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Sunflower meal in commercial layer diets formulated on total and digestible amino acids basis

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ABSTRACT

An experiment was conduced to evaluate the inclusion of sunflower meal (SBM) in commercial layer diets formulated on total or digestible amino acids basis. One hundred forty-four 41-week-old Lohmann LSL layers were distributed in a completely randomized experimental design in a 2 x 4 factorial arrangement with three replications of six birds each. Treatments consisted of a combination of four SBM inclusion levels SBM(0%, 4%, 8%, and 12%) and feed formulation according two amino acid recommendations (total or digestible). The experimental period was divided into five periods of fourteen days. Performance parameters (egg production, feed intake, feed conversion, egg mass) were evaluated for each period. In the last two days of each period, three eggs per replication were collected to evaluate egg quality (Haugh units, specific gravity, egg weight, eggshell thickness, and eggshell percentage). Hens fed on total amino acid recommendation presented the highest values for egg weight. Diets formulated on digestible amino acids basis showed an improvement in eggshell percentage and egg specific gravity. SBM addition in commercial layer diets did not influence performance; however, increasing SBM dietary levels SBM improved eggshell quality.

INTRODUCTION

Feed is the main cost of poultry production, and often accounts for 60-65% of total costs of commercial egg production. Soybean meal is the conventional protein source in layer diets, and it is influenced by external fluctuations. Increasing ingredient prices remain the greatest single item that determines profit margins in poultry production. The best strategy to reduce costs is the development of diet formulation using alternative, locally available, ingredients, thereby decreasing feed costs. SBM is a well-established and relatively inexpensive protein source for poultry diets. In addition, it can be harvested two or three times a year in tropical areas, being a good alternative for oil producers and for the feed mill sector (Vieira *et al.*, 1992). However, the use of SBM in poultry diets is limited by variations in its chemical composition, and the two main components apparently restricting its use are high fiber/low energy and low lysine contents (Senkoylu and Dale, 1999).

Variations in the chemical composition of SBM are a consequence of the different processing methods, which determine the composition of this ingredient use as feedstuff. The extent of dehulling is an important determinant of the protein and fiber content of the resulting meal, whereas the processing method influences fat content. High temperatures associated with processing can damage proteins and reduce the availability of several amino acids, particularly lysine. (Ravindran and Blair, 1992; Dale, 1996)

According to Cuca *et al.* (1973) and Michael & Sunde (1985), SBM is relatively rich in sulfur amino acids, but if not used together with other proteins sources or synthetic amino acids, two amino acid deficiencies should be expected: lysine, as first limiting amino acid, and threonine. Some studies indicate that lysine is the first limiting amino acid in broiler diets containing SBM (McGinnis *et al.*, 1948, Thomas *et al.*, 1965, Rad & Keshavarz, 1976); however, lysine supplementation to SBM-based layer diets does not appear to be as critical as in broiler diets because their lysine requirement is much lower (Senkoylu and Dale, 1999).

Unlike most other oilseed meals, SBM does not contain high concentrations of anti-nutritive factors. Milic *et al.* (1968) detected 1.56% of a tannin-like chlorogenic acid compound, which inhibits the activity of digestive enzymes, including trypsin, chymotrypsin, amylase, and lipase in sunflower seeds. Heating the seeds at 100°C, or at 135°C for 5 hours, destroyed about 43% of this chlorogenic acid. On the other hand, there is no data on the effects of heat treatments on lysine availability (Senkoylu and Dale, 1999). The addition of methionine and choline are required to counteract the effect of chlorogenic acid when SBM is used in the diet (Swick, 1999).

Reports on the use of SBM in poultry diets are not always consistent, probably due to differences in plant variety, chemical composition, processing method, bird age, and food formulation techniques used in the various studies. Uwayjan *et al.* (1983) evaluated three levels of sunflower seeds (10, 20, or 30%) in replacement of 15, 30, or 45% of soybean meal or 9.5, 19 or 28.6% of corn, respectively, in commercial layer diets during production phase aiming at establishing the best level of sunflower inclusion. Results indicated that all tested levels of sunflower seed inclusion promoted relative worse performance, and diet supplementation with lysine or methionine did not correct this negative result.

Michel & Sunde (1985) verified standard performance in 12-20 week-old layers fed diets in which soybean meal was completely replaced by sunflower seed, with supplementation or not of lysine and/or methionine. Also working with 12-20 week-old layers, Pinheiro *et al.* (1999) observed that, up to the inclusion level of 21%, SBM (with no lysine addition) did not impair bird performance.

On the other hand, Serman *et al.* (1997), evaluating the effect of decorticated SBM as protein source in commercial layer diets on production performance, concluded that diets formulated with this ingredient needed to be supplemented with lysine and also with an energy source. Karunajeewa *et al.* (1989) previously evaluated the inclusion of SBM, sunflower seed, and other byproducts of sunflower oil extraction in layer diets, and also concluded that this ingredient may replace up to 75% of the protein source when energy and essential amino acid are supplemented.

In a trial with broiler chickens, Furlan *et al.* (2001) evaluated the inclusion of increasing SBM levels, and found that soybean meal crude protein could be replaced by sunflower protein up to a level of 30% in diets with equal energy and amino acid (digestible methionine + cysteine and lysine) ratios, approximately corresponding to an inclusion of 15%. Similar results were found by Pinheiro *et al.* (2002), who added 0%, 4%, 8%, or 12% of SBM in broiler chicken diets. No change in weight gain and feed intake from 3 to 42 days of age was observed.

The objective of the present study was to evaluate the performance and the egg quality of commercial layers fed diets with increasing SBM levels, and formulated on total or digestible amino acids basis.

MATERIAL AND METHODS

One hundred and forty-four commercial layers (Lohmann LSL) were housed in wire cages (25x40x40) in conventional layers houses at the Experimental Poultry Farm of Faculdade de Ciências Agrárias e Veterinárias (FCAV-Unesp). A completely randomized design was used, with three replications of six birds each, two hens per cage. The experiment started when the hens were 41 weeks of age, and consisted of five periods of fourteen days. Light was provided for 16 hours per day during the experimental period. Feed and water were offered *ad libitum.*

The treatments were distributed using a factorial arrangement (2x4), which consisted of the combination of two amino acid (AA) recommendations (TA or DA), and four SBM inclusion levels (0%, 4%, 8%, or 12%).

The experimental diets were formulated to supply the requirements of total or digestible amino acids, as recommended by Rostagno *et al.* (2000). The following treatments were defined:

- TA – 0%, 4%, 8%, or 12% → Total amino acid recommendations and 0%, 4%, 8%, or 12% of SBM inclusion level, respectively;
- DA – 0%, 4%, 8%, or 12% → Digestible amino acid recommendations and 0%, 4%, 8%, or 12% of SBM inclusion level, respectively.

The diets were formulated to provide the same levels of energy (2.85 Mcal ME/kg), calcium (3.70%), and available phosphorus (0.34%). Total amino acid based diets were formulated with 14.5% crude protein, and the digestible amino acid based diets with 12.8% crude protein. Analyzed SBM nutritional composition was 28% CP, 12.1% CF, 0.4% Ca, 0.16% available phosphorus (P_a), and 0.20% Na. The composition of the experimental diets, and calculated nutritional values are presented in Table 1.

Egg production (EP) was recorded daily, and the average of each replicate was expressed per period. All eggs produced during the last 2 days were used to evaluate specific gravity (SG – g/cm^3) by egg flotation method, and 3 eggs were randomly collected from each experimental unit in order to determine egg weight (EW – g), Haugh Units (HU), eggshell thickness (ST – mm), and egg percentage (EP - %). Feed intake (FI – g/bird/day), egg mass (EM – g), egg weight (EW – g), and feed conversion ratio (FCR - kg feed/kg eggs) were measured at the end of each period.

The obtained data were submitted to analysis of variance, using the *General Linear Model* procedure (GLM) of SAS® software (SAS Institute, 1996). Means were compared by the test of Tukey at 5% probability. Regression analysis of SBM levels was performed using treatments based on total or digestible amino acid basis when the SBM level was significant, and the AAxSM interaction was not.

RESULTS AND DISCUSSION

Laying performance and egg quality parameters are present in Tables 2 and 3. The results for performance parameters (Table 2), feed intake, egg production, egg mass, and feed conversion ratio, were not statistically different ($p>0.05$) between amino acid feed formulation treatments. However, egg weight of birds fed the diet formulated on digestible amino acid basis was lower than egg weight of birds fed the total amino acid diet ($p<0.05$). Interactions among SBM inclusion levels of and amino acid recommendations were not observed. There was no statistical difference ($p>0.05$) among SBM inclusion levels of for performance parameters.

Egg quality results (Table 2) showed that SBM did not influence Haugh units. A linear response for SBM

Table 1 – Ingredient composition and calculated nutritional levels of diets based on total or digestible amino acids.

Ingredients	Total amino cid diets				Digestible amino acid diets			
	0	4	8	12	0	4	8	12
Corn	70.97	66.97	64.64	62.29	74.33	73.76	70.03	54.87
Soybean meal	11.00	16.32	13.84	11.36	9.00	9.00	9.00	9.00
Sunflower meal	0.00	4.00	8.00	12.00	0.00	4.00	8.00	12.00
Limestone	6.34	8.41	8.39	8.37	8.48	8.45	8.41	8.36
Starch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Corn gluten meal 60% CP	5.53	0.00	0.00	0.00	3.73	1.59	0.00	0.00
Dicalcium phosphate	1.35	1.35	1.35	1.35	1.40	1.38	1.38	1.41
Sand	3.51	0.00	0.00	0.00	1.63	0.00	0.00	4.92
Vitam. Min. Suplement*	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sodium chloride	0.44	0.42	0.40	0.39	0.44	0.42	0.41	0.40
L-Lysine HCl (78%)	0.23	0.07	0.10	0.14	0.29	0.27	0.24	0.23
DL-Methionine (98%)	0.08	0.11	0.09	0.08	0.13	0.14	0.14	0.14
Soybean oil	0.00	1.83	2.67	3.50	0.00	0.43	1.84	6.13
Antioxidant	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
L-Tryptophan (10%)	0.03	0.00	0.00	0.00	0.05	0.04	0.03	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CALCULATED VALUE								
Metab. energy (Mcal/Kg)	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
Crude protein (%)	14.50	14.50	14.50	14.50	12.70	12.70	12.70	12.70
Crude Fibre (%)	1.88	2.53	2.84	3.14	1.81	2.26	2.67	2.89
Calcium (%)	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70
Available phosphorus (%)	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Sodium (%)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Aminoacids (%)	Total amino acids				Digestible amino acids			
Lysine	0.72	0.72	0.72	0.72	0.64	0.64	0.64	0.64
Met. + Cys	0.62	0.62	0.62	0.62	0.56	0.56	0.56	0.56
Methionine	0.35	0.36	0.35	0.35	0.35	0.35	0.35	0.36
Threonine	0.55	0.56	0.56	0.56	0.42	0.42	0.42	0.42
Tryptophan	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.14

* Vitamin and mineral supplement added per kg of diet: Vit A – 8.000 UI; Vit D3 - 2.000 UI; Vit E - 50 mg; Vit K3 – 3 mg; Vit B1 – 1.5 mg; Vit B2 – 4 mg; Vit B6 – 0.12 mg. Vit B12 – 15 mcg; Folacin – 0.6 mg; Pantothenic Acid 10 mg; Niacine – 30 mg; Biotine - 0.1 mg; Choline – 300 mg; Iron – 50 mg; Copper – 10 mg; Zinc – 70 mg; Manganese – 100 mg; Iodine – 1 mg; Selenium – 0.3 mg; Antioxidant 50 mg.

Table 2 – Performance and egg quality parameters from layers fed diets containing different SBM levels and formulated on total or digestible amino acid (AA) basis.

Treatments	FI	EP	EW	EM	FCR	HU	SP	SG
TA – 0	94.72	65.79	65.07	42.86	2.196	96.80	9.10	1.0825
TA – 4	91.84	71.32	64.00	45.71	2.013	95.77	9.43	1.0850
TA – 8	92.80	71.62	62.32	44.66	2.075	94.57	9.69	1.0863
TA – 12	93.56	76.12	63.30	48.12	1.919	95.11	9.49	1.0849
TA mean	93.23	71.22	63.67 A	45.34	2.051	95.56	9.43 B	1.0847 B
DA – 0	94.45	68.20	62.80	42.78	2.150	96.16	9.62	1.0861
DA – 4	87.25	67.05	61.13	40.94	2.120	96.41	9.50	1.0849
DA – 8	89.54	75.82	60.60	45.90	1.940	94.95	9.82	1.0874
DA – 12	88.98	67.12	64.26	43.17	2.055	96.94	9.70	1.0870
DA mean	90.06	69.54	62.19 B	43.20	2.066	96.12	9.66 A	1.0864 A
CV %	4.88	8.12	2.70	7.92	5.66	2.10	2.03	0.11
Factorial analysis								
AA	NS	NS	<0.05	NS	NS	NS	<0.001	<0.001
SBM	NS	NS	NS	NS	NS	NS	<0.05 (1)	<0.05 (2)
AAxSBM	NS	NS	NS	NS	NS	NS	NS	NS
Regression analysis								
Linear	NS	NS	NS	NS	NS	NS	<0.05	<0.01
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS
Cubic	NS	NS	NS	NS	NS	NS	NS	NS
R^2	-	-	-	-	-	-	0.54	0.64

A, B - Means in the same column followed by the same letter are not significantly different (P>0.05). (1) - SP = 9.3942 + 0.025 SBM (R^2=0.54). (2) - SG = 1.0845 + 0.0002 SBM (R^2=0.64).

inclusion levels was observed for eggshell percentage and egg specific gravity (p<0.05): eggshell quality values improved as SMB inclusion levels increased (P<0.05). Eggshell percentage and egg specific gravity values of hens fed digestible amino acid diets were higher (p<0.05) as compared to hens fed total amino acid diets.

In terms of eggshell thickness, the results of AA and SBM treatments were not independent (Table 3). Eggshell was thicker with 8% SBM inclusion level in the total amino acid based diet. The diet with no SBM based on total amino acids presented the thinnest eggshell (p<0.05). Significant results were not observed (p>0.05) among SMB inclusion levels in digestible amino acids based diets.

Table 3 – Factors affecting shell thickness (mm).

AA levels	SBM levels				
	0	4	8	12	Mean
TA	0.385 Bb	0.397 Aab	0.406 Aa	0.397 Bab	0.396
DA	0.405 Aa	0.397 Aa	0.406 Aa	0.409 Aa	0.404
Mean	0.395	0.397	0.406	0.403	0.400
CV% = 1.61					

A, B - Means in the same column followed by the same letter are not significantly different (P>0.05). a, b - Means in the same row followed by the same letter are not significantly different (P>0.05).

The results from the present study are consistent with findings from other authors. When evaluating decorticated SBM levels for layers (0, 5.79, 12.19, or 18.97%), Karunajeewa *et al.* (1989) did not find significant effects of these inclusion levels on egg production, egg mass, or feed conversion ratio; however, the authors observed that, as SMB inclusion levels increased, there was a trend of reduction in Haugh units. Similar results were found by Vieira *et al.* (1992). Egg weight, eggshell quality, and egg production were not affected by graded levels of SBM inclusion in layer diets (13.5, 27, or 40.5%). On the other hand, positive linear effects were observed for feed intake and feed conversion ratio with SBM inclusions. Serman *et al.* (1997) used 24% decorticated SBM in layer diets, and observed that, when lysine and energy were supplemented, bird performances were similar or higher as compared to birds fed diets with no SBM. Evaluating the same SBM inclusion levels as those used in the present study (0, 4, 8, and 12%) in broiler chicken diets, Pinheiro *et al.* (2002) did not observe any effect on feed intake or weight gain, but birds fed diets with no SBM (0%) had a better feed conversion ratio from 3 to 35 days.

Consistent with the observations of the present study, Silva *et al.* (2000) did not find significant improvement in performance or egg quality in layers fed diets formulated on digestible amino acid requirements. According to these authors, the factor responsible for the negative results of digestible amino acid diets could be due to the different amino acid digestibilities, as the values presented in the chemical composition tables were calculated in trials using cecectomized roosters, and therefore cannot be directly applied to commercial layer diets. Similar results were found by Casartelli (2005) and Filardi *et al.* (2005 and 2006). Under the conditions of their studies, diet formulation based on digestible amino acids did not show, in general, any improvement in egg quality.

The results of the present study suggest that layers appear to tolerate the higher levels of SBM, despite its higher crude fiber content, with no decrease in performance or egg quality parameters, which can be explained by the fact that layers have a more developed digestive system in terms of gut capacity as compared to broilers.

CONCLUSION

SBM can be used at 12% in layer diets without impaired performance and egg quality parameters. Diets formulated on digestible amino acid basis improved eggshell percentage and egg specific gravity, but resulted in lower egg weight.

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