Comparison of Quality Characteristics of Soybeans from Brazil, China, and the United States

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Both soybean composition and processing conditions impact the nutritional quality of soybean meal. The objective of this experiment was to compare nutrient compositions of soybeans grown under diverse environmental conditions in a variety of locations. Dry matter, organic matter, and ash concentrations differed in soybeans collected within the countries of Brazil, China, and the United States, although these differences were generally small or due to uniqueness of a particular source. Large differences in dry matter were detected among countries. Differences in crude protein, amino acid, and lipid concentrations of soybeans were detected both within and among countries. Soybeans from China had a greater crude protein concentration (42.14%) than those from Brazil (40.86%), whereas soybeans from China had a lower lipid concentration (17.25%) than those from either Brazil or the United States (18.66 and 18.70%, respectively). Environmental conditions under which soybeans are grown have a great impact on chemical composition and nutrient quality.

Keywords: *Soybean; soybean meal; nutrient quality; international*

INTRODUCTION

Soybean meal (SBM) is used extensively as a protein source in animal nutrition. Characteristics of soybean meal that make it appealing are its desirable amino acid content, relative availability, high consistency, and low cost compared to other high-quality protein sources. Numerous factors impact the composition and quality of soybean meal, not the least of which is the quality of the soybean used to prepare the meal. It is vital that raw soybeans contain an optimal nutrient profile in order to produce the highest quality soybean meal. Because of the diversity of growing conditions within the United States and throughout the world, it is expected that soybeans produced under various environmental conditions would have varying nutrient compositions and qualities.

Soybean genotype and growing conditions influence the compositional analyses of the resultant SBM (*1*, *2*). Hurburgh (*3*) evaluated soybeans produced in five areas within the United States (western corn belt, eastern corn belt, midsouth, southeast, and east coast). Numerical differences were detected in average percent crude protein (CP) (34.1, 34.8, 35.3, 37.2, 35.9, respectively) and percent oil (18.4, 18.8, 18.9, 18.3, 18.7, respectively) in soybeans from the various regions. On a worldwide scale, Baize (*4*) evaluated soybean meal samples collected from Europe, Turkey, Venezuela, Columbia, Mexico, Indonesia, Thailand, Philippines, Korea, China, Japan, and the United States. Numerical differences in percent protein, lipid, fiber, potassium hydroxide solubility, amino acids, and urease pH rise were detected, but because only soybean meals were utilized for these comparisons, it was not possible to determine the amount of variation due to differences in the raw soybeans versus those attributable to the processing conditions used to produce the meal.

The objective of this experiment was to compare the nutrient composition of soybeans grown under diverse environmental conditions in Brazil, China, and the United States. Both within-country and among-country differences in nutrient composition were evaluated.

MATERIALS AND METHODS

Sources of Soybeans. Three major soybean producing countries, Brazil, China, and the United States, were chosen as sources of soybeans in an effort to maximize heterogeneity of samples. Forty-eight soybean samples were collected from five Brazilian states: Mato Grosso Do Sul (B1), Parana (B2), Rio Grande Do Sul (B3), Santa Catarina (B4), and Sao Paulo (B5). Forty-nine soybean samples were collected from six Chinese provinces: Hebei (C1), Heilongjiang (C2), Henan (C3), Jilin (C4), Liaoning (C5), and Shandong (C6). Thirty-six samples were collected from fifteen states located in the major soybean-producing regions of the United States. Soybean samples collected in the U.S. were grouped according to maturity zone in which they were produced, with zone 1 being in the northern U.S. and zone 7 being in the southern part of the country. Following collection, all samples were sent to the University of Illinois for analysis. Complete information was not available on the genetic varieties utilized in each country; therefore, it was not possible to account for this source of variation.

Laboratory Analyses. Prior to their analysis, soybeans were ground in a Wiley Mill, model Y, with dry ice to avoid loss of oil, passed through a 2-mm screen (analysis of KOH protein solubility required an additional grind through a 0.5-mm screen), and then stored at −20 °C until further analysis. The following analyses were conducted on all samples from all countries: dry matter (DM; *5*); organic matter (OM) via determination of ash concentration (AOAC; *5*); crude protein (CP) via Kjeldahl nitrogen determination (*5*); acid hydrolyzed fat (*6*); neutral detergent fiber (NDF; *7*); protein solubility in potassium hydroxide (PS; *8*); and amino acid composition (*9*, *10*). If the error between duplicates of a sample was greater than 5%, the assay was repeated, with the exception of acid hydrolyzed fat and NDF where a variation of less than 10% was accepted, and amino acids, which were not analyzed in duplicate because of high repeatability and cost of the assay.

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Table 1. Comparison of Soybeans from Five Brazilian States[a]

item	Brazilian state					SEM
	B1	B2	B3	B4	B5	
DM, %	85.61[a]	92.11[b]	85.11[a]	86.04[a]	85.65[a]	0.52
OM	94.84	94.92	94.87	94.79	95.03	0.07
ash	5.16	5.08	5.13	5.21	4.97	0.07
CP	42.32[a]	40.30[bcd]	41.23[ac]	39.39[d]	41.14[ab]	0.48
lipid	19.75[a]	18.63[b]	18.60[b]	18.02[b]	18.29[b]	0.32
NDF	11.50[a]	17.13[b]	12.34[a]	12.38[a]	13.26[a]	1.01
PS	27.30[a]	23.47[b]	29.67[a]	28.53[a]	29.83[a]	0.97
essential amino acids						
arginine	3.02[a]	2.61[b]	2.97[ac]	2.82[c]	2.93[ac]	0.06
histidine	1.16[a]	0.98[b]	1.08[cd]	1.05[c]	1.14[ad]	0.02
isoleucine	1.65[a]	1.47[b]	1.69[a]	1.64[a]	1.68[a]	0.03
leucine	3.06[a]	2.77[b]	3.12[a]	3.04[a]	3.17[a]	0.05
lysine	2.54[a]	2.30[b]	2.59[a]	2.50[a]	2.49[a]	0.04
methionine	0.28	0.32	0.28	0.22	0.30	0.02
phenylalanine	2.11[ac]	1.84[b]	2.10[ac]	2.01[c]	2.15[a]	0.04
threonine	1.58[a]	1.42[b]	1.60[a]	1.57[a]	1.62[a]	0.03
valine	1.71[a]	1.54[b]	1.77[a]	1.71[a]	1.74[a]	0.03
nonessential amino acids						
alanine	1.74[a]	1.58[b]	1.89[c]	1.84[ac]	1.80[ac]	0.045
aspartate	4.61[a]	4.12[b]	4.59[a]	4.50[a]	4.70[a]	0.076
cystine	0.78	0.87	0.72	0.59	0.78	0.070
glutamate	7.45[a]	6.65[b]	7.48[a]	7.26[a]	7.58[a]	0.135
glycine	1.68[a]	1.52[b]	1.72[a]	1.67[a]	1.74[a]	0.029
proline	2.17[a]	1.85[b]	2.02[c]	1.91[bc]	2.26[a]	0.047
serine	2.18[a]	1.97[b]	2.20[a]	2.14[a]	2.22[a]	0.036
tyrosine	1.44[a]	1.26[b]	1.43[a]	1.39[a]	1.44[a]	0.027
TEAA	17.10[a]	15.25[b]	17.20[a]	16.57[a]	17.22[a]	0.281
TNEAA	22.04[ac]	19.81[b]	22.06[ac]	21.29[c]	22.52[a]	0.393
TAA	39.14[ac]	35.06[b]	39.26[ac]	37.86[c]	39.74[a]	0.669

[a] Contents are reported as percent dry matter. DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; PS, protein solubility in potassium hydroxide; TEAA, total essential amino acids; TNEAA, total nonessential amino acids; TAA, total amino acids. Means in a row with different superscript letters differ ($P < 0.05$).

Statistical analysis of the compositional data was conducted using the General Linear Models Procedure of SAS (*11*). A completely randomonized designed was used for analysis with the only source of variation in the statistical model being either state or country.

RESULTS

Comparison of Soybeans from Brazil. Compositions of soybeans acquired from the Brazilian states are presented in Table 1. Soybeans from B2 had higher DM and NDF concentrations, and lower PS, than soybeans from any other Brazilian state. Soybeans from B1 had a higher lipid concentration than soybeans from any other Brazilian state. Soybeans from B1, B3, and B5 had greater concentrations of CP than soybeans from B4. No differences in OM or ash concentrations were detected among soybeans from the five Brazilian states.

Amino acid compositions of soybeans from the Brazilian states are presented in Table 1. Differences were detected in the concentrations of all amino acids except methionine and cystine. Soybeans from B2 had lower concentrations of all amino acids compared to those from the other Brazilian states, with the exception of proline, methionine, and cystine. Soybeans from B2 also had lower concentrations of total essential, total nonessential, and total amino acids compared to soybeans from other Brazilian states (Table 1).

Comparison of Soybeans from China. Compositions of soybeans from six Chinese provinces are presented in Table 2. Soybeans from C6 had a higher DM concentration than soybeans from C2, C3, and C4, whereas soybeans from C6 had the lowest OM and highest ash concentrations. The CP concentrations of soybeans from C3 and C6 were higher than the CP concentrations of soybeans from C2, C4, and C5. Soybeans from C1 had a lower lipid concentration than soybeans from any other province, whereas soybeans from C6 had a lower NDF concentration than soybeans from C2, C3, or C4. No differences existed in PS among samples from the various Chinese provinces.

Amino acid compositions of soybeans from the Chinese provinces are presented in Table 2. Soybeans from C3 and C6 had higher concentrations of most amino acids compared to those of soybeans from C2, C4, and C5. Soybeans from C3 and C6 also had higher concentrations of total essential, total nonessential, and total amino acids compared to samples from C2, C4, and C5 (Table 2).

Comparison of Soybeans from the United States. Compositions of soybeans from seven U.S. maturity zones are presented in Table 3. Only slight differences existed in the DM, OM, and ash concentrations of soybeans from the seven maturity zones. Soybeans from zones 4 and 7 had higher CP concentrations than soybeans from any other zones. The NDF concentrations of soybeans from zones 5, 6, and 7 were higher than the NDF concentrations of those from zones 1 through 4, with the exception that no difference existed in the NDF concentrations of soybeans from zones 1 and 6. Protein solubility of soybeans from zone 7 was higher than those of soybeans from zones 2 through 6. No differences existed in lipid concentrations of soybeans from the seven maturity zones.

Amino acid compositions of soybeans from the U.S. maturity zones are presented in Table 3. U.S. soybean amino acid concentrations generally were more consistent than those from either Brazil or China. Differences ($P < 0.05$) were detected in the concentrations of

Table 2. Comparison of Soybeans from Six Chinese Provinces[a]

item	Chinese province						SEM
	C1	C2	C3	C4	C5	C6	
DM, %	92.14^{abc}	91.08^{b}	92.11^{a}	92.44^{ad}	92.75^{cd}	93.10^{c}	0.23
OM	94.97^{ac}	94.92^{c}	94.47^{a}	94.85^{c}	94.52^{a}	94.12^{b}	0.12
ash	5.03^{ac}	5.08^{c}	5.53^{a}	5.15^{c}	5.48^{a}	5.88^{b}	0.12
CP	42.57^{ab}	40.83^{a}	43.73^{b}	41.05^{a}	40.69^{a}	43.61^{b}	0.69
lipid	14.51^{a}	17.12^{bc}	17.48^{b}	17.96^{b}	17.74^{b}	16.38^{c}	0.40
NDF	12.18^{ab}	14.66^{a}	14.22^{a}	14.42^{a}	13.59^{ab}	12.37^{b}	0.55
PS	29.20	29.90	29.07	28.78	28.03	30.39	0.96
essential amino acids							
arginine	3.16^{ab}	2.85^{a}	3.30^{b}	2.91^{a}	2.70^{a}	3.29^{b}	0.14
histidine	1.09^{ab}	1.03^{a}	1.14^{b}	1.03^{a}	0.99^{a}	1.18^{b}	0.04
isoleucine	1.63^{ab}	1.62^{a}	1.83^{b}	1.66^{a}	1.57^{a}	1.89^{b}	0.06
leucine	3.04^{ab}	2.97^{a}	3.33^{b}	3.01^{a}	2.84^{a}	3.39^{b}	0.11
lysine	2.60^{ab}	2.46^{a}	2.71^{b}	2.47^{a}	2.33^{a}	2.77^{b}	0.09
methionine	0.44^{ab}	0.44^{a}	0.46^{a}	0.42^{ac}	0.36^{b}	0.37^{bc}	0.02
phenylalanine	2.01^{ab}	1.96^{a}	2.22^{b}	1.96^{a}	1.83^{a}	2.23^{b}	0.08
threonine	1.64^{abc}	1.55^{ab}	1.64^{a}	1.57^{ab}	1.49^{b}	1.75^{c}	0.04
valine	1.79^{abc}	1.73^{ab}	1.90^{ac}	1.74^{ab}	1.63^{b}	1.97^{c}	0.06
nonessential amino acids							
alanine	1.76^{ab}	1.67^{a}	1.87^{b}	1.68^{a}	1.61^{a}	1.90^{b}	0.06
aspartate	4.63^{ab}	4.43^{a}	4.95^{b}	4.49^{a}	4.24^{a}	5.15^{b}	0.16
cystine	0.91^{abc}	0.91^{ac}	1.03^{a}	0.87^{bc}	0.75^{bd}	0.78^{cd}	0.05
glutamate	7.36^{abc}	7.16^{ab}	7.88^{bc}	7.11^{a}	6.76^{a}	8.07^{c}	0.27
glycine	1.73^{abc}	1.66^{ab}	1.82^{bc}	1.65^{a}	1.57^{a}	1.86^{c}	0.06
proline	2.25^{ab}	2.21^{ab}	2.36^{b}	2.10^{a}	1.99^{a}	2.41^{b}	0.08
serine	2.21^{ab}	2.11^{a}	2.34^{b}	2.10^{a}	2.01^{a}	2.36^{b}	0.08
tyrosine	1.28^{ab}	1.19^{ac}	1.35^{b}	1.21^{ac}	1.12^{a}	1.33^{bc}	0.05
TEAA	17.38^{ab}	16.60^{a}	18.54^{b}	16.76^{a}	15.74^{a}	18.82^{b}	0.60
TNEAA	22.11^{ab}	21.34^{a}	23.59^{b}	21.21^{a}	20.06^{a}	23.86^{b}	0.76
TAA	39.49^{ab}	37.94^{a}	42.13^{b}	37.96^{a}	35.80^{a}	42.68^{b}	1.36

[a] Contents are reported as percent dry matter. DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; PS, protein solubility in potassium hydroxide; TEAA, total essential amino acids; TNEAA, total nonessential amino acids; TAA, total amino acids. Means in a row with different superscript letters differ ($P < 0.05$).

arginine, lysine, methionine, phenylalanine, threonine, aspartate, cystine, glutamate, glycine, proline, and serine. Total essential amino acid concentration of soybeans from maturity zone 7 was higher than those of soybeans from all maturity zones, except zone 5. Total amino acid concentration was also highest in soybeans from zones 5 and 7 (Table 3).

Comparison of Soybeans Among Countries. Differences in DM, OM, ash, CP, lipid, and PS were detected among samples from the different countries (Table 4). Soybeans from Brazil had a lower DM concentration than those from either China or the U.S., whereas soybeans from China had a lower DM concentration than those from the U.S. In contrast, soybeans from Brazil had a higher OM and a lower ash concentration than did soybeans from either China or the U.S.

The CP concentration of soybeans from China was greater than that of soybeans from Brazil, but did not differ from the CP concentration of soybeans from the U.S. In contrast, soybeans from the U.S. and Brazil had higher lipid concentrations than soybeans from China. The NDF concentrations were not different among soybeans from any of the three countries studied. Protein solubility was greatest in soybeans from the U.S., and PS was higher in soybean samples from China than in those from Brazil.

Significant differences in the concentrations of all amino acids except alanine and serine were detected among soybeans from the various countries (Table 4). Soybeans from the U.S. contained higher concentrations of most amino acids compared to those in soybeans from either Brazil or China. Soybeans from the U.S. also had higher concentrations of total essential, total nonessential, and total amino acids compared to those in soybeans from Brazil or China (Table 4).

DISCUSSION

A factor that impacts the nutritional composition of soybeans, and the resulting soybean meal, is growing environment. In this study, three major soybean producing countries, Brazil, China, and the U.S., were chosen as sources of soybeans in an effort to maximize heterogeneity of samples. Soybeans from these countries account for 77% of the 157.2 million metric tons of soybeans produced in 1998 (48% U.S., 20% Brazil, and 9% China) (*12*).

The results of this experiment demonstrate that major differences exist in nutrient composition and quality characteristics of soybeans grown under varying environmental conditions in various parts of the world. Although differences in DM concentration of soybeans from within each country existed, these differences were generally quite small or were due to the uniqueness of one source (e.g., soybeans from the state of Parana (B2) in Brazil). This lack of variation implies that, regardless of the environmental conditions during the growing season, the soybean at harvest contains a fairly constant moisture level. It is also possible that soybeans from particular places may have undergone an initial drying procedure prior to shipment to the University of Illinois, although this information was not provided to the researchers. In contrast, a high level of variability existed in the DM concentration of soybeans from various countries. Soybeans from Brazil had approximately a 7% unit lower DM concentration than those from the U.S. It is likely that the high level of precipita-

Table 3. Comparison of Soybeans from Seven United States Soybean Maturity Zones[a]

item	maturity zone							SEM
	1	2	3	4	5	6	7	
DM, %	93.56^{ac}	93.67^{ac}	94.01^{ab}	93.35^{c}	94.33^{b}	93.49^{c}	94.01^{ab}	0.16
OM	94.59^{ab}	94.49^{ac}	94.35^{a}	94.64^{ab}	94.78^{bc}	94.19^{a}	94.97^{b}	0.15
ash	5.42^{ab}	5.51^{ac}	5.65^{a}	5.36^{ab}	5.23^{bc}	5.81^{a}	5.03^{b}	0.15
CP	40.21^{a}	40.96^{a}	40.69^{a}	43.19^{b}	40.72^{a}	39.97^{a}	44.54^{b}	0.58
lipid	18.46	17.89	18.05	18.89	19.65	19.02	19.54	0.57
NDF	11.70^{ac}	12.03^{a}	12.10^{a}	11.26^{a}	15.03^{b}	14.58^{bc}	18.52^{d}	0.76
PS	30.21^{ab}	29.38^{a}	30.22^{a}	30.00^{a}	30.10^{a}	30.07^{a}	34.05^{b}	1.05
essential amino acids								
arginine	3.01^{a}	3.01^{a}	2.96^{a}	3.13^{ab}	3.10^{ab}	3.01^{a}	3.36^{b}	0.09
histidine	1.13	1.23	1.18	1.19	1.26	1.22	1.23	0.04
isoleucine	1.85	1.90	1.91	1.33	2.02	1.99	2.08	0.13
leucine	3.24	3.29	3.26	2.88	3.42	3.38	3.55	0.13
lysine	2.52^{a}	2.50^{a}	2.55^{a}	2.51^{a}	2.64^{ab}	2.62^{a}	2.78^{b}	0.05
methionine	0.26^{a}	0.40^{cd}	0.48^{bd}	0.57^{b}	0.34^{ac}	0.39^{acd}	0.39^{c}	0.03
phenylalanine	2.13^{a}	2.11^{a}	2.13^{a}	2.11^{a}	2.25^{ab}	2.20^{a}	2.36^{b}	0.05
threonine	1.57^{a}	1.63^{a}	1.67^{a}	1.65^{a}	1.70^{a}	1.67^{a}	2.13^{b}	0.10
valine	1.92	1.97	2.01	1.98	2.08	2.04	2.12	0.04
nonessential amino acids								
alanine	1.74	1.77	1.80	1.79	1.87	1.53	1.92	0.09
aspartate	4.65^{a}	4.81^{a}	4.84^{a}	4.86^{a}	5.01^{ab}	4.99^{ab}	5.29^{b}	0.11
cystine	0.62^{ac}	0.62^{ab}	0.61^{bd}	0.62^{a}	0.61^{b}	0.62^{acd}	0.61^{bc}	0.002
glutamate	7.51^{a}	7.74^{a}	7.85^{a}	7.90^{a}	8.13^{ab}	8.01^{a}	8.55^{b}	0.19
glycine	1.74^{a}	1.77^{a}	1.81^{a}	1.79^{a}	1.87^{ab}	1.87^{ab}	1.93^{b}	0.04
proline	2.11^{a}	2.32^{ad}	2.38^{cd}	2.39^{bcd}	2.62^{b}	2.53^{bc}	2.56^{b}	0.06
serine	2.08^{ad}	2.15^{ade}	2.19^{bd}	2.17^{abd}	2.32^{bc}	2.30^{bce}	2.40^{c}	0.05
tyrosine	1.39	1.37	1.37	1.29	1.46	1.47	1.53	0.05
TEAA	17.60^{a}	18.04^{a}	18.14^{a}	17.34^{a}	18.81^{ab}	18.51^{a}	20.01^{b}	0.48
TNEAA	21.82^{a}	22.54^{a}	22.85^{a}	22.81^{a}	23.89^{ab}	23.30^{ab}	24.79^{b}	0.51
TAA	39.42^{a}	40.58^{a}	40.99^{a}	40.15^{a}	42.70^{ab}	41.82^{a}	44.80^{b}	0.94

[a] All contents reported as percent dry matter. DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; PS, protein solubility in potassium hydroxide; TEAA, total essential amino acids; TNEAA, total nonessential amino acids; TAA, total amino acids. Means in a row with different superscript letters differ ($P < 0.05$).

tion during the typical months when soybeans are grown and harvested in Brazil compared to that of the U.S. affected the DM concentration of the soybeans produced.

Similar to the DM results obtained, only numerically small differences were observed in OM and ash concentrations of the soybeans. In general, soybeans contained approximately 94−95% OM and 5−6% ash. Although Brazilian soybeans contained a statistically greater concentration of OM (94.89 vs 94.58 and 94.56% for Brazil, China, and the U.S., respectively) and a lower concentration of ash (5.10 vs 5.42 and 5.44% for Brazil, China, and the U.S,, respectively), these differences were numerically small and the significance as regards production of soybean meal is questionable.

Because soybean meal is a primary source of CP in animal diets, any factors that impact protein content or quality of soybeans and, therefore, the resulting soybean meal, would be of major interest. Factors that can affect soybean protein content include environmental conditions and cultivar usage. Mieth et al. (*1*) reported differences in CP content of different soybean cultivars grown in Central Europe. In this experiment, soybeans from Brazil contained significantly lower CP concentrations than soybeans from China. Baize (*4*) also reported numerically lower CP concentrations in Brazilian soybean meal samples (45.91%) versus those in U.S. soybean meal samples (46.23%), and Chinese soybean meal samples contained intermediate CP levels (45.27%).

Although no statistical differences were detected in the CP concentrations of soybeans from China and the U.S., soybeans from the U.S. had higher concentrations of most amino acids compared to those from either Brazil or China. Soybeans from the U.S. also had higher concentrations of total essential, total nonessential, and total amino acids compared to those in soybeans from Brazil or China. As most swine and poultry diets are formulated on an amino acid basis rather than a CP basis, this particular information would be important to the formulation of diets.

Although it is impossible to make general recommendations from this relatively small dataset, it would be advantageous for soybean producers in geographical areas where lower-CP soybean samples are obtained to investigate the potential use of high-protein cultivars or to maximize other production criteria. In addition to the differences in protein concentration discussed, differences in protein quality, determined as PS in potassium hydroxide, also were detected. Protein solubility in potassium hydroxide is a good in vitro test for in vivo protein quality in over-processed SBM (*13*). Soybeans from the United States had a higher PS than those from either Brazil or China. Parsons et al. (*13*) found that as autoclave time of SBM increased from 0 to 40 min, PS in potassium hydroxide decreased from 85 to 36% and weight gain of chicks decreased from 157 to 68 g/9 days. When determining the value of soybeans as a protein source, both protein content and quality must be taken into consideration.

Oil is also of considerable importance to the soybean industry because of its high economic value. The lipid concentrations of soybeans from both Brazil (range 18.02−19.75%) and the U.S. (17.89−19.65%) were quite consistent, whereas lipid concentrations of soybeans from China were highly variable (range 14.51−17.96%). In addition, soybeans from China had a lower lipid concentration than soybeans from either Brazil or the U.S. These results are supported by those of Baize (*4*)

Table 4. Comparison of the Composition of Soybeans from Brazil, China, and the United States[a]

item	country			SEM
	Brazil	China	United States	
DM, %	86.98[a]	92.33[b]	93.86[c]	0.29
OM	94.89[a]	94.58[b]	94.56[b]	0.05
ash	5.10[a]	5.42[b]	5.44[b]	0.05
CP	40.86[a]	42.14[b]	41.58[ab]	0.31
lipid	18.66[a]	17.25[b]	18.70[a]	0.19
NDF	13.36	13.79	13.85	0.43
PS	27.68[a]	29.18[b]	30.80[c]	0.47
essential amino acids				
arginine	2.87[a]	3.04[b]	3.08[b]	0.05
histidine	1.08[a]	1.08[a]	1.21[b]	0.02
isoleucine	1.62[a]	1.72[b]	1.91[c]	0.03
leucine	3.03[a]	3.12[a]	3.32[b]	0.05
lysine	2.48[a]	2.56[ab]	2.60[b]	0.03
methionine	0.28[a]	0.41[b]	0.42[b]	0.01
phenylalanine	2.04[a]	2.05[a]	2.19[b]	0.03
threonine	1.56[a]	1.60[a]	1.75[b]	0.03
valine	1.69[a]	1.80[b]	2.03[c]	0.02
nonessential amino acids				
alanine	1.76	1.75	1.79	0.03
aspartate	4.50[a]	4.67[b]	4.95[c]	0.06
cystine	0.75[a]	0.88[b]	0.61[c]	0.03
glutamate	7.27[a]	7.43[a]	8.00[b]	0.10
glycine	1.66[a]	1.72[a]	1.83[b]	0.02
proline	2.04[a]	2.22[b]	2.44[c]	0.03
serine	2.14	2.20	2.24	0.03
tyrosine	1.39[a]	1.25[b]	1.42[a]	0.02
TEAA	16.64[a]	17.39[b]	18.51[c]	0.23
TNEAA	21.52[a]	22.12[a]	23.29[b]	0.29
TAA	38.17[a]	39.51[a]	41.80[b]	0.52

[a] All contents are presented as percent dry matter. DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; PS, protein solubility in potassium hydroxide; TEAA, total essential amino acids; TNEAA, total nonessential amino acids; TAA, total amino acids. Means in the same row with different superscript letters differ ($P < 0.05$).

in which Chinese soybean meals contained a numerically lower concentration of crude fat (1.52%) versus those from either Brazil (1.59%) or the U.S. (1.67%). However, it is not possible to compare Baize's results directly with those obtained in this project because different analytical methods were used to determine lipid concentrations (crude fat vs acid hydrolyzed fat, respectively).

Significant differences in NDF concentrations of soybeans collected from sources within a country existed, but no differences among countries were detected. Dietary fiber in feed ingredients often is associated with nutrient indigestibility and decreased performance. However, fiber in swine diets serves a number of useful purposes as identified by Grieshop et al. (*14*). Fiber from the soybean is of high quality and can be used to positive advantage in feeding.

Soybeans collected from various sources demonstrated key differences in their nutritional composition. Both positive and negative effects of environment can be masked by variations in processing conditions. Improper processing of high-quality soybeans can result in undercooked soybean meal containing high levels of trypsin inhibitor, overcooked soybean meal with poor protein digestibility, or soybean meal that has been nutritionally compromised by less than optimal processing conditions or practices. Because the emphasis on international marketing of soybeans is increasing, information such as that generated in this experiment is vital. It is critical to have information available on the compositional characteristics of international soybeans when marketing decisions are made.

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