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Executive Summary

The experiments indicate a significant consumption of litter from the floor when housed on littered floor. However, the appetite for litter was low when given separately. In correspondence to in layers, also broilers show up to 50 % increase in gizzard weight when access to litter due to the requirement for grinding of hard coarse particles. Also young broilers show a phenomenal grinding activity with smaller median and mean particle sizes behind the gizzard when given coarse particles in feed or litter materials compared with fine materials. Stimulation of the gizzard activity increases the digestibility of starch. This may be caused by the more finely ground feed particles due to the biological gizzard grinding. Furthermore the increased digestibility and feed utilisation may be caused by increased enzyme activity, and in particular maltase activity in the intestine.

The severity of gizzard lesions was gradually reduced with age of the chickens, whereas the *Clostridium perfringens* counts were lowest on day 19 and increased until day 32. Inclusion of oat hulls was the most important predictor of gizzard scores. This was particularly clear on day 19. On day 32 there was a significantly reducing effect on gizzard lesions only in one the combination of feed with oat hulls and access to litter. Access to litter was the most important predictor of *Clostridium perfringens* counts in this trial. This was particularly clear on day 19. On day 32 a specific combination of the two study factors was necessary to exert a significant effect on *Clostridium perfringens* counts. This combination (lack of added oat hulls and denied access to litter) was associated with increased *Clostridium perfringens* counts. These results indicate that availability of non-soluble fibres can influence significantly both the severity of gizzard inflammation and the level of caecal *Clostridium perfringens*. Fibres in the feed and as litter appear to be interacting in their effects.

Introduction

Poultry housed in floor pen systems are able and likely to consume litter materials from the floor. How consumption of different types of litter materials affects growth performance, nutrient digestibility, gut function and gut health in poultry is a largely unexplored research area. Recent data from an experiment with egg-laying hens performed at NULS in Norway (CRC project "Use of different dust bathing materials for layers – Effect on nutrient digestion, gut physiology and welfare") has indicated that the type of litter material in the litter bath affects feed intake and feed utilisation. Hens with access to paper had a higher feed intake than control birds with no access to litter material and birds with access to wood shavings, resulting in a poorer feed utilisation. The consumption of litter from the litter baths was 4 g/hen/day for wood shavings and 11 g/hen/day for paper. The weights of the empty gizzard and gizzard contents were considerably higher ($P < 0.05$) for hens with access to wood shavings as compared with the other treatments. This indicates that the type of litter material available for consumption by the bird plays a role for gizzard development and functionality. The latter is supported by the findings that access to wood shaving decreased the amount of large particles in duodenum whereas the opposite was observed for hens with access to paper as the litter material. Thus, stimulation of the gizzard by consumption of small amounts of hard litter materials, such as wood shavings, seems to increase the grinding capacity of the gizzard and induce more efficient breakdown of the feed, which may improve digestion in the small intestine of the bird. However, these results were obtained with hens and it is not known whether similar responses will be found in young birds, such as broiler chickens.

Ron MacAlpine and Moreen Ali of Inghams Enterprises recently conducted an experiment with broilers recently, in conjunction with Poultry CRC researchers Lene Mikkelsen, Valeria Torok, Sally Elieff and Bob Hughes. Preliminary results indicate an effect of litter material on gizzard development. It was found that birds housed on pine shavings or rice hulls had significantly higher relative gizzard weights compared with birds housed on shredded paper or chopped straw. The effects of litter materials on nutrient digestibility and gut function in broilers have yet to be determined.

In broilers, increased gizzard weight and improved gizzard function have been observed in birds given a coarse feed or feed containing coarse components, such as whole grains (Engberg *et al.*, 2004, Svihus *et al.*, 2004). Inclusion of whole grains in the feed was found to reduce the duodenal mean particle size and improve starch digestibility as compared with ground grains (Hetland *et al.*, 2002). Whole wheat has been reported to increase ileal digestibility and apparent metabolisable energy AME (Svihus *et al.*, 2004).

Another important aspect of stimulating gizzard development is the potential positive role of a functional gizzard in control of bacterial populations. Whole wheat feeding has been reported to reduce the intestinal number of lactose-negative enterobacteria (i.e. *Salmonella* spp) as well as the number of *Clostridium perfringens* (Engberg *et al.*, 2004). Similar results were observed in broiler chickens experimentally infected with *Salmonella typhimurium*. Following infection, lower numbers of *S. typhimurium* were found in the gizzard and ileum of birds receiving whole wheat as compared to pellet-fed birds. Beside this, whole wheat feeding also significantly reduced the numbers of *C. perfringens* in the intestinal tract of the birds (Bjerrum *et al.*, 2005). These results indicate that a functional gizzard may act as a barrier organ preventing potential pathogenic bacteria from entering the distal digestive tract. Thus, if access to gizzard stimulating litter materials has a significant impact in broiler chickens, choosing the right litter material may have important health implications in relation to reduce the prevalence of *Salmonella* spp. in chickens and consequently in chicken meat and also in relation to reduce occurrence of necrotic enteritis which is strongly associated with *C. perfringens*.

At NULS in Norway, we have been increasingly aware of frequent gizzard lesions in birds without clinical symptoms; this was observed in birds from our experiments as well as in birds from commercial flocks. There are several documented and proposed causes of gizzard inflammation. The most obvious cause is toxins; termed gizzerosine, associated with fishmeal. This toxin acts on hydrogen receptors and stimulates gastric acid secretion at low concentrations. Since gizzerosine is formed from lysine and histidine, it could be speculated

whether free synthetic amino acids under influence of overheating could combine with other feed components to form toxic compounds. Furthermore, the gastro-duodenal cycle is of importance to digestive functions, but may also be of importance to the integrity of the gizzard lining and mucosa beneath. It has been speculated whether a well-regulated cycle is necessary to maintain a functional koilin layer and so impaired cycle may increase the risk for defects of the koilin layer and in turn mucosal inflammation. Since feed structure and level of insoluble dietary fibre structures stimulate gizzard activity largely, it can be hypothesised that coarse feed structure or consumption of litter can stimulate the gastroduodenal cycle and so decrease the risk for defects of the koilin layer and inflammation of the mucosa.

Objectives

The aim of the present project is to investigate the consumption of different types of litter by broiler chickens on feed intake and growth performance, gizzard function and gut development, nutrient digestibility and gut microflora. The project will follow up of the previous CRC project 03-27 *Use of different dust bathing materials for layers – Effect on nutrient digestion, gut physiology and welfare.*

The experiments were designed to test the following hypotheses:

- i) Consumption of coarse/hard litter will stimulate gizzard activity and decrease the risk of gizzard lesions in the koilin layer and inflammation of the mucosa.
- ii) Birds housed on a coarse/hard litter type will ingest less litter than birds housed on a soft and fine litter and the reduced quantity of litter consumed will result in increased feed intake and improved growth performance.
- iii) Consumption of coarse/hard litter, even in a small quantity, will stimulate gizzard development and function and consequently improve breakdown of the feed as well as nutrient digestibility. The more functional gizzard will also play a positive role in the control of undesirable bacteria, such as *Clostridium perfringens* and *Salmonella spp.*, and protozoan sporocysts such as *Eimeria spp.* This will have beneficial impact on bird health and productivity and improve safety of the meat product.

Materials and methods

Composition of diets is given in Table 1 for all experiments.

Experiment 1

Over 100 day old male Ross 308 was placed on pens until seven days of age with ad libitum access to commercial starter feed. At day 7, 100 chicks was moved to single bird cages with wire mesh floor, and the half of them fed on high fibre feed and the other half on low fibre feed. Both feeds are optimised to contain similar amount of energy and protein on weight basis despite the considerable difference in dietary fibre level. One half of the bids on each diet had no access to litter, while the other half of the bids on each diet had ad libitum access to litter weighed out into a separate cup (trough) linked to the cage wall.

Thus, totally 25 animals per treatment designed as a two factorial design with the factors dietary fibre and litter consumption. Feed, litter and chicks was weighed weekly until five weeks of age.

At 14 days of age, 10 chickens per treatment was dissected, and content from gizzard, duodenum, ileum was quantitatively collected and freezed in small boxes. Prior to dissection feed and litter consumption behaviour were synchronised by including a darkness period followed by light on the last two hours prior to dissection. The 15 birds/treatment left was dissected in a similar way on day 35.

To determine the gizzards ability of grinding at different age, particle size distribution was measured of duodenal content of all animals using the laser diffraction technology. Samples of feed and feces were collected for analyses of metabolisable energy.

Experiment 2

A total of 100 day old male Ross 308 broilers were housed in battery cages with ad libitum access to commercial starter diet. At seven days of age, 90 of the bids that varied less than 20% in weight from the flock mean was moved to single bird cages with wire mesh floor. One half of the birds were fed on the high-fibre diet as used in Experiment 1, and the other half was fed on the low fibre diet. Feed and weight gain was measured weekly.

At 35 days of age, all chickens were fasted for six hours. 40 chickens on each feed were dissected as follows: 8 chickens/feed after fasting prior to access to feed, 8 chickens/feed after 30 minutes feeding, 8 chickens/feed after 90 minutes feeding, 8 chickens/feed after 180 minutes feeding and 8 chickens/feed after 300 minutes feeding. Gizzard and gizzard were weighed. A standardised five centimetre segment of upper jejunum was collected and freezed in liquid nitrogen. Pancreas was also weighed and freezed in liquid nitrogen. Jejunum and pancreas was analysed for maltase and amylase activity respectively at the National Veterinary College, Oslo.

Experiment 3

A total of 360 broiler chickens (Ross 308) were placed on 24 pens with 15 birds per pen at 4 days of age. One half of the pens had rubber mat on the floor, and the other

half had littered floor. One half of the pens on each floor type were fed on diet without oat hulls and the other half on a diet added 5 % coarse oat hulls. This represents a two factorial design with the factors dietary fibre and litter. Birds and feed were weighed at start, day 19, and day 32 (at finish). At day 19 and 32, two birds per pen were dissected and samples from duodenum and ileum were taken out for particle size distribution and starch content determination, respectively.

Low level of feed Dietary fibre (no oat hulls) was designated Dietary fibre = 0. High level of feed Dietary fibre (added oat hulls) was designated Dietary fibre = 1. All chickens were housed in cages with a floor ensuring that the birds had access to their excreta. Rubber mat as floor type was designated Litter = 1. Floor dressed with wood-derived litter was designated Litter = 2.

Gizzard scores were based on gross lesions found in the koilin layer and on the mucosal surface, according to a predetermined scoring system. Minimum possible score in this system was 0 (zero), maximum possible score was 24. The range of scores in this experiment was 2-13. A total of 48 gizzards (12 per treatment) per sampling day were examined.

Caecal contents were collected from 24 (12 per study factor level and 6 per treatment group) chickens per sampling day. Quantification of *C. perfringens* was based on cultivation from diluted samples on blood agar dishes. Counts were based on numbers of colonies surrounded by the typical double-haemolysis on blood agar. Selected colonies were examined more closely to ensure the identity of *C. perfringens*. Recorded counts were transformed to \log_{10} of the original counts (LogCP). The lower detection limit was 1.000 *Clostridium perfringens* per gram caecal contents. The range of values was below detection limit to $\log 9,0$. The median \log_{10} counts per sampling days were 4.2, below lower detection limit (3.0) and 3.2 on days 6, 19 and 32 respectively.

Table 1. Composition of the diets used in the experiments

Ingredients	Experiment 1 and 2		Experiment 3 ¹
	Low fibre	High fibre	
Wheat	30.0	32.7	70,854
Oats	-	30.0	
Dehulled oats	38.9		
Fish meal	4.0	4.0	5
Soybean meal	17.5	18.2	17
Maize gluten meal	1.0	4.0	
Soy oil	2.0	2.0	3
Vegetable fat	3.0	5.5	
Ground limestone	0.7	0.7	1,5
Mono calcium phosphate	0.9	0.9	1,1
Vitamin/Mineral/Aminoacids	2.0	2.0	1.546

¹Diets used in experiment 3 was the basis diet (low fibre diet) as described in Table and basis diet diluted with 5 % oat hulls (high fibre diet)

Results and Discussion

Both experiment 1 and 3 clearly illustrated at least as good performance with access to dietary fibre and litter fibre as the concentrated control diets (Table 2 and Table 5). The measured consumption level of wood shavings was quite low, less than 1 gram/day (Table 3). The data for gizzard weights also clearly show that voluntary litter consumption among young broilers is very low. However, the individual variation was high.

In contrast, the dietary fibre level caused considerably difference for the gizzard size and -activity. Assuming that hulled oats consist of 20% hulls, the high fibre diet in experiment 1 consist of 6% oat hull fibre. This resulted in approximately 60% increase in gizzard weight, and a huge increase in weight of gizzard contents. The less response of gizzard weight of litter confirms the low numerical appetite for litter. However, the individual variation seems to be high. This phenomenon is in strong contrast to observations for layers which show high appetite for litter from litter bath when access in general (CRC Project 3.27). However, experiment 3 with birds on littered floor showed a more profound effect of litter on gizzard function due to higher appetite. In Hetland *et al.* (2004), 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. This, in turn, results in better regulation of digestive processes, leading to improved digestibility of nutrients.

Similar feed utilisation among 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. In correspondence to in layers, broilers with access to wood shavings and oat hulls resulted in improved starch digestibility. However, the effect seems to be partly dependant on inclusion in the feed since the appetite mechanism does not seem to be developed as well as in older birds. However, in both experiments on littered floor, the effect is significant.

In correspondence to results from CRC Project 3.27, improved nutrient utilisation seem to be related to gizzard activity, which again can be related to the interaction between gizzard and intestine. This may be caused by the fact that the structure of the feed is often too fine to meet the need for gizzard stimulation. In layers and broilers (Hetland *et al.*, 2003) access to wood shavings and oat hulls resulted in improved starch digestibility. 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 reflexes, which regulate the passage through the anterior tract prior to digestion.

Hetland *et al.* (2002; 2003; 2004) illustrated 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, CRC Project 3.17 illustrated 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 show that particle size of intestinal digesta is positively related to gizzard size.

The project also indicates that the more rapid starch digestibility due to structural components may be related to increased secretion of maltase from the intestine (Table 4). In that experiment, no clear effect of structural components on secretion of amylase and pancreas weights was revealed in the experiments. However, Svihus et al (200x) observed increased pancreas weight in broilers due to whole cereals. However, random variation is high for such measurements. Anyway, this observation supports the hypothesis that gizzard activity stimulates other functions of the gut. However, we could expect a combination of the better preparation of nutrient substrate during gizzard grinding and increased secretion of degrading components improve the digestion.

In experiment 3, a highly significant effect of dietary fibre on gizzard score was detected. High levels of dietary fibres reduced the severity of gizzard lesions, as suggested by Figure 1 and Figure 2. A tendency ($p=0.07$) for interaction between dietary fibre and litter was caused by the fact that the reducing effect of Dietary fibre on gizzard lesions was most pronounced when the chickens had access to litter, and only on the borderline of significance ($p=0.0567$) when there was no litter available.

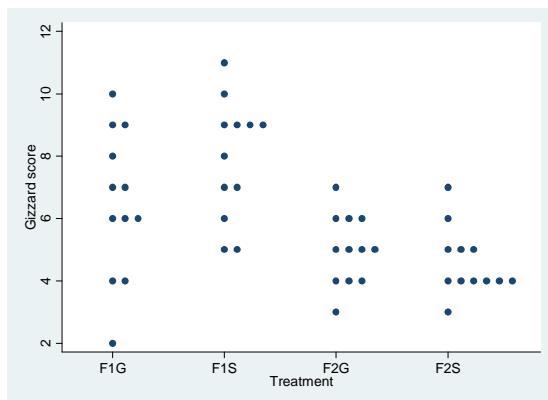


Figure 1. Gizzard score (Y axis) versus combined treatments of Dietary fibre (F1=no oat hulls added, F2=oat hulls added) and Litter (G=no access to litter, S=access to litter) on days 19.

The effect of dietary fibre level and access to litter depended on the duration of exposure to these factors and/or the age of the chickens. The severity of gizzard lesions was gradually reduced with age of the chickens, from a median score of eight on day 6 to a median score of four on day 32. The study factors were introduced on day 4; only two days before our first sampling day. We therefore cannot fully evaluate the effect of the study variables at this age. The effect was most clearly demonstrated on day 19. At this age inclusion of oat hulls significantly reduced the severity of

gizzard lesions. The data also showed that the effect of oat hulls was strongest among chickens with access to litter. On day 32 the interaction between the two study variables was even more important. At this age there was a significant effect of the study variables only among chickens offered feed with oat hulls that also had access to litter. These findings strongly suggest that the level of insoluble dietary fibres is an important predictor of the severity of gizzard lesions, and that this effect can be modified by access to litter.

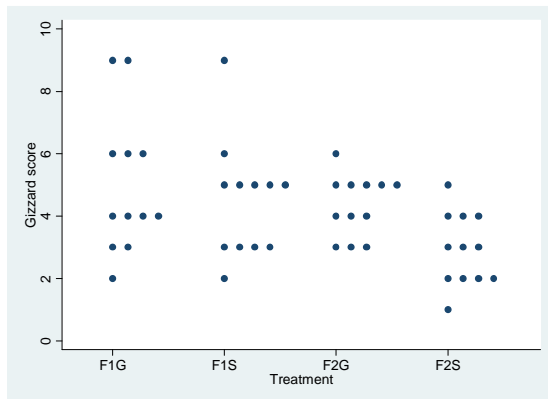


Figure 2. Gizzard score (Y axis) versus combined treatments of Dietary fibre (F1=no oat hulls added, F2=oat hulls added) and Litter (G=no access to litter, S=access to litter) on days 32).

At day 19, 15 out of 24 samples were recorded with counts below the detection limit for *Clostridium perfringens*, and 11 of these low-level samples originated from chickens with access to litter (Figure 4). At this age availability of litter seemed to be associated with reduced bacterial counts. There was no apparent association between dietary fibre and counts at day 19. At 32 days of age 6 out of 24 samples were recorded with caecal counts below the detection limit, and five of these originated from chickens with access to litter (Figure 5).

Litter was found to show significant ($p < 0,03$) on caecal counts while dietary fibre showed no statistically significant effect. Figure 4 also suggest that the effect of litter on gizzard scores was more pronounced on day 19 than on day 32. A Kruskal Wallis analysis of treatment groups on day 32 indicated significant ($p = 0,02$) differences, and a comparison of the two treatments with highest counts (treatments 1 and 4) confirmed that there was a significant ($p = 0,045$) difference between treatment 1 (no oats added to the feed, and no access to litter) and the three other treatment groups. At this age the 75 percentile of *Clostridium perfringens* counts in treatment group 1 was log 6.4.

The *Clostridium perfringens* counts of caecal contents in this trial varied considerably with age, from a median count of log 4.2 on day six to a median count below the lower detection limit on day 19 and a median count of log 3.2 on day 32. No significant effect of Dietary fibre or Litter could be found on day 6, only two days after the first exposure of the chickens to the study variables. However, on days 19 and 32 analysed together, and on day 19 analysed separately, there was a significantly reducing effect of access to litter on *Clostridium perfringens* counts. This effect was not statistically significant ($p = 0,12$) when data collected on day 32 were analysed

Table 2. Performance and gizzard characteristics for birds in Experiment 1

	Low fibre		High fibre		Dietary fibre	P-values		RSD
	No litter	Litter	No litter	Litter		Litter	Interaction	
Weight gain, 7-35 days	2015	2052	2117	2137	0.0174	0.4527	0.8269	144
Feed consumption, 7-35 days	3256	3380	3258	3240	0.3185	0.4406	0.3011	256
Feed/gain, 7-35 days	1.62	1.64	1.54	1.51	<0.0001	0.8945	0.1664	0.078
Empty gizzard, g/kg live wt, 35 days of age	9.0	8.5	14.4	15.2	<0.0001	0.7212	0.1307	1.71
Gizzard content, g/kg live wt, 35 days of age	0.016	0.16	6.3	7.2	<0.0001	0.31188	0.4692	2.01
Empty gizzard, g/kg live wt, 17 days of age	13.4	15.1	22.6	22.3	<0.0001	0.2902	0.1538	1.79
Gizzard content, g/kg live wt, 17 days of age	0.5	1.16	9.2	6.8	<0.0001	0.2577	0.0461	1.95
Weighted mean particle size, μm , 35 days	48		26		<0.0001			14.7
Limit for smallest 10 percentages, μm , 35 days	5		5		0.0010			0.40
Median particle size, μm , 35 days	23		13		<0.0001			3.8
Limit for largest 10 percentages, μm , 35 days	131		53		0.0007			50.1
AMEn, 17-19 days of age	13.3		13.6		0.2019			0.618

Table 3. Mean and individual variation of litter consumption from separate trough in Experiment 1 for birds fed on diets with different fibre level.

Feed	Mean	St dev	Minimum	Maximum
High fibre	0.27	0.28	0.0	0.96
Low fibre	0.92	0.91	0.0	2.74

Table 4. Enzyme secretion in different organs of bird in Experiment 2

	Diet with Oat hulls				Diet without oat hulls				Oat hulls	P-values		RSD	
	0	30	90	180	0	30	90	180		Time	Litter*time		
Time, minutes	0	30	90	180	0	30	90	180					
Maltase mg/g tissue	47.4	49.9	49.8	53.0	45.2	43.3	41.8	42.0	0.0001	0.8575	0.1933	4.564	
Amylase, U/ g pancreas	22.6	15.2	16.4	12.7	21.0	14.2	12.8	14.3	0.3808	0.0006	0.5301	4.144	
Amylase U total pancreas	99.2	65.8	71.0	58.5	82.3	53.7	47.3	68.2	0.1643	0.0286	0.4104	24.06	
Empty gizzard, g/kg	13.5	15.5	15.8	15.6	8.9	8.5	8.9	10.2	<0.0001	0.2147	0.3477	1.86	
Gizzard content, g/kg	5.5	6.2	7.8	7.0	0.0	0.1	0.4	0.4	<0.0001	0.3845	0.7116	1.92	
Pancreas, g/kg	2.17	1.95	1.96	2.02	1.94	1.77	1.59	2.07	0.1697	0.3505	0.7051	0.44	
Weight gain, g		1850				1828				0.6640			221
Feed consumption, g		2961				3082				0.1056			371
Feed/gain, g/g		1.61				1.69				<0.0001			0.089

Table 5. Performance, gizzard characteristics, particle size distribution for Experiment 3

	No oat hulls		Oat hulls included		P-values			RSD
	No litter	Litter	No litter	Litter	Dietary fibre	Litter	Interaction	
Weight gain, g, 6-19 days	702	669	676	660	0.1693	0.0566	0.4800	30.06
Weight gain, g, 19-32 days	1255	1251	1273	1300	0.2352	0.6745	0.5816	67.04
Weight gain, g, 6-32 days	1957	1919	1949	1960	0.6205	0.6802	0.4486	77.11
Feed consumption, g, 6-19 days	1056	933	941	879	0.0002	<0.0001	0.1175	45.42
Feed consumption, g, 19-32 days	2125	2013	2079	2053	0.9531	0.1620	0.3800	116.41
Feed consumption, g, 6-32 days	3181	2945	3021	2931	0.1623	0.0136	0.2376	146.86
Gain/feed 6-19 days	0.67	0.71	0.72	0.75	<0.0001	0.0001	0.3585	0.022
Gain/feed 19-32 days	0.59	0.62	0.61	0.64	0.0599	0.0141	0.6693	0.024
Gain/feed 6-32 days	0.62	0.65	0.65	0.67	0.0044	0.0006	0.4469	0.018
Empty gizzard, g, 19 days of age	15.5	21.9	25.6	26.3	<0.0001	0.0037	0.0169	4.01
Empty gizzard, g, 32 days of age	27.6	31.0	44.9	43.4	<0.0001	0.5303	0.0939	4.88
Weighted mean particle size, μm , 19 days	160.2	120.3	88.6	109.9	0.0748	0.6821	0.1809	77.9
Limit for smallest 10 percentages, μm , 19 days	6.7	6.5	5.7	5.4	0.1923	0.7538	0.9598	2.72
Median particle size, μm , 19 days	80.8	53.8	42.2	50.7	0.1804	0.5496	0.2539	53.14
Limit for largest 10 percentages, μm , 19 days	445.9	346.4	247.6	321.7	0.0692	0.8332	0.1544	207.4
Weighted mean particle size, μm , 32 days	236.5	263.8	136.1	171.9	<0.0001	0.0908	0.8169	63.21
Limit for smallest 10 percentages, μm , 32 days	6.4	7.9	8.8	10.1	0.0092	0.1024	0.9205	2.91
Median particle size, μm , 32 days	87.3	134.1	80.4	97.1	0.1363	0.0336	0.3047	50.09
Limit for largest 10 percentages, μm , 32 days	705.8	729.8	355.8	457.0	<0.0001	0.1755	0.4005	157.5
Starch content, % of ileal content, 19 days of age	14.4	3.5	1.7	2.3	<0.0001	0.0001	<0.0001	4.16
Starch content, % of ileal content, 32 days of age	12.2	9.6	1.1	1.25	<0.0001	0.1042	0.0622	2.61

Implications

Access to litter materials affects nutritional physiology positively. Coarse and hard litter components can play a beneficial role for nutrient digestion and gut health, and thus nutrient utilisation. This phenomenon can be used in commercial optimisation of feed and housing environment.

Recommendations

The project has given basic knowledge about the significance of litter consumption and dietary fibre consumption in general. Thus data from the project can be used to optimise the feed composition to meet the birds' requirement for structural components, and relate this requirement to birds' searching and pecking behaviour.

References

- Engberg, R. M., Hedemann, M. S., Steinfeldt, S., and Jensen, B. B.** (2004) Poultry Science. 83(6):925-38.
- Hetland, H., B. Svihus and V. Olaisen.** (2002). British Poultry Science 43: 416-423.
- Hetland, H., B. Svihus and Å. Krogdahl.** (2003) British Poultry Science, 44: 275-282.
- Hetland, H., Svihus, B. and Choct, M.** (2004) Journal of Applied Poultry Research, 14: 38-46.
- Bjerrum, L., Pedersen, A. B., and Engberg, R. M.** (2005) Avian Disease. 49(1):9-15.
- Svihus, B., Juvik, E., Hetland, H., and Krogdahl, A. (2004)** British Poultry Science. 45(1):55-60.

Plain English Compendium Summary

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Project Overview	
Background	<p>Poultry housed in floor systems are able and likely to consume litter materials from the floor. How consumption of different types of litter materials affects growth performance, nutrient digestibility, gut function and gut health in poultry is a largely unexplored research area. Data from an experiment with egg-laying hens performed at NULS in Norway (CRC project “Use of different dust bathing materials for layers – Effect on nutrient digestion, gut physiology and welfare”) has indicated that the type of litter material in the litter bath affects feed intake and feed utilisation. Hens with access to paper had a higher feed intake than control birds with no access to litter material and birds with access to wood shavings, resulting in a poorer feed utilisation. The weights of the empty gizzard and gizzard contents were considerably higher ($P < 0.05$) for hens with access to wood shavings as compared with the other treatments. This indicates that the type of litter material available for consumption by the bird plays a role for gizzard development and functionality. The latter is supported by the findings that access to wood shaving decreased the amount of large particles in duodenum whereas the opposite was observed for hens with access to paper as the litter material. Thus, stimulation of the gizzard by consumption of small amounts of hard litter materials, such as wood shavings, seems to increase the grinding capacity of the gizzard and induce more efficiently breakdown of the feed, which may improve digestion in the small intestine of the bird. However, these results were obtained with hens and it is not known whether similar responses will be found in young birds, such as broiler chickens. Thus, the aim of the present project was to investigate the consumption of different types of litter by broiler chickens on feed intake and growth performance, gizzard function and gut development, nutrient digestibility and gut microflora.</p>
Research	<p>The experiments indicate a significant consumption of litter from the floor when housed on littered floor. However, the appetite for litter was low when given separately. In correspondence to in layers, also broilers show up to 50 % increase in gizzard weight when access to litter due to the requirement for grinding of hard coarse particles. Also young broilers show a phenomenal grinding activity with smaller median and mean particle sizes behind the gizzard when given coarse particles in feed or litter materials. Stimulation of the gizzard activity increases the digestibility of starch. This may be caused by the more finely ground feed particles due to the biological gizzard grinding. Furthermore the increased digestibility and feed utilisation may be caused by increased enzyme activity, and in particular maltase activity in the intestine.</p> <p>The severity of gizzard lesions was gradually reduced with age of the chickens, whereas the <i>Clostridium perfringens</i> counts were lowest on day</p>

	<p>19 and increased until day 32. Inclusion of oat hulls was the most important predictor of gizzard scores. This was particularly clear on day 19. On day 32 there was a significantly reducing effect on gizzard lesions only in the combination of feed with oat hulls and access to litter. Access to litter was the most important predictor of <i>Clostridium perfringens</i> counts in this trial. This was particularly clear on day 19. On day 32 a specific combination of the two study factors was necessary to exert a significant effect on <i>Clostridium perfringens</i> counts. This combination (lack of added oat hulls and denied access to litter) was associated with increased <i>Clostridium perfringens</i> counts.</p> <p>These results indicate that availability of non-soluble fibres can influence significantly both the severity of gizzard inflammation and the level of caecal <i>Clostridium perfringens</i>. Fibres in the feed and as litter appear to be interacting in their effects.</p>
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	Will be published