J. Agric. Sci. Mansoura Univ., 27(10): 6613 - 6627, 2002

EFFICIENCY OF UTILIZATION OF PLANT PROTEIN DIETS BY THE BROILER CHICKS

Rabie, M. H.; Kh. El. Sherif; F. S. A. Ismail and A. H. Raya
Department of Poultry Production, Faculty of Agriculture, Mansoura University

ABSTRACT

This study was performed to evaluate the performance of broiler chicks fed diets containing different combinations of plant protein sources during the period from 17 to 45 days of age. Five isoenergetic-isonitrogenous diets (ME of about 3000 kcal/kg and CP of about 19%) were formulated and used. Soybean meal (SBM) was used to provide the main plant protein in the control diet. Equal amounts of protein of cottonseed meal (CSM) and corn gluten meal (CGM) were used to replace 25, 50, 75 or 100% of SBM protein in the corn-SBM control diet. Two hundred and ten 17-day-old unsexed broiler chicks were randomly distributed into five equal experimental groups, each with 6 equal replications, kept at the rearing batteries and fed *ad libitum* their respective mash experimental diets. The growth performance criteria, including live body weight, weight gain, feed intake and feed conversion, were measured weekly and for the entire experimental period. Total mortality and net profit per kg gain were also measured. Nutrient digestibilities of the experimental diets were determined when the birds were 35 days of age. The proximate analyses for representative samples of the experimental diets and excreta were undertaken. Also, crude protein and crude fiber contents of CSM were determined. At the end of study, certain criteria of carcass yield and components and some blood constituents (blood hemoglobin concentrations and serum levels of glucose, total protein, total lipids and cholesterol as well as activities of serum transaminases: AST and ALT) were quantified.

The most important results, for the entire experimental period, can be summarized as follows: ← Dietary treatments had no significant effects on either the percentages of carcass yield and components or blood constituents, except blood hemoglobin concentration which decreased significantly in the SBM-free diet group compared with that of the control group. ↑ Dietary treatments did not adversely affect feed intake, feed conversion, net profit per unit of gain or digestibility coefficients of nutrients when up to 50% of SBM protein was replaced by CSM plus CGM. → Replacing 75 or 100% of SBM protein with CSM plus CGM resulted in significant decreases in criteria of growth, feed conversion, digestibilities of dry matter, organic matter, crude protein, ether extract and nitrogen free extract and percentages of nitrogen retention, compared with the corresponding values for the control group.

In conclusion, when SBM represents the main protein source in plant protein broiler diets, taking the practical, nutritional and economic aspects into account, up to 50% of SBM protein can safely be replaced by equal amounts of protein from both CSM and CGM. The diets also should be well balanced in terms of their contents of all nutrients, particularly, the most limiting amino acids.

Keywords: Plant protein sources, broiler diets, growth performance

INTRODUCTION

Several reports have been found in the literature concerning the use of various protein sources in poultry nutrition. In most of these reports, soybean meal (SBM) was used to supply at least one-half the total protein content of the diets, destined for broiler chicks. The use of cottonseed meal (CSM) alone or in combination with other protein sources has been sporadically investigated in broiler chick diets (Morgan and Willimon, 1954; Anderson and Warnick, 1966; Ryan *et al.*, 1986; Raya *et al.*, 1991a,b; Watkins *et al.*, 1993, 1994; Hassan *et al.*, 1996).

Generally, the nutritional value of oil-seed meals depends primarily on their contents of crude protein (CP), crude fiber (CF) and energy, and their protein quality, i.e., amino acid composition and bioavailability as well as the presence of certain antinutritional substances. Soybean meal protein contains all the indispensable amino acids, but the concentrations of cystine and methionine are sub-optimal (McDonald *et al.*, 1988). Nevertheless, properly processed SBM is the major oil-seed meal that can be used safely in poultry diets. Unfortunately, limited amounts of SBM are produced in Egypt; the major portion is imported and thus, is usually more expensive compared with other oil-seed meals, under the Egyptian conditions.

Cottonseed meal, however, is produced in large amounts in Egypt, nevertheless, its use as a protein source is confined to broiler chicks rather than laying hen diets. In general, its limited use in poultry diets is probably attributed to the presence of a polyphenolic compound, gossypol, or cyclopropenoid fatty acids, malvalic and sterculic acids, the high fiber content of the meal or low amino acid availability or digestibility (Phelps, 1966). High concentration of gossypol in poultry diets have been associated with depressed feed intake and weight gains and increased mortality (Couch *et al.*, 1955; Heywang and Bird, 1955; Phelps, 1966). However, Heywang and Bird (1950) reported that increased dietary concentrations of gossypol were not always accompanied by lowered feed efficiency. Heywang *et al.* (1952) reported that free gossypol seems to be the major biologically active form, and this is used as a basis for identifying the permissible inclusion level of CSM in poultry diets.

According to Lyman *et al.* (1953), gossypol is an important factor affecting the nutritional value of CSM protein. However, lysine supplementation of diets containing CSM, with low level of free gossypol, resulted in good growth of chickens. Because gossypol is present in the pigment glands of the cottonseed, its deleterious effects are mainly based on the variety (Hassan *et al.*, 1960) and processing conditions of CSM (Lyman *et al.*, 1953). In this regard, Jones (1981) indicated that the predominant type of CSM available for feeding livestock in the developing countries is that resulting from a screw-press expeller; this meal has lower free gossypol than solvent-extracted meals.

Corn gluten meal (CGM) is the dried residue from corn after the removal of the large part of starch and germ and separation of the bran. It is a good source of protein, energy and methionine, but is quite low in lysine (Scott *et al.*, 1976). CGM is often added to broiler chick diets as an excellent source of xanthophylls for the pigmentation of skin and shanks (NRC, 1994). Also, it is a good source of highly available methionine and cystine (Sasse and Baker, 1973).

In recent years, there is some tendency among nutritionists to formulate animal protein-free diets for poultry; the sole source of protein in these diets is of plant origin. It is well known that protein-rich feedstuffs are usually the most expensive components of the ration. Some of these feedstuffs are locally produced, and some others are imported from the foreign countries. Thus, the availability and market prices of such feedstuffs vary considerably according to the supply-demand balance and other factors, either nationally or internationally.

On the other hand, when nutritional and practical aspects are taken into consideration, the least cost formulation of diets, especially for broiler chicks, may necessitate incorporating a variety of plant protein sources. Therefore, in order to keep pace with these new trends it was suggested that formulating diets for broiler chicks using different combinations of available plant protein sources can be more effective in enhancing their growth performance and/or economic efficiency.

The aim of the present study was to evaluate the performance of broiler chicks fed diets containing different combinations of soybean meal, corn gluten meal and cottonseed meal. The criteria of response were chicks' growth, net profit, digestibility of nutrients, carcass yield, and some blood parameters.

MATERIALS AND METHODS

The present study was carried out (from September to November 1998) at the Agricultural Experiments and Research Station, Poultry Production Farm, Faculty of Agriculture, Mansoura University, Egypt.

Birds and diets:

Two hundred and ten, day-old unsexed Hubbard broiler chicks, obtained from a local hatchery, were used in this study. The chicks were fed on a commercial starter diet (composed of 65% yellow corn, 25% soybean meal and 10% broiler concentrates) until 17 days of age; and then they were switched to the experimental diets. Five isoenergetic-isonitrogenous diets (metabolizable energy of about 3000 kcal/kg and crude protein content of about 19%) were formulated and used. SBM was used as the main source of plant protein in a corn-SBM control diet. Equal amounts of protein of both CSM and CGM were used to replace 25, 50, 75 or 100% of the crude protein content, supplied exclusively by SBM in the control diet. Proximate analysis of CSM samples reveled that it contained 11.2% CF and 44.66% CP. Diets formulation was made on the basis of the tabulated data of nutrient compositions of feed ingredients, published by NRC (1994). Composition and chemical analysis of the experimental diets are presented in Table 1.

Housing and management:

During both the starter and grower-finisher periods, the chicks were raised in an open-sided house, equipped with conventional wire-floored brooding and rearing batteries. The chicks were kept in the brooding batteries until they were 17 days old, then they were wing-banded, weighed individually and randomly distributed into five experimental groups and transferred to the rearing batteries. Each experimental group of 42 chicks was equally divided into 6 replicate groups and each replication served as an experimental unit.

Table 1: Composition and chemical analysis of the experimental diets fed to broiler chicks from 17 to 45 days of age

Ingredients %	Experimental diets				
	Replacement ratio of SBM protein (%)				
	00	25	50	75	100
Yellow corn	58.25	59.31	59.21	59.21	60.56
Soybean meal (SBM, 44%)	31.40	23.55	15.70	7.85	---
Cottonseed meal (CSM, 44.7%)	---	3.86	7.73	11.59	15.45
Corn gluten meal (CGM, 60%)	---	2.88	5.76	8.64	11.50
Wheat bran	1.60	1.60	1.50	1.71	1.50
Corn starch	2.75	3.00	5.00	6.40	6.40
Sunflower oil	2.25	1.75	0.95	0.30	---
Dicalcium phosphate	1.60	1.60	1.60	1.60	1.60
Limestone	1.40	1.60	1.60	1.60	1.80
Common salt	0.30	0.30	0.30	0.30	0.30
Vit. & Min. premix*	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.15	0.15	0.15	0.15	0.13
L-Lysine-HCl	---	0.10	0.20	0.35	0.46
Total	100	100	100	100	100
Calculated analysis					
ME; kcal/kg	3002	3003	3006	3007	3023
Crude protein; %	19.02	19.11	19.09	19.12	19.18
Ether extract; %	4.76	4.37	3.64	3.07	2.88
Crude fiber; %	3.66	3.60	3.50	3.44	3.36
Calcium; %	0.99	1.05	1.03	1.01	1.07
Total phosphorus; %	0.68	0.70	0.71	0.72	0.73
Available phosphorus; %	0.40	0.40	0.40	0.40	0.39
Lysine; %	1.00	0.99	0.98	1.01	1.01
Methionine; %	0.45	0.47	0.48	0.49	0.49
Meth. & Cys.; %	0.77	0.79	0.81	0.83	0.83
Cost P.T/kg diet**	80	79	79	79	79
Determined analysis (dry matter basis)					
Moisture; %	10.13	9.94	9.58	9.80	10.05
Crude protein; %	21.05	21.04	20.85	20.95	21.12
Ether extract; %	5.01	4.74	3.89	3.34	3.22
Crude fiber; %	4.23	4.12	3.80	3.90	3.89
Ash; %	6.46	6.24	6.30	6.52	6.90
NFE; %	63.25	63.86	65.16	65.29	64.87

***: Each 3-kg package contains: Vit. A, 12,000,000 IU; Vit. D_3, 2,500,000 IU; Vit. E, 10,000 mg; Vit. K_3, 2,500 mg; Vit. B_2, 5,000 mg; Vit. B_6, 1,500 mg; Vit. B_{12}, 10 mg; Biotin, 50 mg; Folic acid, 1000 mg; Nicotinic acid, 30 mg; Pantothenic acid, 10 g; Antioxidant, 10 g; Mn, 60 g; Cu, 10 g; Zn, 55 g; Fe, 35 g; I, 1 g; Co, 0.25 g and Se, 0.015 g.**

****: Prices of the experimental diets were calculated according to the average prices of feed ingredients during the period of study.**

Performance of chicks:

The performance of broiler chicks was evaluated in terms of live body weight, daily weight gain, daily feed intake and feed conversion as well as total mortality and net profit per kg gain, during the entire experimental period. Live body weights of the chicks were recorded Individually. Weekly feed intake, body weight gain and feed conversion were determined on a replicate group basis. Mortality was monitored and recorded daily. Net profit per kg gain was computed as price of kg gain (i.e., sale price per kg of live birds) minus feed cost per kg gain. Cost per kg diet (Table 1) and values of feed conversion for the six replicate groups of each dietary treatment were used to calculate the feed cost per kg gain.

Digestibility trial:

When the birds were 35 days old, a digestion trial was conducted for evaluating the digestibility coefficients of nutrients of the experimental diets. Six birds were selected from each treatment on the basis of average body weight, kept in a separate compartment of a growing battery fitted with galvanized metal trays and fed their respective experimental diet for a two-day pretest adaptation period, followed by a three-day test period. During the test period, daily feed intake was recorded and total excreta voided daily by each experimental group were collected, weighed and thoroughly mixed. Then representative excreta samples were taken, immediately dried and kept for later analysis. The proximate analyses for the experimental diets and dried excreta samples as well as for crude protein and crude fiber contents of CSM, were undertaken according to A.O.A.C. (1984). In order to estimate protein digestibility, fractions of fecal and urinary nitrogen in the excreta were chemically separated according to the method of Jakobsen *et al.* (1960). The percent of urinary organic matter was calculated by multiplying the percentage of urinary nitrogen by the factor 2.62 (Abou-Raya and Galal, 1971). Digestibility coefficients were calculated for dry matter, (DM), organic matter (OM), CP, CF, ether extract (EE) and nitrogen free extract (NFE). Percentages of ash and nitrogen retention were also calculated.

Carcass yield:

At the termination of the experiment (45 days of age), six birds were selected from each treatment (3 males and 3 females) on the basis of average weight, individually weighed and immediately sacrificed by decapitation. Then, their carcasses were scalded, feather-plucked and eviscerated. Procedures of cleaning out and excising of the abdominal fat contents were performed on hot carcasses. The abdominal fat includes the adipose tissues surrounding the gizzard and the bursa of Fabricius and cloaca. Records on individual weights of eviscerated carcass and edible organs (i.e., heart, liver without gall bladder and skinned empty gizzard) were maintained. Thereafter, each eviscerated carcass was dissected, at the end of ribs, into two portions, termed breast and thigh yields. Carcass yield was calculated as eviscerated carcass plus giblets. The live weight at slaughter minus carcass yield was considered to be the inedible parts of the carcass. All measurements of carcass yield and its components were expressed as absolute and relative weights.

Blood constituents:

Also, at the end of the experiment (45 days), blood was collected in non-heparinized tubes, by puncturing the wing veins of six birds from each treatment. Then, sera were separated by centrifugation and stored at –20 °C for later analysis. Individual serum samples were analyzed, using commercial kits, for determination of glucose, total protein, total lipids and cholesterol, and also activities of serum transaminases; aspartate aminotransferase (AST) and alanine aminotransferase (ALT), according to the methods of Trinder (1969), Henry (1964), Frings and Dunn (1970), Allain *et al.* (1974) and Reitman and Frankel (1957), respectively. Simultaneously, other six blood samples from the same birds of each treatment were collected in heparinized tubes and used, as soon as possible, for the determination of blood hemoglobin concentration (Van Kampen and Zijlstra, 1961).

Statistical analyses:

A completely randomized design was used. Data were subjected to a computerized one-way analysis of variance; the significant differences among dietary treatments were identified at $P \leq 0.05$ by LSD-multiple range test (Quattro program, Borland International, Inc., 1990 and Statgraphics Program version 5.0, Rockville, 1991).

RESULTS AND DICSUSSION

It is interesting to remind that protein sources involved in the current experimental diets were completely of plant origin. Soybean meal (SBM) was used to provide the main plant protein in the control diet. Cottonseed meal (CSM) and corn gluten meal (CGM) were used, at a ratio of 1:1 (on a protein equivalent basis), to replace part or all the dietary protein contributed by SBM.

Growth performance

Data on the performance and net profit of broiler chicks, fed experimental diets containing different combinations of plant protein sources from 17 to 45 days of age, are presented in Table 2. Live body weight of 45-day-old chicks was not significantly affected by dietary treatments until 50% of SBM protein was replaced by CSM and CGM mixture; while chicks fed diets with the higher replacement ratios (75% or 100% of SBM protein) had significantly lower body weight compared with the control group. The same trend of response was observed for daily weight gain during the whole experimental period; while daily feed intake of chicks fed SBM-free diet was significantly decreased in comparison with that of the control group. Averages of daily weight gain values were 49.6 ± 0.9 and 38.9 ± 0.4 g/bird and those of daily feed intakes were 102.3 ± 1.9 and 87.0 ± 1.0 g/bird for the control group and birds fed the diet having no SBM, respectively.

The highest two inclusion levels of CSM plus CGM, in place of SBM in broiler chick diets, negatively affected feed conversion and net profit per kg gain. The best feed conversion value (2.011± 0.02) was attained by the group of birds fed on the diet where 25% of SBM protein was replaced by CSM plus

Table 2: Means ± standard errors of performance criteria and net profit of broiler chicks fed diets containing different combinations of plant protein sources from 17 to 45 days of age

Criteria	Experimental diets					Sig.[1]
	Replacement ratio of SBM protein (%)					
	00	25	50	75	100	
Live body weight (g):						
17-day old	503±5	504±5	495±5	505±5	500±5	NS
24-day old	772±10^{a}	770±12^{a}	765±10^{ab}	740±10^{b}	688±8^{c}	**
31-day old	1120±15^{a}	1126±13^{a}	1144±18^{a}	1036±17^{b}	967±10^{c}	**
38-day old	1552±15^{ab}	1526±14^{bc}	1571±17^{a}	1502±22^{c}	1281±9^{d}	**
45-day old	1892±18^{a}	1894±14^{a}	1881±19^{a}	1789±20^{b}	1590±10^{c}	**
Daily weight gain (g/bird):						
17-24 days	38.4±1.0^{a}	38.1±1.5^{a}	38.5±1.2^{a}	33.6±0.9^{b}	27.0±0.9^{c}	**
24-31 days	49.8±1.0^{a}	50.8±1.1^{a}	54.2±2.3^{a}	42.3±2.6^{b}	39.8±1.3^{b}	**
31-38 days	61.7±2.0^{ab}	57.1±1.4^{b}	61.0±3.3^{ab}	66.5±2.6^{a}	44.8±1.1^{c}	**
38-45 days	48.3±1.5^{ab}	52.5±0.9^{a}	43.1±2.7^{c}	40.9±1.2^{c}	44.0±1.0^{bc}	**
17-45 days	49.6±0.6^{a}	49.6±0.9^{a}	49.2±1.3^{a}	45.8±0.8^{b}	38.9±0.4^{c}	**
Daily feed intake (g/bird):						
17-24 days	58.7±2.3^{a}	58.2±2.8^{a}	58.6±1.9^{a}	51.4±1.2^{b}	43.5±1.0^{c}	**
24-31 days	92.5±1.3^{a}	94.7±2.1^{a}	99.6±3.7^{a}	79.8±4.3^{b}	76.4±1.8^{b}	**
31-38 days	123.7±4.8	120.4±3.1	121.0±7.4	133.4±4.9	113.5±3.6	NS
38-45 days	134.1±2.8^{a}	129.5±5.3^{a}	125.4±6.2^{ab}	132.0±4.6^{a}	114.6±2.3^{b}	*
17-45 days	102.3±1.9^{a}	100.7±2.3^{a}	101.2±3.6^{a}	99.1±1.3^{a}	87.0±1.0^{b}	**
Feed conversion (g:g):						
17-24 days	1.527±.02	1.526±.03	1.524±.02	1.529±.02	1.614±.03	NS
24-31 days	1.859±.03	1.865±.01	1.841±.03	1.891±.02	1.923±.04	NS
31-38 days	2.004±.03^{c}	2.107±.02^{b}	1.981±.03^{c}	2.007±.01^{c}	2.531±.02^{a}	**
38-45 days	2.782±.07^{bc}	2.463±.08^{d}	2.936±.13^{b}	3.230±.09^{a}	2.609±.05^{cd}	**
17-45 days	2.031±.03^{c}	2.011±.02^{c}	2.055±.03^{c}	2.146±.02^{b}	2.237±.02^{a}	**
Mortality and net profit (17-45 days):						
Mortality ratio[2]	2/42	1/42	2/42	2/42	3/42	
Sale price L.E./kg gain	4.75	4.75	4.75	4.75	4.75	
Feed cost L.E./kg gain	1.62±0.03^{c}	1.59±0.02^{c}	1.62±0.02^{c}	1.69±0.02^{b}	1.77±0.02^{a}	**
Net profit[3] L.E./kg gain	3.13±0.03^{a}	3.16±0.02^{a}	3.13±0.02^{a}	3.06±0.02^{b}	2.98±0.02^{c}	**

a-c: Means in the same row having different superscripts differ significantly.
[1]: NS = not significant; * = significant at P≤0.05; ** = significant at P≤0.01.
[2]: Mortality ratio refers to number of dead birds / initial number of birds.
[3]: Net profit per kg gain = price of kg gain – feed cost per kg gain.

CGM, but was not significantly different from that of the control group (2.031± 0.03). While the worst value (2.237 ± 0.02) was achieved by the group of birds fed on the diet in which all SBM protein was replaced by CSM plus CGM. Net profit per kg gain was significantly reduced when the mixture of CSM plus CGM replaced 75 or 100% of SBM protein in the diet. Taking the total body weight gain into account, further reductions in profit were found when more than one-half of SBM protein was replaced by CSM plus CGM in the broiler chick diets, during the grower and finisher periods. Mortality of birds, however, may not be related to the dietary treatments, since all deaths occurred during the last week of study in both the control group and the other experimental groups.

Increasing the inclusion levels of CSM plus CGM to replace 75 or 100% of SBM protein in the diets depressed the daily weight gain of chicks by 7.66 and 21.57% with concurrent reductions in daily feed intake reached 3.13 and 14.96%, respectively, during the entire experimental period. It was evident that much of the weight gain depression of chicks given these high CSM-CGM diets could be attributed to decreased feed intake. The reduction in feed intake of chicks fed such diets may be due to the presence of gossypol pigments or some unpalatable components in CSM or to specific amino acid imbalances. Since feed conversion is a growth-correlated trait consequently, it was impaired by 5.66 and 10.14%, respectively, for the birds fed those diets in which CSM plus CGM replaced 75 or 100% of SBM protein. Part of the reduction in feed conversion seems to have been mediated through decreased availability or utilization of nutrients, particularly, amino acids.

In this regard, Ryan *et al.* (1986) reported that lysine is the most limiting amino acid when CSM is used as the sole source of protein in a diet for broiler chicks. However, Jonston and Watts (1964) and Anderson and Warnick (1966) found that both lysine and methionine are limiting in meals prepared from glandless cottonseed. But, it should be noted that all diets, used in the present study, were isoenergetic and isonitrogenous and of approximately similar contents of crude fiber, lysine, methionine and total sulfur amino acids (methionine + cystine).

Generally, no definite explanation could be offered for this poor performance of broiler chicks fed the high CSM-CGM diets compared with the control diet, mainly because neither gossypol content of CSM nor its amino acid availability was determined. The present results, however, are in partial agreement with those reported by Raya *et al.* (1991a) who pointed out that the quality of CSM protein was inferior to that of SBM protein, as evidenced by chick growth performance. Working with Dokki-4 and Plymouth Rock chicks, Hermes *et al.* (1983) found that feeding decorticated cottonseed meal up to 25% of the diet from day old to 8 weeks of age decreased body weight gain, feed consumption and feed efficiency for both breeds. Similarly, Fernández *et al.* (1994) indicated that diets containing high levels of CSM resulted in poor growth and feed efficiency when fed to chicks. In disagreement with the present results, Watkins *et al.* (1993, 1994) were able to feed diets containing up to 30% CSM to broiler chicks without a detrimental effect on weight gain. In their latter study, however, efficiency of feed utilization was depressed by CSM.

Nutrient digestibility

Data on digestibility coefficients of nutrients and retention rates of ash and nitrogen, for 5-week-old broiler chicks fed the experimental diets, are presented in Table 3. The statistical analysis of the results detected no significant differences among the various dietary treatments in digestibility of CF or in ash retention. However, significant decreases in both nitrogen retention and digestibilities of DM, OM, CP, EE and NFE were recorded for the birds fed the experimental diets in which 75 or 100% of SBM protein was replaced by CSM plus CGM, compared with those of the control group.

Although the experimental diets, used in this study, were of approximately similar compositions, the diets containing only one-fourth or no SBM protein produced significant reductions in DM, OM, CP, EE and NFE digestibilities as well as in nitrogen retention, compared with those of the control group. These results may account for some of the depression occurred in growth performance for chicks of these two treatments. Whether these observed reductions in nitrogen retention and in digestibilities of nutrients (DM, OM, CP, EE and NFE) are related to using a type of CSM having an inferior protein quality and/or to other dietary factors need to be confirmed. In general, our results are in partial agreement with the findings obtained by Raya *et al.* (1991b). They found significant decreases in the digestion coefficients of DM, OM, CP, EE, CF and NFE as well as in the percentages of ash and nitrogen retention, when SBM was completely replaced by CSM in broiler chick diet.

Table 3: Means ± standard errors of digestibility coefficients of nutrients in 35-day-old broiler chicks fed diets containing different combinations of plant protein sources

Criteria	Experimental diets					Sig.[1]
	Replacement ratio of SBM protein (%)					
	00	25	50	75	100	
Digestibility coefficients (%)						
DM	74.48±0.5[a]	76.30±1.0[a]	75.30±1.0[a]	70.06±0.7[b]	69.48±0.4[b]	**
OM	77.76±0.6[a]	79.62±0.8[a]	78.86±0.9[a]	73.00±0.7[b]	72.37±0.4[b]	**
CP	86.46±0.7[a]	87.71±0.5[a]	86.42±0.2[a]	79.52±1.0[b]	78.37±0.4[b]	**
EE	82.96±0.6[a]	84.29±0.3[a]	81.47±1.7[a]	76.38±1.1[b]	68.11±1.0[c]	**
CF	12.17±1.5	13.31±2.9	13.44±1.4	13.77±1.1	13.02±1.2	NS
NFE	88.33±0.4[a]	89.84±0.7[a]	88.86±0.9[a]	84.38±0.5[b]	84.95±0.3[b]	**
Retention rate (%)						
Ash	34.99±1.0	36.68±3.8	32.32±1.9	31.19±2.1	34.22±0.9	NS
Nitrogen	55.07±1.2[a]	57.48±0.8[a]	56.05±1.7[a]	47.00±1.4[b]	44.10±0.9[b]	**

a-c, Means of the same row having different superscripts differ significantly.
[1]: NS = not significant; ** = significant at P≤0.01.

In this connection, Dalibard and Paillard (1995) found that true digestibilities of protein and amino acids in CSM were lower than those in SBM. Fernández *et al.* (1995) have shown that formulating diets for broiler chicks with up to 20% CSM, on a digestible amino acid basis, gave superior growth performance to the formulation on the basis of ingredient total amino acid content. On the other hand, Fernández and Parsons (1996) have demonstrated that bio-availabilities (assessed by chick growth) of crystalline lysine and valine in amino acid mixtures simulating CSM and SBM were generally lower than those of the digestible lysine and valine in CSM and SBM. These findings may interpret why the current experimental diets, having approximately similar contents of lysine and total sulfur amino acids, did not give consistent responses.

Carcass yield

Table 4 summarizes certain criteria of carcass yield and components of 45-day-old broiler chicks, fed the experimental diets. There were no significant differences among dietary treatments in absolute or relative weights of abdominal fat and heart of broilers. Significant differences were observed among dietary treatments in regard to the absolute weights of the other carcass components and inedible parts; but with no differences in their relative weights. So, it was obvious that such significant differences, in absolute weights of eviscerated carcass, liver, gizzard, giblets, breast yield, thigh yield and carcass yield as well as inedible parts, were in consequence of the variations in live body weight at slaughter. It was observed, however, that percentages of carcass yield were numerically higher, but not significantly, for the experimental groups fed diets in which 50, 75 or 100% of SBM protein was replaced by CSM-CGM mixture compared with that of the control group.

Table 4: Means ± standard errors of absolute and relative weights (% of live body weight) of carcass yield of 45-day-old broiler chicks fed diets containing different combinations of plant protein sources

Criteria	Experimental diets					Sig.[1]
	Replacement ratio of SBM protein (%)					
	00	25	50	75	100	
Live weight, g	1900 ± 15^{a}	1890 ± 10^{a}	1875 ± 13^{a}	1795 ± 13^{b}	1593 ± 8^{c}	**
Eviscerated carcass, g	1335 ± 5^{ab}	1323 ± 17^{ab}	1362 ± 31^{a}	1285 ± 6^{b}	1166 ± 17^{c}	**
%	70.3±0.4	70.0±0.9	72.6±1.2	71.6±0.5	73.2±1.2	NS
Liver, g	42.8 ± 2.0^{a}	39.0 ± 1.1^{ab}	39.7 ± 1.4^{a}	39.2 ± 1.5^{a}	34.8 ± 1.2^{b}	*
%	2.25±0.1	2.06±0.06	2.12±0.07	2.18±0.08	2.19±0.08	NS
Heart, g	10.8±0.7	9.17±0.5	10.3±0.6	9.17±0.3	9.00±0.6	NS
%	0.57±0.04	0.49±0.03	0.55±0.03	0.51±0.02	0.57±0.04	NS
Gizzard, g	29.0 ± 0.7^{a}	31.7 ± 1.1^{a}	29.5 ± 1.3^{a}	30.3 ± 0.8^{a}	25.7 ± 0.5^{b}	**
%	1.53±0.04	1.68±0.06	1.57±0.07	1.69±0.06	1.61±0.03	NS
Giblets, g	82.7 ± 2.8^{a}	79.8 ± 1.9^{a}	79.5 ± 3.0^{a}	78.7 ± 1.7^{a}	69.5 ± 1.1^{b}	**
%	4.35±0.13	4.23±0.11	4.24±0.15	4.38±0.10	4.36±0.08	NS
Breast yield, g	722 ± 8^{a}	716 ± 16^{a}	738 ± 20^{a}	696 ± 12^{a}	639 ± 17^{b}	**
%	38.0±0.5	37.9±0.9	39.3±0.9	38.8±0.8	40.1±1.0	NS
Thigh yield, g	571 ± 9^{ab}	563 ± 7^{ab}	579±12a	549 ± 11^{b}	490 ± 9^{c}	**
%	30.0±0.5	29.8±0.3	30.9±0.5	30.6±0.5	30.8±0.7	NS
Carcass yield, g	1418 ± 7^{ab}	1403 ± 17^{ab}	1441 ± 33^{a}	1364 ± 7^{b}	1236 ± 17^{c}	**
%	74.6±0.5	74.2±0.9	76.8±1.3	76.0±0.6	77.6±1.2	NS
Abdominal fat, g	23.7±3.5	31.8±3.1	28.8±2.9	20.2±1.9	23.3±3.3	NS
%	1.25±0.18	1.68±0.16	1.54±0.15	1.12±0.10	1.47±0.21	NS
Inedible parts, g	482 ± 12^{ab}	487 ± 19^{a}	434 ± 23^{b}	431 ± 12^{b}	358 ± 19^{c}	**
%	25.4±0.5	25.8±0.9	23.2±1.3	24.0±0.6	22.4±1.2	NS

a-c, Means of the same row having different superscripts differ significantly.

[1]: NS = not significant; * = significant at $P\leq0.05$; ** = significant at $P\leq0.01$.

Scarce comparative information could be found in the literature on the effects of dietary inclusion levels of CSM plus CGM in broiler chick diets on carcass yield and components. In contradiction to the present results Atuahene *et al.* (1986) found that dressing percentages were significantly decreased with increasing dietary levels of raw cottonseed meal up to 10% of diets for broiler chickens. In general, regardless of dietary treatments and strain of broiler chicks, the means for percentages of eviscerated carcass and carcass yield obtained herein are in agreement with those reported by Sherif *et al.* (1995) and Rabie *et al.* (1997).

Blood constituents

Blood constituents of broiler chicks, determined herein, were chosen to serve as an indicator for the health, nutritional and metabolic states of the birds. Data on these blood constituents (concentrations of blood hemoglobin, and of serum glucose, total protein, total lipids and cholesterol as well as activities of serum transaminases: AST and ALT) of 45-day-old broiler chicks, fed the experimental diets, are shown in Table 5. Only blood hemoglobin concentration was significantly decreased in the experimental group fed the SBM-free diet (8.39 ± 0.4g/dL), compared with that of the control group (9.87 ± 0.3 g/dL). However, blood hemoglobin concentration in the group fed on SBM-free diet was insignificantly different from that of birds fed the diet in which 75% of SBM protein was replaced by CSM-CGM mixture (9.06 ± 0.3 g/dL).

Table 5: Means ± standard errors of blood constituents of 45-day-old broiler chicks fed diets containing different combinations of plant protein sources

Criteria[1]	Experimental diets					Sig.[2]
	Replacement ratio of SBM protein (%)					
	00	25	50	75	100	
Hemoglobin, g/dL	9.87±0.3[a]	9.96±0.4[a]	9.99±0.3[a]	9.06±0.3[ab]	8.39±0.4[b]	**
Glucose, mg/dL	251±5.8	262±1.7	260±2.4	260±2.0	260±1.1	NS
Total protein, g/dL	3.35±0.67	4.84±0.92	4.09±0.13	4.10±0.08	4.08±0.03	NS
Total lipids, g/L	4.84±0.12	4.76±0.18	4.67±0.03	4.75±0.04	4.77±0.06	NS
Cholesterol, mg/dL	116±1.7	116±2.0	117±1.5	119±0.9	119±1.1	NS
AST, U/L	126±1.5	127±3.1	130±5.8	134±2.5	136±4.2	NS
ALT, U/L	34.3±2.0	33.2±2.3	33.8±2.4	36.0±1.8	36.7±1.3	NS

[1]: Determined on serum samples, except for hemoglobin on the whole blood.
a-b: Means of the same row having different superscripts differ significantly.
[2]: NS = not significant; ** = significant at $P \leq 0.01$.

The decreased feed intake for the SBM-free diet group may have contributed to this difference in blood hemoglobin concentration. Another possible explanation may be related to the interference with iron metabolism, which could be mediated by decreasing the intestinal absorption rate of dietary iron or its availability prior to absorption or at the metabolic level, leading to an impaired rate of heme formation, and thus, of hemoglobin biosynthesis. In this regard, it has been reported that free gossypol, present in CSM, forms complexes with iron in the feed, intestinal tract and blood of birds, leading to possible iron deficiency (Phelps, 1966; NRC, 1994).

Whatever the mechanisms involved, the depressing effects of dietary treatments on blood hemoglobin concentrations are in agreement with those observed by Atuahene *et al.* (1986). However, Raya *et al.* (1991b) observed no significant differences in concentrations of plasma total protein, total lipids, cholesterol, glucose, or in blood hemoglobin and blood sedimentation rate due to complete substitution of CSM for SBM in broilers diet. These authors have determined the blood constituents of 8-week-old Lohmann broiler chicks and used a different type of CSM from that used in this study. The absence of significant differences among the dietary treatments for the other blood parameters, tested herein, may reflect normal metabolic processes and functions of organs and tissues. Regardless of the effect of the dietary treatments and age of growing birds, means of most blood constituents measured in this study are in harmony with those reported by Ross *et al.* (1978), Freeman (1984). El-Deek *et al.* (1999) and Rabie *et al.* (2001).

CONCLUSION

In conclusion, when SBM represents the main protein source in plant protein broiler diets, taking the practical, nutritional and economic aspects into account, up to 50% of SBM protein can safely be replaced by equal amounts of protein from both CSM and CGM. The diets also should be well balanced in terms of their contents of all nutrients, particularly, the most limiting amino acids.

REFERENCES

Abou-Raya, A. K. and A. Gh. Galal (1971). Evaluation of poultry feeds in digestion trials with reference to some factors involved U. A. R. (Egypt), Animal Production, 11: 207-221.

Allain, C. A.; L. S. Poon; C. S. G. Chang; W. Richmond and P. C. Fu (1974). Enzymatic determination of total serum cholesterol. Clinical Chemistry, 20: 470-475.

Anderson, J. O. and R. E. Warnick (1966). Sequence in which essential amino acids became limiting for growth of chicks fed rations containing cottonseed meal. Poultry Science, 45: 84-89.

A. O. A. C.; Association of Official Analytical Chemists (1984). Official Methods of Analysis 14^{th} Ed, A.O.A.C., Arlington, Virginia, USA.

Atuahene,C. C.; A. Donkoh and D.P.Nkansah (1986).Effect of raw cotton-seed meal on the performance, carcass characteristics and certain lood parameters of broiler chickens.J. Anim. Prod. Res., 6(2): 107-114.

Borland International, Inc., (1990). Quattro Program, Version 1.0

Couch, J. R.; W. Y. Chang and C. M. Lyman (1955). The effect of free gossypol on chick growth. Poultry Sci., 34: 178-183.

Dalibard, P. and E. Paillard (1995). Use of the digestible amino acid concept in formulating diets for poultry. Anim. Feed Sci. Technol., 53: 189-204.

El-Deek, A. A.; M. A. Abaza; M. Osman; Y.A. Attia and A. M. Khalaf (1999). Inclusion of sunflower meal and commercial enzymes to egg type strain ration during the growth period.1. Effects on growth erformance, mortality rate, blood parameters and economic returns. Egyptian Poultry Sci. J., 19: 529-547.

Fernández, S. R. and C. M. Parsons (1996). Bioavailabilities of the digestible lysine and valine in cottonseed and soybean meals for chick. Poultry Sci., 75: 216-223.

Fernández, S. R.; Y. Zhang and C. M. Parsons (1994).Effect of overheating on the nutritional quality of cottonseed meal.Poultry Sci., 73: 1563-571.

Fernández, S. R.; Y. Zhang and C. M. Parsons (1995). Dietary formulation with cottonseed meal on a total amino acid versus a digestible amino acid basis. Poultry Sci., 74: 1168-1179.

Freeman, B. M. (1984). Appendix: Biochemical and Physiological Data. In: Physiology and Biochemistry of the Domestic Fowl. Vol. 5, pp. 407-424. B.M. Freeman, Ed., Academic Press, London, UK.

Frings, C. S. and R. T. Dunn (1970). A colorimetric method for determination of total serum lipids based on the sulfo-phosphovanillin reaction. Amer. J. Clin. Pathol., 53: 89-91.

Hassan, I.; A. G. Abdallah; S. Abou El-Wafa and A. Z. Soliman (1996). Utilization of decorticated local cottonseed meal in broiler diets. Egyptian Poultry Sci., 16(1): 31-49.

Hassan, K.; A. Anwar and J. I. Ibrahim (1960). Factors affecting total and free gossypol contents of home-produced cottonseed meals. Annals Agric. Sci., Ain-Shams Univ., 5(2): 67-75.

Henry, R. J. (1964). Clinical Chemistry: Principles and Technics, Harper and Row Publishers, New York.

Hermes, I. H.; N. E. Asker; M. T. Shulkamy and M. El-Sheikh (1983). The effect of using different levels of decorticated cotton seed meal on the performance of chicken. 1. Growth and feed efficiency of starting chicks. Annals Agric. Sci., Ain-Shams Univ., Egypt, 28(3): 1415-1428.

Heywang, B. W. and H. R. Bird (1950). Supplements for cottonseed meal diets for chickens. Poultry Sci., 29: 486-495.

Heywang, B. W. and H. R. Bird (1955). Relationship between the weight of chicks and levels of dietary free gossypol supplied by different cottonseed products. Poultry Sci., 34: 1239-1247.

Heywang, B. W.; H. R. Bird and R. P. Kupperman (1952). The loss or inactivation of pure gossypol in a mixed diet. Poultry Sci., 31: 35-39.

Jakobsen, P. E.; K. Gertov and S. H. Nielsen (1960). Fordøjelighedsforsøg med fjerkrae. "Digestibility trials with poultry) 1. Fordø jelseskanalen hos høns samt metodiske problemer ved gennemførelsen af fordøjelighedsforsøg.322 beretning fra forsøgslaboratoriet,øbenhaven.

Jones, L. A. (1981). Nutritional values for cottonseed meal. Special cottonseed products report. Feedstuffs, December: 19-21.

Jonston, C. and A. B. Watts (1964). The chick feeding value of meals prepared from glandless cottonseed. Poultry Sci., 43: 957-963.

Lyman, C. M.; W. Y. Chang and J. R. Couch (1953). Evaluation of protein quality in cottonseed meals by chick growth and by a chemical index method. J. Nutr., 49: 679-690.

McDonald, P.; R. A. Edwards and J. F. D. Greenhalgh (1988). Chapter 22. Protein Concentrates, pp. 455-483. In: Animal Nutrition, 4th ed., Co-published in the United States by John Wiley & Sons, Inc., New York.

Morgan, C. L. and C. P. Willimon (1954). Cottonseed meal prepared by different methods for broiler rations. Poultry Sci., 33: 528-532.

National Research Council (NRC, 1994). Nutrient Requirements of Poultry. 9th revised edition, National Academy Press, Washington, DC.

Phelps, R. A. (1966). Cottonseed meal for poultry: from research to practical application. World's Poultry Sci. J., 48: 86-112.

Rabie, M. H.; M. A. A. Hussein; Kh. El. Sherif; M. G. Kassem and A.M. Abbas (2001). The use of graded levels of sunflower meal in growing pullet diets. J. Agric. Sci., Mansoura Univ., 26(11): 6723-6734.

Rabie, M. H.; M. Szilágyi; T. Gippert; E. Votisky and D. Gerendai (1997). Influence of dietary L-carnitine on performance and carcass quality of broiler chickens. Acta Biologica Hungarica, 48(2): 241-252.

Raya, A. H.; A. M. Abbas and M. A. A. Hussein (1991a). Comparative studies on the efficiency of some plant protein sources to replace soybean meal in rations for broiler chicks. 1. Performance of chicks and economic efficiency. J. Agric. Sci., Mansoura Univ., 16(11): 2501-2513.

Raya, A. H.; A. M. Abbas and M. A. A. Hussein (1991b). Comparative studies on the efficiency of some plant protein sources to replace soybean meal in rations for broiler chicks. 2. Nutrient digestibility and blood constituents. J. Agric. Sci., Mansoura Univ., 16(11): 2514-2527.

Reitman, S. and S. Frankel (1957). A colorimetric method for the determination of serum glutamic oxaloacetic and glutamic pyruvic transaminases. American. J. Clin. Path., 28: 56-63.

Rockville (1991). Statgraphics program, version 5.0 STSC.

Ross, J. G.; G. Christie; W. G. Halliday and R. Morley-Jones (1978). Haematological and blood chemistry "comparison values" for clinical pathology in poultry. Veterinary Record, 102: 29-31.

Ryan, J. R.; F. H. Kratzer; C. R. Grau and P. Vohra (1986). Glandless cottonseed meal for laying and breeding hens and broiler chicks. Poultry Sci., 65: 949-955.

Sasse, C. A. and D. H. Baker (1973). Availability of sulfur amino acids in corn and corn gluten meal for growing chicks. J. Anim. Sci., 37: 1351-1355.

Scott,M. L.; M. C. Nesheim and R. J. Young (1976). Nutrition of the Chicken. 2nd ed., M. L. Scott & Associates, Ithaca, New York.

Sherif, Kh. El.; T. Gippert and D. Gerendai (1995). Replacing soybean meal with sunflower meal in broiler rations and its effects on the performance of chicks and carcass traits. Állat. Takar., 44(6): 525-532.

Trinder, P. (1969). Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Ann. Clin. Biochem, 6: 24-27.

Van Kampen, E. J. and Zijlstra, W. G. (1961). International committee for standardization in haematology. Brit. J. Haemat. 13 (Suppl.) 71.

Watkins, S. E.; J. T. Skinner; M. H. Adams and P. W. Waldroup (1993). An evaluation of low-gossypol cottonseed meal diets for broiler chickens. 1. Effect of cottonseed meal level and lysine supplementation. J. Appl. Poutry Res., 2: 221-226.

Watkins, S. E.; J. T. Skinner; M. H. Adams and P. W. Waldroup (1994). An evaluation of low-gossypol cottonseed meal diets for broiler chickens. 2.Influence of assigned metabolizable energy values and supplementation with essential amino acids on performance. J. Appl. Poutry Res., 3: 7-16.

كفاءة كتاكيت اللحم في استخدام العلائق نباتية البروتين

محمود حسن ربيع، خليل الشحات شريف، فوزي صديق عبد الفتاح إسماعيل، عبد البصير حمزة محمد ريا
قسم إنتاج الدواجن – كلية الزراعة – جامعة المنصورة

هدفت هذه الدراسة إلي تقييم استجابة كتاكيت اللحم عند التغذية علي علائق تتضمن توليفات مختلفة من مصادر البروتين النباتي خلال الفترة من ١٧ إلي ٤٥ يوماً من العمر. تم تكوين عليقة مقارنة (كنترول) تحتوي علي كسب فول الصويا كمصدر رئيسي لبروتين العليقة كما تم تكوين أربعة علائق تجريبية أخري باستخدام كميات متساوية من البروتين من كسب بذرة القطن وكسب جلوتين الذرة لتحل محل ٢٥، ٥٠، ٧٥ أو ١٠٠% من بروتين كسب فول الصويا. احتوت كل العلائق التجريبية الخمسة علي مقادير متساوية من الطاقة والبروتين (٣٠٠٠ك كالورى/كجم طاقة تمثيلية، ١٩% بروتين خام). تم التقسيم العشوائي لعدد ٢١٠ كتكوت تسمين غير مجنسة في عمر ١٧ يوماً إلي خمس مجموعات تجريبية متساوية بكل منها ٦ مكررات (٧طيور بكل مكررة)، وتم إسكانها في بطاريات النمو وغذيت كل مجموعة علي العليقة الخاصة بها بحرية طوال فترة الدراسة. تم تسجيل الأوزان الفردية للطيور أسبوعياً كما تم تسجيل النفوق يومياً. تم حساب متوسطات استهلاك العلف والزيادة في وزن الجسم والتحويل الغذائي أسبوعياً وكذلك للفترة التجريبية الكلية. تم حساب الأرباح الصافية لكل كجم من الزيادة في وزن الجسم للمجموعات التجريبية المختلفة. عند عمر ٥ أسابيع تم عمل تجارب هضم لحساب معاملات الهضم للمركبات الغذائية المختلفة للعلائق التجريبية. تم تحليل المحتوي الغذائي لعينات ممثلة من العلائق والزرق الناتج، كما تم تحليل محتوي كسب بذرة القطن المستخدم من البروتين الخام والألياف الخام. في نهاية التجربة أجري اختبار ذبح لتقدير محصول الذبيحة ومكوناتها، كما تم أخذ عينات دم من الطيور الحية لتقدير تركيز هيموجلوبين الدم ومحتويات سيرم الدم من كل من الجلوكوز، البروتين الكلي، الدهون الكلية والكوليسترول وكذلك نشاط إنزيمي أسبرتيت أمينوترانسفيريز (AST) والانين أمينوترانسفيريز (ALT) في السيرم.

ويمكن تلخيص أكثر النتائج أهمية (للفترة التجريبية الكلية) في الأتي:

(١) لم تؤثر المعاملات الغذائية معنوياً علي النسب المئوية لمحصول ومكونات الذبيحة أو معايير الدم باستثناء تركيز هيموجلوبين الدم الذي انخفض معنوياً في المجموعة التي غذيت علي العليقة الخالية من كسب فول الصويا مقارنة بنظيره في عليقة الكنترول.

(٢) لم يكن للمعاملات الغذائية تأثيراً سلبياً علي استهلاك العلف، النمو، التحويل الغذائي، الكفاءة الاقتصادية أو معاملات الهضم للمركبات الغذائية المختلفة وذلك عند استبدال ٥٠% من بروتين كسب فول الصويا بمخلوط كسب بذرة القطن + كسب جلوتين الذرة (١:١ علي أساس المحتوي البروتيني لكل منهما).

(٣) أدي استبدال ٧٥ أو ١٠٠% من بروتين كسب فول الصويا بمخلوط كسب بذرة القطن + كسب جلوتين الذرة إلي حدوث نقص معنوي في كل من معايير النمو والتحويل الغذائي ومعاملات هضم المادة الجافة، المادة العضوية، البروتين الخام، المستخلص الأثيري والمستخلص الخالي من النيتروجين وكذلك نسب احتجاز النيتروجين مقارنة بالقيم المناظرة لعليقة الكنترول.

من النواحي العملية والغذائية والاقتصادية يمكن استنتاج أنه في علائق كتاكيت اللحم (المحتوية علي كسب فول الصويا كمصدر رئيسي للبروتين) يمكن استبدال ٥٠% علي الأكثر من بروتين كسب فول الصويا بمقادير متساوية من البروتين من كل من كسب بذرة القطن وكسب جلوتين الذرة دون حدوث أية تأثيرات سلبية علي حيوية الطيور، المظاهر الإنتاجية، خصائص الذبيحة أو معاملات هضم العناصر الغذائية علي أن تكون تلك العلائق متزنة جيداً في محتواها من جميع العناصر الغذائية وخاصة الأحماض الأمينية الحرجة.