALL, N.J. 1951. Protein measurement with the Folin phenol reagent. J. Biol. Chem. 193:265.

REMUSSI, C., and GUTIÉRREZ, H.P. 1968. Description of soybean varieties (Glycine max. (L.) Merrill) (in Spanish). School of Agriculture and Veterinary Science of the University of Buenos Aires.

SNEDECOR, G.W., and COCHRAN, W.G. 1967. Statistical Methods. Iowa State University Press: Ames.

STEELE, B., SAUBERLICH, H., REYNOLDS, M., and BAUMAN, C. 1949. Media for Leuconostoc mesenteroides P60 and Leuconostoc citrovorum 8081. J. Biol. Chem. 177:533.

WEISS, M.G., WEBER, C.R., WILLIAMS, L.F., and PROBST, A.H. 1952. Correlation of agronomic characters and temperature with seed compositional characters in soybeans, as influenced by variety and time of planting. Agron. J. 44:289.

[Received July 18, 1978. Accepted August 30, 1978]