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The effect of dietary inclusion of meat and bone meal on the performance of laying hens at old age

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Abstract

The effect of the inclusion of meat and bone meal (MBM) in the diet of old laying hens on their egg production and the quality of their eggs was investigated. Meat and bone meal containing a high concentration of ash and a low concentration of crude protein was included at levels of 2.0, 4.0 and 6.0% in the diets and fed for 20 weeks. Forced moulted 84-week old laying hens (Brown-Nick) were divided randomly into four treatment groups of 120 hens each. The inclusion of 2.0% MBM to the layer diet increased hen-day egg production significantly, whereas inclusion in excess of 2.0% MBM had no additional beneficial effect on egg production. However, the inclusion of dietary MBM at all three levels depressed egg weight. There were no significant effects of dietary treatments on egg weight, feed intake and feed conversion ratio of the hens. The specific gravity of the eggs from hens fed the control diet was significantly lower than from those receiving the diets containing 2.0 and 4.0% MBM. The Haugh Unit value of eggs in the 6.0% MBM treatment was significantly higher than the other treatments. There were no significant effects of MBM inclusion on yolk colour score, yolk height, eggshell thickness, eggshell weight and eggshell strength. However, MBM inclusion in a diet had a significant beneficial effect on eggshell quality. The eggshell ratios of the 2.0, 4.0 and 6.0% MBM treatments were significantly higher than in the control diet, while the cracked/broken egg ratio was significantly lower. In conclusion, inclusion of MBM containing a high ash and low crude protein content to conventional maize-soya bean diet improved egg production performance of laying hens. The dicalcium phosphate level in the diet could also be reduced without any adverse effects on egg production and egg quality.

Keywords: Meat and bone meal, egg production, egg quality, laying hens
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Introduction

Raw materials consisting of animal by-products, such as meat and bone meal (MBM) and poultry by-product meal (PBP) are included extensively in poultry diets. Meat and bone meal is an excellent dietary source for protein, calcium and phosphorus (Parsons *et al.*, 1997; Shirley & Parsons, 2001). The economic value for such products in poultry diets has been attributed to both their mineral and protein content (Waldroup, 2002). If its phosphorus is highly available and cost effective, MBM can be a primary non-phytate phosphorus source in poultry diets (Dozier, 2000; Mellor, 2002). However, the protein content, amino acid composition and digestibility of MBM can vary greatly depending on the processing system and raw material source (Wang & Persons, 1998b; Shirley & Persons, 2000). The average calcium, phosphorus, crude protein and metabolic energy values derived from a large number of MBM samples were not less than 39, 60, 500 g/kg and 10.2 MJ/kg, respectively (Chandler, 1994; Parsons *et al.*, 1997; Wang & Persons, 1998a). Also, relative dietary availability of phosphorus from MBM was equal (Sell & Jeffrey, 1996) or slightly lower (Van der Klis & Versteegh, 1996) than that of phosphorus in dicalcium phosphate (DCP). However, because of recent sanctions against the inclusion of rendered animal protein of ruminant origin in cattle feeds (Drewyor & Waldroup, 1998), it is possible that greater quantities of MBM may be available for inclusion in poultry feeds. It is well established that the eggshell quality of eggs from old laying hens tends to decline in association with an increasing egg size. The inclusion of dietary MBM to the layer diet was found to increase eggshell quality (Waldroup & Adams, 1994; Sell & Jeffrey, 1996).

This experiment was conducted to determine the effects on the performance of laying hens at old age of the dietary inclusion of MBM containing high ash and low crude protein concentrations, as an ingredient of a maize-soya bean diet.

Materials and Methods

Four hundred and eighty 84-week old Nick-Brown hens at the initiation of post-moult production phase were assigned to four dietary treatments of 120 hens each. Each treatment consisted of four replications of 10 cages (three hens per cage). The trial was conducted in an open-sided naturally ventilated layer house. The individual body weights of all hens were taken at the onset and at termination of the experiment to determine average body weight. The experimental diets were: Diet 1 (D1) was the control diet without MBM; diet 2 (D2) contained 2% MBM; diet 3 (D3) 4% MBM and diet 4 (D4) 6% MBM. The ingredients and chemical composition of the experimental diets are presented in Table 1.

Table 1 Ingredients and chemical composition of the experimental diets (as fed)

	Treatments			
	Diet 1	Diet 2	Diet 3	Diet 4
Ingredients (kg/1000 kg)				
Maize	568.5	483.5	557.1	471.2
Soya bean meal (0.48 crude protein, CP)	240.8	212.4	180.2	155.3
Sunflower meal (0.36 CP)	63.9	67.6	117.2	120.0
Meat and bone meal (MBM) (0.29 CP)	0	20.0	40.0	60.0
Wheat	0	100.0	0	96.8
Fish oil (Anchovy)	18.0	17.0	18.0	18.0
Limestone	85.8	83.3	79.7	72.7
Dicalcium phosphate-P	17.0	10.2	1.8	0.0
Salt	2.5	2.5	2.5	2.5
Mineral premix [1]	1.0	1.0	1.0	1.0
Vitamin premix [2]	2.5	2.5	2.5	2.5
Total	1000	1000	1000	1000
Composition, analysed (g/kg)				
Dry matter	906.5	902.3	899.8	901.6
Crude protein	176.8	178.3	176.5	178.8
Ether extract	45.6	45.8	47.5	48.9
Crude cellulose	33.6	35.0	42.1	44.2
Sugar	59.6	65.5	58.3	56.4
Starch	342.9	339.6	334.9	344.8
Crude ash	119.4	120.6	127.5	129.8
Total calcium	37.3	37.5	37.0	37.6
Total phosphorus	6.2	6.3	6.1	6.4
Apparent metabolisable energy (MJ/kg)*	11.66	11.73	11.55	11.75
Methionin+cyteine*	6.2	6.1	6.2	6.0
Lysine*	9.5	9.3	9.2	9.0

Diet 1: control, without MBM
Diets 2, 3 and 4 contained 20, 40 and 60 g MBM/kg, respectively
[1]Supplied per kilogram of diet: 80 mg Mn; 80 mg Fe; 60 mg Zn; 5 mg Cu; 0.2 mg Co; 0.5 mg I; 0.15 mg Se; 125 mg chorine chloride
[2]Supplied per kilogram of diet: 12 000 IU vitamin A; 2 400 IU vitamin D_3; 30 IU vitamin E; 2.5 mg vitamin K_3; 3 mg vitamin B_1; 7 mg vitamin B_2; 20 mg niacin, 8 mg calcium D-pantothenate; 4 mg vitamin B_6; 0.015 mg vitamin B_{12}; 1 mg folic acid; 0.045 mg D-biotin; 50 mg vitamin C
* Values calculated

The chemical composition of the MBM used in the experiment is presented in Table 2. The MBM used in the experiment were obtained from beef rendering material and contained a high ash (450.7 g/kg) and low crude protein (290.2 g/kg) concentration.

The experimental diets were formulated to be isoenergetic and isonitrogenous and also equal in calcium and phosphorus levels. The experimental diets were in mash form and water was provided *ad libitum* for the duration of the trial. Hens received the diets for 20 weeks. A photoperiod of 17 h/d was maintained. Egg production and proportion of cracked/broken eggs were recorded daily when the hens were between 84 and 104 weeks of age. Random samples of 60 eggs for two consecutive days from each treatment (a total of 9600 eggs) were weighed individually to determine the average egg weight. Mortality was recorded daily. Also, a random sample of 30 eggs from each treatment was collected every four weeks to measure egg quality such as eggshell thickness, eggshell strength, specific gravity, Hough unit (HU), yolk colour score and eggshell weight. The HU was calculated using the formula of Eisen *et al.* (1962) based on the height of albumen determined by a micrometer and egg weight. The specific gravity of an egg was determined by using the saline flotation method of Hempe *et al.* (1988). Feed intake was recorded on a weekly basis. Feed conversion ratio (FCR) was calculated as the ratio of grams of feed consumed per grams of egg weight. Egg mass was calculated by multiplying egg weight by egg production. Production parameters such as feed intake and egg production were adjusted for hen mortalities.

Table 2 Chemical composition of meat and bone meal (MBM) used in the experiment (as fed)

Chemical composition, analysed	g/kg
Dry matter	928.7
Crude protein	290.2
Ether extract	134.2
Crude cellulose	26.2
Crude ash	450.7
Total calcium	149.2
Total phosphorus	64.2
Apparent metabolisable energy* (MJ/kg)	9.64

* Value calculated

The standard techniques of the Proximate analysis were used to determine the nutrient concentrations in the experimental diets and in the meat and bone meal (Naumann & Bassler, 1993). The experimental diets were analysed also for starch, sugar, total calcium and phosphorus according to VDLUFA method (Naumann & Bassler, 1993). Apparent metabolisable energy content of the diets was calculated based on chemical composition (Anon., 1991). The data were analysed using the General Linear Models procedure of SAS (1991). Significant differences between treatment means were separated using the Duncan's multiple range test with a 5% probability.

Results and Discussion

The effects of including MBM in the diet on egg production, feed consumption, feed conversion ratio, egg weight and egg mass are shown in Table 3.

Table 3 The effect of meat and bone meal (MBM) inclusion to the diet on egg production (%), feed consumption (g), feed conversion ratio (g feed/g egg), egg weight (g) and egg mass (g)

Parameters	Control	MBM levels, %			Pooled SEM	Probability
		2	4	6		
Egg production, hen-d, %	63.82^{b}	65.33^{a}	64.34^{ab}	64.37^{ab}	0.37	0.0499
Egg weight, g	70.14^{a}	69.02^{b}	68.96^{b}	69.14^{b}	0.15	0.0001
Egg mass, g/hen/d	44.77	45.06	44.36	44.50	0.44	0.5648
Feed intake, g/hen/d,	117.40	117.65	117.46	116.44	0.54	0.2045
Feed conversion ratio, g/g	2.62	2.61	2.64	2.61	0.03	0.1846

a-b: Means within rows with different superscripts differ at $P < 0.05$

There were significant effects of dietary treatments on egg production and egg weight. The inclusion of 2.0% MBM in the diet increased (P < 0.05) hen-day egg production above that of the control diet. However, the inclusion of MBM in excess of 2.0% had no additional beneficial effect on egg production. Egg weight was reduced significantly with the inclusion of MBM at 2.0, 4.0 and 6.0% to the diet, compared to the control diet. The average egg weight of the control group was 1.0 g heavier than that of the hens receiving the diets containing MBM. On the other hand, there were no differences (P > 0.05) in egg mass, feed intake and feed conversion ratio between the treatments over the 20 weeks period. Some reports have been published on the performance of chickens when MBM was included in broiler diets (Martosiswoyo & Jensen, 1988; Baker & Firman, 1998; Weatherford & Cherry, 1999), but little if any on the inclusion of MBM in layer diets (Oruseibio, 1995). No negative effects were recorded with the inclusion of dietary MBM in turkey and broiler diets (Johri *et al.*, 1980; Sell, 1996; Lilburn *et al.*, 1997; Drewyor & Waldroup, 1998). In agreement with our results, Damron *et al.* (2001) reported that the inclusion of MBM up to a level of 6.0% had no negative effect on laying hen performance. In this study, rendered layer mortality (RLM) was used as a feed ingredient in layer diets. Feed intake, egg production, feed conversion ratio and body weight changes of hens receiving the RLM containing diets were superior to those on the control diet (Damron *et al.,* 2001). Similar to the present results, a reduced egg weight was recorded when the hens received 2.5% or more RLM in their diets compared to the control diet (Damron *et al.*, 2001). Similar observations were reported by Oruseibio (1995) on egg production. He found synergistic effects when protein supplements consisting of a mixture of sunflower meal and MBM were fed. The adverse effect of MBM on egg weight might be associated with the amino acid concentration of MBM used in the experiment. In the formulation of the experimental diets the amino acid values of MBM diets were assessed to be equal to the minimum amino acid composition suggested by the NRC (1994). It seems likely that the MBM used, which contained a high level of ash and a low level of crude protein might have contained lower amino acid concentrations than those used in other studies (Parsons *et al.*, 1997; Wang & Parsons, 1998b; Shirley & Parsons, 2001). In fact, several industry surveys have demonstrated a wide variation in the nutrient composition of MBM (Sell, 1996; Johnson & Parsons, 1997). Furthermore, the increased egg production rate of the hens receiving the MBM supplemented diets could have had a depressive effect on egg weight.

The effect of MBM inclusion to the diet on egg quality criteria is presented in Table 4. The specific gravity of the eggs, eggshell weight ratio, HU and cracked/broken egg ratio differed (P < 0.05) between treatments.

Table 4 Effect of the inclusion of meat and bone meal (MBM) to a layer diet on egg quality criteria

Parameters	Control	MBM levels, %			Pooled SEM	Probability
		2	4	6		
Egg specific gravity, g/cm^3	1.088^b	1.093^a	1.091^a	1.089^{ab}	0.002	0.0506
Eggshell weight, g	8.81	8.94	8.99	9.09	0.10	0.2521
Eggshell weight ratio, %	12.33^b	12.76^a	12.72^a	12.84^a	0.13	0.0330
Eggshell thickness, µm	350.68	359.07	359.77	357.16	3.30	0.1956
Egg yolk height, mm	19.29	19.55	19.68	19.50	0.10	0.0765
Egg yolk colour score[1]	12.35	12.33	12.51	12.50	0.09	0.3368
Shape index	78.41	79.23	78.81	79.10	0.34	0.3628
Haugh Unit (HU)	76.62^b	78.37^b	78.86^b	81.49^a	0.92	0.0028
Eggshell strength, kg/cm^2	2.13	2.26	2.23	2.32	0.07	0.3775
Cracked/broken egg ratio, %	5.98^a	3.75^b	4.00^b	3.52^b	0.25	0.0001

a-b: Means within rows with different superscripts differ at P < 0.05
[1] Roche yolk colour score: 1, light yellow; 15, orange

The specific gravity of the eggs of hens receiving the diets containing 2.0 or 4.0% MBM was higher (P < 0.05) than that of control hens and the HU value of the eggs from the hens fed the diet containing 6.0% MBM was significantly better than that of other dietary treatments. Damron *et al.* (2001) reported similar responses. However, the inclusion of MBM in the layer diet did not affect yolk colour score, eggshell thickness, eggshell weight and eggshell strength, though the percentage eggshell weight was increased (P < 0.05) and the ratio of broken/cracked eggs was decreased (P < 0.01) with the addition of MBM to the diet.

Reduced eggshell quality in old age is frequently observed and often associated with the corresponding increase in egg size. The results demonstrated that the inclusion of MBM to the layer diets was effective in improving eggshell quality. This study was planned to measure the effects of organic calcium and phosphorus derived from MBM on egg quality of old hens. Since the diets were isoenergetic, isonitrogenous and contained equal levels of calcium and phosphorus, the quality of the eggshells of the hens receiving the MBM containing diets was better than that of the hens receiving the control diet. Sell & Jeffrey (1996) and Waldroup & Adams (1994) reported a similar finding that the relative availability of phosphorus from MBM was equal to that from dicalcium phosphate. Although the different experimental diets contained similar phosphorus and calcium concentrations, eggshell quality was improved by the inclusion of MBM. This might have been caused by the fact that the calcium and phosphorus in MBM are in the organic forms which were utilised more efficiently during shell calcification in the hen than the inorganic forms. A contributing factor might be that the MBM in the present study contained a much higher content of calcium and phosphorus than MBM samples analysed in industrial surveys (Sell, 1996; Johnson & Parsons, 1997; Parsons *et al*., 1997; Wang & Parsons, 1998a,b).

The effects of MBM inclusion to the diet on body weight and livability of laying hens are presented in Table 5. Body weight and livability of the hens from 84 wk to 104 wk of age were not affected ($P > 0.05$) by the inclusion of MBM to the layer diet.

Table 5 Effect of meat and bone meal (MBM) inclusion to the diet on the body weight (g) and livability (%) of old hens

Parameters	Control	MBM Levels, %			Pooled SEM	Probability
		2	4	6		
Body Weight, g (84 wk of age)	1746.83	1754.00	1172.00	1765.75	12.57	0.4866
Body Weight, g (104 wk of age)	2010.83	2029.33	2034.50	2033.16	16.61	0.7274
Livability, %	99.16	96.67	99.16	97.50	2.01	0.2437

Conclusion

This study demonstrated that commercially available MBM which contains a high level of ash and a low level of crude protein can be included in the diets of old laying hens at up to an inclusion level of 6.0%. Thus, MBM can be used successfully in diets of laying hens as a source of protein, phosphorus and calcium by substituting a portion of the maize-soya bean meal in the diet. However, egg weight was reduced by the inclusion of MBM. Further investigations are required to determine the bioavailability of the organic phosphorus and calcium in MBM.

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