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A note on the effect of the composition of barley produced at different locations on performance of growing pigs

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Location of production has been shown to affect the nutritive value of barley for growing pigs, but there is a lack of information regarding the effect of this factor on pig performance. The barley variety "Riviera" was produced at nine different locations in Northern Ireland and formulated into diets (barley, soyabean meal and tallow at 650, 283 and 30 g/kg, respectively) for growing pigs. Diets were offered *ad libitum* to a total of 72 individually housed pigs from 8 to 11 weeks of age. Average start and end weights were 19 and 34 kg, respectively. Location of production had no significant effect on animal performance although a wide range was observed, which may be important under commercial conditions. Barley specific weight was not strongly correlated ($r^2 < 0.10$) with any performance trait indicating that an alternative means of predicting the nutritive value of barely for pigs is required. A significant positive relationship was observed between barley β-glucan concentration and feed conversion ratio ($r^2 = 0.65$).

Keywords: barley; location; performance; pigs

Introduction

The results of previous experiments (McCann *et al.,* 2001a; McCann, McEvoy and McCracken, 2001b) indicated that the barley variety Riviera was slightly superior to the variety Dandy in terms of overall digestibility of dry matter (DM) and energy and in digestible energy (DE) concentration. Differences were also observed in digestibility assessments at both the ileal

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and overall level resulting from location of production of both Riviera and Dandy. The soil type and cultivation location can affect the nutritive value of barley (Valaja *et al.*, 1997). However, there is a lack of information in the literature regarding the effect of location of production of spring barley on the nutritive value and performance of growing pigs offered barley-based diets.

Materials and Methods

Performance trial

Seventy-two crossbred (Large White × Landrace) pigs were selected at 46 days of age on the basis of litter weight and gender and allocated to nine treatments in eight blocks. Pigs were randomly allocated to individual pens and offered a commercial diet for 10 days to allow adjustment to surroundings. The pigs were weighed on two consecutive days prior to the start of the experiment. On the first day of the 3-week experimental period, pigs were allocated to experimental diets formulated from Riviera barley produced at nine locations across Northern Ireland (Coleraine, Limavady, Londonderry, Castlewellan, Donaghcloney, Greyabbey, Armagh, Comber and Killough). One sample of barley (250 kg) was obtained for each location. Diet formulation (g/kg) was: barley 650, soyabean 283.4, limestone 12, dicalcium phosphate 8.8, salt 3.3 tallow 30, binder (Exal-H; Groupo Tolsa, France) 8.5, minerals and vitamins (Pig 2.2; Nutec Ltd, Dublin) 2.0, and titanium oxide (used as indigestible marker) 2.0.

The pigs were arranged in a nine (location) × eight (block) randomised block design. Block 1 consisted of the nine heaviest male pigs, block 2 consisted of the nine heaviest female pigs, block 3 consisted of the next nine heaviest males, block 4 consisted of the next nine heaviest females and so on until block 8. This gave eight pigs per treatment (4 male, 4 female). Pigs were fed *ad libitum* and intake was measured daily and weight gain calculated weekly.

Analysis of variance for initial weight, final weight, live-weight gain (LWG), daily intake (DMI) and feed conversion ratio (FCR) (based on DMI) was conducted using Genstat 5 (1993). The model included the effect of block and location and the individual pig was the experimental unit. Simple regression analysis was carried out to establish relationships between various performance traits and barley characteristics.

Samples of barley and diets were dried at 80 °C, milled through a 1 mm screen and analysed for DM, crude protein (CP), oil, neutral detergent fibre (NDF) and ash (Association of Official Analytical Chemists, 1990). Specific weight (SW) of the barley was measured using a chondrometer. The β-glucan concentration of the barley was determined using the Megazyme mixed-linkage β-glucan assay kit (Megazyme International Ireland Ltd) developed by McCleary and Codd (1991). *In vitro* viscosity of the barley was determined using a Brookfield digital viscometer according to the method of Bedford and Classen (1993). Gross energy (GE) was determined using an isoperibol bomb calorimeter (Parr, Model 1271). Starch concentration was determined using the Megazyme International Ireland Ltd. total starch assay kit (amyloglucosidase/α-amylase method; McCleary, Gibson and Mugford, 1997). Total non-starch polysaccharides (NSP) were determined by gas chromatography (Pye Unicam 304) according to Englyst *et al.* (1992). Amino acid analysis was carried out on a LBK4400 Analyser.

Results

Chemical composition

The composition and physical parameters of barley are shown in Table 1. There was a wide range in the values for CP, oil, β-

Table 1. Chemical composition and physical parameters of barley (dry matter basis) grown at nine locations across Northern Ireland

Component[1]	Production location								
	Coleraine	Limavady	Londonderry	Castlewellan	Donaghcloney	Greyabbey	Armagh	Comber	Killough
CP (g/kg)	109	101	105	94	107	108	114	74	132
NDF (g/kg)	213	211	221	207	234	196	236	204	245
Oil (g/kg)	20	24	12	12	22	16	15	16	23
Ash (g/kg)	23	21	22	23	23	19	23	18	19
Starch (g/kg)	549	597	568	568	559	560	600	611	536
Total NSP (g/kg)	171	170	171	168	184	167	170	160	181
β-glucan (g/kg)	34.1	40.3	44.0	38.6	43.2	45.4	43.7	33.6	48.5
GE (MJ/kg)	18.5	18.5	18.4	18.3	18.5	18.6	18.5	18.3	18.8
SW (kg/hL)	61.2	69.0	69.4	65.0	62.4	66.2	61.8	68.8	68.8
Viscosity (mPa s)	4.3	14.2	3.9	14.3	9.7	15.8	10.8	12.1	6.5
Lysine (g/kg)	8.1	7.7	7.8	7.1	8.1	7.9	8.3	5.7	9.8
Total essential amino acids (g/kg)	41.7	37.0	40.1	35.7	39.4	29.7	40.8	28.4	47.8
Total non-essential amino acids (g/kg)	60.7	57.4	62.6	54.7	61.3	62.3	66.2	42.1	78.1

[1] CP = crude protein; NDF = neutral detergent fibre; Total NSP = total non-starch polysaccharide; GE = gross energy; SW = specific weight.

glucan, NDF, ash, lysine, total essential and non-essential amino acids, and viscosity.

The analyses of the diets as formulated are shown in Table 2. The variation in composition was reduced compared with the variation in the barley used, especially for components that showed large variation among the production locations. The range for gross energy concentration was small. The lysine concentration (mean 11.9 g/kg DM) ranged from 11.2 (for Limavady) to 13.0 g/kg DM (for Greyabbey).

Animal performance

The effect of location of production of barley on animal performance is shown in Table 3. Mean values for initial and final live weights were 18.9 and 34.0 kg, respectively. The overall means for DMI, LWG and FCR were 1.32 kg/day, 0.72 kg/day and 1.84 kg/kg, respectively. While there was a considerable range in performance among the production locations for each of the traits none of these approached statistical significance (Table 3).

The only significant relationship detected between performance traits and chemical composition of the barley used in the formulation of diets was a positive relationship between β-glucan concentration and FCR ($y = -0.012x + 2.348$, s.e. (of regression coefficient) 3.19, r^2 0.65, $P < 0.05$. The relationship between barley SW and performance was not significant for any performance trait ($r^2 < 0.10$).

Discussion

The chemical composition and specific weight values of the barley produced at the nine locations were within the expected range (Kong *et al*., 1995; McDonald, Edwards and Greenhalgh, 1995) as were the values obtained for animal performance (Middaugh *et al*., 1989; Baidoo, Liu and Yungblut, 1998). The absence of any significant effect of location on per-

Table 2. Chemical analysis of formulated diets based on barley grown at nine locations across Northern Ireland (g/kg dry matter)

Component[1]	Production location								
	Coleraine	Limavady	Londonderry	Castlewellan	Donaghcloney	Greyabbey	Armagh	Comber	Killough
CP	218	213	227	225	237	229	231	204	234
NDF	158	171	156	165	167	159	159	156	165
Oil	51	55	54	54	56	54	55	51	55
Ash	73	73	71	71	80	73	76	69	75
Starch	368	366	365	356	341	359	351	378	337
GE (MJ/kg)	18.7	18.7	18.7	18.7	18.8	18.8	18.7	18.6	18.9
Lysine	11.3	11.2	11.4	12.3	12.5	13.0	11.7	11.7	12.4
Total essential amino acids	78.5	77.7	80.0	82.9	85.3	90.2	79.6	80.7	87.3
Total non-essential amino acids	112.7	110.8	115.1	118.3	122.7	127.7	113.2	115.7	125.4

[1]See footnote to Table 1.

Table 3. The effect of location of barley production on pig performance[1]

	Initial weight (kg)	Final weight (kg)	DMI (kg/day)	LWG (kg/day)	FCR
Coleraine	18.93	33.76	1.37	0.700	1.97
Limavady	19.11	35.14	1.38	0.751	1.83
Londonderry	18.88	33.56	1.31	0.699	1.88
Castlewellan	18.89	34.06	1.31	0.722	1.83
Donaghcloney	18.47	33.44	1.31	0.716	1.86
Greyabbey	18.66	34.00	1.26	0.731	1.72
Armagh	19.38	34.94	1.34	0.741	1.81
Comber	18.84	33.19	1.30	0.683	1.92
Killough	19.06	33.94	1.29	0.735	1.76
s.e.	0.497	1.076	0.059	0.038	0.067
P	0.938	0.933	0.899	0.934	0.318

[1] DMI = dry matter intake, LWG = live-weight gain, FCR= feed conversion ratio (dry matter basis).

formance parameters is attributed to the relatively high variability in animal performance. The wide range in FCR (1.72 for Greyabbey to 1.97 for Coleraine) could be important in a commercial situation as diets formulated from barley grown at Greyabbey would result in lower cost of production if the difference observed was real. It would appear that the eight replicates per diet in this study were not adequate. The power of the experiment was calculated for FCR and it was found that the power of detecting a 5, 10, 15 or 20% difference was 0.17, 0.51, 0.84 and 0.98 respectively.

Regression analyses revealed a positive relationship between β-glucan concentration and FCR, which was unexpected as it has been reported that a high β-glucan concentration has a detrimental effect on DE concentration of barley diets (Taylor *et al*., 1985). De Lange (2000) suggested that the anti-nutritive effect of NSP only becomes apparent when a high level is included in the diets of pigs. As the barley used for this study contained a low level (33.6 to 48.5 g/kg DM) of β-glucan, it is therefore not surprising that anti-nutritive effects were not observed. It has been reported that almost 100% of the β-glucan is digested in the small intestine, contributing to the energy available to the pig (Graham, Hesselman and Aman, 1986). Valaja *et al*. (1997) also suggested that β-glucans may have a positive influence on the nutritive value of barley for pigs as they found a positive relationship between β-glucan concentration and *in vitro* digestibility of CP (r^2 0.37). Furthermore, Fairbairn *et al*. (1999) reported a positive relationship between β-glucan concentration and barley digestible energy but the relationship was weak with (r^2 0.15). These workers observed a stronger negative relationship of ADF (r^2 0.85) and NDF (r^2 0.68) with DE concentration, and suggested that ADF may be a useful indicator of barley nutritive value. In this study, ADF was not measured but there was no significant relationship between NDF concentration and performance indicating that this parameter is of little use in predicting the nutritive value of barley for pigs. However, the relationships reported in the current study are based on a set of only nine samples, which would need to be increased before firm conclusions can be drawn. The lack of relationship between grain specific weight and animal performance has been reported previously (Miller *et al*., 2001) and this work further indicates the need for an alternative means of predicting grain quality.

Although there was no significant effect of location of production of barley on pig performance, quite large numerical differences were observed which may be important both biologically and in commercial pig production. Specific weight is not useful as a means of predicting the nutritive value of barley and an alternative to this measurement is required.

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References

Association of Official Analytical Chemists. 1990. Official methods of analysis of the Association of Official Analytical Chemists, 15th Edition, Arlington, Virginia, USA.

Baidoo, S.K., Liu, Y.G. and Yungblut, D. 1998. Effect of microbial enzyme supplementation on energy, amino acid digestibility and performance of pigs fed hulless barley-based diets. *Canadian Journal of Animal Science* **78:** 625–631.

Bedford, M.R. and Classen, H.L. 1993. An *in vitro* assay for prediction of broiler intestinal viscosity and growth when fed rye-based diets in the presence of exogenous enzymes. *Poultry Science* **72:** 137–143.

De Lange, C.F.M. 2000. Characterisation of non-starch polysaccharides in animal feeds. In: "New Developments in Feed Evaluation", International Postgraduate Seminar, Wageningen University, The Netherlands, pages 77–92.

Englyst, H.N., Quigley, M.E., Hudson, G.J. and Cummings, J.H. 1992. Determination of dietary fibre as non-starch polysaccharides by gas-liquid chromatography. *Analyst* **117:** 1707–1713.

Fairbairn, S.L., Patience, J.F., Classen, H.L. and Zijlstra, R.T. 1999. The energy content of barley fed to growing pigs: characterizing the nature of its variability and developing prediction equations for its estimation. *Journal of Animal Science* **77:** 1502–1512.

Genstat 5 Committee. (1993). Genstat 5 Release 3 reference manual. Clarendon Press, Oxford.

Graham, H., Hesselman, K. and Aman, P. 1986. The influence of wheat bran and sugar-beet pulp on the digestibility of dietary components in a cereal based pig diet. *Journal of Nutrition* **116:** 242–251.

Kong, D., Choo, T.M., Jui, P., Ferguson, T., Therrien, M.C., Ho, K.M., May, K.W. and Narasimhalu, P. 1995. Variation in starch, protein, and fibre of Canadian barley cultivars. *Canadian Journal of Plant Science* **75:** 865–870.

McCann, M.E.E., Fablet, S., McCracken, K.J., McEvoy, J.D.G. and Urquhart, R. 2001a. The effect of variety and location of production on the nutritive value of barley fed to growing pigs. In: "Eighth Symposium on Digestive Physiology in Pigs" (eds. J.E. Lindberg and B. Ogle). CAB International Publishing, United Kingdom, pages 172–174.

McCann, M.E.E., McEvoy, J.D.G. and McCracken, K.J. 2001b. Effect of barley variety, year and location of production on overall and ideal digestibility in growing pigs. *Proceedings, British Society of Animal Science*, *Scarborough*, *England*, page 210.

McCleary, B.V. and Codd, R. 1991. Measurement of (1-3) (1-4)-β-D-glucan in barley and oats, a streamlined enzymic procedure. *Journal of the Science of Food and Agriculture* **55:** 303–312.

McCleary, B.V., Gibson, T.S. and Mugford, D.C. 1997. Measurement of total starch in cereal products by amyloglucosidase – α-amylase method, Collaborative study. *Journal of the Association of Official Analytical Chemists* **80:** 571–579.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. and Morgan, C.A. 1995. *Animal Nutrition, 5th Edition.* Longman Scientific and Technical, Harlow, Essex, England, pages 546–554.

Middaugh, K.F., Froseth, J.A., Ullrich, S.E. and Males, J.R. 1989. Effect of growing conditions and cultivar on nutrient composition and feeding value of barley for young pigs. *Proceedings of the Western Section of American Society of Animal Science Pullman, Washington State, USA*. **40:** 201–205.

Miller, H.M., Wilkinson, J.M., McCracken, K.J., Knox, A., McNab, J. and Rose, S.P. 2001. Nutritional value to farm livestock of wheat of low specific weight. HGCA Project No. 260. HGCA, London, pages 41–89.

Taylor, P.F., Froseth, J.A., Ullrich, S.E. and Males, J.R. 1985. The effect of cultivar and growing season on the feeding value of barley for growing swine. *Proceedings of the Western Section of American Society of Animal Science, University of Idaho, Idaho, USA*. **36:** 260–264.

Valaja, J., Suomi, K., Alaviuhkola, T. and Mela, T. 1997. Effects of variety, soil type and nitrogen fertilizer supply on the nutritive value of barley for growing pigs. *Agricultural Food Science in Finlan* **6:** 295–303.

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