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Temporal restriction of enzyme supplementation in barley-based diets has no effect in broiler performance

V. Cardoso[b,1], A.P. Ferreira[b,1], M. Costa[a,1], P.I.P. Ponte[a], L. Falcão[b], J.P. Freire[b], M.M. Lordelo[b], L.M.A. Ferreira[a], C.M.G.A. Fontes[a], T. Ribeiro[a,*]

[a] *CIISA - Faculdade de Medicina Veterinária, Pólo Universitário do Alto da Ajuda, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal*
[b] *Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal*

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ABSTRACT

It is now well established that exogenous microbial β-glucanases effectively contribute to improve the nutritive value of barley based diets for broilers while they are predominantly effective in the first stages of the production cycle. Here, the performance of broilers fed on barley-based diets supplemented with a β-glucanase enzyme mixture, in part or during the entire length of the production cycle, was evaluated. Six hundred 1-day-old Ross 308 chicks were randomly divided into 4 groups. Animals were fed on a barley-based diet supplemented with a commercial enzyme cocktail for the entire duration of the trial (35 days) or exclusively during the first 11 or 23 days of the experiment. Animals of the control group were fed on the basal diet not containing the microbial biocatalyst mixture. Body weight and feed intake were recorded weekly and weight gain and feed conversion ratios were determined. At the end of the trial, 2 animals were slaughtered to collect gastrointestinal contents to evaluate viscosity and enzymatic activity. Weight/length of gastrointestinal compartments were also recorded. Data revealed that all β-glucanase supplemented groups outperformed non-supplemented birds at day 35. Significant differences in body weight were detected at day 11, suggesting that response to enzyme supplementation occurs, primarily, during the initial stages of broiler growth. In addition, final body weight of animals fed on diets supplemented during the first 11 or 23 days of the experiment was identical to animals supplemented during the entire trial ($P>0.05$). Together the data suggest that in barley-based diets exogenous enzymes act primarily in the earliest periods of broilers growing period and that enzyme supplementation may be restricted to the first 11 days of the production cycle without negatively affecting animal performance. Zymogram analysis allowed detecting β-glucanase activity in the crop of non-supplemented birds at day 35. This activity does not arise from endogenous enzymes present in the feed suggesting colonization of the crop with a β-glucanase secreting microbial population. Although this activity was not sufficient to reduce digesta viscosity in the upper portions of the GI tract when compared with birds exposed during the entire period of the experiment to the exogenous enzymes, it might have contributed to attenuate the antinutritive effects of β-glucans at later stages of animal growth.

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* Corresponding author at: Faculdade de Medicina Veterinária, Universidade Técnica de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal Tel.: +351 213652876; fax: +351 213652889.
E-mail address: teresaribeiro@fmv.ulisboa.pt (T. Ribeiro).
[1] Equal contribution.

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1. Introduction

Barley incorporation in poultry diets is limited mainly by its relatively high content in soluble non-starch polysaccharides (NSP) which may account up to 4.5% of DM (Choct, 1997), in particular β-1,3-1,4 glucans (3.6% DM). These antinutritive factors lead to an increase in digesta viscosity, reducing digesta passage rate and affecting the interaction of the endogenous digestive enzymes with their target substrates, consequently affecting both feed intake and digestibility, respectively (Pettersson and Åman, 1989; Smits and Annison, 1996; Jósefiak et al., 2007a). The prolonged digesta passage rate also promotes a modification in gut physiology such as an enlargement of the gastrointestinal organs, which is detrimental for final carcass yield (Smits and Annison, 1996). Finally, high digesta viscosity favors the proliferation of anaerobic microbes in the upper parts of the gastrointestinal (GI) tract thus affecting animal's health (Jozefiak et al., 2007b). The cumulative negative impacts associated with the presence of soluble NSPs contribute to significantly reduce animal performance. To prevent the detrimental effects associated with the presence of anti-nutritive elements in barley-based diets, commercial enzyme mixtures are currently added to diets promoting the breakdown of soluble NSP (Bedford and Morgan, 1996). Total or partial hydrolysis of barley β-glucans contributes to decrease their degree of polymerization leading to a reduction in digesta viscosity, an improvement of diet digestibility and feed intake, thus contributing to an overall improvement in animal performance (Bedford and Morgan, 1996).

The mode of action of exogenous enzymes used to improve the nutritive value of cereal based diets for poultry remain, nevertheless, not completely understood. β-glucanases act primarily in small intestines reducing digesta viscosity (Fontes et al., 2004, Ponte et al., 2008), thus improving digesta passage rate and nutrient digestibility at the lower parts of the intestine (Choct et al., 1999). Choct et al. (1999) have also shown an increase in starch digestibility especially at jejunum and ileum level. Bedford and Apajalahti (2001) suggested that feed enzymes also act in two different steps: the ileal phase and the caecal phase. In the ileal phase, enzymes act primarily by limiting the increase of digesta viscosity through the hydrolysis of plant recalcitrant polysaccharides. In contrast, in the caecal phase, degradation products generated by exogenous enzymes become the substrates for fermentation by caecal microbes contributing to promote the proliferation of beneficial microflora populations in the bird's intestinal tract (Jamroz et al., 2002; Jozefiak et al., 2006). However, there is today considerable evidence that exogenous enzymes act, initially, at the crop level, soon after entering the bird's digestive tract (Fontes et al., 2004; Ponte et al., 2008; Jozefiak et al., 2006). Fontes et al. (2004) suggested that the lower pH values found in gizzard and proventriculus may contribute to a partial denaturation and inactivation of the exogenous microbial enzymes, suggesting that the maximum of their action occurs on the first portions of the GI tract, such as at crop level. In addition, studies developed by Ponte and colleagues (2008) detected β-glucanase activity in the crop of animals both supplemented and non-supplemented with exogenous enzymes.; Jozefiak et al. (2006) also suggested that the β-glucanase activity starts in the crop and will influence digesta viscosity in the small intestine or even in the caecum.

It is now well recognized that temporal response to enzymatic supplementation may vary among the sources of raw-materials used to prepare broilers diets. For example, in wheat-based diets, exogenous enzymes seem to be more important at later phases of the productive cycle (Fontes et al., 2004). In general, viscosity of wheat-based diets is usually not as pronounced as in barley or oat, and thus exogenous enzymes are not critical to reduce digesta viscosity, but rather to generate novel substrates, in particular xylo-oligosaccharides, which are used by the beneficial bacteria colonizing the final portions of the GI tract (Jamroz et al., 2002; Fontes et al., 2004). Thus, in wheat-based diets exogenous enzymes influence animal performance through the caecal phase, which predominantly occurs at later stages of the productive cycle when a dynamic caecal microbial population is established. Hence, Figueiredo et al. (2012) recently demonstrated that in broilers fed low-viscosity wheat-based diets, diet supplementation with exogenous xylanases may be circumscribed to the final stages of animal growth without compromising animal performance. In contrast, it is now well established that broilers fed barley-based diets display an improved performance in response to β-glucanase supplementation in particularly at the early stages of their life (Newman and Newman, 1988; Rotter et al., 1989; Nahas and Lefrancois, 2001) when the young chick has a poorly developed digestive system. Hence, the production of endogenous digestive enzymes at an early stage of growth is scarce and may hinder feed digestion (Nitsan et al., 1991; Dunnigton and Siegel, 1995; Kirjavainen and Gibson, 1999). Therefore, by effectively contributing to reduce digesta viscosity, exogenous plant cell wall hydrolases contribute to improve the effectiveness of endogenous enzymes enhancing the animal's digestive capacity, particularly when the raw-materials used in animals' diets are highly prone to display higher viscosities. However, the enzymes used in feed supplementation are only effective if they resist to the proteolytic inactivation of endogenous proteases and the low proventriculus pH and high temperatures observed during feed processing.

From the above discussion it is anticipated that in barley-based diets the effect of exogenous enzymes is primarily restricted to the earlier stages of animal growth and it is anticipated that they function primarily in the upper regions of the GI tract. In this study, we investigated the impact of restricting enzyme supplementation in barley-based diets, to different periods of production cycle. This approach will allow determining the critical periods when exogenous enzymes are crucial to improve animal performance.

2. Materials and methods

Bird experiments were conducted in accordance with the Ethics Committee of Interdisciplinary Centre of Research in Animal Health (CIISA, Faculty of Veterinary Medicine, University of Lisbon, Portugal), and approved by the Animal Care

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