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Dietary Effects of Soy Isoflavones on Growth and Carcass Traits of Commercial Broilers[1,2]

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ABSTRACT Three experiments (EXP) were conducted to determine the effect of soy isoflavones (ISF) on growth and carcass traits of commercial broilers. The EXP were conducted simultaneously and a common control was used. In each EXP, treatments were replicated five times with five chicks each. Average initial and final BW were 102 and 2,890 g, 102 and 2,657 g, and 102 and 2,803 g for EXP 1, 2, and 3, respectively, and the EXP were conducted from 9 to 52 d posthatching. In EXP 1, the effects of graded levels of supplemental ISF above those typically found in a corn-soybean meal (C-SBM) diet were studied. The treatments were 1) C-SBM, 2) C-SBM + ISF levels two times those in C-SBM (2×), and 3) C-SBM + ISF levels five times those in C-SBM (5×). The 2× and 5× levels of ISF decreased gain:feed (linear, $P < 0.04$) but increased ($P < 0.04$) breast weight compared with the C-SBM diet. Other performance and carcass traits were not affected ($P > 0.05$) by treatment. In EXP 2, the effects of low ISF levels in a C-soy protein concentrate (C-SPC) diet were studied. The treatments were 1) C-SBM, 2) C-SPC (low ISF), and 3) C-SPC + ISF (ISF levels equal to those in C-SBM). Average daily gain (ADG) and average daily feed intake (ADFI) were decreased (16 and 9%, respectively; $P < 0.01$) in chicks fed the C-SPC diets, regardless of ISF level. Gain:feed of chicks fed the C--SPC + ISF diet was decreased 9% ($P < 0.02$) compared with chicks fed the C-SBM diet, and gain:feed of chicks fed C-SPC was intermediate between the two. Carcass traits were not affected ($P > 0.05$) by treatment. In EXP 3, the effects of low ISF levels in a low CP diet were studied. The treatments were 1) C-SBM, 2) low CP (17, 14, and 12% in the starter, growing, and finishing diets, respectively) with supplemental crystalline amino acids (low CP-AA), and 3) low CP-AA + ISF (ISF levels equal to C-SBM). Daily gain and gain:feed were decreased from 7 to 9% ($P < 0.01$) in chicks fed the low CP-AA and low CP-AA + ISF diet relative to those fed the C-SBM diet. Abdominal fat pad percentage was increased ($P < 0.01$) in chicks fed the low CP-AA diets compared with those fed the C-SBM diet. Dietary ISF can affect ADG and ADFI and may affect carcass traits in some instances.

(*Key words*: broiler, isoflavone, growth, carcass trait)

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INTRODUCTION

Chicken consumption and production continue to increase, and producers are faced with finding ways to increase profitability while decreasing fat and increasing lean meat yield in commercial broilers. Research is being conducted to evaluate ways to decrease fat deposition in broiler chickens. One potential dietary supplement that may affect lean and fat deposits is soy isoflavones (ISF). Isoflavones are diphenolic compounds and are one of three naturally occurring phytoestrogens (Kudou et al., 1991). The ISF exist in conjugated or unconjugated (aglycone) forms; the aglycone ISF forms are daidzein, genistein, and glycitein (Kudou et al., 1991). Isoflavones have several biological properties including inhibition of tyrosine kinase and DNA topoisomerase, antioxidant activity, immune system activity, and estrogenic and antiestrogenic activities (Kurzer and Xu, 1997; Zhang et al., 1997). They are structurally and functionally similar to natural estrogens and can weakly bind to estrogen receptors, causing competition with natural estrogens (Kurzer and Xu, 1997).

Isoflavones may have efficacy as a feed supplement to decrease fat deposition in animals because of this estro-

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Abbreviation Key: AA = amino acid; ADFI = average daily feed intake; ADG = average daily gain; C = corn; EXP = experiment; ISF = soy isoflavone; SBM = soybean meal; SPC = soy protein concentrate; 2× = two times isoflavone level; 5× = five times isoflavone level.

gen-like function. Cook (1998) reported that supplemental ISF (1,585 mg/kg diet) increases growth rate and carcass muscling, but carcass fat is not affected in pigs from 6 to 32 kg BW. Payne et al. (2001) reported that addition of ISF to a corn-soy protein concentrate diet (C-SPC), practically void of ISF, increases carcass leanness and decreases carcass fat and results in carcass traits similar to, or better than, those of barrows fed corn-soybean meal (C-SBM). However, in a second study, Payne et al. (2001) reported that ISF supplementation in excess of that present in a typical C-SBM diet does not affect growth performance, carcass traits, or meat quality of growing-finishing gilts. The different responses in barrows versus gilts may be due to the different treatments used or to an actual gender difference. Previous research indicates that barrows respond more to fed or implanted estrogenic hormones than gilts (DeWilde and Lauwers, 1984; Plimpton and Teague, 1972).

To our knowledge, there has been no research conducted with ISF in poultry. Therefore, the objectives of this research were to determine the effects of ISF on growth performance and carcass traits of commercial broilers. The effects of graded levels of ISF in a C-SBM diet were evaluated as well as the effect of ISF below those typically found in C-SBM diets. This latter objective was determined with a diet containing SPC, which is essentially void of ISF, and also with a diet containing low levels of CP but with crystalline amino acids (AA) added.

MATERIALS AND METHODS

General

Three experiments (EXP) were conducted with 175 Cornish × Plymouth Rock male broilers to evaluate the effects of ISF on growth and carcass traits of commercial broilers. Average initial and final BW were 102 g and 2,890 g, 102 g and 2,657 g, and 102 g and 2,803 g for EXP 1, 2, and 3, respectively. Chicks were placed on a standard C-SBM starter diet formulated to meet or exceed the nutrient requirements from Days 0 to 8 posthatching (NRC, 1994). On Day 8, the chicks were held overnight without feed and water and were then allotted to dietary treatments on Day 9 in a completely randomized design. They were weighed before allotment, and the extreme high and low weight chicks were discarded. Chicks were housed in thermostatically controlled starter batteries with raised wire floors and continuous fluorescent lighting from Days 9 to 21. After Day 21 and until Day 52, they were housed in finishing batteries with raised wire floors. Feed in mash form and water were provided ad libitum throughout the EXP. Feed was provided in three growth phases. The starter phase was fed from Days 9 to 21, followed by the growing phase from Days 21 to 42, and the finishing phase diet was fed from Days 42 to 52. The EXP were conducted simultaneously, and the C-SBM treatment was used as the control for all three EXP. Each treatment was replicated five times with five chicks each.

Prevastein,[4] a concentrated ISF product, was used to provide supplemental ISF in all EXP. In EXP 1, the effects of graded levels of supplemental ISF above those typically found in a C-SBM diet were studied. The basal diets for all EXP are reported in Table 1. The treatments for EXP 1 were 1) C-SBM, 2) C-SBM + ISF levels two times those in C-SBM (2×), and 3) C-SBM + ISF levels five times those in C-SBM (5×). These ISF levels were provided by the addition of 0, 1.20, or 4.79% supplemental Prevastein in the starter period; 0, 0.89, or 3.56% supplemental Prevastein in the growing period; and 0, 0.68, or 2.78% supplemental Prevastein in the finishing period, respectively. The ISF levels in Diets 1 to 3 were 346.7, 693.3, and 1,733.3 mg/kg for the starter period; 257.9, 515.8, and 1,289.5 mg/kg in the growing period; and 202.4, 404.8, and 1,012.0 mg/kg in the finishing period, respectively.

In EXP 2, the effect of low ISF levels in a C-SPC diet was studied. The treatments were 1) C-SBM, 2) C-SPC (low ISF), and 3) C-SPC + ISF (ISF levels equal to those in C-SBM). These ISF levels were provided by the addition of 0, 0, or 1.14% supplemental Prevastein in the starter period; 0, 0, or 0.85% supplemental Prevastein in the growing period; and 0, 0, or 0.66% supplemental Prevastein in the finishing period, respectively. The ISF levels in Diets 1 to 3 were 346.7, 13.4, and 346.7 mg/kg for the starter period; 257.9, 9.98, and 257.9 mg/kg in the growing period; and 202.4, 8.1, and 202.4 mg/kg in the finishing period, respectively.

In EXP 3, the effects of low ISF levels in a low CP diet were studied. The treatments were 1) C-SBM, 2) low CP with supplemental crystalline AA (low CP-AA), and 3) low CP-AA + ISF (ISF levels equal to C-SBM). These ISF levels were provided by addition of 0, 0, or 0.48% supplemental Prevastein in the starter period; 0, 0, or 0.52% supplemental Prevastein in the growing period; and 0, 0, or 0.48% supplemental Prevastein in the finishing period, respectively. The ISF levels in Diets 1 to 3 were 346.7, 207.6, and 346.7 mg/kg for the starter period; 257.9, 108.7, and 257.9 mg/kg in the growing period; and 202.4, 59.6, and 202.4 mg/kg in the finishing period, respectively.

The diets for EXP 3 were formulated to meet the true digestible histidine requirement from the protein in corn and SBM, and the other AA were added in crystalline form. All diets were formulated to meet the true digestible AA requirements and ratios as suggested by Emmert and Baker (1997). The ideal protein ratios used for isoleucine and tryptophan were 0.67 and 0.16 in the starter period, and 0.69 and 0.17 in the growing and finishing periods, respectively (D. H. Baker, 2000, University of Illinois, Urbana, IL 61801, personal communication). Digestibility of AA was calculated using true digestibility coefficients of Heartland Lysine, Inc.[5]

Diets in all EXP were formulated to have equal ME levels, and all other nutrients met or exceeded the nutrient requirements of commercial broilers (NRC, 1994). Diet

[4]Central Soya, Co., Inc., Fort Wayne, IN 46801.
[5]Heartland Lysine, Inc., Chicago, IL 60631.

TABLE 1. Composition of starter diets[1,2]

Ingredient	C-SBM	C-SBM +2× ISF	C-SBM +5× ISF	C-SPC	C-SPC +ISF	Low CP-AA[3]	Low CP-AA + ISF[3]
Corn	57.30	56.25	53.13	71.96	70.78	71.12	70.72
Soybean meal (47.5% CP)	33.77	33.29	31.86	. . .	. . .	20.22	20.02
Soy protein concentrate[4]	. . .	. . .	. . .	23.35	23.04	. . .	. . .
Corn oil	4.64	4.96	5.89	0.30	0.65	2.69	2.81
Monocalcium phosphate	1.57	1.58	1.61	1.51	1.52	1.66	1.66
Limestone	1.47	1.46	1.46	1.56	1.55	1.54	1.54
Mineral premix[5]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix[6]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Choline chloride	0.07	0.07	0.08	0.18	0.18	0.07	0.07
DL-Methionine	0.15	0.15	0.15	0.14	0.14	0.30	0.30
L-Threonine	0.03	0.04	0.03	. . .	. . .	0.23	0.23
L-Lysine·HCl	. . .	. . .	. . .	. . .	. . .	0.48	0.48
L-Arginine·HCl	. . .	. . .	. . .	. . .	. . .	0.28	0.28
L-Isoleucine	. . .	. . .	. . .	. . .	. . .	0.19	0.19
L-Tryptophan	. . .	. . .	. . .	. . .	. . .	0.04	0.04
L-Valine	. . .	. . .	. . .	. . .	. . .	0.18	0.18
Isoflavone[7]	. . .	1.20	4.79	. . .	1.14	. . .	0.48
Calculated composition							
ME, kcal/kg	3,200	3,200	3,200	3,200	3,200	3,200	3,200
Crude fat, %	7.89	8.19	9.06	3.89	4.14	6.07	6.19
Crude protein, %	20.90	20.96	21.10	21.41	21.46	17.06	17.07
Lysine, %[8]	1.25	1.25	1.25	1.19	1.19	1.22	1.22
Methionine, %[8]	0.51	0.51	0.51	0.50	0.50	0.58	0.58
TSAA, %[8]	0.90	0.90	0.90	0.86	0.87	0.89	0.89
Tryptophan, %[8]	0.24	0.25	0.25	0.26	0.26	0.20	0.20
Threonine, %[8]	0.84	0.85	0.85	0.85	0.85	0.81	0.81
Calcium, %[9]	1.00 (1.13)	1.00 (1.08)	1.00 (1.10)	1.00 (1.22)	1.00 (1.12)	1.00 (1.04)	1.00 (1.04)
Available phosphorous, %	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Potassium, %[9]	0.92 (1.06)	0.93 (1.08)	0.97 (1.13)	0.82 (0.81)	0.83 (0.78)	0.67 (0.72)	0.68 (0.78)
Isoflavone, mg/kg[10]	346.70	693.30	1,733.26	13.43	346.70	207.60	346.70

[1]C-SBM = corn-soybean meal; ISF = isoflavone; C-SPC = corn-soy protein concentrate; Low CP-AA = low crude protein with supplemental crystalline amino acids; 2× = two times; 5× = five times. The C-SBM diet was used as the control for all experiments.

[2]Grower and finisher diets were similar to the starter diet. The grower diets were formulated to 3,206 kcal/kg ME, 1,300 mg/kg choline, 0.89% true digestible (TD) lysine, 0.67% TD TSAA, 0.90% calcium, and 0.35% available phosphorous. The finisher diets were formulated to 3,223 kcal/kg ME, 1,000 mg/kg choline, 0.76% TD lysine, 0.57% TD TSAA, 0.80% calcium, and 0.30% available phosphorous.

[3]Low crude protein diets for the grower and finisher diets were similar to the starter diet, but they contained 0.33 and 0.34% L-arginine·HCl, 0.17 and 0.16% L-isoleucine, 0.51 and 0.51% L-lysine·HCl, 0.24 and 0.19% DL-methionine, 0.22 and 0.19% L-threonine, 0.06 and 0.06% L-tryptophan, and 0.17 and 0.15% L-valine, respectively. The finisher diets also contained 0.05% L-glycine.

[4]Profine E, Central Soya Co., Inc., Fort Wayne, IN 46801.

[5]Provided per kilogram of diet: copper (copper sulfate·5 H_2O), 4.0 mg; iodine (potassium iodate), 1.0 mg; iron (ferrous sulfate·7 H_2O), 60 mg; manganese (manganese sulfate·H_2O), 60 mg; selenium (as sodium selenite), 0.1 mg; zinc (zinc sulfate·7H_2O), 44 mg; calcium (calcium carbonate), 723 mg.

[6]Provided per kilogram of diet: vitamin A (vitamin A palmitate), 4,500 IU; vitamin D3, 450 IU; vitamin E (vitamin E acetate), 50 IU; menadione (menadione sodium bisulfite), 1.5 mg; vitamin B_{12}, 0.02 mg; biotin (d-biotin), 0.6 mg; folacin (folic acid), 6 mg; niacin, 50 mg; thiamin (thiamin·HCl), 13.4 mg.

[7]Prevastein, Central Soya Co., Inc., Fort Wayne, IN 46801.

[8]Values are based on the actual amino acid analysis of the ingredients; with the exception of SPC, which used amino acid analysis provided by Central Soya Co., Inc., Fort Wayne, IN 46801. See Table 2.

[9]Analyzed mineral concentrations in the diets are reported in parentheses. Mineral concentration was determined using inductively coupled plasma emission spectroscopy after digestion by nitric acid and hydrogen peroxide.

[10]In Experiment 1, the isoflavone levels in Diets 1 to 3 were 257.9, 515.8, and 1,289.5 mg/kg in the growing period and 202.4, 404.8, and 1,012.0 mg/kg in the finishing period, respectively. In Experiment 2, the isoflavone levels in Diets 1 to 3 were 257.9, 9.98, and 257.9 mg/kg in the growing period and 202.4, 8.1, and 202.4 mg/kg in the finishing period, respectively. In Experiment 3, the isoflavone levels in Diets 1 to 3 were 257.9, 108.7, and 257.9 mg/kg in the growing period and 202.4, 59.6, and 202.4 mg/kg in the finishing period, respectively.

formulations were based on an initial AA analysis of corn, SBM, and Prevastein (Table 2). The AA content of SPC was provided by Central Soya Co. (Table 2). The ME used for SPC and Prevastein in poultry were 3,235 and 1,364 kcal/kg, respectively. The AA compositions of corn, SBM, and Prevastein were determined after acid hydrolysis (AOAC, 1990). Sulfur AA were determined after performic acid oxidation followed by acid hydrolysis (AOAC, 1990). Tryptophan was determined after alkaline hydrolysis (AOAC, 1990). The true digestibility coefficients of SBM were used in determining the true digestible AA content of Prevastein. The mineral composition of the diets and SPC was determined using inductively coupled plasma emission spectroscopy[6] after samples were digested in nitric acid and hydrogen peroxide.

[6]Optima 3000, Perkin-Elmer, Norwalk, CT 06859.

TABLE 2. Total amino acid analysis[1]

Ingredient	Corn digestibility coefficient	Corn[2]	Corn[3]	SBM digestibility coefficient	SBM	ISF[4]	SPC digestibility coefficient	SPC[5]
Arginine, %	90.0	0.35	0.42	92.9	3.85	1.95	98.5	5.08
Cysteine, %	81.4	0.19	0.18	83.7	0.84	0.59	94.2	0.99
Glycine, %	. . .	0.33	0.33	. . .	2.14	1.22	. . .	2.85
Histidine, %	88.0	0.23	0.25	89.6	1.37	0.76	96.8	1.78
Isoleucine, %	88.5	0.24	0.31	91.8	2.25	1.33	97.3	2.96
Leucine, %	93.8	0.89	1.18	92.0	3.92	2.35	97.3	5.39
Lysine, %	81.3	0.25	0.26	90.6	3.28	1.50	96.1	4.34
Methionine, %	91.0	0.19	0.21	92.0	0.75	0.40	96.3	0.95
Phenylalanine, %	91.0	0.35	0.49	92.3	2.58	1.62	97.8	3.36
Serine, %	. . .	0.38	0.41	. . .	2.44	1.32	. . .	3.79
Tyrosine, %	. . .	0.21	0.30	. . .	1.82	1.08	97.8	2.38
Threonine, %	82.7	0.26	0.32	88.4	1.97	1.15	95.7	2.85
Tryptophan, %	78.5	0.06	0.05	87.8	0.62	0.44	95.1	0.92
Valine, %	87.3	0.33	0.43	90.9	2.40	1.48	96.2	3.36

[1]SBM = soybean meal; ISF = isoflavone; SPC = soy protein concentrate. True ileal digestibility was calculated by using Heartland Lysine, Inc. (Chicago, IL 60631) digestibility coefficients for poultry, 1998. The SBM digestibility coefficients were used to determine true digestible amino acid content of ISF.

[2]Corn used during starter period (9 to 21 d) of trial.

[3]Corn used during growing (21 to 42 d) and finishing (42 to 52 d) periods.

[4]Prevastein, Central Soya Co., Inc., Fort Wayne, IN 46801.

[5]Profine E, Central Soya Co., Inc., Fort Wayne, IN 46801.

Soybean meal, SPC, and Prevastein were analyzed for aglycone daidzein, aglycone genistein, and aglycone glycitein concentrations (Thiagarajan et al., 1998). Isoflavone concentration was determined by extraction with an 80:20 methanol:0.1 *N* hydrochloric acid mixture. A filtered aliquot was analyzed by HPLC with a C18 column and ultraviolet detection. The SBM contained 1.14 mg total ISF/g, which consisted of 0.54 mg daidzein/g, 0.15 mg glycitein/g, and 0.45 mg genistein/g adjusted for aglycone content. The SPC contained 0.06 mg total ISF/g, which consisted of 0.03 mg daidzein/g, 0 mg glycitein/g, and 0.03 mg genistein/g adjusted for aglycone content. The Prevastein contained 29.4 mg total ISF/g, which consisted of 11.6 mg daidzein/g, 1.35 mg glycitein/g, and 16.4 mg genistein/g adjusted for aglycone content.

At the end of each growth phase, all chicks and feeders were weighed for calculation of average daily gain (ADG), average daily feed intake (ADFI), and gain:feed. At the conclusion of the EXP, three chicks per replicate were randomly selected for slaughter. The chicks were taken off feed and water for 6 h and then transported to the Louisiana State University Agricultural Center Poultry Science Slaughter Facility for processing. Immediately after evisceration, whole, ready-to-cook carcass and abdominal fat pad weights were recorded. The carcasses were then chilled for 2 h in an ice-water bath. After the chilling period, each carcass was processed into front and rear halves by separating behind the seventh rib and between the notarium (thoracic vertebrae) and the synsacrum (lumbar vertebrae). Front half weight, rear half weight, and left breast weight were recorded.

Carcass yield was calculated using the following equation: [(whole, ready-to-cook weight/final BW) × 100]. Left breast, front half, rear half, and fat pad weight were calculated similarly, and all carcass trait data were expressed as a percentage of final BW of the chicks used for collection of the carcass data.

Statistical Analysis

Data in each EXP were analyzed by analysis of variance procedures (Steel and Torrie, 1980) appropriate for a completely randomized design. Effects of graded levels of ISF (EXP 1) were evaluated by linear and quadratic contrasts appropriate for unequally spaced treatments. The coefficients used in the contrast statements were calculated using the interactive matrix language procedure of SAS.[7] The results for EXP 2 and 3 were evaluated by the general linear models procedure of SAS using the pdiff option. The pen of chicks was the experimental unit for all data.

RESULTS

EXP 1

Gain:feed (linear, $P < 0.04$) was decreased by both the 2× and 5× levels of ISF (Table 3). Daily gain and feed intake were not affected ($P > 0.05$) by ISF. Front and rear half and fat pad weights as a percentage of final BW were not affected ($P > 0.05$) by ISF. There were no linear or quadratic effects ($P = 0.12$) of ISF on left breast weight. However, a comparison of the C-SBM diet with the two diets with added ISF suggests that ISF increases ($P < 0.04$) breast weight.

EXP 2

Average daily gain and ADFI were decreased ($P < 0.05$) in chicks fed the C-SPC and C-SPC + ISF diets compared

[7]SAS Inst. Inc., Cary, NC 27513.

TABLE 3. Effect of soy isoflavones on growth and carcass traits (Experiment 1)[1]

Item	C-SBM	C-SBM + 2× ISF	C-SBM + 5× ISF	Pooled SEM
Daily gain, g	63.41	60.57	61.91	1.01
Daily feed intake, g	113.34	111.34	115.62	2.05
Gain:feed,[a] g	0.560	0.544	0.536	0.007
Mortality	3	3	2	
Final BW,[2] g	2,956	2,827	2,888	45
Final BW,[3] g	2,967	2,961	3,053	46
Carcass yield, %	69.70	69.81	70.05	0.61
Left breast PBW[b]	6.94	7.48	7.40	0.18
Front half PBW	39.65	39.67	39.72	0.38
Rear half PBW	31.06	30.96	31.12	0.34
Fat pad PBW	1.07	1.16	1.20	0.11

[a]Linear, $P < 0.04$.

[b]C-SBM versus C-SBM + 2× ISF and C-SBM + 5× ISF, $P < 0.04$.

[1]Data are means of five replicates of five (growth data) or three (carcass data) chicks per replicate. The initial weight was 102 g, and the experiment lasted from 9 to 52 d posthatching. C-SBM = corn-soybean meal; C-SBM + 2× ISF = C-SBM plus two times the isoflavone (ISF) levels present in C-SBM; C-SBM + 5× ISF = C-SBM plus five times the ISF levels found in C-SBM; PBW = percentage of final body weight.

[2]Final body weight of all chicks in experiment.

[3]Final body weight of only the chicks selected for the carcass data.

with those fed the C-SBM diet (Table 4). Gain:feed was decreased ($P < 0.02$) in chicks fed the C-SPC + ISF diet compared to those fed the C-SBM diet. Chicks fed the C-SPC had gain:feed intermediate between chicks fed the C-SBM and C-SPC + ISF diets. Carcass traits were not affected ($P > 0.05$) by diet.

EXP 3

Average daily gain and gain:feed were decreased ($P < 0.01$) in chicks fed the low CP-AA and low CP-AA + ISF diets compared with those fed the C-SBM diet (Table 5). Feed intake was not affected ($P > 0.05$) by diet. Abdominal fat pad weight as a percentage of final BW was increased ($P < 0.01$) in chicks fed the low CP-AA or low CP-AA + ISF diets compared with those fed the C-SBM diet.

DISCUSSION

The effects of soy ISF on growth performance and carcass traits of animals have been variable (Winters and Banz, 1997; Cook, 1998; Payne et al., 2001). However, to our knowledge, no previous research has been conducted to determine the effects of ISF in commercial broilers. In this study, ISF levels in excess of those in a C-SBM diet decreased gain:feed but did not affect ADG or ADFI. These excess levels of ISF also increased percentage of breast, which is in agreement with results in nursery pigs (Cook, 1998) but not in growing-finishing gilts (Payne et al., 2001).

Diets with low levels of ISF (C-SPC) did not negatively affect percentage of breast or carcass yield compared with ISF levels in the C-SBM or C-SPC + ISF diets (EXP 2).

TABLE 4. Effect of soy isoflavones on growth and carcass traits (Experiment 2)[1]

Item	C-SBM	C-SPC	C-SPC + ISF	Pooled SEM
Daily gain, g	63.41[a]	54.09[b]	52.84[b]	1.52
Daily feed intake, g	113.34[a]	101.96[b]	104.49[b]	2.86
Gain:feed	0.560[a]	0.532[ab]	0.506[b]	0.014
Mortality	3	2	2	
Final BW,[2] g	2,956[a]	2,534[b]	2,481[b]	68
Final BW,[3] g	2,967[a]	2,563[b]	2,563[b]	66
Carcass yield, %	69.70	69.54	70.15	0.57
Left breast PBW	6.94	7.39	7.15	0.22
Front half PBW	39.65	39.47	39.53	0.65
Rear half PBW	31.05	31.04	31.77	0.35
Fat pad PBW	1.07	1.13	0.97	0.08

[a,b]Means within a row with different superscripts differ, $P < 0.05$.

[1]Data are means of five replicates of five (growth data) or three (carcass data) chicks per replicate. The initial weight was 102 g and the experiment lasted from 9 to 52 d posthatching. C-SBM = corn-soybean meal; C-SPC = corn-soy protein concentrate; C-SPC + ISF = corn-soy protein concentrate plus isoflavones to equal the level in C-SBM; PBW = percentage of body weight.

[2]Final body weight of all chicks in experiment.

[3]Final body weight of only the chicks selected for the carcass data.

TABLE 5. Effect of soy isoflavones on growth and carcass traits (Experiment 3)[1]

Item	C-SBM	Low CP-AA	Low CP-AA + ISF	Pooled SEM
Daily gain, g	63.41[a]	57.91[b]	58.69[b]	1.05
Daily feed intake, g	113.34	112.16	114.66	2.01
Gain:feed	0.560[a]	0.517[b]	0.512[b]	0.008
Mortality	3	2	0	
Final BW,[2] g	2,956[a]	2,708[b]	2,744[b]	47
Final BW,[3] g	2,967[a]	2,787[b]	2,797[b]	49
Carcass yield, %	69.70	71.09	70.67	0.62
Left breast PBW	6.94	7.02	7.24	0.25
Front half PBW	39.65	39.35	39.36	0.57
Rear half PBW	31.06	31.98	31.62	0.39
Fat pad PBW	1.07[a]	1.92[b]	1.62[b]	0.11

[a,b]Means within a row with different superscripts differ, $P < 0.05$.

[1]Data are means of five replicates of five (growth data) or three (carcass data) chicks per replicate. The initial weight was 102 g and the experiment lasted from 9 to 52 d posthatching. C-SBM = corn-soybean meal; Low CP-AA = low crude protein with supplemental crystalline amino acids; Low CP-AA + ISF = low crude protein with supplemental crystalline amino acids plus isoflavones to equal the level present in C-SBM; PBW = percentage of final body weight.

[2]Final body weight of all chicks in experiment.

[3]Final body weight of only the chicks selected for slaughter data.

These findings are in contrast to results from a study with pigs (barrows), in which a C-SPC (low ISF) diet resulted in decreased leanness and increased fatness, but addition of ISF to the C-SPC diets resulted in carcass traits equal to or better than those of the barrows fed the C-SBM diet (Payne et al., 2001).

In our study, ADG, ADFI, and feed efficiency were decreased in both diets containing SPC, regardless of ISF, compared to the C-SBM diet. Emmert and Baker (1995) reported that ADG and ADFI are decreased in chicks fed semi-purified diets containing SPC, relative to a semi-purified diet containing SBM. However, feed efficiency and protein efficiency ratio are not affected by protein sources. Other researchers also have reported that refined soy products result in decreased ADG, ADFI, and gain:feed in broiler chicks compared with those fed C-SBM diets (Welch et al., 1988; Shelton et al., 2000). However, Payne et al. (2001) reported that growth performance in growing-finishing barrows is not affected by SPC (same SPC as used in this study) relative to SBM.

In EXP 3, abdominal fat pad weight as a percentage of final BW was increased in broilers fed the low CP-AA diet. However, addition of ISF to the low CP-AA diet resulted in abdominal fat pad weights that were intermediate between chicks fed the C-SBM and low CP-AA diets. Although major differences in lean growth were not observed, the addition of ISF to low CP-AA diets decreased fat pad weight. Thus, these data suggest that the increased fatness in broilers fed the low CP-AA diet may be partially attributed to a reduced level of ISF in these diets.

In the low CP-AA diets, ADG and feed efficiency were reduced, but ADFI was not affected. Si et al. (2000) reported a reduction in body weight of broilers when dietary CP was less than 20%, even though indispensable AA were provided at 100 or 110% of NRC (1994). Reduction of dietary CP also has resulted in decreased weight gain and feed intake from 18 to 42 d of age in broilers (Cantor et al., 2000).

Soy ISF decreased growth performance in broiler-type chickens at levels above those typically found in C-SBM diets. Addition of ISF to low CP-AA supplemented diets resulted in decreased abdominal fat pad weight in the broilers. Our data also suggest that broilers fed SPC or low CP-AA supplemented diets do not grow as well as those fed typical C-SBM diets.

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