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Effects of xylanase supplementation on performance, total volatile fatty acids and selected bacterial population in caeca, metabolic indices and peptide YY concentrations in serum of broiler chickens fed energy restricted maize–soybean based diets

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ABSTRACT

The effects of xylanase supplementation on production performance, carcass traits, caecal volatile fatty acid and peptide YY concentration in serum of broiler chickens fed maize–soybean based diets were tested in a 42 d experiment. Dietary metabolizable energy (AME, N uncorrected) was decreased in the experimental diets by 0 (E_1), 230 (E_2) and 420 kJ/kg (E_3). Each of these diets was supplemented with 0 (X_1) or 16,000 units/kg (X_2) of a commercial xylanase. The objective was to ascertain if the xylanase could spare dietary energy for growth through its effects on peptide YY concentration in blood. Reduction of dietary AME depressed body weight gain (P=0.014), deteriorated feed conversion ratio (P=0.018) and decreased carcass yield (P=0.0001) over 42 d. Irrespective of the level of supplemental xylanase, breast meat yield was the poorest in the E_2 groups (P=0.003). Supplementation of xylanase had no effect on body weight gain, feed consumption, feed conversion ratio (feed consumption: body weight gain) and carcass traits (P>0.05). Low energy diets increased total volatile fatty acids (VFA) in caeca (P=0.0001). Xylanase supplementation tended to decrease caecal VFA irrespective of dietary AME (P=0.07). Increasing dietary AME reduced *Salmonella* (P=0.018) and *Escherichia coli* (P=0.019) and increased *Enterobacteriaceae* (P=0.012) populations in caeca. Reduction in dietary AME decreased glucose (P=0.0001) and cholesterol (P=0.012) in serum, particularly in the E_3 groups. Serum glucose increased due to xylanase supplementation in the E_1 and E_3 groups but not in the E_2 group (energy × xylanase P=0.0001). Supplementation of xylanase to the E_2 groups decreased serum cholesterol as compared with the E_1 and E_3 groups (energy × xylanase P=0.002). On the other hand, xylanase supplementation decreased serum concentrations of protein in the E_1 and E_2 groups (energy × xylanase P=0.0001) and uric acid in the E_2 and E_3 groups (energy × xylanase P=0.006). Serum insulin reached a maximum (P=0.0001) in the E_2 group irrespective of xylanase supplementation and added xylanase increased serum insulin (P=0.0001) at all dietary AME levels. There was an interaction between dietary AME and supplemental xylanase on serum peptide YY concentration (P=0.0001) which suggested that the xylanase induced increase in the serum peptide YY concentration was dependent on dietary energy density. It was concluded from the present investigation that

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supplementation of xylanase to a maize–soybean based diet of broiler chickens may consistently increase serum peptide YY concentration and improve metabolic indices like serum insulin levels. However, the results also indicated that with maize–soybean based diet, such positive effects on metabolic indices may not translate into performance if the diet is compromised with energy by 230 kJ/kg or more.

1. Introduction

The endogenous enzymes of broiler chickens cannot adequately digest the dietary nonstarch polysaccharides (NSP) and a high level of ingestion of these NSP may exert anti-nutritional effects in broilers by increasing digesta viscosity and depressing nutrient digestibility (Annison, 1991; Kocher et al., 2003). Exogenous carbohydrases, including cellulase, xylanase and amylase, reportedly increased the digestibility of diets with high NSP (Café et al., 2002) and improve performance of poultry (Marsman et al., 1997; Zanella et al., 1999; Gracia et al., 2003). However, the scope for improving the nutritive values of maize and soybean meal based diets with carbohydrases is perhaps limited since the nutrients in maize and soybean are considered to be highly digestible (Kocher et al., 2003). Nevertheless, considerable quantities of NSP are present in maize (9 g/kg soluble NSP and 6 g/kg insoluble NSP) and soybean (60 g/kg soluble NSP and 180–210 g/kg insoluble NSP) and these may affect energy utilization of diets containing these ingredients (Bach Knudsen, 1997). Indeed several research groups have found beneficial responses to pure xylanases and mixtures of carbohydrases in maize–soybean based diets for ducks and chicks (Hong et al., 2002; Cowieson et al., 2010; Olukosi et al., 2007a). Even so, it is suggested that since carbohydrases may improve energy digestibility, their beneficial effects are more likely to be observed when applied to nutritionally marginal diets (Kocher et al., 2003; Cowieson and Adeola, 2005).

It is not clear how such enzymes improve digestibility of maize based diets. Maize does not induce high gut viscosity to the extent of other cereals such as barley and rye and so viscosity reduction may not be relevant in such diets. Although cell wall dissolution has also been suggested (Daveby et al., 1998; Meng and Slominski, 2005), the pH profile of the enzymes employed coupled with transit time of digesta in the broiler suggest that there is not enough time for exogenously applied enzymes to appreciably degrade cell walls directly by the mid-jejunum, the point at which microscopic work has shown cell wall degradation. A third method may be relevant in these circumstances. Courtin et al. (2008) showed that the inclusion of wheat bran oligosaccharides derived from digestion of wheat bran with xylanase improved feed conversion ratio (FCR) of maize-fed birds to the same extent as the inclusion of the same xylanase in the ration. It is suggested that such oligosaccharides exert a pre-biotic effect (Courtin et al., 2008) which may then induce the production of gut hormones such as peptide YY (Goodlad et al., 1987).

Peptide YY is a hormone, produced primarily by endocrine cells in the ileum and colon, which is released into blood in response to various nutritional stimuli (Adrian et al., 1987). It is a putative humoral agent which slows down gastric emptying and intestinal transit when the distal bowl is exposed to unabsorbed nutrients (Taylor, 1993). Effects of peptide YY on intestinal transit time have been reported by several workers although the possible role of a xylanase enzyme on the actions of peptide YY was not explored.

The present investigation was conducted with a commercial xylanase enzyme and it was hypothesized that the xylanase would produce soluble, fermentable xylo-oligomers which would result in enhanced peptide YY secretion and influence digestibility of the diet employed. Thus the objectives of the investigation were, (i) to evaluate the effects of xylanase supplementation on performance of broiler chickens, (ii) to evaluate the energy sparing effect of supplemental xylanase and (iii) to investigate the interaction effects between dietary energy and exogenous xylanase on concentration of peptide-YY and other metabolic indices in broilers.

2. Materials and methods

2.1. Bird husbandry and dietary treatments

A straight-run flock of one-day-old Cobb 400 chicks ($n = 396$) was used in a 42 d study. There were 6 dietary treatments and each treatment had 6 replicates with 11 birds per replicate pen. The birds were raised on saw dust and wood shavings litter. The mean temperature of the experimental house was maintained at 32–34 °C in the first week and at 26–28 °C during the subsequent period. The lighting program was 24 h light for 7 d and 20 h afterwards. The birds were vaccinated against Marek's disease (0 d), Newcastle disease (ND live B1 at 7 d and La Sota at 21 d) and infectious bursal disease (14 d). In a three phase feeding program, the starter, grower and finisher mash were offered during 1–16 d, 17–28 d and 29–42 d respectively. Feed and water was offered for *ad libitum* consumption.

The diets were offered to the birds in mash form and were composed of maize and soybean meal and did not contain any antibiotic growth promoter or exogenous enzymes except the xylanase in the treatment groups (Table 1). However, Maduramycin was added as a coccidiostat. The experimental diets were formulated in such a way that they were deficient in AME by 0 (E_1), 230 (E_2) and 420 (E_3) kJ/kg. The E_2 diet was energy compromised during the grower and finisher phases only and was identical to the E_1 diet during the starter phase. Energy reduction was accomplished by replacing oil with maize and