OPTIMISING THE DOSE OF XYLANASE IN BROILER DIETS BASED ON WHEAT QUALITY AND ECONOMIC FACTORS

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Summary

The present paper outlines a model developed to determine the most economical xylanase dose rates for use in broiler diets based on wheat. In this model, wheat quality and the subsequent response potential to xylanase addition are estimated via \textit{in vitro} extract viscosity determination in the wheat grain. The extract viscosity data correlated closely with \textit{in vivo} digesta viscosity in the bird. Feed conversion ratio (FCR) response prediction to graded enzyme doses provides a basis for calculation of marginal income versus marginal cost, which can then be used to determine the economic dose optimum for any given situation.

I. INTRODUCTION

The application of xylanase-based enzymes in wheat diets for broilers has become a routine practice in countries where wheat is the most cost-effective cereal. It is recognised that the high viscosity of the intestinal digesta brought about by the soluble arabinoxylans present in wheat is the major problem in these diets. Endo-xylanases are an effective means of reducing viscosity by partially breaking down these non-starch polysaccharide components (Choc\-t and Annison, 1992; Bedford and Morgan, 1996; Smits and Annison, 1996). It has also been shown that differences in the feeding value of different wheats for broilers closely correlate with the \textit{in vivo} digesta viscosity in the chicken gut. Increasing viscosity due to increased content of soluble arabinoxylans will lead to lower wheat AME content and higher FCR in broilers (Classen \textit{et al.}, 1995; Jeroch \textit{et al.}, 1997; Barrier-Guillot \textit{et al.}, 1997).

For the practical application of this knowledge, however, there is a need to develop an \textit{in vitro} tool to conveniently determine wheat quality on small samples, and then use this information to predict responses to xylanase addition. The present paper outlines a model integrating the \textit{in vitro} estimation of wheat quality with response prediction to graded levels of xylanase supplements, where the enzyme dose optimum is determined based on the economics of the responses relative to the cost of the enzyme.

II. EXTRACT VISCOSITY CHARACTERIZES WHEAT QUALITY

Various attempts have been made to establish an \textit{in vitro} method which accurately predicts \textit{in vivo} intestinal viscosity. However, they have generally failed to give an accurate reflection of the \textit{in vivo} result. These methods were adequate to distinguish between very good and very poor quality wheat, but did not always give a close fit to the full range of viscosities seen in the chick assay and consequently in bird performance (Classen \textit{et al.}, 1995; Jeroch \textit{et al.}, 1997). In our laboratory, we have recently developed a more sophisticated approach to this assay by introducing \textit{in vitro} enzymatic digestion steps before extracting the soluble fibre components and measuring viscosity of the extract (aviCheck\textsuperscript{TM} extract viscosity, Finnfedds proprietary method, unpublished).

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This method has been shown to give a good fit to the digesta viscosity measured in vivo, and hence provides the tool to determine wheat (and other viscous cereals) quality in a rapid and comparatively inexpensive laboratory assay (Figure 1).

![Graph showing correlation between digesta viscosity and extract viscosity](image1)

**Figure 1.** Correlation between digesta viscosity and in vitro wheat extract viscosity.

### III. PREDICTING THE XYLANASE RESPONSE POTENTIAL

The next step towards establishing the most economical xylanase dose rate in wheat diets requires a good prediction of the maximum response potential (expressed as broiler FCR or wheat AME) to xylanase addition. It has been shown that the response will depend on the initial quality of the cereal in the diet. In fact there is a strong linear correlation between the wheat extract viscosity and the AME in young broilers, and the response to xylanase is larger in the low AME wheats (Figure 2). It is apparent, therefore, that the determination of extract viscosity provides the most important measure of wheat quality in order to estimate how much response to enzyme addition can be expected. There are a few other factors that have been shown to have an impact on the size of the enzyme response, such as dietary fat type (Dänicke et al., 1995; Chocq et al., 1996), wheat inclusion level or processing temperature (Nissinen, 1994). These factors are worth accounting for in response prediction, but it appears that viscosity is by far the most important single predictor of the enzyme response in wheat diets for broilers (Bedford and Morgan, 1996; Barrier-Guillot et al., 1997).

![Graph showing correlation between wheat AME and extract viscosity](image2)

**Figure 2.** Correlation between wheat AME and in vitro extract viscosity (AME data as determined by Classen et al. (1995) vs. aviCheck™ wheat extract viscosity).

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\(^1\) aviCheck™, trademark Finnfeeds International Ltd
The enzyme used in the trials referred to in this paper was Avizyme 1300 (*Trichoderma longibrachiatum* xylanase, 2500 U/g, *Bacillus subtilisin* protease, 800 U/kg). Dose rate was held constant at 1 kg per tonne. Although xylanase addition alleviated much of the initial variability in wheat AME, there is still a difference between the best and the worst wheats even after enzyme addition. This has been demonstrated for both wheat and barley (Hughes et al., 1996; Kocher et al., 1997), and raises the questions (1) whether higher enzyme dosage would have been beneficial for the highly viscous wheats, and (2) whether the full dose of 1 kg/tonne is necessary for the wheats showing lower viscosity. In order to answer these questions, it is vital to understand the relationship between enzyme dose and bird performance.

IV. Xylanase DOSE-RESPONSE

There is limited published information on xylanase dose responses, and if available, the information is often confined to two dose levels per experiment, which is clearly inadequate to establish an accurate dose response pattern. From recent studies, it is apparent that the xylanase response follows a nonlinear pattern, which can well be described by exponential functions (Figures 3 and 4).

![High viscous wheat](image1)

Figure 3. Feed:gain response in broilers to increasing xylanase dose (Chris Belyavin Technical, UK, broilers 1-42 days).

![Low viscous wheat](image2)

Figure 4. Feed:gain response in broilers to increasing xylanase dose (CNEVA Ploufragan, France, broilers 1-32 days).
It is noteworthy that a similar pattern was exhibited irrespective of the initial viscosity of the wheat. Hence the shape of the curve can be generalised for response prediction purposes. Differences in wheat quality as determined by extract viscosity determination merely result in an adjustment of the maximum response over the performance of the unsupplemented basal diet. Data are available only for the dose response to varying doses of Avizyme *Trichoderma longibrachiatum* xylanase. To date, it has not been established if different xylanases would follow a similar dose response pattern. Therefore one cannot generalise the present findings to cover other xylanase enzymes.

V. ECONOMIC DOSE OPTIMUM

On the basis of the finding outlined above, it is possible to accurately predict the response of a given wheat-based diet to xylanase addition. In the proposed model, (1) extract viscosity is determined as a means to identify the maximum response potential to xylanase, (2) adjustments to this response may be necessary to account for wheat inclusion rate, dietary fat source and processing conditions, and (3) the dose response prediction calculates the expected FCR depending on xylanase dose. This provides the basis for the calculation of the most economical enzyme dose, which is effectively done using the first derivative of the response curve along with prices for feed and enzyme. This gives a stepwise comparison of marginal income (through savings of feed cost with better FCR) *versus* marginal cost of the enzyme. The maximum profit is achieved where the marginal income from the respective last unit of enzyme added just matches the marginal cost of the enzyme. This approach, rather than using maximum performance as the parameter, gives the most relevant decision-making information for the commercial user of xylanase in wheat-based diets for broilers. It is meant to be used as a tool to optimise the benefit from using wheat as well as the xylanase in broiler feeds, and it can be employed to run various simulations on the effects of different wheat qualities or different feed and enzyme prices on the economic dose optimum.

REFERENCES


