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Abstract and Summary

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Defining feed wheat quality for broilers

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ABSTRACT

The aim of this project was to identify chemical and/or physical parameters which consistently related to the nutritive value of wheat in diets for poultry. To achieve this, selected physical and chemical parameters were measured in a wide range of wheat samples, and these were correlated with measurements of animal performance. The possibility of using near infrared spectroscopy (NIRS) was then investigated as an effective method of screening the nutritive value of wheat.

This project was an expansion on a previous HGCA-funded project (Project Report No. 260). Chemical and physical parameters measured included specific weight, thousand grain weight, *in vitro* viscosity, gross energy, nitrogen, neutral detergent fibre (NDF), starch, total and soluble non-starch polysaccharides (NSP), lysine, threonine, amylose, grain hardness, rate of starch digestion and protein profiles. Animal performance parameters measured included dry matter intake (DMI), live weight gain (LWG), gain:feed, *in vivo* viscosity, apparent metabolisable energy (AME), ME:gain, dry matter retention, ileal dry matter digestibility, ileal starch digestibility and ileal protein digestibility.

The wheat database used in this study had wide-ranging chemical and physical parameters, leading to all bird performance parameters being significantly affected by wheat sample. Fungicide and fertiliser application and seed rate affected wheat nutritive value. When correlations between wheat parameters and bird performance were calculated, specific weight was not significantly related to performance (r = 0.031, 0.008 and -0.019 for DMI, LWG and gain:feed respectively). However, thousand grain weight, hardness, the rate of starch digestion, and *in vitro* viscosity were weakly related (r < 0.523 for DMI, LWG and gain:feed).

Using NIRS, the chemical parameters of wheat are best predicted by scanning milled wheat, while the nutritive value of wheat was best predicted by scanning the undried whole kernel wheat samples. Calibrations for milled samples produced acceptable (>0.75) coefficients of cross validation (R^2_{cv}) for specific weight, crude protein and rate of starch digestion, while calibrations for whole wheat samples, undried, produced acceptable R^2_{cv} for total live weight gain and gain:feed.

In conclusion, the choice of wheat fed to broiler chickens substantially affected bird performance. It appears that NIRS has the potential to be an effective and rapid technique for establishing wheat nutritive value; additionally the wheat can be scanned on an "as is" basis for more rapid determination. A larger database of samples would be recommended to fully test this concept.

SUMMARY

Background

Specific weight is currently used as a measure of wheat quality in the poultry feed industry, despite reports from literature which show a lack of relationship between specific weight and nutritive value for poultry. There is therefore a requirement for an alternative, accurate and rapid means of assessing wheat quality.

Objectives

The aims of a previous HGCA-funded project (Project Report No. 260) were to identify chemical and physical parameters which consistently related to the nutritive value of wheats in diets for poultry, to correlate these measurements with animal performance and to evaluate the possibility of using near infrared spectroscopy (NIRS) as an effective method of screening nutritive value of wheat. The chemical and physical parameters measured in HGCA Project Report 260 included specific weight (SW), thousand grain weight (TG), *in vitro* viscosity, gross energy, nitrogen, neutral detergent fibre (NDF), starch, total and soluble non-starch polysaccharides (NSP), lysine and threonine. Animal performance parameters measured included dry matter intake (DMI), live weight gain (LWG), gain: feed, apparent metabolisable energy (AME) and ME:gain.

This project aimed to expand on the previous project by incorporating additional chemical and bird performance parameters including grain hardness, amylose content, rate of starch digestion (RSD) and protein fractionation, ileal dry matter digestibility, ileal starch digestibility and ileal protein digestibility. The number of wheats used in this study was increased from sixty two (Project Report 260) to one hundred and sixty four and it was hoped that increasing the number of samples in the dataset would improve the possibility of achieving an effective method of predicting values for wheat using NIRS.

Materials and Methods

Wheat Samples

The one hundred and sixty four wheat samples used in this study were collected from a wide range of different sources, locations, varieties and years. This included wheat varieties from the 1998, 1999, 2003, 2004 and 2005 harvests from the plant testing station at Northern Ireland, at high and low nitrogen application (n = 102); high and low level nitrogen and fungicide treated varieties, and different seed rate samples from ADAS (n = 30); commercial samples from Moy Park Ltd (n = 10) and Canadian samples from Pacific Agri-Food Research Centre, Canada (n = 22).

Diets

Of the newly sourced wheat samples, sixty-two were selected for inclusion in three bird trials. The formulation and preparation of the diets were identical to those of Project Report 260. The diet formulation was a typical UK starter/grower, which was balanced for essential amino acid content, so that protein inadequacy should not be a factor affecting nutritional value. An indigestible marker (titanium dioxide) was added and the diets were mixed, heat treated and pelleted.

Birds and Management

At the start of the experimental period (7 days of age) birds were randomised to individual wire metabolism cages. Birds were offered water and food *ad libitum* to 28 days of age. Dry matter intake (DMI), live weight gain (LWG) and feed conversion efficiency were recorded weekly. A balance collection was carried out between 14 and 21 days for determination of apparent metabolisable energy (AME). At 28 days the birds were humanely killed, the contents of the jejunum removed for determination of *in vivo* viscosity and the contents of the ileum removed for determination of ileal digestibility.

Analysis of wheat samples, diets, excreta and ileal digesta

The wheat samples were analysed for dry matter, specific weight, thousand grain weight, hardness, *in vitro* viscosity, gross energy, nitrogen, neutral detergent fibre (NDF), starch, total and soluble non-starch polysaccharides (NSP), lysine, threonine, amylose, rate of starch digestion and protein profiles. The diets were analysed for titanium dioxide, dry matter, crude protein (N × 6.25), B-oil, NDF, ash, starch and gross energy. The excreta samples were analysed for dry matter and gross energy. The ileal digesta were analysed for dry matter, titanium dioxide, crude protein (N × 6.25) and starch. All analyses were carried out in duplicate and results reported on a dry matter (DM) basis.

Statistical analysis

The results of the three trials were subjected to analysis of variance, with initial weight as a co-variate for growth parameters. The treatments were also tested for linear and quadratic trends between bird parameters and all the measured wheat chemical and physical parameters. Trends between selected chemical and physical parameters were also measured. Regression relationships between various parameters were established and a number of multiple regressions examined.

NIRS analysis

The wheat samples were scanned on a NIRSystems 6500 spectrophotometer. Samples were presented as whole wheat (dried and undried) and milled (dried and undried). Calibrations were developed using modified partial least squares (MPLS) regression plus scatter corrections applied. The NIRS analysis was performed with and without the Canadian wheat samples.

Results

The wheat database used in this study had a wide range of chemical and physical parameters, leading to AME content and bird DMI, LWG, gain:feed, ME:GE and ileal starch and protein digestibility being significantly ($p<0.05$) affected by wheat sample. A high level of nitrogen fertiliser application to the ADAS and NI wheat samples tended to benefit bird performance, with increases of up to 3.4, 7.2 and 3.8% in DMI, LWG and gain:feed respectively. Fungicide application also appeared to have a positive affect on bird performance, with +F treated wheat increasing bird DMI, LWG and gain:feed by 6.6, 9.3 and 2.7%, over the –F wheats. A significant increase of 9.3% in gain:feed was also observed at the low seed rate of 40 compared to 640 seeds/m^2.

When wheat parameters were correlated with bird performance data, it was found that specific weight was not significantly ($p>0.05$) related to bird performance. Bird DMI and LWG were best correlated ($p<0.05$) with the rate of starch digestion, although the coefficients of correlation were still low ($r = 0.246$ to 0.523). A negative relationship ($p<0.01$) between AME and total ($r = -0.432$) and soluble ($r = -0.304$) NSP was observed in this study. TG was positively correlated with DMI ($r = 0.299$), LWG ($r = 0.343$) and gain:feed ($r = 0.371$). When establishing multiple regression relationships, correlation coefficients greater than 0.8 were achieved for DMI, LWG, gain:feed and ileal crude protein digestibility. Unfortunately, the costs and time involved in determining the parameters involved in the regressions make the process valueless.

The NIRS calibrations, excluding the Canadian wheat samples, for specific weight were acceptable for the dried wheat samples, with the calibration for milled wheat being stronger, producing a coefficient of cross validation (R^2_{cv}) of 0.747 and a low standard error of cross validation (SECV) of 1.93, which represents a percentage error of the mean of 2.72%. Nitrogen content was well predicted by all forms of wheat, with the milled and dried wheat samples providing the highest R^2_{cv} (0.983) and very low SECV (1.63%) when expressed as a percentage of the mean. The rate of starch digestion is also well predicted using NIRS, but only on the milled wheat. Coefficients of cross validation from 0.699-0.829 were achieved when predicting the amount of starch digested at 7.5, 15, 22.5, 30, 45 and 60 minutes and the RSD rate constant was 0.780 and 0.797 for dried and undried wheat respectively. The calibrations for starch and amylose were also good (R^2_{cv}= 0.711 and 0.632 respectively, for milled dried wheat). Gross energy also produced good calibrations, the highest R^2_{cv} being 0.760 for milled dried wheat. R^2_{cv} for ME:GE, AME content and ME:gain were quite good (0.683, 0.608 and 0.775 respectively for milled dried wheat). Prediction of the different bands of proteins seems possible when observing R^2_{cv} from 0.613 to 0.860 for dried and undried milled wheat. However, the correlating SECV values expressed as a percentage of the mean, were high for protein bands 1 and 3, ranging from 10.81 to 13.15% for milled wheat. Robust predictions for total LWG and gain:feed were achieved using the undried whole wheat samples (R^2_{cv} = 0.817 and 0.825 respectively), with relatively small SECV (4.93 and 2.35 % respectively).
The NIRS calibrations, including the Canadian wheat samples, provides more robust calibrations for gross energy (R^2_{cv} = 0.858) and starch (R^2_{cv} = 0.809) content of the dried milled wheat samples. The equations for rates of starch digestibility are also very good with the inclusion of Canadian wheat (R^2_{cv}= 0.613-0.820).

Conclusions

- Wheat sample significantly affects bird performance.
- Specific weight of wheat does not indicate its nutritive value.
- Rate of starch digestion plays an important role in bird performance.
- Nutritive value can be predicted using several parameters, but this is not of use commercially.
- NIRS calibrations for milled wheat samples may be useful for determining specific weight, nitrogen and rate of starch digestion.
- NIRS calibrations for whole wheat samples (undried) may be useful for determining wheat nutritive value.
- Inclusion of the Canadian wheat samples in the NIRS analysis for milled wheat samples may provide useful calibrations for gross energy and starch content.

Implications

The implications of this study are far reaching. There is the potential for nitrogen and the rate of starch digestion to be predicted using NIRS and, including the Canadian samples, for gross energy and starch content to be predicted. The determination of these parameters using NIRS would be a great deal more economic and labour saving than the traditional methods. Also, it has been clearly demonstrated, yet again, that the specific weight of a wheat sample does not reflect its nutritive value. Therefore, the use of the industry standard of 72kg/hl, when trading feed wheat, cannot be justified. Fortunately, under the conditions of this study, NIRS scanning of whole wheat on an "as is" basis appears to provide reasonable predictions of both live weight gain and feed conversion efficiency for broilers. If it transpires, through further study, that this is correct, then at last a cheap, rapid and accurate technique for screening feed wheat quality will have been established.