Inclusion of Dust Bathing Materials Affects Nutrient Digestion and Gut Physiology of Layers

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Primary Audience: Egg Producers, Researchers, Nutritionists, Feed Manufacturers

SUMMARY

Effect of access to wood shavings and processed paper in the litter bath of modified cages on performance, gizzard activity, plumage condition, and peck damages was studied for layers 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 utilization. A significantly higher AME_n was observed for birds with access to wood shavings than in the control. Consumption of wood shavings and paper from the litter bath was 4 and 11 g/hen per day, respectively. Weights of empty gizzard and gizzard contents were considerably higher for birds with access to wood shavings. The median particle size in the duodenum decreased with access to wood shavings. In contrast, birds with access to paper showed a higher mean particle size in the duodenum.

Key words: laying hen, litter material, plumage condition, nutrient utilization

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DESCRIPTION OF PROBLEM

Advances in genetics, nutrition, and husbandry management during the past half century have resulted in a phenomenal improvement in productivity. Today's diet consists of highly concentrated feedstuffs providing the flow of nutrients for efficient digestion and utilization. However, as production efficiency increases, so do challenges in maintaining that efficiency while sustaining production. One such challenge is the fiber fraction in the diet, which is regarded as a nutrient diluent or antinutrient depending on its solubility. However, cereals and legumes, the bulk of modern commercial poultry diets, contain a significant amount of fiber. In addition to the fiber from the feed, poultry housed in floor systems are able to ingest litter materials from the floor. Similarly, layers in modified cages will be able to pick up fibrous materials from the litter bath. Their effects on digestibility, gut functions, and bird behavior are largely unknown.

Indeed, insoluble fiber itself has shown beneficial effects on nutrient digestion and gizzard activities [1, 2, 3]. Recent research has shown that digesta passing through the gizzard has a remarkably consistent particle size distribution, with the majority of particles being smaller than 40 μm in size regardless of the original feed structure [4]. Thus, the aim of these studies was to investigate the response to coarse wood shavings and processed paper on gizzard functions and plumage condition in laying hens. Furthermore, we examined the effect of litter materials with and without gizzard-stimulating

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Table 1. Diet composition[1]

Ingredients	Inclusion level (%)
Wheat	53.47
Corn	14.00
Soybean meal	12.58
Limestone	5.22
Monocalcium phosphate	0.83
Corn gluten	4.00
Animal fat	1.96
Fish meal[2]	2.6
Shell meal	3.85
Natrium bicarbonate	0.29
L-Lys (HCl)	0.10
DL-Met	0.10
Vitamin-mineral premix[3]	1.00

[1]Calculated nutrient contents: AME_n, 11.6 MJ/kg; CP, 169.2 g/kg; Lys, 7.8 g/kg; Met, 4.1 g/kg; Met + Cys, 6.8 g/kg; Thr, 6.0 g/kg; Ca, 39.9 g/kg; P, 5.6 g/kg.
[2]Norse LT-94 low temperature dried fish meal, 71% CP (Norwegian Fish Meal and Fish Oil Ind., Bergen, Norway).
[3]Vitamin-mineral premix provided the following per kilogram of diet: retinyl acetate, 2.7 mg; cholecalciferol, 0.056 mg; DL-α-tocopheryl acetate, 36 mg; menadione, 4.2 mg; pyridoxine, 3.2 mg; riboflavin, 9.8 mg; Ca pantothenate, 11.8 mg; biotin, 0.15 mg; thiamine, 2 mg; niacin, 34 mg; cobalamin, 0.016 mg; folic acid, 1.55 mg; Fe, 50 mg; Mn, 40 mg; Zn, 70 mg; Cu, 10 mg; I, 0.5 mg; Se, 0.2 mg.

properties on the voluntary intake of such materials among birds fed a wheat-based diet.

MATERIALS AND METHODS

The experiment included nonbeak-trimmed layers [5] reared at a commercial pullet farm until 16 wk of age. At this age, the birds were moved to the experimental facility, and 420 birds were randomly placed in a total of 60 commercial furnished cages [6] with perches, and a litter bath was placed on top of the nest box at the end of each cage unit with 7 birds each and a total area of 6,000 cm^2 per cage unit. The litter bath opening was time-controlled and available from 23 wk of age for 4 h before darkness. Feed consumption and daily egg production were registered from 26 wk of age.

A wheat-based diet was used in the experiment as a typical commercial diet with low fiber content (73 g of NDF/kg). The limestone included in the diet was in powder form. A detailed description of the diet is given in Table 1.

From 25 wk of age, wood shavings and coarsely cut hard paper (cellulose) were included in the litter bath (1,200 cm^2) of 20 cages at random, respectively, whereas no litter was used in the last 20 cages. Thus, the experiment was balanced with 20 replicates and 7 birds in each replicate. The wood shavings used in the study were commercially available, dried, and pressed for use as litter for poultry and pig production. Particle size distribution (based on dry sieving) was 2.7, 17.5, and 80.6%, respectively, for <1, 1 to 2, and 2 to 9 mm sizes. Paper was from 2.5-mm thick cellulose plates obtained from a commercial paper factory and was manually cut to correspond with particle size of the wood shavings, with a particle size of <2 mm (8%) and 2 to 9 mm (92%). Litter was refilled twice weekly. Furthermore, litter consumption was measured 3 times before 35 wk of age. At 35 wk, plumage condition was scored [7] for 28 birds per treatment by scoring all birds in 4 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 means of the 6 plumage scores were calculated. Lesions of comb, neck, rear body, and cloaca, as indicators of cannibalistic pecks, were scored according to the same scale. Score 4 indicates no injuries and 1 indicates >5 wounds or lesions. Two persons were involved in scoring all birds. Afterwards, the same birds were dissected, and gizzard and gizzard contents were weighed. Duodenal contents were collected for determination of particle size distribution. From 35 wk of age, the treatment with processed paper was excluded from the experiment. At 62 wk 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 in 5 cages per treatment were killed and dissected for weighing of the gizzard and gizzard contents. The contents of the duodenum were gently squeezed out for particle size analysis. Particle size distribution was measured using the laser diffraction method, which detected particle diameters in the range from 0.02 to 2,000 μm [8]. At 62 wk of age, 6 birds without access to litter and 6 birds with access to wood shavings were moved to single bird cages for determination of ME. Consumption of feed and wood shavings and production of feces over a

Table 2. Performance, plumage condition, and peck damages

Item	Control	Paper	Wood shavings	*P*-value	SEM
Laying, %	97.1	97.1	97.4	0.7038	0.28
Egg weight, g	59.2	59.4	59.4	0.9256	0.39
Egg production, g/hen per day	57.5	57.7	57.8	0.8475	0.41
Feed consumption, g/hen per day	108[b]	110[a]	107[b]	0.0092	0.85
Feed/egg[1]	1.87[b]	1.92[a]	1.85[b]	0.0262	0.02
AME, MJ/kg, 62 wk of age	10.8[b]	ND[3]	11.3[a]	0.0442	0.14
Plumage condition,[2] 35 wk of age	3.1	3.1	3.0	0.7902	0.01
Peck damages,[2] 35 wk of age	3.8	3.7	3.7	0.1597	0.03
Plumage condition, 62 wk of age	2.2	ND	2.4	0.4418	0.07
Peck damages, 62 wk of age	3.7	ND	3.7	0.1508	0.03

[a,b]Means with different superscripts are significantly different ($P \leq 0.05$).
[1]Weight of feed intake per pen divided by weight of eggs laid in the same period and pen.
[2]Plumage condition and peck damages scored from 1 to 4, where 1 is the poorest and 4 is the best.
[3]ND = no data were collected.

period of 4 d were registered for the birds. Samples of feed, wood shavings, and feces were analyzed for gross energy [9]. Apparent ME was corrected for wood shavings by assuming that no wood shavings were digested. Also, ME was corrected to zero N-retention by assuming that eggs contain 12% protein and that the protein contains 16% N. Data were analyzed using the GLM procedure of SAS, and differences between means were separated by using the least significant difference test [10].

RESULTS AND DISCUSSION

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

Consumption of paper as litter material was considerably higher than for wood shavings. Birds with access to wood shavings showed approximately 70% higher ($P < 0.05$) weight of empty gizzard and almost 3 times higher ($P < 0.05$) weight of gizzard contents compared with the control (Table 3). These results agree with findings of another of our recent studies [11], in which we also observed that the amount of bile acids and NDF in gizzard contents in-

Table 3. Gizzard characteristics and litter consumption

Item	Control	Paper	Wood shavings	*P*-value	SEM
Weight of empty gizzard, g/kg of live weight, 35 wk of age	6.33[c]	7.80[b]	10.80[a]	<0.0001	0.30
Weight of gizzard contents, g/kg of live weight, 35 wk of age	1.75[c]	3.45[b]	4.71[a]	0.0016	0.35
pH of gizzard contents, 35 wk of age	4.37	4.40	4.14	0.2303	0.10
Live weight, g, 35 wk of age	1,767	1,729	1,766	0.3091	8.18
Weight of empty gizzard, g/kg of live weight, 62 wk of age	5.89[b]	ND[1]	9.27[a]	<0.0001	0.21
Weight of gizzard contents, g/kg of live weight, 62 wk of age	2.10[b]	ND	3.92[a]	0.0003	0.21
pH of gizzard contents, 62 wk of age	5.06	ND	5.15	0.0761	0.03
Live weight, g, 62 wk of age	1,867	ND	1,809	0.4273	24.6
Consumption of litter, g/hen per day, 30 wk of age	—	7.3	4.1		—
Consumption of litter, g/hen per day, 35 wk of age	—	11.0	4.0		—
Consumption of litter, g/hen per day, 62 wk of age	—	—	4.3		—

[a–c]Means with different superscripts are significantly different ($P \leq 0.05$).
[1]ND = no data were collected.

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- and 62-wk-old birds

Item	Control	Access to paper	Access to wood shavings	*P*-value	SEM
Weighted mean particle size, μm, 35 wk	111[b]	237[a]	68[b]	0.0284	33.7
Limit for smallest 10%, μm, 35 wk	5.1	5.5	4.7	0.5506	0.40
Median particle size, μm, 35 wk	52	134	32	0.0660	25.1
Limit for largest 10%, μm, 35 wk	316[b]	640[a]	192[b]	0.0206	83.4
Weighted mean particle size, μm, 62 wk	191[a]	ND[1]	139[b]	0.0350	14.4
Limit for smallest 10%, μm, 62 wk	8.7	ND	7.2	0.0847	0.5
Median particle size, μm, 62 wk	100[a]	ND	62[b]	0.0083	7.7
Limit for largest 10%, μm, 62 wk	497	ND	390	0.0553	33.7

[a,b]Means with different superscripts are significantly different ($P \leq 0.05$).
[1]ND = no data were collected.

creased significantly when birds consumed wood shavings. A well-functioning gizzard should be large and muscular and able to retain feed components. This, in turn, results in better regulation of digestive processes, leading to improved digestibility of nutrients [1, 2, 3]. 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 did not stimulate gizzard function to the same extent as wood shavings.

Similar feed utilization among control birds and birds with access to wood shavings indicates that the grinding cost of wood shavings in the gizzard and handling cost through the gut is completely compensated by the utilization of nutrients from the digestive processes. This agrees with a previous study with layers and broilers [2], in which access to wood shavings and oat hulls resulted in improved starch digestibility. Because paper easily breaks down to small particles, it does not extensively stimulate gizzard function. Furthermore, paper passes through the gut undigested, contributing primarily to the indigestible part of the digesta. Based on experience, a typical DM digestibility of typical broiler feeds, as in the current experiment, is approximately 80%. Thus, the birds consuming paper in the current experiment increased the daily intake of indigestible components by approximately 50% when related to feed consumption. This phenomenon could be expected to affect the digestive capacity as well as energy expenditure related to moving the bulk digesta through the gut. In contrast, hard wood shavings need to be ground before leaving the gizzard, thereby stimulating muscular contractions of the gizzard. Improved nutrient utilization, as indicated by the increase in ME, 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 before digestion [2, 11]. However, the measured ME was lower than the calculated value for both treatments.

In the previous studies [2, 11], it was also shown that broilers had 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 illustrate that the gizzard of layers can grind feed components even more extensively than that of broilers (Table 3 and 4). However, the data also indicate that the grinding capacity or grinding functionality may be dependent on litter source. Hard fiber 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 less extensively stimulates gizzard activity, even though the consumption of paper was twice the amount of wood shavings. The data show that particle size of intestinal digesta decreases for birds with access to hard wood shavings. However, the paper showed an opposite effect, which could be caused by the very high amount

of indigestible material to be handled through the gut, in turn causing less complete particle degradation.

Another area of interest in relation to the effect of structural components of feed on chickens is whether hard, insoluble fiber sources alleviate welfare problems such as feather pecking, vent pecking, and cannibalism [12, 13, 14]. It is conceivable that an appetite for structural components in the environment could reduce feather pecking when fed low-fiber diets. However, plumage scores and incidence of skin lesions in the current study did not provide statistically significant evidence that wood shavings have a beneficial effect on pecking behavior.

CONCLUSIONS AND APPLICATIONS

1. Wood shavings consumed from the litter bath do not reduce performance, whereas access to paper causes reduced feed utilization.
2. Voluntary consumption of wood shavings from litter bath increases gizzard size by 70%, which causes a remarkable reduction in particle size of digesta passing from the gizzard.

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