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Effect of Soybean Meal from Different Midwest Soybean Varieties on Growth Performance of Broilers^{1,2}

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Summary

At hatch, 360 one-d old Cobb500 male broilers were placed in battery cages to determine the effect of soybean meal (SBM) from different Midwest soybean varieties on growth performance of broilers. There were 6 broilers per cage and 15 replicates per treatment. Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into SBM. Two sources consisted of soybeans from a similar region and processed either commercially solvent extracted or experimentally solvent extracted at Texas A&M University. Additional sources included a low quality and high quality soybean, experimentally solvent extracted into SBM at Texas A&M University. Therefore, dietary treatments consisted of a commercially processed SBM with 47% CP (CSBM), or experimentally processed SBM with 42% CP (42SBM), 49% CP (49SBM), or 52% CP (52SBM). Diets were formulated to 1.05% digestible Lys and balanced using digestible AA values previously determined. Added dietary fat provided by vegetable oil was kept constant in the formulation across treatments. Data were analyzed using the GLIMMIX procedure in SAS 9.4, with cage as the experimental unit, cage location as the blocking factor with Tukey-Kramer adjustment for multiple comparisons used. From d 0 to 18, body weight gain (BWG) and d 18 BW increased ($P < 0.001$) in broilers fed CSBM, compared to 42SBM, 49SBM, and 52SBM. Broilers fed the CSBM had increased ($P < 0.001$) ADFI, compared to 42SBM and 52SBM, with 49SBM intermediate. There was no evidence for feed conversion ratio (FCR) differences in broilers fed 42SBM, 49SBM, and 52SBM. There was no evidence for difference among broilers fed experimentally processed soybean meal; however, there were increases in diet cost of \$28.81 and 5.41 per ton for the 42SBM and 49SBM, respectively, compared to 52SBM. Feed cost per bird decreased ($P < 0.001$) in birds fed 52SBM (\$0.244) compared to CSBM (\$0.271) and 42SBM (\$0.266) with 49SBM (\$0.256) intermediate, CSBM and 42SBM. Therefore, the lower inclusion of 52SBM in the diet could be used to maintain growth performance with potential cost savings.

¹ This study was completed following the study: Dunmire, K. M.; Braun, M. B.; Evans, C. E.; Stark, C. R.; and Paulk, C. B. (2021) "Determining the amino acid digestibility of soybean meal from different Midwest soybean varieties fed to broilers." Kansas Agricultural Experiment Station Research Reports Vol. 7, Issue 10. <https://newprairiepress.org/kaesrr/vol7/iss10/>.

² The authors would like to thank the Illinois Soybean Association, Bloomington, IL, for providing partial financial support for this study.

Introduction

In recent years, ingredient cost has increased utilization of crystalline amino acids and by-product ingredients, which has ultimately influenced commercial broiler diet formulation. Previous research indicates that high quality soybean meal (increasing CP) has increased AA concentrations and AA digestibility.¹ This suggests selecting for soybean varieties that lead to increased available AA concentrations in SBM will provide an improvement in the feeding value of soybean meal and reduce the diet cost by altering ingredient composition. Therefore, the objective of this study was to determine the effect of soybean meal from different soybean varieties on growth performance of broilers using previously determined AA digestibility coefficients.¹

Materials and Methods

The Institutional Animal Care and Use Committee at Kansas State University (Manhattan, KS) reviewed and approved the protocols. A total of 360 one-d old male broilers (initially 0.091 lb; Cobb 500, Cobb-Vantress, Siloam Springs, AR) were used in an 18-d study to determine effects of soybean meal quality on broiler growth performance. Broilers were placed in 1 of 3 Petersime batteries with 6 broilers per cage (dimensions, 38.0 × 13.0 in.), balanced by BW. Cages were randomly assigned to 1 of 4 dietary treatments within location block with 15 replicates per treatment. The treatments were replicated in 15 blocks, and each treatment was randomized within each block. Illumination was provided by fluorescent bulbs for the duration of the experiment. A HOBOWare data logger was used to record temperature, relative humidity, and light intensity of the battery room. For the first 7 d, averages were 87.4°F, 57.2%, and 7.5 lum/ft², followed by 81.7°F, 66.4% and 7.5 lum/ft² for the remainder of the experiment for temperature, relative humidity, and light intensity, respectively. Feed was provided *ad libitum* in a one pan feeder (capacity approximately 4.4 lb) per pen. Water was provided *ad libitum* through water troughs. Broilers were weighed on day 0, 7, and 18 for calculation of BWG, FI, and FCR. Body weight and feed consumption were measured on day 0, 7 and 18. Mortalities were recorded daily. An initial study was also completed to determine amino acid digestibility for the same 4 SBM sources fed to broilers in this study.¹

Dietary treatments

Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into SBM. Two sources consisted of soybeans from a similar region and processed either commercially solvent extracted or experimentally solvent extracted at Texas A&M University. Additional sources included a low quality and high quality soybean, experimentally solvent extracted into SBM at Texas A&M University. Therefore, dietary treatments consisted of a commercially processed SBM with 47% CP (CSBM) or experimentally processed SBM with 42% CP (42SBM), 49% CP (49SBM), or 52% CP (52SBM). Individual SBM and diet samples were analyzed for proximate analysis and complete AA profile,³ available Lys,⁴ protein solubility,⁵ and trypsin inhibitor activity⁶ (Tables 1 and 3).

³ AOAC Official Method 982.30 E(a,b,c), chp. 45.3.05, 2006.

⁴ AOAC Official Method 975.44, chp. 45.4.03, 2006.

⁵ KOH method, J Anim Sci, 69:2918-2924, 1991.

⁶ AACC Official Method 22-40, 2006.

Dietary treatments were corn- and SBM-based and formulated to 90% of the digestible Lys requirement suggested by Cobb500 broiler recommendations (Table 2). Vegetable oil and L-Lys remained constant for all treatments. Standardized ileal digestibility (SID) AA values of SBM were based on amino acid concentrations previously determined.¹ Additionally, energy was not balanced in these diets since vegetable oil was kept constant. Calcium, available phosphorus, and AA:Lys ratios were balanced to meet or exceed Cobb500 broiler recommendations. The following prices for major ingredients were used to calculate diet cost: corn at \$6.72/bu (\$264/ton) and soybean meal at \$373/ton (June 2021). Additional ingredient costs included \$0.66/lb for vegetable oil, \$0.88/lb for Lys, \$2.04/lb for Met, \$0.93/lb for Thr, \$0.23/lb for monocalcium phosphate, \$0.02/lb for salt and limestone, \$0.39/lb for choline chloride, \$2/lb for vitamin trace mineral premix, and \$1.50/lb for phytase (June 2021). Soybean meal prices were held constant to demonstrate the value of high quality CP soybean meal. Diet cost was determined by the sum of ingredient costs. The total feed cost per bird was calculated by multiplying the total feed consumed (FI) by the cost per lb of feed. The total feed cost/per lb of gain was calculated by multiplying the feed conversion ratio (FCR) by the cost per lb of feed.

Statistical analysis

Data were analyzed using the GLIMMIX procedure in SAS v. 9.4 (SAS Institute Inc., Cary, NC), with pen as the experimental unit, pen location as the blocking factor and adjusted using Tukey-Kramer multiple comparisons. Results were considered significant if $P \leq 0.05$.

Results and Discussion

Individual SBM samples contained 46.9, 41.8, 49.1, and 51.8% CP and 2.97, 2.60, 3.09, and 3.21% Lys in the CSBM, 42SBM, 49SBM, and 52% SBM, respectively (Table 1). The 49SBM was sourced from the same geographical region as the CSBM, therefore it was expected these would be similar in CP content. The 42SBM, 49SBM, and 52SBM were processed into soybean meal on a pilot scale crush facility at Texas A&M University. These samples had an increased dry matter (DM) compared to the CSBM. Therefore, the 49SBM and CSBM had similar CP and Lys when expressed on a DM basis. Individual SBM samples contained 2.80, 2.43, 2.89, and 3.08% available Lys and 86.27, 74.30, 85.72, and 76.95% KOH solubility in the CSBM, 42SBM, 49SBM, and 52SBM, respectively. In addition, individual soybean meal samples contained 2.65, 0.71, 2.01, and 3.08 TIU/lb for trypsin inhibitor, respectively. The AA concentrations determined in previous research¹ provided precise diet formulation, therefore providing opportunity for improved diet cost.

From d 0 to 18, BWG increased ($P < 0.002$) in broilers fed the CSBM compared to 42SBM, 49SBM, and 52SBM (Table 4). Broilers fed CSBM had increased ($P < 0.001$) ADFI compared to 42SM and 52SBM, with 49SBM being intermediate. There was no evidence for differences in FCR for d 0 to 18. Therefore, these data indicate that processing of soybean meal using pilot scale solvent extraction led to a decrease in feed intake and gain of broilers. However, there was no evidence of difference in growth performance of broilers fed 42SBM, 49SBM, and 52SBM when fed at 38.0%, 29.5%, and 27.5% of the diet. Approximate diet costs for CSBM, 42SBM, 49SBM and 52SBM were \$296.46, \$318.67, \$295.27, and \$289.86 per ton, respectively. Feed cost per bird decreased ($P < 0.001$) in birds fed 52SBM (\$0.244) compared to CSBM (\$0.271)

and 42SBM (\$0.266), with 49SBM (\$0.256) intermediate, CSBM and 42SBM. Feed cost per lb of gain was greatest ($P < 0.001$) in birds fed 42SBM compared to all other sources.

In conclusion, broilers fed commercially processed SBM had improved d 18 BW, ADG, and ADFI. Soybean meal processed from low, medium, and high CP soybeans resulted in 42%, 49%, and 52% CP, and 2.60, 3.90, and 3.21% total Lys, respectively. There was no evidence for difference among broilers fed experimentally processed soybean meal; however, there were differences in diet cost of \$28.81 and 5.41 per ton for the 42SBM and 49SBM diet cost compared to 52SBM. Therefore, the lower inclusion of 52SBM in the diet could be used to maintain growth performance with potential diet cost savings.

Table 1. Chemical analysis of individual soybean varieties (as-is)^{1,2,3}

Item, %	CSBM	42SBM	49SBM	52SBM
Dry matter	89.53	93.74	92.62	93.74
Crude protein	46.86	41.82	49.19	51.79
Crude fat	1.58	1.94	1.61	1.84
Crude fiber	3.85	5.91	3.60	3.41
ADF	6.68	7.75	6.83	6.93
NDF	12.03	14.24	7.83	8.24
Ash	6.89	6.37	6.93	6.82
Available Lys	2.80	2.43	2.89	3.08
Lys:crude protein	6.34	6.22	6.28	6.20
KOH solubility	86.27	74.30	85.72	76.95
Trypsin inhibitor, TIU/lb	2.651	0.711	2.013	3.079
Total AA	45.30	40.56	47.85	50.64
Indispensable AA				
Arg	3.25	2.79	3.42	3.67
His	1.20	1.10	1.28	1.33
Ile	2.23	2.00	2.35	2.48
Leu	3.55	3.19	3.75	3.98
Lys	2.97	2.60	3.09	3.21
Met	0.65	0.59	0.70	0.73
Phe	2.36	2.10	2.49	2.64
Thr	1.78	1.65	1.90	1.97
Trp	0.64	0.64	0.72	0.74
Val	2.31	2.09	2.45	2.56

¹ At hatch, 360 Cobb500 male broilers were placed in battery cages with 6 broilers per cage and 15 replicates per treatment.

² Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into soybean meal (SBM). Treatments consisted of a commercially processed SBM with 47% CP (CSBM) or experimentally processed SBM with 42% CP (42SBM), 49% CP (49SBM), or 52% CP (52SBM).

³ Samples were analyzed at the University of Missouri Agricultural Experiment Station Chemical Laboratories in Columbia, MO.

Table 2. Diet composition (as-is)^{1,2}

Ingredient, %	CSBM	42SBM	49SBM	52SBM
Corn	66.01	57.68	66.06	68.02
Soybean meal	29.50	38.00	29.50	27.50
Vegetable oil	0.70	0.70	0.70	0.70
Lys	0.15	0.15	0.15	0.15
Met	0.23	0.22	0.21	0.21
Thr	0.05	---	0.03	0.04
Monocalcium phosphate	1.25	1.20	1.25	1.25
Calcium carbonate	1.35	1.30	1.35	1.37
Sodium chloride	0.40	0.40	0.40	0.40
Choline chloride	0.10	0.10	0.10	0.10
Vitamin trace mineral premix ³	0.25	0.25	0.25	0.25
Phytase ⁴	0.005	0.005	0.005	0.005
Total	100	100	100	100
Calculated analysis				
Nitrogen-corrected metabolizable energy (ME _n), kcal/lb	1,462	1,436	1,426	1,522
Crude protein, %	19.62	20.95	20.28	20.19
Ca, %	0.90	0.90	0.90	0.90
Available P, %	0.47	0.47	0.47	0.47
Digestible amino acids				
Lys	1.05	1.05	1.05	1.05
Arg	1.06	1.08	1.09	1.11
His	0.44	0.45	0.45	0.45
Ile	0.73	0.78	0.76	0.76
Leu	1.50	1.54	1.55	1.57
Met	0.49	0.49	0.48	0.48
Total sulfur AA	0.76	0.76	0.76	0.76
Phe	0.82	0.86	0.85	0.86
Thr	0.67	0.67	0.67	0.67
Trp	0.19	0.22	0.21	0.21
Val	0.82	0.86	0.84	0.84

¹At hatch, 360 Cobb500 male broilers were placed in battery cages with 6 broilers per cage and 15 replicates per treatment.

²Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into soybean meal (SBM). Treatments consisted of a commercially processed SBM with 47% CP (CSBM) or experimentally processed SBM with 42% CP (42SBM), 49% CP (49SBM), or 52% CP (52SBM).

³ Provided per lb of premix: 1,400,000 IU vitamin A; 500,000 ICU vitamin D₃; 3,000 IU of vitamin E; 2 mg vitamin B₁₂; 150 mg menadione; 1,200 mg of riboflavin; 200 mg thiamine; 1,200 mg of pantothenic acid; 5,000 mg of niacin; 250 mg vitamin B₆; 125 mg folic acid; 70,000 mg choline chloride; 6 mg biotin; 4% manganese; 4% zinc; 2% iron; 4500 ppm copper; 600 ppm iodine; and 60 ppm selenium.

⁴Quantum Blue 10G (AB Vista, Plantation, FL) provided 227 FTU/lb to release 0.15% P.

Table 3. Chemical analysis of experimental diets^{1,2}

Ingredient, %	CSBM	42SBM	49SBM	52SBM
Dry matter	88.55	89.60	89.04	89.03
Crude protein	19.19	20.94	20.60	20.75
Crude fat	2.78	2.90	2.98	3.07
ADF	4.69	5.87	3.97	3.78
NDF	10.41	10.69	10.25	10.83
Ash	4.84	5.06	4.95	4.53
Lysine:crude protein	6.10	5.87	5.73	6.02
Total AA	19.45	20.44	20.02	19.89
Ile	0.88	0.95	0.91	0.89
Lys	1.17	1.23	1.18	1.25
Met	0.45	0.47	0.43	0.46
Thr	0.76	0.79	0.75	0.75
Trp	0.22	0.24	0.24	0.23
Val	0.96	1.04	1.00	0.97

¹At hatch, 360 Cobb500 male broilers were placed in battery cages with 6 broilers per cage and 15 replicates per treatment.

²Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into soybean meal (SBM). Treatments consisted of a commercially processed SBM with 47% CP (CSBM) or experimentally processed SBM with 42% CP (42SBM), 49% CP (49SBM), or 52% CP (52SBM).

Table 4. Effect of different Midwest soybean varieties on broiler growth performance^{1,2}

Item	CSBM	42SBM	49SBM	52SBM	SEM	Probability, <i>P</i>
BW, lb						
d 0	0.091	0.091	0.091	0.092	0.0002	0.904
d 18	1.52 ^a	1.40 ^b	1.41 ^b	1.40 ^b	0.025	0.002
d 0 to 18						
BWG, lb	1.43 ^a	1.31 ^b	1.32 ^b	1.31 ^b	0.024	0.002
FI, lb	1.83 ^a	1.67 ^b	1.74 ^{ab}	1.68 ^b	0.032	0.005
FCR	1.28	1.28	1.30	1.29	0.013	0.694
Mortality, %	0.8	2.5	2.5	3.3	---	---
Economics, \$						
Diet cost, per ton	296.46	318.67	295.27	289.86	---	---
Feed cost, per bird	0.271 ^a	0.266 ^a	0.256 ^{ab}	0.244 ^b	0.0048	0.001
Feed cost, per lb of gain	0.189 ^b	0.204 ^a	0.191 ^b	0.187 ^b	0.0019	0.001

¹ At hatch, 360 male broilers (Cobb 500, Cobb-Vantress, Siloam Springs, AR) were placed in battery cages with 6 broilers per cage and 15 replicates per treatment.

² Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into soybean meal (SBM). Treatments consisted of a commercially processed SBM with 47% CP (CSBM) or experimentally processed SBM with 42% CP (42SBM), 49% CP (49SBM), or 52% CP (52SBM).

⁴ Means within a row followed by a different letter (^{a-c}) are significantly different ($P \leq 0.05$).

⁵ BWG = body weight gain. FI = feed intake. FCR = feed conversion ratio.