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Original Article

Evaluation Corn Gluten Meal Nutritive Value for Broiler Chicks

Arash Hassanzadeh Seyedi[1*] and Ali Hosseinkhani[2]

[1]*Young Researchers and Elite Club, Tabriz Branch, Islamic Azad University, Tabriz, Iran*
[1, 2]*Department of Animal Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran*

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ABSTRACT

Objective: The aim of this experiment was to determine chemical composition, protein quality of corn gluten meal (CGM) and its effect on growth performance of broiler chicks. **Methods:** Chemical composition and nitrogen corrected true metabolizable energy of CGM was determined by standard and precision-fed cockerel assay methods. For evaluating of protein quality, 90 male broiler chicks in a completely randomized design was used and fed experimental diets from 8 to 17 days of age and in the growth assay, 1200-day-old broiler chickens in a completely randomized design were used for evaluating effects of four levels of CGM on the growth performance, carcass characteristics. **Results:** The average of TME_n and crude protein content of CGM sample were 4145 kcal/kg and 60.44 %, respectively. The protein efficiency ratio (PER) and Net protein ratio (NPR) values for CGM were 1.26 and 2.30, respectively. The growth assay result showed that the all level of CGM had positive effect on broiler performance (P<0.01), While, the best weight gain and FCR were obtained in the birds were fed 12% of CGM in different weeks of experimental period. **Conclusions:** Therefore, it is suggested that the CGM can be used in the ration for improvement broiler chicks' performance.

1.INTRODUCTION

Corn gluten meal (CGM), a by-product from corn-wet milling, is a high protein (60% minimum), highly digestible source of plant proteins. Protein from corn gluten meal is composed mainly of zein (68%), glutelin (27%) and small amounts of globulins (1.2%) (Cha et al. 2000). It is, also, rich in Methionine (Sasse and Baker 1973), but, its Arginine, lysine and tryptophan contents are rather low (Peter et al. 2000). CGM is a rich source of vitamins E and B complex and contains low amounts of phosphorus (Peter et al. 2000). Dewatered or wet CGM contains 35 – 40% solids. However before being marketed it is dried to obtain a ~90% of dry matter content (Park et al. 1997). Due to its high nutritional value, low cost and relatively good availability, CGM is generally utilized as a feed ingredient for a wide variety of ruminant and mono gastric animals including fish. The CGM has been used in poultry diets due to its high protein content (NRC 1994), high-energy content, and high level of xanthophylls (Peter et al. 2000). In recent years, poultry industry has been increasingly developed in Iran and, therefore, this industry need to high quality protein sources, such as CGM. Many studies have been conducted on protein quality changes and other nutritional characteristics of CGM in several countries (Sasse and Baker 1973; Peter et al. 2000; Kim et al. 2012). Little new researches are available on CGM use in feeding poultry; As Kim et al. (2012) reported that this

***Corresponding Author:** Arash Hassanzadeh Seyedi, Young Researchers and Elite Club, Tabriz Branch, Islamic Azad University, Tabriz, Iran.

by-product could be using as a protein supplement in poultry rations (Peter et al. 2000; Malik et al. 1971). CGM largely produced in Iran and it is often added to broiler chick diets as an excellent source of xanthophylls for the pigmentation of shanks and skin, but little information has been reported on the nutritive value of CGM for broiler chicks. Therefore, the objective of the present study was to evaluate the chemical composition, protein quality and the optimum level of CGM in the ration of broiler chicks for the best performance.

2. MATERIALS AND METHODS

2.1. Birds and Experimental Design

All bird procedures were conducted according to the 2006 Guidelines on Animal Care of the Agriculture Organization of East Azerbaijan, Tabriz, Iran. One-day-old male broiler chickens (Ross 308) were obtained from a commercial hatchery. They were placed in a commercial brooder at 32°C and given ad libitum access to a standard chick starter food and water in all period of the experiment. The initial room temperature was 32°C and this was reduced by 1°C at 2-d intervals to 24°C. Room humidity was set at50% for the duration of the experiment and light was continuous during the whole experimental period.

2.2. TME_n and Chemical Analysis of Corn Gluten Meals

The precision-fed cockerel assay of Sibbald et al. (1986) was used for determining the true metabolizable energy (TME_n) of the corn gluten meal. The birds were housed in individual metabolism cages that were 0.40-m wide, 0.40-m long, and0.50-m high. Following a period of 24 h without feed, 25 g of the different ground CGM samples were fed by intubation to 12 adult leghorn male roosters (6 per CGM). Another6 roosters were fasted to estimate endogenous losses. Total excreta voided over the following48-h period were dried and ground for subsequent analyses. Corn gluten meal and excreta samples were freeze-dried before analysis and the CP, EE, DM, TVN and ash content of feed and excreta were determined according to AOAC methods (1991). Energy was determined by a Parr adiabatic calorimetric bomb (1975). The amino acid composition of corn gluten meal was analyzed by ion exchange chromatography (Llames and Fontaine 1994).

2.2.1. Protein Quality Assay

Ninety -day-old Ross-308 male broiler chicks were fed a 23% CP corn-soybean meal pretest diet during the first week post hatching. Following an overnight period fasting, the chicks were weighed and allotted to dietary treatments as described by Sasse and Baker (1973). Five groups of six chicks were assigned to each dietary treatment. The experimental diets were fed from 8 to 17 days post-hatching and weight gain and feed consumption were measured for each group of chicks in 9 day of assay. The chicks were kept in cages with raised wire floors and subjected to 23 h light and 1 h dark daily. Feed and water were offered as ad-libitum. An N-free basal diet was used in the chick assays for determining protein quality of the CGM samples. Dietary treatments consisted of the N-free basal diet (Table 1) or the basal diet plus 10% CP provided solely by one of the CGM and Casein (Casein was also evaluated to blank) samples which replaced in portion of the cornstarch and glucose. PER and NPR was calculated as follows:

PER = body weight gain /CP intake

NPR=[(body weight gain of chicks fed semi purified diets – body weight gain of chicks fed nitrogen free basal diet]/CP intake.

Table 1.

feed ingredient and composition of nitrogen free basal diet

ingredient	Percent
Corn starch	62.00
Glucose	31.00
Soybean oil	2.28
Oyster shell	1.13
Dicalcium phosphate	2.67
Iodized salt	0.4
Vitamin premix	0.25
Mineral premix	0.25
Antioxidant	0.01
Calculated chemical composition	
ME kcal/kg	3600
Crude protein	0
Ca	1
P	0.5

2.3. Growth bioassay

The protocol for this experiment was reviewed and approved by the University of Tabriz Animal Care Committee, and chicks were cared for according to the 2006 Guidelines on Animal Care of the Agriculture Organization of East Azerbaijan, Tabriz, Iran. The 1200 -day-old male broiler chickens (Ross 308) were obtained from a commercial producer. Broiler chicks were randomly grouped into five groups of six replicates, and each replication containing 40 chicks (initial weight 44.21±0.19). Four level of corn gluten meal C1, C2, C3 and C4 (3, 6, 9 and 12%, respectively), and 0% corn gluten meal for control group were used to evaluate nutritive value of corn gluten meal in broiler diets (table 2). The diets were provided as mash and fed in the experimental period from 0 to 42 d of age (feed and water were available ad libitum). Chicks were weighed ensemble every week and weight gain was determined. Feed was added, as necessary, and weekly and cumulative feed intakes were determined from feed left as opposed to feed given.

2.4. Statistical analysis

A completely randomize design was to execute this experiment for biological data of weight gain, feed intake and feed/gain ratio, and other data were subjected to statistical analysis using analysis of variance and the means were separated if they were significantly different using Duncan Multiple range test of SAS (9.1) (2002).

Table 2.

Ingredient composition of the experimental diets

	Starter 0-10 day					Grower 14-28 day					Finisher 29-49 day				
CGM %	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
ingredient															
corn	53.11	53.44	53.73	54.02	54.33	55.01	55.30	55.60	55.90	56.20	60.00	60.30	60.60	60.90	61.20
Soybean	39.33	38.82	38.33	37.84	37.35	36.70	36.21	35.72	35.22	34.72	31.22	30.73	30.23	29.73	29.24
CGM	---	0.3	0.6	0.9	1.2	---	0.3	0.6	0.9	1.2	---	0.3	0.6	0.9	1.2
Soybean oil	3.23	3.11	2.99	2.87	2.75	4.31	4.19	4.07	3.96	3.86	4.94	4.82	4.70	4.58	4.47
DCP*	1.93	1.93	1.94	1.94	1.94	1.69	1.69	1.69	1.7	1.7	1.6	1.61	1.61	1.61	1.61
Oyster shell	1.2	1.21	1.21	1.21	1.21	1.1	1.1	1.1	1.1	1.1	1.05	1.06	1.06	1.06	1.06
Premix**	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Na_2Co_3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Salt	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
DL-	0.18	0.17	0.16	0.15	0.14	0.19	0.18	0.17	0.16	0.15	0.2	0.19	0.18	0.17	0.16
Lysine	0.08	0.1	0.12	0.14	0.16	0.07	0.09	0.11	0.13	0.15	0.05	0.07	0.09	0.11	0.13
Chemical															
AME_n kcal/kg	2950	2950	2950	2950	2950	3050	3050	3050	3050	3050	3150	3150	3150	3150	3150
Cp %	22	22	22	22	22	21	21	21	21	21	19	19	19	19	19
Ca%	1	1	1	1	1	0.9	0.9	0.9	0.9	0.9	0.85	0.85	0.85	0.85	0.85
P %	0.5	0.5	0.5	0.5	0.5	0.45	0.45	0.45	0.45	0.45	0.42	0.42	0.42	0.42	0.42
Lysine %	1.45	1.45	1.45	1.45	1.45	1.26	1.26	1.26	1.26	1.26	1.09	1.09	1.09	1.09	1.09
Methionine%	0.52	0.52	0.52	0.52	0.52	0.47	0.47	0.47	0.47	0.47	0.4	0.4	0.4	0.4	0.4

*Di-calcium phosphate
** Mineral and vitamin premix: vitamin A 10000 IU; vitamin D3 3000 IU; vitamin E 40 mg; vitamin K3 2 mg; vitamin B1 2.4 mg; vitamin B2 6 mg; vitamin B6 3.5 mg; vitamin B12 0.16 mg; biotin 0.125 mg; panthotenate 12 mg; nicotinamide 35 mg; folic acid 1.0 mg; choline chloride 200 mg; Zn80 mg; Fe 50 mg; Mn 70.0 mg; Cu 15 mg; Se 0.3 mg; Co 0.3 mg; Ca 0.076%; J 0.8 mg; salinomycin 60 mg.

3. RESULTS AND DISCUSSION

3.1. TME_n, Chemical composition, amino acid content and Protein quality

Table 3 shows the nutrient composition of the Iranian produced CGM. TME_n, crude protein and total volatile nitrogen content ranged from 4132.87 to 4157.13 kcal/kg, 60.23 to 60.65% and 32.87 to 33.95, respectively, and the Lysine and Tryptophan content ranged from 1.04 to 1.14 % and 0.3 to 0.46 %, respectively.

Table 3.

Chemical composition of CGM

Item	Average ± SD
Dry Matter, %	89.48±0.08
Crude Protein, %	60.44±0.21
Ether extract, %	2.9±0.05
Total Volatile Nitrogen, %	33.41±0.54
Ash, %	2.1±0.06
Arginine, %	2.01±0.01
Lysine, %	1.09±0.05
Methionine, %	1.44±0.01
Threonine, %	1.88±0.04
Tryptophan, %	0.38±0.08
Gross energy, Kcal/kg	5509±34.66
True Metabolizable Energy, Kcal/kg	4145±12.13

The PER and NPR values for chicks fed diets containing 10% CP furnished by CGM and Casein are presented in the table 4. The results of this study indicated that PER and NPR values for CGM were lower than Casein. The average PER and NPR values of CGM were 1.26 and 2.30, respectively.

Table 4.

Protein quality values for the CGM

Item	Weight gain(g)	CP intake (g)	PER	NPR
CGM	16.25	12.86	1.26	2.30
Casein	51.79	17.7	2.92	4.01
SEM	0.544	0.379	0.062	0.127

The proximate nutrient and amino acids content of CGM sample were in a similar range to those reported in NRC (1994). The CP content of Iranian CGM was less than that reported by peter et al. (2000) (60.44 vs. 65.4 %). The Iranian CGM had a relatively high amount of energy content. . Mean TME_n content obtained in the present study was higher than the reported by NRC (1994) (4145 vs. 3811 kcal/kg). Such discrepancies might have resulted from differences in the varieties of corn seed samples used in the CGM production, or it might have resulted from a higher fat content in compare to this reported in NRC (1994). Similarly, gross energy content averaged 5509 kcal/kg and was considerably higher (5509 vs. 5467 kcal/kg) than reports of Rochell et al. (2011). Peter et al. (2000) reported the Arginine, Lysine, Methionine and Threonine content of CGM samples to be 2.03, 0.98, 1.46 and 2.00 %, respectively. In the current study, amounts of the mentioned amino acids were in agreement by result of Kim et al. (2012). However, any differences in chemical composition can be due to the variety of corn, CGM production conditions, agronomic and climatologically conditions of corn cultivate. Protein quality of plant protein sources commonly evaluate by integrative methods such as PER and NPR. Some information is present on probably damages during processing and bioavailability of amino acids in tissue level for birds. At the present study, PER values of CGM sample was similar to that reported by peter et al. (2000). In this experiment, the large, positive differences in PER and NPR values observed between casein and

CGM supplemented diets, and all differences in PER and NPR values were due to the high potential of casein amino acid bioavailability in compared to imbalance amino acids structure of CGM, specially deficiency of Arginine, lysine and tryptophan contents are remarkable (peter et al. 2000). Protein quality values reported here can be affect by the raw material storage duration prior to rendering, methods and conditions of processing of CGM. However, we did not have similar studies to compare the differences between the NPR content of CGM. Therefore, differences between NPR content of CGM remain unknown.

3.2. Performance

Result of weight gain, feed consumption and feed conversion ratio (FCR) are shown in the table 5.

Table 5.

Effects of different CGM levels on growth performance

performance	Level of CGM%	Weeks					
		1	2	3	4	5	6
Body weight gain(g)	0	165.25^{d}	447.50^{d}	852.50^{e}	1386.00^{d}	1862.25^{e}	2645.50^{e}
	3	170.50^{c}	458.50^{c}	866.25^{d}	1404.50^{c}	1887.25^{d}	2678.50^{d}
	6	175.50^{b}	462.75^{b}	874.00^{c}	1421.00^{b}	1959.75^{c}	2701.50^{c}
	9	179.50^{a}	468.00^{a}	883.50^{b}	1461.25^{a}	2008.00^{b}	2731.50^{b}
	12	181.75^{a}	470.50^{a}	887.50^{a}	1466.25^{a}	2074.50^{a}	2756.75^{a}
	SEM	1.87	1.31	1.89	5.78	11.05	6.32
Feed intake(g)	0	167.50	542.00^{a}	1251.00^{a}	2299.25^{a}	3380.00^{a}	4914.00^{a}
	3	166.75	540.25^{ab}	1232.00^{b}	2277.50^{b}	3374.75^{ab}	4840.00^{b}
	6	166.00	538.75^{b}	1217.00^{c}	2248.50^{c}	3367.75^{b}	4811.50^{bc}
	9	165.75	536.00^{c}	1204.25^{d}	2202.00^{d}	3348.00^{c}	4805.75^{c}
	12	165.50	535.00^{c}	1196.25^{d}	2176.50^{e}	3337.50^{d}	4768.25^{d}
	SEM	1.25	1.19	5.31	8.34	4.63	14.26
FCR	0	1.013^{a}	1.211^{a}	1.467^{a}	1.658^{a}	1.815^{a}	1.857^{a}
g feed/g live weight	3	0.978^{b}	1.178^{b}	1.422^{b}	1.621^{b}	1.788^{b}	1.806^{b}
	6	0.945^{bc}	1.164^{c}	1.392^{c}	1.582^{c}	1.718^{c}	1.781^{c}
	9	0.923^{cd}	1.145^{d}	1.363^{d}	1.506^{d}	1.667^{d}	1.759^{d}
	12	0.910^{d}	1.137^{e}	1.347^{d}	1.484^{e}	1.608^{e}	1.729^{e}
	SEM	0.015	0.003	0.007	0.008	0.009	0.007

^{a,b} means within a column without a common superscript are significantly different (p<0.01).

Increasing CGM levels in the diet significantly improved broiler performance (p<0.01), and the best weight gain and FCR obtained in the birds were fed 12% of CGM during the experimental period. No differences were found between the groups received 9 and 12% CGM in the four initial weeks, however 12% dietary CGM had the highest weight gain during the two last weeks (p<0.05). Interestingly 12% dietary CGM showed the lowest feed intake among the experimental groups which resulted the lowest FCR in the mentioned group (p<0.01), but, this result in contrast with result of peter et al. (2000). These researchers showed that feed intake and FCR were not affected by consuming the fully fortified CGM diet (with 18.34% of diet) compared to the corn-soybean meal diet. The reason of this observation was probably due to nutrient requirements supplementation for broiler chicks in these experimental diets of present study. The best representation of the weight gain was observed in level 12% of CGM diet, and this result reflected on the feed conversion ratio. In this experiment, increasing of CGM content in the diets had beneficial effect on weight gain, but Ismail et al. (2005) reported that increasing dietary CGM beyond 9% adversely affected broiler chicks' growth performance and weight gain reduced a little with increasing the CGM supplementation in diets. In early studies, Waldroup (2000) reported that CGM could be included in broiler diets without impairing performance at rates of 10%. However, Rose et al. (2003) demonstrated a significant increase in feed intake when broiler chicks were fed a diet containing 10% CGM. In more recent studies that have evaluated the use of high levels of CGM in broilers diets, supplementation with liquid and dried CGM products had no negative effect on growth performance compared to control diets (Koreleski 2003). The reason of poor performance of CGM contains diets in different studies can be due to imbalance amino acids structure of CGM. Moreover, the imbalance amino acids content in the ingested feed due to CGM consumption can transmit some signals to appetite center in brain, which brings about lower feed intake (Harper 1964). Pang et al. (1972) demonstrated that amino acid imbalance can reduce the consumption of lysine as the first limiting amino acid in broiler which in turn, through making some signals in brain, it causes a reduction in feed intake and reduce the broiler chicks performance. However, in the present experiment, CGM containing diets were fortified with synthetic amino acids to reduce the effect of amino acid imbalance. Remarkable improvement for FCR was observed in broilers chicks fed all levels of CGM during all of rearing weeks. These results were in agreement with those of Silva et al. (2003) who observed positive effect of CGM supplementation and reported that FCR improved with increasing CGM (Koreleski 2003). With regard to table 6, the CGM had remarkable effect on carcass efficiency. Basic factors in relation to carcass efficiency in broiler chickens are: abdominal fat, breast weight and empty body weight that, these three cases in nourished chickens with ration contain of CGM have significant difference with control group (p<0.01).

Table 6.

Effects of different CGM levels on carcass traits

Item	Variable (g)			
	Empty body weight	Breast weight	Leg weight	Abdominal fat
	Level of CGM			
0	1869.36^{d}	723.13^{d}	432.67^{b}	71.33^{a}
3	2093.46^{c}	818.05^{cd}	724.00^{ab}	88.50^{a}
6	2127.25^{c}	857.38^{bc}	712.00^{ab}	84.33^{a}
9	2183.95^{b}	927.37^{ab}	762.00^{a}	84.00^{a}
12	2246.01^{a}	995.17^{a}	767.33^{a}	63.00^{a}
SEM	15.72	33.04	15.54	4.69

^{a,b} means within a column without a common superscript are significantly different (p<0.01).

The researches on the use of CGM have almost entirely been focused on ruminants (Bowman and Paterson 1988). However the results of present study clearly showed that CGM incorporation in broiler diets at low amounts (up to 6 percent of diet) has no effect on performance or carcass characteristics, and higher amount of CGM in the broiler diets (i.e. 12%) can improve empty body weight and breast weight (p<0.01) and numerical reduce abdominal fat of the birds. Rose et al. (2003) have also reported well comparable result, which supplemented varied CGM levels in broiler ration and found increase carcass fat which ultimately improved the dressing percentage, and fortified CGM with lysine influence the composition of carcass and fat metabolism. In contrast, Ismail et al. (2005) reported that CGM supplementation in broiler diets have an adverse effect on carcass treats. It can be due to amino acids imbalance, reduction of lysine consumption, reduction of protein consumption and imbalanced ratio of energy to amino acids which are followed by considerable fat deposit in abdomen.

CONCLUSION

Corn gluten meals can be ideally improved broiler chick weight gain, FCR and carcass treats, further increase in CGM n broiler chick diets not show any negative effect on production and profitable broiler farming.

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