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Effects of phytase inclusions in diets containing ground wheat or 12.5% whole wheat (pre- and post-pellet) and phytase and protease additions, individually and in combination, to diets containing 12.5% pre-pellet whole wheat on the performance of broiler chickens

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A B S T R A C T

Each of eight dietary treatments was offered to seven replicates (six birds per cage) of male Ross 308 chicks from 7 to 28 days post-hatch. The diets contained 741 g/kg wheat incorporated as ground (3.2 mm hammer-mill screen) wheat or 125 g/kg whole wheat included in diets, either pre- or post-pelleting. In Experiment 1 of the study, ground grain, pre-pellet and post-pellet whole grain diets were offered with and without phytase as a 3 × 2 factorial array of treatments. The effects of dietary treatments on gizzard and pancreas weights, bone mineralisation, excreta dry matter, growth performance, nutrient utilisation, digestibility coefficients and disappearance rates of starch and protein (N) in four small intestinal segments were determined. Post-pellet whole grain addition significantly increased gizzard weight by 12.5% (18.17 versus 16.15 g/kg; $P < 0.001$). Pre- and post-pellet whole grain additions improved FCR ($P < 0.10$) by 1.40% and 2.28%, respectively. Exogenous phytase significantly enhanced weight gain by 4.76% (1519 versus 1450 g/bird; $P < 0.001$) and FCR by 1.99% (1.332 versus 1.359; $P < 0.03$) irrespective of the context. Significant interactions between grain and phytase treatments were observed for energy utilisation parameters. However, pre- and post-pellet whole grain additions to non-supplemented diets significantly improved AMEn by 0.31 MJ (11.89 versus 11.58 MJ/kg; $P < 0.04$) and 0.48 MJ (12.06 versus 11.58 MJ/kg; $P < 0.001$), respectively. Post-pellet whole grain addition to non-supplemented diets significantly improved AME (13.49 versus 12.99 MJ/kg; $P < 0.001$) and ME:GE ratios (0.79 versus 0.77; $P < 0.003$). Phytase addition significantly improved AME in ground grain and pre-pellet whole grain diets by 0.43 MJ and 0.30 MJ, respectively. Phytase addition improved AMEn by 0.49 MJ in ground grain diets but this was not significant and otherwise did not influence AMEn. In Experiment 2, phytase and protease, individually and in combination, were included in diets containing 12.5% pre-pellet whole wheat as a 2 × 2 factorial treatment array. There was a significant interaction ($P < 0.015$) for weight gain following phytase and protease additions to pre-pellet whole grain diets where phytase significantly increased weight gain by 6.91% (1548 versus 1448 g/bird). Protease supplementation alone numerically increased weight gain, but in combination with phytase,

Abbreviations: AIA, acid insoluble ash; AME, apparent metabolisable energy; FCR, feed conversion ratio; GE, gross energy; IP_6, myo-inositol hexaphosphate; ME, metabolisable energy; ME:GE, metabolisable to gross energy ratios; N, nitrogen; NSP, non-starch polysaccharide

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numerically decreased weight gain. Phytase improved FCR by 2.15% (1.319 versus 1.348; P < 0.01) and protease improved FCR by 1.41% (1.324 versus 1.343; P < 0.05), but in combination, both feed enzymes improved FCR by 3.52% (1.317 versus 1.365; P < 0.005) relative to the negative control. It is noteworthy that in the first experiment, whole wheat inclusions did not significantly influence starch digestibility but phytase inclusions increased distal ileal starch digestibility by 5.10% (0.948 versus 0.902; P < 0.05) in pre-pellet and by 3.85% (0.943 versus 0.908; P < 0.05) in post-pellet whole grain treatments.

1. Introduction

Whole grain feeding is an increasingly accepted practice in countries where wheat is the dominant feed grain for chicken-meat production. This includes Australia where whole grain and a balancing pelleted concentrate are usually offered as a blend and New Zealand where whole grain is incorporated into the pelleted ration for compliance reasons. In a previous study (Truong et al., 2017), post-pellet whole wheat inclusions of 4.5, 9.0 and 18.0% increased relative gizzard weights, reduced gizzard digesta pH, and improved both feed conversion ratios and energy utilisation. In this study, pre-pellet whole wheat inclusions increased relative gizzard weights by 7.70% (15.67 versus 14.55 g/kg), improved FCR by 4.45% (1.439 versus 1.506), increased AME by 0.20 MJ (12.27 versus 12.07 MJ/kg) and enhanced ME:GE ratios by 1.43% (0.710 versus 0.700). Pre-pellet whole wheat inclusions are of interest in that anecdotal evidence suggests that this approach precludes wastage from "feed flicking" that may occur when whole grain and pelleted concentrate are offered as a blend. Moreover, FCR responses to pre- and post-pellet whole grain additions were very similar in the Truong et al. (2017) study.

The inclusion of phytate degrading enzymes in poultry diets is now standard practice as is the inclusion of NSP-degrading enzymes in wheat-based diets. Tandem inclusions of phytase and xylanase in wheat-based diets has been shown to be beneficial (Ravindran et al., 1999) and it has been demonstrated that the transition from conventional diets to whole grain feeding regimes does not detract from the benefits of xylanase supplementation in wheat-based diets (Jones and Taylor, 2001; Wu and Ravindran, 2004; Wu et al., 2004). However, to the best of the authors' knowledge, evaluations of phytase in the context of whole grain feeding are limited in the study of Abdollahi et al. (2016), which focused on tandem inclusions of phytase and xylanase rather than phytase *per se*. The hallmark of whole grain feeding regimes is heavier, and presumably more functional, gizzards (Liu et al., 2014; Singh et al., 2014). The gizzard is almost certainly the primary site of phytate degradation in the avian digestive tract by bacterial phytases (Truong et al., 2016). While spec ulative, exogenous phytase may be more effective under whole grain feeding regimes because enzymic degradation of dietary phytate could be facilitated by the grinding and mixing actions of a heavier, more powerful gizzard. Interest in exogenous proteases is emerging and their efficacy in combination with phytase is obviously pertinent. Therefore, the primary objective of this study was to evaluate pre- and post-pellet whole grain feeding regimes in comparison to ground grain, control diets without and with phytase. The secondary objective was to assess phytase and protease, individually and in combination, with pre-pellet whole grain feeding.

2. Materials and methods

This feeding study comprised a total of eight dietary treatments as listed in Table 1; each dietary treatment was offered to seven replicate cages (six birds per cage) or a total of 336 male Ross 308 chicks from 7 to 28 days post-hatch. The data generated was analysed as two factorial treatment arrays. The first 3 × 2 factorial (Experiment 1) compared a ground grain control diet, a diet with 12.5% whole grain added prior to pelleting, a diet with 12.5% whole grain added following pelleting, without and with 1000 FTU/kg phytase (Axtra® PHY, Danisco Animal Nutrition/DuPont). Relevant diets were analysed for phytase activity using the method of Engelen et al. (1994) which confirmed the accurate addition of the exogenous phytase as shown in Table 1. The second 2 × 2 factorial (Experiment 2) investigated the addition of phytase and protease, individually and in combination, to diets with 12.5%

Table 1
Schedule of eight dietary treatments and analysed phytase activity.

Treatment	Description	Phytase activity (FTU/kg)
1A[a]	Control, 100% ground grain	–
2B[a]	1A + 1000 FTU/kg phytase	1100
3C[a,b]	Pre-pellet 12.5% whole grain	360
4D[a,b]	3C + 1000 FTU/kg phytase	1030
5E[b]	3C + 300 units/g protease	–
6F[b]	3C + 1000 FTU/kg phytase + 300/g units protease	1200
7G[a]	Post-pellet 12.5% whole grain	–
8H[a]	7G + 1000 FTU/kg phytase	1210

[a] Experient 1.
[b] Experient 2.