The Effect of Using Different Levels of Shrimp Meal in Laying Hen Diets

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ABSTRACT The shrimp industry in Central America has grown significantly. Much waste is generated by this industry because of the high percentage of shrimp heads, exoskeletons, and soluble components lost during processing. The objective of this study was to measure the effect of substituting different levels of shrimp meal (SM) for soybean meal (SBM) in layer diets. A control corn-soybean layer diet and four different levels of SM substituted for SBM were fed to Single Comb White Leghorn hens from 18 to 38 wk of age. The SM replaced 0, 20, 40, 60, or 80% of SBM. The hens were housed three per cage, 30.5 cm wide × 45.7 cm deep. The five treatments were assigned randomly to three contiguous cages in each of eight rows in a randomized complete block design. Egg production was recorded daily, and feed consumption was recorded for an entire week every 21 d. Egg weight, specific gravity, and yolk pigmentation were recorded for three consecutive days every 21 d. Mortality was recorded daily. Our results showed that the different levels of SM in the diet did not significantly affect egg production. Feed consumption increased significantly ($P < 0.01$) only when 40 or 80% SM was used in the diet. Feed conversion was poorer for the same treatments. No significant differences were observed for mortality. Egg weights and specific gravities did not differ significantly among the treatments. Yolk pigmentation increased significantly ($P < 0.001$) as the levels of SM increased in the diets. In conclusion, properly processed SM can be used in relatively high levels to replace SBM in layer diets without causing detrimental effects on layer performance.

(*Key words*: shrimp meal, egg, yolk pigmentation, layer, chitin)

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INTRODUCTION

In the last few years, the shrimp industry in Central America has grown significantly. A significant amount of waste is generated by this industry because of the large percentage of shrimp heads, exoskeleton, and soluble components not used during the various processing operations. Shrimp heads compose approximately 44% of the whole shrimp (Meyers and Rutledge, 1971). Honduras alone produces approximately 24,000 tons of waste annually (Asociacion Nacional de Acuicultores de Honduras, 1994). This waste product from the shrimp processing plants has the potential of being an alternative protein source in layer rations, partially or totally replacing conventional protein sources such as soybean meal (SBM), meat and bone meal, and fish meal, which in most cases are imported or not easily attainable. Shrimp meal (SM) is basically the dried waste of the shrimp industry, comprising heads, hulls (or shells) in some instances, whole shrimp, and a certain percentage of fish that are caught when shrimp are harvested. Shrimp meal has long been used as a source of marine protein in fish and crustacean feeds. The chitin present in SM has an essential role in the metabolism of shrimp. Shrimp meal is also used as a natural source of carotenoid pigment (astaxanthin) to produce desired coloration in trout, salmon, shrimp, and feathers of exotic birds and as a flavoring agent in pet foods. It is not unusual for as much as 20% SM to be used in pond trout formulations or in commercially raised fish, shellfish, and other economically valuable animals. Raab et al. (1971) observed that increasing the levels of SM in broiler diets increased the amount of skin pigmentation. By using 4% SM in a conventional corn-soybean diet, Chawan and Gerry (1974) found that skin pigmentation in broilers was considerably more intense.

In starter and grower rations, SM can be used as a sole source of protein; however, better growth is obtained when more than one protein source is included (Singletary et al., 1935). By using SM at various levels, Damron et al. (1964), Raab et al. (1971), Ilian et al. (1985), Islam et al. (1994), and Rosenfeld et al. (1997) found no negative effects when used as a feed ingredient in broiler diets. With shrimp head meal, Arellano et al. (1997) found that 3, 6, and 9% in broiler diets produced no significant effects on weight gain, feed consumption, feed efficiency, or shank pigmentation. There were also no peculiar odors or flavors in the breast meat.

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Abbreviation Key: SM = shrimp meal; SBM = soybean meal.

TABLE 1. Analysis of shrimp and soybean meal (as-fed basis)

Components	Shrimp meal	Soybean meal
	(%)	
Dry matter[1]	89.50	91.90
Crude protein[1]	52.70	48.90
Ether extract[1]	6.20	1.90
Ash[1]	20.41	6.00
Crude fiber[1]	11.38	3.50
Calcium[1]	5.21	0.26
Available phosphorus[1]	1.47	0.25
TME_n, kcal/kg[2]	2,234	2,230
Amino acid, %[3]		
Methionine	0.82	0.75
Lysine	3.07	2.90
Arginine	2.49	2.71
Tryptophane	0.41	0.60
Threonine	1.59	1.89
Aspartic acid	3.98	5.48
Serine	1.48	2.07
Glutamic acid	5.71	8.36
Proline	1.81	2.48
Glycine	2.58	2.11
Alanine	2.64	2.16
Cysteine	0.38	0.74
Valine	2.19	2.43
Isoleucine	1.76	2.60
Leucine	3.01	3.80
Tyrosine	1.44	1.75
Phenylalanine	1.86	2.72
Histidine	0.85	1.80

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To date, little research has been done or data published concerning the use of SM in layer rations. The objective of this study was to evaluate the effect of substituting graded levels of SM for SBM on layer performance.

MATERIALS AND METHODS

Analyses (Table 1) of the SM used in this study followed procedures of the Association of Official Analytical Chemists (AOAC, 1990). An amino acid profile was determined by an amino acid analyzer cation exchanger. True metabolizable energy was measured using a modification of the method established by Sibbald (1976). The modification involved nitrogen correction and an extended excreta collection.

Four hundred eighty Hyline W-77®,[2] Single Comb White Leghorn hens, 18 wk of age, were randomly selected and assigned three per cage. The cage dimensions were 30.5 cm wide × 45.7 cm deep, and cages were divided into two sections. Each section consisted of four double-decked rows with 20 cages to a row in an open-sided, naturally ventilated house. The treatments consisted of five different levels of SM in the diet replacing 0, 20, 40, 60, or 80% of the SBM. Each of the five treatments was assigned randomly to three contiguous cages in each of the eight rows in a randomized complete block design. Hens were maintained on 16 h light:8 h darkness cycle. The control diet contained 17% crude protein and was composed mainly of corn and SBM. All diets were calculated to contain similar levels of protein, energy, minerals, and amino acids (Table 2). Water was supplied ad libitum. Performance data were collected for the 20-wk experimental period. Egg production was recorded daily; feed consumption and feed conversion were recorded for an entire week every 21 d. Egg weight, specific gravity (flotation method in saline solution with increments of 0.004 units ranging from 1.068 to 1.100), and yolk pigmentation (Roche yolk color fan, yolk color ranges from 1 to 15 units) were recorded for three consecutive days every 21 d. Mortality was recorded daily.

[2]Hy-Line® Indian River Co., West Des Moines, IA 50265.

Statistical Analysis

Data were analyzed using the general linear models procedure of SAS® software (SAS Institute, 1991). Percentage data were subjected to arc sine square root of the percentage transformation, and treatment means were separated by least significant differences. A probability of $P < 0.05$ was required for statements of significance.

RESULTS AND DISCUSSION

No significant differences in egg production were found among the different treatments (Table 3). A significant ($P < 0.01$) increase in feed consumption was observed with 40 and 80% SM compared to the 0% treatment. Due to the increase in feed consumption, feed efficiency was poorer ($P < 0.05$) for the same treatments. These results might be attributed to the high levels of chitin found in SM. The exoskeleton of the shrimp is composed mainly of chitin, an N-acetylated glucosamine polysaccharide that forms part of the protein complex, and is considered to have low digestibility when fed to animals (Austin et al., 1981). Due to this low digestibility, chitin physically blocks the access of digestive enzymes to lipids and proteins, thus affecting the utilization of these nutrients (Castro et al., 1989; Karasov, 1990). Some species of birds produce chitinase in the proventriculus. When chitin and chitosan were fed to hens and broilers, Hirano et al. (1990) observed that the two ingredients were 88 and 98% digestible. This finding led us to believe that birds may have the capability of digesting chitin, because chitonase may be present in the digestive system, thus facilitating the utilization of chitin found in the SM. In the case of the chicken, amounts of chitinase produced are low (Jeuniaux and Cornelius, 1978). Even in species that produce useful levels of chitinase the energy value of chitin is very low, due to poor absorption (Jeuniaux and Cornelius, 1978; Karasov, 1990). Because chitin reduces dietary energy, the layers fed the diets with the higher levels of SM increased feed consumption to maintain their energy needs.

No significant differences were observed for mortality (data not shown); mortalities for all treatments were less

TABLE 2. Composition of experimental diets[1]

Ingredients and analyses	0% SM	20% SM	40% SM	60% SM	80% SM
Ground corn	58.40	61.60	64.60	67.80	69.80
Soybean meal (46% CP)	26.80	20.80	15.00	9.20	3.80
Shrimp meal	0.00	4.60	9.40	14.00	18.60
Dicalcium phosphate	1.60	1.40	1.20	1.00	0.80
Ground limestone	8.60	7.80	6.80	6.00	5.40
NaCl	0.35	0.35	0.35	0.35	0.35
Vitamin + mineral premix[2]	0.25	0.25	0.25	0.25	0.25
Tylan 40®,[3]	0.14	0.14	0.14	0.14	0.14
Vegetable oil	3.80	3.00	2.20	1.40	1.20
DL-Methionine	0.10	0.10	0.08	0.07	0.05
Calculated analyses					
Crude protein[4]	17.08	16.80	16.70	16.75	17.05
ME, kcal/kg	2,875	2,875	2,875	2,875	2,875
Calcium[4]	3.57	3.56	3.55	3.53	3.69
Available phosphorus	0.50	0.50	0.50	0.50	0.50
Methionine	0.40	0.40	0.40	0.40	0.40
Lysine	0.98	0.93	0.89	0.84	0.82

[1]Shrimp meal.

[2]The vitamin and mineral premix provided the following quantities per kilogram of diet: vitamin A, 5,500 IU (*all-trans*-retinal); cholecalciferol, 1,100 IU; vitamin E, 11 IU (dl-α-tocopheryl); vitamin K_3, 1.5 mg; riboflavin, 9.0 mg; niacin, 26 mg; D-calcium pantothenic acid, 12 mg; choline chloride, 220 mg; vitamin B_{12}, 0.01 mg; folic acid, 1.5 mg; manganese, 55 mg; zinc, 50 mg; iron, 30 mg; copper, 5 mg; iodine, 1.5 mg; selenium, 0.1 mg; antioxidant, 125 mg.

[3]Tylan® 40, Tylosin phosphate, 50 g/ton; Elanco Animal Health, Indianapolis, IN.

[4]Determined analyses.

TABLE 3. The effect of different levels of shrimp meal (SM) in layer diets on egg production, feed consumption, and feed conversion from 18 to 38 wk of age

Variable	Egg production	Feed consumption	Feed conversion	
	(%)	(g/bird)	(g egg:g feed)	(Kg/dozen)
0% SM	87.3	96.2[b]	0.557[a]	1.55[b]
20% SM	89.3	96.2[b]	0.565[a]	1.52[b]
40% SM	84.3	105.3[ab]	0.522[b]	1.75[a]
60% SM	89.2	101.6[ab]	0.534[ab]	1.61[ab]
80% SM	88.6	109.1[a]	0.490[b]	1.75[a]
SEM	3.47	6.34	0.03	0.20
P	0.067	0.006	0.006	0.001

[a,b]Means within columns without a common superscript are significantly different ($P < 0.01$).

than 1%. Egg weights and specific gravities were not significantly lower among treatments (Table 4). The presence of chitin might have affected the absorption of Ca or P to a small degree; however, this did not cause adverse effects on egg shell quality. Yolk pigmentation significantly ($P < 0.001$) increased as the levels of SM were increased in the diet due to the high level of astaxanthin in the meal (Table 4). Chawan and Gerry (1974) and Raab et al. (1971), using SM in broiler diets, found that the SM had a marked effect on skin pigmentation as levels of SM were increased in the diet.

In general, amino acid content and protein quality of animal protein sources are superior to those of vegetable sources. Also the processing method used can directly affect the nutritional value of the meal. The waste from the shrimp processing plant was collected on a daily basis. This material contained some ice that was added at the processing plant. The presence of this ice could have helped to preserve the quality of the waste material during storage and transport. The preservation could have reduced the amount of bacterial activity that could pro-

TABLE 4. The effect of diffeent levels of shrimp meal (SM) in layer diets on egg weight, specific gravity, and yolk pigmentation from 18 to 38 wk of age

Variable	Egg weight (g)	Specific gravity	Yolk pigmentation[1]
0% SM	52.3	1.0885	1.4[a]
20% SM	53.6	1.0871	3.5[b]
40% SM	52.5	1.0871	4.4[c]
60% SM	52.6	1.0875	8.0[d]
80% SM	52.1	1.0871	9.2[e]
SEM	0.85	0.0003	0.19
P	0.267	0.162	0.001

[a–e]Means within a column without a common superscript are significantly different ($P < 0.01$).

[1]Roche yolk color fan; F. Hoffmann-La Roche Ltd., Basel, Switzerland.

duce toxic effects due to dicarboxylic reactions and, in turn, change amino acids from animal protein into biogenic amines. These biogenic amines may cause a reduction in performance and livability in birds (Dale, 1994). This waste material was taken to the plant for processing within hours of delivery. It was then put through a cooking process and tunnel dried. The entire process takes approxitmately 25 to 30 min. Results of the present study show that properly processed SM can be used in relatively high levels in place of SBM in layer diets without negatively affecting bird performance.

REFERENCES

Arellano, L., Carillo, F. Perez-Gil, E. Avila, and F. Ramos, 1997. Shrimp head meal utilization in broiler feeding. Poultry Sci. 76(Suppl.1):85. (Abstr.).

Association of Official Analytical Chemists, 1990. Official Method of Analysis. 15th ed. Association of Analytical Chemists, Washington, DC.

Asociacion Nacional de Acuicultores de Honduras (ANDAH), 1994. Carateristicas del cultivo de camaron en Honduras, boletin informativo. ANDAH, Choluteca, Honduras.

Austin, P. R., C. J. Brine, J. E. Castle, and J. P. Zikakis, 1981. Chitin: New facets of research. Science 212:749–753.

Castro, G., N. Stoyan, and J. P. Nyers, 1989. Assimilation efficiency in birds: A function of taxon and food type? Comp. Biochem. Physiol. 92A:271–278.

Chawan, C. B., and R. W. Gerry, 1974. Shrimp waste as a pigment source in broiler diets. Poultry Sci. 53:671–676.

Dale, N., 1994. Aminas biogenicas. Avi. Prof. 11(3):114–116.

Damron, B. L., P. W. Waldroup, and R. H. Harms, 1964. Evaluation of shrimp meal in broiler diets. Poultry Science Mimeograph Series No. PY65-1. University of Florida, Gainesville, FL.

Hirano, S., C. Itakura, H. Siro, Y. Akiyama, I. Nonaka, N. Kanabara, and T. Kawakami, 1990. Chitosanas an ingredient for domestic feeds. J. Agric. Food Chem. 38:1214–1217.

Ilian, M. A., C. A. Bond, A. J. Salam, and S. Al-Hooti, 1985. Evaluation of shrimp by-catch meal as broiler feedstuff. Nutr. Rep. Int. 31:487–492.

Islam, M. A., M. D. Hossian, S. M. Baibul, and M. A. Howlider, 1994. Unconventional feed for broilers. Indian Vet. J. 74:775–780.

Jeuniaux, C., and C. Cornelius, 1978. Distribution and activity of chitinolytic enzymes in the digestion tract of birds and mammals. Pages 542–549 *in*: Proceedings of the First International Conference on Chitin/Chitosan. R.A.A. Muzzarelli and E. R. Pariser, ed. MIT Press, Cambridge, MA.

Karasov, W. H., 1990. Digestion in birds: Chemical and physiological determinants and ecological implications. Stud. Avian Biol. 13:391–415.

Meyers, S. P., and J. E. Rutledge, 1971. Shrimp meal—A new look at an old product. Feedstuffs 43:31–32.

Raab, P., E. Bergqvist, and O. Caceres, 1971. Uso e incidencia pigmentante de la harina de camarones y langostinos en broilers. Trabajo de tesis. Escuela de Agronomia, U. Catolica de Valparaiso, Chile.

Rosenfeld, D. J., A. G. Gernat, J. D. Marcano, J. G. Murillo, G. H. Lopez, and J. A. Flores, 1997. The effect of using different levels of shrimp meal in broiler diets. Poultry Sci. 76:581–587.

SAS Institute, 1991. SAS® User's Guide: Statistics. Version 6.04 Edition. SAS Institute, Cary, NC.

Sibbald, I. R., 1976. A bioassay for true metabolizable energy of feedingstuffs. Poultry Sci. 55:303–308.

Singletary, J. R., D. J. Bray, and H. J. Davis, 1935. Shrimp meal as a protein supplement for chickens. Page 31 *in*: Bulletin 262. Louisiana State University, Baton Rouge, LA.