NIRS calibrations for predicting the nutritional quality of feed ingredients for pigs
1B-101

Report prepared for the
Co-operative Research Centre for an Internationally Competitive Pork Industry

By

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August 2011

Established and supported under the Australian Government's Cooperative Research Centres Program

Executive Summary

Two hundred and twenty four cereal grains have so far been included in NIR calibrations for predicting feacal and ileal DE content of grains for pigs (approx. 90 samples from PGLP and 134 Pork CRC). The original calibrations developed in the Premium Grains for Livestock Program (PGLP) contained just over 90 grains, including wheat, barley, triticale, sorghum and rice. Research in the Pork CRC projects, co-funded by GRDC, has more than doubled the number of grains in the calibrations. An emphasis was placed in the Pork CRC experiments to select grains that would increase the reliability of the calibrations for predicting accurately values for unknown samples.

Four experiments were conducted to determine feacal and ileal DE content of grains. The results from each experiment were used first to determine the accuracy with which the results could be predicted using the existing NIR calibrations. The results from each experiment were then added to all existing results to develop the next generation calibrations. The ability of the new calibrations to predict the results from previous experiments and the statistics for these calibrations were determined.

Approximately 25 new grains were selected because they were either grown under dry conditions and were drought affected or were sprayed with desiccant herbicides at intervals after flowering to simulate rapid, early finish to the growing season. Approximately 20 other grains were selected because they were either naturally or artificially germinated. Several grains were frost affected. Other grains were selected because they were found to be spectral ‘outliers’ in the WINISI software used for calibration development. Other grains were selected because they had unusual characteristics, such as different coloured seed coats, large or small seeds, waxy or non-waxy endosperms.

A comprehensive chemical analysis was performed on all the grains that were collected including any cereal grain that were used as connectivity grains from the PGLP collection. A covariate analyses was conducted to explore the relationship between digestibility measurements on the pigs and the various chemical measurements of the grains that was fed to the pigs. Generally, crude protein, crude fat and starch had positive association and fibre and ash negatively associated with grain energy values.

Very good prediction of feacal DE both on dry matter and as received basis can be made from proximate analysis of the grain. However, the prediction of ileal DE from proximate analysis would be less accurate especially for sorghum.
Feed intake experiments were conducted using different age of pigs (weaners and growers) on most of the cereal grains that were collected in years one and two. There were significant differences both between and within grain types in both the weaner and grower experiments. In both experiments, pigs on sorghum diets performed the worst whereas pigs on triticale and wheat diets performed the best. Within the sorghums, pigs that were fed Liberty (white sorghum) performed the best in both the weaner and grower experiments.

Both between and within grain types were highly significant for all feacal DE and ileal DE traits. Mean feacal DE value on as received basis for sorghum was 14.5MJ/kg, wheat 13.8MJ/kg, barley 12.7MJ/kg and triticale 13.45MJ/kg. Similar values were obtained in the PGLPP experiments. There was 1MJ/kg difference between the cereal grain types. The mean ileal DE on as received basis for sorghum, wheat and triticale were similar 12.5MJ/kg and barley had the lowest ileal DE of 10.6MJ/kg.

Inclusion of results from the Pork CRC experiments substantially improved the regression coefficient relating predicted to measured values (R^2), the accuracy expected for a predicted value (SECV) and the robustness or reliability of the calibration for predicting values for unknown samples (RPD). The R^2 values for predicting unknown samples increased from 0.79 to 0.91 for feacal DE and from 0.69 to 0.85 for ileal DE. With the fourth generation calibrations, there was little bias in the predictions with the slope of the relationship being near 1.0 and the intercept near 0.0.

The accuracy with which feacal DE could be predicted with 95% confidence improved ±0.38 MJ/kg for the PGLP calibration to ±0.27 MJ/kg for the fourth generation calibration. The accuracy of prediction of ileal DE improved from ±0.68 to ±0.52 MJ/kg as fed. Similarly, the robustness of the calibrations improved with RPD increasing from 2.08 for the PGLP calibration to 2.73 for the fourth generation feacal DE calibration. The RPD values increased from 1.96 to 2.18 for ileal DE. These results suggest the calibrations have good predictive ability for feacal DE and are generally quantitative for ileal DE. However, RPD values above 3.0 are needed for the calibrations to be regarded as excellent.

Inclusion of a large number of extremely unusual grains for the last experiment provided important information about the calibrations. Values for several of these grains were not well predicted. However, the addition of these grains improved the robustness of the calibrations (feacal DE) or ability to predict unknowns (ileal DE). The experiment also demonstrated that many more grains need to be added to the calibrations to improve their reliability and make them more suitable for use as the basis for trading grains for pigs. The results suggest that at least 100 more grains with differing characteristic need to be added to the calibrations. Some of these grains should be selected for unusual characteristics and as spectral ‘outliers’ while others should be regarded as more normal grains. These grains are needed to demonstrate the reliability and precision of the NIR calibrations for more normal grain samples.

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1. Introduction

As feed costs represent the largest proportion of pig production costs, and with the greatest cost pressure against the supply of energy in diet formulations, any improvement in the measurement of available energy from diet ingredients will significantly reduce the cost of pig production in Australasia – a major priority for the Pork CRC.

Since 1996, the pork industry has been investing in the development of rapid and objective measures of feed grain quality through the Premium Grains for Livestock Program (PGLP). To date, NIR (Near infra red spectrophotometry) calibrations have been developed for ileal and feacal DE (whole and milled, as fed and dry matter), ileal: feacal DE ratio, feed intake and a feed intake index, however, further research is required to enhance these calibrations so they can be used for the commercial trading of grains.

NIR calibrations for whole and milled cereal grain: NIR calibrations were developed from a large number of results generated within the Premium Grains for Livestock Program (PGLP) and included calibrations for the digestible energy content across the whole gastrointestinal tract (Feacal DE, MJ/kg) and digestible energy to the end of the ileum (Ileal DE, MJ/kg) of cereal grains for growing pigs. Both Feacal and Ileal DE were expressed on a dry matter and as fed basis. The calibrations were developed using a Foss 6500 instrument and showed acceptable reliability for initial estimation of the energy value of grains for the pig industry (Black 2008). A little over 90 grain samples were used to establish the calibrations and this number is regarded as being less than the minimum needed for reliable and robust calibration for predicting accurate values for unknown samples. There were relatively few weather damaged and pinched grains included in the PGLP samples. In addition, the ability of the calibrations to predict the energy value of unknown samples of grains was not tested in PGLP.

Examination of whole grain feacal DE (as fed) calibration statistics from PGLP based on only 82 samples shows that there is a good overlap between samples of varying grain type (justifying the use of a global calibration set), shows an SECV that is superior to that currently being used as part of the eNIRgy analysis service (0.38 MJ/kg), and the RPD (SD/SECV) suggests that quantitative predictions can be made using this calibration. This calibration in its current form (or minor variants thereof) could be utilized for case studies or commercial trials, but there is little doubt that the calibration could be further enhanced through the addition of more samples and close attention to selection of samples to enhance the calibration set. This is supported by the fact that the calibration for milled grain feacal DE had an SECV of 0.45 MJ/kg when based on 84 samples and an RPD of 1.9 with this improving to 0.38 MJ/kg and an RPD of 2.2 when based on 92 samples. As with previous calibrations, the whole grain calibration has a higher degree of accuracy compared with the milled grain calibrations making commercial application easier and the prospect of real time DE analysis via a silo probe a possibility.

NIR calibrations for feed intake: The calibrations developed for feed intake in pigs show little promise at this stage. They have a poor RPD and a low level of accuracy. There are likely to be a number of contributing factors to this including the number of samples available for use in the calibrations (61-63), the experimental methodology and the diet formulations used in the experiments. There is also the issue that the pigs used in these feed intake experiments were consuming in the order of 4-6 MJ/day. Whether this has any commercial relevance is yet to be determined through validation studies. It is likely that PGLP calibrations will not be a useful base for this project and that new feed intake calibrations will have to be developed from scratch using modified experimental methodology.

Influence of grain processing on energy yield: Research investigating the effects of grain processing demonstrated that some increases in energy yield were possible with either extrusion or expansion, but for grains such as barley and sorghum these increases were not as great as expected, responses were variable and in some cases responses were negative. While a useful starting point, further research is required to ascertain which processes are likely to be commercially beneficial in addition to understanding how different components of grains respond to processing and interact during processing so that prediction of processing yields can be made.

Improving the feeding value of sorghum

Relative to wheat, barley and maize, there has been very little research conducted on feed additives to improve the feeding value of sorghum for pigs.

Sorghum is one of the least used grains in pig diets around the world, thus researchers and commercial companies regard evaluation of sorghum as a low priority. Most published studies on sorghum are regarding the effects of tannin levels. The tannin levels of current sorghum cultivars, although variable, are low and unlikely to effect pig growth performance. Approximately 35% of growing pigs are fed sorghum-based diets in Australia, however, and there is increasing evidence that pigs are not performing as consistently on diets containing sorghum as opposed to wheat-based diets. Furthermore, there is little information on the variation in pig voluntary feed intake and growth produced by different sorghum types (between different cultivars and within same variety). Studies similar to those conducted on analysing the effects of wheat type on feed intake by Cadogan (1999) are urgently required for different sorghum sources. The capacity to rapidly and accurately measure the nutritional quality of cereal grains prior to diet formulation empowers pork producers to reduce feed costs and utilise limited grain resources more efficiently. Significant variation (eg. up to 2 MJ/kg in DE) has been shown in the nutritional quality of primary cereal grains used in pig production in Australia including sorghum, barley, wheat and triticale. The pork industry together with the grains, chicken meat, egg and beef industries have invested in the Premium Grains for Livestock Program since 1996. This investment has led to the development of NIR calibrations for the analysis of feed intake and ileal and feacal digestible energy in cereals for pigs. While holding potential, these calibrations will be significantly improved through the development of a more robust calibration set of grains.

The Pork CRC recognised the potential benefit from being able to predict rapidly using NIR technology the energy value of individual samples of grains for the pig and grains industries. Consequently, the Pork CRC in collaboration with the Grains Research and Development Corporation funded projects (1B-101 & 1B-104) to provide additional results to evaluate and improve the accuracy of the calibrations for pigs.

Thus the objectives were:

1. Identify the chemical and physical characteristics of grains that influence variation in the nutritional quality of grains for pigs.
2. Develop rapid and objective analytical tests for the nutritional quality of grains for pigs.
3. Apply rapid and objective analytical tests and information on the chemical and physical characteristics of grains that influence nutritional quality to improve the efficiency of utilisation of grains by pigs and as a rational basis for trading grains.
4. To evaluate variation in pig growth performance produced by up to 50 grains annually. These cereal grains will be analysed for ileal and feacal DE and voluntary feed intake. The information on nutrient quality and voluntary feed intake of up to 90 selected grains for inclusion in existing NIR calibration sets improving accuracy to a point that they are suitable for use.
5. To maximise nutrient intake and pig performance on cereal (especially sorghum) based diets using feed additives diets.

2. Methodology

This project used methodology employed within the PGLP. Each year selected grains were evaluated to determine their chemical composition and to establish ileal and feacal digestible energy content. Feed intake studies were conducted for grains collected in year 1 and 2. These grains were collected at the start of each year, and assessed in a single experiment as a non-resolvable incomplete block design for the digestibility and feed intake experiments. To ensure experiments can be linked across years, bulk samples of some grains were stored so that they can provide connectivity between experiments.

The number of grains used in experiments was as follows:

Year 1	32 grains of which 6 were connectivity grains used in PGLP experiments
Year 2	50 grains of which 16 were connectivity grains used in year 1 and PGLP experiments (13 grains from year 1 collection and 3 from PGLP)
Year 3	50 grains (15 connectivity grains)

2.1 Chemical and physical parameters

<u>Dry matter and ash in grains, feeds, faeces and digesta</u>

Dry matter was determined by heating to constant weight at 105°C under an atmosphere of Nitrogen using an automated LECO Thermogravimetric TGA 701 Analyser (LECO Corporation, St Joseph, Michigan, USA).

The ash content was determined by further heating the dry samples in the Thermogravimetric Analyser at 600°C to constant weight, in an atmosphere of oxygen.

Acid Detergent Fibre (ADF) in grains and feeds

Acid-detergent fibre was determined by the method of Van Soest (1963)adapted for the Fibertec 2021 Fibrecap System (Application Sub-Note ASN 3804) by FOSS TECATOR.

FOSS TECATOR Application Sub-Note ASN 3804 - The Determination of Acid Detergent Fibre Using the Fibercap System, Foss Tecator AB, Box 70, SE-263 21 Hoganas, Sweden.

Neutral Detergent Fibre (NDF) in grains and feeds

Neutral-detergent fibre was determined by the method of Van Soest and Vine (1967) adapted for the Fibertec 2021 Fibrecap System (Application Sub-Note ASN 3805) by FOSS TECATOR.

FOSS TECATOR Application Sub-Note ASN 3805 - The Determination of Neutral Detergent Fibre Using the Fibercap System, Foss Tecator AB, Box 70, SE-263 21 Hoganas, Sweden.

Crude Fibre in grains, feeds, faeces and digesta

Crude Fibre is determined by the AOAC (1975) method, adapted for the Fibertec 2021 Fibrecap System (Application Sub-Note ASN 3801) by FOSS TECATOR.
FOSS TECATOR Application Sub-Note ASN 3801 - The determination of crude fibre in feed according to AOAC, ISO, AACC and AOCS standards using the Fibercap System

Crude Fat (Ether Extract) in grains, feeds, faeces and digesta

Crude fat was determined by the Randall or submersion method using boiling hexane, Randall (1974), adapted for the Soxtec 2050 automatic system (Application Note AN 3004) by FOSS Analytical.

Nitrogen in grains, feeds, faeces and digesta

Total nitrogen was determined by a combustion method (Sweeny 1989) using an ELEMENTAR RapidN III analyser. The instrument was calibrated using AR grade aspartic acid.

ELEMENTAR ANALYSENSYSTEME GmbH
Donaustrabe 7
D-63452 Hanau
GERMANY

Phosphorus in grains, feeds, faeces and digesta

Phosphorus was measured by a colorimetric method (A.O.A.C. 1980) following ignition at 600°C to constant weight, in an atmosphere of oxygen, and concentrated HCl digestion.

Calcium in grains, feeds, faeces and digesta

Calcium was measured by atomic absorption flame spectroscopy using a nitrous oxide-acetylene flame. Samples were prepared by igniting at 600°C for 3 hours followed by a concentrated HCl digestion. Samples were further diluted in KCl to prevent interference caused by ionisation of calcium (A.O.A.C. 1984).

Sodium and Potassium in grains, feeds, faeces and digesta
Samples were digested using a triple acid digest (concentrated H_2SO_4, HNO_3 and Perchloric acids) then heated to remove nitric and perchloric acids leaving Na and K ions in the sulphuric acid. After dilution with Caesium chloride (1000mg/L) the level of Sodium and Potassium was measured using Atomic Absorption Spectroscopy.

Clinical Analysis by Atomic Absorption. Varian Techtron Pty. Ltd, edited by Ludmilla Duncan.

Analytical Methods for Flame Spectroscopy. Varian Techtron Pty. Ltd.

Starch in grains, feeds, faeces and digesta

Starch was analysed, after extraction in Di-Methyl Sulphoxide, by conversion to glucose using a 2-step enzyme treatment, and colorimetric determination of the glucose with a Glucose Oxidase/Peroxidase Reagent. All enzymes and reagents were supplied in kit form from Megazyme available from Deltagen Australia. 31 Wadhurst Drive, Boronia, Victoria 3155. Telephone: (03) 9887 5240. Fax: (03) 9887 0019. Email: deltagen@iaccess.com.au. The enzymatic breakdown of the starch using a heat stable α-amylase and amyloglucosidase is based on the procedure of McCleary et al (1992 and 1997).

β-glucans in barley grain

β-glucans were assayed enzymatically by the method of McCleary and Codd (1991) using an enzyme kit from Megazyme available from Deltagen Australia. 31 Wadhurst Drive, Boronia, Victoria 3155. Telephone: (03) 9887 5240. Fax: (03) 9887 0019. Email: deltagen@iaccess.com.au.

Gross Energy in grains, feeds, faeces and digesta

Gross energy was determined using a Leco AC-500 Automatic Calorimeter (LECO Corporation, St Joseph Michigan USA) on pelleted (~1000mg) samples. The instrument was calibrated using AR grade benzoic acid.

Amino Acids in grains, feeds, faeces and digesta

Samples were hydrolysed in 6N HCl at 110°C for 18 hours in sealed tubes, blanketed with nitrogen.

A sub sample for cystine and methionine determination were oxidised prior to hydrolysis (as above) with performic acid at 0°C overnight.

The amino acids were quantitated via pre-column derivatisation with 6-*N*-aminoquinolyl-*N*-hydroxysuccinimidyl carbamate, (Accq-Tag method, Waters

Corporation) and separated by reverse phase high pressure liquid chromatography (HPLC) on a Waters Accq-Tag column, on a Waters Alliance 2690 separation module and detected on Waters 474 fluorescence detector (Waters Corporation)

Tryptophan was determined by hydrolysis in 4.2N NaOH at 110°C for 20 hrs in sealed tubes, blanketed with nitrogen. Separation was via reverse phase HPLC and detected with UV/Vis detector at 280nm.

Tryptophan was separated on a Waters Alliance 2690 system and detected on a Waters 486 variable wavelength detector (Waters Corporation).

1. Tryptophan
   Official Methods of Analysis of the Association of Official Analytical Chemists, Volume Two, Fifteenth Edition, 1990, pp1101-1102.
   988.15 Tryptophan in Foods and Food and Feed Ingredients

2. Hydrolysis
   FINLAYSON, A.J. (1964) Amino Acid Recoveries in the Analysis of Some Feed Samples.
   Can J Plant Sci, 45,184-188

3. Cystine & Methionine
   MOORE, S (1963) On the Determination of Cystine as Cysteic Acid
   J. Biol. Chem, 238, 235-237

4. Other AA's

SPACKMAN, D.H., STEIN, W.H. and MOORE, S.(1958) Automatic Recording Apparatus For Use in the Chromatography of Amino Acids
Anal. Chem., 30, 1190.

2.2 Digestibility experiments

2.2.1 Digestibility experiment 1 (DS002).

This experiment has been design to enhance the NIR calibrations for pig digestion developed by the Premium Grains for Livestock Project (PGLP).

The aim of this experiment was to estimate DE values, using feacal and ileal measurements, in weaner/grower pigs fed the test grains and to determine the effect of grain type and grain id on these differences.

Ileal and feacal DE assessment *Diets:* A total of 32 diets were fed to male weaner pigs. These included 9 wheat, 7 barley, 5 triticale and 10 sorghum. Of these grains 4 wheat and 2 barley were connectivity grains used in previous experiments (Table 1). One of the sorghum varieties was also treated with a ginger based product called Zingibain. Diets were cold press pelleted (5mm diameter) in 2 batches. A total of 42 pigs were fed in the experiment. In each time period 10 pure bred large white male pigs (approx. 35 kg) were used. This experiment was conducted over 16 periods with each pig used in 4 different time periods. The design used for this experiment was a non-resolvable incomplete block design. The test grains were included as the only protein source. Diet composition is given in Table 2. All diets were cold-press pelleted.

The pigs were fitted with simple T-piece cannulas about 150 mm anterior to the ileo-caecal valve as described by van Barneveld (1993) with the exception that skin barriers for use around stoma in human ileostomy patients (Stomahesive® System 2 with 70mm flange; Bristol-Myers Squibb, Princeton, NJ, 08543-4000 USA) was incorporated between the flange of the cannula and the skin to promote healing of the wound and to prevent any leakage around the cannula. Following surgery, pigs were housed individually in solid-sided pens (1.5 x 2.2m) and fed a commercial grower diet (0.7 g available lysine /MJ DE; 14.0 MJ DE /kg) for a recovery period of seven days. Water was provided *ad libitum* via nipple drinkers. The area surrounding the cannula was washed with Iovone daily.

Daily feeding rates was adjusted to three times maintenance (3 x (0.5 MJ DE kg^{-1} body $weight^{0.75}$)/diet DE). Daily rations were halved and fed at 12 h intervals and water will be provided *ad libitum* via nipple drinkers. Experimental diets will be introduced over a three day period and then fed for a further five days.

Following a 7 day recovery period, experimental diets were introduced over three days. Diets were fed for 5 days with collections of ileal digesta made on days 6 and 7. Ileal digesta was collected and immediately frozen to prevent further digestion of the sample. To facilitate collections, pigs were transferred into metabolism cages. Following collection of digesta, diets were re-allocated and the procedure repeated until all pigs had received the five diets. Following each collection samples were bulked, mixed, sub sampled, and freeze-dried prior to chemical analysis.

While the pigs were housed in the metabolism cages for continuous collection of digesta, random subsamples of faeces voided during this two day period was collected, bulked and stored at -20° for determination of feacal DE. At the end of each collection period, samples of digesta and feaces were thawed, sub sampled, freeze-dried and ground prior to chemical analyses. Digesta samples were sent to Prof Mike Gidley (UQ) for further testing for factors responsible for digestion of starch in cereal grain.

Table 1. Grain used in digestibility experiment 1.

Grain	Grain ID	Treatment No.	PGLP sample ID	Variety
Wheat1	W1	1	1753	Bellaroi
Wheat2	W2	2	1755	Ammrock
Wheat3	W3	3	1754	Sentinal
Wheat4	W4	4	1757	unknown
Wheat5	W5	5	1758	Chara
Barley1	B1	6	3861	Binnalong
Barley2	B2	7	3865	Gairdner
Barley3	B3	8	3866	Gairdner
Barley4	B4	9	3867	Gairdner
Barley5	B5	10	3868	Schooner
Triticale1	T1	11	6824	Jackie
Triticale2	T2	12	6825	Prime 322
Triticale3	T3	13	6826	Credit
Triticale4	T4	14	6828	Tahara

Grain	Grain ID	Treatment No.	PGLP sample ID	Variety
Triticale5	T5	15	6827	Everest
Sorghum1	S1	16	7855	MR Maxi
Sorghum2	S2	17	7856	Liberty
Sorghum3	S3	18	7857	Pacer
Sorghum4	S4	19	7858	MR43
Sorghum5	S5	20	7859	Buster
Sorghum6	S6	21	7860	Dawn
Sorghum7	S7	22	7861	Venture
Sorghum8	S8	23	7862	Buster
Sorghum9	S9	24	7863	Red 1
Sorghum10	S10	25	7864	Red 2
Sorghum11	S11	26	7858 ZT	MR43 Zingibain
CWheat1	W1C	27	1727	Oxley
CWheat2	W2C	28	1728	QAL 2000
CWheat3	W3C	29	1749	Wollaroi
CWheat4	W4C	30	1841	H45
CBarley1	B1C	31	3756	Tallon
CBarley2	B2C	32	3757	Trebi

Table 2 Diet composition

Ingredient	kg	%
Grain	189.01	94.505
Dicalcium phosphate	6.0	3.00
Salt	0.55	0.275
Minerals*	0.14	0.07
Vitamins**	0.1	0.05
Choline chloride	0.2	0.10
Celite	4.0	2.0
Total	**200**	**100.0**

2.2.2 Digestibility experiment 2. (DS004)

The aim of this experiment was to further enhance the NIR calibrations for pig DE developed by PGLP.

There were 50 grain treatments for this experiment is listed below. There were 15 sorghum, 15 wheat, 11 barley and 4 triticale diets. Of these 16 were connectivity grains.

Table 3 Grain used in digestibility experiment 2.

ID	Grain type	Treatment	Diet Number	Connectivity
7855	sorghum	normal	Diet 1	DS002
7856	sorghum	normal	Diet 2	DS002
7857	sorghum	normal	Diet 3	DS002
7858	sorghum	normal	Diet 4	DS002
7859	sorghum	normal	Diet 5	DS002
7860	sorghum	normal	Diet 6	DS002
7861	sorghum	normal	Diet 7	DS002
7862	sorghum	normal	Diet 8	DS002
7863	sorghum	normal	Diet 9	DS002
7864	sorghum	normal	Diet 10	DS002
7865	sorghum	normal	Diet 11	new
7866	sorghum	normal	Diet 12	new
7867	sorghum	normal	Diet 13	new
7868	sorghum	normal	Diet 14	new
NA	sorghum	sprouted	Diet 15	new
NA	sorghum	sprouted	Diet 16	new
NA	sorghum	sprouted	Diet 17	new
NA	sorghum	sprouted	Diet 18	new
NA	sorghum	sprouted	Diet 19	new
NA	sorghum	sprouted	Diet 20	new
1746	wheat	normal	Diet 21	PGLP_connectivity
1753	wheat	normal	Diet 22	DS002
1756	wheat	normal	Diet 23	new
1759	wheat	normal	Diet 24	new
1760	wheat	normal	Diet 25	new
1762	wheat	normal	Diet 26	new
1763	wheat	normal	Diet 27	new
1764	wheat	normal	Diet 28	new
1765	wheat	normal	Diet 29	new
1766	wheat	normal	Diet 30	new
1767	wheat	normal	Diet 31	new
1768	wheat	normal	Diet 32	new
1769	wheat	normal	Diet 33	new
1770	wheat	normal	Diet 34	new
1771	wheat	normal	Diet 35	new
3750	barley	normal	Diet 36	PGLP_connectivity
3861	barley	normal	Diet 37	DS002
3867	barley	normal	Diet 38	DS002
3869	barley	normal	Diet 39	new
3870	barley	normal	Diet 40	new
3871	barley	normal	Diet 41	new
3872	barley	normal	Diet 42	new
3873	barley	normal	Diet 43	new
3874	barley	normal	Diet 44	new
3875	barley	normal	Diet 45	new
3876	barley	normal	Diet 46	new
6708	triticale	normal	Diet 47	PGLP_connectivity
6829	triticale	normal	Diet 48	new
6830	triticale	normal	Diet 49	new
6831	triticale	normal	Diet 50	new

The methodology adopted was the same as for the first year digestibility experiment.

The design was based on a non-resolvable incomplete block design. Initially four replicates were included in the design as per the protocol but a fifth replicate was required and was added to the original design after the initial experiment was almost complete. The final design had 5 replicates with 25 periods (or runs) of 10 cages.

A total of 53 pigs were used with most pigs being used in 5 runs, being fed adifferent diet in each run. The diets were comprised of approximately 94.5% of the test grains. As per the first digestibility experiment the other 5.5% of the diet was a combination of Dicalcium phosphate, Salt, Minerals, Vitamins, Choline chloride and Celite.

One of the sorghums (7712) was subjected to stress (sprayed with a desiccant to retard the uptake of moisture and promote quicker maturity) and/or sprouting treatments. Thus there were six combinations of treatments involving this one grain.

They were:

1. 7714 RAW0 (This grain was grown in the field under irrigation.)
2. 7714 STRESS1 (This grain was grown in the field under drought conditions.)
3. 7714 STRESS2 (This grain was grown similarly to the STRESS1 grain but towards the end of the growing season it was sprayed with Roundup to speed up the maturing process.)
4. 7714 SPROUT (Some of the 7714 RAW0 grain was artificially SPROUTED.)
5. 7714 STRESS1SPROUT (Some of the 7714 STRESS1 grain was artificially SPROUTED)
6. 7714 STRESS2SPROUT (Some of the 7714 STRESS2 grain was artificially SPROUTED)

2.2.3 Digestibility experiment 3. (HR001)

The methodology adopted was the same as in experiment 2 and the grains used were as follows:

Table 4. Grain used in digestibility experiment 3.

Order	Diet No.	Sample ID + Info code	Grain Type	Variety and other information	Connectivity
1	Diet 37	3861_RAW0	barley	Binalong, PBI Narrabri	DS002 DS004
2	Diet 40	3870_RAW0	barley	Grout (PBI Narrabri - light country)	DS004
3	Diet 41	3871_RAW0	barley	Gairdner (Livingston farm)	DS004
4	Diet 42	3872_RAW0	barley	Gairdner (Kevin Schultz)	DS004
5	Diet 43	3873_RAW0	barley	Tilga (F.Colless)	DS004
6	Diet 44	3874_RAW0	barley	Schooner (D. Manwarring)	DS004
7	Diet 54	3879_SPROUT	barley	Fitzroy (normal maybe be sprouted?)	New
8	Diet 55	3879_STRESS2	barley	Fitzroy (sprayed with roundup)	New

Order	Diet No.	Sample ID + Info code	Grain Type	Variety and other information	Connectivity
9	Diet 56	3880_RAW0	barley	NRB03470 (normal)	New
10	Diet 57	3880_STRESS2	barley	NRB03470 (drought stressed)	New
11	Diet 61	3877_SPROUT	barley	Tallon (naturally Sprouted)	New
12	Diet 77	3890_RAW0	barley	NRB03470	New
13	Diet 78	3891_RAW0	barley	NRB03470	New
14	Diet 79	3897_RAW0	barley	Grout	New
15	Diet 83	3918_SPROUT	barley	ND19119	New
16	Diet 85	3919_SPROUT	barley	NRB03470	New
17	Diet 86	3898	barley	Dave Cadogan - excess used in phytase trial	New
18	Diet 87	3818_RAW0	barley	grown for Danny at Toowoomba	New
19	Diet 88	3818_SPROUT	barley	grown for Danny at Toowoomba	New
20	Diet 2	7856_RAW0	sorghum	Liberty (white)	DS002, DS004
21	Diet 3	7857_RAW0	sorghum	Pacer (Livingston Farm)	DS002, DS004
22	Diet 4	7858_RAW0	sorghum	MR43 (Livingston farm)	DS002, DS004
23	Diet 13	7867_RAW0	sorghum	MR43 (Livingston Farm)	DS004
24	Diet 72	7869_RAW0	sorghum	KARPER 669	New
25	Diet 73	7870_RAW0	sorghum	ICSV 400	New
26	Diet 74	7871_RAW0	sorghum	MR 43 (damaged)	New
27	Diet 75	7872_RAW0	sorghum	Liberty - white sorghum	New
28	Diet 99	7876_RAW0	sorghum	organised by D. Cagogan from Ridley	New
29	Diet 48	6829_RAW0	triticale	triticale_Kosciusko (Jim Watson)	DS004
30	Diet 49	6830_RAW0	triticale	triticale_Everest (UNE)	DS004
31	Diet 93	6835_RAW0	triticale	grown for Danny at Toowoomba	New
32	Diet 94	6835_SPROUT	triticale	grown for Danny at Toowoomba	New
33	Diet 95	6836_RAW0	triticale	JRCT74 - new Line from J. Roake - Usyd	New
34	Diet 96	6837_RAW0	triticale	Tobruk - Usyd variety	New
35	Diet 22	1753_RAW0	wheat	Bellaroi (Moree)	DS002, DS004
36	Diet 28	1764_RAW0	wheat	Sunco (Livingston farm)	DS004
37	Diet 31	1767_RAW0	wheat	Cunningham (F. Colless)	DS004
38	Diet 34	1770_RAW0	wheat	Sunbri (Livingston Farm)	DS004
39	Diet 62	1772_RAW0	wheat	Wollaroi (normal)	New
40	Diet 63	1772_SPROUT	wheat	Wollaroi (naturally sprouted)	New
41	Diet 64	1773_RAW0	wheat	Baxter (normal)	New
42	Diet 65	1773_SPROUT	wheat	Baxter (naturally sprouted)	New
43	Diet 66	1856_RAW0	wheat	QAL1064	New
44	Diet 80	1864_SPROUT	wheat	SUN 525D	New
45	Diet 81	1865_SPROUT	wheat	SUN 526A	New
46	Diet 89	1879_SPROUT	wheat	grown for Danny at Toowoomba	New
47	Diet 90	1874_SPROUT	wheat	grown for Danny at Toowoomba	New
48	Diet 92	1868_RAW0	wheat	Bellaroi (1 tonne from PBI)	New
49	Diet 97	1876_RAW0	wheat	red wheat, Dairy trial organised by R.King	New
50	Diet 98	1877_RAW0	wheat	white wheat, Dairy trial organised by R.King	New

2.3 Feed Intake experiments

2.3.1 Experiment 1 Weaner experiment at QAF (DS001)

The aim of this experiment was to determine the live weight gains and feed conversion ratios (FCR) in weaner pigs fed 10 sorghums and how this compares to other grain types.

Thirty-two grains (9 wheat, 7 barley, 5 triticale and 11 sorghum) were fed. Of theses grains 4 wheat and 2 barley were connectivity grains used in previous experiments. One sorghum was treated with Zingibain (S11). The grains used are given in Table 3.

Table 5. Grain used in feed intake experiment 1 at QAF.

Grain	Grain ID	Treatment No	PGLP sample ID	Variety
Wheat1	W1	1	1753	Bellaroi
Wheat2	W2	2	1755	Ammrock
Wheat3	W3	3	1754	Sentinal
Wheat4	W4	4	1757	unknown
Wheat5	W5	5	1758	Chara
Barley1	B1	6	3861	Binnalong
Barley2	B2	7	3865	Gairdner
Barley3	B3	8	3866	Gairdner
Barley4	B4	9	3867	Gairdner
Barley5	B5	10	3868	Schooner
Triticale1	T1	11	6824	Jackie
Triticale2	T2	12	6825	Prime 322
Triticale3	T3	13	6826	Credit
Triticale4	T4	14	6828	Tahara
Triticale5	T5	15	6827	Everest
Sorghum1	S1	16	7855	MR Maxi
Sorghum2	S2	17	7856	Liberty
Sorghum3	S3	18	7857	Pacer
Sorghum4	S4	19	7858	MR43
Sorghum5	S5	20	7859	Buster
Sorghum6	S6	21	7860	Dawn
Sorghum7	S7	22	7861	Venture
Sorghum8	S8	23	7862	Buster
Sorghum9	S9	24	7863	Red 1
Sorghum10	S10	25	7864	Red 2
Sorghum11	S11	26	7858 ZT	MR43 Zingibain
CWheat1	W1C	27	1727	Oxley
Wheat2	W2C	28	1728	QAL 2000
CWheat3	W3C	29	1749	Wollaroi
CWheat4	W4C	30	1841	H45
CBarley1	B1C	31	3756	Tallon
CBarley2	B2C	32	3757	Trebi

Six hundred and forty pure bred large white male weaner pigs (approx. 7-9.2 kg) were used over the course of the experiment. This experiment was conducted over 4 periods or 11 runs. Each grain was feed 20 times and each animal was used once only. The design allowed for the animals to be introduced into the experiment as follows:

	Period 1			Period 2			Period 3			Period 4
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1
Week 1	64									
Week 2	animals	64								
Week 3	Cages	animals	64							
Week 4	1 - 64	Cages	animals							
Week 5		65 - 128	Cages	64						
Week 6			129 - 192	animals	64					
Week 7				Cages	animals	64				
Week 8				1 - 64	Cages	animals				
Week 9					65 - 128	Cages	64			
Week 10						129 - 192	animals	64		
Week 11							Cages	animals	64	
Week 12							1 - 64	Cages	animals	
Week 13								65 - 128	Cages	64
Week 14									129 - 192	animals
Week 15										Cages
Week 16										1 - 64
Week 17										

Break

However, there were insufficient animals in period 1 Run 3 so the design was altered as follows:

		Period 1				Period 2			Period 3			Period 4
		Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1
Week 1	26/07/2006	64										
Week 2	02/08/2006	animals	64									
Week 3	09/08/2006	Cages	animals									
Week 4	16/08/2006	1 - 64	Cages	32								
Week 5	23/08/2006		65 - 128	animals	32							
Week 6	30/08/2006				animals	64						
Week 7	06/09/2006					animals	64					
Week 8	13/09/2006					Cages	animals	64				
Week 9	20/09/2006					1 - 64	Cages	animals				
Week 10	27/09/2006						65 - 128	Cages	64			
Week 11	04/10/2006							129 - 192	animals			
Week 12	11/10/2006								Cages			
Week 13	18/10/2006								1 - 64	64		
Week 14	25/10/2006									animals		64
Week 15	01/11/2006									Cages	64	animals
Week 16	08/11/2006									65 - 128	animals	Cages
Week 17	15/11/2006										Cages	1 - 64
Week 18	22/11/2006										129 - 192	

Although the original protocol called for the exclusive use of male pigs, a small number of female pigs (7 pigs) were introduced into the experiment as there were insufficient male pigs. Also, missing values were introduced into the experiment through the pigs being removed from the experiment due to being “unthrifty” (29 pigs). An additional 11 pigs died during the experiment.

Table 6 Diet composition Feed intake experiment 1

Diets	100 kg
Ingredient	**Amt kg**
Grain	65.00
Whey Powder	12.00
Fish meal 64%	10.00
Skim milk	3.30
Vegie/Canola Oil	3.00
Blood meal	2.30
Meat meal 52%	2.10
Limestone	0.38
Lysine HCL	0.39
DL Methionine	0.12
Threonine	0.19
Isoleucine	0.11
Tryptophan	0.06
Zinc oxide	0.25
QAF creep premix	0.30
Amoxycillan	0.20
Acidal NC	0.30
Total	100.00
Mould Zap	0.22

FEEDING PROTOCOL:

Diets were cold press pelleted (5mm diameter) in one batch. Daily feed and water was provided *ad libitum* via nipple drinkers.

PERIOD/RUN PROTOCOL:

- 640 pure bred large white male weaner pigs (approximately 7- 9.2 kg) were selected from the commercial herd.
- Pigs were housed in purpose built individual pens with a commercial trough feeder and water nipple in each pen.
- Pigs receive water and feed *ad libitum*.
- Pigs have a settling in period of 5 days in which they are fed a commercial diet and are handled to settle them down prior to the start of the experiment and are monitored for signs of distress or disease before being chosen to participate in the trial.
- Diets were fed for 26 days, with a 5 day period of diet adaptation. The 6th day of feeding becomes day 0 of the trial.
- The pigs and feed residue were weighed on days 0, 14 and 21 of the trial.
- Daily intake, body weight gain and feed conversion ratio are calculated from the data collected throughout trial.

MEASUREMENTS RECORDED:

Body weight (kg) at 0, 14 and 21 days
Total feed eaten (kg) at 14 and 21 days

FORMULA FOR DERIVED RESPONSES:

Average Daily Feed Intake (*ADI*) 0- 21 days = $\frac{\text{total feed eaten 0-21 days}}{\text{Number of days (21)}}$ (kg/day)

Rate of Gain (*ROG*) 0-21 days = $\frac{\text{body weight 21 days - body weight 0 days}}{\text{Number of days (21)}}$

Feed Conversion Ratio (*FCR*) 0-21 days = $\frac{\text{ADI 0-21 days}}{\text{ROG 0-21 days}}$

2.3.2 Experiment 2: Wacol Sorghum grower intake (AF001)

In an effort to better understand pig live weight response and feed conversion efficiencies when fed a diet predominantly consisting of sorghum this trial was conducted in Wacol Queensland, using 10 test sorghum grains.

PROTOCOL:

ANIMAL PROTOCOL:

A total of 120 pure bred large white male pigs (approx. 20- 25 kg) were used over the course of the experiment, with each pig being fed one diet only. The diets are listed below:

Table 7. Grain used in Feed intake experiment 2.

Diet Code	Sample ID	Grain Type	Variety	Variety Characteristics
Diet 1	7855	sorghum	MR_Maxi	red
Diet 2	7856	sorghum	Liberty	white
Diet 3	7857	sorghum	Pacer	red
Diet 4	7858	sorghum	MR43	red
Diet 5	7859	sorghum	Buster	red
Diet 6	7860	sorghum	Unknown	red
Diet 7	7861	sorghum	Venture	red
Diet 8	7862	sorghum	Buster	red
Diet 9	7863	sorghum	Red1	red
Diet 10	7864	sorghum	Red2	red

This experiment was conducted over 6 periods with 20 pigs used in each different time periods. The design was for an incomplete block design with two replicates within each time period or run.

Number of cages: 40
Number of rows: 18
Number of columns: 4
Replicates: 12

The initial live weight of the pig will be used in the analysis as a covariate to adjust for the differences between the pigs. Also, the pellets used for the pigs were made in two separate batches, these batches were then randomised within the run.

Table 8. Diet Composition Feed intake experiment 2:

Ingredients	Amount (kg)	%
Diet X (sorghum)	81.885	81.885
Blood meal 85	2.5	2.5
SBM 52	8.25	8.25
M&B 50	6.5	6.5
Lys	0.35	0.35
Met	0.125	0.125
Thr	0.05	0.05
Choline 60	0.04	0.04
Grower Premix	0.1	0.1
Salt	0.2	0.2
Total	100	100

FEEDING PROTOCOL:

Diets were cold press pelleted (5mm diameter) in two batches. Daily feed and water was provided *ad libitum* via nipple drinkers.

PERIOD/RUN PROTOCOL:

- 120 pure bred large white male pigs (approximately 20-25 kg) are selected from the commercial herd.
- Pigs are housed in purpose built individual pens with a commercial trough feeder and water nipple in each pen.
- Pigs receive water and feed *ad libitum*.
- Pigs have a settling in period of 5 days in which they are fed a commercial diet and are handled to quieten them down prior to the start of the experiment and are monitored for signs of distress or disease before being chosen to participate in the trial.
- Diets will be fed for 26 days, with a 5 day period of diet adaptation. The 6th day of feeding becomes day 0 of the trial.
- The pigs and feed residue will be weighed on days 0, 7, 14 and 21 of the trial.
- Daily intake, body weight gain and feed conversion ratio are calculated from the data collected throughout trial.

MEASUREMENTS RECORDED FOR DATABASE:

Body weight (kg) at 0, 7, 14 and 21 days
Total feed eaten (kg) at 7, 14 and 21 days

FORMULA FOR DERIVED RESPONSES:

Average Daily Feed Intake (*ADI*) 0-7 days = $\dfrac{\text{total feed eaten 0-7 days}}{\text{Number of days (7)}}$ (kg/day)

Rate of Gain (*ROG*) 0-7 days = $\dfrac{\text{body weight 7 days - body weight 0 days}}{\text{Number of days (7)}}$

Feed Conversion Ratio (*FCR*) 0-7 days = $\dfrac{\text{ADI 0-7 days}}{\text{ROG 0-7 days}}$

ADI, ROG and FCR are calculated for 0-7, 0-14, 0-21, 7-14 and 14-21 days

RESPONSES TO BE ANALYSED:

Average Daily Feed Intake (ADI) for 0-7, 0-14, 0-21, 7-14 and 14-21 days

Rate of Gain (ROG) for 0-7, 0-14, 0-21, 7-14 and 14-21 days

Feed Conversion Ratio (FCR) for 0-7, 0-14, 0-21, 7-14 and 14-21 days

2.3.3 Experiment 3, 37 grains from 2nd year's collection (DS003).

The aim of this experiment was to determine the live weight gains, feed conversion efficiencies and batch effects on grower pigs fed 37 test grains.

The design was based on a non-resolvable incomplete block design with 6 runs of 53 cages and the last run having only 52 cages. This resulted in each of the 37 GrainID's being replicated 10 times within the seven runs. The diets were comprised of approximately 82% of the test grains. The other 18% of the diet was a combination of Blood meal 85, SBM 52, M&B 50, Lysine, Methonine, Threonine, Choline 60,Grower Premix and Salt. This portion of the diet was pre-mixed in a single batch to try and ensure uniformity of the other ingredients. The assumption being that if the responses are different then it will be due to the GrainID's that make up the other 82% of the diet.

To determine if there were any other effects due to making the pellets, the pellets for a single treatment were made in two feed batches, these were randomised to the generated base design

TREATMENTS:

The treatments consisted of 37 grains. There were 14 sorghum, 11 wheat, 9 barley and 3 triticale diets. For each diet 2 separate batches of pellets were prepared.

Table 9. Grain used in Feed intake experiment 3.

Grain no.	Sample ID + info code	Grain type	Variety and other information
Diet 1	7855_RAW0	sorghum	Maxi (Livingston Farm)
Diet 2	7856_RAW0	sorghum	Liberty (white)
Diet 3	7857_RAW0	sorghum	Pacer (Livingston Farm)
Diet 4	7858_RAW0	sorghum	MR43 (Livingston Farm)
Diet 5	7859_RAW0	sorghum	Brigalow Research Station Buster
Diet 6	7860_RAW0	sorghum	Allora grain and Mill
Diet 7	7861_RAW0	sorghum	Venture
Diet 8	7862_RAW0	sorghum	Buster
Diet 9	7863_RAW0	sorghum	Red 1
Diet 10	7864_RAW0	sorghum	Red 2
Diet 11	7865_RAW0	sorghum	Bonus (Livingston farm)
Diet 12	7866_RAW0	sorghum	Pacer (Livingston Farm)
Diet 13	7867_RAW0	sorghum	MR43 (Livingston Farm)
Diet 14	7868_RAW0	sorghum	MR Maxi (Livingston farm)
Diet 22	1753_RAW0	wheat	Bellaroi (Moree)
Diet 26	1762_RAW0	wheat	H45 (Jim O'Halloran)
Diet 27	1763_RAW0	wheat	H45 (Peter Barry)
Diet 28	1764_RAW0	wheat	Sunco (Livingston farm)
Diet 29	1765_RAW0	wheat	Lang (Martin Dunlop)
Diet 30	1766_RAW0	wheat	H45 (Nigel Martin)
Diet 31	1767_RAW0	wheat	Cunningham (F. Colless)
Diet 32	1768_RAW0	wheat	Janz (F. Colless)
Diet 33	1769_RAW0	wheat	Bellaroi (durum) - Livingston Farm
Diet 34	1770_RAW0	wheat	Sunbri (Livingston Farm)
Diet 35	1771_RAW0	wheat	Drysdale (James Butt)
Diet 37	3861_RAW0	barley	Binalong, PBI Narrabri
Diet 39	3869_RAW0	barley	Grout (PBI Narrabri - hydrants)
Diet 40	3870_RAW0	barley	Grout (PBI Narrabri - light country)
Diet 41	3871_RAW0	barley	Gairdner (Livingston farm)
Diet 42	3872_RAW0	barley	Gairdner (Kevin Schultz)
Diet 43	3873_RAW0	barley	Tilga (F.Colless)
Diet 44	3874_RAW0	barley	Schooner (D.Manwarring)
Diet 45	3875_RAW0	barley	Wyalong (M. Williams)
Diet 46	3876_RAW0	barley	Schooner (N. Martin)
Diet 48	6829_RAW0	triticale	Kosciusko (Jim Watson)
Diet 49	6830_RAW0	triticale	Everest (UNE)
Diet 50	6831_RAW0	triticale	Kosciusko (Chris Wirth)

PROTOCOL:

ANIMAL PROTOCOL:

370 pure bred large white male pigs (approx. 20- 25 kg) will be used over the course of the experiment. This experiment will be conducted over 7 periods with 6 periods using 53 cages and 1 period using 52 cages.

DIET COMPOSITION:

The pellets for each diet were made in two separate batches, each being 225 kg, to make a total of 450 kg per grain. To make the pellets other ingredients are required. To ensure that the other ingredients are not adding extra variability into the process these ingredients were mixed together by Bettterblend in a premix which was then used across the different grain samples. The premix was bagged in 25 kg bags and delivered to QPRDC. These are not part of the statistical randomisation process but a record was kept of the pre-mix bag number and the actual pellets that the pre-mix was used to make.

Table 10. Diet composition Feed intake experiment 3

Ingredients	Amount (kg)	%
Diet X (grain type)	368.48	81.885
Blood meal 85	11.25	2.5
SBM 52	37.12	8.25
M&B 50	29.25	6.5
Lysine	1.58	0.35
Methonine	0.56	0.125
Thronine	0.23	0.05
Choline 60	0.18	0.04
Grower Premix	0.45	0.1
Salt	0.9	0.2
Total	450	100

FEEDING PROTOCOL:

Diets were cold press pelleted (5mm diameter) in two batches/diet (225 kg per batch). Daily feed and water was provided *ad libitum* via nipple drinkers.

PERIOD/RUN PROTOCOL:

- For 6 periods 58 pure bred large white male pigs and for 1 period 57 pure bred large white male pigs (approximately 20-25 kg) were selected from the commercial herd. Five of the pigs in all periods were spares.

- Pigs were housed in purpose built individual pens with commercial trough feeder and water nipple in each pen.

- Pigs received water and feed ad libitum.

- Pigs have a settling in period of 3 days where they are handled to quieten them down prior and are monitored for signs of distress or disease before being chosen to participate in the trial. If a pig does show these signs then they are replaced with a spare during this period.

- Feeding of trial diets commences on day 4 for a period of 28 days.

- Diets will be fed for 28 days, with a 3 day period of diet adaptation.

- On days 0, 7, 14, 21 and 28 days on the test diets the pigs and feed residue will be weighed.

- Daily intake, body weight gain, feed conversion ratio and efficiency are calculated from the data collected throughout trial.

SAMPLES REQUIRED:

Samples of each premix, whole grain, hammer milled grain and diet pellets were collected for appropriate chemical and NIR analysis.

3. Outcomes

3.1 Chemical Analyses

A covariate analyses was conducted to explore the relationship between digestibility measurements on the pigs and the various physical and chemical measurements of the grains that was fed to the pigs. The fitted values (with standard errors in brackets) of the 5 digestibility measurements are given below:

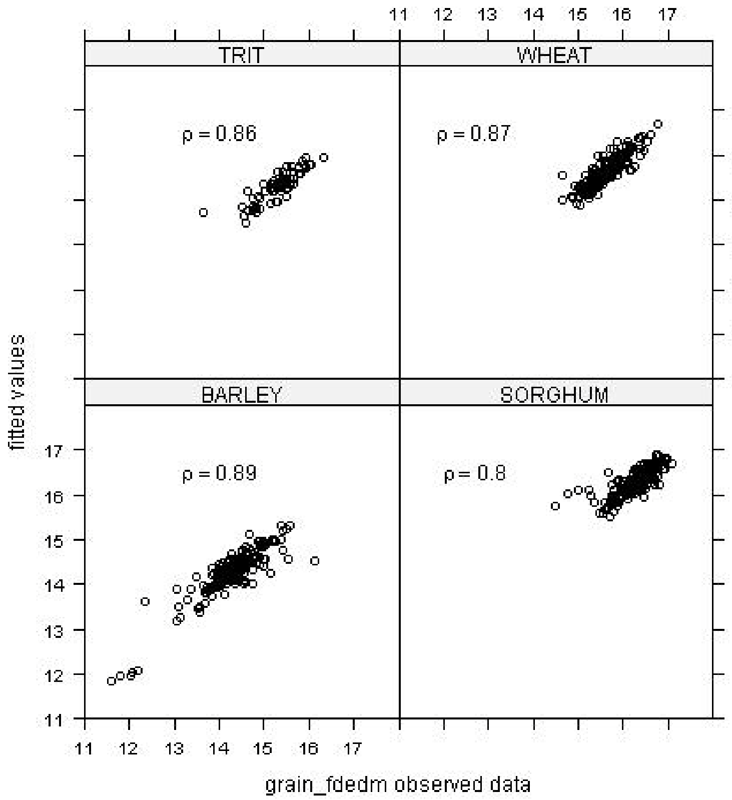
For feacal DE of grain on a dry matter basis, the backward elimination scheme only contained the covariates crude fat (cfat). The conditional F-statistics for the fixed effects
associated with the final model were id-code 19.43, ash 3.41 and cfat 6.88. The final model fitted values (with standard errors in brackets) formula for grain fdedm for the $_{ith}$ observation (rep) for the $_{jth}$ id_code can be written as:

$$FDEG_{(i..j)idcode}\ (MJ/kg\ DM) \sim \underset{(0.2451)}{15.4766} + id\_code_{jth} + \underset{(0.0541)}{0.1420}*cfat(\%) - \underset{(0.1142)}{0.210}*ash(\%)$$

(Where i = 4 or 5 reps and j = 1-102 id-codes)

Very good correlations were observed between the fitted values and the measured fdegdm for each grain type. Triticale p=0.86, Wheat p= 0.87, Barley p=0.89 and sorghum p=0.8 (fig 1).

Fig 1. Correlation between measured and fitted FDE of grain on dry matter basis



For FDE grain as received basis the backward elimination scheme contained the covariates cfat, ndf, lignin and beta-glucans and the conditional F-statistics for the fixed effects associated with the final model were: id_code 9.89, cfat 5.51, ndf 10.94, lig 10.44 ts 6.83, amylose 8.75 and betag 8.39. The formula can thus be written as:

$FDEG_{(i..j)idcode}$ (MJ/kg AR) ~ 16.1966 + id_code$_{jth}$ + 0.3303*betag(%) – 0.535*amylose(%)

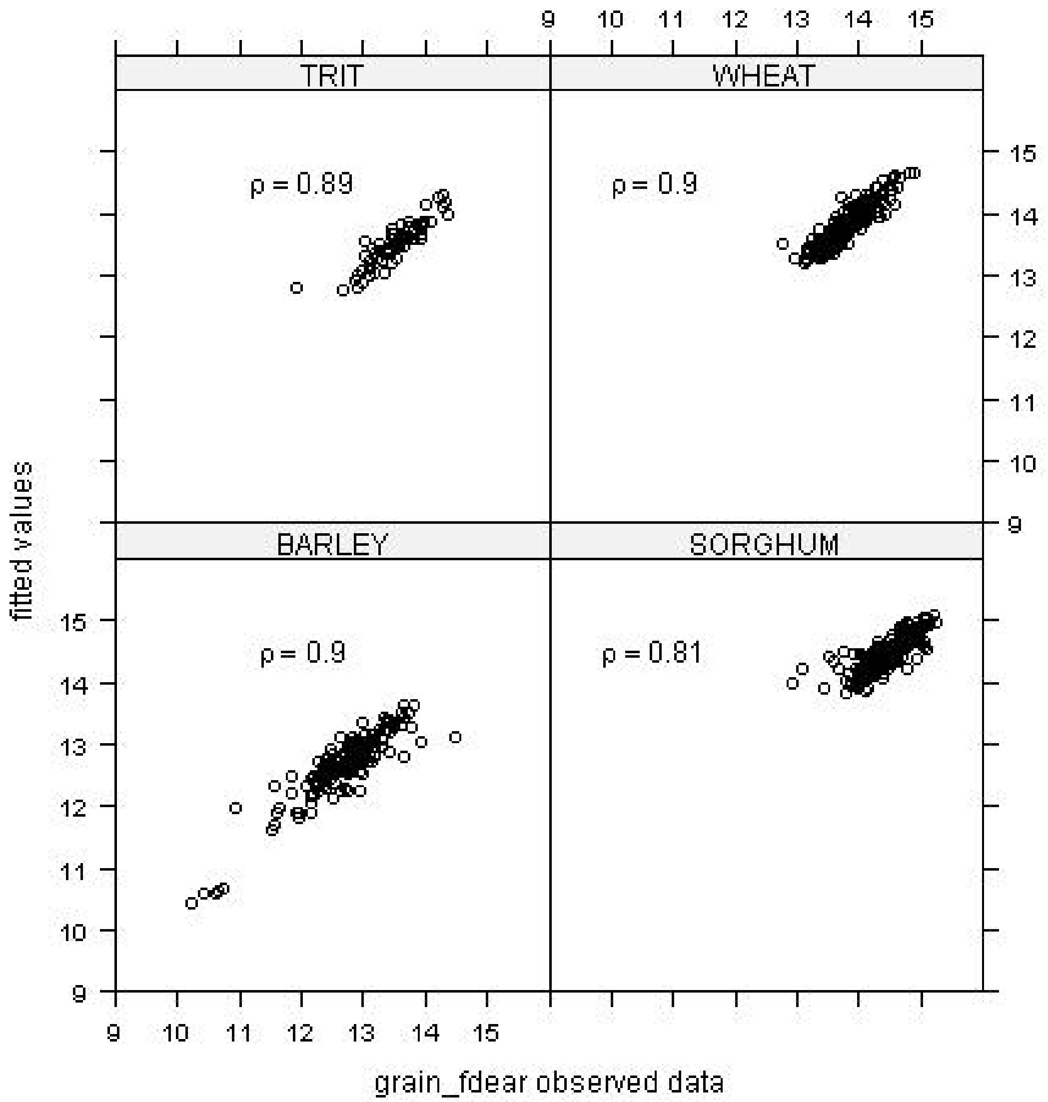
(0.8348) (0.1141) (0.0181)

+ 0.0129*ts(%) - 0.4424*lig(%) - 0.2372*ndf(%) + 0.0985*cfat(%)

(0.0049) (0.1369) (0.0717) (0.0419)

Again very good correlations were observed for the grain fdear. Triticale p=0.89, Wheat p= 0.9, Barley p= 0.9 and sorghum p= 0.81 (fig 2).

Fig 2. Correlation between measured and fitted FDE of grain on as received basis



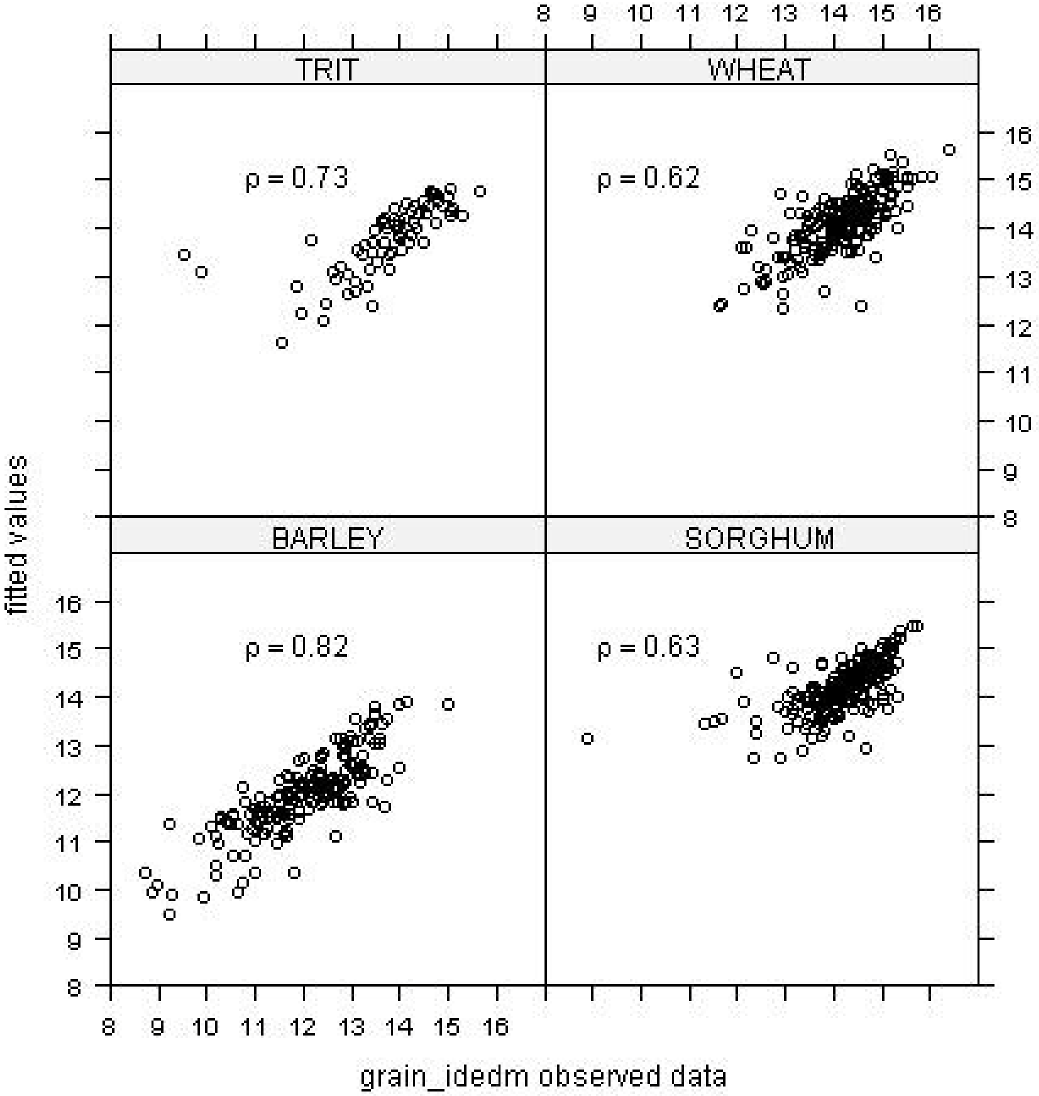
The equation for grain ileal DE on dry matter basis was:

ILDEG $_{(i..j)id\text{-}code}$ (MJ/kg DM) ~ 0.0673 + id_code$_{jth}$ + 0.8262*betag(%) - 0.0128*ts(%) + .6890*cp(%)

(7.606) (0.2954) 0.0068) (0.3649)

The correlation of the fitted values and measured grain ileal DE on dry matter basis was good for triticale (p=0.73) and barley (p=0.82) but not as good for wheat (p=0.62) and sorghum (p=0.63). (fig 3).

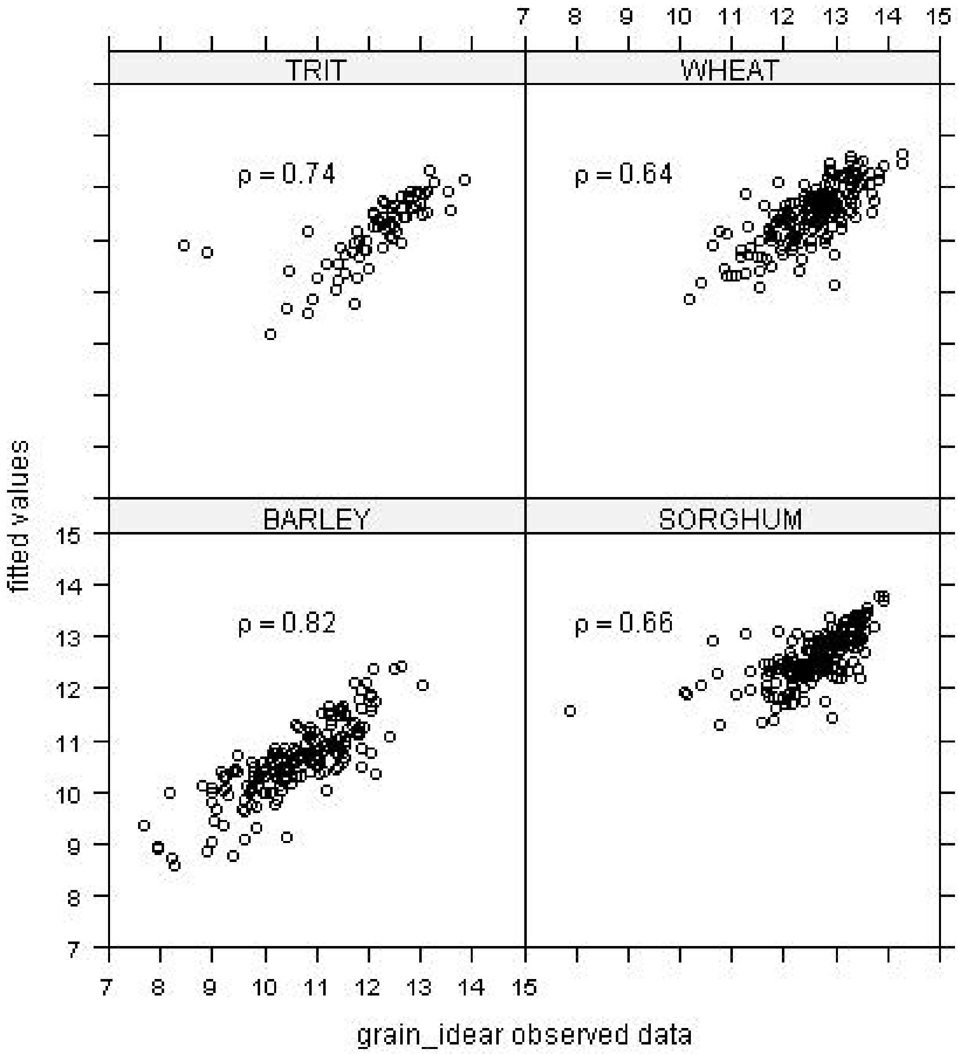
Fig 3. Correlation between measured and fitted IDE of grain on dry matter basis.



Similar correlations were measured for grain ileal DE on as received basis. Triticale (p=0.74), barley (p=0.82), wheat (p= 0.64) and sorghum (p=0.66) (fig4). The equation for grain ileal DE on as received basis is:

$$\text{IDEG}_{(i..j)id\text{-}code}\ (\text{MJ/kg AR}) \sim \underset{(6.3442)}{0.8472} + id\_code_{jth} + \underset{(0.2897)}{1.0195}*betag(\%) - \underset{(0.0087)}{0.0241}*amylop(\%) + \underset{(0.3461)}{0.6827}*cp(\%) + \underset{(0.1452)}{0.3635}*cfat(\%) - \underset{(0.3240)}{0.5830}*ash(\%).$$

Fig 4. Correlation between measured and fitted IDE of grain on as received basis.



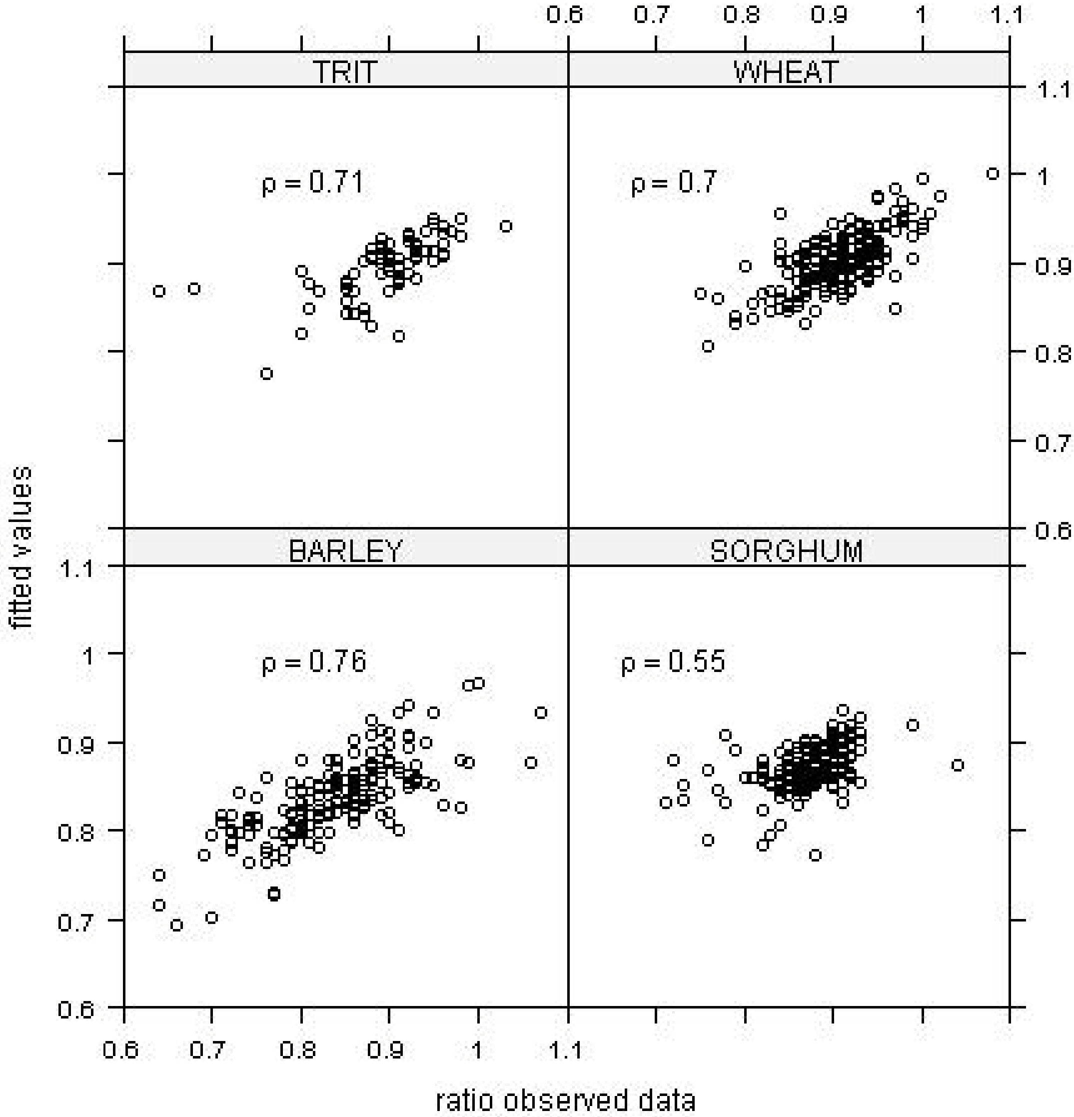
Fitted values (with standard errors in brackets) formula for ratio of grain feacal DE and grain ileal DE on dry matter basis can be written as:

$Ratio_{(i..j)id\text{-}code} \sim 0.9387 + id\_code_{jth} + 0.0603{*}betag(\%) - 0.0010{*}ts(\%)$

(0.350) (0.0195) (0.0004)

The correlation of fitted values and observed ratio were very good for triticale, barley and wheat (p=0.7) but poor for sorghum (p=0.55) (fig 5).

Fig 5. Correlation between measured and fitted Ratio of grain feacal DE and ileal DEon dry matter basis.



Generally, crude protein, crude fat and starch had positive association and fibre and ash negatively associated with grain energy values.

Very good prediction of feacal DE both on dry matter and as received basis can be made from proximate analysis of the grain. The prediction of ileal DE from proximate analysis would be less accurate especially for sorghum.

Chemical analysis all cereal grains collected over 3 years.

Mean values of all cereal grain type collected over 3 years is summarized in tables below. Table 11 shows the proximate data, Table 12 amino acid, Table 13 fatty acids and Table 14 the starch and beta glucan data. Chemical analysis of all grains collected is provided in appendix 2.

Table 11 Proximate results

		Wheat (n=35)			Barley (n=29)			Triticale (n=13)			Sorghum (n=26)	
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
DM %	90.40	88.1	92.9	90.10	88.6	91.2	90.00	89	91.1	89.70	88.6	90.7
Ash %DM	1.74	1.1	2.4	2.65	1.9	4.5	1.82	1.6	2.1	1.61	1.1	2.1
N %DM	2.70	1.82	3.53	2.46	1.66	3.38	2.38	1.39	3.1	2.06	1.53	2.46
CP%DM	16.90	11.38	22.06	15.36	10.38	21.13	14.84	8.69	19.38	12.87	9.56	15.38
ADF %DM	2.92	2	4.3	5.10	3.8	8.9	3.46	2.7	4.2	4.27	3.3	5.5
GE MJ/kg DM	18.45	18.04	18.83	18.45	18	18.84	18.32	18.04	18.57	18.75	18.4	19.08
NDF %DM	10.81	9.2	13.8	16.67	13.7	24.5	12.30	11.1	13.7	7.82	6.3	10.5
CF %DM	2.19	1.1	3.6	4.17	3	7.6	2.46	1.6	3.5	1.89	1.3	2.6
Fat %DM	2.08	1.2	3.3	2.26	1.8	3.7	1.74	1	2.3	3.62	2.4	4.8
Lignin %DM	0.64	0.1	1.6	0.70	0.1	1.4	0.98	0.5	1.5	0.62	0.2	1
K %DM	0.41	0.19	0.64	0.54	0.29	0.99	0.46	0.3	0.58	0.36	0.22	0.49
P %DM	0.32	0.25	0.4	0.34	0.25	0.46	0.31	0.24	0.4	0.32	0.19	0.45
Ash %ar	1.58	0.99	2.19	2.40	1.73	4.09	1.64	1.46	1.88	1.44	0.98	1.87
N %ar	2.45	1.61	3.2	2.22	1.47	3.08	2.14	1.27	2.8	1.85	1.36	2.19
CP% ar	15.28	10.08	20.02	13.88	9.19	19.25	13.36	7.91	17.5	11.54	8.5	13.67
ADF %ar	2.65	1.79	3.93	4.61	3.46	8.08	3.12	2.45	3.83	3.83	2.93	4.87
GE MJ/kg ar	16.68	16.23	17.49	16.66	16.24	17.15	16.49	16.19	16.83	16.82	16.46	17.25
NDF %ar	9.78	8.22	12.61	15.06	12.49	22.25	11.07	10	12.48	7.01	5.61	9.36
CF %ar	1.98	0.98	3.24	3.77	2.69	6.9	2.21	1.44	3.12	1.69	1.18	2.3
Fat %ar	1.88	1.07	3.03	2.04	1.63	3.37	1.56	0.9	2.05	3.25	2.15	4.27
Lignin %ar	0.58	0.09	1.44	0.63	0.09	1.24	0.88	0.45	1.37	0.55	0.18	0.9
K %ar	0.37	0.17	0.58	0.49	0.26	0.9	0.41	0.27	0.52	0.32	0.2	0.44
P %ar	0.29	0.23	0.36	0.31	0.22	0.41	0.28	0.22	0.36	0.29	0.17	0.4

***ar as received**

Table 12 Amino acid data

	Wheat (n=35)			Barley (n=29)			Triticale (n=13)			Sorghum (n=26)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
All values on %DM basis												
Alanine	0.49	0.36	0.61	0.54	0.40	0.69	0.52	0.33	0.67	1.12	0.82	1.34
Arginine	0.78	0.58	1.01	0.78	0.60	1.01	0.76	0.53	0.97	0.47	0.39	0.56
AsparticAcid	0.68	0.53	0.86	0.77	0.57	1.00	0.76	0.49	1.03	0.75	0.60	0.84
Cystine	0.38	0.25	0.49	0.33	0.21	0.43	0.34	0.21	0.44	0.25	0.18	0.34
GlutamicAcid	4.50	2.94	6.24	3.49	2.16	5.14	3.58	1.80	4.87	2.45	1.81	2.82
Glycine	0.63	0.40	0.86	0.55	0.39	0.72	0.57	0.34	0.72	0.35	0.30	0.41
Histidine	0.36	0.22	0.49	0.31	0.20	0.43	0.32	0.18	0.43	0.26	0.19	0.31
isoLeucine	0.52	0.34	0.69	0.50	0.31	0.68	0.46	0.26	0.63	0.47	0.36	0.56
Leucine	1.01	0.63	1.34	0.95	0.61	1.32	0.85	0.48	1.15	1.60	1.15	1.95
Lysine	0.38	0.29	0.45	0.47	0.35	0.59	0.42	0.30	0.54	0.22	0.17	0.25
Methionine	0.26	0.15	0.34	0.24	0.14	0.33	0.23	0.13	0.31	0.25	0.16	0.33
Phenylalanine	0.72	0.44	0.99	0.77	0.46	1.17	0.62	0.33	0.85	0.63	0.48	0.76
Proline	1.56	0.92	2.26	1.68	0.93	2.77	1.30	0.57	1.85	1.00	0.81	1.17
Serine	0.72	0.44	1.00	0.60	0.38	0.83	0.61	0.34	0.82	0.53	0.42	0.63
Threonine	0.44	0.29	0.57	0.47	0.31	0.64	0.42	0.25	0.56	0.37	0.30	0.44
Tryptophan	0.18	0.13	0.23	0.18	0.13	0.33	0.15	0.11	0.22	0.14	0.09	0.17
Tyrosine	0.46	0.27	0.67	0.44	0.27	0.63	0.38	0.18	0.51	0.46	0.34	0.56
Valine	0.62	0.40	0.81	0.67	0.42	0.91	0.57	0.33	0.78	0.56	0.45	0.65
All values on % as received basis												
Alanine	0.45	0.32	0.56	0.48	0.36	0.62	0.46	0.30	0.61	1.00	0.73	1.19
Arginine	0.71	0.52	0.92	0.70	0.53	0.91	0.68	0.48	0.88	0.43	0.34	0.50
AsparticAcid	0.61	0.47	0.77	0.70	0.51	0.90	0.69	0.44	0.92	0.67	0.54	0.75
Cystine	0.35	0.22	0.44	0.29	0.18	0.39	0.31	0.19	0.39	0.23	0.16	0.30
GlutamicAcid	4.07	2.61	5.66	3.15	1.91	4.66	3.23	1.64	4.41	2.19	1.61	2.53
Glycine	0.57	0.36	0.78	0.50	0.34	0.65	0.51	0.31	0.66	0.32	0.26	0.37
Histidine	0.33	0.20	0.45	0.28	0.18	0.39	0.28	0.16	0.39	0.23	0.17	0.28
isoLeucine	0.47	0.30	0.63	0.45	0.28	0.62	0.41	0.23	0.58	0.42	0.32	0.50
Leucine	0.92	0.56	1.22	0.86	0.54	1.20	0.77	0.43	1.04	1.43	1.02	1.73
Lysine	0.34	0.26	0.41	0.42	0.31	0.53	0.38	0.27	0.49	0.20	0.16	0.23
Methionine	0.23	0.13	0.31	0.22	0.12	0.30	0.21	0.12	0.27	0.23	0.14	0.29
Phenylalanine	0.65	0.39	0.90	0.69	0.41	1.06	0.56	0.30	0.77	0.56	0.43	0.67
Proline	1.41	0.81	2.05	1.52	0.82	2.51	1.17	0.52	1.67	0.89	0.72	1.04
Serine	0.65	0.39	0.91	0.54	0.34	0.75	0.55	0.31	0.74	0.48	0.37	0.56
Threonine	0.40	0.26	0.52	0.43	0.27	0.58	0.38	0.22	0.51	0.34	0.26	0.39
Tryptophan	0.17	0.12	0.21	0.17	0.11	0.30	0.14	0.10	0.20	0.12	0.08	0.15
Tyrosine	0.42	0.24	0.61	0.40	0.24	0.57	0.34	0.16	0.46	0.41	0.30	0.49
Valine	0.56	0.35	0.73	0.61	0.38	0.82	0.52	0.30	0.71	0.50	0.40	0.59

Table 13. Fatty acid

		All values on %DM basis											
		Wheat			Barley			Triticale			Sorghum		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Palmitic	16	0.325	0.287	0.402	0.425	0.361	0.501	0.265	0.249	0.293	0.426	0.322	0.491
stearic acid	18	0.024	0.017	0.038	0.038	0.033	0.043	0.016	0.013	0.020	0.050	0.044	0.058
oleic	18:1n-9	0.289	0.216	0.424	0.294	0.221	0.362	0.307	0.208	0.382	1.057	0.764	1.269
Linoleic	18:2n-6	1.103	1.001	1.344	1.144	0.942	1.298	1.023	0.927	1.101	1.287	0.902	1.547
		All values on % as received basis											
Palmitic	16	0.292	0.260	0.364	0.383	0.325	0.454	0.238	0.222	0.261	0.382	0.288	0.439
stearic acid	18	0.021	0.016	0.035	0.034	0.030	0.039	0.014	0.011	0.018	0.045	0.040	0.051
oleic	18:1n-9	0.260	0.195	0.384	0.265	0.200	0.328	0.276	0.185	0.341	0.948	0.684	1.134
Linoleic	18:2n-6	0.990	0.905	1.217	1.031	0.850	1.177	0.920	0.827	1.003	1.154	0.808	1.378

The oleic and linoleic levels in sorghum were much higher than in the other grains.

Table 14. Starch and Beta analyses

	All values on %DM basis											
	Wheat (n=35)			Barley (n=29)			Triticale (n=13)			Sorghum (n=26)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Total Starch (%dm)	63.0	55.6	70.6	53.6	47.1	58.9	61.6	55.7	66.3	68.2	64.0	75.4
Amylose (%dm)	11.5	7.1	14.8	8.6	5.5	11.4	10.1	7.4	13.6	15.9	9.8	20.1
Amylopectin (%dm)	51.5	44.7	59.3	45.0	38.8	49.1	51.5	45.2	54.8	52.3	46.9	59.6
bGlucan (%dm)	na	na	na	3.2	1.3	4.1	na	na	na	na	na	na
	All values on % as received basis											
Total Starch (%ar)	56.9	51.0	64.3	48.4	42.8	53.0	55.5	50.5	60.1	61.2	57.2	67.7
Amylose (%ar)	10.4	6.4	13.4	7.8	5.0	10.3	9.1	6.7	12.3	14.3	8.8	17.9
Amylopectin (%ar)	46.5	41.0	53.0	40.6	35.1	44.0	46.4	40.7	49.9	46.9	41.8	53.5
bGlucan (%ar)	na	na	na	2.9	1.2	3.7	na	na	na	na	na	na

3.2.1 Results Digestibility Experiment 1 (DS002).

Summary

Grain	FDEDAR	IDEDAR	FDEGAR	IDEGAR	FDEGDM	IDEGDM	RIFDE
Wheat	13.36^{b}	12.09^{a}	13.73^{b}	12.38^{a}	16.09^{b}	14.07^{a}	0.904^{b}
Barley	12.48^{d}	10.68^{c}	12.79^{d}	10.89^{c}	15.12^{d}	12.37^{c}	0.856^{a}
Triticale	12.97^{c}	11.44^{b}	13.32^{c}	11.70^{b}	15.69^{c}	13.31^{b}	0.880^{ab}
Sorghum	13.94^{a}	12.27^{a}	14.38^{a}	12.57^{a}	16.66^{a}	14.21^{a}	0.877^{ab}
P-values							
Grain type	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.036
Grain type.grain id	<0.001	ns	<0.001	ns	<0.001	ns	ns
Within sorg.zigiban	ns	ns	ns	ns	0.017	ns	ns

^{a,b,c,d} Values within same column with different superscripts are significantly different

There were significant grain type effect for all parameters measured (FDEDAR (feacal DE of diet as received), IDEDAR, (ileal DE of diet as received), FDEGAR (feacal DE of grain as received), IDEGAR ,(Ileal DE of grain as received), FDEGDM, (feacal DE of grain on dry matter basis), IDEGDM IDEGDM (ileal DE of grain on dry matter basis),and RIFDE (ratio of ileal and feacal DE) and significant within grain type effect for FDEAR, FDEGAR and FDEGDM. Inclusion of zigibain had a significant negative effect (p=0.017) on sorghum 7858 feacal DE on DM basis. Decrease in feacal DE (on DM basis) of sorghum 7858 from 16.69 to 16.15 MJ/kg with the inclusion of zigibain. The feacal energy content of sorghum was significantly higher than wheat followed by triticale and barley. There was approximately 1MJ/kg difference in feacal DE content of individual cereal grains samples within cereal grain type (Table15).

The ileal DE of sorghum was not significantly different to wheat but was significantly different to triticale and barley. The range in values for ileal DE was greater than the range in feacal DE. The ratio of ileal to feacal DE content was significantly higher for wheat compared to barley but was similar to triticale and sorghum.

Table 15 Feacal digestible energy of the diet (as received basis)

Grain Type	Grain Idsize	Predicted Value
Sorghum	7863_RAW0	14.40 m
Sorghum	7861_RAW0	14.37 lm
Sorghum	7862_RAW0	14.30 klm
Sorghum	7855_RAW0	14.02 jklm
Wheat	1753_RAW0	13.98 jkl
Sorghum	7856_RAW0	13.98 jkl
Sorghum	7864_RAW0	13.98 jkl
Sorghum	7860_RAW0	13.90 j
Sorghum	7859_RAW0	13.89 jk
Sorghum	7858_RAW0	13.74 ij
Wheat	1749_RAW0	13.70 ij
Sorghum	7857_RAW0	13.47 hi
Wheat	1754_RAW0	13.44 ghi
Wheat	1727_RAW0	13.42 ghi
Triticale	6824_RAW0	13.41 ghi
Wheat	1755_RAW0	13.22 fgh
Wheat	1728_RAW0	13.20 fgh
Wheat	1841_RAW0	13.16 fgh
Triticale	6825_RAW0	13.11 efgh
Triticale	6828_RAW0	13.10 efgh
Wheat	1758_RAW0	13.10 efgh
Wheat	1757_RAW0	13.06 defg
Barley	3756_RAW0	12.98 def
Barley	3757_RAW0	12.75 cde
Triticale	6826_RAW0	12.69 cd
Triticale	6827_RAW0	12.55 c
Barley	3866_RAW0	12.53 c
Barley	3868_RAW0	12.49 bc
Barley	3867_RAW0	12.43 abc
Barley	3861_RAW0	12.11 ab
Barley	3865_RAW0	12.05 a

Table 16 Ileal digestible energy of the diet (as received basis)

Grain Type	Grain Idsize	Zigibain	Predicted Value
Sorghum	7855_RAW0	no	12.26
Sorghum	7858_RAW0	no	11.83
Sorghum	7858_RAW0	yes	12.49
Sorghum	7862_RAW0	no	12.77
Sorghum	7863_RAW0	no	12.28
Sorghum	7856_RAW0	no	12.54
Sorghum	7857_RAW0	no	11.56
Sorghum	7864_RAW0	no	12.42
Sorghum	7859_RAW0	no	12.58
Sorghum	7861_RAW0	no	12.60
Sorghum	7860_RAW0	no	11.57
Barley	3866_RAW0	no	11.13
Barley	3867_RAW0	no	10.65
Barley	3865_RAW0	no	10.57
Barley	3757_RAW0	no	11.08
Barley	3868_RAW0	no	10.85
Barley	3756_RAW0	no	10.57
Barley	3861_RAW0	no	9.89
Triticale	6825_RAW0	no	11.22
Triticale	6828_RAW0	no	11.94
Triticale	6827_RAW0	no	11.05
Triticale	6826_RAW0	no	10.91
Triticale	6824_RAW0	no	12.09
Wheat	1753_RAW0	no	12.50
Wheat	1841_RAW0	no	11.62
Wheat	1727_RAW0	no	11.81
Wheat	1754_RAW0	no	10.86
Wheat	1758_RAW0	no	11.86
Wheat	1749_RAW0	no	12.43
Wheat	1757_RAW0	no	12.27
Wheat	1755_RAW0	no	12.85
Wheat	1728_RAW0	no	12.62

Table 17 Feacal digestible energy of cereal grain (as received basis)

Grain Type	Grain Idsize	Predicted Value
Sorghum	7863_RAW0	14.83 m
Sorghum	7861_RAW0	14.80 lm
Sorghum	7862_RAW0	14.72 klm
Sorghum	7855_RAW0	14.43 jklm
Wheat	1753_RAW0	14.39 jkl
Sorghum	7856_RAW0	14.38 jkl
Sorghum	7864_RAW0	14.38 jkl
Sorghum	7860_RAW0	14.30 j
Sorghum	7859_RAW0	14.29 jk
Sorghum	7858_RAW0	14.13 ij
Wheat	1749_RAW0	14.09 ij
Sorghum	7857_RAW0	13.84 hi
Wheat	1754_RAW0	13.81 ghi
Wheat	1727_RAW0	13.79 ghi
Triticale	6824_RAW0	13.78 ghi
Wheat	1755_RAW0	13.58 fgh
Wheat	1728_RAW0	13.56 fgh
Wheat	1841_RAW0	13.51 fgh
Triticale	6825_RAW0	13.47 efgh
Triticale	6828_RAW0	13.46 efgh
Wheat	1758_RAW0	13.45 efgh
Wheat	1757_RAW0	13.41 defg
Barley	3756_RAW0	13.33 def
Barley	3757_RAW0	13.09 cde
Triticale	6826_RAW0	13.02 cd
Triticale	6827_RAW0	12.87 c
Barley	3866_RAW0	12.85 c
Barley	3868_RAW0	12.80 bc
Barley	3867_RAW0	12.74 abc
Barley	3861_RAW0	12.40 ab
Barley	3865_RAW0	12.34 a

Table 18 Ileal digestible energy of cereal grain (as received basis)

Grain Type	Grain ID	Predicted Value
Sorghum	7862	13.87 l
Wheat	1755	13.80 kl
Sorghum	7861	13.65 jkl
Sorghum	7859	13.64 jkl
Wheat	1753	13.60 jkl
Sorghum	7856	13.55 ijkl
Wheat	1728	13.43 hijkl
Sorghum	7864	13.41 hijkl
Wheat	1749	13.39 hijkl
Sorghum	7863	13.32 hijkl
Sorghum	7855	13.26 hijkl
Sorghum	7858	13.20 hijkl
Triticale	6828	13.16 ghijkl
Wheat	1727	13.15 fghijkl
Wheat	1757	13.12 efghijkl
Triticale	6824	13.00 defghijkl
Wheat	1758	12.82 cdefghijk
Wheat	1841	12.81 cdefghijk
Sorghum	7860	12.62 bcdefghij
Sorghum	7857	12.53 bcdefgh
Triticale	6825	12.51 bcdefghi
Barley	3757	12.24 bcdefg
Barley	3866	12.20 bcdefg
Triticale	6827	12.17 bcdef
Wheat	1754	12.14 bcde
Triticale	6826	12.05 bcd
Barley	3867	11.86 abc
Barley	3756	11.80 ab
Barley	3868	11.80 ab
Barley	3865	11.69 ab
Barley	3861	10.96 a

Table 19 Feacal digestible energy of cereal grain (dry matter basis)

Grain Type	Grain Id	Zigibain	Predicted Value
Sorghum	7861	no	16.99 m
Sorghum	7863	no	16.95 m
Sorghum	7862	no	16.80 m
Sorghum	7856	no	16.79 m
Sorghum	7859	no	16.77 m
Sorghum	7858	no	16.69 lm
Sorghum	7864	no	16.67 lm
Wheat	1753	no	16.65 lm
Sorghum	7860	no	16.63 lm
Sorghum	7855	no	16.60 klm
Wheat	1749	no	16.33 jkl
Sorghum	7857	no	16.23 ijk
Wheat	1754	no	16.18 hij
Sorghum	7858	yes	16.15 hij
Triticale	6824	no	16.12 hij
Wheat	1755	no	16.04 hij
Wheat	1728	no	16.00 hij
Wheat	1841	no	16.00 hij
Wheat	1727	no	15.95 ghij
Triticale	6828	no	15.89 ghi
Wheat	1758	no	15.87 ghi
Wheat	1757	no	15.81 fgh
Triticale	6825	no	15.59 efg
Barley	3756	no	15.57 efg
Triticale	6826	no	15.45 def
Triticale	6827	no	15.39 cde
Barley	3757	no	15.34 cde
Barley	3866	no	15.23 cde
Barley	3867	no	15.15 bcd
Barley	3868	no	15.05 abc
Barley	3865	no	14.81 ab
Barley	3861	no	14.71 a

Table 20 Ileal digestible energy of cereal grain (dry matter basis)

Grain Type	Grain Idsize	Zigibain	Predicted Value
Sorghum	7855_RAW0	no	14.14
Sorghum	7858_RAW0	no	13.85
Sorghum	7858_RAW0	yes	14.30
Sorghum	7862_RAW0	no	14.58
Sorghum	7863_RAW0	no	14.11
Sorghum	7856_RAW0	no	14.69
Sorghum	7857_RAW0	no	13.51
Sorghum	7864_RAW0	no	14.40
Sorghum	7859_RAW0	no	14.78
Sorghum	7861_RAW0	no	14.51
Sorghum	7860_RAW0	no	13.46
Barley	3866_RAW0	no	12.95
Barley	3867_RAW0	no	12.38
Barley	3865_RAW0	no	12.37
Barley	3757_RAW0	no	12.73
Barley	3868_RAW0	no	12.52
Barley	3756_RAW0	no	12.16
Barley	3861_RAW0	no	11.46
Triticale	6825_RAW0	no	12.77
Triticale	6828_RAW0	no	13.99
Triticale	6827_RAW0	no	12.95
Triticale	6826_RAW0	no	12.75
Triticale	6824_RAW0	no	14.09
Wheat	1753_RAW0	no	14.42
Wheat	1841_RAW0	no	13.55
Wheat	1727_RAW0	no	13.50
Wheat	1754_RAW0	no	12.60
Wheat	1758_RAW0	no	13.90
Wheat	1749_RAW0	no	14.35
Wheat	1757_RAW0	no	14.40
Wheat	1755_RAW0	no	15.06
Wheat	1728_RAW0	no	14.82

Table 21 Ratio of the diet ileal DE to the feacal DE

Grain Type	Grain ID	Zigibain	Predicted Value
Sorghum	7855	no	0.90
Sorghum	7858	no	0.89
Sorghum	7858	yes	0.93
Sorghum	7862	no	0.92
Sorghum	7863	no	0.88
Sorghum	7856	no	0.92
Sorghum	7857	no	0.88
Sorghum	7864	no	0.91
Sorghum	7859	no	0.93
Sorghum	7861	no	0.90
Sorghum	7860	no	0.86
Barley	3866	no	0.90
Barley	3867	no	0.90
Barley	3865	no	0.91
Barley	3757	no	0.91
Barley	3868	no	0.89
Barley	3756	no	0.85
Barley	3861	no	0.85
Triticale	6825	no	0.89
Triticale	6828	no	0.93
Triticale	6827	no	0.90
Triticale	6826	no	0.89
Triticale	6824	no	0.92
Wheat	1753	no	0.91
Wheat	1841	no	0.92
Wheat	1727	no	0.90
Wheat	1754	no	0.86
Wheat	1758	no	0.92
Wheat	1749	no	0.92
Wheat	1757	no	0.95
Wheat	1755	no	0.98
Wheat	1728	no	0.95

3.2.2 Results Digestibility Experiment 2

Summary

Grain	FDEDAR	IDEDAR	FDEGAR	IDEGAR	FDEGDM	IDEGDM	RIFDE
Wheat	13.59c	12.62b	13.97c	12.82b	15.72b	14.42b	0.928b
Barley	12.62a	11.04a	12.95a	11.16a	14.51a	12.51a	0.876a
Triticale	13.38b	12.45b	13.75b	12.64b	15.60b	14.34b	0.929b
Sorghum	14.16d	12.58b	14.58d	12.77b	16.39c	14.36b	0.888a
p-values							
Grain type	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Grain type x grain id	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.305

Both GrainType and SampleID were highly significant, having p-values<0.001 for all the FDEDAR, IDEDAR, FDEGAR, IDEGAR, FDEGDM and IDEGDM. Whereas grain type was highly significant for RIFDE , within GrainType was not significant (p=0.305). The feacal energy content of sorghum was significantly higher than wheat followed by triticale and barley. There was approximately 1MJ/kg feacal DE content of individual cereal grains samples within cereal grain type (Tables 23-29).

The ileal DE of sorghum was not significantly different to wheat and triticale but was significantly different to barley. The range in values for ileal DE was greater than the range in feacal DE. The ratio of ileal to feacal DE content was significantly higher for wheat and triticale compared to barley and sorghum. The predicted GrainType values are given in table above

Table 22 Effect of stress on the energy content of sorghum

Grain Type	FDEDAR	IDEDAR	FDEGAR	IDEGAR	FDEGDM	IDEGDM	RIFDE
Sorghum 7714	13.713	12.033	14.101	12.201	15.880	13.739	0.878
Stressed 1	14.519	12.966	14.954	13.179	16.579	14.612	0.893
Stressed 2	14.36	12.718	14.785	12.919	16.483	14.402	0.885
Sprouted	14.026	12.352	14.432	12.535	16.326	14.181	0.880
Stressed1:Sprouted	14.314	12.643	14.736	12.841	16.483	14.636	0.882
Stressed2:Sprouted	14.157	12.406	14.571	12.592	16.335	14.115	0.879
p-values							
Stressed 1	<0.001	0.217	<0.001	0.216	0.112	0.568	0.979
Stressed 2	0.048	0.919	0.047	0.919	0.537	0.718	0.582
Sprouted	0.023	0.228	0.023	0.228	0.264	0.421	0.658
Stressed1:Sprouted	0.053	0.342	0.052	0.341	0.115	0.411	0.784
Stressed2:Sprouted	0.009	0.263	0.009	0.263	0.012	0.283	0.974

Table 23 Feacal digestible energy of the diet (as received basis)

GrainType	Grain_id	Predicted Value	Standard Error	Ranking
Barley	3876_ RAW0	12.060	0.103	a
Barley	3861_ RAW0	12.198	0.103	a
Barley	3870_ RAW0	12.294	0.103	ab
Barley	3871_ RAW0	12.483	0.103	bc
Barley	3867_ RAW0	12.598	0.103	c
Barley	3869_ RAW0	12.617	0.103	c
Barley	3874_ RAW0	12.693	0.103	cd
Barley	3875_ RAW0	12.706	0.103	cd
Barley	3873_ RAW0	12.936	0.103	de
Wheat	1763_ RAW0	13.004	0.103	ef
Barley	3872_ RAW0	13.022	0.103	ef
Triticale	6831_ RAW0	13.033	0.103	ef
Barley	3750_ RAW0	13.232	0.103	fg
Triticale	6829_ RAW0	13.248	0.103	fgh
Wheat	1760_ RAW0	13.256	0.103	fghi
Wheat	1766_ RAW0	13.358	0.103	ghi
Triticale	6830_ RAW0	13.388	0.103	ghij
Wheat	1756_ RAW0	13.437	0.103	ghijk
Wheat	1759_ RAW0	13.500	0.103	ghijkl
Wheat	1771_ RAW0	13.526	0.103	hijklm
Wheat	1762_ RAW0	13.534	0.103	ijklm
Wheat	1765_ RAW0	13.653	0.103	jklmn
Wheat	1768_ RAW0	13.675	0.103	klmn
Wheat	1746_ RAW0	13.710	0.103	klmn
Sorghum	7714_ RAW0	13.713	0.103	klmn
Wheat	1764_ RAW0	13.717	0.103	klmn
Sorghum	7855_ RAW0	13.742	0.103	lmno
Wheat	1770_ RAW0	13.759	0.103	lmno
Sorghum	7858_ RAW0	13.771	0.103	lmno
Wheat	1767_ RAW0	13.773	0.103	lmno
Sorghum	7862_ RAW0	13.811	0.103	mno
Wheat	1769_ RAW0	13.832	0.103	no
Sorghum	7861_ RAW0	13.834	0.103	no
Sorghum	7857_ RAW0	13.835	0.103	no
Triticale	6708_ RAW0	13.860	0.103	nop
Sorghum	7714_ SPROUT	14.026	0.103	opq
Wheat	1753_ RAW0	14.132	0.103	pqr
Sorghum	7864_ RAW0	14.149	0.103	qr
Sorghum	7714_STRESS2SPROUT	14.157	0.103	qr
Sorghum	7863_ RAW0	14.206	0.115	qr
Sorghum	7866_ RAW0	14.255	0.103	qrs
Sorghum	7714_ STRESS1SPROUT	14.314	0.103	rs
Sorghum	7868_ RAW0	14.326	0.103	rst
Sorghum	7856_ RAW0	14.345	0.103	rst
Sorghum	7714_ STRESS2	14.360	0.115	rst
Sorghum	7867_ RAW0	14.367	0.103	rst
Sorghum	7865_ RAW0	14.417	0.103	rst
Sorghum	7714_ STRESS1	14.519	0.103	st
Sorghum	7859_ RAW0	14.535	0.103	st
Sorghum	7860_ RAW0	14.601	0.103	t

There are some differences between the sorghum grains that were stressed and sprouted. There was a significant effect due to both types of stressing, with Stressed1 having a stronger effect with a p-value of < 0.001. Stressed2 had a p-value of 0.048. There was an overall effect due to sprouting, p-value 0.023. The combination of the raw 7714 and sprouting had a greater effect than the Stressed2 7714 and sprouting, they had p-values 0.003 and 0.009, respectively.

Table 24 Diet Ileal Digestible Energy (as received) MJ/kg -- Diet IDEAF

GrainType	SampleID	Predicted Value	Standard Error	Ranking
Barley	3870_ RAW0	10.280	0.273	a
Barley	3876_RAW0	10.549	0.273	ab
Barley	3872_ RAW0	10.611	0.273	ab
Barley	3869_ RAW0	10.767	0.272	abc
Barley	3861_ RAW0	10.778	0.273	abc
Barley	3875_ RAW0	11.241	0.276	bcd
Barley	3874_ RAW0	11.268	0.272	bcd
Barley	3871_ RAW0	11.278	0.272	bcde
Wheat	1763_ RAW0	11.393	0.272	cdef
Barley	3750_ RAW0	11.403	0.272	cdefg
Barley	3873_ RAW0	11.410	0.272	cdefg
Barley	3867_ RAW0	11.818	0.272	defgh
Sorghum	7714_ RAW0	12.033	0.272	efghi
Sorghum	7862_ RAW0	12.099	0.274	fghij
Wheat	1765_ RAW0	12.116	0.273	fghijk
Triticale	6829_ RAW0	12.142	0.273	ghijkl
Triticale	6831_ RAW0	12.153	0.272	fghijkl
Sorghum	7858_ RAW0	12.171	0.272	hijkl
Sorghum	7861_ RAW0	12.233	0.272	hijklm
Sorghum	7855_ RAW0	12.238	0.274	hijklm
Wheat	1760_ RAW0	12.238	0.273	hijklm
Sorghum	7714_ SPROUT	12.352	0.272	hijklmn
Wheat	1766_ RAW0	12.358	0.273	hijklmn
Sorghum	7714_ STRESS2SPROUT	12.406	0.272	hijklmn
Sorghum	7867_ RAW0	12.425	0.272	hijklmn
Sorghum	7857_ RAW0	12.477	0.273	hijklmn
Triticale	6830_ RAW0	12.513	0.272	hijklmn
Sorghum	7864_ RAW0	12.516	0.276	hijklmno
Sorghum	7863_ RAW0	12.536	0.304	hijklmnop
Wheat	1756_ RAW0	12.547	0.272	hijklmnop
Wheat	1759_ RAW0	12.563	0.273	hijklmnop
Wheat	1771_ RAW0	12.580	0.304	hijklmnop
Sorghum	7714_ STRESS1SPROUT	12.643	0.272	ijklmnop
Sorghum	7714_ STRESS2	12.718	0.272	ijklmnop
Wheat	1768_ RAW0	12.745	0.272	ijklmnop
Wheat	1767_ RAW0	12.796	0.272	jklmnop
Wheat	1769_ RAW0	12.799	0.272	jklmnop
Sorghum	7866_ RAW0	12.820	0.272	jklmnop
Sorghum	7868_ RAW0	12.842	0.272	jklmnop
Wheat	1764_ RAW0	12.850	0.272	klmnop
Sorghum	7859_ RAW0	12.875	0.273	lmnop
Sorghum	7865_ RAW0	12.941	0.272	mnop
Sorghum	7856_ RAW0	12.957	0.272	mnop
Wheat	1762_ RAW0	12.959	0.274	mnop
Sorghum	7714_ STRESS1	12.966	0.272	mnop
Triticale	6708_ RAW0	12.985	0.272	mnop
Wheat	1753_ RAW0	13.064	0.273	nop
Wheat	1746_ RAW0	13.070	0.272	nop
Sorghum	7860_ RAW0	13.273	0.273	op
Wheat	1770_ RAW0	13.281	0.273	p

There does not appear to be strong differences between the sorghum grains that have been stressed and sprouted. There are no differences in the stressed and sprouted grains, p-value > 0.050.

Table 25 Grain Feacal Digestible Energy (as received) MJ/kg – Grain FDEAF

GrainType	SampleID	Predicted Value	Standard Error	Ranking
Barley	3876_ RAW0	12.352	0.109	a
Barley	3861_ RAW0	12.498	0.109	a
Barley	3870_ RAW0	12.599	0.109	ab
Barley	3871_ RAW0	12.799	0.109	bc
Barley	3867_ RAW0	12.920	0.109	c
Barley	3869_ RAW0	12.941	0.109	c
Barley	3874_ RAW0	13.022	0.109	cd
Barley	3875_ RAW0	13.036	0.109	cd
Barley	3873_ RAW0	13.279	0.109	de
Wheat	1763_ RAW0	13.350	0.109	ef
Barley	3872_ RAW0	13.370	0.109	ef
Triticale	6831_ RAW0	13.382	0.109	ef
Barley	3750_RAWO	13.592	0.109	fg
Triticale	6829_RAWO	13.609	0.109	fgh
Wheat	1760_RAWO	13.617	0.109	fghi
Wheat	1766_RAWO	13.725	0.109	ghi
Triticale	6830_RAW0	13.758	0.109	ghij
Wheat	1756_RAW0	13.808	0.109	ghijk
Wheat	1759_RAW0	13.876	0.109	ghijkl
Wheat	1771_ RAW0	13.903	0.109	hijklm
Wheat	1762_ RAW0	13.912	0.109	ijklm
Wheat	1765_ RAW0	14.037	0.109	jklmn
Wheat	1768_ RAW0	14.061	0.109	klmn
Wheat	1746_ RAW0	14.097	0.109	klmn
Wheat	7714_ RAW0	14.101	0.109	klmn
Wheat	1764_ RAW0	14.105	0.109	klmn
Sorghum	7855_ RAW0	14.131	0.109	lmno
Wheat	1770_ RAW0	14.150	0.109	lmno
Sorghum	7858_ RAW0	14.162	0.109	lmno
Wheat	1767_ RAW0	14.165	0.109	lmno
Sorghum	7862_ RAW0	14.204	0.109	mno
Wheat	1769_ RAW0	14.227	0.109	no
Sorghum	7861_ RAW0	14.229	0.109	no
Sorghum	7857_ RAW0	14.230	0.109	no
Triticale	6708_ RAW0	14.257	0.109	nop
Sorghum	7714_ SPROUT	14.432	0.109	opq
Wheat	1753_ RAW0	14.544	0.109	pqr
Sorghum	7864_ RAW0	14.562	0.109	qr
Sorghum	7714_ STRESS2SPROUT	14.571	0.109	qr
Sorghum	7863_ RAW0	14.622	0.121	qr
Sorghum	7866_ RAW0	14.674	0.109	qrs
Sorghum	7714_ STRESS1SPROUT	14.736	0.109	rs
Sorghum	7868_ RAW0	14.749	0.109	rst
Sorghum	7856_ RAW0	14.770	0.109	rst
Sorghum	7714_ STRESS2	14.785	0.122	rst
Sorghum	7867_ RAW0	14.793	0.109	rst
Sorghum	7865_ RAW0	14.845	0.109	rst
Sorghum	7714_ STRESS1	14.954	0.109	st
Sorghum	7859_ RAW0	14.971	0.109	st
Sorghum	7860_ RAW0	15.041	0.109	t

Both GrainType and SampleID were highly significant, having p-values < 0.001.

There are some differences between the sorghum grains that have been stressed andsprouted. There was a significant effect due to both types of stressing, with Stress1 (drought conditions) having a stronger effect (14.95MJ) with a p-value of < 0.001. Stress 2 (14.79MJ) had a p-value of 0.047. There was an overall effect due to sprouting (14.58MJ), p-value 0.023. The combination of Stress2 7714 and sprouting (14.57MJ) had a greater effect than the raw 7714 and sprouting (14.43MJ), they had p-values 0.009 and 0.003, respectively. Feacal DE of sorghum grown in the field under irrigation was significantly lower-14.MJ/kg.

Table 26 Grain Ileal Digestible Energy (as received) MJ/kg - GrainIDEAF

Grain Type	SampleID	Predicted Value	Standard Error	Ranking
Barley	3870 RAW0	10.364	0.286	a
Barley	3876 RAW0	10.646	0.286	ab
Barley	3872 RAW0	10.711	0.286	ab
Barley	3869 RAW0	10.875	0.285	abc
Barley	3861 RAW0	10.887	0.286	abc
Barley	3875 RAW0	11.371	0.289	bcd
Barley	3874 RAW0	11.400	0.285	bcd
Barley	3871 RAW0	11.410	0.285	bcde
Wheat	1763 RAW0	11.531	0.285	cdef
Barley	3750 RAW0	11.541	0.285	cdefg
Barley	3873 RAW0	11.549	0.285	cdefg
Barley	3867 RAW0	11.976	0.285	defgh
Sorghum	7714 RAW0	12.201	0.285	efghi
Sorghum	7862 RAW0	12.270	0.287	fghij
Wheat	1765 RAW0	12.288	0.286	fghijk
Triticale	6829 RAW0	12.316	0.286	ghijkl
Triticale	6831 RAW0	12.327	0.285	fghijkl
Sorghum	7858 RAW0	12.346	0.285	hijkl
Sorghum	7861 RAW0	12.410	0.285	hijklm
Sorghum	7855 RAW0	12.415	0.288	hijklm
Wheat	1760 RAW0	12.416	0.286	hijklm
Sorghum	7714 SPROUT	12.535	0.285	hijklmn
Wheat	1766 RAW0	12.542	0.286	hijklmn
Sorghum	7714STRESS2SPROUT	12.592	0.285	hijklmn
Sorghum	7867 RAW0	12.611	0.285	hijklmn
Sorghum	7857 RAW0	12.666	0.286	hijklmn
Triticale	6830 RAW0	12.704	0.285	hijklmn
Sorghum	7864 RAW0	12.707	0.289	hijklmno
Sorghum	7863 RAW0	12.728	0.318	hijklmnop
Wheat	1756 RAW0	12.739	0.285	hijklmnop
Wheat	1759 RAW0	12.757	0.286	hijklmnop
Wheat	1771 RAW0	12.774	0.319	hijklmnop
Sorghum	7714STRESS1SPROUT	12.841	0.285	ijklmnop
Sorghum	7714 STRESS2	12.919	0.285	ijklmnop
Wheat	1768 RAW0	12.947	0.285	ijklmnop
Wheat	1767 RAW0	13.000	0.285	jklmnop
Wheat	1769 RAW0	13.004	0.285	jklmnop
Sorghum	7866 RAW0	13.025	0.285	jklmnop
Sorghum	7868 RAW0	13.049	0.285	jklmnop
Wheat	1764 RAW0	13.057	0.285	klmnop

Grain Type	SampleID	Predicted Value	Standard Error	Ranking
Sorghum	7859 RAW0	13.083	0.286	lmnop
Sorghum	7865 RAW0	13.153	0.285	mnop
Sorghum	7856 RAW0	13.170	0.285	mnop
Wheat	1762 RAW0	13.171	0.287	mnop
Sorghum	7714 STRESS1	13.179	0.285	mnop
Triticale	6708 RAW0	13.199	0.285	mnop
Wheat	1753 RAW0	13.281	0.286	nop
Wheat	1746 RAW0	13.288	0.285	nop
Sorghum	7860 RAW0	13.501	0.286	op
Wheat	1770 RAW0	13.509	0.286	p

Both GrainType and SampleID are highly significant, having p-values < 0.001. There does not appear to be differences between the sorghum grains that have been stressed and sprouted. There are no differences in the stressed and sprouted grains, p-value > 0.050.

Table 27 Grain Feacal Digestible Energy (dry matter) MJ/kg -GrainFDEDM

Grain Type	SampleID	Predicted Value	Standard Error	Ranking
Barley	3861_ RAW0	13.916	0.122	a
Barley	3876_RAWO	13.941	0.123	a
Barley	3870_ RAWO	14.188	0.123	ab
Barley	3871_ RAWO	14.429	0.123	bc
Barley	3867_ RAWO	14.436	0.122	bc
Barley	3874_ RAWO	14.453	0.122	bc
Barley	3869_ RAWO	14.508	0.122	bcd
Barley	3873_ RAWO	14.754	0.122	cde
Barley	3875_ RAWO	14.830	0.123	de
Barley	3872_ RAWO	14.855	0.123	e
Wheat	1763_ RAWO	14.983	0.122	e
Barley	3750_ RAWO	15.324	0.122	f
Wheat	1766_ RAWO	15.335	0.123	f
Triticale	6831_ RAWO	15.365	0.123	f
Wheat	1760_ RAWO	15.387	0.122	fg
Triticale	6829_ RAWO	15.395	0.122	fgh
Wheat	1771_ RAWO	15.621	0.122	fghi
Wheat	1759_ RAWO	15.625	0.122	fghij
Wheat	1756_ RAWO	15.638	0.122	fghij
Wheat	1762_ RAWO	15.719	0.123	ghijk
Wheat	1746_ RAWO	15.734	0.122	hijkl
Wheat	1765_ RAWO	15.737	0.122	ijkl
Triticale	6830_ RAWO	15.778	0.122	ijkl
Wheat	1768_ RAWO	15.816	0.122	ijklm
Wheat	1764_ RAWO	15.867	0.122	ijklm
Triticale	6708_ RAWO	15.876	0.122	ijklm
Sorghum	7714_ RAWO	15.880	0.122	ijklm
Wheat	1770_ RAWO	15.916	0.122	ijklm
Sorghum	7858_ RAWO	15.966	0.122	jklm
Wheat	1769_ RAWO	16.003	0.122	klmn
Sorghum	7855_ RAWO	16.004	0.123	klmn
Wheat	1767_ RAWO	16.060	0.122	lmn
Sorghum	7857_ RAWO	16.115	0.122	mn
Sorghum	7861_ RAWO	16.133	0.122	mno

Grain Type	SampleID	Predicted Value	Standard Error	Ranking
Sorghum	7862_ RAWO	16.141	0.123	mno
Sorghum	7856_ RAWO	16.318	0.122	nop
Wheat	1753_ RAWO	16.324	0.122	nop
Sorghum	7714_ SPROUT	16.326	0.122	nop
Sorghum	7714_ STRESS2SPROUT	16.335	0.122	nop
Sorghum	7714_ STRESS2	16.483	0.137	opq
Sorghum	7714_ STRESS1SPROUT	16.483	0.122	pq
Sorghum	7864_ RAW0	16.529	0.123	pq
Sorghum	7859_ RAW0	16.542	0.123	pq
Sorghum	7868_ RAW0	16.572	0.122	pq
Sorghum	7714_ STRESS1	16.579	0.122	pq
Sorghum	7863_ RAW0	16.616	0.136	pq
Sorghum	7866_ RAW0	16.619	0.122	pq
Sorghum	7867_ RAW0	16.640	0.122	pq
Sorghum	7860_ RAW0	16.787	0.122	q
Sorghum	7865_ RAW0	16.793	0.122	q

Both Grain Type and SampleID are highly significant, having p-values < 0.001. There are some differences between the sorghum grains that have been stressed and sprouted. The effect of sprouting the raw 7714 was significant (16.33MJ), having a p-value of 0.002. Also, the effect of sprouting the Stressed2 grain was significant (16.34MJ), having a p-value of 0.012.

Table 28 Grain Ileal Digestible Energy (dry matter) MJ/kg - GrainIDEDM

Grain Type	SampleID	Predicted Value	Standard Error	Ranking
Barley	3870 RAW0	11.672	0.322	a
Barley	3872 RAW0	11.899	0.322	ab
Barley	3876 RAW0	12.016	0.322	abc
Barley	3861 RAW0	12.124	0.322	abcd
Barley	3869 RAW0	12.190	0.320	abcde
Barley	3874 RAW0	12.650	0.321	bcdef
Barley	3873 RAW0	12.832	0.321	cdef
Barley	3871 RAW0	12.865	0.321	cdefg
Barley	3875 RAW0	12.936	0.325	defgh
Wheat	1763 RAW0	12.940	0.321	defgh
Barley	3750 RAW0	13.012	0.321	efgh
Barley	3867 RAW0	13.378	0.321	fghi
Sorghum	7714 RAW0	13.739	0.321	ghij
Wheat	1765 RAW0	13.774	0.322	hijk
Sorghum	7858 RAW0	13.919	0.321	ijkl
Triticale	6829 RAW0	13.930	0.322	ijkl
Sorghum	7862 RAW0	13.943	0.324	ijkl
Wheat	1766 RAW0	14.014	0.322	ijklm
Wheat	1760 RAW0	14.029	0.322	ijklm
Sorghum	7855 RAW0	14.059	0.324	ijklm
Sorghum	7861 RAW0	14.072	0.320	ijklm
Sorghum	7714 STRESS2SPROUT	14.115	0.321	ijklm
Triticale	6831 RAW0	14.157	0.321	ijklm
Sorghum	7714 SPROUT	14.181	0.321	ijklm
Sorghum	7867 RAW0	14.185	0.321	ijklm
Sorghum	7857 RAW0	14.343	0.322	jklmn
Wheat	1771 RAW0	14.352	0.359	jklmn
Sorghum	7714 STRESS1SPROUT	14.363	0.321	jklmn

Grain Type	SampleID	Predicted Value	Standard Error	Ranking
Wheat	1759 RAW0	14.365	0.323	jklmn
Sorghum	7714 STRESS2	14.402	0.321	jklmn
Sorghum	7864 RAW0	14.424	0.326	jklmn
Sorghum	1756 RAW0	14.428	0.321	jklmn
Sorghum	7859 RAW0	14.455	0.322	jklmn
Sorghum	7863 RAW0	14.464	0.358	jklmn
Sorghum	7856 RAW0	14.553	0.321	jklmn
Wheat	1768 RAW0	14.564	0.321	jklmn
Triticale	6830 RAW0	14.571	0.321	jklmn
Sorghum	7714 STRESS1	14.612	0.321	jklmn
Wheat	1769 RAW0	14.628	0.321	klmn
Sorghum	7868 RAW0	14.660	0.321	lmn
Wheat	1764 RAW0	14.687	0.321	lmn
Triticale	6708 RAW0	14.700	0.321	lmn
Wheat	1767 RAW0	14.738	0.321	lmn
Sorghum	7866 RAW0	14.750	0.321	lmn
Wheat	1746 RAW0	14.832	0.321	mn
Sorghum	7865 RAW0	14.878	0.321	mn
Wheat	1762 RAW0	14.882	0.324	mn
Wheat	1753 RAW0	14.908	0.322	mn
Sorghum	7860 RAW0	15.067	0.322	n
Wheat	1770 RAW0	15.195	0.322	n

Both GrainType and SampleID are highly significant, having p-values < 0.001. There does not appear to be any differences between the sorghum grains that have been stressed and sprouted. When formally tested, there are no differences in the stressed and sprouted grains, p-value > 0.050.

Table 29 Ratio Ileal to Feacal Digestible Energy - RIFDE

Grain Type	SampleID	Predicted Value	Standard Error
Wheat	1746 RAW0	0.952	0.021
Wheat	1753 RAW0	0.924	0.021
Wheat	1756 RAW0	0.933	0.021
Wheat	1759 RAW0	0.931	0.021
Wheat	1760 RAW0	0.922	0.021
Wheat	1762 RAW0	0.956	0.021
Wheat	1763 RAW0	0.876	0.021
Wheat	1764 RAW0	0.937	0.021
Wheat	1765 RAW0	0.888	0.021
Wheat	1766 RAW0	0.926	0.021
Wheat	1767 RAW0	0.927	0.021
Wheat	1768 RAW0	0.932	0.021
Wheat	1769 RAW0	0.925	0.021
Wheat	1770 RAW0	0.965	0.021
Wheat	1771 RAW0	0.923	0.023
Barley	3750 RAW0	0.862	0.021
Barley	3861 RAW0	0.885	0.021
Barley	3867 RAW0	0.942	0.021
Barley	3869 RAW0	0.856	0.021
Barley	3870 RAW0	0.837	0.021
Barley	3871 RAW0	0.903	0.021
Barley	3872 RAW0	0.817	0.021
Barley	3873 RAW0	0.884	0.021
Barley	3874 RAW0	0.891	0.021

Grain Type	SampleID	Predicted Value	Standard Error
Barley	3875 RAW0	0.883	0.021
Barley	3876 RAW0	0.872	0.021
Triticale	6708 RAW0	0.935	0.021
Triticale	6829 RAW0	0.915	0.021
Triticale	6830 RAW0	0.934	0.021
Triticale	6831 RAW0	0.932	0.021
Sorghum	7714 RAW0	0.878	0.021
Sorghum	7714 SPROUT	0.880	0.021
Sorghum	7714 STRESS1	0.893	0.021
Sorghum	7714 STRESS1SPROUT	0.882	0.021
Sorghum	7714 STRESS2	0.885	0.023
Sorghum	7714 STRESS2SPROUT	0.879	0.021
Sorghum	7855 RAW0	0.891	0.021
Sorghum	7856 RAW0	0.905	0.021
Sorghum	7857 RAW0	0.900	0.021
Sorghum	7858 RAW0	0.884	0.021
Sorghum	7859 RAW0	0.888	0.021
Sorghum	7860 RAW0	0.909	0.021
Sorghum	7861 RAW0	0.883	0.021
Sorghum	7862 RAW0	0.876	0.021
Sorghum	7863 RAW0	0.882	0.023
Sorghum	7864 RAW0	0.884	0.021
Sorghum	7865 RAW0	0.901	0.021
Sorghum	7866 RAW0	0.899	0.021
Sorghum	7867 RAW0	0.866	0.021
Sorghum	7868 RAW0	0.896	0.021

Only GrainType is significant, having a p-value < 0.001. There are no differences in the stressed and sprouted grains, p-value > 0.050.

3.3.3 Results Digestibility Experiment 3

Summary

Grain	FDEDAR	IDEDAR	FDEGAR	IDEGAR	FDEGDM	IDEGDM	RIFDE
Wheat	13.37c	11.97b	13.73c	12.25 b	15.56c	13.38b	0.90c
Barley	12.20a	9.98a	12.50a	10.15 a	14.12a	11.46a	0.82a
Triticale	13.11b	11.78b	13.47 b	12.05 b	15.12b	13.61b	0.90c
Sorghum	13.89d	12.01b	14.25 d	12.30 c	16.04d	13.88b	0.87b

Grain type and diet were all highly significant (P < 0:001) for the 4 ileal and 4 feacal traits. For the ratio of ileal DE of diet on an as received basis to feacal DE of diet on an as received basis grain type was highly significant (P < 0:001), however diet was only significant at the 5% level (P < 0:039). DE content of individual grains are given in Tables 30-36.

Table 30 Feacal digestible energy of the diet (as received basis)

database_grain_ID	diet FDE (ar)	std error
1753_RAW0	13.92	0.11
1764_RAW0	13.51	0.11
1767_RAW0	13.61	0.11
1770_RAW0	13.60	0.11
1772_RAW0	13.80	0.12
1772_SPROUT	13.17	0.11
1773_RAW0	13.06	0.12
1773_SPROUT	12.99	0.11
1856_RAW0	13.05	0.11
1864_SPROUT	13.42	0.11
1865_SPROUT	13.16	0.11
1868_RAW0	13.85	0.11
1874_SPROUT	13.13	0.11
1876_RAW0	13.15	0.11
1877_RAW0	13.30	0.11
1879_SPROUT	13.14	0.11
3861_RAW0	11.61	0.11
3870_RAW0	11.92	0.12
3871_RAW0	12.13	0.11
3872_RAW0	13.07	0.11
3873_RAW0	12.36	0.11
3874_RAW0	12.20	0.11
3877_SPROUT	12.36	0.11
3879_SPROUT	12.32	0.11
3879_STRESS2	10.37	0.11
3880_RAW0	12.08	0.11
3880_STRESS2	11.57	0.11
3890_RAW0	12.41	0.11
3891_RAW0	12.36	0.11
3897_RAW0	12.26	0.11
3898_RAW0	12.86	0.12
3918_SPROUT	12.46	0.11
3919_SPROUT	12.41	0.11
3921_RAW0	12.34	0.11
3921_SPROUT	12.74	0.11
6829_RAW0	13.29	0.11
6830_RAW0	13.39	0.11
6835_RAW0	12.70	0.12
6835_SPROUT	13.01	0.11
6836_RAW0	13.12	0.11
6837_RAW0	13.16	0.11
7856_RAW0	13.88	0.12
7857_RAW0	13.44	0.11
7858_RAW0	13.73	0.11
7867_RAW0	14.22	0.11
7869_RAW0	14.00	0.11
7870_RAW0	14.03	0.11
7871_RAW0	13.60	0.12
7872_RAW0	13.97	0.11
7876_RAW0	13.85	0.11

Table 31 Ileal digestible energy of the diet (as received basis)

database_grain_ID	diet IDE (ar)	std error
1753_RAW0	12.34	0.28
1764_RAW0	12.47	0.28
1767_RAW0	11.99	0.28
1770_RAW0	12.14	0.28
1772_RAW0	12.43	0.31
1772_SPROUT	12.15	0.28
1773_RAW0	11.67	0.31
1773_SPROUT	11.72	0.28
1856_RAW0	11.79	0.28
1864_SPROUT	12.05	0.28
1865_SPROUT	11.93	0.28
1868_RAW0	12.09	0.28
1874_SPROUT	11.64	0.28
1876_RAW0	11.40	0.28
1877_RAW0	11.67	0.28
1879_SPROUT	12.00	0.28
3861_RAW0	10.02	0.28
3870_RAW0	9.22	0.31
3871_RAW0	10.18	0.28
3872_RAW0	9.81	0.28
3873_RAW0	10.51	0.28
3874_RAW0	9.74	0.28
3877_SPROUT	10.11	0.28
3879_SPROUT	10.32	0.28
3879_STRESS2	8.93	0.28
3880_RAW0	9.78	0.28
3880_STRESS2	9.79	0.31
3890_RAW0	10.25	0.28
3891_RAW0	10.34	0.28
3897_RAW0	8.84	0.28
3898_RAW0	10.51	0.31
3918_SPROUT	10.52	0.28
3919_SPROUT	10.31	0.28
3921_RAW0	10.02	0.28
3921_SPROUT	10.39	0.28
6829_RAW0	11.89	0.28
6830_RAW0	12.02	0.28
6835_RAW0	11.45	0.31
6835_SPROUT	11.92	0.28
6836_RAW0	11.23	0.28
6837_RAW0	12.16	0.28
7856_RAW0	11.80	0.28
7857_RAW0	11.61	0.28
7858_RAW0	11.92	0.28
7867_RAW0	12.40	0.28
7869_RAW0	12.23	0.28
7870_RAW0	12.00	0.31
7871_RAW0	11.87	0.31
7872_RAW0	12.38	0.28
7876_RAW0	11.93	0.28

Table 32 Feacal digestible energy of the grain (as received basis)

database_grain_ID	grain FED (ar)	std error
1753_RAW0	14.32	0.12
1764_RAW0	13.88	0.12
1767_RAW0	13.99	0.12
1770_RAW0	13.98	0.12
1772_RAW0	14.19	0.13
1772_SPROUT	13.53	0.12
1773_RAW0	13.41	0.13
1773_SPROUT	13.34	0.12
1856_RAW0	13.40	0.12
1864_SPROUT	13.79	0.12
1865_SPROUT	13.52	0.12
1868_RAW0	14.25	0.12
1874_SPROUT	13.48	0.12
1876_RAW0	13.50	0.12
1877_RAW0	13.66	0.12
1879_SPROUT	13.50	0.11
3861_RAW0	11.87	0.12
3870_RAW0	12.20	0.13
3871_RAW0	12.42	0.12
3872_RAW0	13.42	0.12
3873_RAW0	12.67	0.12
3874_RAW0	12.50	0.11
3877_SPROUT	12.67	0.12
3879_SPROUT	12.63	0.12
3879_STRESS2	10.57	0.12
3880_RAW0	12.37	0.12
3880_STRESS2	11.84	0.12
3890_RAW0	12.72	0.12
3891_RAW0	12.67	0.12
3897_RAW0	12.56	0.12
3898_RAW0	13.20	0.13
3918_SPROUT	12.77	0.12
3919_SPROUT	12.72	0.12
3921_RAW0	12.65	0.12
3921_SPROUT	13.07	0.12
6829_RAW0	13.66	0.12
6830_RAW0	13.76	0.12
6835_RAW0	13.03	0.13
6835_SPROUT	13.36	0.12
6836_RAW0	13.47	0.12
6837_RAW0	13.52	0.12
7856_RAW0	14.28	0.13
7857_RAW0	13.81	0.12
7858_RAW0	14.12	0.12
7867_RAW0	14.63	0.12
7869_RAW0	14.40	0.12
7870_RAW0	14.44	0.12
7871_RAW0	13.99	0.13
7872_RAW0	14.38	0.12
7876_RAW0	14.25	0.12

Table 33 Ileal digestible energy of the grain (as received basis)

database_grain_ID	grain IDE (ar)	std error
1753_RAW0	12.65	0.30
1764_RAW0	12.78	0.30
1767_RAW0	12.27	0.30
1770_RAW0	12.44	0.30
1772_RAW0	12.74	0.33
1772_SPROUT	12.45	0.30
1773_RAW0	11.94	0.33
1773_SPROUT	11.99	0.30
1856_RAW0	12.07	0.30
1864_SPROUT	12.34	0.30
1865_SPROUT	12.22	0.30
1868_RAW0	12.38	0.30
1874_SPROUT	11.90	0.30
1876_RAW0	11.65	0.30
1877_RAW0	11.94	0.30
1879_SPROUT	12.29	0.30
3861_RAW0	10.19	0.30
3870_RAW0	9.35	0.33
3871_RAW0	10.37	0.30
3872_RAW0	9.97	0.30
3873_RAW0	10.71	0.30
3874_RAW0	9.90	0.30
3877_SPROUT	10.29	0.30
3879_SPROUT	10.51	0.30
3879_STRESS2	9.04	0.30
3880_RAW0	9.94	0.30
3880_STRESS2	9.95	0.33
3890_RAW0	10.43	0.30
3891_RAW0	10.53	0.30
3897_RAW0	8.94	0.30
3898_RAW0	10.71	0.33
3918_SPROUT	10.73	0.30
3919_SPROUT	10.50	0.30
3921_RAW0	10.20	0.30
3921_SPROUT	10.58	0.30
6829_RAW0	12.17	0.30
6830_RAW0	12.31	0.30
6835_RAW0	11.70	0.33
6835_SPROUT	12.20	0.30
6836_RAW0	11.47	0.30
6837_RAW0	12.45	0.30
7856_RAW0	12.07	0.30
7857_RAW0	11.87	0.30
7858_RAW0	12.20	0.30
7867_RAW0	12.71	0.30
7869_RAW0	12.53	0.30
7870_RAW0	12.29	0.33
7871_RAW0	12.15	0.33
7872_RAW0	12.69	0.30
7876_RAW0	12.21	0.30

Table 34 Grain Feacal digestible energy (as dry matter basis)

database_grain_ID	grain FED (dm)	std error
1753_RAW0	16.13	0.13
1764_RAW0	15.58	0.13
1767_RAW0	15.77	0.13
1770_RAW0	15.76	0.13
1772_RAW0	16.00	0.14
1772_SPROUT	15.51	0.13
1773_RAW0	15.40	0.14
1773_SPROUT	15.52	0.13
1856_RAW0	15.13	0.13
1864_SPROUT	15.41	0.13
1865_SPROUT	15.15	0.13
1868_RAW0	15.94	0.13
1874_SPROUT	15.32	0.13
1876_RAW0	15.52	0.13
1877_RAW0	15.54	0.13
1879_SPROUT	15.30	0.13
3861_RAW0	13.39	0.13
3870_RAW0	13.79	0.14
3871_RAW0	14.14	0.13
3872_RAW0	15.02	0.13
3873_RAW0	14.25	0.13
3874_RAW0	14.03	0.13
3877_SPROUT	14.44	0.13
3879_SPROUT	14.27	0.13
3879_STRESS2	11.97	0.13
3880_RAW0	14.15	0.13
3880_STRESS2	13.43	0.13
3890_RAW0	14.41	0.13
3891_RAW0	14.42	0.13
3897_RAW0	14.04	0.13
3898_RAW0	14.75	0.14
3918_SPROUT	14.48	0.13
3919_SPROUT	14.36	0.13
3921_RAW0	14.16	0.13
3921_SPROUT	14.71	0.13
6829_RAW0	15.36	0.13
6830_RAW0	15.45	0.13
6835_RAW0	14.74	0.14
6835_SPROUT	15.30	0.13
6836_RAW0	15.23	0.13
6837_RAW0	15.19	0.13
7856_RAW0	16.08	0.14
7857_RAW0	15.46	0.13
7858_RAW0	15.72	0.13
7867_RAW0	16.40	0.13
7869_RAW0	16.24	0.13
7870_RAW0	16.35	0.13
7871_RAW0	15.84	0.14
7872_RAW0	16.26	0.13
7876_RAW0	15.96	0.13

Table 35 Grain Ileal digestible energy (as dry matter basis)

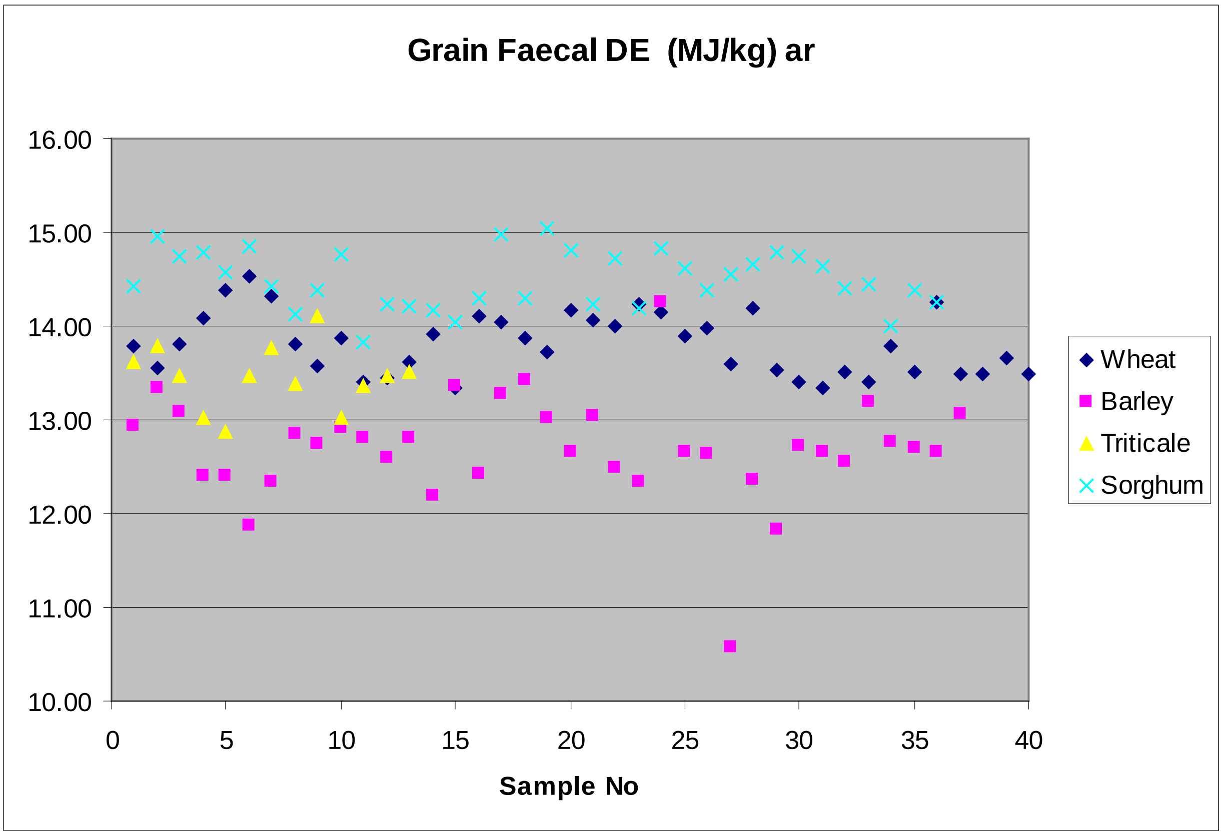
database_grain_ID	grain IDE (dm)	std error
1753_RAW0	14.25	0.34
1764_RAW0	14.35	0.34
1767_RAW0	13.84	0.34
1770_RAW0	14.02	0.34
1772_RAW0	14.37	0.37
1772_SPROUT	14.27	0.34
1773_RAW0	13.71	0.37
1773_SPROUT	13.96	0.34
1856_RAW0	13.62	0.34
1864_SPROUT	13.79	0.34
1865_SPROUT	13.70	0.34
1868_RAW0	13.85	0.34
1874_SPROUT	13.53	0.34
1876_RAW0	13.39	0.34
1877_RAW0	13.58	0.34
1879_SPROUT	13.93	0.34
3861_RAW0	11.49	0.34
3870_RAW0	10.56	0.37
3871_RAW0	11.79	0.34
3872_RAW0	11.15	0.34
3873_RAW0	12.05	0.34
3874_RAW0	11.11	0.34
3877_SPROUT	11.73	0.34
3879_SPROUT	11.88	0.34
3879_STRESS2	10.24	0.34
3880_RAW0	11.38	0.34
3880_STRESS2	11.29	0.37
3890_RAW0	11.82	0.34
3891_RAW0	11.98	0.34
3897_RAW0	9.99	0.34
3898_RAW0	11.97	0.37
3918_SPROUT	12.16	0.34
3919_SPROUT	11.85	0.34
3921_RAW0	11.42	0.34
3921_SPROUT	11.90	0.34
6829_RAW0	13.69	0.34
6830_RAW0	13.82	0.34
6835_RAW0	13.24	0.37
6835_SPROUT	13.98	0.34
6836_RAW0	12.96	0.34
6837_RAW0	13.99	0.34
7856_RAW0	13.60	0.34
7857_RAW0	13.29	0.34
7858_RAW0	13.58	0.34
7867_RAW0	14.25	0.34
7869_RAW0	14.13	0.34
7870_RAW0	13.91	0.37
7871_RAW0	13.76	0.37
7872_RAW0	14.36	0.34
7876_RAW0	13.68	0.34

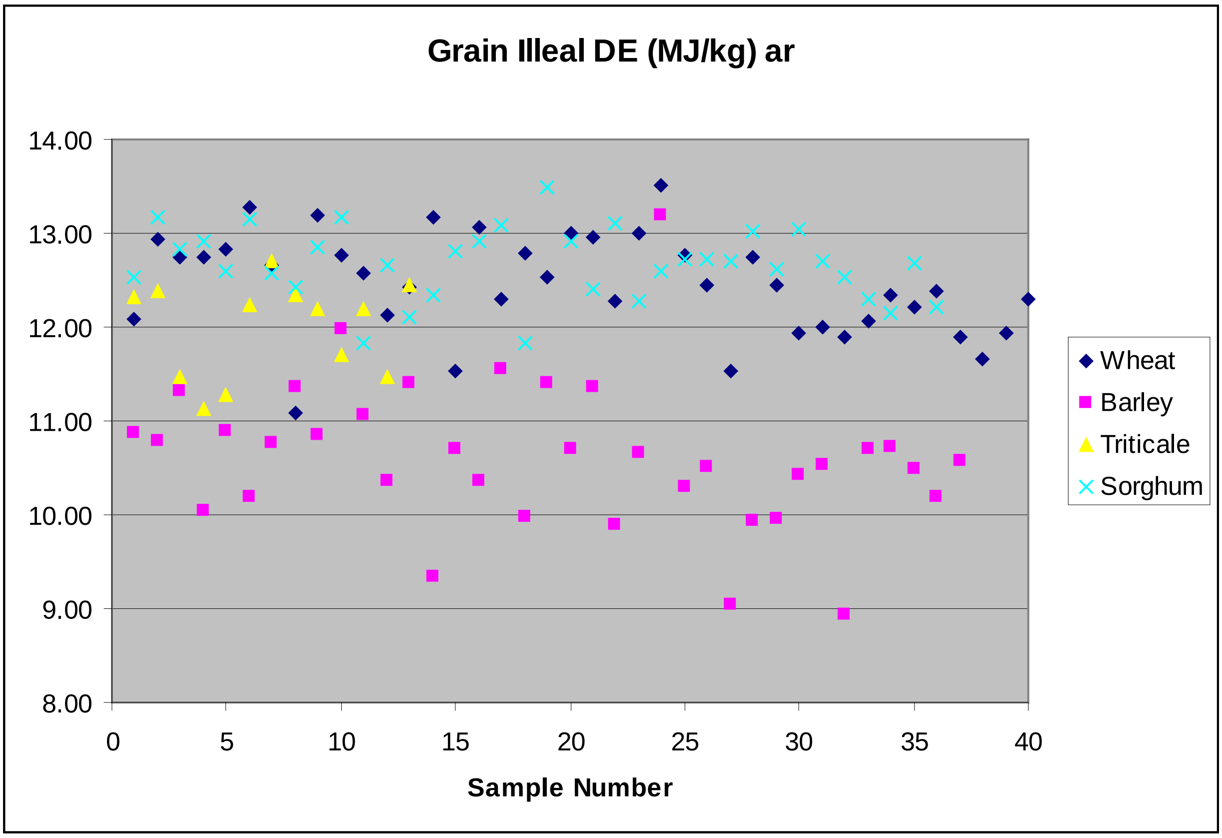
Table 36 Ratio Ileal to Feacal Digestible Energy – RIFDE

database_grain_ID	ratio I:F DE	std error
1753_RAW0	0.88	0.02
1764_RAW0	0.92	0.02
1767_RAW0	0.88	0.02
1770_RAW0	0.89	0.02
1772_RAW0	0.90	0.03
1772_SPROUT	0.93	0.02
1773_RAW0	0.89	0.03
1773_SPROUT	0.90	0.02
1856_RAW0	0.90	0.02
1864_SPROUT	0.90	0.02
1865_SPROUT	0.91	0.02
1868_RAW0	0.87	0.02
1874_SPROUT	0.89	0.02
1876_RAW0	0.87	0.02
1877_RAW0	0.87	0.02
1879_SPROUT	0.91	0.02
3861_RAW0	0.86	0.02
3870_RAW0	0.78	0.03
3871_RAW0	0.84	0.02
3872_RAW0	0.75	0.02
3873_RAW0	0.85	0.02
3874_RAW0	0.80	0.02
3877_SPROUT	0.82	0.02
3879_SPROUT	0.84	0.02
3879_STRESS2	0.86	0.02
3880_RAW0	0.81	0.02
3880_STRESS2	0.85	0.03
3890_RAW0	0.83	0.02
3891_RAW0	0.84	0.02
3897_RAW0	0.72	0.02
3898_RAW0	0.82	0.03
3918_SPROUT	0.84	0.02
3919_SPROUT	0.83	0.02
3921_RAW0	0.81	0.02
3921_SPROUT	0.82	0.02
6829_RAW0	0.89	0.02
6830_RAW0	0.90	0.02
6835_RAW0	0.90	0.03
6835_SPROUT	0.92	0.02
6836_RAW0	0.86	0.02
6837_RAW0	0.92	0.02
7856_RAW0	0.84	0.03
7857_RAW0	0.86	0.02
7858_RAW0	0.86	0.02
7867_RAW0	0.87	0.02
7869_RAW0	0.88	0.02
7870_RAW0	0.84	0.03
7871_RAW0	0.87	0.03
7872_RAW0	0.89	0.02
7876_RAW0	0.86	0.02

Summary of 3 digestibility experiments

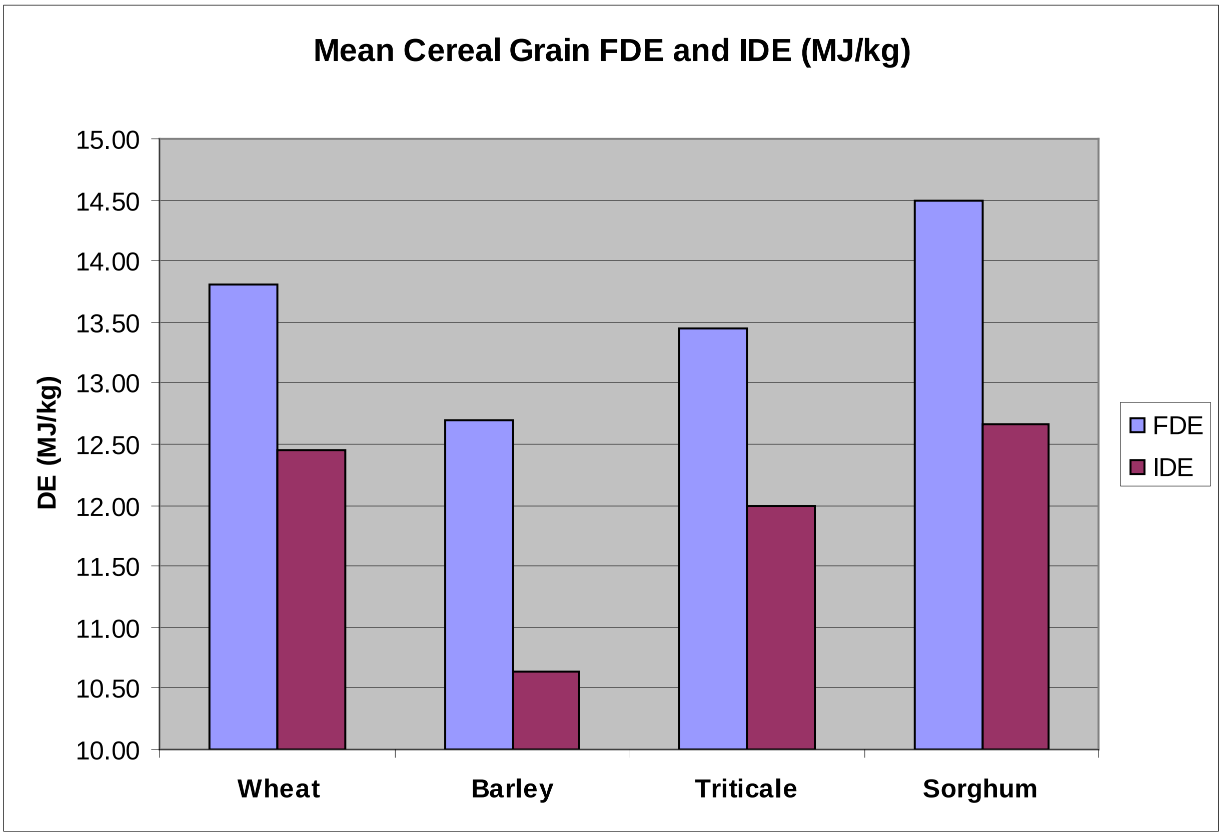
The graph below shows the feacal and ileal DE (as received) of all grains used in the three digestibility experiments.



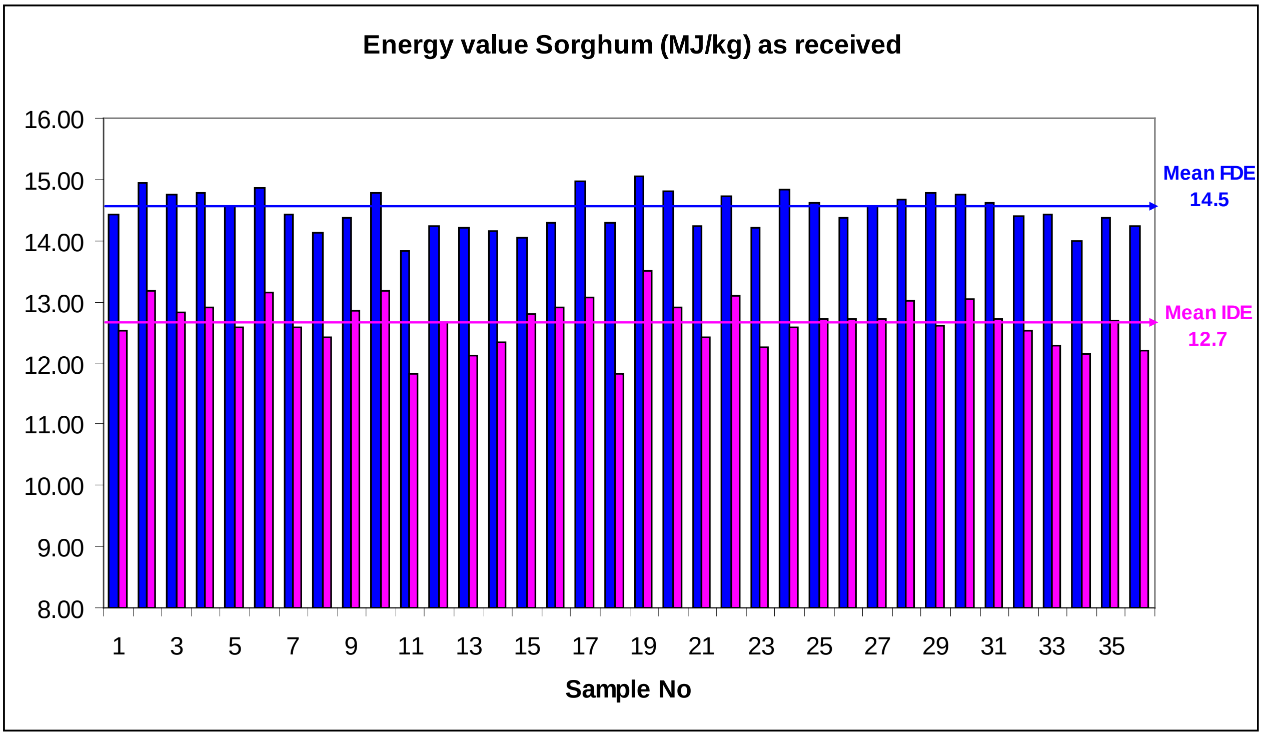


Mean FDE and ILDE as received of the cereal grains tested is given in the graphs below. Mean FDE on as received basis for wheat was 13.8MJ/kg, for barley 12.7MJ/kg, sorghum 14.5MJ/kg and triticale 13.5MJ/kg. Similar values were obtained in PGLP experiments.

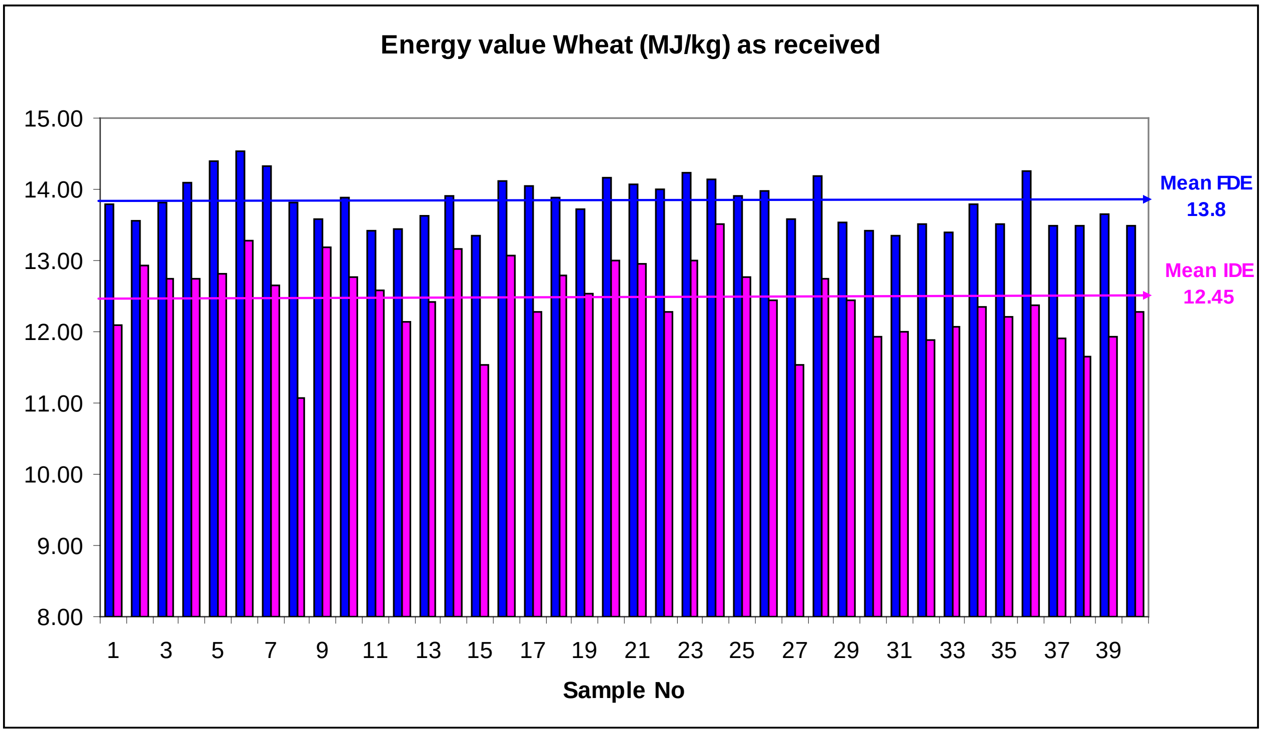
An average of 10, 16, 11 and 13% of digestion of wheat, barley, triticale and sorghum, respectively, appeared to occur in the large intestine of the pig.



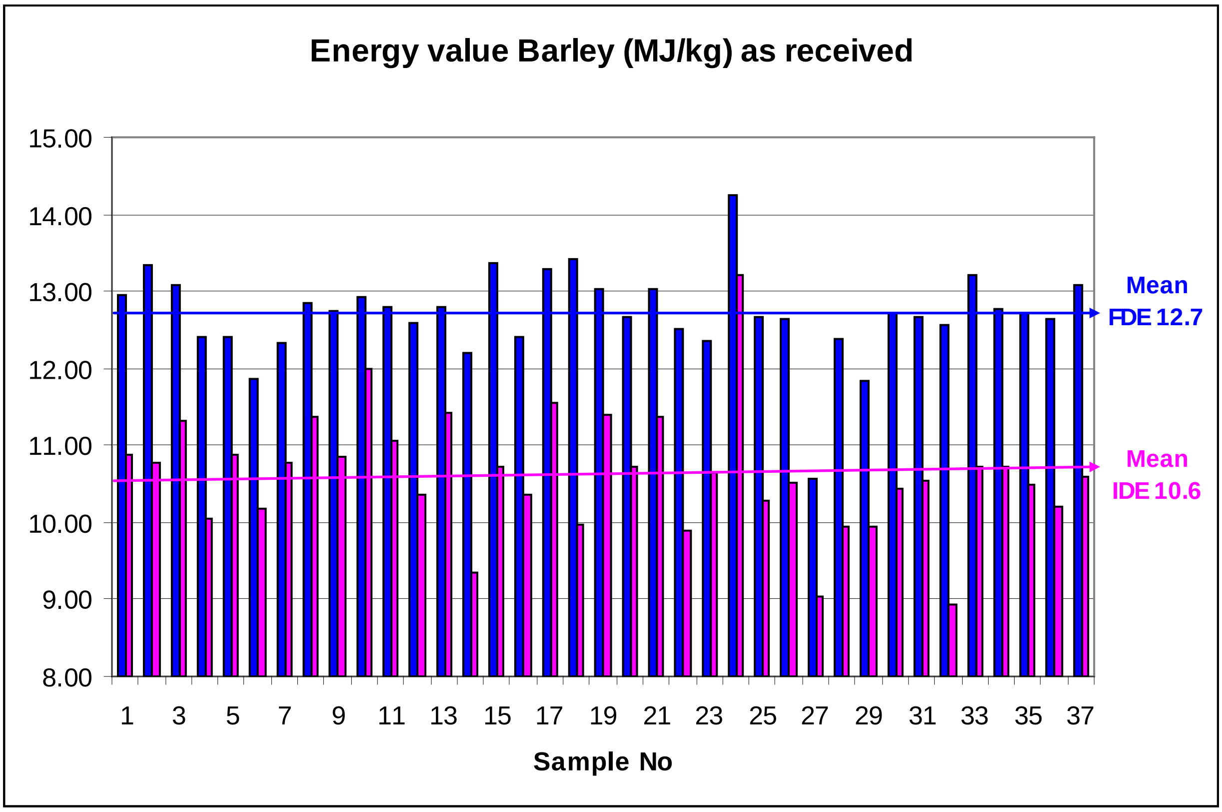
Mean Cereal Grain FDE and IDE (MJ/kg)
DE (MJ/kg)
15.00
14.50
14.00
13.50
13.00
12.50
12.00
11.50
11.00
10.50
10.00
Wheat
Barley
Triticale
Sorghum
FDE
IDE

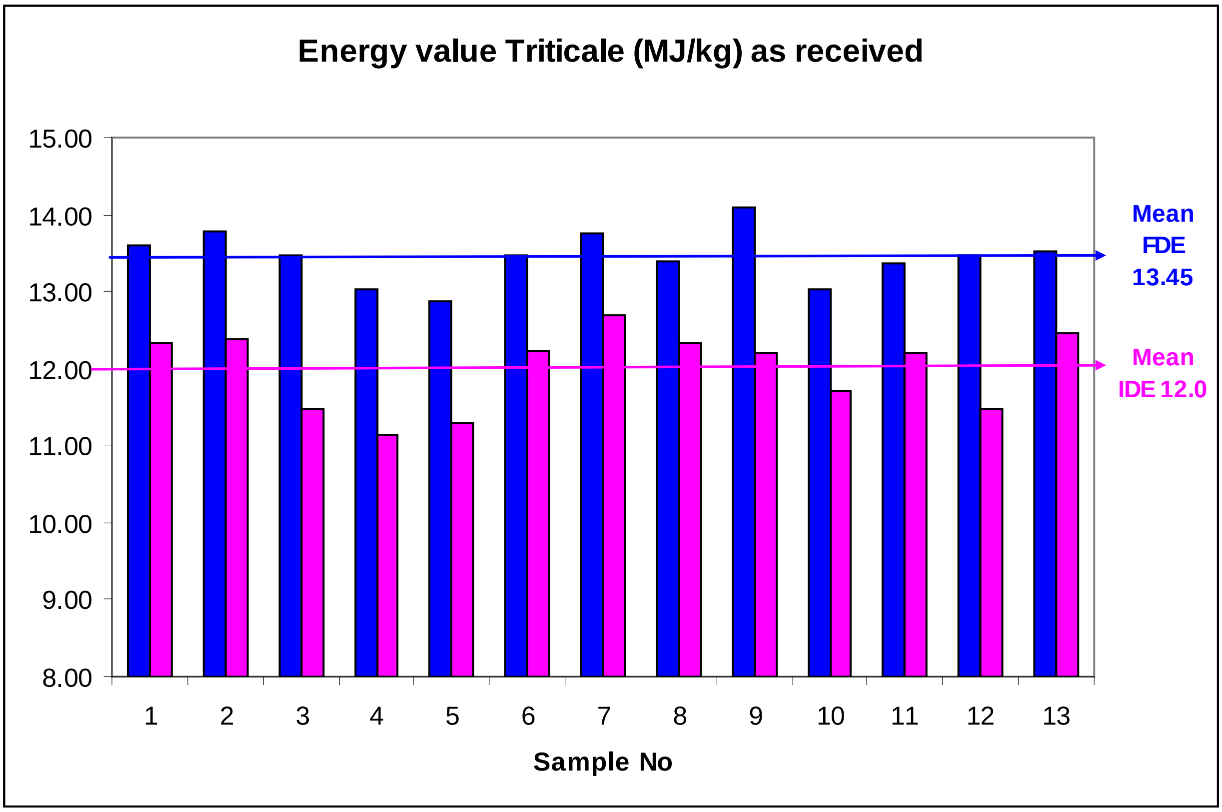


Energy value Sorghum (MJ/kg) as received
16.00
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Sample No
Mean FDE
14.5
Mean IDE
12.7



Energy value Wheat (MJ/kg) as received
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
Sample No
Mean FDE
13.8
Mean IDE
12.45


Energy value Barley (MJ/kg) as received
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37
Sample No
Mean FDE 12.7
Mean IDE 10.6


Energy value Triticale (MJ/kg) as received
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
1 2 3 4 5 6 7 8 9 10 11 12 13
Sample No
Mean FDE 13.45
Mean IDE 12.0

3.3 Results of Feed Intake Experiments

3.3.1 Feed intake experiment 1 QAF (DS001)

Summary

Table 37 P values of significant effects on intake and performance of weaner pigs

Source	Total intake 0 - 21 d	Daily intake (kg/d) 14 - 21 d	FCR 14 - 21 d	Daily Gain (kg/d) 14 - 21 d
Sex	0.003	0.015	NS	NS
Between grain types	<0.001	0.010	0.045	<0.001
Within grain types	0.033	0.008	0.019	0.010

There were significant sex effects for total grain intake and daily intake. The between and within grain type effects were significant for total intake (0-21d), daily intake (14-21d), feed conversion ratio (FCR) (14-21d) and daily liveweight gain (14-21d). The differences between grain types were influenced by sorghum which performed poorer in all areas compared to wheat, barley and triticale. In summary, there is evidence to suggest that the 32 grains fed showed variation in pig performance which was influenced by both within and between grain types.

Table 38 Effect of cereal type on weaner pig performance.

Source	Total Intake (kg)	ADI 14-21d (kg/d)	ROG 0-21d (kg/d)	FCR 0-21d	Total weight gain (kg)
Barley	11.33 b	0.802 b	0.425 b	1.277 b	8.93 b
Wheat	11.21 b	0.786 b	0.424 b	1.265 b	8.91 b
Triticale	10.98 b	0.784 b	0.423b	1.263 b	8.90 b
Sorghum	10.23 a	0.731 a	0.355 a	1.419 a	7.46 a
Start weight	< 0.001	< 0.001	< 0.001	ns	< 0.001
sex	0.005	0.038	0.008	ns	0.008
sorghum	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
other grain types	ns	ns	ns	ns	ns
within(grain_id, 7858).enzyme	ns	ns	ns	ns	ns
within(wheat).grain_id	0.029	0.001	ns	0.006	ns
within(triticale).grain_id	0.025	0.033	ns	0.001	ns
within(sorghum).grain_id	ns	ns	0.013	ns	0.013
within(barley).grain_id	ns	ns	ns	ns	ns

Significant fixed terms included start_weight, sex and sorghum for Total intake, ADI14-21d, ROG 0-21d and Total weight gain. Start weight and sex were not different in terms of FCR but sorghum was significantly different ($p<0.001$). The inclusion of enzyme zingabin with sorghum 7858 diet had no effect on feed intake, ADI, ROG FCR and Total weight gain. The mean average daily feed intake and total feed intake over 21 days of different grain types are given in Table 39. Intake of sorghum based diet was significantly lower than diets based on the other grains. Total feed intake of sorghum based diet over the 21 day period was 10.23 kg compared to 11.33 for barley, 11.21 for wheat and 10.98 kg for triticale. Total feed consumed by pigs on wheat diets ranged from 9.93 – 12.10 k ($p = 0.029$) and pigs on triticale diets ranged 9.85 – 11.97 ($p = 0.025$), whereas the barley and sorghum diets were not significant ranging 10.96 – 12.01k and 9.44 – 10.87k respectively.

ROG of pigs on sorghum diet (0.355 kg/d) was significantly lower($p<0.001$) than those on other cereal grains ie wheat 0.4245, barley 0.4253 and triticale 0.4236 kg/d. ROG of pigs on different sorghum cultivars were significantly different ($p=0.013$). The best performing sorghum in terms of ROG was Liberty (0.3932 kg/d) and the worst performer was Venture (0.3103 kg/d) (Table 43).

FCR (0-21d) of pigs on sorghum diets (1.419) were significantly different ($p<0.001$) from those on wheat (1.265), or barley (1.277) or triticale diets (1.263). However, FCR of pigs on different wheat cultivars and different triticale cultivars were significantly different with $p=0.006$ and $p=0.001$ respectively (Table 44).

Table 39 Daily (kg/d) and total feed intake (kg) of different grain type diets fed to weaner pigs

Grain Type	0-7d	0-14d	7-14d	14-21d	Total Intake
barley	0.3248 b	0.4022 b	0.4823 b	0.8016 b	11.33 b
wheat	0.3144 b	0.3948 b	0.4819 b	0.7858 b	11.21 b
triticale	0.3024 ab	0.3800 b	0.4659 b	0.7836 b	10.98 b
sorghum	0.2867 a	0.3520 a	0.4272 a	0.7308 a	10.23 a

Feed intake of wheat based diet during 14-21 days on trial and in terms of total feed intake were significantly different ($p=0.001$and 0.029 respectively).(Table 40). Similarly for intake of triticale based diets over the 21 day period and in terms of daily feed intake were significantly different ($p=0.003$ and $p=0.025$ respectively).

Table 40 Daily feed intake (kg/d) of wheat and triticale diets fed to weaner pigs

Grain Type	Grain id	Predicted Value
wheat	1757	0.851 j
wheat	1758	0.839 j
wheat	1755	0.835 j
wheat	1754	0.827 ij
wheat	1841	0.814 ghi
wheat	1749	0.793 cefghi
wheat	1753	0.756 abcefghi
wheat	1728	0.681 ab
wheat	1727	0.676 ab
triticale	6827	0.8443 c
triticale	6826	0.8333 c
triticale	6825	0.7995 bc
triticale	6828	0.7304 ab
triticale	6824	0.7108 a

Table 41 Total feed intake during the experiment

Grain Type	Grain id	Predicted Value
wheat	1758	12.10 g
barley	3867	12.01 g
triticale	6827	11.97 fg
wheat	1757	11.81 efg
wheat	1754	11.77 efg
wheat	1755	11.74 efg
triticale	6826	11.64 efg
barley	3756	11.55 defg
barley	3868	11.44 defg
barley	3861	11.31 cdefg
wheat	1749	11.29 cdefg
wheat	1841	11.27 cdefg
barley	3757	11.07 bcdefg
triticale	6825	10.97 bcdefg
barley	3866	10.96 bcdefg
barley	3865	10.96 bcdefg
sorghum	7858	10.87 bcdefg
sorghum	7863	10.74 abcdefg
sorghum	7862	10.72 abcdefg
sorghum	7857	10.57 abcde
sorghum	7856	10.55 abcdef
wheat	1753	10.51 abcde
triticale	6828	10.47 abcde
wheat	1728	10.43 abcde
sorghum	7864	10.13 abcd

sorghum	7855	10.05 abc
wheat	1727	9.93 abc
triticale	6824	9.85 ab
sorghum	7860	9.71 ab
sorghum	7859	9.51 a
sorghum	7861	9.44 a

Total feed consumed (Table 41) by pigs on wheat diets ranged from 9.93 – 12.10 k ($p = 0.029$) and pigs on triticale diets ranged 9.85 – 11.97 ($p = 0.025$), whereas the barley and sorghum diets were not significant ranging 10.96 – 12.01k and 9.44 – 10.87k respectively.

Table 42 Total weight gained during the experiment

Grain Type	Grain id	Predicted Value
wheat	1757	9.74 k
barley	3867	9.61 k
wheat	1754	9.53 jk
barley	3868	9.43 ijk
wheat	1841	9.32 hijk
triticale	6826	9.24 ghijk
barley	3756	9.21 fghijk
triticale	6825	9.20 fghijk
triticale	6824	9.19 fghijk
wheat	1755	9.15 fghijk
wheat	1758	8.85 fghijk
barley	3757	8.81 efghijk
barley	3861	8.76 efghijk
triticale	6827	8.67 defghijk
wheat	1753	8.65 defghijk
wheat	1749	8.58 defghijk
barley	3866	8.40 defghij
barley	3865	8.30 defghi
sorghum	7856	8.26 defgh
wheat	1728	8.24 defgh
triticale	6828	8.18 cdefgh
wheat	1727	8.16 cdefg
sorghum	7857	8.11 cdef
sorghum	7863	8.08 cdef
sorghum	7855	7.71 bcde
sorghum	7858	7.67 bcd
sorghum	7862	7.65 abcde
sorghum	7860	7.07 abc
sorghum	7864	6.82 ab
sorghum	7859	6.71 ab
sorghum	7861	6.52 a

Table 43 Rate of growth (0 - 21 days) of weaner pigs fed different cereal grain based diets

Grain Type	Grain id	Predicted Value
wheat	1757	0.4637 k
barley	3867	0.4578 k
wheat	1754	0.4538 jk
barley	3868	0.4489 ijk
wheat	1841	0.4439 hijk
triticale	6826	0.4398 ghijk
barley	3756	0.4384 fghijk
triticale	6825	0.4379 fghijk
triticale	6824	0.4376 fghijk
wheat	1755	0.4358 fghijk
wheat	1758	0.4216 fghijk
barley	3757	0.4194 efghijk
barley	3861	0.4173 efghijk
triticale	6827	0.4130 defghijk
wheat	1753	0.4121 defghijk
wheat	1749	0.4086 defghijk
barley	3866	0.3998 defghij
barley	3865	0.3954 defghi
sorghum	7856	0.3932 defgh
wheat	1728	0.3924 defgh
triticale	6828	0.3896 cdefgh
wheat	1727	0.3886 cdefg
sorghum	7857	0.3862 cdef
sorghum	7863	0.3847 cdef
sorghum	7855	0.3671 bcde
sorghum	7858	0.3650 bcd
sorghum	7862	0.3641 abcde
sorghum	7860	0.3366 abc
sorghum	7864	0.3248 ab
sorghum	7859	0.3193 ab
sorghum	7861	0.3103 a

Table 44 FCR (0 - 21 days) of weaner pigs fed different cereal grain based diets

Grain Type	Grain id	Predicted Value
sorghum	7864	1.553 j
sorghum	7858	1.493 ij
sorghum	7861	1.492 hij
sorghum	7859	1.489 hij
sorghum	7862	1.462 ghij
sorghum	7860	1.395 defghij
triticale	6827	1.389 efghij
wheat	1758	1.387 eghi
triticale	6828	1.366 deghi
sorghum	7863	1.364 cdeghij
barley	3865	1.344 degh
sorghum	7857	1.335 bcdeghi
sorghum	7855	1.321 bcdegh
wheat	1749	1.316 cdeg
barley	3866	1.312 cdeg
wheat	1755	1.294 bcde
barley	3861	1.287 bcdf
sorghum	7856	1.284 bcdeg
wheat	1728	1.271 bcdf
barley	3867	1.266 bcdf
triticale	6826	1.266 bcde
barley	3756	1.256 bcd
wheat	1754	1.253 bcd
barley	3757	1.248 bcd
barley	3868	1.228 bc
wheat	1757	1.225 bc
wheat	1727	1.221 bc
triticale	6825	1.217 abcd
wheat	1753	1.216 bc
wheat	1841	1.204 ab
triticale	6824	1.079 a

3.3.2 Results Feed intake experiment 2 (AF001).

The results of experiment AF001 in which a comparison of 10 sorghum cultivars were fed to 20 kg pigs for 21 days is summarized in Table 45.

Table 45 Effects of 10 different sorghum varieties on the growth performance of male weaner grower pigs, during the 0 to 21 day period

Sorghum variety	ADI 0-21d (kg/d)	Rate of gain (kg/d)	FCR
MR Maxi 7855	1.72 ^{ab}	0.84 ^{a}	2.02 ^{ab}
Liberty 7856	1.82 ^{bc}	1.00 ^{c}	1.94 ^{ab}
Pacer 7857	1.79 ^{abc}	0.89 ^{ab}	2.02 ^{ab}
MR43 7858	1.68 ^{a}	0.85 ^{a}	1.96 ^{ab}
Buster (QLD) 7859	1.86 ^{c}	0.93 ^{bc}	2.04 ^{ab}
Allora Grain 7860	1.69 ^{a}	0.87 ^{ab}	1.96 ^{ab}
Venture 7861	1.73 ^{ab}	0.93 ^{bc}	1.87 ^{a}
Buster (NSW) 7862	1.69 ^{a}	0.91 ^{ab}	1.86 ^{a}
Red 1 7863	1.69 ^{a}	0.84 ^{a}	2.11 ^{b}
Red 2 7864	1.75 ^{abc}	0.87 ^{ab}	2.01 ^{ab}
P values			
Initial weight	< 0.001	< 0.001	ns
Batch	0.005	< 0.001	ns
Grain_id	< 0.001	0.009	0.004
Grain_id.batch	0.006	ns	ns
Initial weight.grain_id	0.002	ns	ns
Initial weight.batch	ns	ns	ns
Initial weight.batch.grain_id	ns	ns	ns

a,b,c Values in a column with different superscripts are significantly different ($P \leq 0.05$)

Average daily intake and rate of growth were significantly affected by starting weight (P<0.001), sorghum ID (P<0.001 for ADI and P=0.009 for ROG) and batch of feed. Whereas FCR was significantly affected by sorghum ID (P=0.004). There were significant differences within the sorghum samples in feed intake, rate of grain and FCR.

Overall there was a difference between the highest and lowest ADI, ROG and FCR of 10%, 18.2% and 17.4% respectively. It was interesting to note that the best performing sorghum was Liberty (ROG 1.00) which is the only white/yellow sorghum represented. The two varieties of Buster from different areas (QLD and NSW) produced a 10.5% difference in daily gain which was not significantly different. The results suggests that feeding weaner pigs with the 10 test sorghum grains will result in differences in animal performance both between varieties and within varieties as evidence by difference between the red and white sorghums and difference among the red sorghums.

3.3.3 Results Feed intake experiment 3 (DS003).

Summary

Table 46 Predicted values of the effects on intake and performance of pigs growing from 20 – 40 kg with mould effect removed.

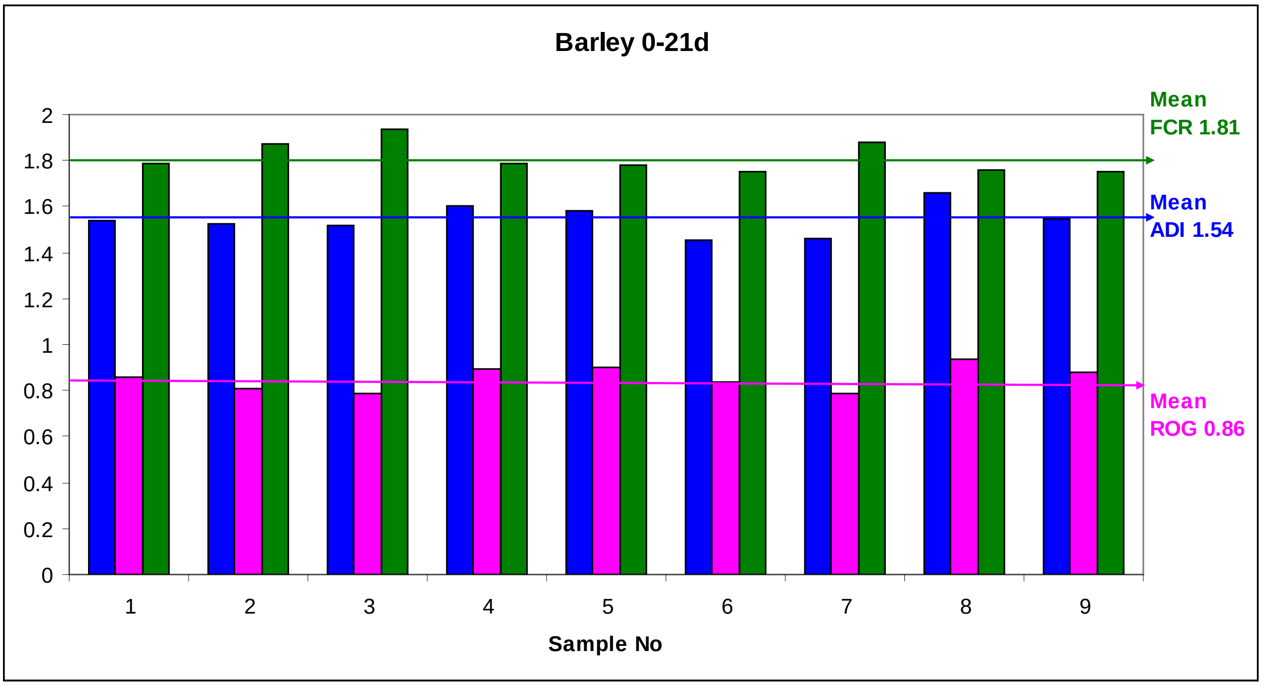
Grain Type	Average daily intake (kg/d)	Rate of growth (kg/d)	FCR(kg feed/kg gain)
Barley	1.54[ab]	0.86 [b]	1.81 [a]
Sorghum	1.55[b]	0.79 [a]	1.96 [b]
Triticale	1.49[a]	0.81[ab]	1.86 [a]
Wheat	1.49 [a]	0.84 [b]	1.79 [a]
P (Between Grain Types)	0.021	0.029	<0.001
P (Within Grain Types)	0.043	0.115	0.018

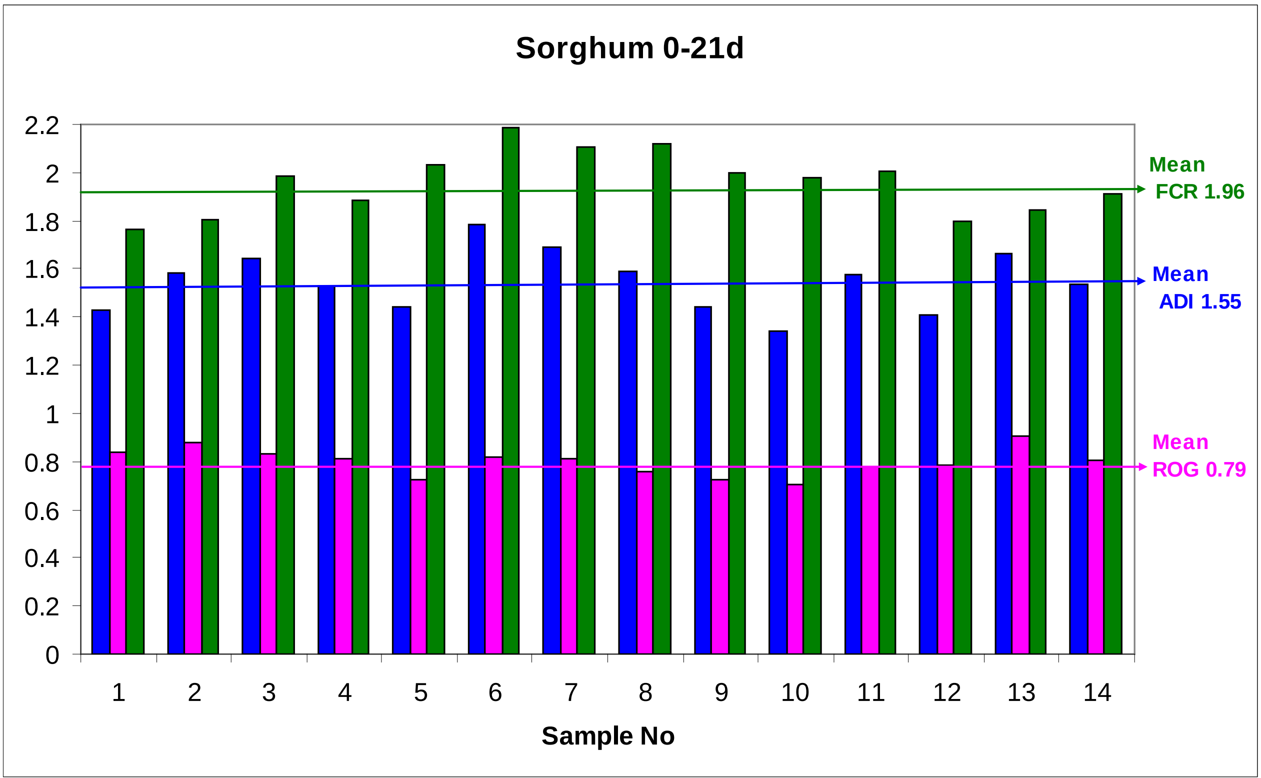
[a,b,c] Values in the same column with different superscripts are significantly different ($P \leq 0.05$)

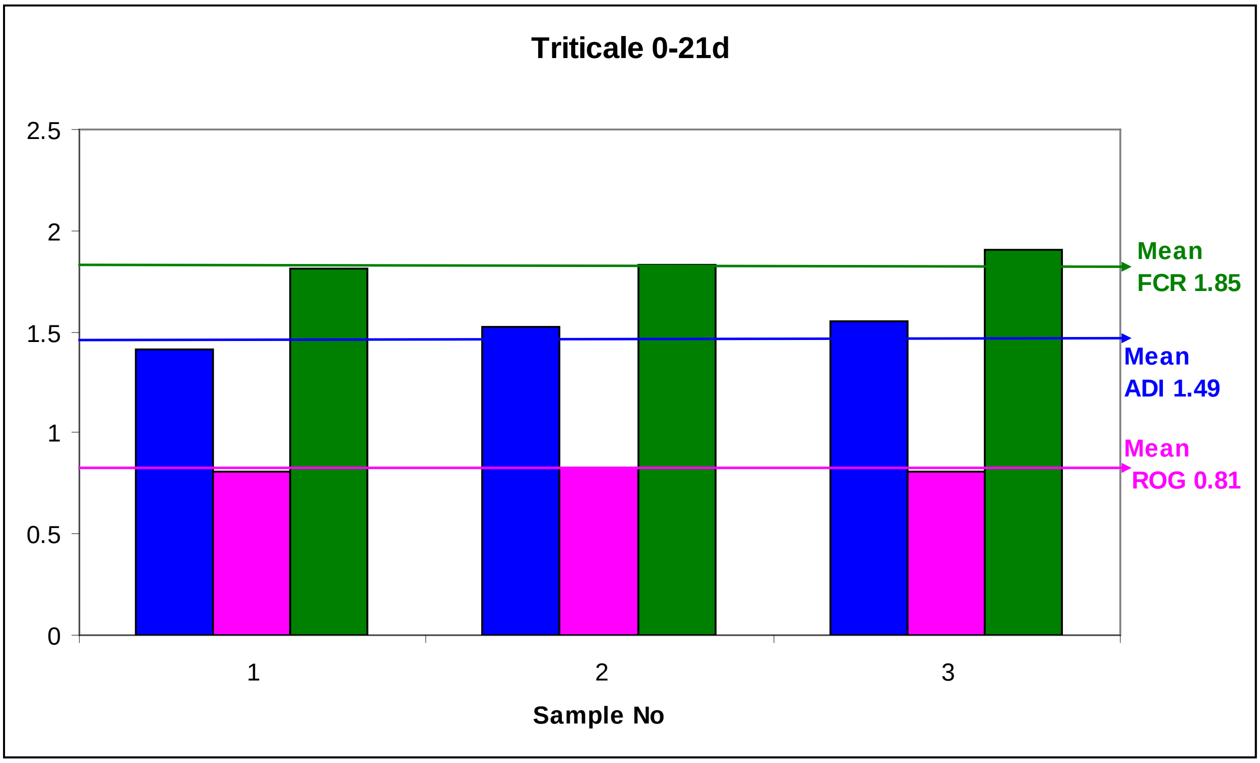
Average daily intake was significantly affected by starting weight (P<0.001), grain type (P<0.05) and by mould-grain type interaction. The experiment was conducted for only 5 periods due to the growth of mould in feeds. Rate of growth was significantly affected by starting weight (P<0.001) and grain type (P=0.029). However, FCR was significantly affected by start weight (P<0.001), presence of mould (P<0.05), grain type (P<0.001) and grain ID within grain type (P<0.05). Feed intake of sorghum based diets was significantly higher than wheat and triticale based diets but similar to barley based diets.

Both the between and within grain type effects for daily feed intake and feed conversion ratio (FCR) were significant (Table 46) and only between grain type effect was significant for growth rate. FCR for pigs on sorghum diets ranged 1.76-2.19, barley 1.75-1.97, wheat 1.73-1.88 and triticale 1.81-1.91. There was a significant mould by grain type interaction (P=0.02) for feed intake. Although presence of mould had a significant effect on the feed intake of pigs on sorghum based diets only (1.74 and 1.55 kg/d respectively for mouldy and non-mouldy sorghum), the FCR was not significantly different. The FCR difference between sorghum and barley was 10.3%, sorghum and triticale 9.4% and sorghum and wheat 10.7%. ROG of pigs on sorghum diet (0.79 kg/d) was significantly different to those on wheat (0.84 kg/d) and barley (0.86 kg/d) diet but there was no difference in ROG of pigs on triticale diet (0.81 kg/d). Within grain type results are given in Table 47. The results provide further evidence to that the variation in pig performance is influenced by both within and between grain types.

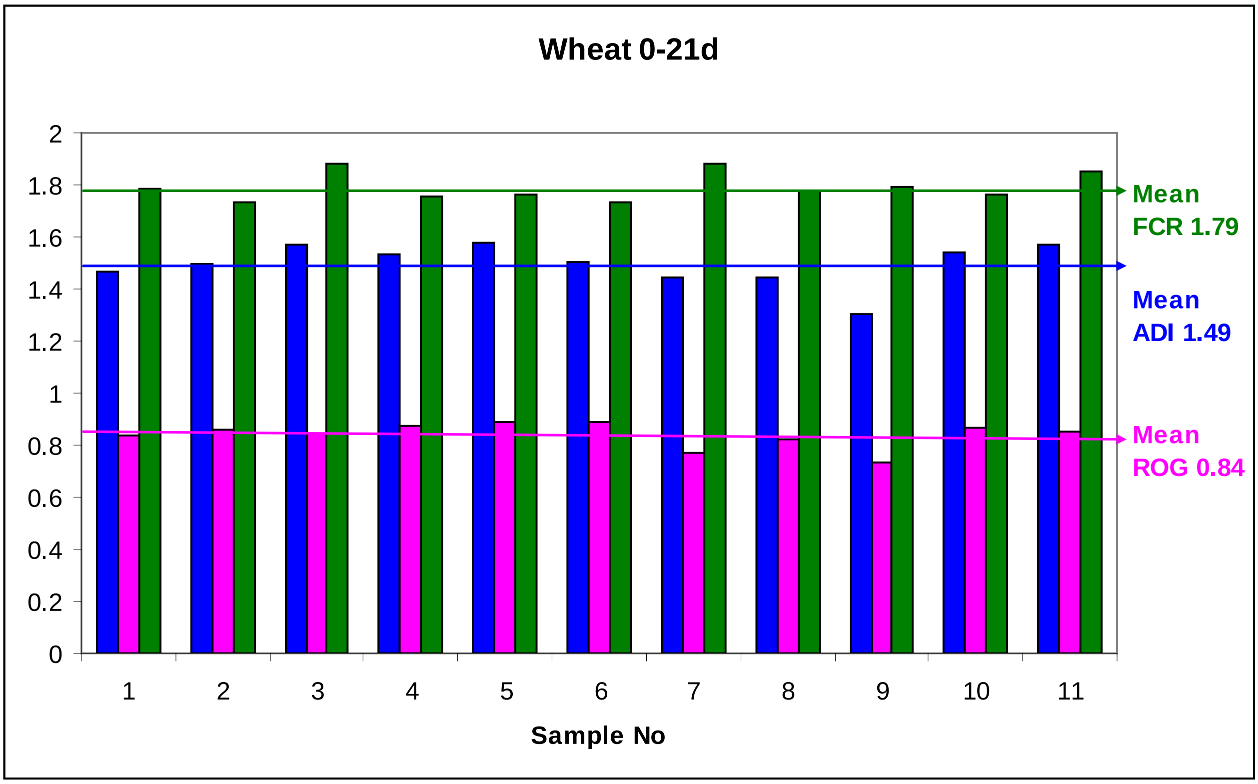
Performance of pigs consuming different cultivars of barley, sorghum, triticale and wheat is illustrated by graphs below.


Barley 0-21d
Mean
FCR 1.81
Mean
ADI 1.54
Mean
ROG 0.86
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
9
Sample No


Sorghum 0-21d
Mean
FCR 1.96
Mean
ADI 1.55
Mean
ROG 0.79
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Sample No



Triticale 0-21d
2.5
2
1.5
1
0.5
0
1
2
3
Sample No
Mean
FCR 1.85
Mean
ADI 1.49
Mean
ROG 0.81



Wheat 0-21d
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
7
8
9
10
11
Sample No
Mean
FCR 1.79
Mean
ADI 1.49
Mean
ROG 0.84

Table 47. Results for average daily intake (ADI), rate of gain and feed:grain from experiment DS003 conducted with 24 kg pigs at Wacol.

Grain type	Grain ID	ADI 0-21 days (kg/d)	Significance P<0.05[a]	Rate of gain (kg/d)	Significance P<0.05[a]	FCR	Significance P<0.05[a]
WHEAT	1753_RAW0	1.46	abcdef	0.83	abcdefghi	1.79	abde
WHEAT	1762_RAW0	1.49	abcdef	0.86	defghi	1.74	a
WHEAT	1763_RAW0	1.57	bcdefg	0.85	bcdefghi	1.88	abdef
WHEAT	1764_RAW0	1.53	abcdef	0.87	efghi	1.75	a
WHEAT	1765_RAW0	1.58	bcdefg	0.89	fghi	1.77	ab
WHEAT	1766_RAW0	1.50	abcdef	0.89	fghi	1.73	a
WHEAT	1767_RAW0	1.44	abcd	0.77	abcdef	1.88	abde
WHEAT	1768_RAW0	1.45	abcde	0.82	abcdefgh	1.78	abd
WHEAT	1769_RAW0	1.30	a	0.73	abcd	1.79	abde
WHEAT	1770_RAW0	1.54	abcdef	0.87	efghi	1.76	ac
WHEAT	1771_RAW0	1.57	bcdefg	0.85	cdefghi	1.85	abde
BARLEY	3861_RAW0	1.54	abcdef	0.86	defghi	1.79	abd
BARLEY	3869_RAW0	1.53	abcdef	0.81	abcdefghi	1.87	abdefg
BARLEY	3870_RAW0	1.52	abcdef	0.78	abcdefgh	1.94	abdefg
BARLEY	3871_RAW0	1.60	cdefg	0.89	ghi	1.79	abd
BARLEY	3872_RAW0	1.59	bcdefg	0.90	hi	1.78	abd
BARLEY	3873_RAW0	1.45	abcde	0.84	abcdefghi	1.75	ac
BARLEY	3874_RAW0	1.46	abcde	0.79	abcdefgh	1.88	abde
BARLEY	3875_RAW0	1.66	efg	0.94	i	1.76	a
BARLEY	3876_RAW0	1.54	abcdef	0.88	efghi	1.75	ab
TRITICALE	6829_RAW0	1.41	abc	0.81	abcdefgh	1.81	abde
TRITICALE	6830_RAW0	1.52	abcdef	0.83	abcdefghi	1.83	abde
TRITICALE	6831_RAW0	1.55	abcdefg	0.81	abcdefghi	1.91	abdefg
SORGHUM	7855_RAW0	1.43	abcd	0.84	abcdefghi	1.76	ab
SORGHUM	7856_RAW0	1.58	bcdefg	0.88	fghi	1.81	abd
SORGHUM	7857_RAW0	1.64	defg	0.83	abcdefghi	1.99	bdefgh
SORGHUM	7858_RAW0	1.53	abcdef	0.81	abcdefgh	1.88	abde
SORGHUM	7859_RAW0	1.44	abcd	0.72	ab	2.03	efgh
SORGHUM	7860_RAW0	1.78	g	0.82	abcdefgh	2.19	h
SORGHUM	7861_RAW0	1.69	fg	0.81	abcdefgh	2.10	fgh
SORGHUM	7862_RAW0	1.59	bcdefg	0.76	abcde	2.12	gh
SORGHUM	7863_RAW0	1.45	abcde	0.73	abc	2.00	bcdefgh
SORGHUM	7864_RAW0	1.34	ab	0.70	a	1.98	abdefgh
SORGHUM	7865_RAW0	1.57	bcdefg	0.78	abcdefg	2.01	defgh
SORGHUM	7866_RAW0	1.41	abc	0.79	abcdefgh	1.80	abde
SORGHUM	7867_RAW0	1.66	defg	0.90	hi	1.84	abde
SORGHUM	7868_RAW0	1.54	abcdef	0.81	abcdefgh	1.91	abdefg
Mean		**1.53**		**0.83**		**1.86**	
Approx LSD P<0.05		**0.231**		**0.122**		**0.237**	

[a]Treatments without similar letters are significantly different

4. Conclusions and Recommendations

Including results from additional grains into the NIR calibrations for predicting the Feacal DE and Ileal DE of cereal grains has consistently improved the accuracy and robustness of the calibrations for pigs. The precision of the calibrations for predicting Feacal DE is down to 0.27 MJ/kg as fed and further improvement should be expected down to near 0.2 MJ/kg as fed, which is twice the standard error of the measurement. The precision of the prediction for Ileal DE is only 0.52 MJ/kg as fed and could be further improved if the standard error of the measurement can be reduced. The higher variation in measurements of Ileal DE compared with Feacal DE may reflect the difficulty in obtaining sufficient ileal material from the T can cannulae with even distribution of the acid insoluble ash marker digestible. The details of the experimental protocol may need to be readdressed and more material collected from the terminal ileum of each pig in an effort to reduce the unaccounted variation. This could be achieved by withholding the pigs in the crate for an extra day, thereby having a three day collection time compared to the current practice where digesta is collected over two days.

The results from experiment HR001, where the grains were selected because they either had different NIR scan patterns or they had different characteristics from the previous grains used, showed that there is still an opportunity to further improve the ability of calibrations to predict values for unknown grains. The effectiveness of the calibrations would be further increased with the addition of more grains. It is important to continue to identify grain samples that are labeled as ‘outliers’ by the WINISI software and where possible obtain sufficient of these grains for pig digestibility experiments. Including more grains that are labeled ‘outliers’ should substantially improve the robustness of the calibrations and increase the RPD values to ensure reliable measurements over a far wider range of grains. However, it is also important to include a range of more normal grains to validate the ability of the calibrations to predict accurately the Feacal and DE values for these samples.

Pig feeding experiments using weaners and growers showed that there were both between and within grain type differences. Performance of pigs on sorghum based diets was lower than pigs on wheat, triticale and barley diets. Within the sorghum grain type there was significant difference in pig performance with pigs on white sorghum based diet performing much better than diets based on the other sorghum varieties. The unaccounted variation in both experiments are unacceptably high so that greater than 10% difference between treatments was needed for significance at the 95% level of probability. This variation could be decreased if fewer treatments were compared at the same time thereby the selection of pigs would be made from the same batch with narrower weight range and age. In both experiments initial pig weight was highly significant. The choice of treatments should be more targeted, and based on NIR DE values.

5. References

A.O.A.C. (1980), *Official Methods of Analysis of the Association of Official Analytical Chemists*, 13th Edition (Washington): Sections 3.098-3.100.

A.O.A.C. (1984): *Official Methods of Analysis of the Association of Official Analytical Chemists*. 14th Edition (Washington): Section 7.099 (a).

Application Note AN 3004 – *Hexane extraction of fat in feed, cereal grain and forage*, Foss Analytical AB, Box 70, SE-263 21 Hoganas, Sweden

Black, J.L. (2008). Premium Grains for Livestock Program, Component 1: Co-ordination. *Final Report. Grains Research and Development Corporation, Canberra, Australia, 237 pp.*

Goering, H.K and Van Soest, P.J.(1970) in *Forage Fibre Analyses*. (USDA Agric Handbk No. 379, Jacket No. 387-598.)

McCleary, B.V., Gibson, T.S., and Solah, V. (1992). A rapid procedure for total starch measurement in cereal grains and products *Proc. 42nd RACI Cereal Chem. Conf*. Christchurch, New Zealand 7-11 Sept, 1992 (Ed. V. J. Humphrey-Taylor), 304-312.

McCleary, B.V., Gibson, T.S., and Mungford, D. C. (1997) Measurement of total starch in cereal products by amyloglucosidase - α-amylase method: Collaborative study. J. AOAC Int. **80**, 571-579.

McCleary, B.V., and Codd, R. (1991). Measurement of (1-3)(1-4)-β-D-glucan in barley and malt. *J. Sci Fd. Agric*. **55**, 303-12

Randall, Edward L, *Improved method for fat and oil analysis by a new process of extraction*, *J Assoc Off. Anal. Chem.* 1974, vol. 57, no. 5, 1165-1168

Van Barneveld, R. J. 1993. Effect of heating proteins on the digestibility, availability and utilisation of lysine by growing pigs. Ph.D. dissertation. Univ. of Queensland, Brisbane, Australia

Van Soest, P.J. and Vine, R.H. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell wall constituents. J. Assoc. Off. Anal. Chem. 1967, 50, 50-55

Van Soest, P.J (1963). Journal of Association of Official Analytical Chemists.46.829

Appendices

Appendix 1: Grains used in 1B-101 and 1B-104 experiments

Grain type	Sample ID	Variety	Sample condition	Experiment	Hydration Capacity (%)	Screenings % (<2.0; <2.2 mm[a])	Specific weight (kg/hl)	1000 grain weight (g)
Wheat	1727	OXLEY		PGLP, DS002, DS005	44.19	6.0	76.22	29.62
Wheat	1728	QAL 2000		PGLP, DS002	39.53		77.3	38.7
Wheat	1738	Kewel		PGLP, DS005	48.343		77.1	36.2
wheat	1746	VULCAN		PGLP, DS002, DS004	41.503		80.8	30.6
Wheat	1753	BELLAROI		DS002, DS004. HR001	41.24	1.38	77.93	44.3
Wheat	1754	SENTINAL		DS002	40.17	2.69	76.42	36.9
Wheat	1755	AMMROCK		DS002	44.63	2.62	74.42	33.9
wheat	1756	KELALLAC		DS004	41.14	1.7	75.61	38.4
Wheat	1757	UNKNOWN 1		DS002	45.01	3.03	76.33	33.6
Wheat	1758	CHARA		DS002	38.11	6.46	76.8	35.1
wheat	1759	UNKNOWN 2		DS004	42.37	2.83	81.3	34.1
wheat	1760	KELALLAC		DS004	43.46	4.2	77.79	31.13
wheat	1762	H45	DROUGHT AFFECTED	DS004	54.22	53.061	74.64	17.933
wheat	1763	H45	DROUGHT AFFECTED	DS004	50.57	24.902	76.74	22.067
wheat	1764	SUNCO		DS004, HR001	43.79	7.526	79.66	25.433
wheat	1765	LANG	DROUGHT AFFECTED	DS004	46.69	11.142	79.08	26.133
wheat	1766	H45	DROUGHT AFFECTED	DS004	53.42	33.012	74.34	19.133
wheat	1767	CUNNINGHAM	DROUGHT AFFECTED	DS004, HR001	46.22	14.156	78.46	24.433
wheat	1768	JANZ	DROUGHT AFFECTED	DS004	47.89	8.965	79.71	25.167
wheat	1769	BELLAROI		DS004	45.9	6.254	78.45	35.4
wheat	1770	SUNCO		DS004, HR001	40.12	6.687	80.51	27.667
wheat	1771	DRYSDALE	DROUGHT AFFECTED	DS004	53.11	17.981	76.31	23.567
Wheat	1841	H45	DROUGHT AFFECTED	PGLP, DS002	56.306	30.5	76.29	21.34
Wheat	1772	WOLLAROI	DURUM	HR001	NA	0.85	78.86	46.8
Wheat	1772	WOLLAROI	DURUM SPROUTED	HR001	NA	1.87	75.34	44.8
Wheat	1773	BAXTER		HR001	NA	1.84	77.30	40.9
Wheat	1773	BAXTER	SPROUTED	HR001	NA	1.50	73.31	37.8
Wheat	1856	QAL 1064		HR001	NA	1.13	74.11	44.2
Wheat	1864	SUN 525D	SPROUTED	HR001	NA	23.00	69.56	18.6
Wheat	1864	SUN 526A	SPROUTED	HR001	NA	11.50	72.55	23.9
Wheat	1868	BELLAROI		HR001	NA	3.51	78.88	40.9
Wheat	1874	UNKNOWN	SPROUTED	HR001	NA	1.13	73.74	31.4
Wheat	1876	TENNANT	RED FEED WHEAT	HR001	36.95	6.01	83.38	49.0
Wheat	1877	UNKNOWN	MAINLAND WHITE FEED	HR001	36.84	0.93	83.68	63.3
Wheat	1879	UNKNOWN	SPROUTED	HR001	NA	1.70	75.90	32.6
barley	3750	HARUNA NIJO		DS004	43.032		66.5	40.9
Barley	3756	TALLON	DROUGHT AFFECTED	PGLP, DS002	48.101	28.4	66.21	29.88
Barley	3757	TREBI		PGLP, DS002	46.269		55.8	33.5
Barley	3861	BINALONG	DROUGHT AFFECTED	DS002, DS004, HR001	48.52	37.07	61.31	29.4

Grain type	Sample ID	Variety	Sample condition	Experiment	Hydration Capacity (%)	Screenings % (<2.0; <2.2 mm[a])	Specific weight (kg/hl)	1000 grain weight (g)
Barley	3865	GAIRDNER		DS002	43.85	5.28	66.9	44.3
Barley	3866	GAIRDNER	DROUGHT AFFECTED	DS002	43.43	9.51	65.69	45.4
Barley	3867	GAIRDNER		DS002, DS004	41.53	2.42	68.43	43.87
Barley	3868	SCHOONER		DS002	39.39	3.17	71.2	45.2
barley	3869	GROUT	DROUGHT AFFECTED	DS004	39.65	11.527	65.82	40.2
barley	3870	GROUT	DROUGHT AFFECTED	DS004, HR001	41.26	16.82	63.78	36.0
barley	3871	GAIRDNER	DROUGHT AFFECTED	DS004, HR001	46.32	19.517	62.63	35.433
barley	3872	GAIRDNER	DROUGHT AFFECTED	DS004, HR001	52.99	42.913	66.56	30.6
barley	3873	TILGA	DROUGHT AFFECTED	DS004, HR001	42.35	66.96	63.91	31.033
barley	3874	SCHOONER	DROUGHT AFFECTED	DS004, HR001	43.99	53.179	64.64	28.967
barley	3875	WYALONG	DROUGHT AFFECTED	DS004	42.38	52.088	63.72	28.433
barley	3876	SCHOONER	DROUGHT AFFECTED	DS004	42.47	50.283	65.69	29.733
barley	3877	TALLON	SPROUTED	HR001	NA	8.45	65.60	32.3
barley	3879	FITZROY	SPROUTED	HR001	NA	2.15	64.29	51.5
barley	3879	FITZROY	STRESSED (SPRAYED)	HR001	NA	47.72	39.42	21.7
barley	3880	NRB03470		HR001	NA	2.89	65.82	47.0
barley	3880	NRB03470	STRESSED (DROUGHT)	HR001	NA	22.85	58.94	33.1
barley	3890	NRB03470		HR001	NA	1.77	66.70	45.0
barley	3891	NRB03470		HR001	NA	1.61	66.75	44.4
barley	3897	GROUT		HR001	NA	36.45	60.44	32.9
barley	3898	UNKNOWN		HR001	38.70	19.50	72.61	38.4
barley	3818	ND19119	SPROUTED	HR001	NA	3.61	62.12	60.2
barley	3819	NRB03470	SPROUTED	HR001	NA	2.16	62.47	42.9
barley	3921	UNKNOWN		HR001	NA	2.80	67.68	42.1
barley	3921	UNKNOWN	SPROUTED	HR001	NA	2.01	64.77	42.4
Triticale	6708	ABACUS		DS004	55.685		65.1	34.3
Triticale	6824	JACKIE		DS002	50.39	3.43	71.63	45.3
Triticale	6825	PRIME 322		DS002	48.57	1.31	73.48	45.6
Triticale	6826	CREDIT		DS002	49.52	2.65	68.4	37.97
Triticale	6827	EVEREST		DS002	43.22	2.15	72.22	43.8
Triticale	6828	TAHARA		DS002	50.94	6.05	69.77	43.6
Triticale	6829	KOSCIUSZKO	DROUGHT AFFECTED	DS004, HR001	60.12	8.766	73.46	32.233
Triticale	6830	EVEREST		DS004, HR001	49.79	0.952	77.74	36.133
Triticale	6831	KOSCIUSZKO		DS004	54.06	3.979	75.24	41.0
Triticale	6835	UNKNOWN		HR001	NA	2.62	67.77	37.9
Triticale	6835	UNKNOWN	SPROUTED	HR001	NA	0.92	60.13	38.9
Triticale	6836	JRCT74		HR001	NA	1.95	65.76	40.6
Triticale	6837	TOBRUK		HR001	NA	20.10	74.09	30.7
Sorghum	7712	Buster		PGLP, DS005	33.448		80.1	29.0
sorghum	7714	MR43		DS004	32.62	9.67	76.11	24.4
sorghum	7714	MR43	SPROUTED	DS004	34.18	12.51	74.31	24.9
sorghum	7714	MR43	DROUGHT AFFECTED	DS004	32.95	35.78	78.01	17.8
sorghum	7714	MR43	DROUGHT AFFECTED & SPROUTED	DS004	34.09	34.28	76.99	16.93

Grain type	Sample ID	Variety	Sample condition	Experiment	Hydration Capacity (%)	Screenings % (<2.0; <2.2 mm[a])	Specific weight (kg/hl)	1000 grain weight (g)
sorghum	7714	MR43	DROUGHT AFFECTED & DESICATED	DS004	30.82	40.36	79.28	18.33
sorghum	7714	MR43	DROUGHT AFFECTED & DESICATED & SPROUTED	DS004	32.04	39.92	75.95	17.6
Sorghum	7855	MR Maxi		DS002, DS004	35.16	2.14	72.98	27.3
Sorghum	7856	LIBERTY		DS002, DS004, HR001	34.74	8.2	75.27	19.0
Sorghum	7857	Pacer		DS002, DS004, HR001	34.77	3.82	73.85	27.6
Sorghum	7858	MR43		DS002, DS004	37.86	8.92	73.63	21.1
Sorghum	7858	MR43		DS002, HR001				
Sorghum	7859	BUSTER	DROUGHT AFFECTED	DS002, DS004	31.8	16.79	80.66	23.2
Sorghum	7860	unknown		DS002, DS004	28.82	1.46	80.98	33.7
Sorghum	7861	VENTURE		DS002, DS004	28.88	7.41	80.86	29.1
Sorghum	7862	BUSTER		DS002, DS004	39.13	9.18	73.42	24.4
Sorghum	7863	RED 1		DS002, DS004	30.15	3.59	79.2	28.2
Sorghum	7864	RED 2	DROUGHT AFFECTED	DS002, DS004	33.22	24.41	78.97	19.0
Sorghum	7865	BONUS		DS004	28.7	3.255	80.18	25.6
Sorghum	7866	Pacer		DS004	31.46	2.437	80.24	26.3
Sorghum	7867	MR43		DS004, HR001	29.98	2.407	81.3	26.1
Sorghum	7868	MR Maxi		DS004	31.71	2.251	79.55	25.6
Sorghum	7869	KARPER 669		HR001	30.53	2.98	77.45	28.5
Sorghum	7870	ICSV 400	LARGE SEEDED, WHITE MALI	HR001	30.38	0.60	78.75	36.6
Sorghum	7871	MR43	DAMAGED	HR001	NA	3.24	72.86	24.4
Sorghum	7872	LIBERTY	WHITE	HR001	NA	8.81	75.93	19.3
Sorghum	7876	UNKNOWN		HR001	27.28	4.92	80.17	29.1
pearl millet	8091	NPM3		DS005				
pearl millet	8092	NPM4		DS005				

Appendix 2: Proximate analysis of all grains collected

Wheat

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	DM %	Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
			All values on %dm basis											
wheat	1727	Oxley (connectivity)	90	1.9	3.31	20.69	3.3	18.64	11.0	3.6	2	1.2	0.46	0.39
wheat	1728	QAL 2000 (connectivity)	89.4	1.6	2.37	14.81	3.6	18.47	11.9	2.8	1.6	1.1	0.44	0.28
wheat	1746	Vulcan	91.0	1.8	2.62	16.38	2.5	18.58	10.2	2.1	2.3	0.3	0.46	0.30
wheat	1749	Wollaroi (connectivity)	90.5	1.7	2.94	18.38	2.9	18.72	9.2	2.2	2.5	1.3	0.45	0.29
wheat	1753	Bellaroi	90.57	2	3.23	20.21	2.77	18.7	10.2	2.27	2.47	0.77	0.43	0.33
wheat	1754	Sentinal	90.5	2.1	2.52	15.75	3.6	18.21	11.5	3.0	2	1.5	0.51	0.37
wheat	1755	Ammrock	90.3	1.8	2.81	17.56	3.8	18.37	10.9	2.7	2	1.2	0.45	0.37
wheat	1756	Roache Silo 2, Logan Grains (Kellalac)	89.8	1.7	2.5	15.63	2.8	18.48	10.5	1.8	1.9	0.3	0.42	0.28
wheat	1757	unknown	88.6	1.7	1.82	11.38	3.2	18.33	11.3	3.0	2.2	1.3	0.41	0.32
wheat	1758	Chara	88.1	1.5	2.06	12.88	3.1	18.44	10.5	2.7	2.3	1.3	0.36	0.28
wheat	1759	Fraser Silo 5, Logan Grains (unknown)	91.1	1.4	2.02	12.63	2.7	18.31	10.8	1.8	2.2	0.3	0.44	0.25
wheat	1760	Wisewood silo 9, Logan Grains (Kellalac)	90.4	1.8	1.96	12.25	3.4	18.28	10.9	2.1	2.1	0.6	0.46	0.30
wheat	1762	H45 (Jim O'Halloran)	91.9	1.8	3.2	20.00	3.1	18.73	12.0	1.9	2.1	0.5	0.54	0.29
wheat	1763	H45 (Peter Barry)	91.4	2.4	3.29	20.56	4.3	18.79	13.8	2.7	1.9	0.7	0.64	0.31
wheat	1764	Sunco (Livingston farm)	90.85	1.7	2.95	18.41	2.85	18.5	10.55	1.9	1.85	0.6	0.37	0.31
wheat	1765	Lang (Martin Dunlop)	90.9	2.0	2.71	16.94	3.1	18.53	11.4	1.9	1.7	0.6	0.52	0.39
wheat	1766	H45 Nigel Martin	91.7	2.0	3.02	18.88	3.5	18.68	13.1	2.3	1.8	0.7	0.61	0.30
wheat	1767	Cunningham (F. Colless)	90.75	1.75	3.53	22.06	2.8	18.75	11.8	2.15	2.95	0.65	0.41	0.31
wheat	1768	Janz (F. Colless)	91.3	1.8	3.38	21.13	3.1	18.81	11.9	1.9	2.9	0.5	0.47	0.28
wheat	1769	Bellaroi (durum) - Livingston Farm	92.9	1.8	2.93	18.31	3.2	18.83	11.3	2.5	3.2	0.5	0.44	0.29
wheat	1770	Sunbri (Livingston Farm)	91.1	1.7	2.72	17.00	2.75	18.35	10.15	2.05	2.45	0.55	0.38	0.34
wheat	1771	Drysdale (James Butt)	91.7	1.8	3.17	19.81	3.3	18.75	11.5	2.6	3.3	0.4	0.47	0.28
wheat	1772	Wollaroi (normal)	89.9	1.8	2.84	17.75	2.3	18.42	9.2	1.9	2.4	0.4	0.26	0.34
wheat	1772	Wollaroi (naturally sprouted)	89.4	1.5	2.96	18.50	2.3	18.51	9.3	1.8	2.3	0.3	0.29	0.37
wheat	1773	Baxter (normal)	89.2	1.7	2.81	17.56	2.3	18.41	9.6	1.6	1.9	0.3	0.42	0.4
wheat	1773	Baxter (naturally sprouted)	89.6	1.7	2.97	18.56	2.2	18.45	9.3	1.5	1.7	0.3	0.19	0.4
wheat	1841	H45 (connectivity)	90.1	2.0	2.88	18.00	3.6	18.56	12.5	3.4	1.9	1.6	0.46	0.34
wheat	1856	QAL1064	90.2	1.2	1.86	11.63	2.9	18.04	11.6	2.2	1.7	0.4	0.28	0.26
wheat	1864	SUN 525D	90.8	1.7	2.79	17.44	3.1	18.11	11	2.2	1.6	0.4	0.28	0.39

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	All values on %dm basis											
			DM %	Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
wheat	1865	SUN 526A	90.4	1.5	2.65	16.56	2.6	18.11	10.6	2.1	1.5	0.6	0.39	0.31
wheat	1868	Bellaroi (1 tonne from PBI)	90.9	2.1	2.53	15.81	2.5	18.2	9.7	1.8	2	0.3	0.47	0.4
wheat	1874	grown for Danny at Toowoomba	89.5	2.3	2.63	16.44	2.4	18.22	9.8	1.8	1.2	0.3	0.24	0.29
wheat	1876	red wheat, Dairy trial organised by Ray King	89.3	1.3	1.89	11.81	2	18.17	9.2	1.1	1.8	0.2	0.36	0.3
wheat	1877	white wheat, Dairy trial organised by Ray King	89.6	1.4	2.11	13.19	2.1	18.17	10	1.6	1.4	0.1	0.29	0.32
wheat	1879	grown for Danny at Toowoomba	89.8	1.1	2.63	16.44	2.4	18.21	10.3	1.8	1.6	0.4	0.23	0.31
N	35													
Mean			**90.4**	**1.74**	**2.70**	**16.90**	**2.92**	**18.45**	**10.81**	**2.19**	**2.08**	**0.64**	**0.41**	**0.32**
Min			**88.1**	**1.1**	**1.82**	**11.38**	**2**	**18.04**	**9.2**	**1.1**	**1.2**	**0.1**	**0.19**	**0.25**
Max			**92.9**	**2.4**	**3.53**	**22.06**	**4.3**	**18.83**	**13.8**	**3.6**	**3.3**	**1.6**	**0.64**	**0.4**

grain type	pglp id	variety	All values on a % as received basis										
			Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
wheat	1727	Oxley (connectivity)	1.71	2.98	18.62	2.97	16.78	9.90	3.24	1.80	1.08	0.41	0.35
wheat	1728	QAL 2000 (connectivity)	1.43	2.12	13.24	3.22	16.51	10.64	2.50	1.43	0.98	0.39	0.25
wheat	1746	Vulcan	1.64	2.38	14.90	2.28	16.91	9.28	1.91	2.09	0.27	0.42	0.27
wheat	1749	Wollaroi (connectivity)	1.54	2.66	16.63	2.62	16.94	8.33	1.99	2.26	1.18	0.41	0.26
wheat	1753	Bellaroi	1.81	2.93	18.30	2.51	16.94	9.24	2.05	2.23	0.69	0.39	0.30
wheat	1754	Sentinal	1.90	2.28	14.25	3.26	16.48	10.41	2.72	1.81	1.36	0.46	0.33
wheat	1755	Ammrock	1.63	2.54	15.86	3.43	16.59	9.84	2.44	1.81	1.08	0.41	0.33
wheat	1756	Roache Silo 2, Logan Grains (Kellalac)	1.53	2.25	14.03	2.51	16.60	9.43	1.62	1.71	0.27	0.38	0.25
wheat	1757	unknown	1.51	1.61	10.08	2.84	16.24	10.01	2.66	1.95	1.15	0.36	0.28
wheat	1758	Chara	1.32	1.81	11.34	2.73	16.25	9.25	2.38	2.03	1.15	0.32	0.25
wheat	1759	Fraser Silo 5, Logan Grains (unknown)	1.28	1.84	11.50	2.46	16.68	9.84	1.64	2.00	0.27	0.40	0.23
wheat	1760	Wisewood silo 9, Logan Grains (Kellalac)	1.63	1.77	11.07	3.07	16.53	9.85	1.90	1.90	0.54	0.42	0.27
wheat	1762	H45 (Jim O'Halloran)	1.65	2.94	18.38	2.85	17.21	11.03	1.75	1.93	0.46	0.50	0.27
wheat	1763	H45 (Peter Barry)	2.19	3.01	18.79	3.93	17.17	12.61	2.47	1.74	0.64	0.58	0.28
wheat	1764	Sunco (Livingston farm)	1.54	2.68	16.72	2.59	16.80	9.59	1.72	1.68	0.54	0.33	0.28
wheat	1765	Lang (Martin Dunlop)	1.82	2.46	15.40	2.82	16.84	10.36	1.73	1.55	0.55	0.47	0.35
wheat	1766	H45 Nigel Martin	1.83	2.77	17.31	3.21	17.13	12.01	2.11	1.65	0.64	0.56	0.28
wheat	1767	Cunningham (F. Colless)	1.59	3.20	20.02	2.54	17.01	10.71	1.95	2.68	0.59	0.37	0.28
wheat	1768	Janz (F. Colless)	1.64	3.09	19.29	2.83	17.17	10.86	1.73	2.65	0.46	0.43	0.26

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	***All values on %dm basis***											
			DM %	**Ash**	**N**	**CP**	**ADF**	**GE MJ/kg**	**NDF**	**CF**	**Fat**	**Lignin**	**K**	**P**
wheat	1769	Bellaroi (durum) - Livingston Farm	1.67	2.72	17.01	2.97	17.49	10.50	2.32	2.97	0.46	0.41	0.27	
wheat	1770	Sunbri (Livingston Farm)	1.55	2.48	15.49	2.51	16.71	9.25	1.87	2.24	0.50	0.34	0.31	
wheat	1771	Drysdale (James Butt)	1.65	2.91	18.17	3.03	17.19	10.55	2.38	3.03	0.37	0.43	0.26	
wheat	1772	Wollaroi (normal)	1.62	2.55	15.96	2.07	16.56	8.27	1.71	2.16	0.36	0.23	0.31	
wheat	1772	Wollaroi (naturally sprouted)	1.34	2.65	16.54	2.06	16.55	8.31	1.61	2.06	0.27	0.26	0.33	
wheat	1773	Baxter (normal)	1.52	2.51	15.67	2.05	16.42	8.56	1.43	1.69	0.27	0.37	0.36	
wheat	1773	Baxter (naturally sprouted)	1.52	2.66	16.63	1.97	16.53	8.33	1.34	1.52	0.27	0.17	0.36	
wheat	1841	H45 (connectivity)	1.80	2.59	16.22	3.24	16.72	11.26	3.06	1.71	1.44	0.41	0.31	
wheat	1856	QAL1064	1.08	1.68	10.49	2.62	16.27	10.46	1.98	1.53	0.36	0.25	0.23	
wheat	1864	SUN 525D	1.54	2.53	15.83	2.81	16.44	9.99	2.00	1.45	0.36	0.25	0.35	
wheat	1865	SUN 526A	1.36	2.40	14.97	2.35	16.37	9.58	1.90	1.36	0.54	0.35	0.28	
wheat	1868	Bellaroi (1 tonne from PBI)	1.91	2.30	14.37	2.27	16.54	8.82	1.64	1.82	0.27	0.43	0.36	
wheat	1874	grown for Danny at Toowoomba	2.06	2.35	14.71	2.15	16.31	8.77	1.61	1.07	0.27	0.21	0.26	
wheat	1876	red wheat, Dairy trial organised by Ray King	1.16	1.69	10.55	1.79	16.23	8.22	0.98	1.61	0.18	0.32	0.27	
wheat	1877	white wheat, Dairy trial organised by Ray King	1.25	1.89	11.82	1.88	16.28	8.96	1.43	1.25	0.09	0.26	0.29	
wheat	1879	grown for Danny at Toowoomba	0.99	2.36	14.76	2.16	16.35	9.25	1.62	1.44	0.36	0.21	0.28	
N	35													
Mean			**1.58**	**2.45**	**15.28**	**2.65**	**16.68**	**9.78**	**1.98**	**1.88**	**0.58**	**0.37**	**0.29**	
Min			**0.99**	**1.61**	**10.08**	**1.79**	**16.23**	**8.22**	**0.98**	**1.07**	**0.09**	**0.17**	**0.23**	
Max			**2.19**	**3.2**	**20.02**	**3.93**	**17.49**	**12.61**	**3.24**	**3.03**	**1.44**	**0.58**	**0.36**	

Barley

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	DM %	Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
			All values on %dm basis											
barley	3750	Haruna nijo	91.2	2.8	2.71	16.94	3.9	18.6	13.7	3.1	3.7	0.3	0.53	0.39
barley	3756	Tallon (connectivity)	90.7	3.1	2.66	16.63	4.8	18.53	15.9	4.0	2.3	1.3	0.49	0.38
barley	3757	Trebi (connectivity)	90.2	3.6	3.18	19.88	6.8	18.6	18.2	5.9	2.3	1.3	0.51	0.44
barley	3861	Binalong, PBI Narrabri	90.57	3.5	2.5	15.60	5.97	18.35	17.53	4.63	2.77	0.9	0.51	0.41
barley	3865	Gairdner	88.6	2.2	1.66	10.38	5.2	18.45	15.9	5.1	2.6	1.4	0.43	0.36
barley	3866	Gairdner	89.5	2.4	1.85	11.56	5.2	18.37	15.8	5.2	2.5	1.2	0.48	0.36
barley	3867	Gairdner	90.2	2.2	2.52	15.75	5.7	18.6	16.7	4.6	2.2	0.75	0.45	0.29
barley	3868	Schooner	91.1	2.6	2.25	14.06	5.9	18.37	16.3	5.0	2.5	1.3	0.50	0.35
barley	3869	Grout (PBI Narrabri - hydrants)	90.5	2.3	2.3	14.38	4.9	18.44	15.6	3.3	1.8	0.1	0.52	0.29
barley	3870	Grout (PBI Narrabri - light country)	89.95	2.5	1.95	12.16	5.25	18.29	17.85	4.05	2.25	0.55	0.64	0.25
barley	3871	Gairdner (Livingston farm)	90.3	2.55	2.55	15.91	4.8	18.53	16.2	3.65	2.15	0.6	0.47	0.35
barley	3872	Gairdner (Kevin Schultz)	91.1	2.95	3.38	21.13	3.8	18.82	15.95	3.05	2.25	0.4	0.82	0.42
barley	3873	Tilga (F.Colless)	90.65	2.4	3.3	20.59	5.2	18.84	17.95	4.4	2.05	0.6	0.72	0.32
barley	3874	Schooner (D. Manwarring)	90.55	2.55	2.81	17.53	5.15	18.68	17.85	4.05	2.15	0.5	0.66	0.32
barley	3875	Wyalong (M. Williams)	90.9	2.3	2.83	17.69	5.2	18.68	18.9	4.1	1.8	0.8	0.72	0.31
barley	3876	Schooner (N. Martin)	90.5	2.5	2.49	15.56	5.3	18.54	18.1	4.1	2.0	0.8	0.69	0.31
barley	3877	Tallon (naturally Sprouted)	89.7	3	3.11	19.44	4.1	18.78	15.1	3.2	2.7	0.4	0.41	0.46
barley	3879	Fitzroy (normal maybe be sprouted?)	90	2.5	2.24	14.00	4.2	18.33	15.4	3.8	2.4	0.4	0.33	0.38
barley	3879	Fitzroy (sprayed with roundup)	90.8	4.5	2.17	13.56	8.9	18	24.5	7.6	1.8	0.8	0.99	0.38
barley	3880	NRB03470 (normal)	89.5	3.1	1.82	11.38	5.1	18.14	16.5	4	2.3	0.6	0.45	0.34
barley	3880	NRB03470 (drought stressed)	90.3	3.3	2.43	15.19	6.6	18.3	18.9	5.3	2	0.7	0.54	0.36
barley	3890	NRB03470	90	2.1	2.2	13.75	4.9	18.28	15.4	3.9	2	0.7	0.52	0.28
barley	3891	NRB03470	89.9	2.2	2.05	12.81	4.7	18.24	15.5	3.5	2.1	0.5	0.88	0.28
barley	3897	Grout	90.9	2.8	2.2	13.75	5	18.16	17.6	4.2	2	0.4	0.38	0.33
barley	3898	Dave Cadogan - excess used in phytase trial	91	1.9	2.16	13.50	4.5	18.42	16.2	3.7	2.3	0.4	0.39	0.28
barley	3918	ND19119	89.7	2.6	2.25	14.06	4	18.27	14.2	3	2.1	0.7	0.31	0.4
barley	3919	NRB03470	89.5	2.3	2.55	15.94	4.6	18.55	15.6	3.8	2.1	0.5	0.64	0.33
barley	3921	grown for Danny at Toowoomba	90.4	2.2	2.58	16.13	4.2	18.48	15.6	3.5	2.2	0.7	0.29	0.33
barley	3921	grown for Danny at Toowoomba	90.3	2	2.61	16.31	4.1	18.5	14.6	3.2	2.2	0.8	0.42	0.29
N	29													

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	*All values on %dm basis*											
			DM %	Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
Mean			**90.3**	**2.65**	**2.46**	**15.36**	**5.10**	**18.45**	**16.67**	**4.17**	**2.26**	**0.70**	**0.54**	**0.34**
Min			**88.6**	**1.90**	**1.66**	**10.38**	**3.80**	**18.00**	**13.70**	**3.00**	**1.80**	**0.10**	**0.29**	**0.25**
Max			**91.2**	**4.50**	**3.38**	**21.13**	**8.90**	**18.84**	**24.50**	**7.60**	**3.70**	**1.40**	**0.99**	**0.46**

grain type	pglp id	variety	*All values on a % as received basis*										
			Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
barley	3750	Haruna nijo	2.55	2.47	15.45	3.56	16.96	12.49	2.83	3.37	0.27	0.48	0.36
barley	3756	Tallon (connectivity)	2.81	2.41	15.08	4.35	16.81	14.42	3.63	2.09	1.18	0.44	0.34
barley	3757	Trebi (connectivity)	3.25	2.87	17.93	6.13	16.78	16.42	5.32	2.07	1.17	0.46	0.40
barley	3861	Binalong, PBI Narrabri	3.17	2.26	14.13	5.40	16.62	15.88	4.20	2.51	0.81	0.46	0.37
barley	3865	Gairdner	1.95	1.47	9.19	4.61	16.35	14.09	4.52	2.30	1.24	0.38	0.32
barley	3866	Gairdner	2.15	1.66	10.35	4.65	16.44	14.14	4.65	2.24	1.07	0.43	0.32
barley	3867	Gairdner	1.98	2.27	14.21	5.14	16.78	15.06	4.15	1.98	0.68	0.40	0.26
barley	3868	Schooner	2.37	2.05	12.81	5.37	16.74	14.85	4.56	2.28	1.18	0.46	0.32
barley	3869	Grout (PBI Narrabri - hydrants)	2.08	2.08	13.01	4.43	16.69	14.12	2.99	1.63	0.09	0.47	0.26
barley	3870	Grout (PBI Narrabri - light country)	2.25	1.75	10.93	4.72	16.45	16.06	3.64	2.02	0.49	0.57	0.22
barley	3871	Gairdner (Livingston farm)	2.30	2.30	14.36	4.33	16.73	14.63	3.30	1.94	0.54	0.42	0.32
barley	3872	Gairdner (Kevin Schultz)	2.69	3.08	19.25	3.46	17.15	14.53	2.78	2.05	0.36	0.74	0.38
barley	3873	Tilga (F.Colless)	2.18	2.99	18.67	4.71	17.08	16.27	3.99	1.86	0.54	0.65	0.29
barley	3874	Schooner (D. Manwarring)	2.31	2.54	15.87	4.66	16.91	16.16	3.67	1.95	0.45	0.60	0.29
barley	3875	Wyalong (M. Williams)	2.09	2.57	16.08	4.73	16.98	17.18	3.73	1.64	0.73	0.65	0.28
barley	3876	Schooner (N. Martin)	2.26	2.25	14.08	4.80	16.78	16.38	3.71	1.81	0.72	0.62	0.28
barley	3877	Tallon (naturally Sprouted)	2.69	2.79	17.44	3.68	16.85	13.54	2.87	2.42	0.36	0.37	0.41
barley	3879	Fitzroy (normal maybe be sprouted?)	2.25	2.02	12.60	3.78	16.50	13.86	3.42	2.16	0.36	0.30	0.34
barley	3879	Fitzroy (sprayed with roundup)	4.09	1.97	12.31	8.08	16.34	22.25	6.90	1.63	0.73	0.90	0.35
barley	3880	NRB03470 (normal)	2.77	1.63	10.18	4.56	16.24	14.77	3.58	2.06	0.54	0.40	0.30
barley	3880	NRB03470 (drought stressed)	2.98	2.19	13.71	5.96	16.52	17.07	4.79	1.81	0.63	0.49	0.33
barley	3890	NRB03470	1.89	1.98	12.38	4.41	16.45	13.86	3.51	1.80	0.63	0.47	0.25
barley	3891	NRB03470	1.98	1.84	11.52	4.23	16.40	13.93	3.15	1.89	0.45	0.79	0.25
barley	3897	Grout	2.55	2.00	12.50	4.55	16.51	16.00	3.82	1.82	0.36	0.35	0.30
barley	3898	Dave Cadogan - excess used in phytase trial	1.73	1.97	12.29	4.10	16.76	14.74	3.37	2.09	0.36	0.35	0.25
barley	3918	ND19119	2.33	2.02	12.61	3.59	16.39	12.74	2.69	1.88	0.63	0.28	0.36

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	DM %	Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
			All values on %dm basis											
barley	3919	NRB03470	2.06	2.28	14.26	4.12	16.60	13.96	3.40	1.88	0.45	0.57	0.30	
barley	3921	grown for Danny at Toowoomba	1.99	2.33	14.58	3.80	16.71	14.10	3.16	1.99	0.63	0.26	0.30	
barley	3921	grown for Danny at Toowoomba	1.81	2.36	14.73	3.70	16.71	13.18	2.89	1.99	0.72	0.38	0.26	
N	29													
Mean			**2.40**	**2.22**	**13.88**	**4.61**	**16.66**	**15.06**	**3.77**	**2.04**	**0.63**	**0.49**	**0.31**	
Min			**1.73**	**1.47**	**9.19**	**3.46**	**16.24**	**12.49**	**2.69**	**1.63**	**0.09**	**0.26**	**0.22**	
Max			**4.09**	**3.08**	**19.25**	**8.08**	**17.15**	**22.25**	**6.90**	**3.37**	**1.24**	**0.90**	**0.41**	

Triticale

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	*All values on %dm basis*											
			DM %	Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
triticale	6708	Abacus	90.1	2.0	3.1	19.38	3.2	18.57	11.1	1.6	1.2	0.7	0.58	0.36
triticale	6824	Jackie	91.1	1.6	2.4	15.00	3.8	18.33	11.3	2.8	2.1	1.3	0.39	0.3
triticale	6825	Prime 322	89.1	1.8	2.07	12.94	3.7	18.38	13.0	3.0	2.3	1.5	0.40	0.34
triticale	6826	Credit	89	1.9	1.63	10.19	3.5	18.19	11.9	3.2	2.1	1.3	0.53	0.34
triticale	6827	Everest	91.1	1.7	1.39	8.69	4.2	18.06	13.7	3.2	1.9	1.5	0.40	0.31
triticale	6828	Tahara	89.2	1.8	2.2	13.75	4.0	18.38	13.1	3.5	1.8	1.3	0.40	0.34
triticale	6829	triticale_Kosciusko (Jim Watson)	90.75	1.75	3.09	19.28	3.1	18.55	12.45	2.0	1.9	0.85	0.44	0.27
triticale	6830	triticale_Everest (UNE)	90.1	1.7	2.75	17.16	3.4	18.47	12.0	2.2	1.7	0.7	0.38	0.34
triticale	6831	Kosciusko (Chris Wirth)	89.5	2.1	2.34	14.63	3.4	18.33	12.6	2.2	1.0	0.5	0.58	0.40
triticale	6835	grown for Danny at Toowoomba	90	1.8	2.43	15.19	3.5	18.28	13.2	2.5	1.8	0.9	0.5	0.26
triticale	6835	grown for Danny at Toowoomba	89.7	1.7	2.66	16.63	3.4	18.43	12.5	2.1	1.7	0.8	0.3	0.26
triticale	6836	JRCT74 - new Line from Jeremy Roake - Usyd	89.9	1.9	2.43	15.19	3.1	18.15	11.9	2	1.7	0.7	0.58	0.24
triticale	6837	Tobruk - Usyd variety	90.6	1.9	2.39	14.94	2.7	18.04	11.2	1.7	1.4	0.7	0.45	0.25
N	13													
Mean			**90.01**	**1.82**	**2.38**	**14.84**	**3.46**	**18.32**	**12.30**	**2.46**	**1.74**	**0.98**	**0.46**	**0.31**
Min			**89.0**	**1.60**	**1.39**	**8.69**	**2.70**	**18.04**	**11.10**	**1.60**	**1.00**	**0.50**	**0.30**	**0.24**
Max			**91.1**	**2.10**	**3.10**	**19.38**	**4.20**	**18.57**	**13.70**	**3.50**	**2.30**	**1.50**	**0.58**	**0.40**

grain type	pglp id	variety	*All values on a % as received basis*										
			Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
triticale	6708	Abacus	1.80	2.79	17.46	2.88	16.73	10.00	1.44	1.08	0.63	0.52	0.32
triticale	6824	Jackie	1.46	2.19	13.67	3.46	16.70	10.29	2.55	1.91	1.18	0.36	0.27
triticale	6825	Prime 322	1.60	1.84	11.53	3.30	16.38	11.58	2.67	2.05	1.34	0.36	0.30
triticale	6826	Credit	1.69	1.45	9.07	3.12	16.19	10.59	2.85	1.87	1.16	0.47	0.30
triticale	6827	Everest	1.55	1.27	7.91	3.83	16.45	12.48	2.92	1.73	1.37	0.36	0.28
triticale	6828	Tahara	1.61	1.96	12.27	3.57	16.39	11.69	3.12	1.61	1.16	0.36	0.30
triticale	6829	triticale_Kosciusko (Jim Watson)	1.59	2.80	17.50	2.81	16.83	11.30	1.81	1.72	0.77	0.40	0.24
triticale	6830	triticale_Everest (UNE)	1.53	2.47	15.46	3.06	16.64	10.81	1.98	1.53	0.63	0.34	0.30

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

triticale	6831	Kosciusko (Chris Wirth)	1.88	2.09	13.09	3.04	16.41	11.28	1.97	0.90	0.45	0.52	0.36
triticale	6835	grown for Danny at Toowoomba	1.62	2.19	13.67	3.15	16.45	11.88	2.25	1.62	0.81	0.45	0.23
triticale	6835	grown for Danny at Toowoomba	1.52	2.39	14.91	3.05	16.53	11.21	1.88	1.52	0.72	0.27	0.23
triticale	6836	JRCT74 - new Line from Jeremy Roake - Usyd	1.71	2.18	13.65	2.79	16.32	10.70	1.80	1.53	0.63	0.52	0.22
triticale	6837	Tobruk - Usyd variety	1.72	2.17	13.53	2.45	16.34	10.15	1.54	1.27	0.63	0.41	0.23
N	13												
Mean			**1.64**	**2.14**	**13.36**	**3.12**	**16.49**	**11.07**	**2.21**	**1.56**	**0.88**	**0.41**	**0.28**
Min			**1.46**	**1.27**	**7.91**	**2.45**	**16.19**	**10.00**	**1.44**	**0.9**	**0.45**	**0.27**	**0.22**
Max			**1.88**	**2.80**	**17.50**	**3.83**	**16.83**	**12.48**	**3.12**	**2.05**	**1.37**	**0.52**	**0.36**

Sorghum

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

grain type	pglp id	variety	DM %	Ash	N	CP	ADF	GE MJ/kg	NDF	CF	Fat	Lignin	K	P
			All values on %dm basis											
sorghum	7714	MR43 (Biloela)	89.8	1.7	2.01	12.56	3.9	18.68	7.3	1.6	3.5	0.7	0.39	0.34
sorghum	7714	MR43 (Biloela)	90.7	1.6	2.01	12.56	3.5	18.75	6.4	1.4	3.6	0.2	0.38	0.36
sorghum	7714	MR43 (Biloela)	89.1	2.1	2.38	14.88	4.9	18.99	10.5	2.5	4.4	0.5	0.49	0.44
sorghum	7714	MR43 (Biloela)	90.5	1.9	2.39	14.94	4.3	19.06	9.3	1.7	4.4	0.6	0.48	0.42
sorghum	7714	MR43 (Biloela)	88.9	2.1	2.46	15.38	4.6	19.08	9.9	1.9	4.8	0.7	0.49	0.45
sorghum	7714	MR43 (Biloela)	90.2	2.0	2.42	15.13	4.5	19.06	9.4	2.3	4.4	0.3	0.45	0.43
sorghum	7855	Maxi (Livingston Farm)	89.55	1.25	1.82	11.38	4.0	18.51	7.2	1.95	2.7	0.7	0.29	0.24
sorghum	7856	Liberty (white)	89.97	1.7	1.88	11.75	4.63	18.56	7.8	2.07	3.37	0.83	0.47	0.29
sorghum	7857	Pacer (Livingston Farm)	88.83	1.63	2.15	13.42	4.77	18.67	8.03	2.47	3.07	0.8	0.3	0.33
sorghum	7858	MR43 (Livingston Farm)	90.33	1.5	2.21	13.81	5.1	18.71	8.6	2.37	3.2	0.83	0.28	0.27
sorghum	7858	MR44	88.6	1.8	2.19	13.69	5.5	18.76	8.8	2.6	3.2	1.0	0.28	0.34
sorghum	7859	Brigalow Research Station Buster	89.55	1.5	1.85	11.53	4.5	18.79	8.0	2.1	4.35	0.85	0.38	0.3
sorghum	7860	Allora grain and Mill	89.05	1.6	1.97	12.31	4.05	18.78	6.3	2.1	4.35	0.65	0.34	0.32
sorghum	7861	Venture	89.8	1.75	2.25	14.03	5.4	18.87	8.85	2.4	3.75	0.85	0.4	0.33
sorghum	7862	Buster	90.65	1.6	2.05	12.81	5.1	18.61	7.7	2.05	3.2	0.7	0.35	0.3
sorghum	7863	Red 1	89.4	1.65	2.17	13.56	4.65	18.81	6.9	1.7	3.65	0.9	0.41	0.35
sorghum	7864	Red 2	89.8	1.8	2.32	14.50	5.2	18.84	7.35	1.9	3.45	1.0	0.4	0.38
sorghum	7865	Bonus (Livingston farm)	89.3	1.1	1.93	12.06	3.4	18.87	7.4	1.4	3.2	0.5	0.33	0.27
sorghum	7866	Pacer (Livingston Farm)	90.5	1.1	2.02	12.63	3.7	18.96	6.9	1.3	3.4	0.5	0.36	0.20
sorghum	7867	MR43 (Livingston Farm)	89.9	1.25	1.82	11.38	3.7	18.85	7.75	1.45	4.15	0.35	0.28	0.25
sorghum	7868	MR Maxi (Livingston farm)	89.4	1.1	2.01	12.56	3.9	18.91	6.7	1.8	4.1	0.8	0.34	0.19
sorghum	7869	KARPER 669	89.5	1.9	2.15	13.44	3.3	18.46	6.8	1.4	2.4	0.4	0.43	0.39
sorghum	7870	ICSV 400	89.6	1.6	1.97	12.31	3.5	18.49	7.3	1.4	3.2	0.2	0.25	0.3
sorghum	7871	MR 43 (damaged)	88.9	1.7	1.53	9.56	3.3	18.51	7.5	1.7	3.4	0.4	0.22	0.3
sorghum	7872	Liberty - white sorghum	89.8	1.3	1.69	10.56	3.8	18.4	7	1.9	3.1	0.5	0.24	0.23
sorghum	7876	organised by D. Cagogan from Ridley	89.8	1.6	1.88	11.75	3.9	18.63	7.7	1.6	3.9	0.3	0.32	0.27
N	26													
Mean			**89.67**	**1.61**	**2.06**	**12.87**	**4.27**	**18.75**	**7.82**	**1.89**	**3.62**	**0.62**	**0.36**	**0.32**
Min			**88.6**	**1.1**	**1.53**	**9.56**	**3.3**	**18.4**	**6.3**	**1.3**	**2.4**	**0.2**	**0.22**	**0.19**
Max			**90.7**	**2.1**	**2.46**	**15.38**	**5.5**	**19.08**	**10.5**	**2.6**	**4.8**	**1.0**	**0.49**	**0.45**

grain type	pglp id	variety	All values on a % as received basis										
			Ash	**N**	**CP**	**ADF**	**GE MJ/kg**	**NDF**	**CF**	**Fat**	**Lignin**	**K**	**P**
sorghum	7714	MR43 (Biloela)	1.53	1.80	11.28	3.50	16.77	6.56	1.44	3.14	0.63	0.35	0.31
sorghum	7714	MR43 (Biloela)	1.45	1.82	11.39	3.17	17.01	5.80	1.27	3.27	0.18	0.34	0.33
sorghum	7714	MR43 (Biloela)	1.87	2.12	13.25	4.37	16.92	9.36	2.23	3.92	0.45	0.44	0.39
sorghum	7714	MR43 (Biloela)	1.72	2.16	13.52	3.89	17.25	8.42	1.54	3.98	0.54	0.43	0.38
sorghum	7714	MR43 (Biloela)	1.87	2.19	13.67	4.09	16.96	8.80	1.69	4.27	0.62	0.44	0.40
sorghum	7714	MR43 (Biloela)	1.80	2.18	13.64	4.06	17.19	8.48	2.07	3.97	0.27	0.41	0.39
sorghum	7855	Maxi (Livingston Farm)	1.12	1.63	10.19	3.58	16.58	6.45	1.75	2.42	0.63	0.26	0.21
sorghum	7856	Liberty (white)	1.53	1.69	10.57	4.17	16.69	7.02	1.86	3.03	0.75	0.42	0.26
sorghum	7857	Pacer (Livingston Farm)	1.45	1.91	11.92	4.23	16.58	7.14	2.19	2.72	0.71	0.27	0.29
sorghum	7858	MR43 (Livingston Farm)	1.35	2.00	12.48	4.61	16.90	7.77	2.14	2.89	0.75	0.26	0.25
sorghum	7858	MR44	1.59	1.94	12.13	4.87	16.62	7.80	2.30	2.84	0.89	0.25	0.30
sorghum	7859	Brigalow Research Station Buster	1.34	1.65	10.33	4.03	16.82	7.16	1.88	3.90	0.76	0.34	0.26
sorghum	7860	Allora grain and Mill	1.42	1.75	10.96	3.61	16.72	5.61	1.87	3.87	0.58	0.30	0.28
sorghum	7861	Venture	1.57	2.02	12.60	4.85	16.95	7.95	2.15	3.37	0.76	0.35	0.29
sorghum	7862	Buster	1.45	1.86	11.61	4.62	16.87	6.98	1.86	2.90	0.64	0.31	0.27
sorghum	7863	Red 1	1.48	1.94	12.12	4.16	16.82	6.17	1.52	3.26	0.81	0.37	0.31
sorghum	7864	Red 2	1.62	2.08	13.02	4.67	16.91	6.60	1.71	3.10	0.90	0.36	0.34
sorghum	7865	Bonus (Livingston farm)	0.98	1.72	10.77	3.04	16.85	6.61	1.25	2.86	0.45	0.29	0.24
sorghum	7866	Pacer (Livingston Farm)	1.00	1.83	11.43	3.35	17.16	6.24	1.18	3.08	0.45	0.33	0.18
sorghum	7867	MR43 (Livingston Farm)	1.12	1.64	10.23	3.33	16.94	6.97	1.30	3.73	0.31	0.25	0.22
sorghum	7868	MR Maxi (Livingston farm)	0.98	1.80	11.23	3.49	16.91	5.99	1.61	3.67	0.72	0.30	0.17
sorghum	7869	KARPER 669	1.70	1.92	12.03	2.95	16.52	6.09	1.25	2.15	0.36	0.38	0.35
sorghum	7870	ICSV 400	1.43	1.77	11.03	3.14	16.57	6.54	1.25	2.87	0.18	0.22	0.27
sorghum	7871	MR 43 (damaged)	1.51	1.36	8.50	2.93	16.46	6.67	1.51	3.02	0.36	0.20	0.27
sorghum	7872	Liberty - white sorghum	1.17	1.52	9.49	3.41	16.52	6.29	1.71	2.78	0.45	0.22	0.21
sorghum	7876	organised by D. Cagogan from Ridley	1.44	1.69	10.55	3.50	16.73	6.91	1.44	3.50	0.27	0.29	0.24
N	26												
Mean			**1.44**	**1.85**	**11.54**	**3.83**	**16.82**	**7.01**	**1.69**	**3.25**	**0.55**	**0.32**	**0.29**
Min			**0.98**	**1.36**	**8.5**	**2.93**	**16.46**	**5.61**	**1.18**	**2.15**	**0.18**	**0.2**	**0.17**
Max			**1.87**	**2.19**	**13.67**	**4.87**	**17.25**	**9.36**	**2.3**	**4.27**	**0.9**	**0.44**	**0.4**

Appendix 3: Amino acid analysis of all grains collected

Wheat

Note: Connectivity grains between Pork CRC expts were averaged, where grains were tested in both PGLP and CRC the CRC value has been reported

			amino acid analysis % dry matter																	
grain	**id**	**variety**	**Ala**	**Arg**	**AspAcid**	**Cyst**	**GlutAcid**	**Glyc**	**Hist**	**isoLeuc**	**Leuc**	**Lys**	**Meth**	**Phenal**	**Prol**	**Ser**	**Threo**	**Tryp**	**Tyro**	**Val**
wheat	1727	Oxley (connectivity)	0.53	0.91	0.75	0.43	4.83	0.71	0.40	0.60	1.10	0.41	0.30	0.79	1.66	0.80	0.49	0.23	0.52	0.67
wheat	1728	QAL 2000 (connectivity)	0.44	0.72	0.59	0.36	3.41	0.53	0.30	0.44	0.82	0.34	0.24	0.57	1.13	0.58	0.37	0.18	0.37	0.51
wheat	1746	Vulcan	0.51	0.78	0.71	0.43	4.11	0.62	0.35	0.50	0.98	0.38	0.29	0.66	1.44	0.68	0.44	0.17	0.44	0.61
wheat	1749	Wollaroi (connectivity)	0.49	0.77	0.64	0.40	4.53	0.54	0.37	0.56	1.06	0.36	0.29	0.74	1.53	0.74	0.43	0.23	0.44	0.62
wheat	1753	Bellaroi	0.59	0.97	0.75	0.47	5.29	0.67	0.47	0.67	1.29	0.42	0.34	0.89	1.88	0.90	0.52	0.21	0.54	0.78
wheat	1754	Sentinal	0.41	0.72	0.59	0.32	3.58	0.54	0.31	0.45	0.85	0.35	0.22	0.62	1.23	0.62	0.39	0.18	0.39	0.51
wheat	1755	Ammrock	0.41	0.81	0.61	0.36	3.90	0.59	0.32	0.51	0.92	0.34	0.25	0.69	1.49	0.66	0.42	0.19	0.46	0.56
wheat	1756	Roache Silo 2, Logan Grains (Kellalac)	0.44	0.68	0.62	0.36	4.17	0.58	0.32	0.47	0.93	0.33	0.25	0.67	1.47	0.64	0.39	0.14	0.42	0.55
wheat	1757	unknown	0.36	0.63	0.53	0.25	2.94	0.40	0.22	0.34	0.63	0.29	0.15	0.44	0.92	0.44	0.29	0.15	0.27	0.40
wheat	1758	Chara	0.39	0.66	0.55	0.27	3.41	0.43	0.25	0.38	0.71	0.29	0.17	0.51	1.07	0.51	0.31	0.15	0.31	0.43
wheat	1759	Fraser Silo 5, Logan Grains (unknown)	0.41	0.62	0.60	0.32	3.45	0.53	0.28	0.39	0.75	0.31	0.21	0.51	1.16	0.57	0.36	0.16	0.36	0.49
wheat	1760	Wisewood silo 9, Logan Grains (Kellalac)	0.39	0.59	0.58	0.32	2.98	0.47	0.26	0.38	0.73	0.31	0.19	0.50	1.03	0.51	0.33	0.13	0.32	0.46
wheat	1762	H45 (Jim O'Halloran)	0.53	0.83	0.69	0.41	5.35	0.80	0.42	0.58	1.16	0.39	0.29	0.86	1.90	0.83	0.49	0.19	0.58	0.66
wheat	1763	H45 (Peter Barry)	0.56	0.87	0.72	0.46	5.39	0.79	0.43	0.62	1.20	0.39	0.32	0.89	1.98	0.85	0.51	0.18	0.57	0.70
wheat	1764	Sunco (Livingston farm)	0.55	0.86	0.74	0.41	5.15	0.73	0.40	0.58	1.13	0.41	0.27	0.78	1.78	0.82	0.50	0.19	0.52	0.71
wheat	1765	Lang (Martin Dunlop)	0.50	0.78	0.69	0.42	4.43	0.64	0.36	0.52	1.03	0.38	0.29	0.73	1.57	0.71	0.45	0.13	0.46	0.63
wheat	1766	H45 Nigel Martin	0.53	0.81	0.69	0.41	5.11	0.75	0.39	0.55	1.10	0.40	0.28	0.80	1.80	0.79	0.47	0.18	0.54	0.64
wheat	1767	Cunningham (F. Colless)	0.61	1.01	0.78	0.46	6.24	0.86	0.49	0.69	1.34	0.44	0.29	0.99	2.26	1.00	0.57	0.23	0.67	0.81
wheat	1768	Janz (F. Colless)	0.56	0.91	0.73	0.49	5.59	0.77	0.44	0.64	1.24	0.41	0.30	0.92	2.06	0.89	0.52	0.20	0.59	0.72
wheat	1769	Bellaroi (durum) - Livingston Farm	0.50	0.82	0.67	0.46	4.69	0.59	0.42	0.60	1.18	0.38	0.33	0.81	1.68	0.81	0.46	0.20	0.47	0.68
wheat	1770	Sunbri (Livingston Farm)	0.50	0.81	0.70	0.41	4.63	0.66	0.37	0.53	1.04	0.39	0.27	0.72	1.58	0.76	0.46	0.19	0.47	0.64
wheat	1771	Drysdale (James Butt)	0.52	0.84	0.71	0.46	5.41	0.75	0.42	0.60	1.16	0.39	0.32	0.85	1.89	0.85	0.50	0.18	0.56	0.70
wheat	1772	Wollaroi (normal)	0.52	0.81	0.71	0.38	5.12	0.59	0.40	0.59	1.19	0.39	0.26	0.82	1.72	0.81	0.46	0.20	0.48	0.70
wheat	1772	Wollaroi (naturally sprouted)	0.54	0.82	0.73	0.41	5.25	0.60	0.41	0.61	1.22	0.41	0.28	0.84	1.81	0.83	0.48	0.20	0.49	0.72
wheat	1773	Baxter (normal)	0.57	0.87	0.82	0.41	5.18	0.70	0.39	0.57	1.09	0.43	0.27	0.77	1.73	0.79	0.48	0.18	0.51	0.72
wheat	1773	Baxter (naturally sprouted)	0.60	0.91	0.86	0.40	5.42	0.73	0.42	0.60	1.15	0.45	0.26	0.82	1.89	0.85	0.52	0.20	0.53	0.75
wheat	1841	H45 (connectivity)	0.42	0.73	0.54	0.39	4.07	0.65	0.35	0.51	0.95	0.32	0.27	0.74	1.51	0.69	0.43	0.19	0.49	0.56
wheat	1856	QAL1064	0.43	0.64	0.63	0.30	3.10	0.49	0.25	0.37	0.70	0.35	0.18	0.47	1.04	0.50	0.34	0.16	0.33	0.48
wheat	1864	SUN 525D	0.55	0.85	0.77	0.38	4.91	0.71	0.37	0.53	1.07	0.43	0.25	0.74	1.61	0.77	0.47	0.19	0.49	0.66
wheat	1865	SUN 526A	0.54	0.85	0.79	0.36	4.90	0.69	0.38	0.52	1.04	0.43	0.24	0.73	1.62	0.76	0.46	0.18	0.49	0.68
wheat	1868	Bellaroi (1 tonne from PBI)	0.52	0.79	0.70	0.36	4.63	0.56	0.38	0.53	1.04	0.40	0.25	0.71	1.52	0.74	0.44	0.18	0.44	0.66
wheat	1874	grown for Danny at Toowoomba	0.51	0.77	0.72	0.43	4.63	0.63	0.35	0.52	1.03	0.39	0.27	0.71	1.56	0.72	0.45	0.19	0.46	0.64
wheat	1876	red wheat, Dairy trial organised by Ray King	0.39	0.58	0.54	0.29	3.30	0.44	0.26	0.38	0.75	0.31	0.17	0.52	1.08	0.51	0.33	0.16	0.32	0.47
wheat	1877	white wheat, Dairy trial organised by Ray King	0.41	0.63	0.56	0.31	3.79	0.51	0.27	0.42	0.81	0.32	0.19	0.57	1.31	0.56	0.36	0.18	0.38	0.51
wheat	1879	grown for Danny at Toowoomba	0.51	0.78	0.71	0.38	4.70	0.63	0.35	0.52	1.04	0.39	0.25	0.71	1.55	0.73	0.45	0.19	0.46	0.64

N	35																		
Mean		**0.49**	**0.78**	**0.68**	**0.38**	**4.50**	**0.63**	**0.36**	**0.52**	**1.01**	**0.38**	**0.26**	**0.72**	**1.56**	**0.72**	**0.44**	**0.18**	**0.46**	**0.62**
Min		**0.36**	**0.58**	**0.53**	**0.25**	**2.94**	**0.40**	**0.22**	**0.34**	**0.63**	**0.29**	**0.15**	**0.44**	**0.92**	**0.44**	**0.29**	**0.13**	**0.27**	**0.40**
Max		**0.61**	**1.01**	**0.86**	**0.49**	**6.24**	**0.86**	**0.49**	**0.69**	**1.34**	**0.45**	**0.34**	**0.99**	**2.26**	**1.00**	**0.57**	**0.23**	**0.67**	**0.81**

Triticale

			amino acid analysis % dry matter																	
			Ala	**Arg**	**AspAcid**	**Cyst**	**GlutAcid**	**Glyc**	**Hist**	**isoLeuc**	**Leuc**	**Lys**	**Meth**	**Phenal**	**Prol**	**Ser**	**Threo**	**Tryp**	**Tyro**	**Val**
triticale	6708	Abacus	0.62	0.94	1.03	0.41	4.64	0.72	0.41	0.60	1.11	0.50	0.28	0.85	1.85	0.78	0.54	0.22	0.51	0.72
triticale	6824	Jackie	0.47	0.68	0.66	0.30	3.22	0.53	0.29	0.43	0.79	0.38	0.22	0.57	1.15	0.57	0.38	0.15	0.37	0.51
triticale	6825	Prime 322	0.43	0.64	0.63	0.28	2.85	0.48	0.26	0.38	0.70	0.36	0.20	0.52	1.01	0.49	0.34	0.13	0.32	0.45
triticale	6826	Credit	0.38	0.57	0.58	0.25	2.08	0.38	0.20	0.29	0.54	0.33	0.16	0.38	0.72	0.38	0.28	0.11	0.24	0.37
triticale	6827	Everest	0.33	0.53	0.49	0.21	1.80	0.34	0.18	0.26	0.48	0.30	0.13	0.33	0.57	0.34	0.25	0.12	0.18	0.33
triticale	6828	Tahara	0.44	0.74	0.71	0.29	3.19	0.48	0.27	0.40	0.74	0.38	0.19	0.53	1.07	0.53	0.36	0.14	0.32	0.49
triticale	6829	triticale_Kosciusko (Jim Watson)	0.67	0.97	0.98	0.43	4.87	0.72	0.43	0.63	1.15	0.54	0.30	0.84	1.83	0.82	0.56	0.16	0.50	0.78
triticale	6830	triticale_Everest (UNE)	0.60	0.90	0.89	0.37	4.48	0.67	0.39	0.55	1.04	0.49	0.25	0.75	1.62	0.76	0.50	0.16	0.46	0.71
triticale	6831	Kosciusko (Chris Wirth)	0.51	0.73	0.80	0.36	3.37	0.55	0.31	0.46	0.86	0.44	0.26	0.62	1.26	0.60	0.42	0.15	0.37	0.57
triticale	6835	grown for Danny at Toowoomba	0.58	0.81	0.82	0.39	4.00	0.65	0.35	0.48	0.90	0.47	0.26	0.67	1.46	0.67	0.47	0.17	0.41	0.65
triticale	6835	grown for Danny at Toowoomba	0.60	0.83	0.85	0.44	4.26	0.66	0.36	0.51	0.99	0.48	0.31	0.74	1.57	0.70	0.49	0.18	0.43	0.67
triticale	6836	JRCT74 - new Line from Jeremy Roake - Usyd	0.56	0.76	0.77	0.38	3.94	0.59	0.34	0.48	0.92	0.41	0.26	0.66	1.44	0.65	0.44	0.16	0.41	0.63
triticale	6837	Tobruk - Usyd variety	0.52	0.75	0.75	0.34	3.91	0.57	0.32	0.46	0.89	0.41	0.24	0.65	1.39	0.64	0.42	0.15	0.39	0.58
N	13																			
Mean			**0.52**	**0.76**	**0.76**	**0.34**	**3.58**	**0.57**	**0.32**	**0.46**	**0.85**	**0.42**	**0.23**	**0.62**	**1.30**	**0.61**	**0.42**	**0.15**	**0.38**	**0.57**
Min			**0.33**	**0.53**	**0.49**	**0.21**	**1.80**	**0.34**	**0.18**	**0.26**	**0.48**	**0.30**	**0.13**	**0.33**	**0.57**	**0.34**	**0.25**	**0.11**	**0.18**	**0.33**
Max			**0.67**	**0.97**	**1.03**	**0.44**	**4.87**	**0.72**	**0.43**	**0.63**	**1.15**	**0.54**	**0.31**	**0.85**	**1.85**	**0.82**	**0.56**	**0.22**	**0.51**	**0.78**

Sorghum

			amino acid analysis % dry matter																	
			Ala	**Arg**	**AspAcid**	**Cyst**	**GlutAcid**	**Glyc**	**Hist**	**isoLeuc**	**Leuc**	**Lys**	**Meth**	**Phenal**	**Prol**	**Ser**	**Threo**	**Tryp**	**Tyro**	**Val**
sorghum	7714	MR43 (Biloela)	1.11	0.42	0.71	0.26	2.36	0.33	0.24	0.46	1.60	0.19	0.25	0.62	0.97	0.51	0.36	0.14	0.45	0.54
sorghum	7714	MR43 (Biloela)	1.12	0.44	0.70	0.27	2.37	0.33	0.24	0.47	1.61	0.19	0.26	0.63	1.01	0.51	0.36	0.14	0.45	0.54
sorghum	7714	MR43 (Biloela)	1.30	0.53	0.82	0.32	2.73	0.40	0.30	0.54	1.88	0.23	0.32	0.73	1.14	0.61	0.42	0.15	0.53	0.62
sorghum	7714	MR43 (Biloela)	1.31	0.56	0.83	0.33	2.77	0.41	0.31	0.55	1.91	0.25	0.32	0.74	1.15	0.62	0.44	0.16	0.53	0.65
sorghum	7714	MR43 (Biloela)	1.34	0.55	0.84	0.34	2.81	0.41	0.31	0.56	1.95	0.25	0.33	0.76	1.17	0.63	0.44	0.16	0.56	0.64
sorghum	7714	MR43 (Biloela)	1.31	0.53	0.81	0.32	2.77	0.40	0.30	0.55	1.91	0.24	0.31	0.74	1.16	0.61	0.42	0.17	0.53	0.63
sorghum	7855	Maxi (Livingston Farm)	0.95	0.42	0.64	0.19	2.16	0.30	0.21	0.42	1.38	0.17	0.18	0.54	0.87	0.44	0.32	0.13	0.39	0.48
sorghum	7856	Liberty (white)	0.98	0.46	0.69	0.22	2.18	0.34	0.23	0.42	1.38	0.22	0.20	0.57	0.88	0.48	0.34	0.13	0.41	0.50
sorghum	7857	Pacer (Livingston Farm)	1.17	0.47	0.79	0.25	2.63	0.34	0.24	0.50	1.71	0.20	0.27	0.66	1.06	0.54	0.38	0.14	0.48	0.57
sorghum	7858	MR43 (Livingston Farm)	1.17	0.49	0.79	0.26	2.60	0.37	0.26	0.49	1.66	0.22	0.26	0.63	1.07	0.54	0.39	0.15	0.48	0.58
sorghum	7858	MR44	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
sorghum	7859	Brigalow Research Station Buster	0.93	0.42	0.63	0.24	2.05	0.31	0.23	0.40	1.33	0.20	0.23	0.53	0.83	0.45	0.32	0.11	0.39	0.46
sorghum	7860	Allora grain and Mill	1.02	0.45	0.69	0.24	2.24	0.32	0.24	0.44	1.45	0.21	0.24	0.58	0.89	0.49	0.34	0.13	0.42	0.50
sorghum	7861	Venture	1.14	0.51	0.74	0.27	2.49	0.36	0.28	0.51	1.70	0.22	0.28	0.67	1.02	0.56	0.39	0.16	0.49	0.58
sorghum	7862	Buster	1.06	0.44	0.72	0.25	2.33	0.34	0.25	0.46	1.53	0.21	0.27	0.60	0.94	0.50	0.35	0.14	0.44	0.52
sorghum	7863	Red 1	1.20	0.53	0.81	0.25	2.64	0.38	0.29	0.51	1.69	0.25	0.27	0.66	1.06	0.58	0.41	0.10	0.50	0.60
sorghum	7864	Red 2	1.20	0.50	0.75	0.27	2.65	0.36	0.29	0.52	1.76	0.22	0.26	0.69	1.04	0.58	0.40	0.09	0.49	0.59
sorghum	7865	Bonus (Livingston farm)	1.21	0.49	0.83	0.23	2.57	0.37	0.29	0.46	1.58	0.25	0.20	0.60	1.07	0.56	0.39	0.12	0.47	0.60
sorghum	7866	Pacer (Livingston Farm)	1.10	0.48	0.79	0.26	2.38	0.36	0.25	0.46	1.58	0.23	0.28	0.62	1.00	0.52	0.37	0.13	0.45	0.55
sorghum	7867	MR43 (Livingston Farm)	1.00	0.46	0.71	0.23	2.21	0.34	0.24	0.42	1.41	0.22	0.23	0.56	0.90	0.48	0.34	0.13	0.41	0.52
sorghum	7868	MR Maxi (Livingston farm)	1.06	0.45	0.73	0.28	2.31	0.34	0.25	0.45	1.54	0.21	0.29	0.59	0.95	0.50	0.36	0.12	0.44	0.53
sorghum	7869	KARPER 669	1.26	0.47	0.84	0.22	2.82	0.37	0.27	0.52	1.78	0.23	0.26	0.70	1.08	0.59	0.40	0.15	0.51	0.62
sorghum	7870	ICSV 400	1.12	0.49	0.78	0.23	2.53	0.36	0.25	0.48	1.62	0.24	0.22	0.64	1.00	0.53	0.38	0.15	0.47	0.59
sorghum	7871	MR 43 (damaged)	0.82	0.39	0.60	0.18	1.81	0.31	0.19	0.36	1.15	0.21	0.16	0.48	0.81	0.42	0.30	0.12	0.34	0.45
sorghum	7872	Liberty - white sorghum	0.97	0.41	0.64	0.21	2.16	0.32	0.22	0.41	1.36	0.21	0.20	0.55	0.86	0.46	0.33	0.13	0.40	0.49
sorghum	7876	organised by D. Cagogan from Ridley	1.13	0.50	0.77	0.22	2.54	0.37	0.27	0.45	1.52	0.24	0.21	0.60	1.01	0.54	0.38	0.14	0.47	0.58
N	26																			
Mean			**1.12**	**0.47**	**0.75**	**0.25**	**2.45**	**0.35**	**0.26**	**0.47**	**1.60**	**0.22**	**0.25**	**0.63**	**1.00**	**0.53**	**0.37**	**0.14**	**0.46**	**0.56**
Min			**0.82**	**0.39**	**0.60**	**0.18**	**1.81**	**0.30**	**0.19**	**0.36**	**1.15**	**0.17**	**0.16**	**0.48**	**0.81**	**0.42**	**0.30**	**0.09**	**0.34**	**0.45**
Max			**1.34**	**0.56**	**0.84**	**0.34**	**2.82**	**0.41**	**0.31**	**0.56**	**1.95**	**0.25**	**0.33**	**0.76**	**1.17**	**0.63**	**0.44**	**0.17**	**0.56**	**0.65**

Wheat

			amino acid analysis % as received																	
			Ala	Arg	AspAcid	Cyst	GlutAcid	Glyc	Hist	isoLeuc	Leuc	Lys	Meth	Phenal	Prol	Ser	Threo	Tryp	Tyro	Val
wheat	1727	Oxley (connectivity)	0.48	0.82	0.67	0.39	4.35	0.64	0.36	0.54	0.99	0.37	0.27	0.71	1.49	0.72	0.45	0.21	0.47	0.60
wheat	1728	QAL 2000 (connectivity)	0.40	0.64	0.53	0.32	3.05	0.47	0.27	0.39	0.73	0.30	0.22	0.51	1.01	0.52	0.33	0.16	0.33	0.45
wheat	1746	Vulcan	0.46	0.71	0.64	0.40	3.74	0.57	0.31	0.46	0.89	0.35	0.26	0.60	1.31	0.62	0.40	0.15	0.40	0.55
wheat	1749	Wollaroi (connectivity)	0.44	0.69	0.58	0.36	4.10	0.49	0.33	0.51	0.96	0.33	0.27	0.67	1.39	0.67	0.39	0.21	0.39	0.56
wheat	1753	Bellaroi	0.53	0.88	0.68	0.43	4.79	0.60	0.42	0.61	1.17	0.38	0.31	0.81	1.70	0.81	0.47	0.19	0.49	0.70
wheat	1754	Sentinal	0.37	0.65	0.53	0.29	3.24	0.48	0.28	0.41	0.77	0.31	0.20	0.57	1.12	0.56	0.35	0.16	0.35	0.46
wheat	1755	Ammrock	0.37	0.73	0.55	0.33	3.52	0.54	0.29	0.46	0.83	0.31	0.23	0.62	1.35	0.60	0.38	0.17	0.41	0.51
wheat	1756	Roache Silo 2, Logan Grains (Kellalac)	0.40	0.61	0.56	0.32	3.75	0.52	0.29	0.42	0.83	0.30	0.22	0.60	1.32	0.57	0.35	0.13	0.38	0.50
wheat	1757	unknown	0.32	0.56	0.47	0.22	2.61	0.36	0.20	0.30	0.56	0.26	0.13	0.39	0.81	0.39	0.26	0.13	0.24	0.35
wheat	1758	Chara	0.34	0.58	0.48	0.24	3.00	0.38	0.22	0.33	0.63	0.26	0.15	0.45	0.94	0.45	0.28	0.13	0.27	0.38
wheat	1759	Fraser Silo 5, Logan Grains (unknown)	0.38	0.56	0.55	0.29	3.14	0.48	0.25	0.35	0.68	0.29	0.19	0.47	1.05	0.52	0.33	0.15	0.33	0.45
wheat	1760	Wisewood silo 9, Logan Grains (Kellalac)	0.35	0.53	0.52	0.29	2.69	0.42	0.23	0.34	0.66	0.28	0.17	0.45	0.93	0.46	0.30	0.12	0.28	0.42
wheat	1762	H45 (Jim O'Halloran)	0.49	0.77	0.63	0.38	4.92	0.73	0.39	0.53	1.06	0.36	0.26	0.79	1.75	0.76	0.45	0.18	0.53	0.61
wheat	1763	H45 (Peter Barry)	0.51	0.79	0.66	0.42	4.92	0.72	0.40	0.56	1.10	0.36	0.29	0.81	1.81	0.77	0.47	0.16	0.52	0.64
wheat	1764	Sunco (Livingston farm)	0.50	0.78	0.68	0.37	4.68	0.66	0.37	0.53	1.03	0.37	0.25	0.71	1.61	0.75	0.45	0.18	0.47	0.64
wheat	1765	Lang (Martin Dunlop)	0.46	0.71	0.63	0.38	4.03	0.58	0.33	0.48	0.94	0.34	0.26	0.66	1.43	0.64	0.41	0.12	0.42	0.57
wheat	1766	H45 Nigel Martin	0.49	0.74	0.63	0.38	4.69	0.69	0.36	0.51	1.01	0.37	0.26	0.74	1.65	0.72	0.43	0.16	0.49	0.59
wheat	1767	Cunningham (F. Colless)	0.56	0.92	0.71	0.41	5.66	0.78	0.45	0.63	1.22	0.40	0.27	0.90	2.05	0.91	0.52	0.21	0.61	0.73
wheat	1768	Janz (F. Colless)	0.51	0.83	0.67	0.44	5.11	0.71	0.40	0.58	1.14	0.37	0.27	0.84	1.88	0.81	0.48	0.19	0.54	0.66
wheat	1769	Bellaroi (durum) - Livingston Farm	0.47	0.76	0.62	0.42	4.36	0.55	0.39	0.56	1.10	0.36	0.31	0.75	1.56	0.75	0.43	0.19	0.44	0.63
wheat	1770	Sunbri (Livingston Farm)	0.46	0.73	0.64	0.37	4.21	0.61	0.34	0.49	0.94	0.35	0.25	0.66	1.44	0.69	0.42	0.17	0.43	0.58
wheat	1771	Drysdale (James Butt)	0.48	0.77	0.65	0.42	4.96	0.69	0.39	0.55	1.06	0.36	0.29	0.78	1.73	0.78	0.46	0.17	0.52	0.64
wheat	1772	Wollaroi (normal)	0.47	0.73	0.63	0.34	4.60	0.53	0.36	0.53	1.07	0.35	0.24	0.74	1.55	0.73	0.42	0.18	0.43	0.63
wheat	1772	Wollaroi (naturally sprouted)	0.49	0.73	0.65	0.36	4.69	0.54	0.37	0.54	1.09	0.36	0.25	0.75	1.62	0.74	0.43	0.18	0.44	0.64
wheat	1773	Baxter (normal)	0.51	0.78	0.73	0.37	4.62	0.62	0.35	0.51	0.97	0.39	0.24	0.68	1.55	0.71	0.43	0.16	0.46	0.64
wheat	1773	Baxter (naturally sprouted)	0.54	0.81	0.77	0.36	4.85	0.65	0.37	0.54	1.03	0.41	0.24	0.74	1.69	0.76	0.46	0.18	0.48	0.67
wheat	1841	H45 (connectivity)	0.38	0.66	0.49	0.35	3.67	0.59	0.31	0.46	0.86	0.29	0.24	0.67	1.36	0.62	0.39	0.17	0.44	0.50
wheat	1856	QAL1064	0.39	0.58	0.57	0.27	2.80	0.45	0.23	0.33	0.63	0.32	0.16	0.42	0.94	0.45	0.31	0.14	0.30	0.44
wheat	1864	SUN 525D	0.50	0.77	0.70	0.35	4.46	0.64	0.34	0.48	0.97	0.39	0.23	0.67	1.46	0.70	0.42	0.17	0.44	0.60
wheat	1865	SUN 526A	0.49	0.77	0.71	0.32	4.43	0.62	0.34	0.47	0.94	0.39	0.22	0.66	1.46	0.68	0.42	0.16	0.44	0.61
wheat	1868	Bellaroi (1 tonne from PBI)	0.47	0.72	0.64	0.32	4.20	0.51	0.34	0.48	0.94	0.37	0.22	0.64	1.39	0.67	0.40	0.16	0.40	0.60
wheat	1874	grown for Danny at Toowoomba	0.46	0.69	0.65	0.38	4.15	0.56	0.32	0.47	0.92	0.35	0.24	0.63	1.39	0.65	0.40	0.17	0.41	0.58
wheat	1876	red wheat, Dairy trial organised by Ray King	0.35	0.52	0.48	0.26	2.95	0.39	0.23	0.34	0.67	0.28	0.15	0.47	0.96	0.45	0.29	0.14	0.29	0.42
wheat	1877	white wheat, Dairy trial organised by Ray King	0.37	0.56	0.50	0.28	3.40	0.46	0.24	0.38	0.73	0.29	0.17	0.51	1.18	0.50	0.32	0.16	0.34	0.45
wheat	1879	grown for Danny at Toowoomba	0.46	0.70	0.64	0.34	4.22	0.57	0.32	0.47	0.93	0.35	0.22	0.64	1.40	0.65	0.40	0.17	0.41	0.58
N	35																			
Mean			**0.45**	**0.71**	**0.61**	**0.35**	**4.07**	**0.57**	**0.33**	**0.47**	**0.92**	**0.34**	**0.23**	**0.65**	**1.41**	**0.65**	**0.40**	**0.17**	**0.42**	**0.56**
Min			**0.32**	**0.52**	**0.47**	**0.22**	**2.61**	**0.36**	**0.20**	**0.30**	**0.56**	**0.26**	**0.13**	**0.39**	**0.81**	**0.39**	**0.26**	**0.12**	**0.24**	**0.35**
Max			**0.56**	**0.92**	**0.77**	**0.44**	**5.66**	**0.78**	**0.45**	**0.63**	**1.22**	**0.41**	**0.31**	**0.90**	**2.05**	**0.91**	**0.52**	**0.21**	**0.61**	**0.73**

Barley

			amino acid analysis % as received																	
			Ala	Arg	AspAcid	Cyst	GlutAcid	Glyc	Hist	isoLeuc	Leuc	Lys	Meth	Phenal	Prol	Ser	Threo	Tryp	Tyro	Val
barley	3750	Haruna nijo	0.52	0.76	0.76	0.39	3.53	0.53	0.32	0.52	0.95	0.45	0.30	0.77	1.68	0.59	0.48	0.16	0.44	0.66
barley	3756	Tallon (connectivity)	0.49	0.73	0.67	0.30	2.95	0.49	0.29	0.47	0.83	0.39	0.25	0.67	1.37	0.54	0.42	0.30	0.39	0.59
barley	3757	Trebi (connectivity)	0.48	0.81	0.69	0.34	3.41	0.54	0.34	0.51	0.97	0.40	0.29	0.85	1.73	0.63	0.48	0.18	0.46	0.65
barley	3861	Binalong, PBI Narrabri	0.44	0.77	0.65	0.32	2.91	0.52	0.33	0.46	0.85	0.37	0.24	0.75	1.41	0.58	0.47	0.16	0.44	0.60
barley	3865	Gairdner	0.36	0.53	0.51	0.18	1.91	0.34	0.18	0.28	0.54	0.31	0.12	0.41	0.82	0.34	0.27	0.11	0.24	0.38
barley	3866	Gairdner	0.37	0.57	0.54	0.23	2.16	0.37	0.20	0.31	0.59	0.33	0.15	0.45	0.95	0.37	0.29	0.14	0.26	0.41
barley	3867	Gairdner	0.47	0.71	0.72	0.35	2.99	0.50	0.28	0.44	0.86	0.43	0.26	0.68	1.42	0.53	0.43	0.16	0.39	0.58
barley	3868	Schooner	0.39	0.61	0.60	0.28	2.48	0.42	0.24	0.38	0.73	0.37	0.20	0.57	1.14	0.45	0.36	0.17	0.33	0.49
barley	3869	Grout (PBI Narrabri - hydrants)	0.46	0.68	0.70	0.26	2.97	0.47	0.28	0.44	0.83	0.42	0.17	0.66	1.40	0.51	0.40	0.12	0.36	0.58
barley	3870	Grout (PBI Narrabri - light country)	0.43	0.59	0.65	0.23	2.36	0.42	0.23	0.37	0.71	0.38	0.15	0.53	1.08	0.43	0.34	0.13	0.30	0.51
barley	3871	Gairdner (Livingston farm)	0.52	0.74	0.75	0.29	3.54	0.55	0.31	0.47	0.93	0.46	0.20	0.75	1.70	0.59	0.47	0.17	0.44	0.66
barley	3872	Gairdner (Kevin Schultz)	0.58	0.86	0.80	0.33	4.56	0.63	0.38	0.60	1.15	0.52	0.27	1.06	2.49	0.72	0.55	0.21	0.54	0.76
barley	3873	Tilga (F.Colless)	0.61	0.91	0.86	0.36	4.66	0.65	0.39	0.62	1.20	0.53	0.28	1.06	2.51	0.75	0.58	0.21	0.57	0.82
barley	3874	Schooner (D. Manwarring)	0.53	0.79	0.76	0.33	3.75	0.56	0.32	0.52	1.03	0.48	0.23	0.84	1.92	0.61	0.48	0.17	0.46	0.69
barley	3875	Wyalong (M. Williams)	0.52	0.79	0.76	0.31	3.56	0.55	0.32	0.52	1.00	0.48	0.25	0.82	1.83	0.60	0.49	0.19	0.45	0.67
barley	3876	Schooner (N. Martin)	0.48	0.71	0.71	0.32	3.13	0.51	0.29	0.46	0.91	0.45	0.22	0.72	1.56	0.53	0.43	0.15	0.40	0.61
barley	3877	Tallon (naturally Sprouted)	0.62	0.90	0.90	0.34	4.06	0.60	0.36	0.59	1.07	0.53	0.28	0.87	2.02	0.69	0.54	0.19	0.50	0.77
barley	3879	Fitzroy (normal maybe be sprouted?)	0.45	0.64	0.66	0.31	3.07	0.45	0.26	0.42	0.79	0.37	0.21	0.63	1.45	0.50	0.38	0.15	0.36	0.57
barley	3879	Fitzroy (sprayed with roundup)	0.54	0.67	0.77	0.26	2.49	0.55	0.24	0.41	0.76	0.47	0.20	0.56	1.22	0.50	0.42	0.14	0.34	0.59
barley	3880	NRB03470 (normal)	0.40	0.53	0.56	0.22	2.30	0.39	0.21	0.33	0.64	0.33	0.15	0.49	1.06	0.40	0.32	0.13	0.29	0.47
barley	3880	NRB03470 (drought stressed)	0.53	0.71	0.73	0.31	3.44	0.53	0.29	0.47	0.90	0.46	0.23	0.71	1.60	0.58	0.46	0.16	0.43	0.67
barley	3890	NRB03470	0.45	0.64	0.65	0.26	3.01	0.45	0.26	0.41	0.80	0.39	0.19	0.63	1.37	0.50	0.38	0.14	0.37	0.58
barley	3891	NRB03470	0.44	0.60	0.62	0.25	2.80	0.43	0.24	0.39	0.76	0.37	0.18	0.58	1.27	0.47	0.36	0.16	0.35	0.55
barley	3897	Grout	0.46	0.61	0.64	0.25	3.02	0.44	0.25	0.41	0.80	0.38	0.18	0.64	1.37	0.49	0.38	0.16	0.34	0.56
barley	3898	Dave Cadogan - excess used in phytase trial	0.45	0.63	0.66	0.29	2.85	0.46	0.25	0.40	0.80	0.41	0.19	0.61	1.30	0.49	0.39	0.14	0.36	0.55
barley	3918	ND19119	0.49	0.64	0.68	0.28	2.95	0.47	0.26	0.42	0.83	0.40	0.19	0.64	1.53	0.51	0.40	0.15	0.38	0.57
barley	3919	NRB03470	0.51	0.70	0.73	0.30	3.51	0.50	0.29	0.47	0.91	0.44	0.22	0.73	1.67	0.57	0.44	0.17	0.42	0.65
barley	3921	grown for Danny at Toowoomba	0.52	0.75	0.76	0.35	3.56	0.54	0.32	0.49	0.94	0.46	0.26	0.74	1.60	0.61	0.46	0.18	0.43	0.68
barley	3921	grown for Danny at Toowoomba	0.52	0.74	0.78	0.30	3.53	0.53	0.32	0.49	0.94	0.46	0.22	0.74	1.59	0.60	0.46	0.18	0.43	0.68
N	29																			
Mean			**0.48**	**0.70**	**0.70**	**0.29**	**3.15**	**0.50**	**0.28**	**0.45**	**0.86**	**0.42**	**0.22**	**0.69**	**1.52**	**0.54**	**0.43**	**0.17**	**0.40**	**0.61**
Min			**0.36**	**0.53**	**0.51**	**0.18**	**1.91**	**0.34**	**0.18**	**0.28**	**0.54**	**0.31**	**0.12**	**0.41**	**0.82**	**0.34**	**0.27**	**0.11**	**0.24**	**0.38**
Max			**0.62**	**0.91**	**0.90**	**0.39**	**4.66**	**0.65**	**0.39**	**0.62**	**1.20**	**0.53**	**0.30**	**1.06**	**2.51**	**0.75**	**0.58**	**0.30**	**0.57**	**0.82**

Triticale

			amino acid analysis % as received																	
			Ala	Arg	AspAcid	Cyst	GlutAcid	Glyc	Hist	isoLeuc	Leuc	Lys	Meth	Phenal	Prol	Ser	Threo	Tryp	Tyro	Val
triticale	6708	Abacus	0.55	0.84	0.92	0.37	4.18	0.65	0.37	0.54	1.00	0.45	0.25	0.77	1.67	0.70	0.48	0.20	0.46	0.65
triticale	6824	Jackie	0.43	0.62	0.60	0.28	2.93	0.49	0.26	0.39	0.72	0.35	0.20	0.52	1.05	0.52	0.35	0.13	0.33	0.46
triticale	6825	Prime 322	0.38	0.57	0.56	0.25	2.54	0.42	0.23	0.34	0.62	0.32	0.18	0.46	0.90	0.44	0.30	0.12	0.28	0.40
triticale	6826	Credit	0.34	0.51	0.51	0.22	1.85	0.34	0.18	0.26	0.48	0.30	0.14	0.34	0.64	0.33	0.25	0.10	0.21	0.33
triticale	6827	Everest	0.30	0.48	0.44	0.19	1.64	0.31	0.16	0.23	0.43	0.27	0.12	0.30	0.52	0.31	0.22	0.10	0.16	0.30
triticale	6828	Tahara	0.39	0.66	0.63	0.26	2.85	0.43	0.24	0.35	0.66	0.34	0.17	0.47	0.96	0.47	0.32	0.13	0.28	0.44
triticale	6829	triticale_Kosciusko (Jim Watson)	0.61	0.88	0.89	0.39	4.41	0.66	0.39	0.58	1.04	0.49	0.27	0.76	1.66	0.74	0.51	0.14	0.45	0.71
triticale	6830	triticale_Everest (UNE)	0.54	0.81	0.80	0.33	4.04	0.61	0.35	0.49	0.94	0.44	0.23	0.68	1.46	0.68	0.45	0.15	0.42	0.64
triticale	6831	Kosciusko (Chris Wirth)	0.46	0.65	0.72	0.33	3.01	0.49	0.28	0.41	0.77	0.40	0.23	0.56	1.13	0.53	0.38	0.13	0.33	0.51
triticale	6835	grown for Danny at Toowoomba	0.53	0.73	0.74	0.35	3.60	0.58	0.31	0.43	0.81	0.42	0.23	0.60	1.32	0.60	0.42	0.15	0.37	0.58
triticale	6835	grown for Danny at Toowoomba	0.53	0.75	0.76	0.39	3.82	0.59	0.32	0.46	0.89	0.43	0.27	0.66	1.41	0.63	0.44	0.16	0.39	0.60
triticale	6836	JRCT74 - new Line from Jeremy Roake - Usyd	0.50	0.69	0.69	0.34	3.54	0.53	0.30	0.43	0.83	0.37	0.24	0.59	1.29	0.59	0.40	0.14	0.37	0.57
triticale	6837	Tobruk - Usyd variety	0.47	0.68	0.68	0.31	3.55	0.52	0.29	0.42	0.80	0.38	0.21	0.59	1.26	0.58	0.38	0.13	0.35	0.53
N	13																			
Mean			**0.46**	**0.68**	**0.69**	**0.31**	**3.23**	**0.51**	**0.28**	**0.41**	**0.77**	**0.38**	**0.21**	**0.56**	**1.17**	**0.55**	**0.38**	**0.14**	**0.34**	**0.52**
Min			**0.30**	**0.48**	**0.44**	**0.19**	**1.64**	**0.31**	**0.16**	**0.23**	**0.43**	**0.27**	**0.12**	**0.30**	**0.52**	**0.31**	**0.22**	**0.10**	**0.16**	**0.30**
Max			**0.61**	**0.88**	**0.92**	**0.39**	**4.41**	**0.66**	**0.39**	**0.58**	**1.04**	**0.49**	**0.27**	**0.77**	**1.67**	**0.74**	**0.51**	**0.20**	**0.46**	**0.71**

Sorghum

			amino acid analysis % as received																	
			Ala	Arg	AspAcid	Cyst	GlutAcid	Glyc	Hist	isoLeuc	Leuc	Lys	Meth	Phenal	Prol	Ser	Threo	Tryp	Tyro	Val
sorghum	7714	MR43 (Biloela)	1.00	0.38	0.63	0.23	2.12	0.30	0.22	0.42	1.44	0.17	0.22	0.56	0.87	0.46	0.32	0.12	0.41	0.48
sorghum	7714	MR43 (Biloela)	1.02	0.40	0.64	0.24	2.15	0.30	0.22	0.42	1.46	0.17	0.23	0.57	0.91	0.47	0.33	0.13	0.41	0.49
sorghum	7714	MR43 (Biloela)	1.15	0.47	0.73	0.28	2.43	0.36	0.27	0.48	1.68	0.21	0.28	0.65	1.01	0.54	0.38	0.13	0.47	0.56
sorghum	7714	MR43 (Biloela)	1.19	0.50	0.75	0.30	2.51	0.37	0.28	0.50	1.72	0.23	0.29	0.67	1.04	0.56	0.39	0.15	0.48	0.59
sorghum	7714	MR43 (Biloela)	1.19	0.49	0.74	0.30	2.49	0.37	0.28	0.50	1.73	0.22	0.29	0.67	1.04	0.56	0.39	0.14	0.49	0.57
sorghum	7714	MR43 (Biloela)	1.18	0.48	0.73	0.29	2.50	0.36	0.27	0.49	1.72	0.21	0.28	0.67	1.04	0.55	0.38	0.15	0.48	0.57
sorghum	7855	Maxi (Livingston Farm)	0.85	0.37	0.58	0.17	1.94	0.26	0.19	0.38	1.24	0.16	0.16	0.48	0.78	0.40	0.28	0.12	0.35	0.43
sorghum	7856	Liberty (white)	0.88	0.41	0.62	0.20	1.96	0.30	0.20	0.38	1.24	0.20	0.18	0.51	0.79	0.43	0.31	0.12	0.37	0.45
sorghum	7857	Pacer (Livingston Farm)	1.04	0.41	0.70	0.22	2.34	0.30	0.21	0.44	1.52	0.17	0.24	0.59	0.94	0.48	0.33	0.13	0.43	0.51
sorghum	7858	MR43 (Livingston Farm)	1.06	0.45	0.71	0.23	2.35	0.33	0.23	0.44	1.49	0.19	0.24	0.57	0.97	0.49	0.35	0.13	0.44	0.52
sorghum	7858	MR44	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
sorghum	7859	Brigalow Research Station Buster	0.83	0.37	0.56	0.22	1.84	0.28	0.20	0.36	1.19	0.18	0.20	0.47	0.74	0.41	0.29	0.10	0.35	0.41
sorghum	7860	Allora grain and Mill	0.90	0.40	0.62	0.22	2.00	0.29	0.21	0.39	1.29	0.19	0.21	0.52	0.80	0.43	0.30	0.12	0.37	0.45
sorghum	7861	Venture	1.02	0.46	0.66	0.24	2.24	0.33	0.25	0.46	1.53	0.20	0.25	0.60	0.91	0.50	0.35	0.15	0.44	0.52
sorghum	7862	Buster	0.96	0.40	0.65	0.23	2.11	0.30	0.22	0.42	1.39	0.19	0.24	0.55	0.85	0.46	0.32	0.13	0.40	0.48
sorghum	7863	Red 1	1.07	0.48	0.72	0.23	2.36	0.34	0.25	0.45	1.51	0.22	0.24	0.59	0.95	0.52	0.36	0.09	0.45	0.54
sorghum	7864	Red 2	1.08	0.44	0.67	0.24	2.38	0.33	0.26	0.46	1.58	0.20	0.23	0.62	0.94	0.52	0.35	0.08	0.44	0.53
sorghum	7865	Bonus (Livingston farm)	1.08	0.44	0.74	0.20	2.30	0.33	0.25	0.41	1.41	0.22	0.18	0.53	0.95	0.50	0.35	0.11	0.42	0.53
sorghum	7866	Pacer (Livingston Farm)	1.00	0.43	0.71	0.23	2.15	0.32	0.23	0.42	1.43	0.21	0.25	0.56	0.90	0.47	0.33	0.12	0.40	0.50
sorghum	7867	MR43 (Livingston Farm)	0.90	0.41	0.64	0.21	1.99	0.31	0.21	0.38	1.26	0.20	0.21	0.50	0.81	0.43	0.31	0.11	0.37	0.46
sorghum	7868	MR Maxi (Livingston farm)	0.95	0.40	0.65	0.25	2.07	0.31	0.22	0.40	1.37	0.19	0.26	0.53	0.85	0.45	0.32	0.10	0.39	0.47
sorghum	7869	KARPER 669	1.12	0.42	0.75	0.20	2.53	0.33	0.24	0.46	1.59	0.21	0.23	0.63	0.97	0.52	0.36	0.14	0.46	0.55
sorghum	7870	ICSV 400	1.01	0.44	0.70	0.21	2.27	0.32	0.22	0.43	1.45	0.21	0.20	0.57	0.89	0.48	0.34	0.13	0.42	0.52
sorghum	7871	MR 43 (damaged)	0.73	0.34	0.54	0.16	1.61	0.27	0.17	0.32	1.02	0.18	0.14	0.43	0.72	0.37	0.26	0.10	0.30	0.40
sorghum	7872	Liberty - white sorghum	0.87	0.37	0.57	0.19	1.94	0.28	0.19	0.36	1.22	0.18	0.18	0.49	0.77	0.41	0.30	0.12	0.36	0.44
sorghum	7876	organised by D. Cagogan from Ridley	1.01	0.45	0.70	0.20	2.28	0.34	0.24	0.40	1.37	0.22	0.19	0.54	0.90	0.49	0.34	0.13	0.42	0.53
N	26																			
Mean			**1.00**	**0.43**	**0.67**	**0.23**	**2.19**	**0.32**	**0.23**	**0.42**	**1.43**	**0.20**	**0.23**	**0.56**	**0.89**	**0.48**	**0.34**	**0.12**	**0.41**	**0.50**
Min			**0.73**	**0.34**	**0.54**	**0.16**	**1.61**	**0.26**	**0.17**	**0.32**	**1.02**	**0.16**	**0.14**	**0.43**	**0.72**	**0.37**	**0.26**	**0.08**	**0.30**	**0.40**
Max			**1.19**	**0.50**	**0.75**	**0.30**	**2.53**	**0.37**	**0.28**	**0.50**	**1.73**	**0.23**	**0.29**	**0.67**	**1.04**	**0.56**	**0.39**	**0.15**	**0.49**	**0.59**