

THE EFFECTS OF DIETS CONTAINING DIFFERENT LEVEL OF NON-STARCH POLYSACCHARIDES ON PERFORMANCE AND CANNIBALISM IN LAYING HENS

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Received July 22, 2010; Accepted August 24, 2010

ABSTRACT

An experiment was conducted to observe the effect of different diets containing different level of non-starch polysaccharides (NSP) on performance and cannibalism of laying hens. Six diets (wheat-based, rice hull-based, plant protein-based, millrun-based, MOS, and bentonite) were used and were randomly given to 6 groups of ISA Brown hens, with 18 replicates per group and 5 birds per replicate for 8 weeks. The results showed that diets did not have a significant effect ($P > 0.05$) on cannibalism mortality, but numerically the rice hull diet gave the lowest effect, the millrun gave the intermediate effect, whereas the plant protein diet gave the largest negative effect. Diet significantly affected feed intake ($P < 0.01$), egg production ($P < 0.01$), feed to egg ratio ($P < 0.01$) and egg weight ($P < 0.05$). Birds on millrun diet had the lowest intake, but the feed to egg ratio was superior and egg production was the highest compared to those fed other diets. In contrast, the feed to egg ratio in rice hull diet was inferior, and egg weight was also lighter than those fed other diets. In conclusion, fibre sources have been verified as contributing factors involved in the outbreak of cannibalism in laying hens. Diets containing high insoluble NSP had a potential to decrease the mortality due to cannibalism.

Keywords: cannibalism mortality, dietary fibre, egg production, ISA Brown hens, NSP

INTRODUCTION

Cannibalism in poultry is a great concern for poultry producers since its occurrence causes significant economic losses. Beak trimming is a technique commonly used by poultry industry to reduce feather pecking leading to cannibalism, however, the application of beak trimming is not suitable process since it causes acute pain (Gentle, 1986). Since then, several studies either in housing factors (Huber and Wechsler, 1997; Riber and Mench 2009), genetic factors (Ellene *et al.*, 2008; Bolhuis *et al.*, 2009), or nutritional factors (Ambrosen and Petersen, 1997; Hartini *et al.*, 2002) to reduce the incidence of cannibalism had been proposed. Among those factors, preventing cannibalism through dietary manipulation appears an attractive and feasible option since it does not need a long term approach and it is not costly. An increased level of dietary protein (Ambrosen and Petersen 1997) and sodium (Cooke, 1992) had been reported to decrease cannibalism mortality.

However, the effect of dietary protein (McKeegan *et al.* 2001; Kjaer and Sorensen, 2002, Elwinger *et al.*, 2008), and sodium (Cooke, 1992) in reducing mortality due to cannibalism seem not consistent. The use of fiber in reducing cannibalism mortality had also been applied many years ago. Supplementation of oat hulls in diets reduced the mortality due to cannibalism (Esmail, 1997; Wahlström *et al.*, 1998). In addition, hens fed high-non-starch polysaccharides (NSP) diets (oat hulls as NSP source) had less feather damage (van Krimpen *et al.*, 2009). Mortality due to cannibalism also reduced in hens fed millrun diets (Hartini *et al.*, 2002). These findings suggest that dietary fiber has a potential in reducing cannibalism.

The objectives of the current study therefore, were to observe whether different diets having different level of NSP would yield different outcomes on performance and cannibalism in layers. However, to observe if other nutrient such as protein and sodium having an effect on the

occurrence of cannibalism, diets were formulated as having different levels of protein and sodium as well.

MATERIALS AND METHODS

Birds management and experimental diets

Non-beaked-trimmed ISA Brown hens (n =540) at 45 weeks of age were used in this experiment. Birds were divided into 6 groups with 18 replicate cages per group and 5 birds per cage and were given the experimental diets for 8 weeks. The six experimental diets were a wheat-based diet (700 g/kg wheat), rice hull-based diet (100 g/kg rice hull), plant protein diet (680 g/kg wheat + plant protein replacing animal protein), millrun-based diet (320 g/kg millrun), MOS diet (700 g/kg wheat + 1.5 g/kg mannoooligosaccharides) and bentonite diet (670 g/kg wheat + 50 g/kg bentonite) (Table 1). Bentonite was included as a non-nutritive “filler”, to test the effect of nutrient dilution on cannibalism. Diets were analysed for NSP, protein and mineral content. All diets were given in pelleted form. Feed and water were available *ad libitum* throughout the experiment.

Concentrations of NSP in the diets were determined by the methods described by Theander and Westerlund (1993). The nitrogen content of diets was determined using LECO FP-2000 automatic analyser (Leco Corporation, St. Joseph, MI). The protein content was calculated by multiplying by a factor of 6.25. Minerals analyses were determined using a Milestone ETHOS PLUS Microwave digester with HPR-1000/10S rotor. The minerals analyses were Calcium, Phosphor, and Sodium.

Variables measurement

Variables measured were feed intake (g/b/d), hen-day egg production (HDEP, %), egg weight (g), body weight (g) and mortality (%). Total feed intake, % HDEP, egg weight (samples of eggs), and body weight were recorded weekly, whereas mortality was recorded daily. For welfare reason, birds, which were wounded or blood seen were removed from the cage and recorded as “dead”.

Statistical Analyses

The data obtained were analysed statistically using one-way analysis of variance (Manugistics, Inc., Rockville, MD). After a significant F test ($P < 0.05$), Duncan's multiple-range test was used

to inspect differences among group means.

RESULTS AND DISCUSSION

The results of the present study showed that diets did not have a significant effect ($P > 0.05$) on cannibalism mortality, but numerically the rice hull diet gave the lowest effect (22%), the millrun diet gave the intermediate effect, whereas the plant protein diet gave the largest negative effect (44%) (Table 2).

The rice hull and millrun diets contain high insoluble NSP, 114.7 g/kg and 115.6 g/kg, respectively (Table 1). The lowest cannibalism mortality in birds fed those diets compared to those fed other diets supported the previous research that high-NSP diets reduced cannibalism (Esmail, 1997; Wahlström *et al.*, 1998; Hartini *et al.*, 2002). The numerically lower mortality rate in birds fed the rice hull diet than those fed the millrun diet suggests that different polysaccharides elicit different physiological function in the gut. It has been suggested that the way the monomer units of polysaccharides link together differentiates the physical properties among polysaccharides (Morris, 1990). In addition, the lowest mortality in birds fed the rice hull-based diet may also relate to its physical structure. It has been demonstrated in some studies (Hetland *et al.*, 2002; Hetland and Choct, 2003; 2004) that chickens have a requirement for coarse fibre to stimulate gizzard function. Their findings basically show that a proper developed gizzard will improve the overall digestive potential of the gut in such a way that deleterious behaviours are reduced. Indeed, van Krimpen *et al.* (2009) found that increasing gizzard weight and its contents in hens fed high-NSP diet linear with the reduction in feather damage.

The gizzard is the driving force for the peristaltic movement of the avian gastrointestinal tract. The contractions of the gizzard serve to coordinate the movement of digesta in the gut and optimize digestion and absorption. Therefore, the gizzard, if properly developed, is the pacemaker for the entire tract. An empty gizzard will not have feed stimuli and such a condition will not be able to regulate downstream digestive processes (Hetland and Chot, 2004). A poorly developed gizzard acts more like a passage organ than a grinding organ (Cumming, 1994). Thus, in the present study, it is likely that the rice hull diet was able to stimulate the gizzard function more than the millrun-based diet, resulting in birds feeling

Table 1. Ingredients of the Experimental Diets (g/kg)

Ingredients	Wheat	Rice hulls	Plant protein	Millrun	MOS ^A	Bentonite
Wheat	707.5	607.5	683	-	706	671.6
Rice hulls	-	100	-	-	-	-
Millrun	-	-	-	320	-	-
Sorghum	-	-	-	423.1	-	-
MOS ^A	-	-	-	-	1.5	-
Bentonite	-	-	-	-	-	50
Meat meal	100	100	-	105	100	95
Soybean meal	8.5	8.5	110	50	8.5	8
Sunflower meal	50	50	68.5	-	50	47.5
Cottonseed meal	5	5	-	-	5	5
Rice pollard	63	63	37.5	-	63	60
Soy flour	-	-	0	-	-	-
Oil	-	-	10	35	-	-
Limestone	59.5	59.5	75	57.5	59.5	56.5
Kynofos ^B	-	-	10	-	-	-
Salt	1	1	1.3	1.1	1	1
Choline chloride	0.3	0.3	0.3	0.3	0.3	0.3
DL-methionine	0.6	0.6	0.9	1.5	0.6	0.6
L-Lysine	1.1	1.1	-	3	1.1	1
Layer premix	2	2	2	2	2	2
Pigment	1.5	1.5	1.5	1.5	1.5	1.5
<i>Chemical composition</i>						
ME, MJ/kg	11.6	10.4	11.4	11.3	11.4	11
Crude Protein, %	19	18	18	18	20	19
Fat, %	3.69	3.54	3.27	7.11	3.66	3.51
Crude Fibre, %	3.64	7.42	3.97	4.4	3.6	3.46
Methionine, %	0.32	0.33	0.35	0.38	0.32	0.31
Lysine, %	0.74	0.73	0.68	0.96	0.76	0.72
Calcium, %	3.6	3.8	3.8	3.5	3.3	3.5
Non-phytate Phosphorus,	0.54	0.48	0.35	0.57	0.5	0.47
Sodium, %	0.11	0.14	0.08	0.1	0.15	0.12
Soluble NSP (g/kg)	8.6	2.1	5.7	6.5	8.7	8
Insoluble NSP (g/kg)	77	114.7	84.93	115.6	82	80.4

^ASource of manno-oligosaccharides: BIO-MOS (Alltech)

^Bkynofos: Dicalcium Phosphate dihydrate, feed grade, and is produced by reacting defluorinated phosphoric acid (H₃PO₄) with slake lime (Ca(OH)₂) to produce a dicalcium phosphate dihydrate (CaHPO₄·2H₂O). Total Phosphorus (P) 18%, Calcium 23% and Magnesium 1.5%.

less frustrated. Consequently, birds will reduce aggressive behaviours which can eventually lead to cannibalism. Another interesting finding is the total ineffectiveness of the inert filler, bentonite, on cannibalism. Birds fed the bentonite diet obviously ate more but did not produce the same physiological effect as insoluble NSP present in the rice hull and millrun diets. This reinforced the hypothesis that the ability of insoluble fibre to alleviate cannibalism mortality in hens is due to

its active physiological effect on gut functions, rather than a simple nutrient dilution effect on feed intake.

Birds fed the plant-protein diet tended to have the highest rate of mortality due to cannibalism. Both the rice hull and plant-protein diets had an equal protein level (18%). These findings suggest that low protein levels *per se* may not be a contributing factor on the increased incidence of cannibalism as reported by Elwinger

et al. (2008). Cooke (1992), on the other hand, suggested that changes in protein source might affect the sodium level in the diet, which, in turn, could trigger the incidence of cannibalism. Indeed, in the present study, the use of plant protein reduced the sodium level in the diet, and tended to increase cannibalism. However, birds fed the MOS diet, which had the highest sodium level, did not have the lowest cannibalism mortality suggesting that sodium may not be a contributing factor in the outbreak of cannibalism either. Rather, it is possible that the type of carbohydrates present in the diet, e.g. more soluble pectins in this diet, may be important in modulating bird behaviour, such as cannibalism.

Diet significantly ($P<0.01$) influenced feed intake (Table 2). Birds given the bentonite diet ate significantly more (153 g/bird/d) compared to those given other diets. Birds on millrun diet on the other hand, had the lowest intake (125 g/bird/d). It is likely that birds on the bentonite diet ate a great deal more to compensate for the energy dilution caused by inclusion of 50 g/kg bentonite. The result is in agreement with the finding by van der Meulen *et al.* (2008) and van Krimpen *et al.* (2009) who found that birds were able to compensate for decreased energy density by increasing their feed intake. In addition, increasing feed intake was linear with the increased in energy dilution (van Krimpen *et al.*, 2009). Birds fed the rice hull diet also increased their intake; but those fed the millrun diet did not, despite their similar high level of insoluble NSP content. This indicates that the increased intake in

birds fed the rice hulls may not be due to energy dilution. There were two possibilities that could be suggested in this case. First, the rice hull diet may stimulate a faster digesta passage than the millrun diet, resulting in an increase in feed intake. Hetland and Svihus (2001) found that birds fed coarsely-ground oats hulls increased the digesta passage rate. Harlander-Matauschek *et al.* (2006) also found that birds fed downy feather, as indigestible components, increased the speed of feed passage. The increase in feed passage might initiate the feeling of hunger. Second, the physical structure of the rice hulls may increase the gut volume, increasing feed consumption. Hetland and Svihus (2001) found increased feed intake in birds fed coarsely-ground oat hulls, but not in those fed finely-ground oat hulls. van Krimpen *et al.* (2009) also found a linear increase in feed intake with increasing oat hulls concentration in diets. In addition, the gizzard weight increased with increasing insoluble NSP intake (van Krimpen *et al.*, 2009). So, it was suggested that the physical structure of fiber might initiate an increase in gut capacity, leading to increased feed consumption.

Diets significantly affect egg production ($P<0.01$), feed to egg ratio ($P<0.01$) and egg weight ($P<0.05$) (Table 2). Birds fed the millrun diet had the highest ($P<0.01$) egg production (64%) than those fed other diets, whereas birds fed the wheat and MOS diets had the lowest egg production, which are 58% and 56%, respectively. The feed to egg ratio of birds fed the millrun diet was superior ($P<0.01$) to those fed other diets,

Table 2. Feed Intake, Hen-day Egg Production (HDEP), Feed:Egg Ratio, Egg Weight, Body Weight and Cannibalism Mortality of Laying Hens Fed Different Dietary Fibres

Diet	Feed intake (g/bird/d)	HDEP (%)	Feed:Egg Ratio	Egg weight (g)	Body weight (g)	Cannibalism mortality (%)
Wheat	137 ^{bc}	58 ^b	1.9 ^{bc}	71 ^a	2227	35.0
Rice hulls	150 ^{ab}	59 ^{ab}	2.4 ^a	67 ^b	2148	22
Plant protein	148 ^{ab}	63 ^a	2.2 ^{ab}	69 ^{ab}	2149	44
Millrun	125 ^c	64 ^a	1.8 ^c	70 ^a	2076	32
MOS	138 ^{abc}	56 ^b	2.0 ^{bc}	71 ^a	2370	33
Bentonite	153 ^a	62 ^a	2.2 ^{ab}	70 ^a	2177	41
Pooled SEM	5.1	1.6	0.1	1	92.3	4.9
Significance	**	**	**	*	ns	ns

a,b,c mean values within a column with different superscripts indicate differ significantly ($P<0.05$).

* $P<0.05$; ** $P<0.01$, ns= not significant

whereas that in those fed the rice hull diet was inferior. Egg weight in birds fed the rice hull diet was also lighter (67 g, $P < 0.05$) than those fed other diets.

With increasing fibre intake, the partitioning of retained energy between body protein and body fat changed in favour of protein (Jorgensen *et al.*, 1996). The higher egg production (64%) in birds fed the millrun diet is more likely due to a superior feed to egg ratio since birds on this diet had a low intake. This indicates that the property of insoluble NSP in the millrun diet does not impede the absorption of nutrients, rather it enhanced it. In addition, the millrun diet contained 480 g/kg sorghum. Sorghum is very high in starch and low in NSP (40-50 g/kg) (Choct, 1997). The higher starch content in the diet may have added to the high nutrient digestibility and eventually nutrient availability for production. The mechanism in which birds fed the rice hull diet had inferior feed to egg ratio and the lighter egg weight, on the other hand, has not been clearly understood yet. It is likely that increasing digesta passage rate might not allow enough time for nutrient to be absorbed properly. This finding again supported the statement that the physicochemical properties of fiber is not the same among grains (Choct, 1997).

The inclusion of bentonite did not have a negative effect on egg production and egg weight. This finding supports the previous finding that diets with a reduced energy concentration did not affect egg production and egg weight (van der Muelen *et al.*, 2008). However, the present results are not in agreement with the finding of Almirall *et al.* (1997), who found that diets with a reduced energy concentration reduced egg production. In this study, birds fed the bentonite diet had high feed intake, providing enough nutrients needed for egg production.

CONCLUSION

In the present study, fibre sources have been verified as contributing factors involved in the outbreak of cannibalism in laying hens. The mechanism by which fibre reduces cannibalism in laying hens is believed to be through its effect in modulating gut function and bird behaviour, in which the degree of response is dependant on the chemical and physical nature of fibre. Diets containing high insoluble NSP decrease the mortality due to cannibalism.

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