

High protein and low trypsin inhibitor varieties of full-fat soybeans in broiler chicken starter diets¹

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Chohan, A. K., Hamilton, R. M. G., McNiven, M. A. and MacLeod, J. A. 1993. **High protein and low trypsin inhibitor varieties of full-fat soybeans in broiler chicken starter diets.** *Can. J. Anim. Sci.* 73: 401-409. Two broiler growth trials of randomized block design were conducted to evaluate the nutritional quality of two new varieties of full-fat soybeans (SB) in starter diets. Use of the high protein (HP) SB (44% CP) has the potential to replace conventional soybeans in poultry rations and reduce the amount of SB needed. Use of the low-trypsin inhibitor (LTI) SB may eliminate the cost of heat treatment before feeding to poultry. The protein sources were raw SB (39% CP, 70 Trypsin Inhibitor Units (TIU) g⁻¹ DM), autoclaved SB, autoclaved HP SB, LTI (42 TIU g⁻¹ DM) and commercially roasted SB. Diets were formulated to be isonitrogenous and isoenergetic. Supplementation of diets with 0.3% DL-methionine was also studied, as the antiproteolytic activity of the TI makes sulphur amino acids less available for growth. Mean body weight gains, feed efficiency, dry matter and crude protein digestibilities and total carcass protein and energy content of the chickens fed HP, autoclaved or roasted SB were superior ($P < 0.05$) to those fed the raw SB diet. Performance of the chickens fed the HP SB diet was similar to those on the roasted SB diet. Growth and feed conversion of chicks fed the LTI diet were similar to those fed the raw SB diet. However, mean pancreas weights of the chicks fed LTI were lower ($P < 0.001$) than those fed raw SB which could be due to the lower trypsin inhibitor activity of the LTI beans. Chickens given the methionine supplemented LTI diet made greater weight gains ($P < 0.05$) than those on the nonsupplemented diet. Heat treatment is required for the LTI beans. Full-fat HP soybeans may replace conventional soybean meal in broiler chicken starter diets if the formulation is adjusted for the differences in their protein and fat contents.

Key words: Soybeans, trypsin inhibitor, broiler, chicken growth

Chohan, A. K., Hamilton, R. M. G., McNiven, M. A. et MacLeod, J. A. 1993. **Valeur de variétés de soja à haute teneur en protéine et à faibles niveaux d'inhibiteurs de trypsine dans les aliments de démarrage pour poulets de chair.** *Can. J. Anim. Sci.* 73: 401-409. Deux essais de croissance en dispositif aléatoire par blocs ont été réalisés sur des poulets de chair pour mesurer la valeur nutritive de deux nouvelles variétés de soja dans l'aliment de démarrage. Le soja HP, à haute teneur en protéine (44% PB), pourrait remplacer le soja ordinaire dans l'alimentation des volailles, tout en permettant de réduire la quantité de soja utilisé. La variété à faible niveau d'inhibiteur de trypsine (BIT) éliminerait la nécessité et le coût additionnel du traitement thermique actuellement requis avant sa distribution du soja aux volailles. Les sources de complément protéique comparées étaient: soja cru, soja autoclavé (39% PB, 70 unités inhibiteurs de trypsine (UIT g⁻¹ ms), soja HP, soja BIT (42 UIT g⁻¹ ms) et soja torréfié selon la méthode courante dans le commerce. Les régimes étaient isoazotés et isocaloriques. On examinait aussi l'effet d'un complément de 0,3% de DL-méthionine, étant donné que l'activité antiprotéolytique de IT réduit la disponibilité des acides aminés sulfurés pour la croissance. Le gain

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de poids moyen, l'indice de conversion, la digestibilité de m.s. et de PB ainsi que la teneur totale en protéine et en énergie de la carcasse des poulets recevant le soja HP et le soja autoclavé ou torréfié étaient supérieurs ($P < 0,05$) à ceux des poulets consommant le soja cru. Les performances des poulets au régime soja HP se comparaient avec celles des sujets recevant le soja torréfié. La croissance et l'indice de consommation des poulets nourris au BIT étaient semblables à ce qu'on observait chez les poulets consommant le soja cru. Toutefois le poids moyen du pancréas chez les poulets recevant le BIT était plus léger ($P < 0,001$) que chez les poulets au soja cru, ce qui s'expliquerait par la plus faible activité tryptino-inhibitrice de la variété BIT. Quand le régime BIT était complété avec de la méthionine, les poulets affichaient un gain de poids plus important ($P < 0,05$) que dans le régime sans méthionine. Un traitement thermique demeure nécessaire pour le soja BIT. Le soja HP entier pourrait remplacer le tourteau de soja ordinaire dans les aliments de départ pour poulets de chair, à condition d'ajuster la formulation de la ration en fonction de sa teneur différente en protéine et en graisse.

Mots clés: Soja, inhibiteur de la trypsine, poulets de chair, croissance

Soybean meal (SBM) is a primary source of plant protein in poultry diets (Patrick and Schaible 1980). Considerable interest has developed in the use of full-fat soybeans (SB) in animal diets to increase the dietary energy content and eliminate the cost of oil extraction (Arnold et al. 1971; Simovic et al. 1972). However, the presence of heat-labile trypsin inhibitors (TI) and other anti-nutritional factors limits the use of raw SB in animal diets (Rackis 1974). The TI are associated with growth depression and pancreatic enlargement in chickens. The latter response is due to hyperplasia arising from hypersecretion of the pancreas which leads to loss of essential amino acids, especially the sulphur amino acids (Schneeman and Gallaher 1986). As a result, the growth depression observed in growing birds is a combined effect of loss of essential amino acids and decreased intestinal proteolysis (Tan-Wilson and Wilson 1986) caused by anti-proteolytic action of the TI in raw SB. This growth depression can be partially corrected with methionine supplementation (Booth et al. 1960).

To be used effectively, SB should be heat-treated before being fed to animals (Leeson et al. 1987). During the heat treatment the anti-nutritional factors are inactivated and thus the inhibition of the proteolytic pancreatic enzymes is reduced (Kakade et al. 1973; Rackis et al. 1986). On the other hand, overheating usually causes protein deterioration which decreases the nutritive value and has a negative impact on animal growth (Rackis

et al. 1986). Therefore, precise control of the heating processes is critical to the preparation of protein products of maximum nutritive value.

Improved cultivars of SB have been developed which contain higher protein levels or lower levels of trypsin inhibitor (MacLeod and Goit 1985). High-protein whole SB have the potential to substitute on an equivalent protein basis for soybean meal in animal rations and thus reduce the cost of protein supplementation. Cultivars with lower levels of TI could eliminate the cost of heat treatment of SB before feeding to livestock and poultry. Recently, high protein (HP) and low trypsin inhibitor (LTI) lines of SB have been developed by Agriculture Canada (Ottawa). This study was done to evaluate these new varieties of SB as protein sources for poultry using broiler chickens.

MATERIALS AND METHODS

Soybean Sources

The soybean sources used were: conventional SB (cv. *Maple Isle*), a HP variety (OT 89-16) and a LTI variety (X2033). Commercially produced, solvent extracted SBM was used as the control protein source.

Since there was not a sufficient quantity of HP SB for processing in a commercial roaster, the conventional and HP beans were heat-treated by autoclaving at 89.6 KPa for 15 min. Commercially roasted conventional SB were used as a control for the autoclaved beans in order to determine if the heat treatment received during autoclaving was

sufficient to destroy the anti-nutritional factors. These beans were heated in a commercial propane flame roaster (Gem Grain Roasting Co., Winona, MN; Model 7700) to an exit temperature of 107°C. The LTI SB were not heat-treated. Conventional raw SB were used as a control for the LTI beans.

The beans were ground (1-mm screen) and analyzed for dry matter (DM), crude protein and ether extract according to the methods of Association of Official Analytical Chemists (AOAC) (1984). Gross energy was determined using an isoperibolic calorimeter (Model no. 1261, Parr Instruments, Moline, IL). Amino acid analysis was performed, in duplicate, by the method of Moore and Stein (1963) using a LKB Alpha Plus Amino Acid Analyzer equipped with a Hewlett-Packard Model 3396A Integrator. Methionine and cystine were determined in separate samples after oxidation by the performic acid procedure as described by Moore (1963). Solubility of proteins in 0.2% KOH according to the method of Araba and Dale (1990) was used to determine if the SB were overheated. Anti-tryptic activity of SB was determined by the enzymatic method of Keshun and Markakis (1989) and expressed as Trypsin Inhibitor Units (TIU) g⁻¹ DM and TIU g⁻¹ crude protein of the sample. Benzoyl-DL-arginine-*p*-nitroanilide hydrochloride (Sigma Chemical Co., St. Louis, MO) was used as the protease substrate.

The true metabolizable energy (TME) contents of the diets and the protein sources were determined using adult Single Comb White Leghorn roosters according to the precision feeding method described by Sibbald (1976) modified to a 48-h collection period (Sibbald 1986). Five replicate measurements were done on each diet and protein source.

Chicken Assays

The SB sources were included at the level of 25% by weight in corn-wheat based experimental diets. The diets were formulated to be isonitrogenous (24% crude protein) by the use of corn gluten and to be isoenergetic (12.5 MJ ME kg⁻¹; Table 1). Crude SB oil was added to the HP SB diet to compensate for the lower fat content of these beans. One-half of each diet was supplemented with 0.3% DL-methionine. The diets will subsequently be identified by protein source as follows: soybean meal (SBM), autoclaved conventional SB (Ac SB), autoclaved HP SB (Ac HP), roasted conventional SB (Rt SB), raw conventional SB (Rw SB) and LTI SB (LTI).

The experimental diets were fed to male broiler chickens in two separate growth trials. Day-old male broiler chickens were obtained from a local hatchery and were fed a broiler starter diet (Proudfoot et al. 1990; 24% CP and 12.5 MJ kg⁻¹ DM

Table 1. Composition of the diets (g 100 g⁻¹)

Ingredients	SBM ²	Ac SB	Ac HP	Rt SB	Rw SB	LTI
Ground soybean	25.00	25.00	25.00	25.00	25.00	25.00
Ground corn	49.75	20.07	36.08	20.07	22.09	20.09
Ground wheat	10.00	38.28	23.59	38.28	36.72	38.25
Poultry fat	2.44	1.00	1.00	1.00	1.00	1.00
Crude soybean oil	—	—	0.75	—	—	—
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00
Corn gluten	4.56	7.41	6.04	7.41	6.06	7.42
Vitamin-mineral premix ³	3.11	3.23	3.15	3.13	3.41	3.14
Methionine ⁴	0.14	0.11	0.14	0.11	0.17	0.11
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Analyzed composition						
Crude protein (N × 6.25; %)	26.0	25.7	26.0	25.6	25.1	24.8
Ether extract (% kg ⁻¹)	4.9	7.7	7.5	7.7	7.1	6.7
TME _n , MJ kg ⁻¹ DM ⁵	15.66	16.82	15.94	16.12	15.52	15.35

²SBM, soybean meal; SB, conventional soybeans; HP, high protein soybeans; Ac, autoclaved; Rt, roasted; and Rw, raw.

³Amount per kilogram premix: 1 × 10⁷ IU vitamin A; 2 × 10⁶ ICU vitamin D₃; 8 g riboflavin; 12 g calcium pantothenate; 12 mg vitamin B₁₂; 30 g niacin; 3 g vitamin K; 1 g folic acid; 400 g choline chloride; 200 mg biotin; 5 g pyridoxine; 3 g thiamine; 1.5 × 10³ IU vitamin E; 187.5 g Amprol High E (25%); 100 g ethoxyquin; 120 g manganese oxide (60% Mn); 90 g zinc oxide (80% Zn); 25 g copper sulphate (25% Cu); 500 mg calcium iodate (65% I); 200 g ferrous sulphate (36% Fe); and 200 mg sodium selenite (45% Se).

⁴The methionine-supplemented diets contained an *additional* 0.3% DL-methionine.

⁵True metabolizable energy corrected to zero nitrogen balance; SEM ranged between 0.11 and 0.31 (*n* = 7–10).

ME) 7 d posthatching. The birds were housed in wire mesh pens in which the temperature was thermostatically controlled. The batteries of pens were located in a room where temperature was also controlled. The temperature in the battery cages was 32°C until the chickens were 3 d of age and 29°C until 7 d of age after which the temperature was reduced by 3°C weekly. Feed and water were available ad libitum and the light program was 23L:1D throughout the experiment.

After a 2-h fast on day 7 posthatching, the birds were weighed and assigned to the experimental treatments so that the weight distribution for each replicate was similar. Each pen served as a replicate with five chickens per pen in Trial I and four chickens per pen in Trial II. There were five replicates of each diet in Trial I and two replicates for each diet in Trial II, arranged in a random block design. The test diets were fed for 14 d.

Excreta were collected from each pen during the last 3 d of the experiment. The excreta were freeze-dried and ground (1-mm mesh) before analysis for dry matter, Kjeldahl nitrogen and gross energy as described previously. Acid-insoluble ash in the diets and the excreta was measured according to the method of Vogtmann et al. (1975). Dry matter digestibility, crude protein digestibility and the metabolizable energy of the diets were determined using acid-insoluble ash as an internal indicator.

At the termination of the experiments, the birds were individually weighed after a 2-h fast. Feed intake per pen over the experimental period of 14 d was also recorded. After the birds were killed by cervical dislocation, the pancreas was removed from three birds from each pen in Trial I and two birds from each pen in Trial II, weighed (wet weight), dried at 100°C for 24 h and reweighed (dry weight).

To determine body composition, whole birds (including blood, feathers, legs and head), two pen⁻¹ from each replicate in each trial, were autoclaved at 89.6 kPa for 200 min, cooled and homogenized in a Waring blender with 100 mL of distilled water. The homogenate was analyzed for dry matter, protein, and ash according to the standard methods of AOAC (1984). Fat was determined on freeze-dried samples of the homogenate according to the AOAC (1984) method. Carcass energy was calculated using the values of 23.4 and 38.9 kJ g⁻¹ for protein and fat, respectively (Farrell 1974).

Statistical Analysis

Data for individual birds were used for the statistical analysis of body weight gain, pancreas

weight and body composition. Pen means were used to analyze feed intake, feed efficiency and digestibility data. Statistical analysis was carried out by analysis of variance using the Statistical Analysis System (SAS 1988) according to a randomized complete block design in which the treatments were distributed among a 6 × 2 factorial arrangement. Significant differences between diets were determined by the Student Neuman-Keuls test at the $\alpha = 0.05$ level. The factors were six dietary SB sources and two levels of methionine supplementation. The results obtained from the two trials were combined for the analysis as the trial × diet interaction was not significant.

RESULTS AND DISCUSSION

Composition of SB sources

The composition of the SB sources is presented in Table 2. The Ac HP had an 18% higher protein content than the conventional autoclaved beans. The proximate composition of the LTI beans was similar to the raw conventional beans. Han et al. (1991) also reported similarity in proximate composition of their LTI line of SB and the commercial variety (Williams 82).

The amino acid profiles of the SB, heated or unheated, were similar (Table 2). Friedman et al. (1991) also reported no change in the amino acid composition of heated and unheated beans. The Ac HP generally had higher levels of essential amino acids than the other SB varieties, but the amino acid levels were similar when expressed on a crude protein basis (Chohan 1991). Therefore, the higher crude protein levels as observed for these beans are likely the result of increased levels of true protein rather than of any other source of nitrogen. The amino acid levels of the LTI were similar to those found in the conventional beans. Friedman et al. (1991) also found a similar amino acid composition between the commercially grown SB (Williams 82) and an isolate having lower TI activity (L81-4590).

Percent soluble protein in the autoclaved SB was higher than that of the SBM (Table 2), but similar to that of the roasted beans indicating that the autoclaved SB did not receive excessive heat treatment. According

Table 2. Analyzed composition of the SB meal and beans^z

	SBM	Ac SB	Ac HP	Rt SB	Rw SB	LTI
Dry matter (%)	91.7	96.1	95.6	96.3	95.8	95.4
Crude protein (% DM)	54.2	37.2	43.8	37.7	38.6	37.6
Ether extract (% DM)	0.73	19.47	17.60	20.30	16.32	16.46
Protein solubility (%) ^y	64.1	71.1	65.3	71.3	70.9	72.3
TIU g ⁻¹ protein	0	31.7	11.2	0	182.6	111.4
TME _n (MJ kg ⁻¹ DM) ^x	11.99	17.32	15.91	15.95	15.61	16.14
Arginine (% DM)	3.08	2.31	2.72	2.31	2.13	2.30
Cystine (% DM)	0.33	0.25	0.31	0.25	0.25	0.26
Methionine (% DM)	1.07	0.84	0.97	0.97	0.83	0.92
Lysine (% DM)	3.22	3.83	3.65	3.30	3.01	4.20
Isoleucine (% DM)	2.06	1.54	1.76	1.55	1.45	1.51
Leucine (% DM)	3.46	2.60	2.94	2.61	2.40	2.59
Valine (% DM)	2.25	1.70	1.88	1.69	1.57	1.66
Phenylalanine (% DM)	2.32	1.72	1.97	1.72	1.59	1.70
Threonine (% DM)	1.58	1.27	1.42	1.28	1.17	1.30
Histidine (% DM)	1.01	0.89	0.93	0.90	0.82	0.89

^zUnless indicated otherwise $n=2$.^yIn 0.2% KOH.^xMeans for data from 3–5 cocks; SEM ranged between 0.27 and 0.31.

to Araba and Dale (1990), protein solubility values of less than 70% indicate impaired nutritive value for the chick and values less than 65% indicate over processing. Parsons et al. (1991) reported $59 \pm 1.5\%$ to be the critical level of protein solubility needed for maintaining optimal feed efficiency in chicks.

As expected, the levels of TIU were higher in the raw than in the heat-treated beans (Table 2). The raw HP had about 28% higher TIU than that of the conventional raw SB (Chohan 1991). The LTI beans had 40% less TIU than the Rw SB which could be attributed to the lack of the Kunitz trypsin inhibitor (Hymowitz 1986) in the LTI beans (McNiven et al. 1992). Friedman et al. (1991) found that trypsin inhibitory activity in their variety of LTI SB was 54% of the Williams 82 commercial variety.

The TME_n values of the full-fat SB, as expected, were higher ($P < 0.05$) than those of the defatted SBM (Table 2). The TME_n value of the conventional Ac SB was the highest ($P < 0.05$) of the full-fat SB.

The crude protein contents of the experimental diets were within 4.8% of each other (Table 1). Although the SBM diet contained 2.4 times more poultry fat than the other five experimental diets, it contained the least ether-extractable fat (Table 1). The

TME_n contents of the methionine supplemented and non-supplemented Rw SB and LTI diets were on average 0.91 and 0.66 MJ kg⁻¹ DM lower than that of the other diets. These lower values are likely attributable to the presence of anti-nutritional factors in the Rw SB and LTI SB which interfere with the utilization of fat from the beans, and thus, decrease their ME (Grant 1989). Further, heat treatment makes the fat more accessible for digestion and absorption (Leeson et al. 1987). This agrees with the fat analysis results of the beans (Table 2) which showed higher ether extract values for the heat-treated beans. The TME_n values for the full-fat SB were higher than those for the SBM due to their higher fat contents. Han et al. (1991) found higher TME_n values for the LTI variety of SB compared with those for the conventional beans. The variations in the crude protein content of the diets agree with previous published results in which large variations were found in the protein content among poultry diets formulated to be isonitrogenous (Bolton 1959).

Chicken Growth and Digestibility Assay

Since methionine supplementation had little effect on the results except when otherwise indicated, and there were no significant methionine supplementation \times dietary SB

Table 3. Effect of dietary soybean source on growth, feed efficiency, pancreas weights and nutrient digestibility for chickens

	SBM	Ac SB	Ac HP	Rt SB	Rw SB	LTI	SEM ^z
21-d weight (g)	629.4a	550.7c	567.1bc	581.6b	463.4d	453.7d	20.6
7- to 21-d gain (g)	499.6a	422.1c	439.5bc	452.9b	333.1d	325.9d	18.72
7- to 21-d feed intake (g)	729.4a	660.3bc	643.2c	688.4ab	579.8d	565.7d	14.9
Feed gain ⁻¹ (g g ⁻¹)	1.46a	1.56b	1.47a	1.51ab	1.75c	1.76c	0.03
Pancreas weight ⁻¹ (g DM)	0.67c	0.69c	0.65c	0.63c	0.96a	0.78b	0.01
Pancreas body weight ⁻¹ (%)	0.12d	0.14c	0.12d	0.12d	0.21a	0.18b	0.019
Digestibilities (%) ^y							
Dry matter	94.0ab	93.3b	94.4a	93.8ab	93.4b	93.6b	0.24
Crude protein	91.0ab	90.3b	91.6a	90.3ab	90.5b	89.8b	0.44
Metabolizable energy	95.4a	94.2c	95.2ab	94.6bc	94.0c	94.4c	0.25

^zdf = 24.^yDigestibilities calculated using data from excreta collected over the period when the birds were 18–21 d of age. a,b Means within a row with the same letter are not significantly different ($P < 0.05$).

Table 4. Total body composition of broiler chickens fed diets from 7 to 21 d of age that contained soybeans from different sources

	SBM	Ac SB	Ac HP	Rt SB	Rw SB	LTI	SEM ^z
Dry matter (g)	173.8a	145.8b	148.9b	155.5b	116.2c	116.3c	6.9
Crude protein (g)	135.5a	113.4b	115.7b	120.4b	90.9c	90.5c	5.1
Fat (g)	18.2a	15.2b	16.0ab	17.2ab	11.7c	12.4c	1.3
Ash (g)	20.1a	17.2b	18.0b	18.6ab	13.5c	13.4c	0.8
Carcass energy (kJ ^y)	3880a	3244b	3329b	3487b	2585c	2599c	162

^zdf = 24.^yCalculated using the values of 23.4 and 38.9 kJ g⁻¹ for protein and fat, respectively, reported by Farrell (1974). a-c Means within a row with the same letters are not significantly different ($P < 0.05$).

source interactions, means for the dietary treatments are presented in Tables 3 and 4. Highest body weights and gains were obtained from birds fed the diet that contained SBM (Table 3). Among the birds fed the full-fat SB containing diets, those fed the heat-treated SB had higher ($P < 0.05$) 21-d body weights and gains than those fed the diets containing the Rw SB or LTI. The weights and gains of chickens fed Ac HP and Rt SB diets were similar, but greater ($P < 0.05$) than the values for those fed the Ac SB diet. The lowest 21-d body weights and weight gains occurred with the the birds given the diets that contained the Rw SB and LTI SB, even when these diets were supplemented with methionine (Chohan 1991). This indicates that the levels of TI in these SB (Table 2) impaired growth more than could be compensated by methionine supplementation alone. The results for the Rw SB contrast with previously

published findings which indicated that supplementation of diets containing raw SB with methionine partially corrected growth depression (Yen et al. 1973; Bajjalieh et al. 1980).

The weight gain data do not agree with previously published results which indicate that growth performance of chickens fed diets containing heat-treated full-fat SB was similar to that of chicks given SBM-containing diets (Wood et al. 1971; Waldroup and Cotton 1974). Yen et al. (1973), Bajjalieh et al. (1980) and Han et al. (1991) reported that the body weights of birds given diets containing LTI soybean were higher than those fed diets that contained conventional soybeans; the opposite occurred in the results reported herein (Table 3).

Feed intakes of the chickens given the diets that contained SBM, Rt SB, Ac SB and Ac HP were higher ($P < 0.05$) than for those fed the Rw SB or LTI-containing diets (Table 3).

Feed efficiency for the birds given the Ac HP diet was higher ($P < 0.05$) than for those receiving the Ac SB diet, but similar to the values for Rt SB- and SBM-fed chickens. The lowest feed efficiency values occurred with the Rw SB and LTI diets and were not different from each other. However, methionine supplementation of the LTI diet improved feed efficiency (1.68 vs. 1.83) due to higher ($P < 0.05$) weight gains of the birds given the supplemented LTI than for those given the non-supplement LTI diet (Chohan 1991). Methionine supplementation of the Rw SB diet had no significant effect on performance.

Pancreas weights of the birds fed unheated beans (Rw SB) were greater ($P < 0.01$) than those fed heated SB-containing diets (Table 3). The higher pancreas to body weight ratios observed for the birds fed Ac SB diet compared to those for chickens fed the Ac HP or Rt SB diets may be due to the higher residual TI activity (Table 2) in the former than in the latter SB sources. Although the performance of birds given the Rw SB and LTI diets was similar, the pancreas weights of the birds fed LTI and Rw SB diets were different ($P < 0.01$) with the latter being higher. The pancreas weights of the birds fed LTI diets were higher ($P < 0.05$) than for those birds given diets that contained heat-treated SB. The patterns of differences for the pancreas data among dietary SB sources were generally similar whether they were expressed on a dry weight or pancreas/body weight basis (Table 3). Methionine supplementation had no effect ($P > 0.05$) on the pancreas weight.

The digestibility values of dry matter, crude protein and metabolizable energy values for the Ac HP diet were higher ($P < 0.05$) than those for the Ac SB, Rw SB and LTI containing diets (Table 3). The highest digestibility values were obtained for the SBM and Ac HP diets and the lowest values for the Rw SB and LTI diets. The digestibility values of the autoclaved SB diet and the roasted SB diets were similar. The ME values were lowest for the raw SB diet. There was a moderate inverse relationship ($r^2 = 0.697$) between protein solubility (Table 2) and protein digestibility

(Table 3) values which indicates that the heat treatment during the autoclaving was not so excessive as to cause denaturation of the proteins.

The body composition of the birds is presented in Table 4. The dry matter, protein, and carcass energy contents of the birds fed SBM diet were higher ($P < 0.05$) than those fed full-fat SB diets. The body composition values of the chickens fed Ac SB, Rt SB and Ac HP diets were similar, but were higher ($P < 0.05$) than the values for birds fed Rw SB or LTI diets. The body composition of the chickens fed Rw SB and LTI diets was similar. Yen et al. (1973) reported that the body composition of chickens fed diets containing raw SB with differing TI levels was similar.

The increased pancreas weights of birds fed Rw SB and LTI (Table 3) were likely due to the presence of TI (Table 2) in these beans (Bajjalieh et al. (1980). The lower mean pancreas weight of the birds fed the LTI (Table 3) could then be a result of less pancreatic hypersecretion due to TI levels that were 40% less than those of the Rw SB (Table 2). Similar mean pancreas weights of the birds fed SB varying in TI contents have been reported (Bajjalieh et al. 1980). Pancreas weights, when expressed as percent of body weight, in the present study (Table 3) are similar to those quoted by Bajjalieh et al. (1980).

In conclusion, trypsin inhibitor levels in the LTI beans were not sufficiently reduced to support acceptable growth rates when they were incorporated into the starter diets of broiler chickens, even with methionine supplementation. In contrast, growth performance of the birds fed diets that contained the full-fat HP soybeans was similar to that obtained with diets containing conventional SB when the diets were isonitrogenous and isocaloric. Full-fat HP soybeans may replace conventional soybean meal in broiler starter diets if the formulation is adjusted for the differences in protein and fat.

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