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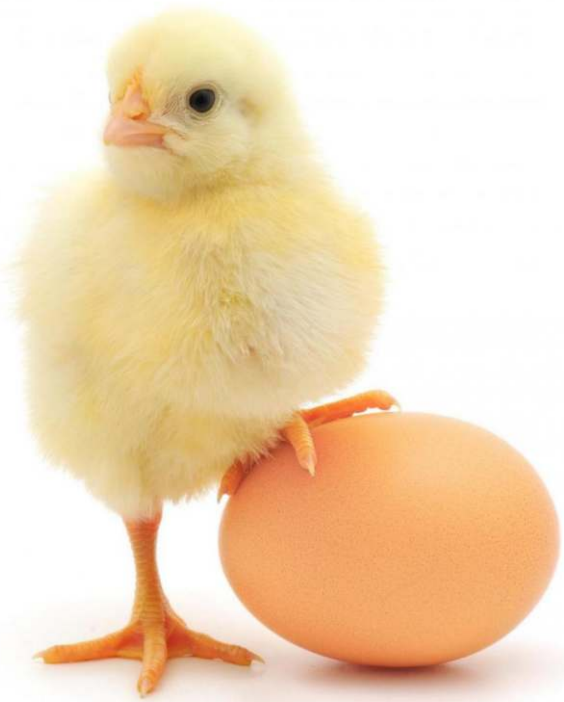

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Use of Various Ratios of Extruded Fullfat Soybean Meal and Dehulled Solvent Extracted Soybean Meal in Broiler Diets

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Abstract: A study was conducted in which whole unextracted soybeans were processed by passing the beans through a roller mill and then extruding without steam. The processed beans were then included into nutritionally adequate broiler diets, replacing solvent extracted soybean meal in ratios of 0/100, 25/75, 50/50, and 0/100 % with dietary energy levels of 3200, 3300, and 3400 ME kcal/kg. This resulted in a 3 x 4 factorial arrangement of treatments. Each treatment was fed to six replicate pens of 60 male chicks of a commercial broiler strain from 1 to 42 days of age. The results of the study demonstrate that the inclusion of extruded fullfat soybean in a pelleted broiler diet supported chick performance equal or superior to that of dehulled solvent extracted soybean meal, and that extruded soybeans could partially or completely replace soybean meal without any adverse effects on body weight, feed conversion, mortality, dressing percentage, or abdominal fat content provided the diets are nutritionally balanced.

Key words: Soybeans, broilers, unextracted soybeans

Introduction

For a number of years there has been considerable interest in the use of whole unextracted or "fullfat" soybeans (FFS) in poultry diets. Whole soybeans contain not only high quality protein, but also have the potential of providing significant amounts of energy due to their high oil content. This can be a valuable asset in countries where the infrastructure does not permit the accumulation of inedible fats and oils typically used to provide supplemental energy in broiler diets, as well as in regions where poultry producers welcome high-energy diets. Soybeans have become a major crop in India, spreading the opportunity to utilize whole soybeans to the southeastern region of Asia.

Because soybeans are known to contain various antinutritive factors such as trypsin inhibitors that may interfere with nutrient digestibility, some form of heat processing is necessary to obtain maximum utilization of FFS. Studies conducted at this station (Hull *et al.*, 1968; Mitchell *et al.*, 1972; Waldroup and Cotton, 1974) and elsewhere (Carew and Nesheim, 1962; Featherston and Rogler, 1966; Sell, 1984; Leeson and Atteh, 1996; Paradis *et al.*, 1978; Zollitsch *et al.*, 1992) have demonstrated that properly processed FFS are capable of supporting performance similar to that obtained from chickens fed diets based on dehulled solvent extracted soybean meal (SBM). These studies have been reviewed in detail by Waldroup (1982).

Questions remain as to the quantity of FFS that can be effectively utilized in broiler diets. Waldroup and Cotton (1974) reported that up to 25% FFS was the effective upper limit in mash diets for young broilers. Other researchers (Carew and Nesheim, 1962; Featherston and Rogler, 1966; Kan *et al.*, 1988; Mitchell *et al.*, 1972) have indicated that pelleting of diets or passing roasted beans through a roller mill may aid in disruption of cells and enhance nutrient release in FFS, allowing for higher usage levels of FFS. This study was conducted to evaluate the use of extruded FFS in pelleted diets for broilers grown to market weights in combination with various ratios of conventional dehulled solvent extracted soybean meal, utilizing all known techniques to maximize the usage of the FFS.

Materials and Methods

Processing of soybeans: Whole soybeans (mixed species) were obtained locally from the Department of Agronomy, University of Arkansas, Fayetteville, AR. The beans were transported to the Department of Grain Science, Kansas State University, Manhattan, KS for processing. The beans were first passed through a roller mill to aid in fracturing the cell wall, ground in a hammer mill, and then extruded without steam in a commercial extruder.(Insta-Pro International Division of Triple "F", Inc., Des Moines, IA 50322). After drying, the product was placed in bags and returned to the University of Arkansas for use in the feeding trials.

A sample of the product was analyzed by a commercial laboratory (A & A Laboratories, Springdale, AR 72764) and found to contain 40.69% CP, 19.8% ether extract, and 0.02 urease rise. This urease level indicates that the FFS was processed sufficiently to denature the trypsin inhibitor without overcooking (Waldroup *et al.*, 1985). A commercial laboratory specializing in amino acid nutrition conducted amino acid analysis of the product, (Degussa Corporation, Allendale, NJ 07401) and the metabolizable energy content was estimated from equations published by NRC (1994).

Diets were formulated using linear programming utilizing different ratios of FFS to SBM at different levels of dietary energy. Diets were formulated for 0 to 21 and 21 to 42 d. The FFS and SBM were fed at five ratios (0/100, 25/75, 50/50, and 100/0 parts of FFS/SBM, respectively) in diets with 3200, 3300, and 3400 ME kcal/kg for a total of fifteen experimental diets. Although these levels of energy are greater than often used in commercial practice, one advantage of using FFS is that it allows for formulation of higher energy diets without recourse to high levels of supplemental fats. Diets met or exceeded the amino acid requirements suggested by the NRC (1994) adjusted to the dietary energy content. Complete vitamin and trace mineral mixes obtained from a commercial poultry integrator were used. All diets were pelleted with steam; diets fed from 0 to 21 d were fed as crumbles. Six replicate pens of birds were fed each of the fifteen experimental treatments.

Birds and Housing: One-d-old male chicks of a commercial broiler strain (Cobb 500, Cobb-Vantress, Inc., Siloam Springs, AR) were obtained from a local hatchery and randomly distributed among pens in a house of commercial design. Sixty chicks were placed in each of 90 pens (0.095 m^2 per bird) with used softwood shavings over concrete floors. Each pen was equipped with two tubular feeders and one automatic water font. Birds were brooded using whole house brooding, beginning at 90 F and reduced by 5 F weekly to a minimum of 70 F. Thermostatically controlled brooder stoves, ventilation fans, and sidewall curtains maintained House temperature and airflow. For the first week lights were on 24 hr daily; for the remainder of the trial supplemental lights were used

Approved for publication by the Director, Arkansas Agricultural Experiment Station

Table 1: Composition (%) of selected diets with varying ratios of fullfat extruded soybeans (FFS) and soybean meal (SBM) with different levels of metabolizable energy fed to chickens 0 to 21 d of age

	Dietary ME (kcal/kg)								
Ingredients	3200			3300			3400		
	Ratio of Fullfat soybeans to soybean meal								
	0/100	50/50	100/0	0/100	50/50	100/0	0/100	50/50	100/0
Soybean meal (46.7%)	34.10	19.69	0.00	36.08	20.83	0.00	38.06	21.97	0.00
Fullfat soybeans	0.00	19.69	46.58	0.00	20.83	49.28	0.00	21.97	51.99
Yellow corn	51.865	49.235	45.655	47.325	44.545	40.725	42.755	39.825	35.815
Poultry oil	6.30	3.70	0.14	8.74	5.98	2.23	11.18	8.28	4.31
Pro-pak[1]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Dicalcium phosphate	0.96	0.96	0.96	1.03	1.03	1.03	1.11	1.11	1.11
Ground limestone	0.71	0.68	0.65	0.73	0.71	0.67	0.75	0.73	0.69
Salt	0.39	0.38	0.37	0.40	0.40	0.39	0.42	0.41	0.40
Vitamin premix[2]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
DL-Methionine (98%)	0.18	0.18	0.17	0.20	0.19	0.19	0.22	0.21	0.20
Trace mineral premix[3]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Coban 60[4]	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Threonine	0.07	0.06	0.05	0.07	0.06	0.06	0.08	0.07	0.06
BMD 50[5]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

[1] Blended animal protein product, H. J. Baker & Bro., 595 Summer Street, Stamford, CT 06901-1407.
[2] Provides per kg of diet: vitamin A (from vitamin A acetate) 7714 IU; cholecalciferol 2204 IU; vitamin E (from dl-alpha-tocopheryl acetate) 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; menadione (from menadione dimethylpyrimidinol) 1.5 mg; folic acid 0.9 mg; thiamin (from thiamin mononitrate) 1.54 mg; pyridoxine (from pyridoxine HCl) 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg.
[3] Provides per kg of diet: Mn (from $MnSO_4$. H_2O) 100 mg; Zn (from $ZnSO_4 7H_2O$) 100 mg; Fe (from $FeSO_4 7H_2O$) 50 mg; Cu (from $CuSO_4.5H_2O$) 10 mg; I from $Ca(IO_3)_2.H_2O$), 1 mg.
[4] Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825. Provides 60 g/lb.(132 g/kg) monensin activity.
[5] Alpharma, Inc., Ft. Lee, NJ 07024. Provides 50 g/lb (110 g/kg) bacitracin activity as bactitracin methylene disalicylate.

Table 2: Composition (%) of selected diets with varying ratios of fullfat extruded soybeans (FFS) and soybean meal (SBM) with different levels of metabolizable energy fed to chickens 21 to 42 d of age

	Dietary ME (kcal/kg)								
Ingredients	3200			3300			3400		
	Ratio of Fullfat soybeans to soybean meal								
	0/100	50/50	100/0	0/100	50/50	100/0	0/100	50/50	100/0
Soybean meal (46.7%	25.01	14.44	0.00	26.71	15.42	0.00	28.40	16.40	0.00
Fullfat soybeans	0.00	14.44	34.17	0.00	15.42	36.48	0.00	16.40	38.79
Yellow corn	62.88	60.97	58.33	58.68	56.63	53.82	54.48	52.29	49.30
Poultry oil	4.64	2.73	0.12	7.03	4.99	2.21	9.42	7.22	4.29
Pro-pak[1]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Dicalcium phosphate	0.48	0.48	0.48	0.54	0.54	0.54	0.60	0.60	0.60
Ground limestone	1.03	1.01	0.99	1.06	1.04	1.01	1.09	1.07	1.04
Salt	0.39	0.38	0.37	0.40	0.40	0.39	0.42	0.41	0.41
Vitamin premix[2]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
DL-Methionine (98%)	0.08	0.07	0.07	0.09	0.09	0.08	0.11	0.10	0.10
Trace mineral premix[3]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Coban 60[4]	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
Threonine	0.06	0.05	0.05	0.06	0.06	0.05	0.06	0.06	0.05
BMD 50[5]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Lysine HCl (98%)	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00

[1] Blended animal protein product, H. J. Baker & Bro., 595 Summer Street, Stamford, CT 06901-1407.
[2] Provides per kg of diet: vitamin A (from vitamin A acetate) 7714 IU; cholecalciferol 2204 IU; vitamin E (from dl-alpha-tocopheryl acetate) 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; menadione (from menadione dimethylpyrimidinol) 1.5 mg; folic acid 0.9 mg; thiamin (from thiamin mononitrate) 1.54 mg; pyridoxine (from pyridoxine HCl) 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg.
[3] Provides per kg of diet: Mn (from $MnSO_4H_2O$) 100 mg; Zn (from $ZnSO_47H_2O$) 100 mg; Fe (from $FeSO_4.7H_2O$) 50 mg; Cu (from $CuSO_4.5H_2O$) 10 mg; I from $Ca(IO_3)_2.H_2O$), 1 mg.
[4] Elanco Animal Health division of Eli Lilly & Co., Indianapolis, IN 46825. Provides 60 g/lb.(132 g/kg) monensin activity.
[5] Alpharma, Inc., Ft. Lee, NJ 07024. Provides 50 g/lb (110 g/kg) bacitracin activity as bactitracin methylene disalicylate.

23 hr daily. The test diets and tap water were provided for ad libitum consumption.

Measurements: Group body weight by pen was taken at 21 and 42 d. Feed consumed by pen was determined at the same time periods. Birds were checked twice daily and the weight of dead birds was used to adjust the feed conversion ratio (FCR; grams of feed per gram of gain). At 42 d, five birds per pen nearest the pen

Table 3: Effects of ratio of fullfat extruded soybeans (FFSOY) to soybean meal (SBM) and dietary energy level on live performance and processing characteristics of broiler chicks

Factor	Body weight (kg) 21 d	Body weight (kg) 42 d	Feed:gain ratio 0-21 d	Feed:gain ratio 0-42 d	Mortality (%) 21 d	Mortality (%) 42 d	42 d Dressing percent	42 d Abdominal fat (%)
A. FFSOY:SBM (wt/wt)								
0/100	0.762	2.534[c]	1.290[a]	1.670[a]	0.28	2.18	65.46	1.84
25/75	0.772	2.520[c]	1.283[a]	1.660[ab]	0.88	1.40	65.68	1.98
50/50	0.784	2.539[c]	1.239[b]	1.631[bc]	0.00	1.67	65.13	1.79
75/25	0.788	2.583[b]	1.243[b]	1.610[cd]	0.57	1.67	65.02	1.95
100/0	0.774	2.594[a]	1.229[b]	1.582[d]	1.10	2.03	65.85	1.92
B. ME_n (Kcal/kg)								
3200	0.745[b]	2.530	1.277[a]	1.652[a]	0.50	0.84	64.94	1.87
3300	0.791[a]	2.573	1.253[b]	1.626[b]	0.83	2.01	65.56	1.96
3400	0.792[a]	2.558	1.241[c]	1.612[b]	0.33	2.52	65.85	1.86
Ratio (R)	0.460	0.020	0.001	0.001	0.38	0.93	0.360	0.29
Energy (E)	0.001	0.110	0.008	0.003	0.54	0.08	0.070	0.38
R x E	0.980	0.660	0.850	0.007	0.84	0.31	0.640	0.25
SEM	0.020	0.036	0.019	0.018	0.73	1.19	0.630	0.12

[abcd]Within comparisons, means with same superscrips do not differ significantly ($P<0.05$).

mean were selected for processing to determine carcass yield and abdominal fat content. Feed but not water was removed from birds eight hours prior to processing. Birds were placed in coops and transported approximately 2 km to a pilot processing plant. The birds were individually weighed, wing-banded, and hung on the slaughter line. They were subjected to a seven second stun of 10-12 mA at 12 V in a 120 cm stunning cabinet (Simmons Model SF 7000, Simmons Engineering Co., Dallas, GA 30132). Approximately ten seconds after stunning, a deep manual throat cut was made to sever the carotid artery and jugular vein with a 120 second bleed time. Carcasses were scalded at 128 F in an inline scalder (Cantrell Model SS3300CF, Cantrell Machine Co., Gainesville, GA 30503), defeathered in an inline picker for 70 seconds (FoodCraft Complex VF-1000, FoodCraft Equipment Co., Lancaster, PA 17601), and rinsed for ten seconds in an inside-outside online rinse cabinet. The carcasses were removed from the slaughter line by passing through an automatic hock cutter (Cantrell Model PHC-4, Cantrell Machine Co., Gainesville, GA 30503) and necks severed by pneumatic cutters. The carcasses were then rehung on the evisceration line and passed through an automated vent cutter and opening machine (Stork Gamco Model V-163, Stork Gamco, Inc., Gainesville, GA 30501) with viscera drawn from the carcass by automated evisceration (Stork Gamco Model CDM-20, Stork Gamco, Inc., Gainesville, GA 30501). The viscera were then manually removed from the carcass. The eviscerated carcasses were chilled in ice water for four hours.

The dressed carcasses and abdominal fat were weighed after chilling. Abdominal fat is defined as the fat surrounding the gizzard extending within the ischium and surrounding the Bursa of Fabricius, cloaca, and adjacent abdominal muscle. Dressing percentage was calculated as carcass weight (including abdominal fat but excluding neck and giblets) as a percentage of fasted live weight.

Statistical analysis: Pen means served as the experimental unit. All percentage data were transformed to arc sine percentage prior to statistical analysis. Data were subjected to analysis of variance suitable for a factorial arrangement of treatments using the General Linear Models procedure of SAS Institute (1991). The model included main effects of FFS:SBM ratios, dietary energy levels, and the interaction of FFS:SBM ratio and dietary energy levels. Statements of statistical significance are based on a probability of $P<0.05$.

Results and Discussion

The effects of ratio of fullfat extruded soybeans to soybean meal and dietary energy level on live performance and carcass characteristics are shown in Table 3. There were no significant interactions between ratio of FFS:SBM and dietary energy level, so only main effects are presented for brevity. The ratio of FFS:SBM had no significant effect on BW at 21 d; at 42 d there was a linear response in BW to increasing the ratio of FFS:SBM. Feed conversion at both 21 and 42 d was inversely related to the ratio of FFS:SBM. This would suggest that the actual Metabolizable energy of the FFS may have been underestimated by the formula used to calculate the energy for this product, as the research upon which this formula was based (Janssen *et al.*, 1979) did not include rolling the beans prior to extrusion, a practice that probably enhanced cellular disruption and subsequent release of the oil from individual cells. The ratio of FFS:SBM had no significant effect on mortality at 21 or 42 d, dressing percentage at 42 d, or abdominal fat as percentage of the carcass at 42 d.

The dietary energy content of the diet had a significant effect on BW at 21 d but not at 42 d. As expected, increasing the dietary energy significantly reduced the amount of feed required per unit of gain. No adverse effects on mortality, dressing percentage, or abdominal fat were observed as the dietary energy level increased. It should be noted that levels of crude protein and amino acids remained constant to dietary energy levels; therefore, no adverse effects on carcass fatness was anticipated.

The results of this study indicate that whole soybeans, processed in a manner to enhance nutrient release and denature the trypsin inhibitor, are a highly effective feed ingredient for broiler diets. When fed in pelleted form, the processed whole soybeans may completely replace solvent extracted soybean meal. The superior performance of the whole soybean product used in this study was probably due to the fact that the energy value available to the bird as a result of rolling and extrusion, coupled with pelleting of the diets, was underestimated. Wiseman (1984) and McNab (1985) demonstrated that use of the extrusion process gave the highest energy value for processed whole soybeans, as compared to other processing methods. Wiseman (1984) also showed that the ME value of diets containing extruded whole soybeans was greatly enhanced by pelleting the diets.

In conclusion, the results of the present study demonstrate that the inclusion of extruded fullfat soybean in a pelleted broiler diet supported chick performance equal or superior to that of dehulled solvent extracted soybean meal, and that extruded soybeans could partially or completely replace soybean meal without any adverse effects on body weight, feed conversion, mortality, dressing percentage, or abdominal fat content provided the diets are nutritionally balanced.

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