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Effect of soybean variety and processing on growth performance of young chicks and pigs[1]

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ABSTRACT: The objective of this study was to determine whether soybeans without the Kunitz trypsin inhibitor and lectins could be fed effectively to young chicks and pigs. Specifically, we compared the growth performance of chicks and pigs fed diets containing modified soybeans: Kunitz trypsin inhibitor-free (KF), lectin-free (LF), lectin and Kunitz trypsin inhibitor-free (LFKF), conventional soybeans (CSB), and commercially obtained, dehulled, solvent-extracted soybean meal (SBM). A 7-d chick experiment was conducted to evaluate the nutritional value of CSB, KF, LF, LFKF, and SBM. The experiment was conducted as a completely randomized design, with four replicates, five treatments, and six male chicks per pen (n = 120). The five treatments consisted of 23% CP dextrose–soybean-based diets containing KF, LF, LFKF, CSB, or SBM as the source of dietary protein. A 28-d pig experiment was conducted to evaluate the nutritional value of CSB, LF, LFKF, and SBM. Pens of four pigs were assigned randomly to a control, corn–SBM, or one of six corn–soybean diets containing raw or extruded soybean varieties as a 2 × 3 factorial arrangement of treatments in a randomized complete block design with five blocks per treatment (n = 140). Chicks fed diets containing any of the raw soybean varieties gained less weight ($P < 0.05$) than chicks fed SBM (22.81 g/d for SBM vs. 14.17 g/d for the raw soybeans combined). Among the raw soybean treatments, there was a greater effect on growth performance ($P < 0.05$) by removing both lectins and Kunitz trypsin inhibitor (ADG of 16.56 g for LFKF) than by removing each antinutritional factor separately (ADG of 14.38 and 14.11 g for KF and LF, respectively). Pig growth performance was different ($P < 0.001$) for SBM (ADG of 409 g) and all the varieties when extruded (ADG of 450 g for CSB, 417 g for LF, and 408 g for LFKF) compared with the raw soybean treatments (ADG of 101 g for CSB, 165 g for LF, and 266 g for LFKF). Among the raw soybean treatments, growth performance improved ($P = 0.003$) as the antinutritional factor, lectin, was removed from the soybean and improved further ($P = 0.045$) when both lectins and Kunitz trypsin inhibitor were removed. The growth-inhibiting effect of feeding modified soybeans to young animals was more detrimental for pigs than for chicks in our experiments. Soybeans without the Kunitz trypsin inhibitor and lectins cannot be fed successfully to young chicks and pigs without heating.

Key Words: Chicks, Growth, Lectin, Pigs, Soybean, Trypsin Inhibitor

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Introduction

The soybean is an excellent source of protein for inclusion in diets for poultry and swine; however, this potential can be achieved only after heat treatment. Osborne and Mendel (1917) were the first to report that raw soybeans had a growth-depressing effect in rats. Heat-labile antinutritional factors present in soybeans, including protease inhibitors, lectins, goitrogens, and antivitamins (Liener, 2000), can cause inhibition of growth, decreased feed efficiency, goitrogenic responses, pancreatic hypertrophy, hypoglycemia, and liver damage in nonruminant animals depending on species, age, size, sex, state of health, and plane of nutrition.

Raw soybeans are known to contain two separate protease inhibitors: 1) proteins with a molecular weight of about 20,000 Da and a specificity directed primarily against trypsin, known as the Kunitz trypsin inhibitor (Kunitz, 1945), and 2) those that have a molecular weight between 6,000 to 12,000 Da and are capable of

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inhibiting chymotrypsin as well as trypsin at independent binding sites, referred to as the Bowman-Birk trypsin inhibitor (Bowman, 1944; Birk, 1961).

The second of the major antinutritional factors are lectins. Lectins are glycoproteins with the ability to bind carbohydrate-containing molecules on the epithelial cells of the intestinal mucosa, with toxicity determined by the extent of this binding (Liener, 2000).

The objective of this study was to determine whether soybeans without the Kunitz trypsin inhibitor and lectins could be fed successfully to young chicks and pigs. Specifically, we compared the growth performance of chicks and pigs fed diets containing modified soybeans: Kunitz trypsin inhibitor-free (**KF**), lectin-free (**LF**), lectin and Kunitz trypsin inhibitor-free (**LFKF**), conventional soybeans (**CSB**), and commercially obtained, dehulled, solvent-extracted soybean meal (**SBM**).

Materials and Methods

Soybean Varieties

New varieties of soybeans with low levels of antinutritional factors have been developed during the last 20 yr. Hymowitz (1986) discovered a soybean lacking the Kunitz trypsin inhibitor (Kunitz, 1945). This Kunitz trypsin inhibitor-free soybean was hybridized to a commercial variety (i.e., Williams 82), and through conventional plant breeding techniques, a soybean that has all the agronomic characteristics of the Williams 82 minus the Kunitz trypsin inhibitor was presented (Bernard and Hymowitz, 1986). The name of this variety is Kunitz, and it is now a commercial variety. Two other new soybean varieties have been developed in the Department of Crop Sciences at the University of Illinois: a lectin-free soybean variety (L90-8047), incorporated into the USDA soybean genetic collection (Bernard and Nelson, 1996), and a lectin-free, Kunitz trypsin inhibitor-free soybean variety (X97-0101). Both are isogenic to the commercial Williams 82 and are experimental strains. Samples of soybean seeds used in these studies were analyzed to verify the absence of Kunitz trypsin inhibitor (Orf and Hymowitz, 1979) and lectins (Orf et al., 1978).

Chick Experiment

The research was carried out at the Poultry Research Center of the University of Illinois and the experimental protocol was approved by the University of Illinois Animal Care Advisory Committee.

A 7-d chick experiment was conducted to evaluate the comparative nutritional value of CSB, KF, LF, LFKF, and SBM. Raw CSB and KF (Illinois Foundation Seeds, Inc., Champaign, IL), LF, and LFKF (Department of Crop Sciences, University of Illinois, Urbana) and SBM (Archer Daniels Midland, Inc., Decatur, IL) were ground to a similar particle size and analyzed for DM and CP (N × 6.25; AOAC, 1980).

Five treatments consisted of 23% CP dextrose–soybean-based diets containing KF, LF, LFKF, CSB, or SBM as the sole source of dietary protein (Table 1). Diets were formulated to meet or exceed all NRC (1994) nutrient requirements. Soybean oil and cellulose were added to the dextrose–SBM diet to approximate the digestible oil and fiber content of the soybean diets.

Eight-day-old male chicks resulting from the cross of New Hampshire males and Columbian Plymouth Rock females were used (n = 120). Chicks were housed in thermostatically controlled starter batteries with raised floors in an environmentally regulated room. Feed and water were supplied for ad libitum consumption, and light was provided 24 h daily. The chicks were fed a 24% CP corn–soybean meal pretest diet during 7d after hatching. Following an overnight period without feed, the chicks were weighed, wing-banded, and allotted to pens such that each pen had a similar initial weight and weight distribution. The average initial BW of the chicks was 89.4 ± 0.2 g.

The experiment was conducted as a completely randomized design, with four replicates, five treatments, and six male chicks per pen. Body weight of individual chicks and pen feed intakes were measured at the termination of the experiment. The experiment was conducted during May 1998.

Pig Experiment

The experiment was carried out at the Swine Research Center of the University of Illinois and the experimental protocol was approved by the University of Illinois Animal Care Advisory Committee.

A 28-d pig experiment was conducted to evaluate the comparative nutritional value of CSB, LF, LFKF, and SBM. Raw CSB (Hoffman Seed House, Hoffman, IL), LF, and LFKF (Department of Crop Sciences, University of Illinois), were ground to a similar particle size and analyzed for DM and CP (N × 6.25; AOAC, 1980). Soybean varieties were dry extruded (model 2000R, InstaPro, Des Moines, IA) for 15 s at 154.4 to 160.0°C.

Each experimental diet was formulated to contain 1.0% of total lysine (Table 2). The contents of lysine of corn and SBM were obtained from NRC (1998). The contents of lysine of CSB, LF, and LFKF were calculated from the measured CP level, assuming the ratio of CP:lysine in heat-processed soybean seed offered by NRC (1998). Soybean oil was added to the corn–SBM diet to approximate the digestible oil content of the soybean diets. None of the diets contained antibiotics. Diets were ground to a similar particle size and analyzed for DM and CP (N × 6.25; AOAC, 1980), and total lysine concentration was determined using ion exchange chromatography in a 12-cm sodium column, with absorbance set at 570 nm (Beckman model 126AA, Beckman Instruments, Palo Alto, CA) following hydrolysis in 6 *N* HCl and nitrogen gas atmosphere for 22 h at 110°C (Table 3). Lysine concentrations were not

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Table 1. Composition (%) of experimental diets (as-fed basis) in the chick experiment

	Diet[a]				
Item	SBM	CSB	KF	LF	LFKF
Ingredients					
Dextrose	36.72	35.54	33.92	35.06	33.41
SBM	47.23	—	—	—	—
CSB	—	60.21	—	—	—
KF	—	—	61.83	—	—
LF	—	—	—	60.69	—
LFKF	—	—	—	—	62.34
Soybean oil	9.10	—	—	—	—
Dicalcium phosphate	2.20	2.20	2.20	2.20	2.20
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.40	0.40	0.40	0.40	0.40
Trace mineral mix[b]	0.15	0.15	0.15	0.15	0.15
Vitamin mix[c]	0.20	0.20	0.20	0.20	0.20
Choline chloride (60%)	0.10	0.10	0.10	0.10	0.10
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Cellulose[d]	2.70	—	—	—	—
Calculated composition[e]					
Energy, kcal ME/kg	3,013	3,002	2,996	3,000	2,994
CP, %	23.0	23.0	23.0	23.0	23.0
Lys, %	1.4	1.4	1.4	1.4	1.4
Ca, %	0.99	1.01	1.02	1.02	1.02
P, %	0.70	0.76	0.77	0.76	0.77

[a]SBM = dehulled soybean meal; CSB = conventional soybeans; KF = Kunitz trypsin inhibitor-free soybeans; LF = lectin-free soybeans; LFKF = lectin and Kunitz trypsin inhibitor-free soybeans.
[b]Provided as milligrams per kilogram of diet: zinc, 75 from zinc oxide; iron, 75 from iron sulfate; manganese, 75 from manganese oxide; copper, 5 from copper sulfate; iodine, 0.35 from ethylene diamine dihydroiodide; selenium, 0.2 from sodium selenite.
[c]Provided per kilogram of diet: retinyl acetate, 1,514 μg; cholecalciferol, 25 μg; DL-α-tocopheryl acetate, 11 μg; menadione sodium bisulfite, 2.33 mg; niacin, 22 mg; d-pantothenic acid, 10 mg; riboflavin, 4.41 mg; vitamin B_{12}, 0.01 mg.
[d]Cellulose, Solka Floc.
[e]All values are based on NRC (1994) tabular values, except for the values of CP (%) of SBM, CSB, KF, LF, and LFKF that were analyzed before formulation. Content of CP (%) expressed on an as-fed basis was as follows: SBM = 48.44; CSB = 38.00; KF = 37.00; LF = 37.70; and LFKF = 36.70.

corrected for incomplete recovery resulting from hydrolysis.

Pigs (PIC, Franklin, KY) were weaned at 20.0 ± 2.2 d of age and fed a series of two nursery diets. After 3 wk, 70 gilts and 70 barrows were formed into outcome groups on the basis of BW, litter, and sex (initial BW = 13.8 ± 1.4 kg) and assigned to 35 pens with two gilts and two barrows per pen. Pens of four pigs were assigned randomly to a control, corn–SBM diet, and six corn–soybean diets containing raw or extruded soybean varieties as a 2 × 3 factorial arrangement of treatments, in a randomized complete block design with five blocks per treatment.

Pigs were housed in a mechanically ventilated grower facility on partially slatted floors. Feed and water were supplied for ad libitum consumption. Individual pigs weights and pen feed intakes were recorded weekly. The experiment was conducted between October and November of 2001.

Statistical Analyses

Growth performance data from the chick experiment were subjected to ANOVA by the GLM procedure of SAS (SAS Inst., Inc., Cary, NC) for a completely randomized design, with the experimental unit being a pen of six male chicks. Average daily gain, ADFI, and G:F are presented as means. Statistical analyses of differences among treatments were analyzed using the LSD test, using an alpha level of 0.05.

Growth performance data from the pig experiment were subjected to ANOVA by the GLM procedure of SAS for a randomized complete block design, with the experimental unit being a pen of four pigs (two gilts and two barrows), and the model composed of block and treatment. Average daily gain, ADFI, and G:F are presented as least squares means because the data were not balanced. One observation for a weekly pen feed intake was lost, so all feed intake data for that pen were deleted from the statistical analyses. Treatments least squares means were compared using preplanned orthogonal contrasts. A probability of $P < 0.05$ was accepted as significant.

Results

Chick Experiment

Chicks fed diets containing any of the raw soybean varieties gained less weight ($P < 0.05$) than did chicks

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Table 2. Composition (%) of experimental diets (as-fed basis) in the pig experiment

	Diet[a]			
Item	SBM	CSB	LF	LFKF
Ingredients				
Corn	66.00	61.36	58.89	57.72
SBM	27.43	—	—	—
CSB	—	35.44	—	—
LF	—	—	37.92	—
LFKF	—	—	—	39.09
Soybean oil	3.48	—	—	—
Dicalcium phosphate	1.50	1.74	1.74	1.75
Limestone	0.81	0.68	0.67	0.66
Trace mineral mix[b]	0.58	0.58	0.58	0.58
Vitamin mix[c]	0.20	0.20	0.20	0.20
Calculated composition[d]				
Energy, kcal DE/kg	3,642	3,630	3,646	3,653
CP, %	18.5	18.6	18.8	18.4
Lys, %	1.0	1.0	1.0	1.0
Ca, %	0.73	0.73	0.74	0.74
P, %	0.65	0.70	0.71	0.72

[a]SBM = dehulled soybean meal; CSB = conventional soybeans; LF = lectin-free soybeans; LFKF = lectin and Kunitz trypsin inhibitor-free soybeans.

[b]Provided as milligrams per kilogram of diet: sodium chloride, 4,971; zinc, 166 from zinc oxide; iron, 149 from iron sulfate; manganese, 33 from manganese oxide; copper, 13 from copper sulfate; iodine, 0.58 from calcium iodide; and selenium, 0.50 from sodium selenite.

[c]Provided per kilogram of diet: retinyl acetate, 2,273 μg; cholecalciferol, 17 μg; DL-α-tocopheryl acetate, 88 mg; menadione sodium bisulfite complex, 4 mg; niacin, 33 mg; D-calcium pantothenate, 24 mg; riboflavin, 9 mg; vitamin B_{12}, 35 μg; choline chloride, 324 mg.

[d]All the values are based on NRC (1998) tabular values, except for the values of crude protein of CSB, LF, and LFKF that were analyzed before formulation. Content of CP (%) on an as-fed basis was as follows: CSB = 38.19; LF = 36.57; and LFKF = 34.93.

fed SBM (Table 4). Among the raw soybean treatments, there was a greater effect on growth performance by removing both lectins and Kunitz trypsin inhibitor (LFKF), than by removing each antinutritional factor separately (KF, LF; $P < 0.05$). The poorest weight gain was achieved by the group fed the raw CSB ($P < 0.05$). Feeding raw soybeans to chicks decreased ADG by 49% for CSB, 37% for KF, 38% for LF, and 27% for LFKF compared with the ADG achieved by chicks fed SBM (Figure 1).

Pig Experiment

An outbreak of diarrhea occurred near the end of the first week of the experiment. All pigs were provided medicated water containing oxytetracycline HCl at 212 mg/L of water (Terramycin-343; Pfizer Animal Health, Exton, PA) for 3 d, starting on d 8 of the experiment. This procedure was not part of our experimental protocol, and we do not believe this procedure affected our results.

Analyzed lysine values (%) for the experimental diets differ somewhat from the calculated composition value (1.0% of total lysine). A possible explanation is that the extrusion process altered the form of lysine enough to affect the analyzed value, and that is consistent with the fact that, within the same variety of soybean used, the total lysine value for the raw treatment was higher than for the extruded one. Furthermore, the assumption used when formulating the experimental diets—equal lysine:CP ratio for raw and heated soybean seeds—may not be completely valid. Perhaps the use of a ratio derived from values for heat-processed seeds was inappropriate for application to raw seeds. Regard-

Table 3. Analyzed values of CP (%) and Lys (%) of experimental diets (as-fed basis) in the pig experiment

	Dietary treatment[a]						
Item	SBM	CSB, raw	CSB, extruded	LF, raw	LF, extruded	LFKF, raw	LFKF, extruded
CP	17.76	18.26	18.79	17.87	17.93	19.98	18.53
Lys	0.92	1.07	0.91	1.02	0.99	1.18	1.09

[a]SBM = dehulled soybean meal; CSB = conventional soybeans; LF = lectin-free soybeans; LFKF = lectin and Kunitz trypsin inhibitor-free soybeans.

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Table 4. Growth performance of chicks fed different soybeans (as-fed basis)[a]

	Dietary treatment[b]						
Response	SBM	CSB	KF	LF	LFKF	Pooled SEM	Model treatment *P*-value
ADG, g	22.81[c]	11.61[f]	14.38[e]	14.11[e]	16.56[d]	0.34	0.001
ADFI, g	30.20[e]	32.25[de]	34.75[cd]	36.51[c]	30.68[e]	1.27	0.013
G:F, g/kg	757.72[c]	360.86[f]	413.78[e]	389.93[ef]	540.91[d]	17.37	0.001

[a]Each mean represents four replicate pens of six males chicks during a 7-day experiment; average initial body weight was 89.4 ± 0.2 g.
[b]SBM = dehulled soybean meal; CSB = conventional soybeans; KF = Kunitz trypsin inhibitor-free soybeans; LF = lectin-free soybeans; LFKF = lectin and Kunitz trypsin inhibitor-free soybeans.
[c,d,e,f]Within a row, means without a common superscript differ ($P < 0.05$).

less of the cause, the variation in dietary lysine concentrations seems not to have affected the results of the experiment materially.

Growth performance data did not differ ($P = 0.127$ to 0.764) when SBM was compared with the extruded soybean treatments combined, or when the comparisons were made among the extruded soybean treatments (Table 5). Growth response was different ($P < 0.001$) for SBM and all the varieties when extruded (CSB, LF, and LFKF) compared with the raw soybean treatments. Among the raw soybean treatments, ADG, ADFI, and G:F improved as the antinutritional factor lectin was removed from the soybean (raw CSB vs. raw LF, LFKF) and improved further when both lectins and Kunitz trypsin inhibitor were removed from the soybeans (raw LF vs. raw LFKF). Feeding raw soybeans to pigs depressed ADG by 78% for CSB, 60% for LF, and 35% for LFKF compared with the ADG achieved by pigs fed the same variety but extruded (Figure 1).

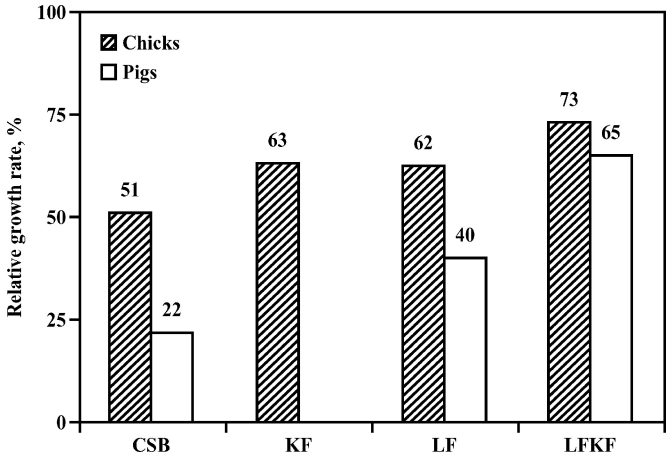

Figure 1. Average daily gain by chicks and pigs fed raw soybeans, expressed as a percentage (i.e., relative growth rate) of that of SBM for the chick experiment or as a percentage of that of extruded soybeans of the same variety for the pig experiment. Abbreviations: SBM = commercially obtained, dehulled, solvent-extracted soybean meal; CSB = conventional soybeans; KF = Kunitz trypsin inhibitor-free soybeans; LF = lectin-free soybeans; LFKF = lectin and Kunitz trypsin inhibitor-free soybeans. Each relative growth rate value was calculated using ADG means of four replicate pens of six chicks (n = 24), or of five replicate pens of four pigs (n = 20).

Discussion

Regarding our pig and chick experiment, both the Kunitz trypsin inhibitor and the lectins are antinutritional factors and can diminish growth performance. Since soybeans lacking the Kunitz trypsin inhibitor were developed (Bernard and Hymowitz, 1986), a large number of experiments with animals regarding the dietary value of these soybeans have been conducted. Feeding trials with rats (Friedman et al., 1991), chicks (Han et al., 1991; Anderson-Hafermann et al., 1992; Zhang et al., 1993), laying hens (Zhang et al., 1991), and pigs (Cook et al., 1988; Stickler, 1992) have all demonstrated that the inclusion of raw KF soybeans in a diet was beneficial in terms of better growth performance compared with raw CSB (that contained Kunitz trypsin inhibitor), but still inferior to the growth performance obtained by SBM (where the Kunitz trypsin inhibitor and other heat-labile antinutritional factors are inactivated by heating). These intermediate results in growth performance between the raw CSB and the SBM were also found in our chick experiment. They reflect the presence of other heat-labile antinutritional factors in raw CSB. According to Liener (2000), the most relevant heat-labile antinutritional factors besides the Kunitz trypsin inhibitor are lectins, the Bowman-Birk trypsin inhibitor (Bowman, 1944; Birk, 1961), goitrogens, and antivitamins. Similar to our experiment with young chicks, the studies cited previously showed that the effect of the antinutritional factor Kunitz trypsin inhibitor present in the soybean is age dependent, and might be more harmful for young animals than for adults (Baker, 2000).

Before the LF variety was developed (Bernard and Nelson, 1996), there have been studies testing lectin extract in feeding trials with rats and pigs. The first, conducted with rats, was done by Liener (1953) and reported a growth-inhibiting effect due to the lectin (called soyin at that time). The second study, conducted with pigs fitted with a postvalvular T-cecum cannula, was done to evaluate the response of the inclusion of

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Table 5. Growth performance of pigs fed different soybeans (as-fed basis)[a,b]

Item	Dietary treatment[c] SBM	CSB, raw	CSB, extruded	LF, raw	LF, extruded	LFKF, raw	LFKF, extruded	Pooled SEM	Model treatment *P*-value
ADG, g	409	101	450	165	417	266	408	22	0.001
ADFI, g	833	513	810	596	757	708	776	28	0.001
Gain:feed, g/kg	491	183	555	272	554	373	530	34	0.001

Contrasts evaluated	*P*-values ADG	ADFI	G:F
SBM and extruded CSB, LF, LFKF vs. raw CSB, LF, LFKF	0.001	0.001	0.001
SBM vs. extruded CSB, LF, LFKF	0.523	0.127	0.177
Raw CSB vs. raw LF, LFKF	0.001	0.001	0.003
Extruded CSB vs. extruded LF, LFKF	0.171	0.232	0.759
Raw LF vs. raw LFKF	0.003	0.010	0.045
Extruded LF vs. extruded LFKF	0.764	0.662	0.645

[a]Each least squares mean represents five replicate pens of four pigs (two gilts and two barrows) during a 28-d experiment; average initial BW of 13.8 ± 1.4 kg.
[b]Least squares means for treatments were compared using preplanned orthogonal contrasts.
[c]SBM = dehulled soybean meal; CSB = conventional soybeans; LF = lectin-free soybeans; LFKF = lectin and Kunitz trypsin inhibitor-free soybeans.

purified soy lectin extract in a diet (Schulze et al., 1995). Nitrogen analysis of the ileal digesta demonstrated that the inclusion of lectin increased the loss of endogenous nitrogen, presumably caused by damage to the intestinal mucosa and a resulting increased secretion of protein.

Studies with the LF variety (Bernard and Nelson, 1996) have been conducted only in young chicks. Douglas et al. (1999) compared its dietary value to the KF variety (Bernard and Hymowitz, 1986) and to SBM. A greater improvement in growth performance was noted for the KF soybean than for the LF soybeans when both were compared with raw CSB. According to Douglas et al. (1999), these results indicate that the Kunitz trypsin inhibitor is a more important antinutritional factor than lectins when fed to young chicks. In contrast, the results from our chick experiment showed that the growth-inhibiting effect achieved with the LF variety (Bernard and Nelson, 1996) was similar to that achieved with the KF variety (Bernard and Hymowitz, 1986). Therefore, our experiment showed that Kunitz trypsin inhibitor and lectins induced growth depression to the same degree and that the effects were completely additive.

Raw LFKF has been tested only in chicks (Batal and Parsons, 2002), comparing its nutritional value with that of raw solvent-extracted soyflakes, SBM, raw and heated CSB, raw KF (Bernard and Hymowitz, 1986), and raw LF (Bernard and Nelson, 1996). For the first week after birth, the growth rate for chicks fed raw LKFK was similar to that of chicks fed solvent-extracted soyflakes, and better than for those fed raw LF (Bernard and Nelson, 1996), raw KF (Bernard and Hymowitz, 1986), and raw CSB. Still, the raw LFKF showed smaller growth rates than did the heated CSB and the SBM. For our pig experiment, the growth performance achieved when pigs were fed raw LFKF was better than that of pigs fed either raw LF or raw CSB but still lower than those fed SBM. Perhaps, the heat-labile antinutritional factor that is diminishing growth performance in a LFKF raw soybean seed is the Bowman-Birk trypsin inhibitor (Bowman, 1944; Birk, 1961).

According to Liener (2000), the growth-inhibiting effect of feeding modified soybeans to young animals is dependant on the species (among other factors) tested. For our experiments, feeding modified soybeans was more detrimental for pigs than for chicks.

Implications

Soybeans without the Kunitz trypsin inhibitor and lectins cannot be fed successfully to young chicks and pigs without heating. There seem to be other heat-labile factors present in modified raw soybeans that diminish growth performance.

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