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The Effect of Free Choice Whole Grain Wheat on Turkey Performance, Caecal Health and Foot Pad Dermatitis

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ABSTRACT

This study was conducted to determine the effect of inclusion of whole grain wheat by a free choice method in the diet of turkey poults on bird performance, caecal health and foot pad dermatitis. A total of 192, four week old, as hatched, commercial line turkeys. Birds were blocked by live weight and then randomly allocated to one of two dietary treatments or whole grain wheat with starter pellet control (CON) treatment. Turkeys were offered their respective treatments for the duration of the study. Feed offered and refused and body weights were determined weekly. Turkeys were fed whole grain wheat (WGW) as free choice, it was observed that intake of WGW was much more variable in birds offered free choice WGW, although mean intake of WGW was greater. Bird performance was better if WGW was not fed. The weight of the (crop, gizzard, liver, pancreas and caecum) were not effect by treatment. Digesta pH was affected by treatment (P=0.045) gizzard digesta pH being lower when birds were offered WGW at 28-48 d old. Cecal content pH, cecal visual appearance scores, cecal content visual appearance scores, foot pad dermatitis were not affected by the WGW to the diet.

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Introduction

The relationship between caecal dysfunction (characterised by caecal distension and abnormal caecal droppings) and foot pad dermatitis (FPD) is poorly understood in turkeys, but is of growing concern in the turkey industry because of negative impacts on bird welfare and economic performance [1]. If such a relationship exists, then an improvement in gut health would reduce the incidence of both wet litter and FPD in turkeys. One means of improving gut health that has been investigated is the inclusion of whole (unground) cereal grains in the birds' diet, and this has become common practice in many countries [2]. The birds are offered whole grain wheat, but because of its lower protein content compared with the complete diet, the protein supply of the diet is diluted [3]. This may explain the poorer feed conversion ratio and diminished weight gain observed by when whole grains were offered to birds [4]. In this feeding system, birds are free to select between the whole grain and another feed (which may be a complete diet or 'balancer' feed, formulated to provide all the nutrients required by the bird if it consumes an 'expected' amount of the whole grain). The gut microbial content has co-evolved with the birds' gastrointestinal tract and its composition should be monitored for both animal welfare and food safety reasons [5, 6]. The composition of the microbial population in the gut may have a great influence on the birds' metabolism as well as its health status , but there are few data on what constitutes a healthy microbiome (especially in turkeys) and most work focuses on the effect of different dietary interventions on the prevalence of key pathogens [7].

Material and Methods

A total of 192 four week old, as hatched, commercial line turkeys (Meleagris gallopavo var. domesticus) were provided by Aviagen (Aviagen Turkeys Ltd, Tattenhall, Cheshire, UK), and were all of the same age, breed, and sourced from a single unit. After arrival turkeys were individually tagged, weighed, blocked by live weight and then randomly allocated to one of two dietary treatments (six pens/treatment, 16 birds/pen. Birds were offered their experimental diet following allocation to pens (on arrival), and turkeys received their experimental diets throughout the experiment. The control (CON) treatment received a proprietary starter pellet (F66502 GP Starter pellets, GLW Feeds Leicestershire, UK) from 28 to 48 d of age, a proprietary grower 1 diet (F66503, GLW-Feeds) from 49-69 d of age and a proprietary grower 2 diet (F66504, GLW-Feeds) from 70-84 d of age. The whole grain wheat with starter pellet (WGW+SP) treatment received whole grain wheat plus the starter diet (F66502) for the entirety of the experimental period (from 28-84 d). Diet changes were conducted abruptly and at the same time for all pens. All feed offered and refused were weighed and recorded weekly on a per pen basis throughout the study. Turkeys

were weighed weekly on an individual basis and weights recorded. Laboratory analysis of Grower1 and Grower 2 pelleted diets and whole wheat used in the study are shown in Table 1.

Table 1: Chemical Composition (g/kg as fed) of wheat and Pelleted Diets

Parameter	Starter	Grower 1	Grower 2	Wheat
Crude protein	246	257	237	124
Starch	265	343	386	607
Sugar (sucrose)	47	67	42	21
Oil A (Ether Extract)	67	85	90	19
Ca	12.4	15	9.9	0.7
Mg	2.2	2.2	2.1	1.1
P	8.7	8.8	6.6	3.2
Metabolisable energy, MJ/kg †DM	11.1	13.5	13.7	13.4

†DM= Dry matter

Birds were kept on white wood shavings. The total floor area for each pen was 4.07 m2. Lighting pattern was 16 hours of continuous light/d at 40 lux followed by an 8 h period of darkness. For birds fed the control (CON) diet, both feeders contained the appropriate, pelleted diet. For birds fed the diet containing WGW, one feeder contained a pelleted, starter diet while the other feeder contained WGW. Water was provided ad libitum from a bell type drinker in each pen and was filled with fresh water each day.

On the Tuesday following the birds' arrival and on each subsequent Tuesday for the duration of the study (eight weeks), either one bird was randomly removed from each pen (when birds were aged 5 to 9 weeks) or two birds were taken from each pen (when birds were aged 10 to 12 weeks). Turkeys were weighed prior to slaughter and euthanased either by cervical dislocation (<5 kg body weight) or by stunning (CASH Poultry Killer, Accles and Shelvoke, Sutton Coldfield, UK) followed by rapid exsanguination (>5kg body weight). One bird per pen was then sampled. The body cavity was instantly opened and the segments of digestive tract (crop, gizzard, caeca, duodenum, ileum, jejunum and colon) were removed. The length and empty weight of the duodenum (gizzard to pancreatic loop), jejunum (pancreatic loop to Merckel's diverticulum), and ileum (Merckel's diverticulum to ileo-caeca junction) were recorded. The weight of the emptied crop, gizzard, pancreas and liver were recorded. The viscera were exposed and the ceca scored in-situ in terms of appearance using a numerical system adapted from Raman et al. (2011); Table 2. Cecal contents were emptied from the cecal sac into an Eppendorf tube, scored for their appearance using a system proposed by Saif (2008); Table 2, and cecal digesta pH measured. The gizzard was removed, the contents emptied into a container, and gizzard digesta pH measured. At 84 days of age, all remaining turkeys were euthanized by captive bolt followed by abrupt exsanguination. Digesta pH (both gizzard and cecal contents) were determined immediately post-sample harvesting. 50 mL of distilled water was added to 5 g of digesta material, mixed thoroughly, and pH measured using a calibrated digital pH probe (Hannah Instruments, HI 110, Bedfordshire, UK). The probe was cleaned with distilled water and calibration checked between samples.

Table 2: Scoring System used for The Assessment of Caecal Appearance and Content

Appearance	Description
0	No pathological changes.
1	Mild distension with no colour change.
2	Moderate distension with pale colour change.
3	Complete distension with blood present in the wall.
4	Complete distension with severe cell necrosis.
Content	
0	No pathological changes (light brown, smooth consistency).
1	Thick and viscous, brown/dark brown in colour.
2	Foamy/liquid content, pale yellow in colour.
3	Foamy/liquid content, pale yellow in colour with blood present.
4	Thick coagulated blood present.

Adapted from Saif (2008) and Raman et al. (2011).

Foot pad score was divided into eight categories by from completely normal (score 0) to over half of the foot covered by lesions (score 7). Feet were photographed and subsequently scored for the extent of foot pad lesions Table3 [8].

Table 3: Foot Pad Scoring System

Score	Description of foot pad
0	Normal foot pad and digital pads.
1	Slight swelling or redness of the skin of the foot pad.
2	The foot pad feels harder and denser than unaffected pad.
3	Small black necrotic areas on the foot pad.
4	The area of necrosis is less one-eighth of the foot pad.
5	The necrotic area extends to a quarter of the foot pad.
6	Half of the foot pad covered by necrotic cells.
7	Over half of the foot pad covered in necrotic scales.

Source: (Mayne et al., 2007)

Data pertaining to turkey performance includes feed intake (calculated average feed intake per turkey based on group pen intake), live weight gain (calculated within pen individual daily live weight gain), and feed conversion ratio (calculated from total pen feed intake and total weight gained within pen with respect to age). Growth data, and digesta pH (gizzard and ceca), were analysed by analysis of variance (ANOVA) using a general linear model (GLM) using the Genstat 17th edition statistical software package (VSN International Ltd, Hemel Hempstead, UK). Sources of variation included wheat inclusion rate (2 df). Results are presented as least square means with the standard error of the mean with orthogonal polynomials. Data pertaining to cecal external visual appearance scores, cecal content visual and foot pad dermatitis scores were analysed by Pearson Chi-Square. Data are presented graphically with the Chi Square value, degrees of freedom, and P-value.

Results

Effect of Treatment on Bird Performance

The effects of treatment in free choice whole grain wheat on feed intake, growth rate and feed conversion ratio in the starter (28-48) d, grower 1 (49-69 d) and grower 2 (70-84 d) phases are shown in (Table 4). There were significant effects of treatment on feed intake and FCR at both 28-48 d and 70-84 d old, with birds offered WGW eating more feed but without growing more (indeed, having a lower growth rate (P=0.018) when they were 28-48 d old) so that their FCR was greater than birds fed CON. This difference in feed intake and FCR was not observed when birds were fed grower 1 and were 49-69 d old.

Table 4: Effect of free Choice WGW on Bird Performance

	*CON	**WGW+SP	SEM	P- value
Starter (28-48 d)				
Feed intake (g/b/d)	181[b]	240[a]	8.32	< 0.001
Growth rate (g/b/d)	125	120	1.21	0.018
FCR (g feed/g gain) †	1.09	1.53	0.081	0.004
Grower 1 (49-69 d)				
Feed intake (g/b/d)	419[a]	461[b]	30.60	< 0.001
Growth rate (g/b/d)	178	180	2.24	0.619
FCR (g feed/g gain) †	272	305	0.218	0.314
Grower 2 (70-84 d)				
Feed intake (g/b/d)	545[b]	665a	12.8	<0.001
Growth rate (g/b/d)	223	229	4.95	0.387
FCR (g feed/g gain) †	2.44[b]	2.86a	0.126	0.032

*CON: Birds were fed a proprietary, pelleted diet appropriate to their age.
**WGW+SP: Birds had free access to a proprietary, pelleted starter diet in one hopper and whole grain wheat in a second hopper throughout the experimental period.

Effect of Treatment on Weight of Gastrointestinal Organs

There was no significant effect of treatment on the weight of the different parts of the gastrointestinal tract (crop, gizzard, liver, pancreas and caecum) of turkeys fed different diets at starter (28-48 d), grower 1 (49-69 d) and grower 2 (70-84 d old), but there was a significant effect on caecum weight (P= 0.038) at grower 2 stage (70-84 d old, Table 5). The weight of the duodenum, jejunum, ileum and caecum increased with bird age as expected.

Table 5: Effect of Treatment on Crop, Gizzard, Liver and Pancreas Weight (g)

	*CON	**WGW+SP	SEM	P- value
Starter (28-48 d)				
Crop	9.0	8.6	0.22	0.162
Gizzard	49.3	53.0	1.95	0.192
Liver	54.7	56.5	1.73	0.479
Pancreas	5.8	6.2	0.20	0.209
Caecum	14.8	14.4	0.69	0.736
Grower 1 (49-69 d)				
Crop	16.0	15.5	1.17	0.770
Gizzard	92.3	90.8	3.63	0.778
Liver	88.5	92.9	4.25	0.485
Pancreas	9.7	9.0	0.62	0.515
Caecum	24.8	27.7	1.30	0.153
Grower 2 (70-84 d)				
Crop	23.0	23.3	0.85	0.784
Gizzard	116.1	125.8	3.73	0.072
Liver	150.5	146.3	3.93	0.442
Pancreas	11.1	12.7	0.39	0.010
Caecum	45.8 [b]	49.5 a	1.21	0.038

*CON: Birds were fed a proprietary, pelleted diet appropriate to their age.
**WGW+SP: Birds had free access to a proprietary, pelleted starter diet in one hopper and whole grain wheat in a second hopper throughout the experimental period.

Effect of Treatment on Digesta Ph and Proportion of Wheat in the Crop

The proportion of WGW in the crop was approximately 35 g/kg when birds were 28-48 d old, 25 g/kg when birds were 49-69 d and 171 g/kg when they were 70-84 d old (Table 6). Digesta pH was affected by treatment (P=0.045) gizzard digesta pH being lower when birds were offered WGW at 28-48 d old (Table 3.16).

Table 6: Effect of Treatment on Digesta Ph and the Proportion of Wheat Observed in Crop Contents Experiment One

	*CON	**WGW+SP	SEM	P- value
Starter (28-48 d)				
Proportion (g/kg DM) of wheat in crop contents	0.00	35.00	0.0135	0.096
Gizzard (pH)	3.83a	3.60b	0.0742	0.045
Caeca (pH)	6.36	6.22	0.188	0.613
Grower 1 (49-69 d)				
Proportion (g/kg DM) of wheat in crop contents	0.00 [b]	24.97 a	0.00605	0.014
Gizzard (pH)	3.45	3.59	0.0862	0.270
Caeca (pH)	5.88	5.98	0.172	0.710
Grower 2 (70-84 d)				
Proportion (g/kg DM) of wheat in crop contents	0.00 [b]	170.80 [a]	0.0380	0.003
Gizzard (pH)	3.54	3.47	0.0851	0.549
Caeca (pH)	5.79	5.84	0.0951	0.744

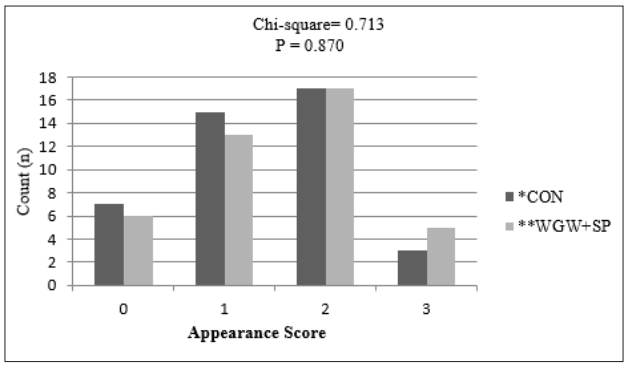
*CON: Birds were fed a proprietary, pelleted diet appropriate to their age.
**WGW+SP: Birds had free access to a proprietary, pelleted starter diet in one hopper and whole grain wheat in a second hopper throughout the experimental period.

Effect of Treatment on Measures of Caecal Health

The caeca of most birds, regardless of dietary treatment (P=0.870) appeared mildly or moderately distended (Figure 1), while most caecal contents were described as either thick and viscous or foamy and liquid but without blood (Figure 2), and dietary treatment had no effect on the appearance of the caecal contents (P = 0.250).

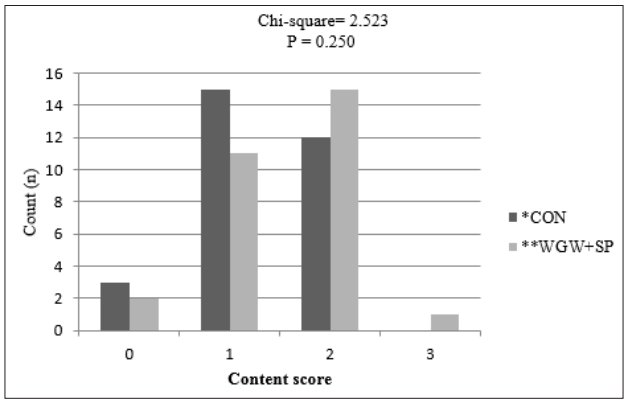
Effect of Treatment on Foot Pad Score

Most birds had a necrotic area covering a quarter of the foot pad (Figure 3) and this was not affected by dietary treatment (P = 0.106).



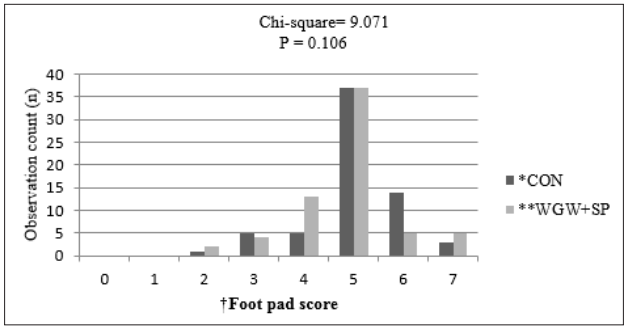
*CON: Birds were fed a proprietary, pelleted diet appropriate to their age.
**WGW+SP: Birds had free access to a proprietary, pelleted starter diet in one hopper and whole grain wheat in a second hopper throughout the experimental period.

Figure 1: The Effect of Treatment on Caecal Appearance Score



*CON: Birds were fed a proprietary, pelleted diet appropriate to their age.
**WGW+SP: Birds had free access to a proprietary, pelleted starter diet in one hopper and whole grain wheat in a second hopper throughout the experimental period.

Figure 2: The Effect of Treatment on Caecal Content Score



*CON: Birds were fed a proprietary, pelleted diet appropriate to their age.
**WGW+SP: Birds had free access to a proprietary, pelleted starter diet in one hopper and whole grain wheat in a second hopper throughout the experimental period.

Figure 3: Effect of Treatment on Foot Pad Score

Discussion

In this study investigated the effects of supplementing turkey diets with whole grain wheat in a free choice feeding (FCF) system in the turkey diet on bird performance and maintenance of gut health. Generally, turkeys fed whole grain wheat in a free choice feeding system increased feed intake. This might be because the consumption of whole grain wheat resulted in higher grinding pressure and abrasive action within the gizzard which in turn led to improved efficiency of digestion of whole grain wheat as observed by, these workers also reported that whole grain wheat was more efficiently digested and absorbed because of grinding in the gizzard and this resulted in increased feed intake by the birds [10, 9]. However, the lack of any significant difference between treatments in the estimates of nutrient availability in this experiment would suggest that this was not the case in this study. In this study, growth rate, bird weight and feed conversion ratio were not improved by increased WGW consumption, and indeed the consumption of WGW worsened FCR in some cases. This may be a result of a lower availability of net energy with the WGW diets because of the energy required for the grinding of the wheat [11]. Alternatively, it may reflect a lower supply of crude protein, oil, sugar and minerals when WGW was consumed, although the reduction in oil and sugar supply would be partly offset by the much higher starch content of WGW compared with the pelleted diet. The high starch content of whole wheat may affect digestion as rapid starch digestion has a negative effect on bird performance compared with more slowly digestible starch as the lower rate of digestion leads to improved efficiency of digestion of protein and amino acids, consequently leading to improved bird performance [12]. That said, the rate of starch digestion in untreated, whole wheat is likely to be rather low. The findings of this experiment is in agreement with the study of who observed that free choice whole wheat in broiler chicken diets negatively affected bird performance parameters with the highest total feed intake being recorded in the free choice feeding (FCF) group [13].

In common with the findings of other studies, including WGW in the diet of turkeys did not affect the weight of the crop, gizzard, liver, pancreas or caecum. This was also observed by [14,15]. These results of gut weights are also consistent with other studies [14-18]. The only exception to this was the small increased weight of the caecum observed in 70-84 d old in birds fed WGW. WGW did not have much effect on bird performance, but did have an effect on gizzard pH as expected and as discussed, whole wheat feeding is generally associated with reduced gizzard pH (and potentially increased counts of beneficial microflora) and it has been hypothesised that this is a consequence of increased grinding activity by the gizzard. The consumption of whole wheat may in part be an attempt by the bird to influence gizzard pH and microflora in the gut [19,20]. However, any such benefit was not observed in this experiment in terms of measures of caecal health and the presence of potential pathogens. There are a number of studies reporting that an increase in gizzard weight is an indication of greater gizzard development and that this is associated with improved digestive health in poultry fed whole grains; increases in gizzard weights in both turkeys and broilers have been reported when fed diets containing whole grains [1,10,14,16,21-25]. The reduction in pH of gizzard contents has been reported in both turkeys and broilers [1,16,26]. proposed that this reduction in pH was most likely due to whole cereals causing an increase in gizzard volume leading to increased digesta retention time resulting in a stimulatory effect on gizzard activity and hydrochloric acid secretion [27]. Benefits of this acidic environment may include reduced pathogenic bacteria and improved gastric digestion, but again, such benefits were not observed in this experiment [1, 16, 26].

Reported that cercal content pH was lower in turkeys fed diets containing high concentrations of whole wheat (225 g/kg) and this was associated with increases in the concentrations of acetic and butyric acids in caecal digesta. The findings of this study was unable to establish any significant effects of treatment on caecal pH nor were short chain fatty acids (SCFA) quantified in caecal digesta.

There was no effect of dietary treatment on scores of caecal health (appearance and content, and while very few had score 1 the scores recorded indicated that the birds were generally in a good state of caecal health, since no birds had a score of 4 and very few birds had a score of 3. There was therefore no evidence to suggest that WGW affected caecal health. Dietary treatment in this experiment had no effect on foot pad score either. Scores of FPD were generally high in both groups. The foot pad lesions that were observed might be a consequence of water from the bell drinker being spilled on to the bedding material increasing the moisture content of bedding material rather than a response to diet. found that bell drinkers increased litter moisture content compared with small cup as well as nipple drinkers, and as has already been noted, litter moisture content alone is a primary cause of foot pad dermatitis in turkeys [28, 8].

Conclusion

Free choice feeding of whole wheat with a more concentrated protein source (the starter pellet) increased gizzard weight and the inclusion of whole wheat in the diet reduced gizzard digesta pH. This may be beneficial for the development of a healthy intestinal flora and nutrient digestion, although no evidence of either of these outcomes was observed in this experiment. The severity of FPD was higher in this study but it is likely that this is a consequence housing of the birds rather than the diets they were fed. The severity of caecal dysfunction was low, and no clinical signs of major digestive dysfunction were observed. As has been noted, the potential benefits of feeding whole wheat are largely associated with the increased fibre content of whole wheat compared with a ground, pelleted diet and the effect this might have on gizzard digesta pH and the physicochemical characteristics of the digesta throughout the tract.

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