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Comparative effects of dietary carbohydrases without or with protease on the ileal digestibility of energy and amino acids and AME_n in young broilers

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ABSTRACT

Four digestibility trials using broilers from 12 to 21 d or 7 to 21 d of age were conducted to evaluate the nutrient digestibility responses of two enzyme combinations when supplemented to maize–soybean meal (SBM) based diets without (trials 1 and 3) or with (trials 2 and 4) 70 or 100 g/kg maize dried distillers grain with solubles (DDGS). Apparent ileal digestible energy (AIDE), apparent ileal digestibility (AID) of amino acids (AA), total tract apparent retention (TTAR) of nitrogen (N) and N-corrected apparent metabolisable energy (AME_n) were assessed. In each trial, a control diet and the control diet supplemented with an enzyme complex containing xylanase and amylase (XA) or one containing protease, xylanase and amylase (PXA) were tested. Trials 1 and 2 had six replicate cages per treatment, with six birds per cage; and trials 3 and 4 had eight replicate cages per treatment, with five birds per cage. Data were analysed by ANOVA for each trial, as well as a combined dataset, which model included the main effects of maize-DDGS inclusion, dietary enzyme and trial site and all two-way interactions. Across trials, both XA (13.61 MJ/kg) and PXA (13.70 MJ/kg) increased the AIDE ($P<0.05$) compared to the control diets (13.29 MJ/kg). XA increased ($P<0.05$) AME_n (12.89 MJ/kg) compared to the control diets (12.61 MJ/kg), and PXA further increased it (13.00 MJ/kg) compared to XA. Supplementation with XA had no effect on the AID of AA, whereas PXA increased the AID of nitrogen and all AA ($P<0.05$) except methionine. The AA with the greatest response to PXA were cysteine (+5.4%), threonine (+4.4%), glycine (+3.6%) and valine (+3.3%). The least responsive AA to PXA inclusion were methionine (+1.0), glutamine (+2.0), lysine (+1.9%) and arginine (+2.2%). Irrespective of the AA, PXA increased AID of AA as a proportion of the ileal undigested fraction of AA in the control diets by 12–13%. Supplemental xylanase and amylase increased AIDE and AME_n and the addition of protease on top of carbohydrases further increased AID of AA and AME_n in young broilers fed maize–SBM diets without or with maize-DDGS.

Abbreviations: AA, amino acids; AME, apparent metabolisable energy; AME_n, nitrogen corrected apparent metabolisable energy; AID, apparent ileal digestibility; AIDE, apparent ileal digestible energy; DDGS, dried distillers grain with solubles; N, nitrogen; NSPs, non-starch polysaccharides; PXA, protease, xylanase and amylase; TTAR, total tract apparent retention; XA, xylanase and amylase.

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1. Introduction

Carbohydrase enzymes such as xylanases, amylases and glucanases are being adopted by the poultry industry worldwide. In wheat-based diets, these enzymes are used to ameliorate the adverse effects of non-starch polysaccharides (NSPs) on digesta viscosity, nutrient digestibility and bird performance (Choct, 2006). Exogenous carbohydrases are now increasingly used in maize-based diets for broilers (Cowieson, 2010) despite low concentrations of soluble NSP in these diets. Economic benefits from the use of these enzymes are obtained through a reduction of feed cost that occurs when improvements on apparent metabolisable energy (AME) and, to a lesser extent, amino acids (AA) digestibility are accounted for in diet formulations. Possible mechanisms of action of carbohydrases in poultry diets include: improved access of endogenous enzymes to cell contents due to hydrolysis of cell wall arabinoxylans (Cowieson, 2005), augmentation of digestive enzymes in young animals, particularly of amylase (Ritz et al., 1995; Gracia et al., 2003), modulation of intestinal microflora (Fernandez et al., 2000) and reduction of endogenous AA losses, particularly through changes on pancreatic amylase (Jiang et al., 2008) and mucin secretion (Cowieson and Bedford, 2009). In general, improvements of AME due to exogenous xylanase and amylase appear to be a combination of two mechanisms, namely, increased digestion and absorption of the undigested portion of starch and fat of the diet and down-regulation of various digestive secretions.

Exogenous proteases of microbial origin are being increasingly used in broiler diets (Adeola and Cowieson, 2011). The economic benefit of the use of exogenous proteases is through improvements in the digestibility of dietary AA. The primary mechanism for this increment appears to be the augmentation of dietary protein hydrolysis and increased protein solubility (Caine et al., 1998). Conclusive evidence is not available supporting a positive or negative change in endogenous secretions caused by exogenous proteases. However, increments of AME caused by exogenous proteases in conjunction with xylanases and amylases are suggestive of the ability of exogenous proteases to disrupt protein–starch interactions in cereal grains (McAllister et al., 1993; Belles et al., 2000). Nonetheless, the additional effect of protease on top of carbohydrases on energy metabolisability and apparent ileal digestibility (AID) of AA has not been fully assessed. That is particularly relevant for modern broiler diets containing non-traditional protein sources such as maize dried distillers grain with solubles (DDGS), where the effects of proteases and carbohydrases may differ in importance compared to traditional maize–soybean meal (SBM) diets. The current study aimed to assess the effect of an exogenous bacterial serine protease in combination with a xylanase and an amylase *versus* xylanase and amylase only in broilers fed either a maize–SBM, or a maize–SBM-DDGS based diet, in terms of apparent ileal digestible energy (AIDE), AID of AA, total tract apparent retention (TTAR) of nitrogen (N) and N-corrected AME (AME_n). The results reported herein were from four independent trials with similar design performed at two research sites.

2. Materials and methods

2.1. Exogenous enzymes

Two enzyme products were used: a prototype enzyme preparation containing endo-1,4-beta-xylanase (EC 3.2.1.8) and alpha-amylase (EC 3.2.1.1); and a commercial enzyme preparation (Avizyme 1502; Danisco Animal Nutrition DuPont Industrial Biosciences, Marlborough, UK) containing endo-1,4-beta-xylanase (EC 3.2.1.8), alpha-amylase (EC 3.2.1.1) and an alkaline serine protease (EC 3.4.21.62). The xylanase originated from *Trichoderma reesei*, the amylase from *Bacillus amyloliquifaciens* and the protease from *Bacillus subtilis*.

2.2. Experimental design

Four digestibility trials were conducted to evaluate AIDE, AID of AA and AME_n of broilers fed maize–SBM diets without (two trials) or with (two trials) maize-DDGS inclusion, supplemented with an enzyme complex containing xylanase and amylase (XA), or one containing protease, xylanase and amylase (PXA), as compared to a control diet. In each trial, three dietary treatments (control, XA and PXA) were evaluated in diets for broilers from hatch to 21 d of age. Trials 1 and 2, conducted at Massey University (Palmerston North, New Zealand) consisted of six replicates per treatment, with six birds per replicate cage. Trials 3 and 4, conducted at the University of Illinois (Urbana, USA), consisted of eight replicates per treatment, with five birds per replicate cage.

2.3. Experimental diets

Ingredients and calculated diet composition are presented in Table 1. The diets were based on maize and SBM, with slight variations in ingredient composition between the trial sites. Diets were provided in mash form. In each research site, one trial was performed without and one with maize-DDGS inclusion. Maize-DDGS was included at 100 g/kg in diets of trial 2 and 70 g/kg in trial 4. Calculated AME values were constant within site. Titanium dioxide (3.0 g/kg) was added to all diets as an indigestible marker. Diets were manufactured in one batch for each trial and then subdivided in three experimental diets, two of them containing enzymes. Concentrates of the test enzymes were sprayed into a wheat carrier and added to the respective diets in dry form at 0.5 g/kg, after being premixed with 5 g of maize/kg from the diets.