The Nutritive Value of New Season Grains for Poultry

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Summary
The nutritive value of cereal grains for poultry generally changes during storage. The apparent metabolisable energy value of some grains improves after 3–4 months of normal storage and feed conversion efficiency of birds fed these grains also improves. With some samples of wheat and barley, however, the changes may be small or nil, especially when they have a high initial AME value. The new season grain phenomenon is probably due to ability of the endogenous glycanases of the grain to break down viscous non-starch polysaccharides (NSP) during storage. These endogenous glycanases are present in variable amounts, in some cases absent in the grain; they most likely become active during high-moisture storage at the time of harvest. The extract viscosity value of grains measured shortly after harvest appears to give good indication of their potential nutritive value for poultry. This paper presents experimental data on the effect of storage on the nutritive quality of wheat, barley, triticale and sorghum for poultry and discusses the possible mechanism of action of this phenomenon.

Introduction
Energy is the most expensive component of feedstuffs for monogastrics and large amounts of cereal grains are used for this purpose throughout the world. Australia alone uses about 10 million tonnes of cereal grains for stock feed each year, 19% of which is used in the chicken meat industry (Meyers Strategy Group Report 1995). Energy utilisation is of paramount importance in poultry and is usually measured by the amount of energy from the feed metabolised in the animal (apparent metabolisable energy; AME). The AME values of cereal grains, however, vary greatly, especially at the time of harvest. Thus the use of newly harvested cereal grain as the main energy source in poultry diets is more problematic compared to stored grains, often depressing bird performance and causing wet droppings. The underlying cause of this phenomenon is the subject of much speculation.

Post-harvest change in the apparent metabolisable energy value of wheat for broiler chickens

Amongst the cereal grains, wheat is regarded as having the most variable composition (Bolton and Blair, 1974). The AME value of wheats for poultry, for instance, has been reported to range from 12.1 to 16.6 MJ/kg DM for North American wheats (Sibbald and Slinger, 1962; Schumaier and McGinnis, 1967), 13.0 to 15.2 MJ/kg DM for U.K. wheats (Wiseman and Inbor, 1990) and 10.4 to 15.9 MJ/kg DM for Australian wheats (Mollah et al. 1983; Rogel et al. 1987). When some of these wheats are included above 50% in broiler diets, the birds have sticky and watery droppings accompanied by poor growth and feed efficiency. This has been described as the low-ME wheat phenomenon (AME <13MJ/kg DM). The occurrence of low-ME wheats is influenced more by environmental factors, such as geographical locations of growth and temperature during grain filling than by varieties (Choct, 1995).

We chose 6 wheat samples from 1994/1995 harvest which were low in AME at time of harvest, to examine any post-harvest change in their nutritive quality (Table 1). The viscosity of the wheat extract was also determined at the time of the first AME trial (one month after harvesting the wheats) as a possible predictor of nutritive quality. The AME values had improved after four months of storage, but the magnitude of improvement differed amongst the samples and ranged from nil to 3 MJ/kg. These changes were closely reflected in the feed conversion ratios of the birds. The extract viscosity was not correlated with AME or FCR values shortly after harvest, but after four months of normal storage the relationship between these parameters
became extremely close (Figures 1 and 2, \( r = -0.92, r^2 = 0.84 \) for extract viscosity vs. AME; \( r = 0.98, r^2 = 0.97 \) for extract viscosity vs. FCR). The extremely high negative correlation between the extract viscosity and the AME of the wheat samples after four months of storage (Figure 1) was in sharp contrast to the lack of relationship for the new season samples.

The nutritive value of cereal grains for poultry is inversely related to the level of NSP (Choct and Annison, 1990; Annison, 1991). This finding has led to the widespread use of feed enzyme supplements as a means of enhancing nutrient digestibilities in monogastric animals. Grains in storage consist of at least two living entities: the grains themselves and the microorganisms colonising them. Both entities induce various degrees of physical and chemical changes during storage. The microbial aspect of the changes is not the scope of this paper, but the activity of the endogenous enzymes of the grain will be discussed.

With increased moisture or storage time, these enzymes can act on the cell walls (predominantly NSP) in a similar manner to feed enzymes, resulting in improved nutritive value of the cereals for poultry. The extract viscosity reflects largely the soluble NSP of the grain. In the current experiment we determined the viscosity of the samples by extracting them in buffer and measuring the viscosity with a viscometer. The procedure did not include steps to deactivate the endogenous glycanases, which may have been present in the samples. It was therefore possible that during the extraction procedure, the endogenous glycanases were activated, accelerating the breakdown of the soluble NSP and reducing the viscosity. However, glycanase activity may differ between samples due to varieties and/or geographical areas where the wheats are grown. If there were none, for example, in some wheats, then the extract viscosity would remain high throughout the extraction procedure. It is not known whether these glycanases remain active in the gastrointestinal tract of the chicken.

Although the data presented here are not extensive, the results suggest that post harvest change of the nutritive quality of wheat may be predicted using this extract viscosity method.

<table>
<thead>
<tr>
<th>Grain Sample</th>
<th>Extract Viscosity (mPa.s)</th>
<th>AME (MJ/kg DM)</th>
<th>FCR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 month</td>
<td>4 months</td>
</tr>
<tr>
<td>Wheat 1</td>
<td>4.8</td>
<td>10.14</td>
<td>12.73</td>
</tr>
<tr>
<td>Wheat 2</td>
<td>4.1</td>
<td>10.31</td>
<td>13.30</td>
</tr>
<tr>
<td>Wheat 3</td>
<td>4.8</td>
<td>12.35</td>
<td>13.95</td>
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<tr>
<td>Wheat 4</td>
<td>12.5</td>
<td>11.18</td>
<td>11.10</td>
</tr>
<tr>
<td>Wheat 5</td>
<td>3.8</td>
<td>12.02</td>
<td>13.94</td>
</tr>
<tr>
<td>Wheat 6</td>
<td>8.2</td>
<td>11.80</td>
<td>11.98</td>
</tr>
</tbody>
</table>

Table 1 Effect of storage for 1 month or 4 months on the nutritive value of wheat for broiler chickens and its predictability by viscosity estimated \textit{in vitro}.

Figure 1 Relationship between AME (four months of storage) and extract viscosity (time of harvest).

Figure 2 Relationship between FCR (four months of storage) and extract viscosity (time of harvest).
Post-harvest changes in nutritive value of other cereal grains for poultry

The nutritive value of maize and sorghum for poultry is usually predictable. During a recent survey to examine the nutritive value of wheat for broiler chickens, the same batch of maize was used as a control diet for two years (Choct, unpublished data). The average AME value of the maize after ten separate determinations over two years was 16.4 ± 0.14 MJ/kg DM. Bartov (1996) reported that AME of maize determined over nine years (110 months) did not exhibit any change. The first determination was done one month after harvest. Both studies indicate that the AME of maize is not influenced by storage conditions, at least for the samples tested. However, it is not known whether different varieties of maize would undergo post-harvest changes. It is well documented that high (circa 40%) moisture storage of barley, oats and wheat can increase their nutritive quality (Svihus et al. 1997). The following data (Table 2) show the effect of storage on the nutritive value of a high AME wheat (Trident), a low AME wheat (Janz) and other cereal grains including barley, triticale and sorghum. As indicated by the results given in Table 1, the nutritive value of the samples improved with storage, but the degree of improvement varied widely. With the Janz wheat and two of the barley samples (SA and WA) there was a slight improvement in their AME values, but these remained very low. There was even a slight deterioration of the AME of the Chebec variety of barley after three months of storage. The area of bright fluorescence representing cell walls of the grains was 22% for Janz wheat, 11% for Trident wheat and 55% for Chebec barley.

The possible mechanism underlying the new season grain phenomenon and strategies minimising its effect on poultry production

The use of feed enzymes to improve the nutritive value of cereal grains for poultry has become a widespread practice today. The feed enzymes are mainly glycanases, e.g., NSP-degrading enzymes because NSP in cereals impair bird performance and cause wet litter problems (Antoniou et al. 1983; Bedford and Classen, 1992; Choct, 1993). During our survey of the nutritive value of Australian wheats for poultry (Choct et al. 1995), we evaluated a wheat which had an AME value of 9.2 MJ/kg DM, the lowest AME value of wheat obtained during the project. After a year of storage, the AME value of the wheat increased to 12.0 MJ/kg DM, and thereafter remained unchanged for 3 years, but enzyme (xylanase) supplementation of diets containing this wheat increased the AME value to 14.9 MJ/kg DM. This suggests that NSP are responsible for the low-ME value of the wheat.

Mature cereal grains contain various amounts of glycans and glycosidases (Conchie et al. 1968; Lee and Ronalds, 1972), although the levels are low. After harvest, grains go into an unstable biological equilibrium, influenced by changes in their endogenous biochemical reactions. An important factor influencing these reactions is the availability of moisture. The water content of grains can be very high at harvest. Svihus et al. (1997) in Scandinavia reported that the dry matter content of barley, oats and wheat at harvest was 54, 75 and 69%, respectively. Slow degradation of the NSP and starch by endogenous enzymes is possible under these conditions. Thus, feed conversion efficiency and

<table>
<thead>
<tr>
<th>Grain</th>
<th>AME (MJ/kg DM)</th>
<th>FCR</th>
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<tbody>
<tr>
<td>Wheat (Janz)</td>
<td>12.64</td>
<td>1.98</td>
</tr>
<tr>
<td>Wheat (Trident)</td>
<td>14.33</td>
<td>1.77</td>
</tr>
<tr>
<td>SA Barley</td>
<td>11.66</td>
<td>2.36</td>
</tr>
<tr>
<td>WA Barley</td>
<td>11.48</td>
<td>2.77</td>
</tr>
<tr>
<td>Barley (Chebec)</td>
<td>12.45</td>
<td>2.45</td>
</tr>
<tr>
<td>Triticale (Tahara)</td>
<td>13.76</td>
<td>1.97</td>
</tr>
<tr>
<td>Sorghum</td>
<td>15.97</td>
<td>2.06</td>
</tr>
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dry matter digestibility were significantly higher in broiler chickens fed barley, oats and wheat which were high-moisture stored compared to those fed the same grains which were dry stored (Svihus et al. 1995; 1997). The improvement in bird performance was related to reduced soluble dietary fibre (NSP) content and extract viscosity of the grains (Svihus et al. 1997). Other well-documented cases in relation to high-moisture storage are the large improvements in performance of birds fed germinated (Fengler et al. 1990), water-treated (Fry et al. 1958; Fernandez et al. 1973) or rain damaged (Choc and Annison, 1993) grains. Germination of wheat also resulted in a large decrease in the molecular weight and viscosity of the NSP with no noticeable amounts of monosaccharides released (Mares and Stone, 1973; Fincher and Stone 1974; Corder and Henry, 1989).

The improvement in bird performance by enzyme supplementation is not due to a complete breakdown of the NSP to monosaccharides and a subsequent absorption of the released sugars by the animal. It is due to the partial cleavage of the polymers, which removes their anti-nutritive activities. Therefore, even a minute amount of enzyme activity capable of cleaving the NSP once or twice could result in a large increase in nutrient digestion and absorption in the gut.

**Conclusion**

The ‘new season grain problem’ is a well-known phenomenon in the poultry industry, but its mechanism of action is not understood. Results presented in this paper suggest that the nutritive value of some grains improve markedly after 3-4 months of storage. The improvement, however, is not universal. It appears to be due to the activation of the endogenous glycanases in the grain during storage, accelerating the breakdown of soluble NSP.

A clear understanding of the mechanism of the new season grain phenomenon will bring about a number of benefits, including strategic use of various grains, increased accuracy in least-cost feed formulations, and cost effective use of enzyme technology.

**Acknowledgments**

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**References**


