Indian Journal of Animal Sciences **83** (10): 1084–1089, October 2013/Article

Influence of the dietary protein level on the incidence of footpad dermatitis in broiler chickens

MIHAI CONSTANTIN SORIN[1], VAN ILIE[2], CIURESCU GEORGETA[3], GHEORGHE ANCA[4] and MIHALCEA TEODOR[5]

University of Agronomic Science and Veterinary Medicine, Bucharest 011 464 Romania

Received: 22 January 2013; Accepted: 27 June 2013

ABSTRACT

The aim of this study was to determine the influence of 3 levels of dietary protein on the broiler performance and on FPD incidence. Day-old unsexed broiler chickens (1,272) were used in this study for 42 days. Three experimental diets having different protein levels— high protein (HP), medium (MP) and low protein (LP) diets— were formulated. All diets were based on corn, wheat, soybean meal, rapeseed meal, corn gluten and synthetic methionine and lysine. The average body weights at the age of 42 days were 2, 442.63 g (HP), 2, 308.16 g (MP) and 2, 215.34 g (LP); the differences were significantly influenced by used protein level. Feed intake was not influenced by the protein levels. However, feed conversion ratio was the lowest at HP. The incidence and development of FPD were recorded weekly. Lesions were scored for both the right and left foot, and classified according to a scale from 0 (no lesion) to 2 (very severe lesions). It may be concluded from the results that protein level influences the body weight of broiler chickens to a great extent at the time of slaughter. The incidences of FPD at slaughter were 32% for LP group, 48% for MP group and 43% for HP group. FPD scores at slaughter were 53 points for LP group, 76 points for MP group and 67 points for HP group.

Key words: Broiler, Footpad dermatitis, Protein level

The Scientific Committee on Animal Health and Animal Welfare of the European Commission (SCAHAW 2000) published a report on the status of the rearing conditions of broilers with particular focus on the factors linked to animal welfare. Footpad dermatitis (FPD) is a relatively widespread problem in the European broiler production. FPD is considered to be an indicator of animal welfare because the diseases likely to affect the health of the birds and inflicts suffering (Martrenchar *et al.* 2002, Dawkins *et al.* 2004, Thomas *et al*. 2004). FPD is a condition that causes necrotic lesions on the plantar surface of the footpads in growing broilers. The footpad lesions may cause pain, which together with a deteriorated state of health constitutes a welfare issue. In an early stage, discolouration of the skin is seen. Hyperkeratosis and necrosis of the epidermis can be seen histologically. In severe cases, the erosions develop into ulcerations with inflammatory reactions of the subcutaneous tissue (Greene *et al.* 1985). Often, the lesions become infected by a variety of bacteria and fungi, especially *Staphylococcus* spp. and *Escherichia coli* (Hester 1994). The lesions may heal (Greene *et al*. 1985). The incidence of FPD is significantly affected by protein level, source and diet density (Bilgili *et al.* 2006, Nagaraj *et al.* 2007a). They observed significantly less incidence of paw lesions with the low-density diet, compared with the high-density diet due to reduced faecal viscosity because of the lower soybean meal content of the diet.

In this experiment we investigated influence of dietary protein level on the performance and incidence of footpad dermatitis in broiler chickens on farm and at slaughter house.

MATERIALS AND METHODS

Experiment was carried out at the National Research and Development Institute for Animal Biology and Nutrition (INCDBNA) in Balotesti, Romania. All experimental procedures used in this experiment were approved by the Animal Care Committee of the INCDBNA, Balotesti. Day-old broiler chickens (1, 272) were divided into 3 groups with 4 replicates (106 chickens each) on a completely randomized design.

Three different types of broiler chicken starter, grower and finisher diets were formulated (Table 1) to contain high

Present address: [1]Ph D Student (mihai_constantin_sorin @yahoo.co.uk), [2]Professor, Department of Poultry Science (ilievan@yahoo.com). [3, 4]Senior Researcher, Laboratory of Animal Nutrition (ciurescu@ibna.ro, anca.gheorghe@ibna.ro), [5]Tehnichal Manager (teodor.mihalcea@ibna.ro), National Research and Development Institute for Animal Biology and Nutrition, Balotesti.

Table 1. Ingredients and chemical composition of the starter, grower and finisher diets

Ingredient (% as is)	Composition of the basal diet								
	Starter 0–10 days			Grower 11–24 days			Finisher 25-slaughter		
	HP	MP	LP	HP	MP	LP	HP	MP	LP
Corn	43.89	43.00	48.20	46.18	49.55	46.18	52.97	56.17	62.47
Wheat	7.00	11.60	10.00	7.00	8.00	7.00	4.00	6.00	6.00
Soybean meal	28.60	28.47	28.75	24.53	24.00	24.53	19.92	17.40	13.04
Rapeseed meal	4.00	4.00	4.00	6.00	6.00	6.00	8.00	8.00	8.00
Corn gluten	8.00	4.00		7.00	3.00	7.00	5.00	2.50	1.20
Sunflower oil	3.10	3.40	3.40	4.44	4.44	4.44	5.56	5.20	4.34
Monocalcium phosphate	1.76	1.76	1.75	1.56	1.58	1.56	1.40	1.40	1.41
Calcium carbonate	1.68	1.68	1.68	1.48	1.48	1.48	1.39	1.40	1.42
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin-mineral premix with coccidiostatic[1]	1.00	1.00	1.00	1.00	1.00	1.00			
Vitamin-mineral premix without coccidiostatic [2]							1.00	1.00	1.00
L-Lys HCl	0.43	0.47	0.51	0.29	0.34	0.29	0.27	0.36	0.49
DL-Met	0.18	0.26	0.35	0.16	0.25	0.16	0.13	0.21	0.27
Choline chloride	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Calculated composition,%									
Metabolizable energy, kcal/kg	3, 000	3, 000	3, 000	3, 100	3, 100	3, 100	3, 200	3, 200	3, 200
Crude protein	24.00	22.00	20.00	22.00	20.00	18.00	20.00	18.00	16.00
Lysine, total	1.43	1.43	1.43	1.24	1.24	1.24	1.10	1.10	1.10
Lysine, digestible	1.27	1.27	1.27	1.08	1.08	1.09	0.97	0.97	0.97
Methionine, total	0.60	0.62	0.66	0.56	0.59	0.62	0.49	0.53	0.56
Methionine, digestible	0.58	0.60	0.64	0.53	0.57	0.60	0.47	0.51	0.53
Met + Cys, total	1.00	1.00	1.00	0.95	0.95	0.95	0.86	0.86	0.86
Met + Cys, digestible	0.92	0.92	0.92	0.86	0.86	0.86	0.76	0.76	0.76
Calcium	1.00	1.00	1.00	0.90	0.90	0.90	0.85	0.85	0.85
Available phosphorous	0.48	0.48	0.48	0.44	0.44	0.44	0.40	0.40	0.40
Crude fat	5.80	6.00	6.10	7.20	7.20	6.50	8.40	8.10	7.40
Crude fibre	3.74	3.75	3.78	3.69	3.68	3.46	3.61	3.49	3.27

[1] Supplied per kg diet: retinyl acetate, 3.79 mg; cholecalciferol, 0.12 mg; DL-a-tocopheryl acetate, 75 mg; menadione sodium bisulphite, 3 mg; thiamine mononitrate, 3 mg; riboflavin, 8 mg; pyridoxine-HCl, 4 mg; cyanocobalamin, 0.016 mg; Ca-panthotenate, 15 mg; niacin, 60 mg; folic acid, 2 mg; Mn, 120 mg; Zn, 100 mg; Fe, 40 mg; Cu, 16 mg; I, 1.25 mg; Se, 0.30 mg; Co, 0.25 mg.[2] Supplied per kg diet: retinyl acetate, 3.10 mg; cholecalciferol, 0.10 mg; DL-a-tocopheryl acetate, 50 mg; menadione sodium bisulphite, 2 mg; thiamine mononitrate, 2 mg; riboflavin, 5 mg; pyridoxine-HCl, 2 mg; cyanocobalamin, 0.010 mg; Ca-panthotenate, 15 mg; niacin, 40 mg; folic acid, 1.5 mg; Mn, 120 mg; Zn, 100 mg; Fe, 40 mg; Cu, 16 mg; I, 1.25 mg; Se, 0.30 mg; Co, 0.25 mg.

protein (HP), medium (MP) and low protein (LP). All diets were based on corn, wheat, soybean meal, rapeseed meal, corn gluten and synthetic methionine and lysine. For each growth phase diets were calculated to be isocaloric and with similar content of total and digestible sulphur amino acids (Met + cys), lysine, calcium and available phosphorus, in accordance with the feeding recommendations for the intensive rearing of these strains (Ross Breeders 2007).

All chickens were placed in 5.0 m ×1.4 m pens. Each pen was littered with wood shavings. During the study, birds received a lighting regimen of 23 h light: 1 h darkness. Automatic heaters were used to raise the temperature in the poultry house. The initial temperature was 33°C and it was gradually reduced according to breeding standards. Control parameters such as temperature, humidity, light, ventilation and vaccination were the same for all groups. Feed and water were provided *ad lib*. The body weight of individual chicks and the feed intake were measured weekly. In cases where mortalities were observed, the numbers and weights of such mortalities were recorded accurately to make necessary corrections in calculating feed intake and feed conversion ratio. Also all broilers were examined for incidence and severity of footpad dermatitis at weekly intervals. Both feet were examined on farm and at slaughter house for footpad dermatitis.

Footpad lesions were assessed according to the Swedish system, which is generally accepted FPD scoring system used in Europe. The footpad lesions were assigned to one of three

classes: score 0 = no lesions, no or very small superficial lesions, slight discolouration on a limited area of the footpad, mild hyperkeratosis (thickening of the outer layer of the skin) or healed; score 1 = mild lesion, discolouration of the footpad, superficial lesions, dark papillae and hyperkeratosis; score 2 = severe lesions, epidermis is affected, ulcers and scabs, sign of haemorrhages or swollen footpads. The footpad score was calculated as follows:

FPD score = [100 × (0 × total number of footpad with score 0 + 0.5 × total number of footpad with score 1 + 2 × total number of footpad with score 2)]/(total number of footpad scored).

$$\text{Incidence of FPD \%} = \frac{\text{(Total number with score 1 + total number with score 2)}}{\text{(Total number of footpad scored)}}$$

On day 42 of the fattening period, prior to stunning, 8 birds were randomly selected from each replicate, were slaughtered and processed. The body weight of broilers before slaughtering and the carcass weight without offal was recorded and used to calculate the carcass yield. Carcass yield was calculated as a proportion of carcass weight after evisceration to body weight of broilers before slaughtering. Leg and breast muscles (with skin and bone in) used for determination of their proportion to total carcass weight were weighed. Proportions of leg and breast muscles were calculated as weight of individual parts to carcass weight after evisceration.

Statistical analysis: All data were analysed by the general linear models (GLM) procedure using the SPSS software version 17. One-way analysis of variance (ANOVA) with the post hoc Tukey's multiple comparison tests was used to evaluate statistical significance of differences among the control and experimental groups. Three treatments were arranged in 4 replications in a randomized complete block design. The results are given as means±standard deviation, standard error of the mean (SEM) and $P<0.05$ was considered as statistically significant difference. Replication was considered as the experiment unit for determined performance.

RESULTS AND DISCUSSION

The largest body weight was observed in the HP group, followed by MP and LP group (Table 2). During the starter period, there was no significant difference between the experimental groups. These differences were maintained until the age of 21 days, when the following average body weight

Table 2. Effects of protein level on body weight (g) of broilers

Item	Dietary treatment			SEM	P-value
	HP	MP	LP		
0 d	43.05±3.40	42.86±3.19	43.19±3.07	0.091	0.327
7 d	167.38±22.99	166.68±22.62	169.62±20.77	0.627	0.136
14 d	416.78±52.70	413.89±50.75	410.75±47.98	1.430	0.227
21 d	801.53±96.71[a]	773.92±87.93[b]	774.06±90.18[b]	2.621	< 0.0001
28 d	1321.85±163.18[a]	1234.60±148.30[b]	1224.51±134.66[b]	4.403	< 0.0001
35 d	1864.03±201.07[a]	1745.92±203.94[b]	1745.37±191.76[b]	5.882	< 0.0001
42 d	2442.63±266.37[a]	2308.16±263.59[b]	2215.34±255.28[c]	7.892	< 0.0001

[a-c] Means within a row with the same or no letter do not differ (P>0.05).

Table 3. Effects of the protein level on the average feed intake (g/d), total feed conversion ratio (g feed/g gain) and mortality (%) of broilers

Item	Dietary treatment			SEM	P-value
	HP	MP	LP		
Feed intake 1–7 d	19.32±10.06	18.99±10.12	18.90±9.90	1.08	0.987
Feed intake 8–14 d	56.90±11.06	56.65±10.93	56.59±10.71	1.17	0.993
Feed intake 15–21 d	85.49±8.45	84.55±8.37	83.91±8.21	0.90	0.775
Feed intake 22–28 d	119.50±9.45	121.60±11.48	121.07±11.28	1.17	0.750
Feed intake 29–35 d	142.36±9.90	141.33±9.71	140.38±9.56	0.50	0.271
Feed intake 36–42 d	166.98±14.23	164.15±14.13	162.79±13.52	1.52	0.521
Total feed intake 0–42 d	98.43±51.66	97.88±51.08	97.27±50.62	2.27	0.971
Total feed conversion ratio	1.744±0.19[c]	1.840±0.22[b]	1.908±0.24[a]	0.007	< 0.0001
Mortality	1.67±0.48	1.43±0.50	1.43±0.50	0.055	0.099

[a-c] Means within a row with the same or no letter do not differ (P>0.05).

Table 4. Effects of protein level on carcass yield, breast and legs of broilers

Item	Dietary treatment			SEM	P-value
	HP	MP	LP		
Carcass yield,%	71.7±0.56	69.80±0.59	70.2±0.44	2.10	0.205
Legs, g	407±1.90	392±1.22	400±1.59	13.78	0.441
Legs,%	28.2±0.19[a]	27.8±0.21[a]	26.9±0.22[b]	0.05	< 0.0001
Breast, g	334±1.40	332±1.46	336±1.51	12.90	0.139
Breast,%	23.1±0.21[a]	23.0±0.18[a]	22.2±0.16[b]	0.08	< 0.0001

[a-c] Means within a row with the same or no letter do not differ (P>0.05).

values were recorded: 801.53 g (HP), 773.92 g (MP) and 774.06 g (LP), with significant differences (P<0.05) between the group. The results obtained in this study lead to the conclusion that protein level influences in a great extent the body weight of broiler chickens at slaughter (42 days).

No significant difference between the experimental groups, both weekly and overall growth period could be seen (P>0.05) for average feed intake (Table 3). During 42-day period, the lowest feed conversion ratio (1.744) was observed in HP group, showing significant difference from other groups (P<0.05). The dietary treatments had no significant effect on mortality. Mortality rate was lower than 1%+0.06% multiplied by 42 days (Commission of the European Communities/European Council, 2007).

The effect of protein level on carcass yield, breast and legs yield at 42 days of age are presented in Table 4. The protein level had no influence on the carcass, breast and leg weight. However, the percentage yield of breast was higher in the HP and MP group compared to LP group (23.1 and 23.0 vs 22.2%, P<0.05). In the HP group higher leg percentage yield was observed than in other groups (28.2 vs 27.8 and 26.9%, P<0.05). This finding is in agreement with other studies (Bilgili *et al.* 1992, Han and Baker 1994, Kidd *et al.* 1998), which showed that the dietary protein level did not significantly affect the carcass yield. However, broilers from HP and MP groups had significantly higher breast and leg meat percentage, which indicates a probable positive effect of the protein level on protein metabolism.

The stocking density (Table 5) can affect the behavioural of birds such as scratching, resting and locomotors activity. The Council Directive 43/2007 (Commission of the European Communities/European Council 2007) has set rules for maximum stocking density, feeding and drinking facilities, ventilation, heating, light, litter, noise, record keeping, training and surgical interventions. The Directive defines the stocking density as the total live weight of the chickens which are present in a house at the same time per square metre of the useable area. According to the Directive the maximum stocking density shall not exceed any time 33 kg/m^2, and only with derogation, the maximum stocking density shall not exceed any time 39 kg/m^2. Only the LP group had a lower stocking density than 33 kg/m^2, the MP and HP group had higher stocking density.

Table 5. Effect of protein levels on stocking density

Item	HP	MP	LP
Stocking density (kg/m^2)	14.75	14.79	14.79
Stocking density (kg/m^2)	36.03	34.12	32.75

Table 6. Incidence and footpad dermatitis score observed at slaughter house (%)

Item	HP	MP	LP
FPD score 0	56.81	52.48	68.28
FPD score 1	12.85	12.53	7.21
FPD score 2	30.33	34.99	24.50
FPD incidence	43.19	47.52	31.72
FPD score, points	67	76	53

Footpad dermatitis was observed in all 3 categories of protein levels. Examples of foot pad lesions are presented in Fig. 1. FPD was occurred at as early as 7 days of age and the lesions became more severe according to age. The incidence and footpad dermatitis score is reported in Table 6. FPD scores ranged from 53 to 76, exceeding the value of 50 points considered by the EU proposal as threshold (Commission of the European Communities/Proposal 221 final a Council Directive, 2005). The footpad dermatitis score was higher in group MP (Fig. 2), which received diets with protein level according to broiler producer. However it was in disagreement with Nagaraj *et al.* (2007a) who reported that incidence and severity of FPD were significantly affected

Fig. 1. Footpad dermatitis scoring observed at slaughter house.

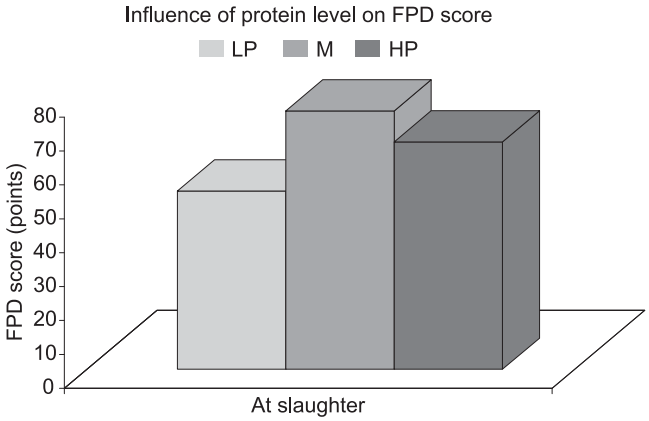

Fig. 2. Footpad dermatitis score evaluated at slaughter house.

by protein level and source. They found that the birds fed with low protein diets presented the lowest incidence of FPD compared with other treatments. Eichner *et al*. (2007) observed similar results but found that the addition of corn gluten meal to an all-vegetable diet reduced the incidence of FPD when compared with a vegetable and animal-based diet. Several experiments have shown that the incidence and severity of FPD is related to multiple factors such as: litter material (Grimes *et al.* 2002), litter moisture (Martland 1985), litter depth (Ekstrand *et al.* 1997), litter amendments (Nagaraj *et al*. 2007b), stocking density (Sørensen *et al*. 2000), seasonal effect (Ekstrand and Carpenter, 1998), nutritional deficiencies (Patrick *et al.* 1943*,* Murillo and Jensen 1976*,* Mayne 2005*,* Kenny *et al.* 2010).

Our results indicated that protein levels influence significantly body weight of broiler chickens at slaughter house. However, the protein levels had no influence on the incidence of footpad lesions.

ACKNOWLEDGMENTS

I would like express my sincere gratitude to PhD school program number: POSDRU/107/1.5/S/76888.

REFERENCES

Bilgili S F, Moran Jr. E T, and Acar N. 1992. Strain cross response of heavy male broiler to dietary lysine in the finisher feed: Live performance and further processing yields. *Poultry Science* **71**: 850–58.

Bilgili S F, Alley M A, Hess J B and Nagaraj M. 2006. Influence of age and sex on footpad quality and yield in broiler chickens. Reared on low and high density diets. *Journal Applied Poultry Research* **15**: 433–41.

Commission of the European Communities 2005. Proposal 221 final a Council Directive/Laying down minimum rules for the protection of chickens kept for meat production, Brussels, Belgium.

Commission of the European Communities 2007. *Council Directive 2007/43/Laying down minimum rules for the protection of chickens kept for meat production.* Official Journal, L182, 12/07/2007, pp 19–28.

Dawkins M S, Donnelly C A and Jones T A. 2004. Chicken welfare is influenced more by housing conditions than by stocking density. *Nature* **427**: 342–44.

Eichner G, Vieira S L, Torres C A, Coneglian, J L B, Freitas D M and Oyarzabal O A. 2007. Litter moisture and footpad dermatitis as affected by diets formulated on an all-vegetable basis or having the inclusion of poultry by-product. *Journal Applied Poultry Research* **16**: 344–50.

Ekstrand C, Algers B and Svedberg J. 1997. Rearing conditions and foot-pad dermatitis in Swedish broiler chickens. *Preventive Veterinary Medicine* **31**: 167–74.

Ekstrand C and Carpenter T E. 1998. Temporal aspects of footpad dermatitis in Swedish broilers. *Acta Veterinaria Scandinavica* **39**: 229–36.

Greene J A, McCracken R M and Evans R T. 1985. A contact dermatitis of broilers -clinical and pathological findings. *Avian Pathology* **14**: 23–38.

Grimes J L, Smith J and Williams C M. 2002. Some alternative litter materials used for growing broilers and turkeys. *World's Poultry Science Journal* **58**: 515–26.

Han Y and Baker H D. 1994. Digestive lysine requirement of male and female broiler chicks during the period three to six weeks post hatching. *Poultry Science* **73**: 1739–45.

Hester P Y. 1994. The role of environment and management on leg abnormalities in meat-type fowl. *Poultry Science* **73**: 904–15.

Kenny M, Kemp C and Fisher C. 2010. Nutrition and pododermatitis in broilers. *Proceedings XIIIth European Poultry Conference*, Tours, France, 23–27 August.

Kidd M T, Kerr B J, Halpan K M, Mcward G W and Quarles C L. 1998. Lysine levels in starter-finisher diets affect broiler performance and carcass traits. *Journal Applied Poultry Research* **7**: 351–58.

Martland M F. 1985. Ulcerative dermatitis in broiler chickens: The effects of wet litter. *Avian Pathology* **14**: 353–64.

Martrenchar A, Boilletot E, Huonnic D and Pol F. 2002. Risk factors of foot-pad dermatitis in chicken and turkey broilers in France. *Preventive Veterinary Medicine* **52**: 213–26.

Mayne R K. 2005. A review of the actiology and possible causative factors of foot pad dermatitis in growing turkeys and broilers. *World's Poultry Science Journal* **61**: 256–67.

Murillo M G and Jensen L S. 1976. Sulfur amino acid requirement and foot pad dermatitis in turkey poults. *Poultry Science* **55**: 554–62.

Nagaraj M, Wilson C A P, Hess J B and Bilgili S F. 2007a. Effect of high-protein and all-vegetable diets on the incidence and severity of pododermatitis in broiler chickens. *Journal Applied Poultry Research* **16**: 304–12.

Nagaraj M, Wilson C A P, Saenmahayak B, Hess J B and Bilgili S F. 2007b. Efficacy of a litter amendment to reduce pododermatitis in broiler chickens. *Journal Applied Poultry Research* **16**: 255–61.

Patrick H, Boucher R V, Dutcher R A and Knadel H C. 1943. Prevention of perosis and dermatitis in turkey poults. *Journal of Nutrition* **26**: 197–204.

Ross Breeders. 2007. *Ross 308 Broiler Nutrition Specifications*. Aviagen Limited, Newbridge, Midlothian EH28 8SZ, Scotland, UK.

SCAHAW. 2000. The welfare of chickens kept for meat production (broilers). *Report of the Scientific Committee in Animal Health*

and Animal Welfare. European Commission, Health and Consumer Protection Directorate General, Brussels, Belgium. http: //ec.europa.eu/food/fs/sc/scah/out39_en.pdf Accessed Mar. 2009.

Sørensen P, Su G and Kestin S C. 2000. Effects of age and stocking density on leg weakness in broiler chickens. *Poultry Science* **79**: 864–70.

Thomas D G, Ravindran V, Thomas D V, Camden B J, Cottam Y H, Morel P C H and Cook C J. 2004. Influence of stocking density on the performance, carcass characteristics and selected welfare indicators of broiler chickens. *New Zealand Veterinary Journal* **52**: 76–81.