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EFFECTS OF COARSENESS AND PROTEIN LEVEL (WITH OR WITHOUT UREA SUPPLEMENTATION) ON PERFORMANCE AND GUT DEVELOPMENT IN BROILERS

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ABSTRACT

Feeding coarse diets stimulates gut motility and development in poultry, by a retrograde flow of non-protein nitrogen (NPN) from the cloaca back to the ceca. In the ceca NPN can potentially be transformed to protein by microbiota and may contribute to the birds' growth.

288 one-day-old Ross 308 broilers, housed in 36 floor pens, were used in a completely randomized design with two feed structures (fine (F; geometric mean diameter (GMD): 154 um) and coarse (C; GMD: 306 um)) and three CP levels (15% (LP), 15% + urea (LU) and 21% (HP)). Effects of dietary factors on broiler performance, gastro-intestinal tract development (at day 35) and cecal microbial population were studied. Birds on the LU diet had a 11.9% lower BW gain and a 4.0% impaired FCR as compared to birds on the LP diet, if they were fed a fine structure. However, if they were fed a coarse structure, birds on the LU diet had a 3.5% higher BW gain and a 1.0% impaired FCR as compared to birds on the LP diet. Overall, birds on the finely ground diet at the HP level had a better performance than the other groups. Coarse fed birds increased gizzard, ceca, colon and pancreas weights by 44.8, 6.2, 7.0, and 13.3%, respectively compared to fine fed birds. Coarse fed birds had a 16.6 and 14.3% lower pH in proventriculus and gizzard, respectively, while it increased duodenal pH by 4.8%. The cecal microbial population differed significantly ($P<0.05$) between fine and coarse fed birds.

KEYWORDS: particle size, crude protein, cecum, microbiology.

INTRODUCTION

The relevance of feeding coarse particles or whole wheat inclusions in poultry diets has been emphasized by several authors in the last decade (Hetland *et al*., 2004; Amerah *et al*., 2007).

On a coarse diet birds develop a muscular and more active gastro intestinal tract (GIT), which enhances digesta reflux and its digestibility, gut health and supports colonization of a diverse and balanced microbial population (Amerah *et al*., 2007; Engberg *et al*., 2004). In addition, improved cloaca-caecal reflux mechanisms transfer urinary nitrogen, such as uric acid and urea, from the cloaca via the colon into the caeca, particularly when a diet is deficient in crude protein (CP) (Karasawa and Maeda 1995). In the caeca bacteria degrade these urine components and ingested urea, in order to synthesize microbial protein and amino acids. This bacterial protein can be utilized by the bird, thereby increasing nitrogen (N)-efficiency when feeding rather low diet CP levels. The main objectives of this study were to investigate the effects of diet structure, CP level, urea supplementation, and their interactions

on broiler performance, GIT development and cecal microbial population.

MATERIALS AND METHODS

The set-up of the experiment was a 2x3 factorial design with main factors diet structure and CP level. The factor diet structure consisted of two levels: fine (F) (GMD: 154 µm) and coarse (C) (GMD: 306 µm). The factor CP level consisted of three levels: 21% CP (HP), 15% CP (LP), and 15% CP + urea (LU). Diets were formulated to be iso-energetic and the HP diets were formulated to supply balanced and adequate amounts of amino acids. Each treatment group comprised 6 replicates (36 experimental units = 6x(2x3)), each consisting of a floor pen bedded with SoftCell® housing 8 male broilers (total of 288 broilers). Body weight (BW) gain, feed intake (FI) and feed conversion ratio (FCR) were determined weekly.

At day 35, all broilers were weighed individually and 6 birds per pen, with BWs closest to the mean weight of the pen, were selected for dissection. After euthanization by T61, broilers were weighed and dissected for all digestive tract segments, including pancreas. For microbial analysis 1-2 g cecal digesta of each individual bird was collected and stored at -20 °C. The digesta from each segment of the six birds per replicate were pooled and the pH was measured immediately. The empty weights of all segments were determined. Cecal microbiology samples were analysed using PCR with denaturing gradient gel electrophoresis (DGGE). Performance and digestive tract data were analysed by General Linear Models using PROC GLM (SAS Institute, 2004). Significant differences between means were separated by the least significant difference (LSD) test, using PDG GLM 800 ($P<0.05$). Microbiology data was analysed by Monte Carlo Permutation Tests ($P<0.05$).

RESULTS AND DISCUSSION

The effects of the different treatments on FI, BW gain and FCR of the broilers during the experiment are presented in Table 1. Between 0-21 days FI and BW gain were 10.2% and 10.1% higher, while the FCR was equal, for the LP fed birds compared to the LU birds, when finely ground. For the coarse diet fed birds FI and BW gain were 2.0% and 3.2% lower, while the FCR was 3.8% higher for the LP fed birds compared to the LU fed birds. However, between 21-35 days FI and BW gain were 9.6% and 15.7% higher, while the FCR was 5.2% lower, for the LP fed birds compared to the LU birds, when finely ground. For the coarse diet fed birds FI, BW gain and FCR were 7.5%, 3.5% and 4.2% lower, respectively, for

Table 1 - Effect of diet structure (S) and crude protein levels (CP) on feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) of birds during 0-21, 21-35 and 0-35 days of age.

		FI (kg)			BWG (kg)			FCR		
S*	**CP***	**0-21**	**21-35**	**0-35**	**0-21**	**21-35**	**0-35**	**0-21**	**21-35**	**0-35**
F	HP	1.19a	2.40a	3.60a	0.92a	1.56a	2.49a	1.29d	1.54c	1.45b
F	LP	1.19a	2.29ab	3.47a	0.76c	1.25b	2.01b	1.56b	1.84ab	1.73a
F	LU	1.08bc	2.09bc	3.18bc	0.69d	1.08c	1.77c	1.57b	1.94a	1.80a
C	HP	1.16ab	2.29ab	3.45ab	0.84b	1.51a	2.35a	1.38c	1.52c	1.47b
C	LP	1.00c	1.98c	2.99c	0.61e	1.10bc	1.71c	1.66a	1.81b	1.76a
C	LU	1.02c	2.14bc	3.16c	0.63de	1.14bc	1.77c	1.60b	1.89ab	1.78a
S	< 0.001	0.045	0.008	< 0.001	0.256	0.011	< 0.001	0.308	0.586	
CP	< 0.001	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
S * CP	0.032	0.066	0.051	0.049	0.173	0.097	0.151	0.928	0.681	

Means within a column followed by different superscripts are significantly different ($P<0.05$). * F= Fine; C= Coarse, HP= High Protein; LP= Low Protein; LU= Urea.

the LP fed birds compared to the LU fed birds. Overall, when fed a fine diet structure, FI and BW gain were 9.1% and 13.6% higher, while the FCR was 3.9% lower, for the LP fed birds compared to the LU fed birds. However, when fed a coarse diet structure, FI, BW gain and FCR were 5.4%, 3.4% and 1.1% lower, for the LP fed birds compared to the LU fed birds.

During the first 21 days, coarse fed birds showed a reduced performance. This is in accordance with Gabriel *et al*. (2008), who showed a lower BW gain for coarse fed birds in the first 21 days compared to standard fed birds. Satiety feeling due to increased gizzard activity and an increased time for GIT development can cause a reduced performance (Hetland *et al*., 2002). The improved growth for the CLU fed birds compared to the CLP groups between 21-35 days indicates a beneficial effect of coarse feeding and urea supplementation on broiler performance. Improved reflux mechanisms increase the backflow of digesta to the cecum, where urea fermented to ammonia. This ammonia can be used by bacteria for amino acid and microbial protein synthesis, which can be utilized for broiler growth (Karasawa *et al*., 1988; Karasawa and Maeda, 1995).

The effects of the different treatments on GIT segment weights and pH are presented in Table 2. Gizzard, caeca, colon and pancreas weights increased by 44.8, 6.2, 7.0, and 13.3%, respectively in coarse fed birds compared to fine fed birds. An increased gizzard weight is the result of larger particles requiring more grinding before passage to the small intestine, which stimulates muscular development (Svihus *et al*., 1997, Amerah *et al*., 2007). For the cecal and colon weights, Svihus *et al*. (1997) did not show an increased cecal and colon weight when birds fed whole or ground barley. In accordance, Amerah *et al*. (2007) and Gabriel *et al*. (2008) showed no significant effect on cecal weight in fine or medium fed birds compared to whole wheat fed birds. Increased cecal and colon weights might be caused by increased reflux of digesta and muscular development. The pancreas showed an increased weight in the coarse fed birds, suggesting a higher activity and enzyme secretion. These results are in accordance with previous studies by Engberg *et al*. (2002, 2004) and Gabriel *et al*. (2008).

In the proventriculus and gizzard the pH was significantly lower in the coarse fed birds, while in the duodenum the pH was increased by 4.8%. The low pH in the gizzard and proventriculus is induced by increased HCl secretion and pepsin activity induced by coarse feeding (Engberg *et al*., 2004; Gabriel *et al*., 2008). The high duodenal pH for coarse fed birds can be related to an increase in sodium bicarbonate secretion by the pancreas (Denbow, 2000).

The cecal microbial population differed

Table 2 - Effect of diet structure (S) and crude protein levels (CP) on gastro intestinal (GIT) segment weights and pH of pooled digesta.

		GIT segment weight (g/100g BW)				pH		
S*	**CP***	**Gizzard**	**Ceca**	**Colon**	**Pancreas**	**Proventriculus**	**Gizzard**	**Duodenum**
F	HP	0.99f	0.43bc	0.15bc	0.21d	3.92a	3.86a	5.21b
F	LP	1.11e	0.43bc	0.14cd	0.23cd	3.70ab	3.58ab	5.36ab
F	LU	1.22d	0.41c	0.14d	0.24bc	3.58ab	3.47ab	5.55ab
C	HP	1.50c	0.45ab	0.16ab	0.24bc	2.85c	3.22bc	5.66a
C	LP	1.63b	0.48a	0.16a	0.28a	3.22bc	2.98c	5.63a
C	LU	1.77a	0.42bc	0.14cd	0.26b	3.27bc	2.85c	5.60a
S	< 0.001	0.012	0.011	< 0.001		< 0.001	< 0.001	0.016
CP	< 0.001	0.045	< 0.001	< 0.001		0.848	0.064	0.503
S * CP	0.885	0.576	0.086	0.012		0.201	0.952	0.280

Means within a column followed by different superscripts are significantly (P<0.05) different.* F= Fine; C= Coarse, HP= High Protein; LP= Low Protein; LU= Urea.

significantly (P<0.05) between fine and coarse fed birds. Within the different treatments, CLU fed birds showed a significant (P<0.05) different cecal microbial population. Differences in microbial profiles between coarse and fine fed birds could have been induced by the lower pH in the gizzard in the coarse fed birds, which acts as a pathogen barrier, thereby decreasing the colonization of *E. coli* and *C. perfringens* (Engberg *et al*., 2004; Gabriel *et al*., 2008). Another contributing factor can be the higher passage rate of digesta in coarse fed birds, that can reduce proliferation of detrimental bacteria (Svihus *et al*., 2002). Increased synthesis of microbial protein and amino acids from urea due to increased reflux of digesta might cause a different microbial profile for the CU fed birds.

CONCLUSION

In conclusion, all HP fed birds showed a similar performances, irrespective of diet structure. Performance decreases by reducing the CP level of the diet and this could only be partly compensated by combining a coarse diet with urea supplementation. Coarse feeding improves GIT development, especially of the gizzard and proventriculus. Throughout the GIT pH barriers are improved through feeding coarse diets, by a decreased pH in proventriculus and gizzard digesta and an increased duodenal pH. Coarse feeding and urea supplementation cause a shift in the microbial population of the ceca.

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