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Use of different dust bathing materials for layers – Effect on nutrient digestion and gut physiology

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Executive Summary

Effect of access to wood shavings and processed paper in the litter bath of modified cages on performance, gizzard activity, plumage condition and pack damages was studied for hens fed a wheat-based diet. Egg production was similar for all treatments, but birds with access to paper showed higher feed consumption than the control birds and birds with access to wood shavings. This resulted in a corresponding difference ($P<0.05$) in feed utilisation. A tendency for better plumage condition was observed for birds with access to wood shavings during the last part of the laying period. Consumption of wood shavings and paper from the litter bath was 4 and 11 g/hen/day, respectively. Weights of empty gizzard and gizzard contents were considerably higher for bids with access to wood shavings. The amount of large particles in duodenum decreased with access to wood shavings. In contrast, birds with access to paper showed a higher portion of large particles in the duodenum.

Contents

Executive Summary..... iii

Contents iv

Introduction.....1

Objectives.....3

Materials and methods 4

Discussion 6

Implications.....10

Recommendations 11

References 12

Plain English Compendium Summary.....13

Introduction

During the last decade community opinion has focused more attention on welfare in animal production. Recently, the European community published a new directive where more space per bird, inclusion of dust-bathing facilities, nests and perches will be required in all housing systems for layers from 2012.

The original idea for the inclusion of suitable litter materials in free range houses is to provide a soft, clean and absorbent bedding material. In addition, to provide a material for dust bathing to assist with the bird's natural behaviour. Consequently, dust bathing facilities have also been included in alternative cage systems. In addition to the behavioural aspect, birds also consume litter, which may result in improved grinding of food in the gizzard and thus improve digestion of nutrients.

Including insoluble fibre in the dietl has been suggested to prevent cannibalism among layers. A high inclusion level of wheat in the diet has resulted in inferior plumage condition due to feather pecking compared with diets based on barley (Abrahamson *et al*., 1996) and oats (Wahlstrøm *et al*., 1998; Al Bustany & Elwinger, 1988), thus supporting the hypothesis that insoluble fibres reduce the harmful pecking behaviour among layers. Particle size distribution in duodenal digesta has shown that particles that leave the gizzard are remarkably small, and quite similar regardless of the original particle size of the feed (Hetland *et al*., 2002). Insoluble fibre accumulates in the gizzard and may play a role in appetite regulation and thus cause a more harmonic satiety feeling (Hetland *et al*., 2003). The selective retention of particles in the gizzard due to size also causes a difference in passage time for different feed ingredients.

Recent research has also revealed that modern high producing genotypes of layers voluntarily consume a considerable amount of wood shavings and paper when given access to such components (Hetland *et al*., 2003). However, consumption of paper and wood shavings was found to be higher when birds were fed wheat based diets than oat diets thus, indicating an interaction between dietary insoluble fibre level and appetite for litter. In two studies, a remarkable increase in gizzard contents was found when poultry had access to wood shavings (Hetland *et al*., 2003). A proportional increase in bile acids in gizzard contents with fibre content was found, thus indicating an increased gizzard-duodenal reflux caused by access to wood shavings. This phenomenon may explain why there is an increased starch digestibility in birds with access to wood shavings (Hetland *et al*., 2003). Since the gizzard plays a major role in the gastro duodenal refluxes (Duke, 1991), an increased gizzard size and activity may interact with the flow and reflux of digesta and thus improve appetite regulation. This may prevent cannibalism. Since litter materials mainly consist of hard fibre structures, they may be

the most important factor for gizzard stimulation, also considerably more important than the use of whole cereals (Hetland *et al*., 2003). In addition, fibre structures act as a material for picking, searching and bathing behaviour, and thus by encouraging non destructive bird activity play an important role in preventing cannibalism (Aerni *et al*., 2000; El-Lethey *et al*., 2000).

Increased H/L-ratio (heterophil lymphocyte ratio) is associated with chronic stress in poultry (Gross, 1983). Campo et *al*. (2001) found increased H/L-ratio in hens with very poor plumage condition compared to those with normal plumage condition. New research indicates that hens with access to foraging material show a lower H/L ratio and an increased immune response to prior immunisation than hens without access to such materials, indicating lower stress in these birds (El-Lethey *et al*., 2000; Aerni *et al*., 2000).

As already described, materials used for dust bathing can affect both nutrient digestion and bird behaviour. However, very little basic knowledge exists on this topic. We have already done two experiments with commercially available cages and dust baths at NLH. These studies have provided applied knowledge about performance, plumage condition and feather picking among layers. However, to understand the physiological role of dust bath materials as a beneficial enrichment in preventing cannibalism among layers, more knowledge about their effect on nutritional physiology and stress physiology is required. Dust bathing materials with different physical properties should be studied, to ascertain the gizzard stimulating effect, as well the effects of the soft and hard fibre structures in litter materials and feedstuffs..

Objectives

To gain basic knowledge about the nutritional and physiological consequences of access to different types of materials for dust bathing, the effects of their cell structure and interactions with feed stuffs used for layers.

Specifically to research:

- The nutrient digestibility and utilisation by layers with access to different dust bath materials
- The bird's preferences for dust bath materials when fed diets with different dietary fibre levels.

Materials and methods

Non-beak-trimmed Lohmann Selected Leghorn (LSL) chickens were reared at a commercial pullet farm until 16 weeks of age. At this age, the birds were moved to the experimental facility. Four hundred and twenty birds were placed in commercial modified cages (Victorson) with perches, and a litter bath placed on top of the nest box at the end of each cage unit. There were 7 birds per cage. he litter bath was available to the birds from 23 weeks of age for 4 hours prior to darkness. Feed consumption, and daily egg production were recorded from 26 weeks of age.

A typical commercial wheat based diet with low fibre content (73 g/kg NDF) was used in the experiment. The composition of the diet is given in Table 1.

Table 1. Diet composition[1]

Ingredients	Inclusion level (%)
Wheat	53.47
Maize	14.00
Soya bean meal	12.58
Limestone	5.22
Mono calcium phosphate	0.83
Maize gluten	4.00
Animal fat	1.96
Fish meal	2.6
Shell meal	3.85
Sodium bicarbonate	0.29
L-lysine	0.10
DL-methionine	0.10
Vitamin-mineral premix	1.00

[1] Calculated nutrient contents; AMEn, 11.7 MJ/kg; crude protein, 169.2 g/kg; lysine, 7.8 g/kg; methionine, 4.1 g/kg; methionine+cysteine, 6.8 g/kg; threonine, 6.0 g/kg; calcium, 39.9 g/kg; phosphorus, 5.6 g/kg.

Wood shavings were used as litter in the litter bath in one third of the cages and coarsely shredded hard paper (cellulose) in another third from 25 weeks of age. In the last third of the cages, no litter was included in the litter bath. The litter baths were refilled twice weekly. Litter consumption was measured thrice before 35 weeks of age. At 35 weeks, plumage condition was scored according to Tauson *et al*. (1984) for 28 birds per treatment by scoring all birds in four cages per treatment. This scoring system assigned values 1, 2, 3 and 4 for each reported character, where 1 was poorest and 4

was best. Plumage condition was recorded separately for neck, breast, wings, back, tail and cloaca, and the means of the 6 plumage scores calculated. Lesions of the comb, neck, rear body and cloaca, were scored as indicators of cannibalistic pecks. Score 4 indicating no injuries and 1 indicating >5 wounds or lesions. Two persons were involved in scoring all birds. These same birds were then dissected, and the gizzard and gizzard contents were weighed separately. Duodenal contents were collected for determination of particle size distribution.

A commercial Norwegian layer diet with a higher fibre content (118 g/kg NDF) was also included in the experiment until 35 weeks of age to study the effect of higher dietary fibre level on the appetite for wood shavings. Analysed fibre level (NDF) of that diet was 118 g/kg and so over 60% higher than the experimental diet.

From 35 weeks of age, the treatment with processed paper was excluded from the experiment. At 62 weeks of age, plumage condition was scored for all birds with or without access to litter in the litter bath. At the same age, all birds from 5 cages per treatment were killed, dissected and the gizzard and gizzard contents weighed. Contents of the duodenum were gently squeezed out for particle size analysis using the Laser Diffraction Method. This method detects particle diameter in the range from 0.02μm to 2000μm. Consumption of feed and wood shavings and production of faeces over a period of four days were recorded. Samples of feed, wood shavings and faeces were analysed for gross energy in a Parr 1281 bomb calorimeter. Apparent metabolisable energy was corrected for wood shavings by assuming that no wood shavings were digested. Data were analysed using the GLM procedure of SAS and the differences between means were separated by using a LSD test.

Discussion

The use of either wood shavings or paper in the litter bath did not affect egg production (Table 2). However, the birds with access to paper showed higher (P<0.05) feed consumption than control birds and those with access to wood shavings. A corresponding poorer feed utilisation was observed also. At this time there were no differences for plumage condition or peck damages, confirming that the difference in feed utilisation was not caused by heat loss due to different feathering among the treatments.

Table 2. Performance, plumage condition and peck damage [1]

	Control	Paper	Wood shavings	RSD
Laying percentage	97.1	97.1	97.4	1.27
Egg weight, g	59.2	59.4	59.4	1.73
Egg prod, g/hen/day	57.5	57.7	57.8	1.84
Feed consumption, g/hen/day	108[b]	110[a]	107[b]	3.79
Feed/egg	1.87[b]	1.92[a]	1.85[b]	0.078
AMEn, MJ/kg, 62 wk of age	11.0[b]		11.8[a]	0.49
Plumage condition, 35 wk of age	3.1	3.1	3.0	0.05
Peck damages, 35 wk of age	3.8	3.7	3.7	0.13
Plumage condition, 62 wk of age	2.2	-	2.4	0.329
Peck damages, 62 wk of age	3.7	-	3.7	0.114

[1] Means within a row with a different letter indicate significant (P<0.05) differences. RSD is square root of MSE in the Analysis of Variance.

The hens appetite for paper was 2-3 times higher than for wood shavings. Birds with access to wood shavings showed approximately 70% higher (P<0.05) empty gizzard weight and almost 3 times higher (p<0.05) gizzard contents weight. These results agree with findings of another of our recent studies (Hetland *et al*., 2004), where we observed that the amount of bile acids and NDF in gizzard content increased significantly when birds consumed wood shavings. It is believed that a functioning gizzard should be large and muscular, and able to retain feed components longer. This, in turn, results in better regulation of digestive processes, leading to improved digestibility of nutrients. This appears to be confirmed in the current study with wood shavings, but no such effect was found for birds consuming paper, probably due to the soft texture, which does not stimulate gizzard function.

Similar feed utilisation among the control birds and birds with access to wood shavings indicate that the grinding cost of wood shavings in the gizzard and handling cost through the gut is completely

compensated by the utilisation of nutrients from the digestive processes. Work with both layers and broilers (Hetland *et al*., 2003) with access to wood shavings and oat hulls showed improved starch digestibility. Since paper easily breaks down to small particles, it does not stimulate gizzard function. Instead it will pass through the gut undigested, contributing primarily to the indigestible part of the digesta. Because of the birds' relative high appetite for paper, the indigestible part will increase by approximately 25%, which may play a role in the digestive capacity as well as energy expenditure related to moving the bulk digesta through the gut (Table 3). In contrast, the harder wood shavings need to be ground before leaving the gizzard.This processtimulating gizzard function.

In several experiments wood shavings have been shown to increase gizzard weight by 50%. Improved nutrient utilisation may be related to this phenomenon because of the role of the gizzard in the gastroduodenal refluxes, which regulate the passage through the anterior tract prior to digestion. When comparing experimental feed and commercial Norwegian feed no significant difference in consumption of wood shavings was found. This may be caused by the fact that the structure of the fibre of the feed is too small to meet any requirement for gizzard stimulation. Furthermore, it could be hypothesised that consumption of litter from the litter bath is at least partly a result of the birds' pecking and searching behaviour.

Table 3. Gizzard characteristics and litter consumption [1]

	Control	Paper	Wood shavings	RSD
Weight of empty gizzard, g/kg lwt, 35 wk of age	6.33[c]	7.80[b]	10.80[a]	0.68
Weight of gizzard contents, g/kg lwt, 35 wk of age	1.75[c]	3.45[b]	4.71[a]	0.79
pH of gizzard contents, 35 wk of age	4.37	4.40	4.14	0.22
pH of gizzard contents, 35 wk of age	5.06	-	5.15	0.07
Live weight, g, 35 wk of age	1767	1729	1766	36.6
Weight of empty gizzard, g/kg lwt, 62 wk of age	5.89[b]	-	9.27[a]	0.47
Weight of gizzard contents, g/kg lwt, 62 wk of age	2.10[b]	-	3.92[a]	0.47
Live weight, g, 62 wk of age	1867	-	1809	110
Consumption of litter, g/hen/day, 30 wk of age	-	7.3	4.1	-
Consumption of litter, g/hen/day, 35 wk of age	-	11.0	4.0	-
Consumption of litter, g/hen/day, 62 wk of age	-	-	4.3	-

[1] Means within a row with different letters indicate significant ($P<0.05$) differences. RSD is square root of MSE in the Analysis of Variance.

Hetland *et al*. (2002; 2003; 2004) demonstrated that broilers have a remarkable ability to grind all feed components in the gizzard down to a relatively narrow range of particle sizes. The particle size

distribution data of the current experiment illustrates that the gizzard of layers can grind feed components even more extensively than that of broilers (Table 4 & 5). However, the data also indicates that the grinding capacity or grinding functionality may be dependant on litter source. Hard fibre structures such as wood shavings need to be ground before entering the small intestine, and the gizzard activity, as indicated by the gizzard size, is strongly stimulated by such components in the feed or environment. In contrast, the measurement of gizzard size suggests that paper does not stimulate gizzard activity, even though the consumption of paper was twice the amount of wood shavings. The particle size data shows that particle size of intestinal digesta is positively related to gizzard size. Furthermore, large, soft ingestible fibre sources like paper do not stimulate gizzard function.

Another area of interest in relation to the effect of structural components of feed on chickens is the ability of hard, insoluble fibre sources to alleviate welfare problems such as feather pecking, vent pecking and cannibalism (Aerni *et al*., 2000; El-Lethey *et al*., 2000; Hartini *et al*., 2002). The current study seems to lend support to this as we have shown numerical improvement in plumage conditions in birds, which had access to wood shavings in the litter bath.

In conclusion, the data from the current study illustrated that consumption of wood shavings from the litter bath did not reduce performance. Wood shavings consumed at appetite increase gizzard size by 70%. This causes a remarkable reduction in the amount of large particles passing through the gizzard. An improved plumage condition can be expected with access to wood shavings in the litter bath.

Table 4. Mean and median particle size of duodenal digesta for birds without access to litter and with access to paper or wood shavings for 35-week old birds [1]

	Control	Access to paper	Access to wood shavings	RSD
Weighted mean particle size, µm	111[b]	237[a]	68[b]	75.4
Limit for smallest 10 percentages, µm	5.1	5.5	4.7	0.9
Median particle size, µm	52	134	32	56.2
Limit for largest 10 percentages, µm	316[b]	640[a]	192[b]	186.5

[1] Means within each row with different letters indicate significant (P<0.05) differences. RSD is square root of MSE in the Analysis of Variance.

Table 5. Mean and median particle size of duodenal digesta for birds without access to litter and with access to paper or wood shavings for 62-week old birds [1]

	Control	Access to wood shavings	P-value	RSD
Weighted mean particle size, µm	191	139	0.0350	32.3
Limit for smallest 10 percentages, µm	8.7	7.2	0.0847	1.2
Median particle size, µm	100	62	0.0083	17.1
Limit for largest 10 percentages, µm	497	390	0.0553	75.4

[1] Means within each row with different letters indicate significant (P<0.05) differences. RSD is square root of MSE in the Analysis of Variance.

Implications

Access to litter materials affects nutritional physiology. Coarse and hard litter components can play a beneficial role for nutrient digestion and gut health, while soft litter particles do not stimulate digestion and thus nutrient utilisation. This phenomenon can be used in commercial optimisation of feed and housing environment.

Recommendations

The project has provided basic knowledge about the significance of litter consumption. However, the way to utilise the positive effects of litter or litter consumption must be studied more, in particular the health aspect, since litter may carry very high numbers and a wide range of microbes.

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Plain English Compendium Summary

Project Title:	Use of different dust bathing materials for layers – Effect on nutrient digestion, gut physiology
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Project Overview	
Background	During the last decade community opinion in many countries has required more focus on animal welfare in animal production. Recently, the European community published a new directive where more space per bird, inclusion of a dust-bath, nest and perches will be required in all housing systems for layers from 2012. The objectives of the study was to gain basic knowledge about the nutritional physiological consequences of access to different types of materials for dust bathing, effects of their structure and interactions with feed structure for layers.
Research	The effect of access to wood shavings and processed paper in the litter bath of modified cages on performance, gizzard activity, plumage condition and picking damage was studied for hens fed a wheat-based diet. Egg production was similar for all treatments, but birds with access to paper showed higher feed consumption than the control birds and birds with access to wood shavings. This resulted in a corresponding difference ($P<0.05$) in feed utilisation. A tendency for better plumage condition was observed for birds with access to wood shavings during the last part of the laying period. Consumption of wood shavings and paper from the litter bath was 4 and 11 g/hen/day, respectively. Weights of the empty gizzard and gizzard contents were considerably higher for birds with access to wood shavings. The amount of large particles in the duodenum decreased with access to wood shavings. In contrast, birds with access to paper showed a higher portion of large particles in the duodenum.
Project Progress	Successfully completed
Implications	Access to litter materials affects nutritional physiology. Coarse and hard litter components can play a beneficial role for nutrient digestion and gut health, while soft litter particles do not stimulate digestion and thus nutrient utilisation. This phenomenon can be used in commercial optimisation of feed and housing environment.
Publications	Manuscript submitted to Journal of Applied Poultry Research