NON-STARCH POLYSACCHARIDE ENZYMES AND VISCOSITY:
THE RELATIONSHIP REVISITED!

P.A. GERAERT¹, F. ROUFFINEAU¹ and B. BARRIER-GUILLOT²

Summary

Controversy exists regarding the relationship between wheat nutritional value, mainly AME, and its in vitro viscosity. Different methodologies are used leading to a wide range of values for viscosity. This review proposes to revisit the viscosity – AME relationship as well as its consequences on non-starch polysaccharides (NSP) enzyme response. The relationship between AME and growth performance is also questioned. In order to benefit from enzyme utilization AME has long been preferred to feed conversion ratio for reformulating diets.

I. INTRODUCTION

Measuring the nutritional value, i.e. the energy value and the protein digestibility of feedstuffs and complete feeds, appears to be critical to allow the poultry industry to build valuable dietary formulations. Many chemical analyses have been developed and used in order to estimate the nutritional value of feedstuffs. However, in order to be efficient and useful in practice simple and reliable parameters have to be found.

Wheat is an important cereal for broiler diets in Europe, Canada and Australia. However, it has long been considered to be a highly variable feedstuff, especially for young chickens. Water-soluble NSP, mainly arabinoxylans, can affect wheat energy value through an increase in intestinal viscosity but recent publications have reported conflicting results regarding the relationship between soluble NSP content, in vitro viscosity, AMEn and growth performance (Dusel et al., 1998 ; McCracken et al., 1998 ; Francesch et al., 2000).

The NSP-enzymes have been developed to overcome intestinal problems. However, enzyme users would benefit if they could predict the potential value of using enzymes with a particular wheat, or even knowing the magnitude of the energy improvement that could be obtained for reformulation purposes.

This short review proposes to summarize the different methodologies used to measure viscosity either in vitro or in vivo and to investigate the recent data dealing with the relationships between viscosity measurements and nutritional value, energy digestibility and growth performance. The effect of NSP-enzymes will be reviewed according to the range of wheat genotypes and their in vitro viscosities.

II. VISCOSITY : METHODOLOGIES AND VALUES

For enzyme users (e.g. formulators, nutritionists), it is often difficult to get a clear view of viscosity values. Indeed, various methodologies are used by different laboratories and this leads to a wide range of viscosities : from 1.0-2.5 to 5-4 to 100 cPs. In order to better understand published results it is valuable to summarize the different ways in which in vitro viscosities of raw materials and complete diets are measured as well as the values for in vivo intestinal viscosities usually measured at the jejunum or ileum.

¹Aventis Animal Nutrition, 42 Avenue Aristide Briand, 92164 ANTONY, France.
²Institut Technique des Céréales et des Fourrages, 91720 BOINGEVILLE, France.
In vitro viscosities:

The wheat water extract viscosity measurement proposed by Grosjean et al. (1999) follow these main steps: grinding the grains at 0.5 mm, soaking with desionised water, centrifugation and denaturation of the endogenous activities by boiling at 100°C. The viscosity is then determined with a capillary-based viscometer. The specific viscosity (SV) is expressed in mL/g DM and is derived from the relative viscosity (RV) (SV = (RV-1)/sample weight).

Real and potential viscosities, relative to acetate buffer pH4.5, are measured using a rotative viscometer (Carré et al, 1994). Denaturation of endogenous xylanase activities is obtained with boiling ethanol.

Finally, Huyghebaert and Mombaerts (2000) reported that a proteolytic treatment improves the correlation between measured viscosity and wheat nutritional value.

In vivo viscosities:

Usually the chyme is collected after slaughtering the animals between 16 and 35 d of age. The intestinal contents from the duodenum, jejunum or ileum, proximal or distal, are collected through gentle manual or mechanical pressure on the intestines. The samples are homogenized, centrifuged and the viscosity of the supernatant is then determined (Scott et al., 1998; Barrier-Guillot et al., 1998).

Another method has recently been proposed by Francesch et al. (2000) which consists not only of measuring the digesta viscosity but also the quantity, volume or dry matter of the supernatant released from digesta during centrifugation.

III. GENETIC VARIATION IN VISCOSITY AND NUTRITIONAL VALUE

Barrier-Guillot et al. (1998) considered 19 wheat samples from France and Great Britain, chosen to cover a wide range of in vitro viscosities (SV from 1.4 to 7.3 mL/g DM). The wheat AMEn values ranged from 9.96 to 14.06 MJ/kg DM. Whereas water-extract viscosity was highly correlated with jejunal viscosity (r > 0.95), the correlation between in vitro viscosity and AMEn only reached 0.65 which means that less than 50% of the variation in AMEn could be attributed to viscosity. However, the main conclusion was that low viscosity varieties seem to have high AMEn whereas wheat varieties with the highest viscosities can lead to variable AMEn values. In order to complete this study Skiba et al. (1999) used 21 wheat varieties and also demonstrated that the correlations between AMEn and either SV or jejunal viscosity were weak : -0.58 and -0.57 respectively. Such results mean that viscosity, measured either in vitro or in vivo, was not the only factor to explain variability in wheat energy values. However, from these studies it was possible to define a threshold in viscosity (SV of 4.0 mL/g DM) below which wheat AMEn is less variable and relatively high while above it, the AMEn was usually lower and highly variable (Figures 1a and 1b).

Scott et al. (1998) studying 9 wheat cultivars grown in replicate in three locations and two crop years demonstrated a significant effect of location on feeding value and subsequent growth performance in broilers. Recently, McCracken and Bedford (2000) demonstrated the importance of diet composition in studying both the wheat AME value and its response to enzyme supplementation. Indeed, the enzyme response was lower when commercial-based diets were used compared with a cereal-casein-based diet. Also, animal fats rich in saturated fatty acids have long been reported to enhance the detrimental effect of wheat viscosity.
IV. VISCOSITY AND RESPONSE TO ENZYME

The NSP-enzymes or hemicellulolytic and cellulolytic enzymes cover a wide range of enzymes. Voragen (2000) stressed the range of β-glucanases required to ensure complete breakdown of β-glucans. The same applies to arabinoxylans and even to more complexed cell wall components. Thus, trying to generalize the effect of NSP-enzymes through the action of one particular product is rather unrealistic. It would be more useful to relate the exact enzyme composition to the effect on different components. The presence of endogenous xylanase activities in wheat grains, and the recently discovered xylanase inhibitors, might be critical in explaining the somewhat weak effect of NSP-enzymes on high quality wheats (McLauchlan et al., 1999).

The NSP-enzymes have often been used to reduce intestinal viscosity which should, thus, improve wheat nutritional value. However, whereas the reduction in viscosity is greater with high- than with low-viscous wheats, the improvement in feed to gain ratio may be similar (Dusel et al., 1998). These authors also observed that the enzyme effect was greater between 29 and 35 d of age than between 1 and 28 d of age. Francesch et al. (2000) demonstrated that
the quantity of supernatant released from digesta by the action of enzymes was better correlated to feed conversion than was the supernatant digesta viscosity.

V. CONCLUSIONS

New criteria need to be developed or a more global approach used. An example is the NIRS technique which has been developed successfully to predict amino acid digestibility. Recently, a new measurement has been proposed by Chesson (2000) which appears to be better linked to assessing enzyme potential: the in vitro release of arabinoxylan oligomers. However, not only improvements in AME have to be considered. Reduction in the variability of bird performance and the effect on amino acid availability, often resulting in improved carcass quality, should be considered when evaluating the potential benefits of enzymes.

REFERENCES