Feeding Value of Pacific Northwest-Grown Soybeans for Broilers

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ABSTRACT

Two broiler feeding experiments were carried out to determine the feeding value of Pacific Northwest-grown soybeans. In both experiments, solvent soybean meal (SBM) protein, when replaced one to one with extruded soybean (ESB) protein, produced no significant effects on body weight, feed conversion and mortality. Protein from raw soybean (RSB) could replace up to 50 percent of SBM protein in the ration. Higher levels of RSB significantly depressed growth and feed conversion. The supplementation of zinc bacitracin to RSB rations did not overcome the inhibitory effects. Supplementing an additional 0.05 percent methionine in the RSB ration also did not improve growth rate and feed conversion. RSB-fed broilers had significantly ($P < 0.05$) larger pancreata, kidneys and proventriculi than the SBM-fed birds. Only pancreatic weights were affected in ESB-fed birds. Wetter caked floor litter was observed in pens that housed broilers fed RSB than either ESB or SBM. Mortality was greater where high levels of RSB was included in the rations.

REVIEW OF LITERATURE

Soybeans are the major source of protein in most broiler rations. In the Pacific Northwest, soybeans are not grown as intensively as they are in the Midwest. This is because of unsuitable climatic and soil conditions in this geographic area. Recently however, a few thousand acres of soybeans have been grown in southeastern Washington. Interest has been generated because of high freight costs for shipping from the Midwest.

Oregon poultry farmers import approximately 60,000 tons of soybeans annually. With the additional freight cost (about $40/ton), they spend about $2.5 million annually for this service. By growing soybeans locally, there could be a savings to the livestock farmers and the consumer.

A great deal of research has been conducted in the past concerning the feeding value of soybeans to chicks. A proteolytic inhibiting substance in raw soybeans, which caused growth retardation and pancreatic hypertrophy in chicks first was isolated by Ham and Sandstedt (1944). Several researchers have reported this inhibiting substance in raw soybeans caused growth retardation and pancreatic hypertrophy in chicks (Ham, et al., 1945; Saxena, et al., 1960; Barnes, et al., 1961; Alumot and Nitsan, 1961; and Pubols, et al., 1966). Young chicks were found to be more sensitive to the growth inhibiting properties and the maximal growth retarding effect was between three to five weeks of age (Saxena, et al., 1963; Borstein and Lipstein, 1963; and Wood, et al., 1971). Waldroup and Cotton (1974) suggested no more than 25 percent full-fat soybeans should be added to all mash broiler diets.

Pelleting of feeds containing full-fat soybeans improved the availability of the oil and increased weight gains in chicks (Carew and Nesheim, 1962; Stephenson and Tollet, 1959; Featherston and Rogler, 1966; White, et al., 1967; Hull, et al., 1968; and Mitchell, et al., 1972). This was found to be especially true on extruded soybean rations (Hull, et al., 1968; and Sloan, et al., 1970).

EXPERIMENTAL PROCEDURE

In experiment 1, 572 straight-run commercial broiler chicks were distributed into 22 pens with 26 chicks per pen. Eleven dietary treatments were tested and each treatment was duplicated. In the second experiment, 720 commercial feather sexed broiler chicks were distributed into 30 pens with 12 of each sex in each pen. Ten dietary treatments were tested and each treatment was triplicated. Each floor pen measured 4 feet by 8 feet (1.23 meters x 2.46 meters), and bird density was approximately 0.95 square feet ($0.009m^2$) per chick for both experiments.

In both experiments, the birds were housed in a windowless positive pressure ventilated room. The chicks were brooded under infrared heat lamps using one 250 watt bulb per pen. Heat lamps were thermostatically controlled using room temperature starting at 85° F. (29.4° C.) and manually lowered by 5° F. each week through the 5th week, then set at 56° F. (13.3° C.) thereafter. Each pen contained a stove pipe hanging type feeder and a 3-gallon water fountain. Incandescent lighting was provided continuously.

In both experiments, the starter and finisher rations were formulated to be isocaloric and isonitrogenous (Tables 1 and 2). Barley, soybean oil or animal fat were used to equalize the energy levels. In experiment 1, extruded (ESB)* and raw (RSB)* full-fat soybeans were added in the rations at 75 and 100 and 15, 25 and 100 percent, respectively, of the solvent soybean protein (SBM). These rations were supplemented further with and without 50 grams zinc bacitracin per ton. In order to simplify mixing and assure the proper percentages of ESB and RSB, the 100 percent SBM, ESB and RSB rations were blended to attain the correct proportions. In experiment 2, RSB protein was added to replace 25, 50, 75, 90 and 100 percent of the SBM protein. The ESB protein was added to replace 100 percent of the SBM protein. Medium energy rations were rations with 3,161 and 3,194 kilocalories metabolizable energy per kilogram for the starter and finisher feeds, respectively. High energy rations were rations with 3,297 and 3,340 kilocalories metabolizable energy per kilogram for the starter and finisher feeds, respectively. These high-energy rations were similar to rations fed in experiment 1. An additional dietary treatment was included where 0.21 percent d, l methionine was supplemented to the medium energy 100 percent RSB ration.

In both experiments, starter feeds were fed until each chick consumed two pounds; thereafter, the finisher feeds were fed to market size (7 weeks). Feed and water were provided ad libitum (or free choice) throughout the test.

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* Raw and extruded soybeans were supplied by Oregon State Department of Agriculture and prepared by McDaniel Grain and Feed Company, McMinnville, Oregon.

Males and females were weighed separately, and feed consumption data were obtained at 4 and 7 or 8 weeks of age. Mortality was recorded daily, and dead birds sent to the University Veterinary Diagnostic Laboratory for necropsy.

At the end of experiment 1 (8 weeks of age), three birds of each sex were sacrificed from the groups fed the 100 percent SBM, ESB and RSB with and without zinc bacitracin. Individual body weights were recorded just before sacrificing. Pancreas, liver, kidney, gizzard, proventriculus and abdominal fat were excised, blotted with paper towels and weighed.

Litter scores for all pens for both experiments were obtained at 7 or 8 weeks. Very wet and severely caked litter was scored as 5, and dry-uncaked litter was scored as 1.

RESULTS AND DISCUSSION

Body weight, feed conversion, mortality, litter score and organ weight data for experiment 1 are presented in Tables 3 and 4. Broilers fed RSB as the primary source of protein in both rations were significantly ($P < 0.05$) smaller in body weights and had poorer feed conversion than the broilers fed SBM as the primary protein source. Floor litter was wetter in pens where broilers were fed RSB than in pens where broilers were fed ESB or SBM. Broilers fed 15 or 25 percent RSB as part of the total protein had average body weights and feed conversion similar to the SBM birds. No meaningful differences in mortality were observed. Body weight, litter score and feed conversion were similar between broilers fed either 75 or 100 percent ESB and 100 percent SBM as the primary protein sources.

The addition of zinc bacitracin to the ESB or RSB diets did not improve body weight and feed conversion. Although the feed conversions between the 100 percent ESB with and without zinc bacitracin and SBM were not statistically different, these values for ESB were numerically better than the SBM (2.10 vs. 2.06 or 2.10 vs. 2.04). These differences may be attributed either to the higher energy level in the ESB rations or to better utilization of energy from the ESB ration even though the energy levels of the rations were isocaloric. Since the energy values for ESB were derived from reported values, the difference between this value and the actual metabolizable energy level in this soybean may not be comparable. These data suggest the metabolizable energy may be higher than the value reported.

Comparisons of organ weights for the dietary treatments indicate both rations concerning protein primarily from ESB and RSB produced significantly heavier ($P < 0.05$) pancreatic weights than the SBM treatment (Table 4). Further, significantly heavier ($P < 0.05$) pancreatic weights were obtained from RSB than with ESB. The addition of zinc bacitracin to the RSB ration did not reduce pancreatic size; however, this antibiotic addition to ESB-fed broilers did lower pancreatic weights that were comparable to the SBM groups. Kidney and proventriculus sizes were significantly larger ($P < 0.05$) in RSB than SBM-fed broilers. Addition of zinc bacitracin to the RSB did not prevent enlarged kidneys and proventriculi. Liver and gizzard weights were not affected by feeding either RSB or ESB. Although significant differences were noted in the quantity of abdominal fat, these differences did not reflect the amount of total fat since removing all the fat deposited in the birds was difficult.

Data for body weight, feed conversion, mortality and litter score for experiment 2 are presented in Table 5. Replacing the SBM protein with ESB protein completely in the ration did not significantly lower body weight, feed conversion and mortality. However, feed conversion was numerically better (2.03 vs. 2.01) with ESB-fed broilers. The replacement of SBM protein with 90 and 100 percent of the protein from RSB in the ration significantly ($P < 0.05$) depressed growth and produced higher feed conversion when compared to the data for the SBM group. With 75 percent RSB, body weight and feed conversion were significantly affected when these two parameters were compared to the SBM group. No significant differences in body weight were recorded when 25 and 50 percent of the protein from RSB replaced similar amounts of protein of SBM. When 0.05 percent d, l methionine was added to the 100 percent RSB ration (0.16 percent d, l methionine added), no statistical significant differences in feed conversion and average body weight were noted.

Broilers fed high energy ration with 100 percent protein from RSB showed a significantly heavier or better ($P < 0.05$) body weight and feed efficiency than the comparable RSB ration with medium energy. Broilers fed all SBM as the protein source with higher energy level performed numerically better in growth and feed conversion than the similar SBM level with medium energy.

Mortality was not affected except for both 100 percent RSB treatments. The increase loss within this protein source suggests a causal relationship.

Pen litter was wetter by comparison and caked in all dietary groups except for the group fed low energy SBM. Broilers fed RSB produced much wetter and caked litter pens than the birds fed ESB.

From the data obtained in these two experiments, protein from RSB can replace SBM protein up to 50 percent in broiler feeds. Higher levels will depress growth and produce poor feed conversion. ESB protein can replace 100 percent of the protein of SBM in broiler feeds.

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Table 1. Compositions of broiler starter and finisher rations (Experiment 1).

Ingredients	Starter SBM (%)	Starter ESB (%)	Starter RSB (%)	Finisher SBM (%)	Finisher ESB (%)	Finisher RSB (%)
Yellow corn	54.85	50.32	50.32	57.63	55.72	55.72
Barley	---	2.00	2.00	---	---	---
Soybean meal solvent, 48.5%	30.00	---	---	26.00	---	---
Raw full-fat soybean	---	---	38.00	---	---	33.00
Extruded full-fat soybean	---	38.00	---	---	33.00	---
Soybean oil	5.50	---	---	6.00	1.00	1.00
Herring meal, 70%	5.50	5.50	5.50	5.00	5.00	5.00
Dehydrated alfalfa meal, 17%	1.25	1.25	1.25	2.50	2.50	2.50
Defluorinated phosphate	1.45	1.35	1.35	1.45	1.35	1.35
Limestone flour	.80	.80	.80	.70	.70	.70
Salt, iodized	.35	.35	.35	.35	.35	.35
Vitamin premix[1]	.20	.20	.20	.20	.20	.20
dl-methionine	.10	.13	.13	.07	.05	.05
Coccidiostat[2]	.05	.05	.05	.05	.05	.05
Trace mineral[3]	.05	.05	.05	.05	.05	.05
Calculated analyses:						
Crude protein, %	23.30	23.30	23.30	21.50	21.50	21.50
Metabolizable energy, Kcal./Kg.	3297	3290	3290	3340	3339	3339
Lysine, %	1.35	1.35	1.35	1.22	1.22	1.22
Methionine + cystine, %	.91	.92	.92	.82	.82	.82

1. Supplied per kilogram of ration: 3340 I.U. vitamin A; 1102 I.C.U. vitamin D_3; 3.3 mg. riboflavin; 5.5 mg. d-pantothenic acid; 22.0 mg. niacin; 169.3 mg. choline; 5.5 mcg. vitamin B_{12}; 1.1 I.U. vitamin E; 0.55 mg. vitamin K; 1.0 mg. folacin.

2. Zoamix, Dow Chemical Company, Midland, Michigan.

3. Supplied per kilogram of ration: 60 mg. manganese; 20 mg. iron; 2.0 mg. copper; 1.2 mg. iodine; 26.2 mg. zinc; 97.3 mg. calcium.

Table 2. Compositions of broiler starter and finisher rations (Experiment 2).

Ingredients	Starter				Finisher			
	SBM (%)	ESB (%)	RSB (%)	RSB+0.05% meth. (%)	SBM (%)	ESB (%)	RSB (%)	RSB+0.05% meth. (%)
Yellow corn	56.35	31.95	31.95	31.90	61.52	42.68	42.68	42.68
Barley	---	18.74	18.74	18.74	---	15.00	15.00	15.00
Soybean meal solvent-47.5%	32.25	---	---	---	27.50	---	---	---
Extruded full-fat soybean	---	41.25	---	---	---	34.50	---	---
Raw full-fat soybean	---	---	41.25	41.25	---	---	34.50	34.50
Meat and bone meal	5.00	6.00	6.00	6.00	5.00	6.00	6.00	6.00
Animal fat	4.00	---	---	---	4.00	---	---	---
Dehydrated alfalfa meal-17%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Defluorinated phosphate	.42	---	---	---	.25	---	---	---
Limestone flour	.35	.35	.35	.35	.13	.13	.13	.13
Salt (iodized)	.25	.25	.25	.25	.25	.25	.25	.25
Vitamin premix[1]	.20	.20	.20	.20	.20	.20	.20	.20
dl-methionine	.13	.16	.16	.21	.10	.14	.14	.19
Coccidiostat[2]	.05	.05	.05	.05	.05	.05	.05	.05
Trace mineral mix[3]	.05	.05	.05	.05	.05	.05	.05	.05
Calculated analyses:								
Crude protein, %	23.10	23.30	23.30	23.30	21.20	21.30	21.30	21.30
Met. energy, kcal/kg	3152	3161	3161	3159	3180	3194	3194	3193
Lysine, %	1.27	1.31	1.31	1.31	1.31	1.16	1.16	1.16
Methionine + cystine, %	.88	.88	.88	.92	.79	.81	.81	.85

1. Supplied per kilogram of ration: 3340 I.U. vitamin A; 1120 I.C.U. vitamin D_3; 3.3 mg. riboflavin; 5.5 mg. d-pantothenic acid; 22.0 mg. niacin; 169.3 mg. choline; 5.5 mcg. vitamin B_{12}; 1.1 I.U. vitamin E; 0.55 mg. vitamin K; 1.0 mg. folacin.

2. Zoamix, Dow Chemical Company, Midland, Michigan.

3. Supplied per kilogram of ration: 60 mg. manganese; 20 mg. iron; 2.0 mg. copper; 1.2 mg. iodine; 26.2 mg. zinc; 97.3 mg. calcium.

Table 3. Effect of feeding solvent extracted soybean (SBM), extruded (ESB) and raw full-fat soybeans (RSB) with and without Zinc Bacitracin (Zn-Bac) on broiler body weight, feed conversion, mortality, and litter score at 8 weeks (Experiment 1).

Treatments	M+F Ave.Body wt. (lbs.)[1]	F.C[1] (feed/ body wt.)	Mortality (dead/ started)	Ave. Litter Score[2]
SBM	4.72[b,c,d]	2.10[a]	1/52	1.87
ESB	4.68[b,c,d]	2.06[a]	0/52	2.50
3/4 ESB-1/4 SBM	4.58[b]	2.05[a]	0/52	2.13
RSB	3.98[a]	2.38[b,c]	1/52	4.25
1/4 RSB-3/4 SBM	4.84[d]	2.08[a]	0/52	2.50
15 RSB-85 SBM	4.61[b,c]	2.21[a,b]	1/52	2.75
ESB + 50 gm. Zn-Bac/T	4.62[b,c]	2.04[a]	2/52	1.75
3/4 ESB-1/4 SBM + 50 gm. Zn-Bac/T	4.84[d]	2.12[a]	3/52	2.25
RSB + 50 gm. Zn-Bac/T	3.91[a]	2.43[c]	1/52	3.28
1/4 RSB-3/4 SBM + 50 gm. Zn-Bac/T	4.62[b,c]	2.15[a]	1/52	1.87
15 RSB-85 SBM + 50 gm. Zn-Bac/T	4.77[c,d]	2.16[a]	2/52	3.13

1. Values with different subscripts are significantly different at $P < 0.05$.
2. Litter scored visually: 1 = very dry; 5 = very wet.

Table 4. Effect of feeding solvent extracted (SBM), extruded (ESB) and raw (RSB) full-fat soybeans on organ size of broilers at 8 weeks of age (Experiment 1).

Soybeans	Ave.[2] Body wt. (gms.)	Ave. Organ Weights[1,2]					
		Pancreas	Liver	Kidney	Gizzard	Provent.	Abdom. fat.
SBM	2359^{b}	.1848^{a}	1.77^{a}	.5933^{a,b}	1.64^{a}	.243^{a}	3.16^{c}
ESB	2359^{b}	.3226^{b}	1.95^{a}	.5925^{a,b}	1.84^{a}	.295^{a,b}	1.80^{a}
RSB	2004^{a}	.4343^{c}	2.08^{a}	.6739^{c}	1.83^{a}	.333^{b}	2.96^{b,c}
ESB + 50 gms. Zn-Bac/T	2433^{b}	.2126^{a}	1.91^{a}	.5562^{a}	1.64^{a}	.292^{a,b}	2.44^{a,b,c}
RSB + 50 gms. Zn-Bac/T	2215^{a,b}	.4626^{c}	2.08^{a}	.6369^{b,c}	1.81^{a}	.315^{b}	2.18^{a,b}

1. Grams of organ weight per 100 grams of body weight.

2. Values with different superscripts are significant at $P < 0.05$.

Table 5. Effect of feeding solvent extracted soybean (SBM), extruded (ESB) and various levels of raw full-fat soybeans (RSB) on broiler body weight, feed conversion, mortality and litter score at 7 weeks of age (Experiment 2).

Treatments	M&F Ave. Body wts. lbs.[1]	F.C.[1] (feed/ body wt.)	Mortality (dead/ started)	Ave. Litter Score[2]
SBM (med. energy)[3]	3.97[e]	2.03[a]	3/72	1.00
ESB (med. energy)	3.92[e]	2.01[a]	0/72	2.67
RSB (med. energy)	3.00[a]	2.36[d]	6/72	3.67
90 RSB + 10 SBM (med. energy)	3.15[a,b]	2.29[c,d]	6/72	4.00
3/4 RSB + 1/4 SBM (med. energy)	3.33[b,c]	2.27[c,d]	0/72	3.67
1/2 RSB + 1/2 SBM (med. energy)	3.81[d,e]	2.16[b]	1/72	3.33
1/4 RSB + 3/4 SBM (med. energy)	3.90[e]	2.05[a]	1/72	2.67
RSB + 0.05% meth (med. energy)	2.88[a]	2.31[c,d]	12/72	4.00
RSB (high energy)[4]	3.56[c,d]	2.25[c]	3/72	4.33
SBM (high energy)	4.12[e]	1.96[a]	3/72	3.00

1. Values with different superscripts are significantly different at $P < 0.05$.

2. Litter scored visually: 1 = very dry, 5 = very wet and caked.

3. Medium energy - starter: 3161 kcal ME/kg
   finisher: 3194 kcal ME/kg.

4. High energy - starter: 3297 kcal ME/kg
   finisher: 3340 kcal ME/kg.