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Variation in chemical composition of soybean hulls

Abstract

The objective of this study was to examine the variation in chemical composition of soybean hulls. Our goal was to develop regression equations characterizing the nutritive value of soybean hulls for use in swine diets. Samples (n = 39) were collected from different processing plants across the United States and analyzed for CP, GE, crude fiber (CF), ADF, NDF, fat, ash, Ca, P, and essential amino acids. One sample was excluded from these results because it contained approximately 10 times the amount of Ca (5.2% vs. a mean of 0.57%) as other samples. The results of chemical analysis of the samples were used to determine maximum, minimum, and mean values on a DM basis. Estimated DE values were calculated according to an equation described by Noblet and Perez (1993). Regression equations among the nutrients also were established. A high correlation was observed between CF and CP (RÂ² = 0.92), ADF (RÂ² = 0.96), NDF (RÂ² = 0.97), and estimated DE (RÂ² = 0.94), indicating that the analyzed fiber content of soybean hulls could be used to predict the other components. A high correlation also was observed between CP and estimated DE (RÂ² = 0.90). Lower correlations were observed between ash concentration and Ca and P. High correlations were observed between CP and lysine (R2 = 0.89), methionine (R2= 0.88), threonine (RÂ² = 0.93), and tryptophan (RÂ² = 0.93). In summary, the chemical composition of soybean hulls can be highly variable; however, CF content can help explain much of the variation in CP, ADF, NDF, and estimated DE, and CP content can be used to predict individual amino acid levels.; Swine Day, 2008, Kansas State University, Manhattan, KS, 2008

Keywords

Swine day, 2008; Kansas Agricultural Experiment Station contribution; no. 09-074-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1001; Nutritive value; Soybean hulls; Swine

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VARIATION IN CHEMICAL COMPOSITION OF SOYBEAN HULLS[1]

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Summary

The objective of this study was to examine the variation in chemical composition of soybean hulls. Our goal was to develop regression equations characterizing the nutritive value of soybean hulls for use in swine diets. Samples (n = 39) were collected from different processing plants across the United States and analyzed for CP, GE, crude fiber (CF), ADF, NDF, fat, ash, Ca, P, and essential amino acids. One sample was excluded from these results because it contained approximately 10 times the amount of Ca (5.2% vs. a mean of 0.57%) as other samples. The results of chemical analysis of the samples were used to determine maximum, minimum, and mean values on a DM basis. Estimated DE values were calculated according to an equation described by Noblet and Perez (1993). Regression equations among the nutrients also were established. A high correlation was observed between CF and CP (R^2 = 0.92), ADF (R^2 = 0.96), NDF (R^2 = 0.97), and estimated DE (R^2 = 0.94), indicating that the analyzed fiber content of soybean hulls could be used to predict the other components. A high correlation also was observed between CP and estimated DE (R^2 = 0.90). Lower correlations were observed between ash concentration and Ca and P. High correlations were observed between CP and lysine (R^2 = 0.89), methionine (R^2= 0.88), threonine (R^2 = 0.93), and tryptophan (R^2 = 0.93). In summary, the chemical composition of soybean hulls can be highly variable; however, CF content can help explain much of the variation in CP, ADF, NDF, and estimated DE, and CP content can be used to predict individual amino acid levels.

Key words: nutritive value, soybean hulls

Introduction

The United States is among the world's top soybean-producing countries. One of the by-products of soybean processing is soybean hulls, which are separated during the oil extraction process. Soybean hulls represent 7 to 8% of the weight of the soybean. Thus, large amounts of soybean hulls are available for swine feeding. Many of the ingredient composition tables used by swine nutritionists do not list the composition for soybean hulls. Tables in some foreign publications (e.g., Brazilian tables for poultry and swine) list values for soybean hulls; however, these values may be based on a limited number of samples and influenced by soybean source and processing techniques. Research to determine the nutrional values of soybean hulls from U.S. soybean crushing facilities has not been completed. Therefore, this study was conducted to examine the variation in chemical composition of soybean hulls. Our goal was to develop regression equations characterizing the nutritive value of soybean hulls for use in swine diets.

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[1] The authors thank Anjinomoto Heartland Lysine, Chicago, IL, for conducting the amino acid analysis.

[2] Food Animal Health and Management Center, College of Veterinary Medicine, Kansas State University.

Procedures

Samples were collected from feed mills and soy processors throughout the United States. A total of 39 samples were collected from processing plants in Alabama (1 sample), Colorado (3 samples), Georgia (1 sample), Illinois (10 samples), Indiana (2 samples), Iowa (6 samples), Kansas (3 samples), Minnesota (6 samples), Missouri (1 sample), North Carolina (1 sample), North Dakota (1 sample), Ohio (2 samples), Oklahoma (1 sample), and Wisconsin (1 sample). The samples were analyzed for crude fiber (CF), GE, CP, ADF, NDF, fat, ash, Ca, P, and indispensable amino acids content. Gross energy was analyzed by bomb calorimetry in the Kansas State University Analytical Lab. Amino acids were analyzed by Ajinomoto Heartland LLC Amino Acid lab (Chicago, IL). All other analysis was conducted by Ward Labs (Kearney, NE). After the analysis of nutrient values, 1 sample was excluded because it contained approximately 10 times the amount of Ca (5.22% vs. a mean of 0.57%) as other samples. Therefore, all the results were obtained from 38 samples. The results for amino acid concentration were obtained from all 39 samples. Estimated DE values were calculated according to an equation described by Noblet and Perez (1993): DE = 4,151 + (122 × % Ash) + (23 × % CP) + (38 × % EE) - (64 x % CF (R^2 = 0.89). Estimated ME values were calculated according to the equation described by May and Bell (1971): ME = DE × (1.012 − (0.0019 × % CP (R^2 = 0.91).

The mean, minimum, maximum, and standard deviation for each analytical variable were determined. Regression equations were developed to determine the relationship between major analytical components.

Results and Discussion

The wide range in soy hull nutrient levels is shown in Table 1. Crude protein ranged from 9.0 to 26.7% with a majority of the samples between 9 and 12%. Crude fiber content ranged from 21.8 to 36.1% on an as-fed basis with the majority of the samples being between 34 and 36% (Figure 1).

Because the wide range in nutrient values was not evenly distributed, the mean values should not be used for diet formulation. Thus, regression equations were developed to predict the nutrient levels from 1 or 2 variables that could be measured relatively inexpensively (Table 2). These equations are an important tool in formulating diets for pigs, reducing the time and cost of laboratory analysis. A high correlation was observed between CF and CP with CF predicting 92% of the variation in CP content (Figure 1). Crude fiber also was highly correlated to other variables with CF predicting almost 96% of the variation in ADF content, 97% of the variation in NDF content, 90% of the variation in estimated DE, and 89% of the variation in estimated ME (Figures 2 to 5, respectively). A high correlation also was observed between CP and estimated DE (Y = 74.79x + 521.9; R^2 = 0.90). Lower correlations were observed between ash concentration and Ca and P. Also, lower correlations were observed between GE and all the other nutrients.

Because of the high variability in CP levels, it was not surprising that individual amino acids were highly variable between soy hull sources (Table 1). When expressed relative to the CP content in the soy hulls, most of the variability can be explained. Crude protein explained most of the variability in lysine (89%), methionine (88%), threonine (93%), and tryptophan (93%) (Figures 6 to 9, respectively) as well many other amino acids.

The chemical composition of the soybean hulls can be influenced by many factors including processing procedure and growing conditions for the soybeans. These data indicate that the chemical composition of soybean hulls can be highly variable; however, CF content can help explain much of the variation in CP, ADF, NDF, and energy content. Crude protein content can explain much of the variation in amino acid content. Thus, the most of the nutrient values for soybean hulls that are required for diet formulation can be estimated from laboratory analysis of the CF and CP level.

Table 1. Nutritional values of soybean hulls on an as-fed basis[1]

Nutrient	Minimum	Mean	Maximum	SD
Moisture, %	3.39	8.18	9.51	1.16
CP, %	9.00	12.27	26.70	3.68
GE, kcal/kg	3,668	4,017	4,401	159
Est. DE, kcal/kg	1,056	1,425	2,413	291
Est. ME, kcal/kg	1,037	1,387	2,272	268
Crude fiber, %	21.80	33.32	36.10	3.04
ADF, %	27.50	42.42	46.70	3.95
NDF, %	37.80	57.28	62.10	5.16
Fat, %	0.60	1.54	4.30	0.83
N free extract, %	36.00	39.18	41.10	1.26
Ash, %	4.11	4.87	6.12	0.46
Ca, %	0.42	0.52	0.70	0.05
P, %	0.10	0.15	0.32	0.05
Amino acids, %				
Lysine	0.67	0.86	1.83	0.21
Methionine	0.10	0.16	0.48	0.07
Threonine	0.37	0.48	1.15	0.14
Tryptophan	0.11	0.15	0.37	0.05
Arginine	0.43	0.65	1.81	0.29
Histidine	0.24	0.31	0.68	0.09
Leucine	0.58	0.82	1.99	0.30
Isoleucine	0.34	0.48	1.17	0.17
Phenylalanine	0.31	0.54	1.26	0.19
Valine	0.39	0.55	1.30	0.18

[1] Values represent the data from 38 samples (39 for amino acids).

Table 2. Regression equations to predict CP, ADF, NDF, estimated DE, and estimated ME from crude fiber (CF) and to predict amino acids content from CP (as-fed basis)

Nutrient	Equation	R^2
Nutrient predicted from CF[1]		
CP	= -1.1622 x CF + 50.998	0.92
ADF	= 1.2697 x CF + 0.1143	0.96
NDF	= 1.6689 x CF + 1.6755	0.97
Estimated DE	= -90.699 x CF + 4447.4	0.90
Estimated ME	= -83.072 x CF + 4155.2	0.89
Amino acid predicted from CP[2]		
Lysine	= 0.05735 x CP + 0.1048	0.89
Methionine	= 0.0168 x CP − 0.0551	0.88
Threonine	= 0.038 x CP − 0.0189	0.93
Tryptophan	= 0.0123 x CP − 0.0078	0.93
Arginine	= 0.0758 x CP − 0.2757	0.93
Histidine	= 0.0241 x CP + 0.0162	0.93
Leucine	= 0.0776 x CP + 0.136	0.93
Isoleucine	= 0.0459 x CP − 0.0162	0.93
Phenylalanine	= 0.0486 x CP − 0.0574	0.93
Valine	= 0.0474 x CP − 0.0339	0.92

[1] CF is expressed as a percentage of the soy hulls on an as-fed basis.
[2] CP is expressed as a percentage of the soy hulls on an as-fed basis.

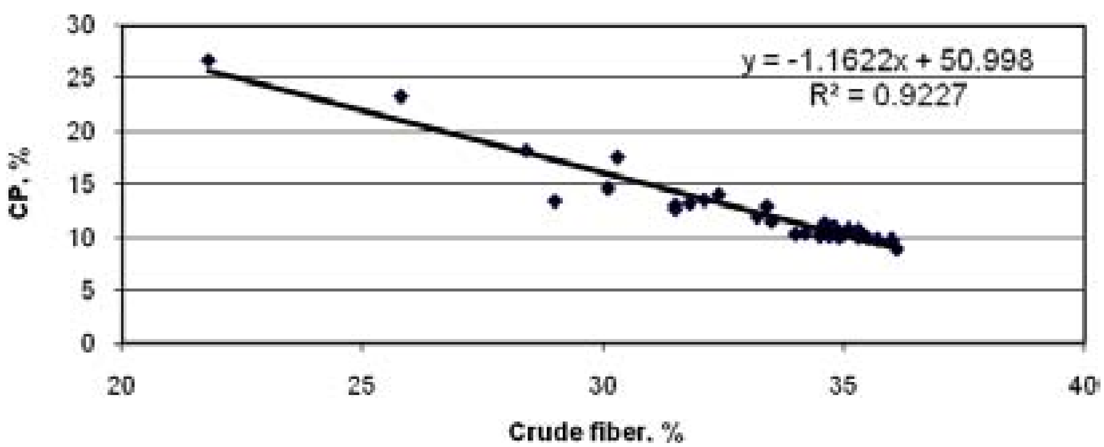

Figure 1. Relationship between crude fiber and CP content of soybean hulls (as-fed basis).

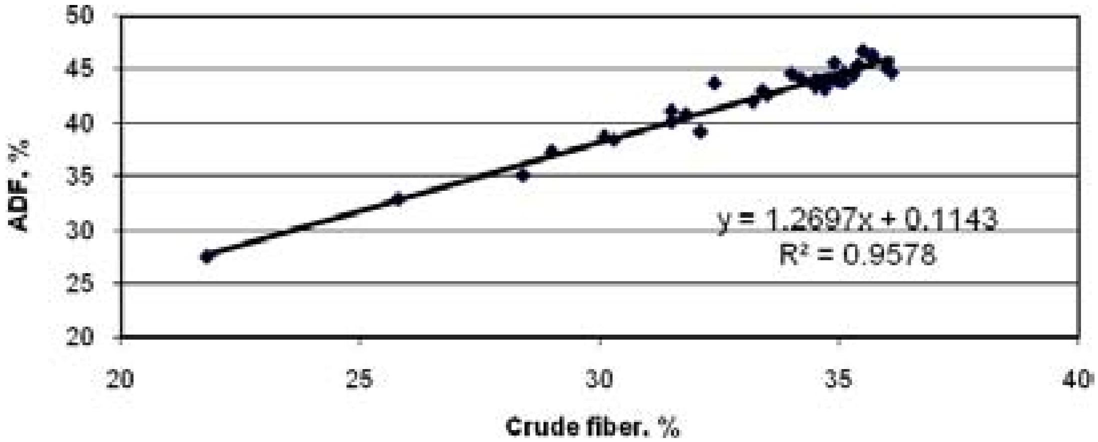

Figure 2. Relationship between crude fiber and ADF content of soybean hulls (as-fed basis).

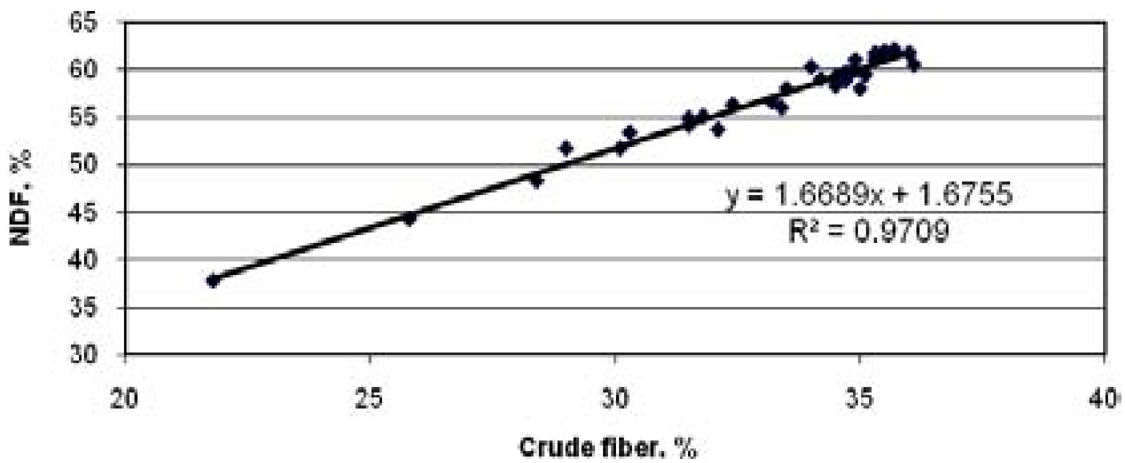

Figure 3. Relationship between crude fiber and NDF content of soybean hulls (as-fed basis).

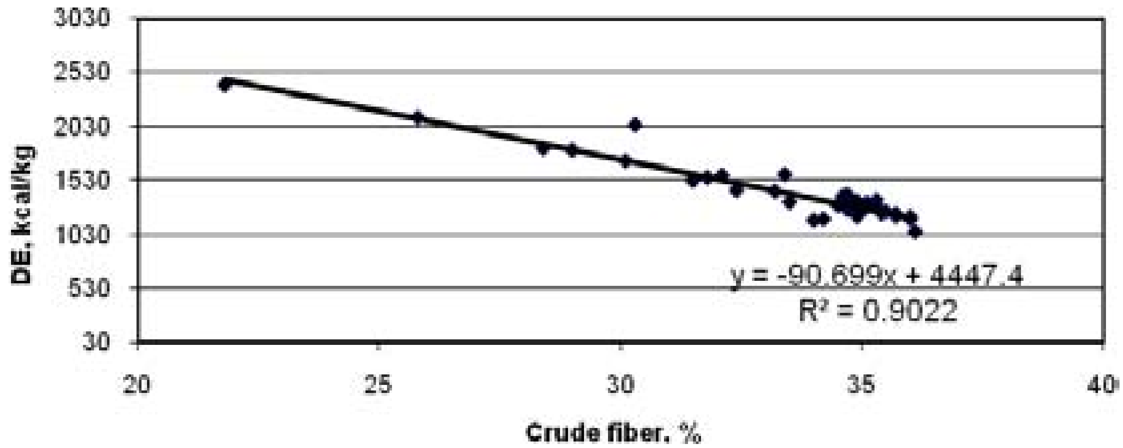

Figure 4. Relationship between crude fiber and estimated DE content of soybean hulls (as-fed basis).

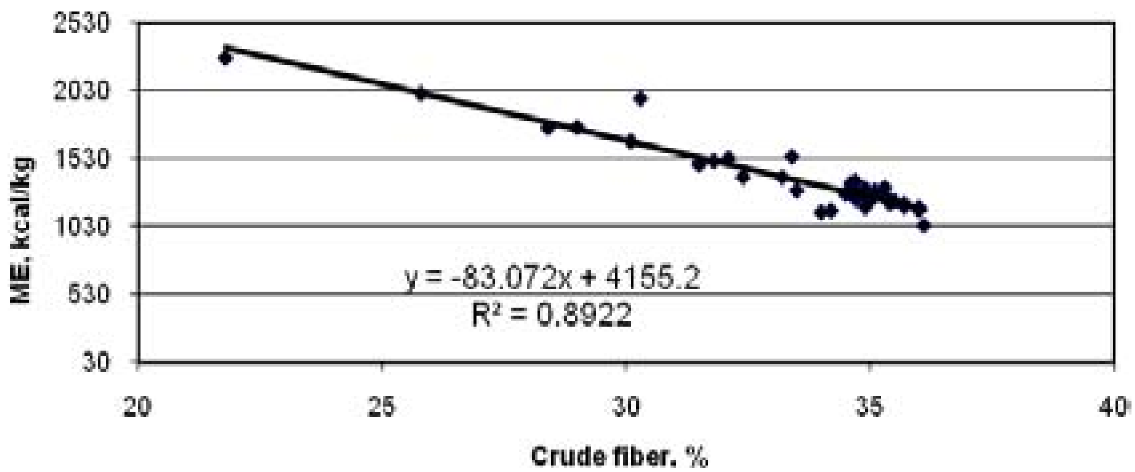

Figure 5. Relationship between crude fiber and estimated ME content of soybean hulls (as-fed basis).

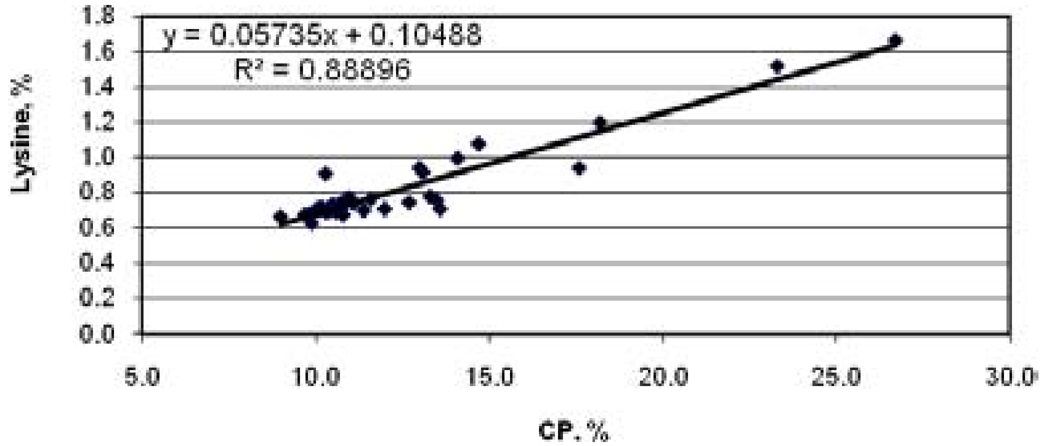

Figure 6. Relationship between CP and lysine content of soybean hulls (as-fed basis).

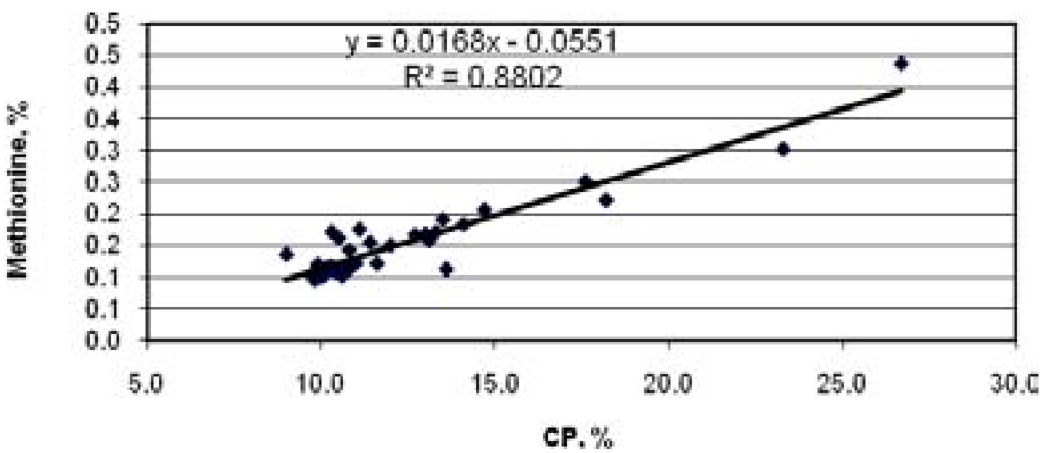

Figure 7. Relationship between CP and methionine content of soybean hulls (as-fed basis).

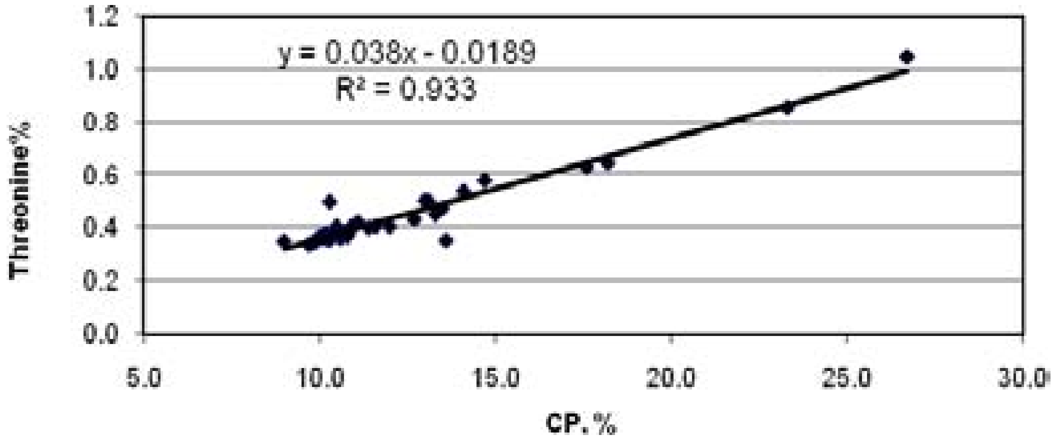

Figure 8. Relationship between CP and threonine content of soybean hulls (as-fed basis).

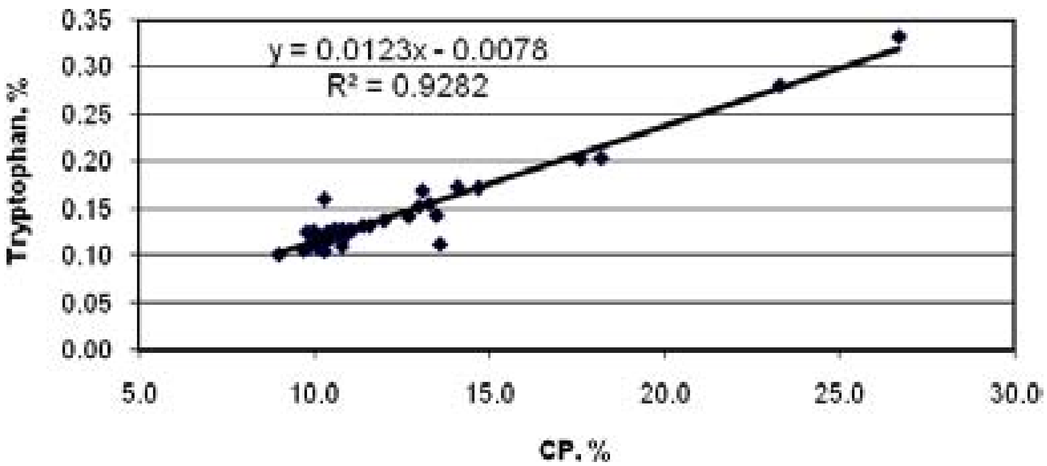

Figure 9. Relationship between CP and tryptophan content of soybean hulls (as-fed basis).