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The effect of incremental inclusion of whole grain wheat in the diet of growing turkeys on growth performance, feed conversion ratio, cecal health, and digesta characteristics

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ABSTRACT

This study was conducted to determine the effects of adding incremental amounts of whole grain wheat (0, 100, and 200 g per kilogram of feed) to the diet of growing turkey poults on growth performance, feed efficiency, digesta pH, and the incidence of cecal distension. Seventy two, 6-wk-old commercial line turkeys were blocked by live weight and randomly allocated to 1 of 3 dietary treatment (n = 4 pens/treatment). Turkeys were offered their respective treatments for the duration of the study. Feed offered and refused and body weights were determined weekly. At 63 days of age 12 turkeys from each treatment were euthanized and crop contents were collected and weighed, pH of gizzard and cecal digesta measured, and ceca and cecal contents visually scored. At 84 days of age, all remaining turkeys were euthanized and the same sampling procedure repeated. Feed conversion ratio was poorer in those turkeys offered diets containing whole grain wheat ($P < 0.05$), declining quadratically ($P < 0.005$) as the proportion of whole grain wheat (**WGW**) in the diet increased. The proportion of WGW found in the crop post-mortem reflected whole wheat inclusion rates of the diets. The pH of gizzard contents at 63 days was lower in turkeys receiving diets supplemented with WGW, declining quadratically ($P = 0.005$) as the proportion of WGW in the diet increased. However, this difference in gizzard pH was not apparent at 84 days of age. Cecal content pH, cecal visual appearance scores, and cecal content visual appearance scores were not affected by the inclusion of WGW to the diet. The inclusion of WGW to the diets of growing turkeys reduces growth performance and feed efficiency suggesting that the addition of whole wheat may have reduced the nutritional quality of the diet as a whole.

1. Introduction

The feeding of whole grains to poultry has been shown as a means of improving poultry gut health whilst reducing feed processing costs (Forbes and Covasa, 1995; Singh et al., 2014). As a consequence there has been renewed attention by the commercial poultry industry to the feeding of whole grains, not only as a way of reducing feeding costs, but as a means of improving gut health and subsequent litter quality, which could impact negatively on performance, welfare, and carcase quality (Amerah and Ravindran, 2008).

The feeding of whole grains to poultry has been associated with a number of effects on performance, although responses seem to be variable and to some extent dependent upon the species of bird and the way in which whole grains were offered. Munt et al. (1995) reported reduced growth rates in broilers offered free choice diets, whereas Erener et al. (2006) reported improved rates of gain in turkeys using a free choice system. Both Husveth et al. (2015) and Singh and Ravindran (2015) reported improved feed conversion ratio (**FCR**) in broilers fed wholegrains that had been incorporated into the pellet, whereas Taylor and Jones (2001) reported no improvement. Jankowski et al. (2014) reported no improvement in turkey performance when whole grains were incorporated into the pellet, but did report an improvement in FCR when whole grains were added to the diet post-pelleting (Jankowski et al., 2012).

During the past 50 years poultry nutrition, structure of the diet and nutrient requirements have changed noticeably due to improvements in nutritional knowledge and advances in poultry genetics (Havenstein et al., 2003). There is considerable research showing that physical structure of feed (type and form) can affect the development of the digestive tract (Amerah et al., 2007b; Engberg et al., 2002; Svihus et al., 2004; Xu et al., 2015; Zaefarian et al., 2016), which in turn has been shown to influence subsequent nutrient digestibility (Amerah et al., 2007a; Gabriel et al., 2008; Hetland et al., 2002; Svihus et al., 2010), and digesta characteristics (e.g., pH) (Zdunczyk et al., 2013).

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Changes in the composition of digesta arriving at the cecum may result in changes in excreta consistency that may in turn impact litter quality (Zdunczyk et al., 2013); both Engberg et al. (2004) and Taylor and Jones (2004) have reported increased digesta viscosity in turkeys fed diets containing whole wheat.

A previous study conducted by this research group investigating the effects that whole grain wheat (**WGW**) had on turkey gut health had noted that consumption of WGW, when offered through a free choice feeding system, was highly variable and that a number of turkeys consumed very little, if any, WGW when given free choice. The aim of this study was to determine whether the feeding of pelleted diets that had been mixed with the graded addition of WGW resulted in selective feeding, and to determine the effects that wheat inclusion, and subsequent nutrient dilution had on turkey growth performance, aspects of gut health, and digesta pH.

2. Materials and methods

The study was subject to local review and conducted in accordance with the University of Reading's current animal research policy and conformed to the United Kingdom's Animal (Scientific Procedures) Act 1986.

A total of seventy two 6-wk-old commercial line turkeys were used in this study. Wing tagged turkey poults 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, weighed, blocked by live weight and then randomly allocated to 1 of 3 dietary treatments. Treatments included an unsupplemented control that comprised a pelleted diet that contained no supplementary WGW, a group that received the pelleted diet supplemented with 100 g WGW per kilogram of feed and a group that received the pelleted diet supplemented with 200 g WGW per kilogram of feed. The pelleted diet comprised of a commercial grower diet (ingredient composition of pelleted diets not disclosed); Grower 1 (F66503, GLW-Feeds Leicestershire, UK) was offered from 42 days of age to 63 days of age, and Grower 2 (F66504, GLW-Feeds) from 63 days to 84 days of age. The change from Grower 1 to Grower 2 was abrupt and occurred in all pens at the same time. The whole grain wheat was mixed with pelleted feed using a mechanical mixer.

The study was conducted in an open pole barn between January and March 2015. The building provided natural ventilation and natural lighting. There were 4 pen replicates per treatment with 6 turkeys in each pen. Each pen provided approximately 0.5 m^2/turkey, was bedded with white wood shavings and equipped with a single bell type drinker, a single suspended feed hopper, and a suspended halogen heat lamp that remained on for the duration of the study.

Turkeys received their experimental diets throughout the entire study period. 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.

At 63 days of age, three turkeys were randomly selected from each pen and euthanized by captive bolt followed by abrupt exsanguination. The crop was removed intact after which the contents were emptied and sorted to determine the proportion of WGW within the crop. 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. 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.

Table 1
Laboratory analysis of Grower 1, Grower 2 pelleted diets and whole wheat (g/kg DM[a] unless otherwise stated).

Calculated analysis	Grower 1	Grower 2	Whole wheat
Crude protein	257	237	124
Starch	343	286	607
Sugar (sucrose)	67	42	21
Ether extract	85	90	19
Ca	15	9.9	0.7
Mg	2.2	2.1	1.1
P	8.8	6.6	3.2
Metabolisable energy (MJ/kg DM[a])	13.5	13.7	13.4

[a] DM = Dry matter.

Table 2
Scoring systems used for the assessment of cecal appearance and content.

Score	Description
Appearance	
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).

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.

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 and cecal content visual scores were analysed by Pearson Chi-Square. Data are presented graphically with the Chi Square value, degrees of freedom, and *P*-value.

3. Results

3.1. Growth performance

There were no effects of WGW inclusion on rates of feed intake at 63 days of age, although there were effects on growth rate and feed conversion ratio (Table 3). Growth rates were greatest in those turkeys receiving the 0 g WGW per kilogram of feed diet ($P = 0.036$) and decreased quadratically ($P = 0.028$) as the proportion of whole wheat inclusion increased. Feed conversion ratios were better in those turkeys