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Nutritive Value for Pigs and Poultry of Barley Cultivars Varying in Beta-Glucan Content and Starch Characteristics

A thesis presented in partial fulfilment of the requirements for the degree of Master in Applied Science (Animal Science) at Massey University, Palmerston North, New Zealand

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Abstract

The nutritive value of a hulled conventional barley (NB) cultivar, four hulless barley cultivars (C0, C1, C2 and C3) that varied in fibre and β-glucan contents and starch characteristics (waxiness), as well as a wheat (WT) was determined for pigs and broiler chickens. In the pig trial, the apparent digestible energy (ADE) of NB, C0, C1, C2, C3 and elsewhere WT was determined. In the broiler trial, the apparent metabolizable energy (AME) content and ileal amino acid digestibility of NB, C1, C2, and C3 were examined without or with exogenous β-glucanase supplementation.

The pig trial utilised 15 growing male pigs (average weight, 32.5 kg). The assay diets contained 99.75% of the test ingredient and were fortified with minerals and vitamins. The total faecal collection method was used. Faeces were collected, weighed and sub-sampled daily for 5 days after a week of acclimatisation period. The apparent digestible energy (ADE) of the four hulless barley cultivars ranged from 15.83 to 16.48 MJ/kg DM. The hulless barley cultivar C2 was significantly different ($P < 0.05$) from hulled NB and wheat WT. However, hulless barley cultivars C0, C1, and C3 did not differ ($P > 0.05$) significantly from each other and, even though they were numerically higher than values for NB and WT. In terms of the apparent digestibility coefficient (ADC), hulless barley C1 and C2 had the highest values (0.8795 and 0.8837, respectively), but these were not significantly different ($P > 0.05$) from hulless barley C0 and WT. The lowest ADE and ADC values were determined for hulled barley (15.59 MJ/kg and 0.8257, respectively). It was observed that the hulless barley with high non-starch polysaccharides (NSP) concentrations had the lowest ADE contents.

In the broiler trial, the influence of exogenous β-glucanase (Allzyme BG; Alltech, Inc., Nicholasville, KY) supplementation on the apparent metabolisable energy (AME) and apparent ileal digestibility coefficient (AID) of amino acids in a normal, hulled barley cultivar and three hulless barley cultivars was investigated. The assay diets contained 96.3% barley, and were fortified with

minerals and vitamins. Titanium oxide was included as an inert marker for the estimation of ileal amino acid digestibility. The AME of barley was influenced (P < 0.001) by the cultivar type. The AME of the NB was determined to be 12.68 MJ/kg DM, while the values for the three hulless cultivars were 10.87, 12.92 and 10.20 MJ/kg DM, respectively. These data suggest that starch characteristics and β-glucan contents are additional factors that may influence the available energy in barley. β-glucanase supplementation improved (P < 0.001) the AME of all barley cultivars, with improvements ranging from 5.4 to 21.9%. The cultivar type had no influence (P>0.05) on the AID of most amino acids. The average AID of 15 amino acids in the hulled barley and the three hulless cultivars were 0.70, 0.68, 0.72 and 0.73, respectively. Enzyme supplementation improved (P < 0.001) the AID of all individual amino acids in the four barley cultivars, with increases in individual amino acid digestibility ranging from 18.1% for threonine to 11.4% for arginine. The average AID of 15 amino acids in the un-supplemented and supplemented cereal was 0.66 and 0.75, respectively.

Overall, it was observed that the barley cultivars, which were high in NSP and β-glucan, had lower energy digestibility for pigs and broiler chickens. Hulless barley C2 that is characterized as having normal starch was found to have the highest available energy for both species.

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List of Abbreviations

AA	**Amino acid**
ADC	**Apparent digestibility coefficient**
ADE	**Apparent digestible energy**
ADG	**Average daily gain**
AID	**Apparent ileal digestibility**
AOAC	**Association of Official Analytical Chemist**
Ala	**Alanine**
Arg	**Arginine**
Asx	**Aspartic Acid**
BGU	**β-Glucanase Unit**
C0	**Cultivar 0**
C1	**Cultivar 1**
C2	**Cultivar 2**
C3	**Cultivar 3**
CP	**Crude protein**
DE	**Digestible energy**
DF	**Dietary fibre**
DM	**Dry matter**

EZ	**Enzyme**
FCR	**Feed conversion ratio**
FI	**Feed intake**
GIT	**Gastro intestinal tract**
Glu	**Glutamic Acid**
Gly	**Glycine**
His	**Histidine**
IDF	**Insoluble dietary fibre**
Ile	**Isoleucine**
Leu	**Leucine**
Lys	**Lysine**
ME	**Metabolisable energy**
MJ	**Mega joule**
NSP	**Non-starch polysaccharides**
Phe	**Phenylalanine**
Pro	**Proline**
Ser	**Serine**
SCFA	**Short chain fatty acid**
Thr	**Threonine**
$Ti0_3$	**Titanium oxide**
Tyr	**Tyrosine**
Val	**Valine**

WG	**Weight gains**
WT	**Wheat**

Chapter One

General Introduction

Barley (*Hordeum vulgare. L*) ranks amongst the top four crops in world grain production after maize, wheat, and sorghum. Barley contributes significantly to the world's food supply, for both human and livestock consumption. The main use of barley is as a malt product for human consumption. As an animal feed, barley is used for the feeding of both ruminant and non-ruminant animals. In non-ruminant animals, however, the use of barley has been limited, particularly in poultry and young pigs. This is due to the limited ability of poultry and young pigs to digest the fibre and non-starch polysaccharides (NSP) in barley (Bach Knudsen, 1997). Therefore, in these diets, the addition of exogenous β-glucanase has been recommended to improve digestibility.

Compared to maize and wheat, conventional hulled barley is nutritionally less preferred due to its high fibre and NSP contents, which lowers energy and nutrient digestibility (Xue *et al.*, 1997) and causes poor performance in monogastric animals. Barley is used extensively in pig and poultry diets, even though the feeding value is lower that that of corn, wheat, and sorghum. Hulless cultivars of barley are now available and these have better nutritive value than the hulled cultivars. In hulless cultivars, the hull is less firmly attached to the kernel and consequently is detached during threshing, resulting in a low fibre content (Thacker *et al.*, 1998). This makes the hulless barley more digestible compared to hulled barley. A number of studies have shown that hulless barley has a better digestibility of nutrients and more available energy than hulled barley (Baidoo & Liu, 1998; Sauer *et al.*, 2002).

The presence of the waxy gene in barley, as in other grains, produces a starch that is predominately amylopectin. In barley, the gene is also associated with an increase in β-glucan and extract viscosity (Wood *et al.*, 2001). The ratio of amylose to amylopectin in the barley endosperm is an important grain characteristic affecting feed quality (Bhatty, 1993). For most barley, the content of amylose is much lower than the content of amylopectin. Low amylose waxy barley is known to have a lower nutritional value than normal waxy barley due to the lower amylose to amylopectin ratio. Waxy barley with a high amylopectin content is more digestible than both low and normal hulless waxy barley cultivars (Tester *et al.*, 2004).

The nutritional value of the barley and the adverse effects of β-glucans on nutrient digestibility and the performance of poultry can be improved by supplementation with exogenous β-glucanases (Xue *et al.*, 1997) The use of β-glucanase is reported to improve the nutritive value of barley for piglets, but the results are variable depending on the cultivar type (hulled vs. hulless) and the waxiness of the barleys. It is generally reported that older pigs are not affected by β-glucan (Campbell & Bedford, 1992) and quite often β-glucanase addition causes only a small improvements in nutrient digestibility in pigs (Graham *et al.*, 1989).

Results from two trials conducted with pigs and broiler chickens are reported in this thesis. The digestible energy of four hulless barley cultivars, one wheat, and one conventional hulled barley was measured in pigs (Chapter 3) using the total excreta collection method. In the broiler chicken trial (Chapter 4), the apparent metabolisable energy as well as the amino acid digestibility of three hulless barley cultivars and one conventional hulled barley cultivar were measured. The influence of β-glucanase supplementation on these nutrient utilisation parameters in broiler chickens was also examined. The over all discussion and conclusions of these two findings are presented in chapter five.

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