

GA014

2009 Wacol Feed Intake Trial - Particle Size

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**Industry &
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1.1 Introduction

The aim of this experiment is to understand the impact of GrainType, ParticleSize and FeedForm on intake and growth of grower pigs.

The null hypotheses were:

H_o : There is no difference in animal performance for grower pigs fed the eight different diets.

H_o : There is no difference in animal performance for grower pigs fed diets depending on grain type, feed form or particle size, or the interaction of these factors.

1.2 Treatments

The treatments consist of eight diets made up from the factorial treatment structure of Grain Type (2 levels - BARLEY and SORGHUM), Feed Form (2 levels - MASH and PELLET) and Particle Size (2 levels - Ground only and Ground + Recycled). Each of the diets will be made in a single batch.

DietNumber	GrainType	Form	ParticleSize
Diet_1	SORGHUM	MASH	Ground
Diet_2	SORGHUM	MASH	Ground+Recycled
Diet_3	SORGHUM	PELLET	Ground
Diet_4	SORGHUM	PELLET	Ground+Recycled
Diet_5	BARLEY	MASH	Ground
Diet_6	BARLEY	MASH	Ground+Recycled
Diet_7	BARLEY	PELLET	Ground
Diet_8	BARLEY	PELLET	Ground+Recycled

1.3 Design

The design consisted of a factorial treatment structure for GrainType, ParticleSize and FeedForm, which was randomised in complete blocks. Either 2 or 3 replicates were completed in each run, depending on pig availability.

1.4 Model

A linear mixed model using restricted maximum likelihood were used to analyse the data using ASReml-R (Butler, Cullis, Gilmour & Gogel 2007). The model contained fixed main effects for GrainType, ParticleSize and FeedForm and all their interactions. The random effects included replicate and run.

The model can symbolically be written as:

$$\text{response} \sim \text{mean} + \text{GrainType} + \text{ParticleSize} + \text{FeedForm} + \\ \text{GrainType:ParticleSize} + \text{ParticleSize:FeedForm} + \text{GrainType:FeedForm} + \\ \text{GrainType:ParticleSize:FeedForm} + \textit{Replicate} + \textit{Run}$$

Notation: Terms fitted in the model as random are italicised; all other terms are fitted as fixed terms.

Note concerning all predicted values: The predicted values have been assigned a rank based on the individual pairwise least significant differences. Therefore, no overall standard error or difference or least significant difference will be provided.

The piglets entering this experiment are sourced from Gatton. Sometimes it is not possible for the supplier to meet the specific requirements needed for this experiment. This could mean that there were not enough piglets to start each run of three replicates and therefore only two replicates were started in a particular run. The start weight of the piglets varied also, as weight is known to have a large influence on intake and growth, the start weight will be fitted in the model as a covariate.

Also, on day 21 some of the pigs had run out of feed (experimental protocol required feed to be available at all times). The amount of residue at day 21 will also be fitted in the model as a covariate.

1.5 Responses

The responses to be analysed are:

1. Total weight gain 0-28 days (kg) - (**WtGain0228**)
2. Total weight gain 7-28 days (kg) - (**WtGain7228**)
3. Total amount of feed eaten 0-28 days (kg DM) - (**TotIntake0228DM**)
4. Total amount of feed eaten 7-28 days (kg DM) - (**TotIntake7228DM**)
5. Average daily intake 0-28 days (kg AF/day) - (**ADI0228AF**)
6. Average daily intake 0-28 days (kg DM/day) - (**ADI0228DM**)
7. Rate of weight gain 0-28 days (kg/day) - (**ROG0228**)
8. Feed conversion ratio 0-28 days (feed eaten - AF basis/weight gained) - **FCR0228AF**
9. Feed conversion ratio 0-28 days (feed eaten - DM basis/weight gained) - **FCR0228DM**
10. Average daily intake 7-28 days (kg AF/day) - **ADI7228AF**
11. Average daily intake 7-28 days (kg DM/day) - **ADI7228DM**
12. Rate of weight gain 7-28 days (kg/day) - **ROG7228**
13. Feed conversion ratio 7-28 days (feed eaten - AF basis/weight gained) - **FCR7228AF**
14. Feed conversion ratio 7-28 days (feed eaten -DM basis/weight gained) - **FCR7228DM**
15. Average daily wasted feed (residue bucket) 0-28 days on a DM basis (kg DM/day) - **ADW0228DM**
16. Average daily wasted feed (residue bucket) 7-28 days on a DM basis (kg DM/day) - **ADW7228DM**

1.6 Data File

An excerpt of the data set are shown below:

Order	Replicate	Run	Cage	Row	Column	PigID	DietNumber	GrainType
1	1	1	1	1	1	7330	Diet_7	BARLEY
2	1	1	2	2	1	7331	Diet_3	SORGHUM
3	1	1	3	3	1	7332	Diet_6	BARLEY
4	1	1	4	4	1	7333	Diet_2	SORGHUM
5	1	1	5	5	1	7334	Diet_1	SORGHUM
6	1	1	6	6	1	7335	Diet_5	BARLEY

FeedForm	ParticleSize	StartWeight	TotTroughResDM21day	WtGain0228
PELLET	Ground	20.53	2.55	21.93
PELLET	Ground	19.97	1.69	26.03
MASH	Ground+Recycled	19.60	1.61	23.03
MASH	Ground+Recycled	19.43	0.40	27.30
MASH	Ground	21.90	0.26	24.37
MASH	Ground	19.80	2.41	21.00

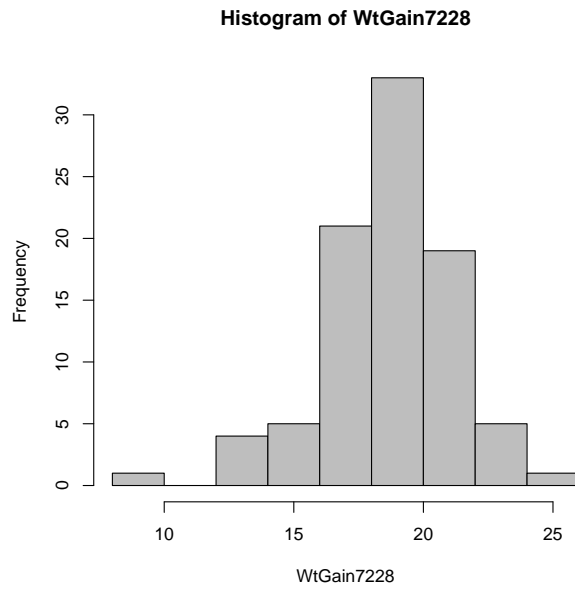
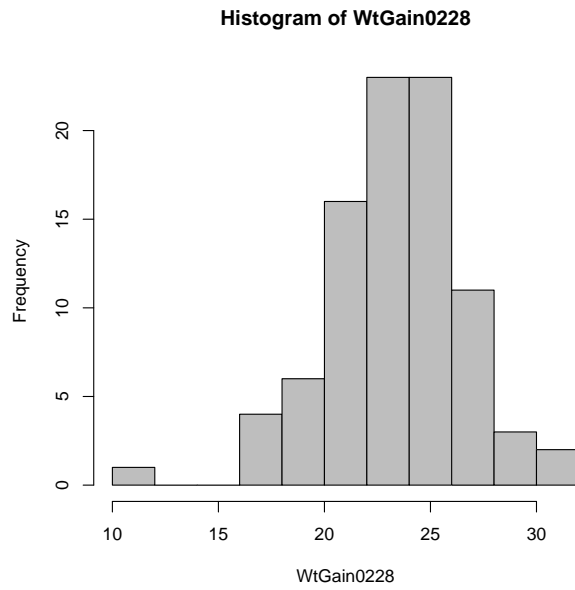
WtGain7228	TotIntake0228DM	TotIntake7228DM	ADI0228AF	ADI0228DM	ROG0228
18.87	36.49	30.46	1.40	1.30	0.78
20.80	42.68	34.98	1.72	1.52	0.93
18.33	36.49	29.90	1.44	1.30	0.82
21.53	47.23	39.03	1.88	1.69	0.97
19.97	45.17	36.98	1.75	1.61	0.87
17.00	37.11	31.34	1.46	1.32	0.75

FCR0228AF	FCR0228DM	ADI7228AF	ADI7228DM	ROG7228	FCR7228AF	FCR7228DM
1.79	1.66	1.55	1.45	0.90	1.73	1.61
1.85	1.64	1.88	1.67	0.99	1.90	1.68
1.75	1.58	1.57	1.42	0.87	1.80	1.63
1.93	1.73	2.08	1.86	1.02	2.02	1.81
2.01	1.85	1.90	1.76	0.95	2.00	1.85
1.94	1.77	1.64	1.49	0.81	2.02	1.84

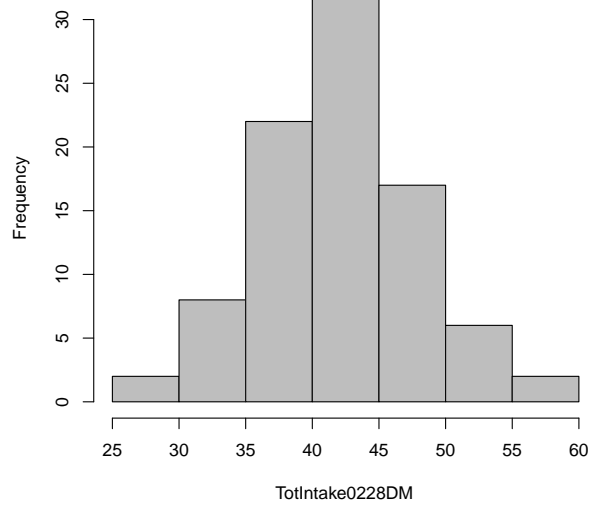
ADW0228DM	ADW7228DM
0.10	0.11
0.01	0.01
0.02	0.02
0.05	0.05
0.49	0.58
0.08	0.06

Data Checking

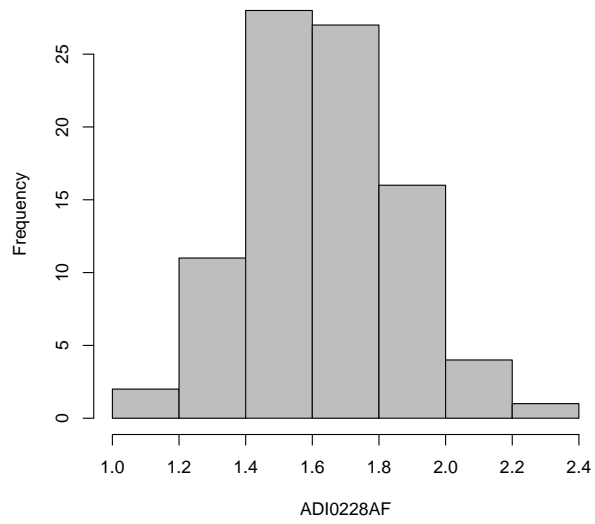
A histogram of the responses will help to identify any outliers:



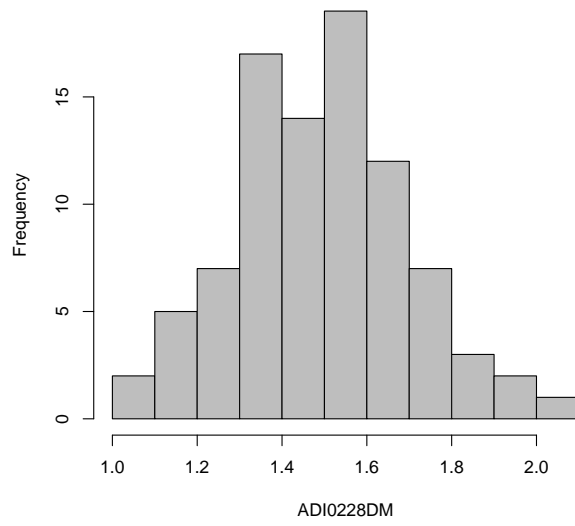
Histogram of TotIntake0228DM



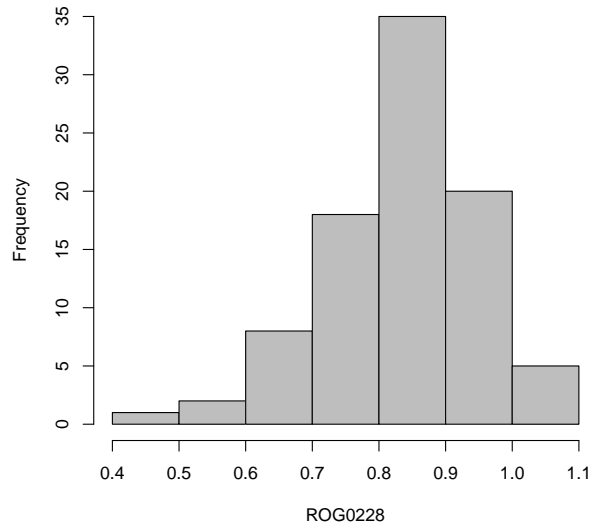
Histogram of ADI0228AF



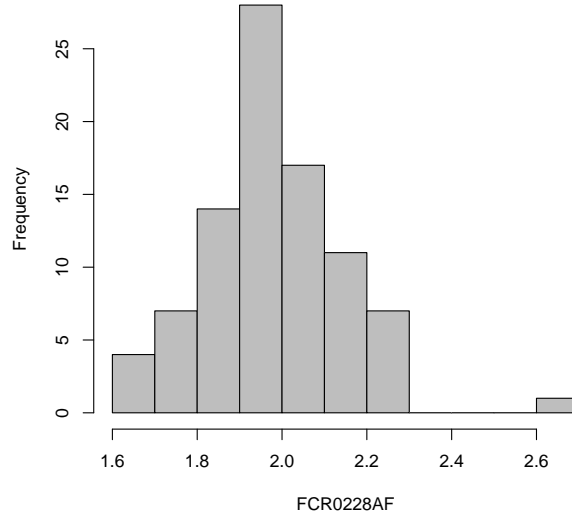
Histogram of ADI0228DM



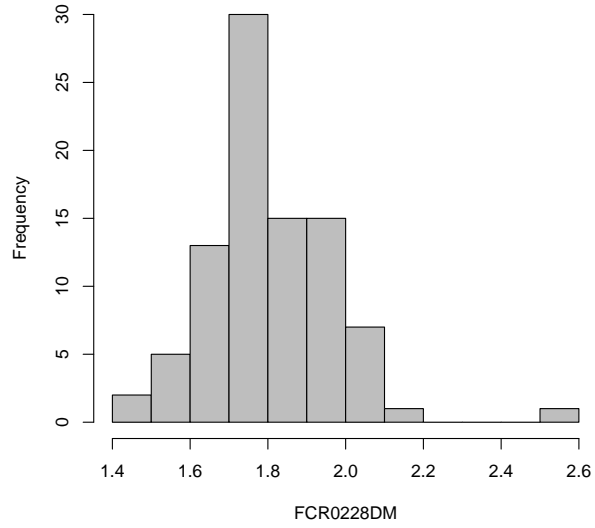
Histogram of ROG0228



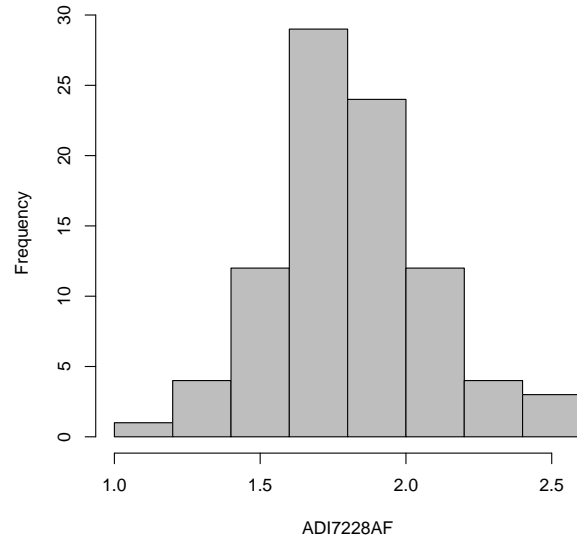
Histogram of FCR0228AF



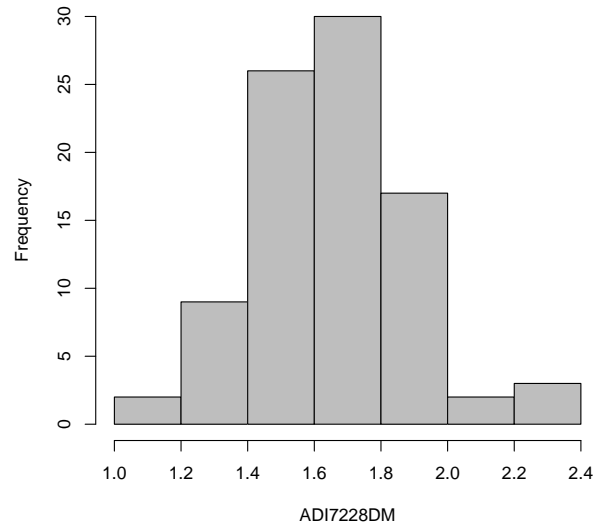
Histogram of FCR0228DM



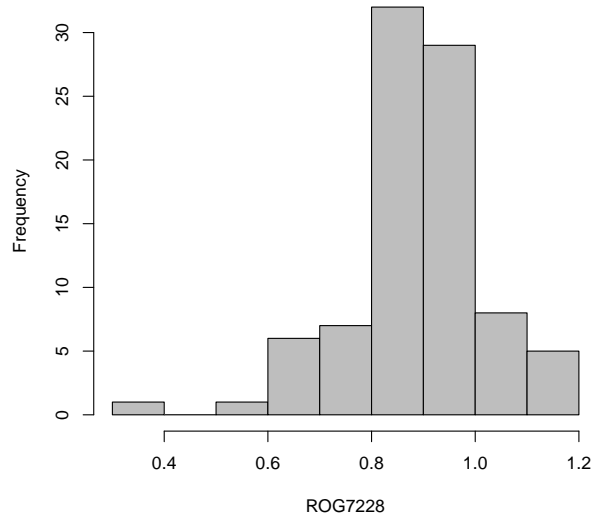
Histogram of ADI7228AF



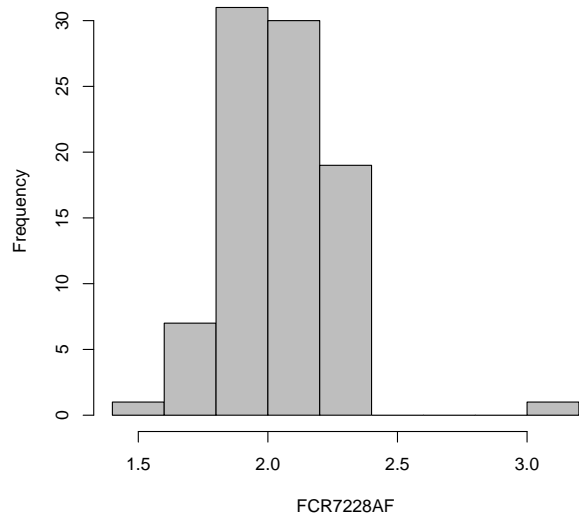
Histogram of ADI7228DM



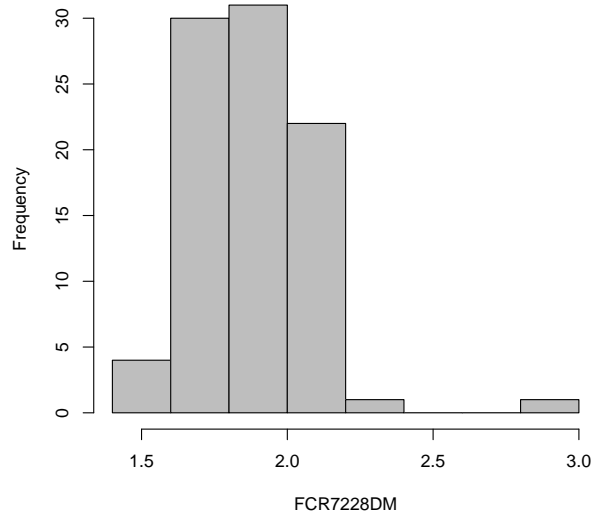
Histogram of ROG7228



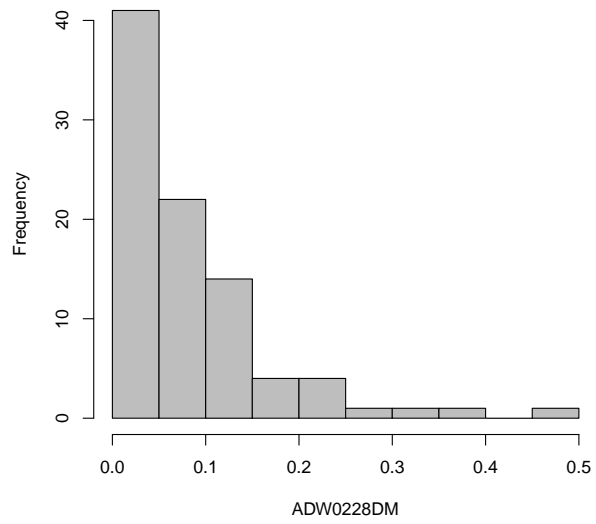
Histogram of FCR7228AF

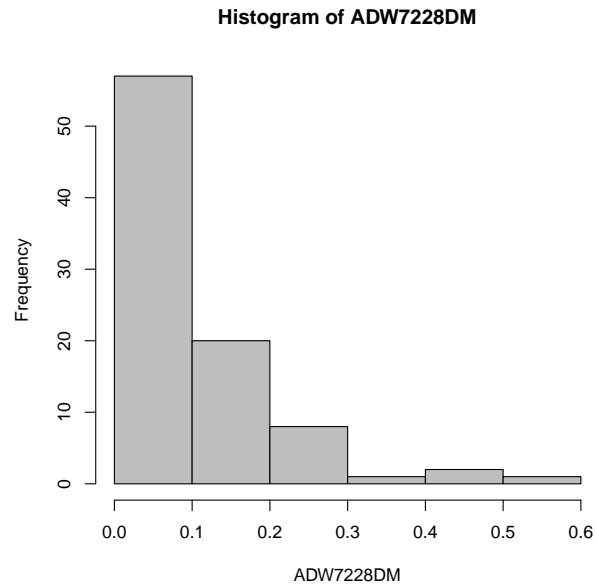


Histogram of FCR7228DM



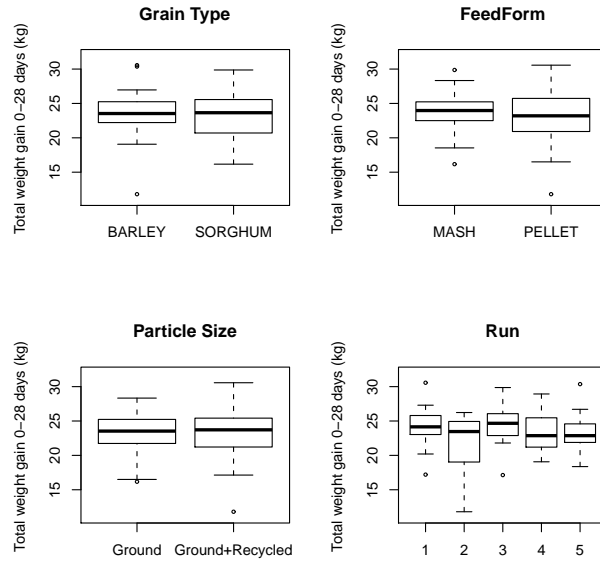
Histogram of ADW0228DM



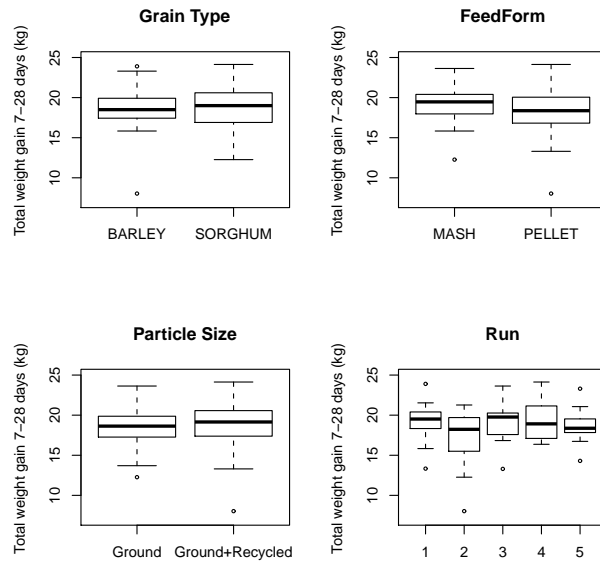


There do not appear to be any outliers. In preparation of the analysis the data can be graphed according to GrainType, ParticleSize, FeedForm and Run, this will give an indication of whether to expect treatment effects and show the variance of these factors.

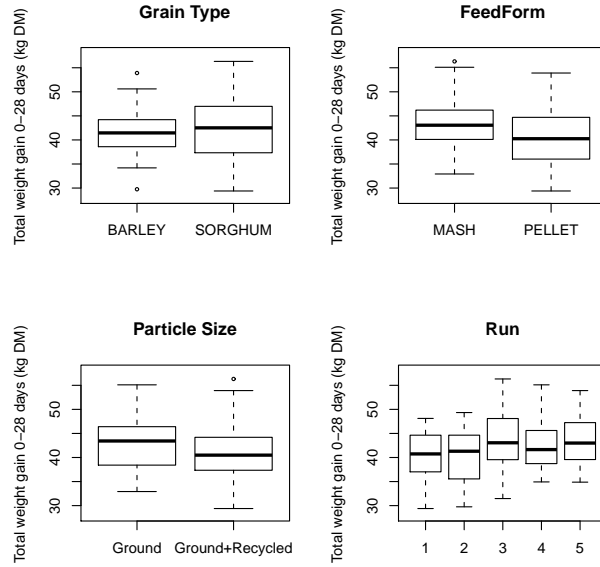
Total weight gain 0-28 days



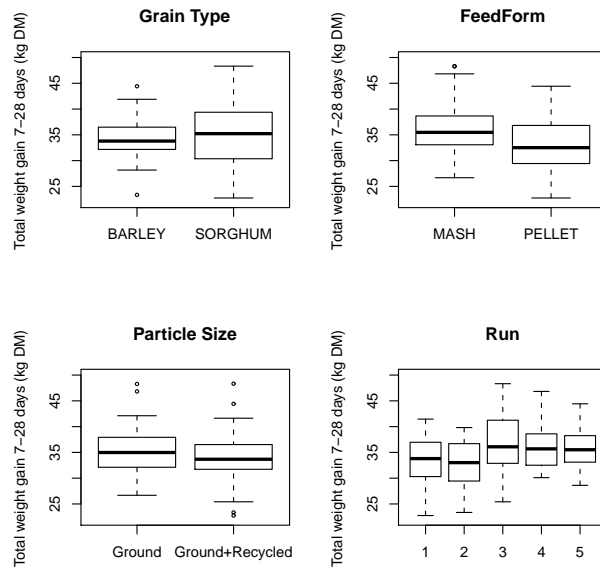
Total weight gain 7-28 days



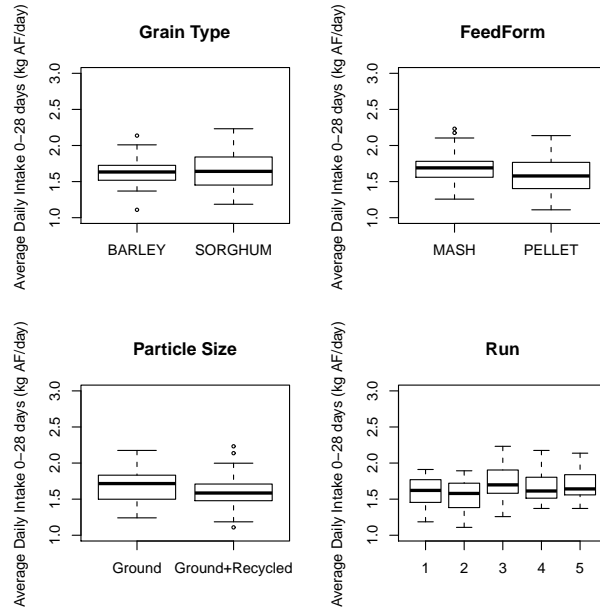
Total amount of feed eaten 0-28 days



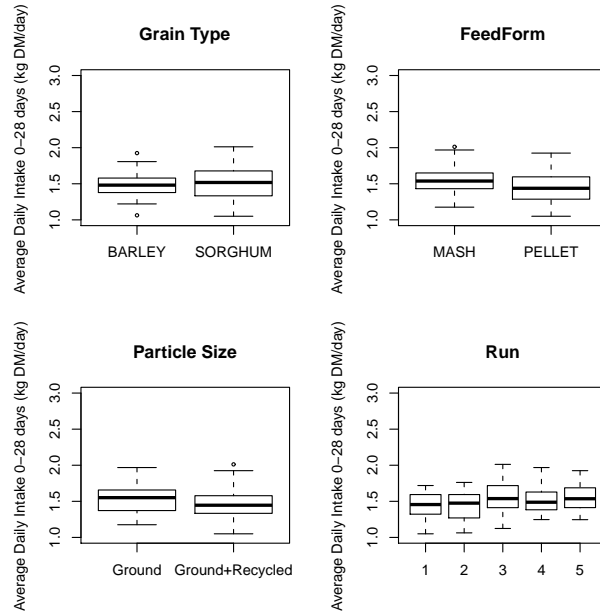
Total amount of feed eaten 7-28 days



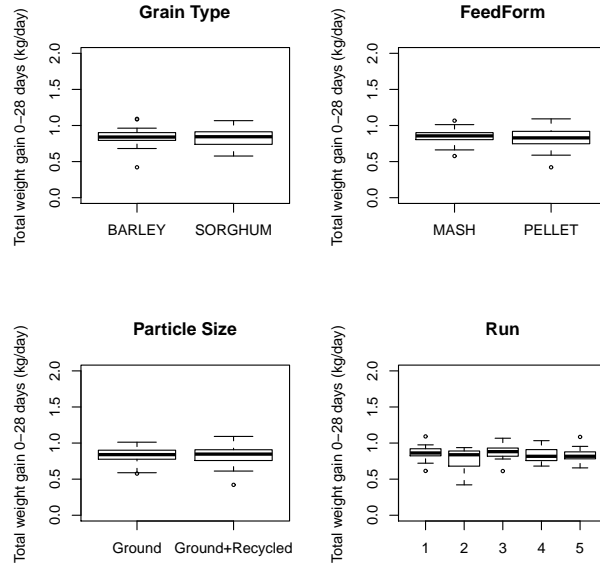
Average Daily Intake 0-28 days AF



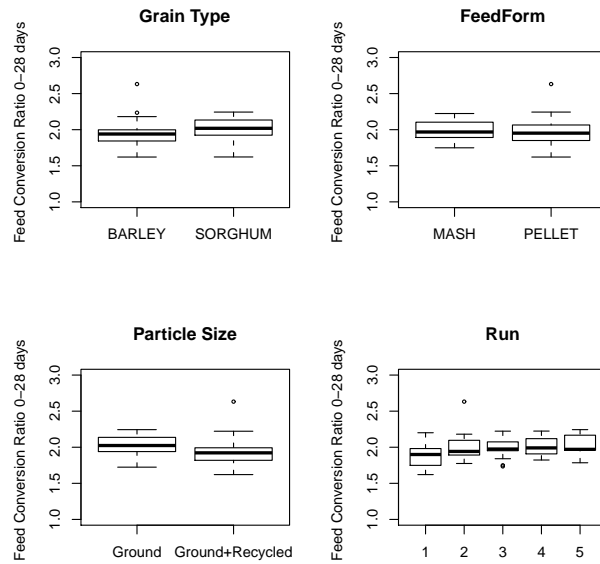
Average Daily Intake 0-28 days DM



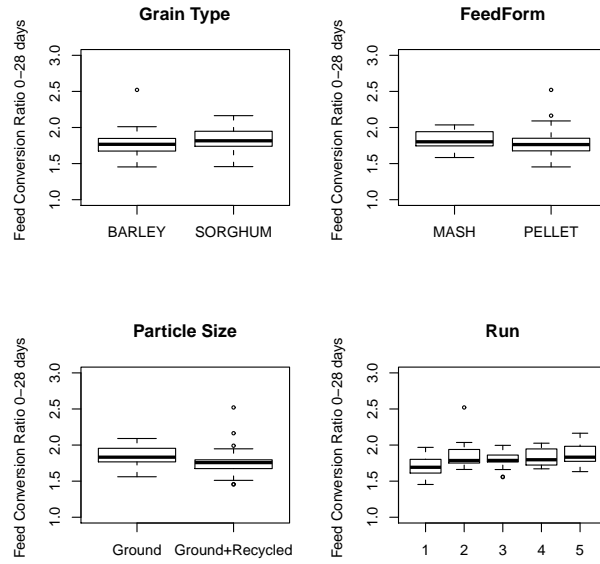
Rate of weight gain 0-28 days



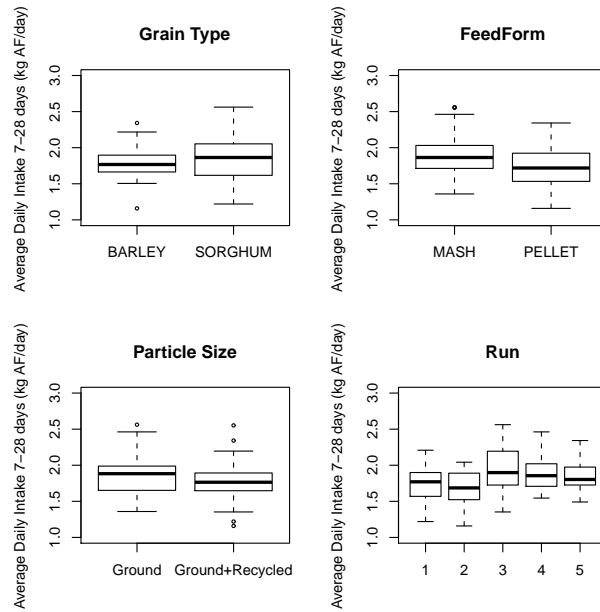
Feed Conversion Ratio 0-28 days AF



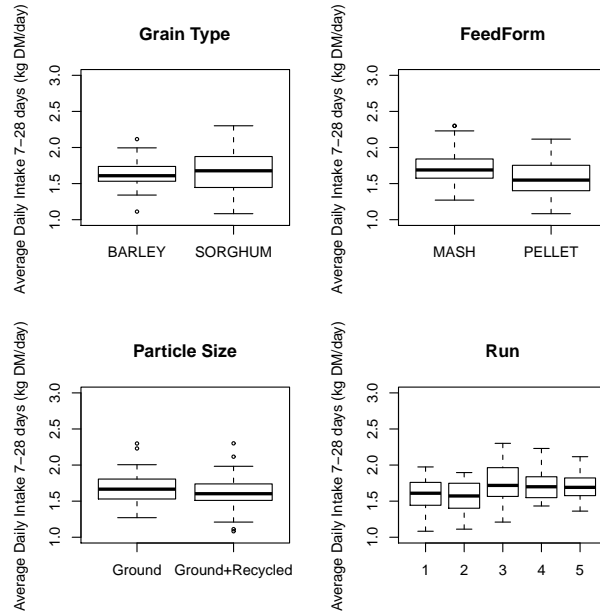
Feed Conversion Ratio 0-28 days DM



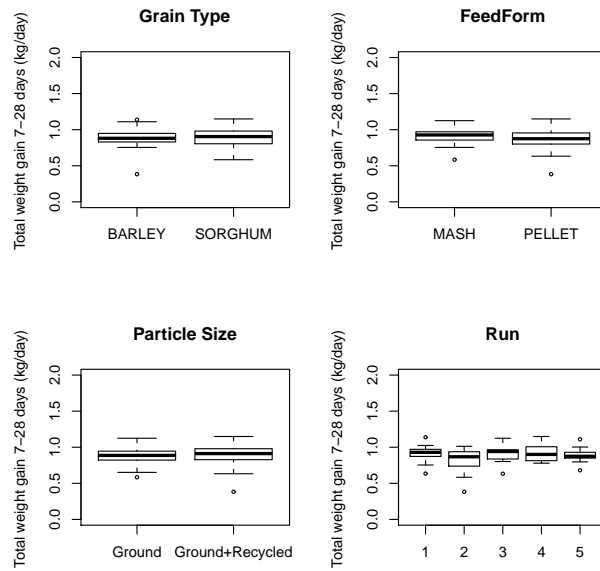
Average Daily Intake 7-28 days AF



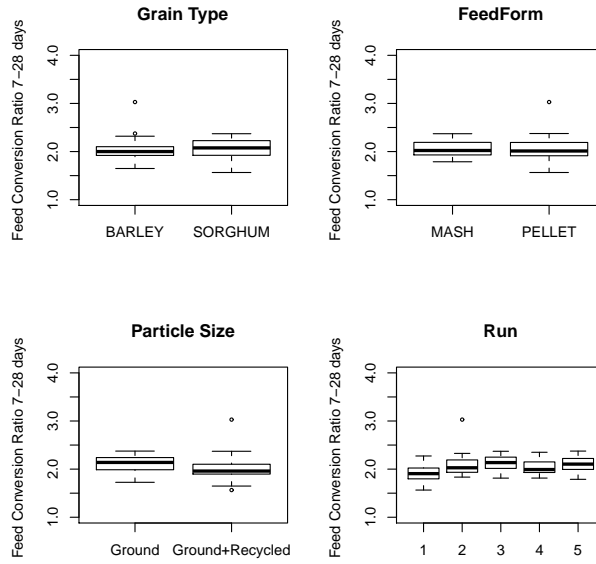
Average Daily Intake 7-28 days DM



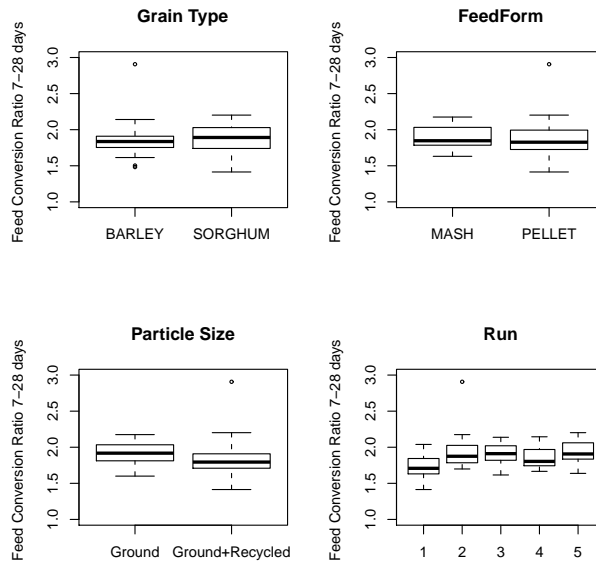
Rate of weight gain 7-28 days



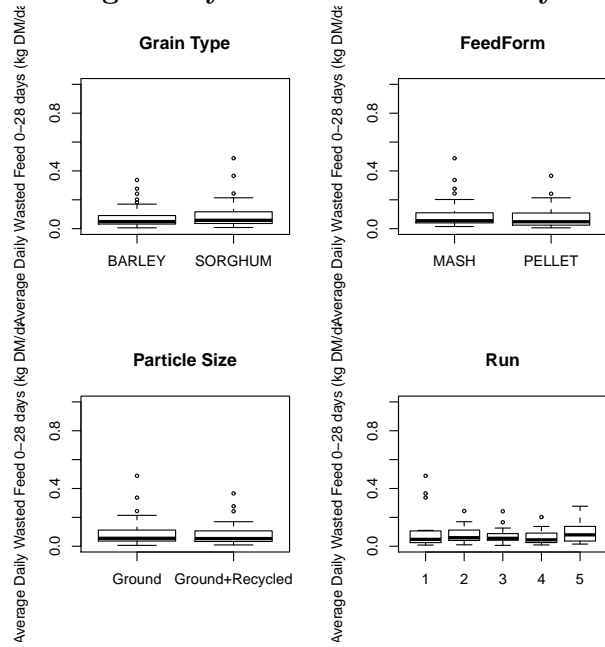
Feed Conversion Ratio 7-28 days AF



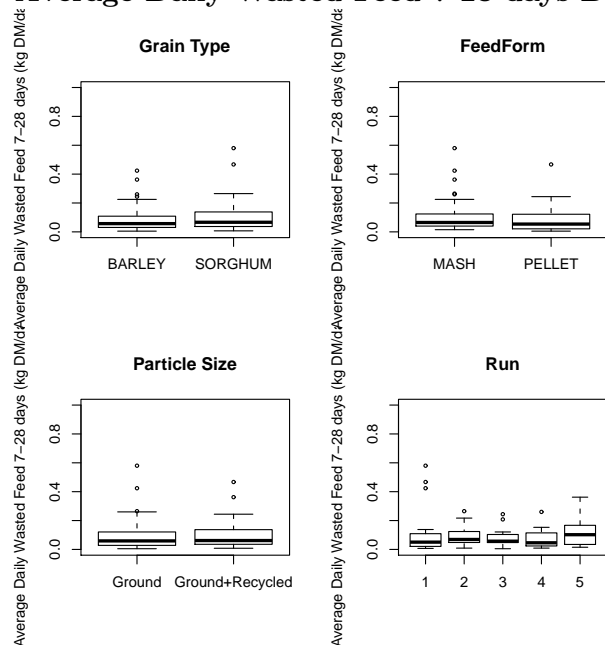
Feed Conversion Ratio 7-28 days DM



Average Daily Wasted Feed 0-28 days DM



Average Daily Wasted Feed 7-28 days DM



These graphs indicate that there are differences between most of these factors.

1.7 Results

Total weight gain 0 - 28 days (kg)

The ANOVA table for total weight gain 0 - 28 days follows:

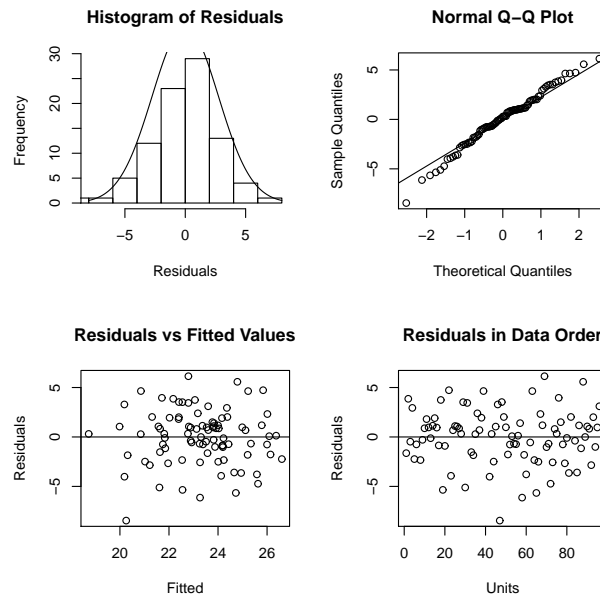
	Df	denDF	F.inc	Pr
StartWeight	1	79.0	14.74	0.000
TotTroughResDM21day	1	79.0	8.51	0.005
GrainType	1	79.0	0.07	0.793
ParticleSize	1	79.0	1.37	0.245
FeedForm	1	79.0	0.55	0.461
GrainType:ParticleSize	1	79.0	0.12	0.733
GrainType:FeedForm	1	79.0	2.98	0.088
ParticleSize:FeedForm	1	79.0	0.22	0.641
GrainType:ParticleSize:FeedForm	1	79.0	0.23	0.631

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values < 0.001 and 0.005 , respectively. There was not any evidence of the random effects.

The coefficient of variation for this response is 12.44%. The residual variation was equal to 8.4. If another similar experiment was used to determine treatment differences 137 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	22.431	0.842
BARLEY	Ground	PELLET	23.564	0.880
BARLEY	Ground+Recycled	MASH	23.931	0.888
BARLEY	Ground+Recycled	PELLET	23.866	0.972
SORGHUM	Ground	MASH	23.810	0.922
SORGHUM	Ground	PELLET	22.253	0.839
SORGHUM	Ground+Recycled	MASH	24.243	0.847
SORGHUM	Ground+Recycled	PELLET	22.680	0.875

Total weight gain 7 - 28 days (kg)

The ANOVA table for total weight gain 7 - 28 days follows:

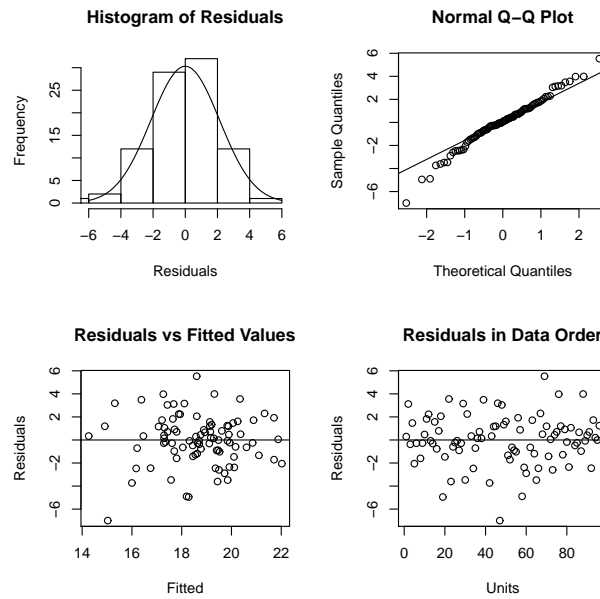
	Df	denDF	F.inc	Pr
StartWeight	1	79.0	23.15	0.000
TotTroughResDM21day	1	79.0	8.22	0.005
GrainType	1	79.0	0.77	0.383
ParticleSize	1	79.0	1.83	0.180
FeedForm	1	79.0	4.49	0.037
GrainType:ParticleSize	1	79.0	0.04	0.843
GrainType:FeedForm	1	79.0	4.11	0.046
ParticleSize:FeedForm	1	79.0	1.25	0.266
GrainType:ParticleSize:FeedForm	1	79.0	0.09	0.771

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values < 0.001 and 0.005 , respectively. The main effect of FeedForm was significant, having a p-value of 0.037 . The interaction of GrainType and FeedForm was also significant, having a p-value of 0.046 . There was not any evidence of the random effects.

The coefficient of variation for this response is 12.04% . The residual variation was equal to 5.06 . If another similar experiment was used to determine treatment differences 128 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
SORGHUM	PELLET	17.854	0.475	a
BARLEY	PELLET	18.397	0.510	a
BARLEY	MASH	18.564	0.479	ab
SORGHUM	MASH	19.905	0.489	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	17.888	0.654
BARLEY	Ground	PELLET	18.407	0.683
BARLEY	Ground+Recycled	MASH	19.241	0.689
BARLEY	Ground+Recycled	PELLET	18.386	0.754
SORGHUM	Ground	MASH	19.474	0.715
SORGHUM	Ground	PELLET	17.830	0.651
SORGHUM	Ground+Recycled	MASH	20.336	0.657
SORGHUM	Ground+Recycled	PELLET	17.879	0.679

Total amount of feed eaten 0 - 28 days (kg DM)

The ANOVA table for total amount of feed eaten 0 - 28 days follows:

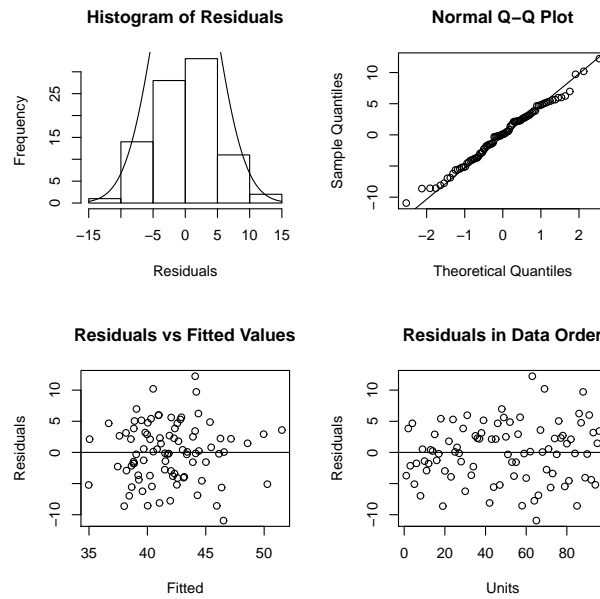
	Df	denDF	F.inc	Pr
StartWeight	1	79.0	10.55	0.002
TotTroughResDM21day	1	72.1	12.30	0.001
GrainType	1	77.4	1.79	0.185
ParticleSize	1	77.2	1.10	0.297
FeedForm	1	78.3	4.25	0.043
GrainType:ParticleSize	1	77.1	0.05	0.819
GrainType:FeedForm	1	76.9	5.33	0.024
ParticleSize:FeedForm	1	77.2	0.49	0.486
GrainType:ParticleSize:FeedForm	1	77.0	0.63	0.428

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of 0.002 and 0.001, respectively. The main effect of FeedForm was significant, having a p-value of 0.043. The interaction of GrainType and FeedForm was also significant, having a p-value of 0.024. There was evidence of the Column random effect, this was not significant at the 5% significance level.

The coefficient of variation for this response is 11.77%. The residual variation was equal to 24.427. If another similar experiment was used to determine treatment differences 123 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
SORGHUM	PELLET	40.662	1.570	a
BARLEY	MASH	41.509	1.553	a
BARLEY	PELLET	41.644	1.603	a
SORGHUM	MASH	45.446	1.572	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	41.938	1.836
BARLEY	Ground	PELLET	42.194	1.888
BARLEY	Ground+Recycled	MASH	41.081	1.897
BARLEY	Ground+Recycled	PELLET	41.094	2.020
SORGHUM	Ground	MASH	47.081	1.955
SORGHUM	Ground	PELLET	40.739	1.838
SORGHUM	Ground+Recycled	MASH	43.812	1.839
SORGHUM	Ground+Recycled	PELLET	40.586	1.914

Total amount of feed eaten 7 - 28 days (kg)

The ANOVA table for total amount of feed eaten 7 - 28 days follows:

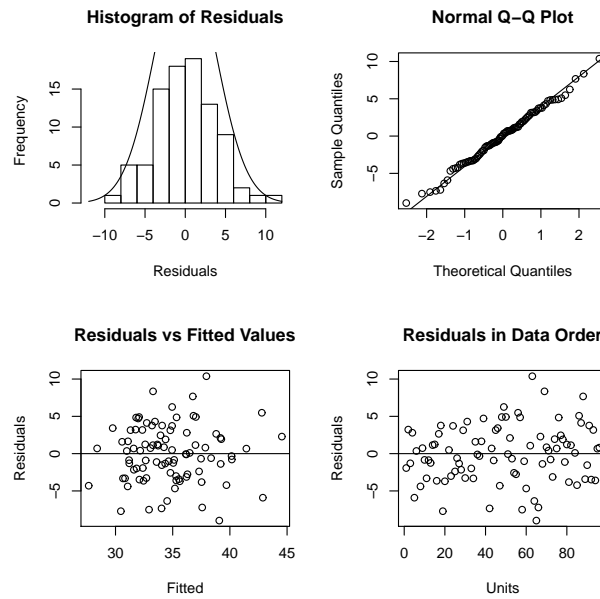
	Df	denDF	F.inc	Pr
StartWeight	1	10.9	12.97	0.004
TotTroughResDM21day	1	22.1	19.51	0.000
GrainType	1	76.0	5.66	0.020
ParticleSize	1	77.1	0.85	0.359
FeedForm	1	74.3	7.13	0.009
GrainType:ParticleSize	1	76.0	0.05	0.818
GrainType:FeedForm	1	76.3	8.91	0.004
ParticleSize:FeedForm	1	76.4	0.18	0.671
GrainType:ParticleSize:FeedForm	1	76.2	0.50	0.482

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of 0.004 and <0.001, respectively. The main effects of GrainType and FeedForm were significant, having p-values of 0.020 and 0.009, respectively. The interaction of GrainType and FeedForm was also significant, having a p-value of 0.004. There was evidence of the Run and Column random effects, these were not significant at the 5% significance level.

The coefficient of variation for this response is 11.6%. The residual variation was equal to 16.389. If another similar experiment was used to determine treatment differences 119 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
SORGHUM	PELLET	33.661	1.459	a
BARLEY	MASH	34.062	1.445	a
BARLEY	PELLET	34.155	1.481	a
SORGHUM	MASH	38.744	1.459	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	34.301	1.653
BARLEY	Ground	PELLET	34.652	1.691
BARLEY	Ground+Recycled	MASH	33.823	1.698
BARLEY	Ground+Recycled	PELLET	33.657	1.791
SORGHUM	Ground	MASH	39.909	1.743
SORGHUM	Ground	PELLET	33.864	1.655
SORGHUM	Ground+Recycled	MASH	37.580	1.655
SORGHUM	Ground+Recycled	PELLET	33.458	1.714

Average Daily Intake 0 - 28 days (kg AF/day)

The ANOVA table for Average Daily Intake 0 - 28 days follows:

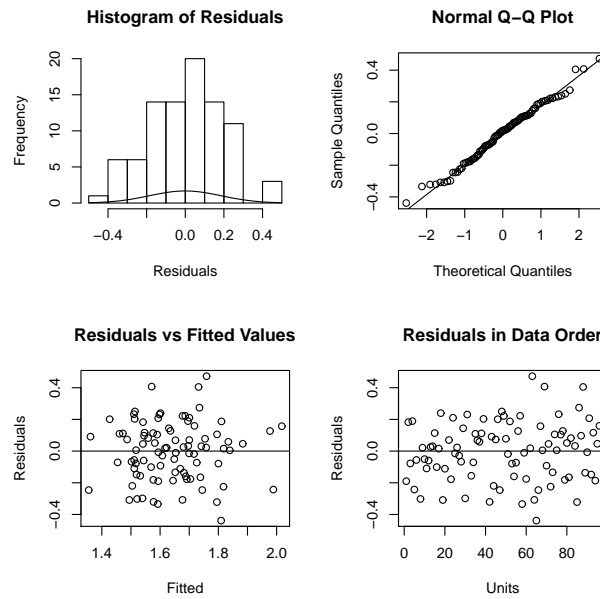
	Df	denDF	F.inc	Pr
StartWeight	1	78.8	11.24	0.001
TotTroughResDM21day	1	64.9	13.76	0.000
GrainType	1	77.4	2.14	0.147
ParticleSize	1	77.3	0.84	0.363
FeedForm	1	78.6	2.88	0.094
GrainType:ParticleSize	1	77.1	0.04	0.834
GrainType:FeedForm	1	76.9	6.29	0.014
ParticleSize:FeedForm	1	77.3	0.28	0.597
GrainType:ParticleSize:FeedForm	1	77.0	0.55	0.462

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of 0.001 and <0.001, respectively. The interaction of GrainType and FeedForm was also significant, having a p-value of 0.014. There was evidence of the Column random effect, this was not significant at the 5% significance level.

The coefficient of variation for this response is 11.95%. The residual variation was equal to 0.039. If another similar experiment was used to determine treatment differences 126 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
SORGHUM	PELLET	1.596	0.057	a
BARLEY	MASH	1.609	0.057	a
BARLEY	PELLET	1.639	0.059	a
SORGHUM	MASH	1.778	0.058	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	1.621	0.069
BARLEY	Ground	PELLET	1.660	0.071
BARLEY	Ground+Recycled	MASH	1.597	0.071
BARLEY	Ground+Recycled	PELLET	1.617	0.077
SORGHUM	Ground	MASH	1.835	0.074
SORGHUM	Ground	PELLET	1.600	0.069
SORGHUM	Ground+Recycled	MASH	1.722	0.069
SORGHUM	Ground+Recycled	PELLET	1.592	0.072

Average Daily Intake 0 - 28 days (kg DM/day)

The ANOVA table for Average Daily Intake 0 - 28 days follows:

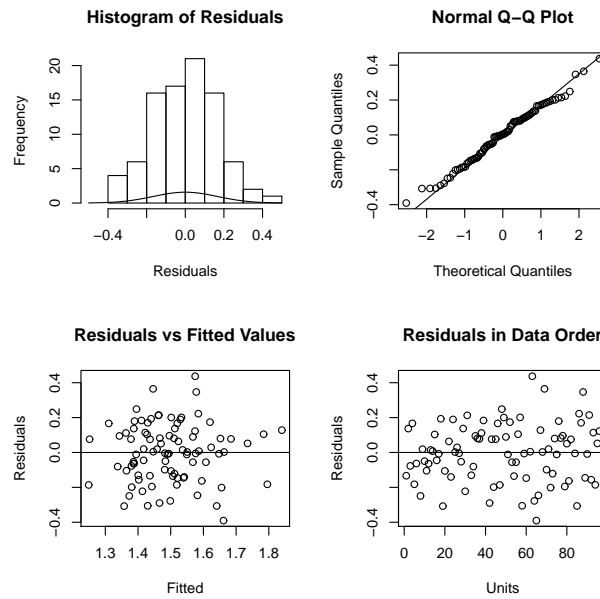
	Df	denDF	F.inc	Pr
StartWeight	1	79.0	10.54	0.002
TotTroughResDM21day	1	72.1	12.31	0.001
GrainType	1	77.4	1.79	0.185
ParticleSize	1	77.2	1.10	0.296
FeedForm	1	78.3	4.25	0.043
GrainType:ParticleSize	1	77.1	0.05	0.819
GrainType:FeedForm	1	76.9	5.33	0.024
ParticleSize:FeedForm	1	77.2	0.49	0.484
GrainType:ParticleSize:FeedForm	1	77.0	0.63	0.428

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of 0.002 and 0.001, respectively. The main effect of FeedForm was significant, having a p-value of 0.043. The interaction of GrainType and FeedForm was also significant, having a p-value of 0.024. There was evidence of the Column random effect, this was not significant at the 5% significance level.

The coefficient of variation for this response is 11.78%. The residual variation was equal to 0.031. If another similar experiment was used to determine treatment differences 123 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
SORGHUM	PELLET	1.452	0.056	a
BARLEY	MASH	1.482	0.055	a
BARLEY	PELLET	1.487	0.057	a
SORGHUM	MASH	1.623	0.056	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	1.498	0.066
BARLEY	Ground	PELLET	1.507	0.067
BARLEY	Ground+Recycled	MASH	1.467	0.068
BARLEY	Ground+Recycled	PELLET	1.468	0.072
SORGHUM	Ground	MASH	1.681	0.070
SORGHUM	Ground	PELLET	1.455	0.066
SORGHUM	Ground+Recycled	MASH	1.565	0.066
SORGHUM	Ground+Recycled	PELLET	1.450	0.068

Rate of Weight Gain 0 - 28 days (kg/day)

The ANOVA table for Rate of Weight Gain 0 - 28 days follows:

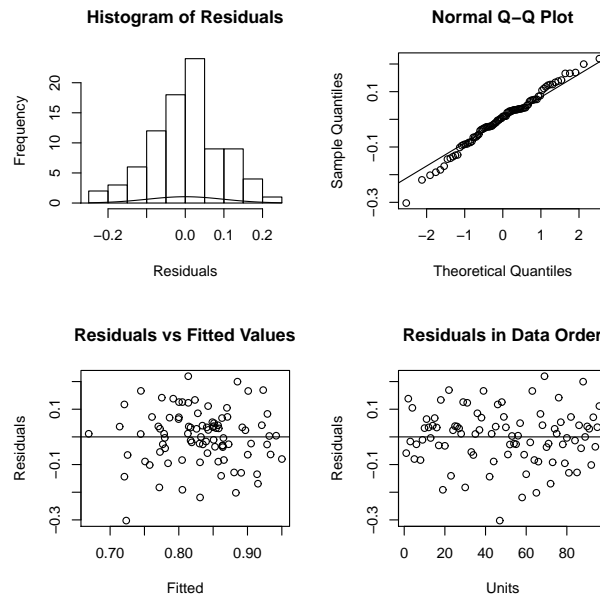
	Df	denDF	F.inc	Pr
StartWeight	1	79.0	14.70	0.000
TotTroughResDM21day	1	79.0	8.54	0.005
GrainType	1	79.0	0.07	0.792
ParticleSize	1	79.0	1.38	0.244
FeedForm	1	79.0	0.54	0.463
GrainType:ParticleSize	1	79.0	0.12	0.731
GrainType:FeedForm	1	79.0	2.98	0.088
ParticleSize:FeedForm	1	79.0	0.22	0.642
GrainType:ParticleSize:FeedForm	1	79.0	0.23	0.632

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of < 0.001 and 0.005 , respectively. There was not any evidence of the random effects.

The coefficient of variation for this response is 12.45%. The residual variation was equal to 0.011. If another similar experiment was used to determine treatment differences 137 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	0.801	0.030
BARLEY	Ground	PELLET	0.841	0.031
BARLEY	Ground+Recycled	MASH	0.855	0.032
BARLEY	Ground+Recycled	PELLET	0.852	0.035
SORGHUM	Ground	MASH	0.850	0.033
SORGHUM	Ground	PELLET	0.795	0.030
SORGHUM	Ground+Recycled	MASH	0.866	0.030
SORGHUM	Ground+Recycled	PELLET	0.810	0.031

Feed Conversion Ratio 0 - 28 days AF

The ANOVA table for Feed Conversion Ratio 0 - 28 days follows:

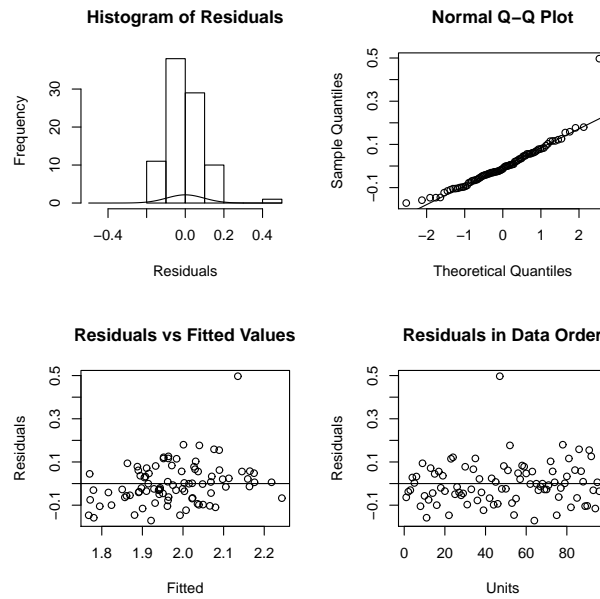
	Df	denDF	F.inc	Pr
StartWeight	1	29.0	0.11	0.738
TotTroughResDM21day	1	67.2	0.10	0.756
GrainType	1	65.7	6.95	0.010
ParticleSize	1	71.0	18.97	0.000
FeedForm	1	66.7	6.06	0.016
ParticleSize:FeedForm	1	65.7	3.21	0.078
GrainType:ParticleSize	1	69.3	0.84	0.364
GrainType:FeedForm	1	55.5	2.52	0.118
GrainType:ParticleSize:FeedForm	1	62.9	0.02	0.881

Neither of the covariates StartWeight and TotTroughResDM21day were significant, having p-values > 0.050 . The main effects of GrainType, ParticleSize and FeedForm were all significant, having p-values of 0.010, < 0.001 and 0.016, respectively. Of the random effects there was evidence of Run, Replicate and Row, none of these terms were significant at the 5% level of significance.

The coefficient of variation for this response is 5.9%. The residual variation was equal to 0.014. If another similar experiment was used to determine treatment differences 31 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted GrainType values follows:

GrainType	Predicted Value	Standard Error	Ranking
BARLEY	1.944	0.039	a
SORGHUM	2.028	0.038	b

The predicted ParticleSize values follows:

ParticleSize	Predicted Value	Standard Error	Ranking
Ground+Recycled	1.918	0.039	a
Ground	2.053	0.039	b

The predicted FeedForm values follows:

FeedForm	Predicted Value	Standard Error	Ranking
PELLET	1.950	0.039	a
MASH	2.022	0.039	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	2.038	0.050
BARLEY	Ground	PELLET	1.959	0.051
BARLEY	Ground+Recycled	MASH	1.880	0.052
BARLEY	Ground+Recycled	PELLET	1.900	0.055
SORGHUM	Ground	MASH	2.195	0.054
SORGHUM	Ground	PELLET	2.023	0.050
SORGHUM	Ground+Recycled	MASH	1.975	0.050
SORGHUM	Ground+Recycled	PELLET	1.919	0.052

Feed Conversion Ratio 0 - 28 days DM

The ANOVA table for Feed Conversion Ratio 0 - 28 days follows:

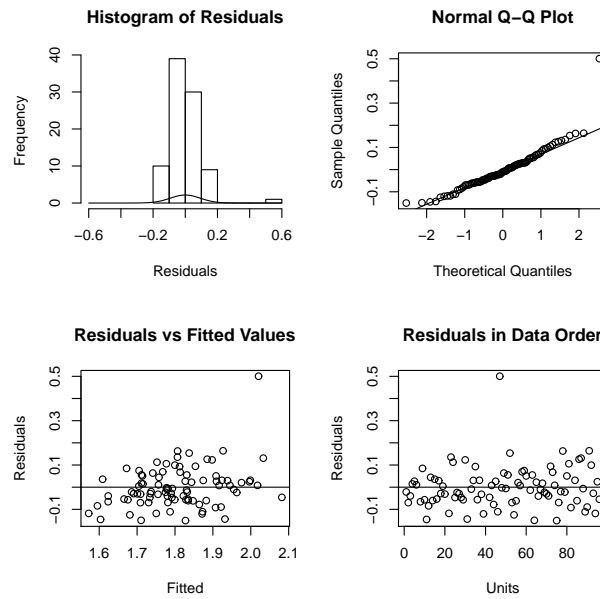
	Df	denDF	F.inc	Pr
StartWeight	1	23.3	0.11	0.748
TotTroughResDM21day	1	67.2	0.01	0.937
GrainType	1	64.6	4.92	0.030
ParticleSize	1	71.0	17.97	0.000
FeedForm	1	65.7	8.80	0.004
ParticleSize:FeedForm	1	64.8	4.00	0.050
GrainType:ParticleSize	1	69.3	1.25	0.268
GrainType:FeedForm	1	54.6	1.12	0.293
GrainType:ParticleSize:FeedForm	1	61.9	0.00	0.965

Neither of the covariates StartWeight and TotTroughResDM21day were significant, having p-values > 0.050 . The main effects of GrainType, ParticleSize and FeedForm were all significant, having p-values of 0.030, < 0.001 and 0.004, respectively. The interaction term of ParticleSize and FeedForm was significant, having a p-value of 0.050. Of the random effects there was evidence of Run, Replicate and Row, only the Row random effect was significant at the 5% level of significance.

The coefficient of variation for this response is 6.26%. The residual variation was equal to 0.013. If another similar experiment was used to determine treatment differences 35 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted GrainType values follows:

GrainType	Predicted Value	Standard Error	Ranking
BARLEY	1.777	0.038	a
SORGHUM	1.848	0.038	b

The predicted interaction of ParticleSize and FeedForm values follows:

ParticleSize	FeedForm	Predicted Value	Standard Error	Ranking
Ground+Recycled	PELLET	1.734	0.044	a
Ground+Recycled	MASH	1.760	0.042	a
Ground	PELLET	1.806	0.042	a
Ground	MASH	1.950	0.044	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	1.885	0.049
BARLEY	Ground	PELLET	1.768	0.050
BARLEY	Ground+Recycled	MASH	1.726	0.051
BARLEY	Ground+Recycled	PELLET	1.729	0.054
SORGHUM	Ground	MASH	2.015	0.053
SORGHUM	Ground	PELLET	1.845	0.050
SORGHUM	Ground+Recycled	MASH	1.794	0.049
SORGHUM	Ground+Recycled	PELLET	1.739	0.051

Average Daily Intake 7 - 28 days (kg AF/day)

The ANOVA table for Average Daily Intake 7 - 28 days follows:

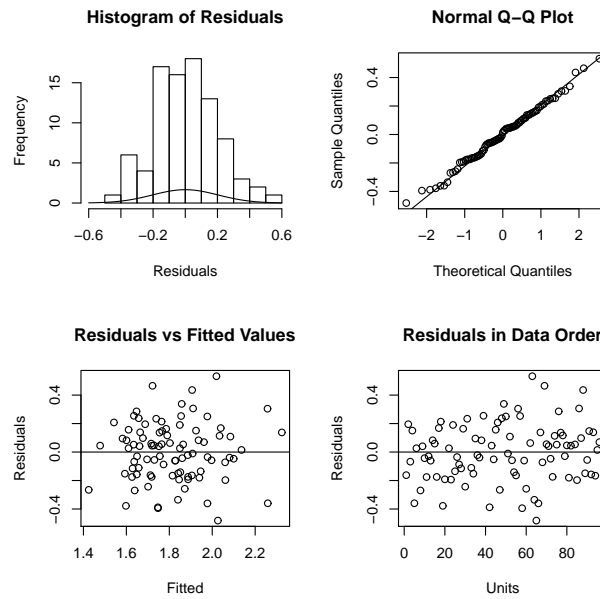
	Df	denDF	F.inc	Pr
StartWeight	1	11.3	12.89	0.004
TotTroughResDM21day	1	24.7	20.46	0.000
GrainType	1	76.1	6.30	0.014
ParticleSize	1	77.2	0.72	0.399
FeedForm	1	75.5	5.30	0.024
GrainType:ParticleSize	1	76.0	0.05	0.824
GrainType:FeedForm	1	76.3	9.43	0.003
ParticleSize:FeedForm	1	76.4	0.04	0.849
GrainType:ParticleSize:FeedForm	1	76.2	0.39	0.533

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of 0.004 and <0.001, respectively. The main effects of GrainType and FeedForm were both significant, having p-values of 0.014 and 0.024, respectively. The interaction of GrainType and FeedForm was also significant, having a p-value of 0.003. There was evidence of the Run and Column random effects, these were not significant at the 5% significance level.

The coefficient of variation for this response is 11.9%. The residual variation was equal to 0.047. If another similar experiment was used to determine treatment differences 125 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
BARLEY	MASH	1.760	0.069	a
SORGHUM	PELLET	1.762	0.070	a
BARLEY	PELLET	1.786	0.071	a
SORGHUM	MASH	2.020	0.070	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	1.767	0.081
BARLEY	Ground	PELLET	1.815	0.083
BARLEY	Ground+Recycled	MASH	1.753	0.084
BARLEY	Ground+Recycled	PELLET	1.758	0.089
SORGHUM	Ground	MASH	2.072	0.086
SORGHUM	Ground	PELLET	1.777	0.081
SORGHUM	Ground+Recycled	MASH	1.967	0.081
SORGHUM	Ground+Recycled	PELLET	1.746	0.085

Average Daily Intake 7 - 28 days (kg DM/day)

The ANOVA table for Average Daily Intake 7 - 28 days follows:

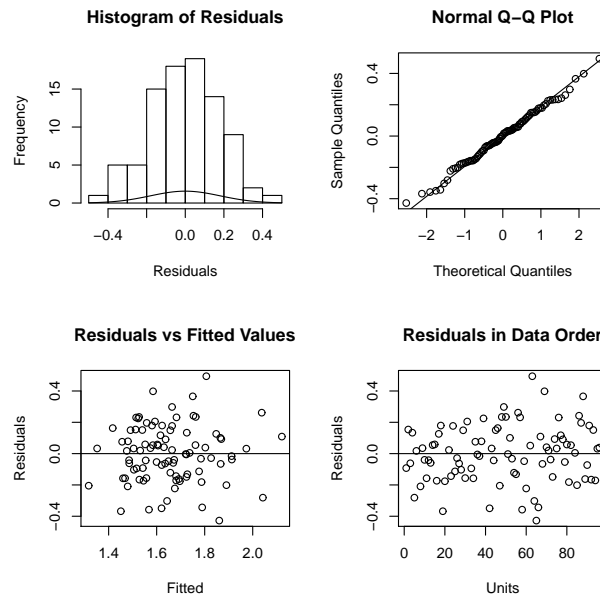
	Df	denDF	F.inc	Pr
StartWeight	1	10.8	12.99	0.004
TotTroughResDM21day	1	22.0	19.50	0.000
GrainType	1	76.0	5.66	0.020
ParticleSize	1	77.1	0.85	0.359
FeedForm	1	74.3	7.12	0.009
GrainType:ParticleSize	1	76.0	0.05	0.819
GrainType:FeedForm	1	76.3	8.92	0.004
ParticleSize:FeedForm	1	76.4	0.18	0.671
GrainType:ParticleSize:FeedForm	1	76.2	0.50	0.483

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of 0.004 and < 0.001 , respectively. The main effects of GrainType and FeedForm were significant, having p-values of 0.020 and 0.009, respectively. The interaction of GrainType and FeedForm was also significant, having a p-value of 0.004. There was evidence of the Run and Column random effects, these was not significant at the 5% significance level.

The coefficient of variation for this response is 11.6%. The residual variation was equal to 0.037. If another similar experiment was used to determine treatment differences 119 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
SORGHUM	PELLET	1.603	0.070	a
BARLEY	MASH	1.622	0.069	a
BARLEY	PELLET	1.626	0.071	a
SORGHUM	MASH	1.845	0.070	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	1.633	0.079
BARLEY	Ground	PELLET	1.650	0.081
BARLEY	Ground+Recycled	MASH	1.610	0.081
BARLEY	Ground+Recycled	PELLET	1.603	0.085
SORGHUM	Ground	MASH	1.900	0.083
SORGHUM	Ground	PELLET	1.613	0.079
SORGHUM	Ground+Recycled	MASH	1.790	0.079
SORGHUM	Ground+Recycled	PELLET	1.593	0.082

Rate of Weight Gain 7 - 28 days (kg/day)

The ANOVA table for Rate of Weight Gain 7 - 28 days follows:

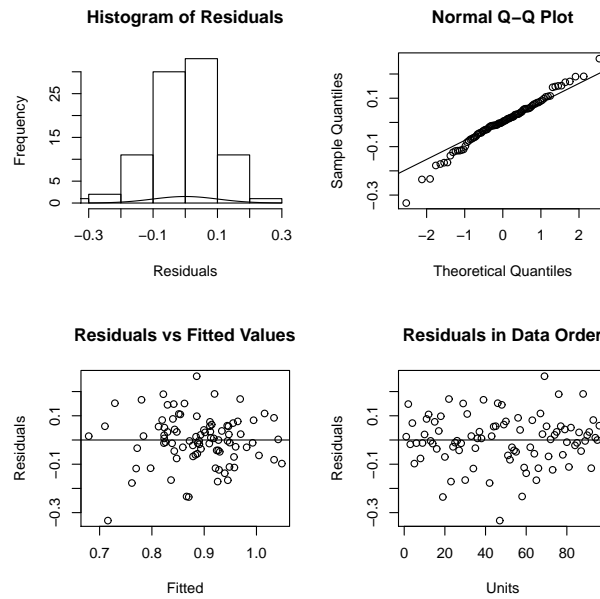
	Df	denDF	F.inc	Pr
StartWeight	1	79.0	23.13	0.000
TotTroughResDM21day	1	79.0	8.23	0.005
GrainType	1	79.0	0.76	0.387
ParticleSize	1	79.0	1.84	0.179
FeedForm	1	79.0	4.47	0.038
GrainType:ParticleSize	1	79.0	0.04	0.844
GrainType:FeedForm	1	79.0	4.11	0.046
ParticleSize:FeedForm	1	79.0	1.25	0.267
GrainType:ParticleSize:FeedForm	1	79.0	0.08	0.772

Both the covariates StartWeight and TotTroughResDM21day are significant, having p-values of < 0.001 and 0.005 , respectively. The main effect of FeedForm was significant, having a p-value of 0.038 . The interaction of GrainType and FeedForm was also significant, having a p-value of 0.046 . There was not any evidence of the random effects.

The coefficient of variation for this response is 12.04% . The residual variation was equal to 0.011 . If another similar experiment was used to determine treatment differences 128 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction for GrainType and FeedForm values follows:

GrainType	FeedForm	Predicted Value	Standard Error	Ranking
SORGHUM	PELLET	0.850	0.023	a
BARLEY	PELLET	0.876	0.024	a
BARLEY	MASH	0.884	0.023	ab
SORGHUM	MASH	0.948	0.023	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	0.852	0.031
BARLEY	Ground	PELLET	0.877	0.033
BARLEY	Ground+Recycled	MASH	0.916	0.033
BARLEY	Ground+Recycled	PELLET	0.876	0.036
SORGHUM	Ground	MASH	0.927	0.034
SORGHUM	Ground	PELLET	0.849	0.031
SORGHUM	Ground+Recycled	MASH	0.968	0.031
SORGHUM	Ground+Recycled	PELLET	0.851	0.032

Feed Conversion Ratio 7 - 28 days AF

The ANOVA table for Feed Conversion Ratio 7 - 28 days follows:

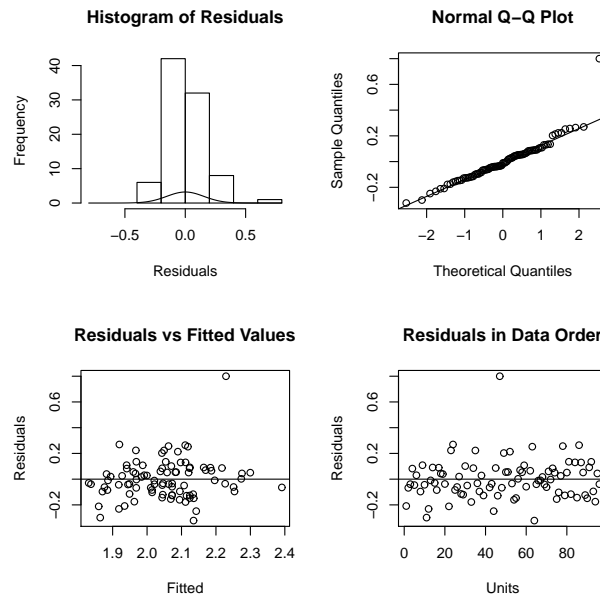
	Df	denDF	F.inc	Pr
StartWeight	1	20.5	2.72	0.115
TotTroughResDM21day	1	62.5	0.01	0.923
GrainType	1	69.6	1.89	0.174
ParticleSize	1	68.5	10.82	0.002
FeedForm	1	73.6	0.88	0.351
ParticleSize:FeedForm	1	70.5	3.34	0.072
GrainType:ParticleSize	1	66.1	0.77	0.382
GrainType:FeedForm	1	62.9	3.89	0.053
GrainType:ParticleSize:FeedForm	1	68.4	0.01	0.922

Neither of the covariates StartWeight and TotTroughResDM21day were significant, having p-values > 0.050 . The main effect of ParticleSize was significant, having a p-value of 0.002. Of the random effects there was evidence of Run, Replicate and Row, none of these terms were significant at the 5% level of significance.

The coefficient of variation for this response is 8.33%. The residual variation was equal to 0.029. If another similar experiment was used to determine treatment differences 62 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted ParticleSize values follows:

ParticleSize	Predicted Value	Standard Error	Ranking
Ground+Recycled	1.998	0.048	a
Ground	2.128	0.048	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	2.097	0.065
BARLEY	Ground	PELLET	2.065	0.067
BARLEY	Ground+Recycled	MASH	1.932	0.068
BARLEY	Ground+Recycled	PELLET	2.043	0.072
SORGHUM	Ground	MASH	2.268	0.070
SORGHUM	Ground	PELLET	2.082	0.065
SORGHUM	Ground+Recycled	MASH	2.024	0.065
SORGHUM	Ground+Recycled	PELLET	1.994	0.068

Feed Conversion Ratio 7 - 28 days DM

The ANOVA table for Feed Conversion Ratio 7 - 28 days follows:

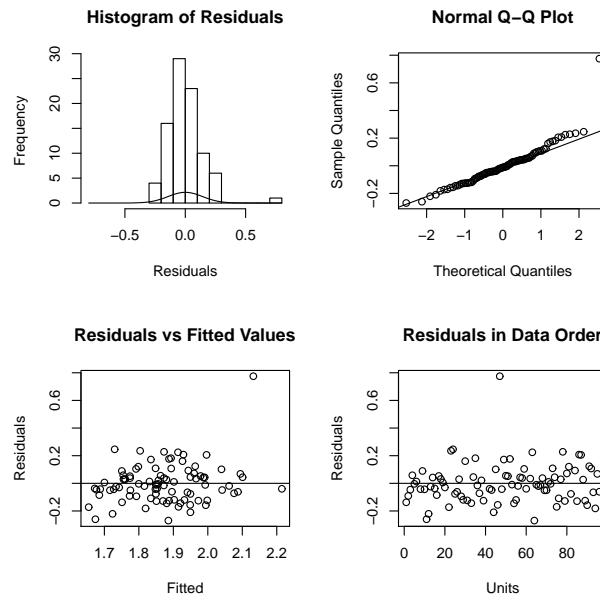
	Df	denDF	F.inc	Pr
StartWeight	1	17.7	2.85	0.109
TotTroughResDM21day	1	63.9	0.04	0.847
GrainType	1	69.1	0.96	0.331
ParticleSize	1	70.0	9.96	0.002
FeedForm	1	72.6	1.89	0.173
ParticleSize:FeedForm	1	69.9	4.38	0.040
GrainType:ParticleSize	1	68.2	1.09	0.301
GrainType:FeedForm	1	61.5	2.85	0.096
GrainType:ParticleSize:FeedForm	1	67.5	0.00	0.991

Neither of the covariates StartWeight and TotTroughResDM21day were significant, having p-values > 0.050 . The main effect of ParticleSize was significant, having a p-value of 0.002. The interaction term of ParticleSize and FeedForm was significant, having a p-value of 0.040. Of the random effects there was evidence of Run, Replicate and Row, none of these were significant at the 5% level of significance.

The coefficient of variation for this response is 8.67%. The residual variation was equal to 0.026. If another similar experiment was used to determine treatment differences 67 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction of ParticleSize and FeedForm values follows:

ParticleSize	FeedForm	Predicted Value	Standard Error	Ranking
Ground+Recycled	MASH	1.805	0.054	a
Ground+Recycled	PELLET	1.838	0.056	a
Ground	PELLET	1.879	0.054	a
Ground	MASH	2.013	0.055	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	1.940	0.064
BARLEY	Ground	PELLET	1.868	0.065
BARLEY	Ground+Recycled	MASH	1.774	0.066
BARLEY	Ground+Recycled	PELLET	1.867	0.070
SORGHUM	Ground	MASH	2.085	0.069
SORGHUM	Ground	PELLET	1.891	0.064
SORGHUM	Ground+Recycled	MASH	1.837	0.064
SORGHUM	Ground+Recycled	PELLET	1.809	0.066

Average Daily Wasted Feed 0 - 28 days DM

The ANOVA table for Average Daily Wasted Feed 0 - 28 days follows:

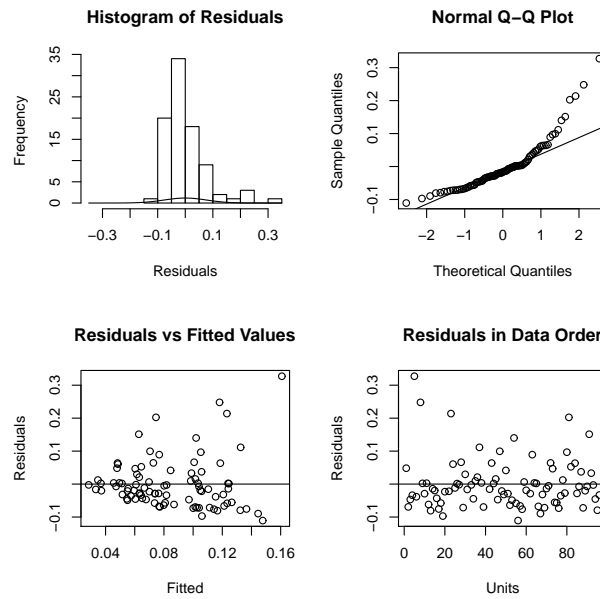
	Df	denDF	F.inc	Pr
StartWeight	1	15.6	0.64	0.435
TotTroughResDM21day	1	37.9	0.33	0.571
GrainType	1	70.2	0.96	0.331
ParticleSize	1	71.8	0.08	0.776
FeedForm	1	77.1	1.04	0.311
ParticleSize:FeedForm	1	71.5	8.96	0.004
GrainType:ParticleSize	1	69.6	0.12	0.729
GrainType:FeedForm	1	69.8	0.05	0.819
GrainType:ParticleSize:FeedForm	1	70.2	0.00	0.982

Neither of the covariates StartWeight and TotTroughResDM21day were significant, having p-values > 0.050 . The interaction term of ParticleSize and FeedForm was significant, having a p-value of 0.004. Of the random effects there was evidence of Replicate only, this was not significant at the 5% level of significance.

The coefficient of variation for this response is 95.47%. The residual variation was equal to 0.007. If another similar experiment was used to determine treatment differences 8029 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction of ParticleSize and FeedForm values follows:

ParticleSize	FeedForm	Predicted Value	Standard Error	Ranking
Ground	PELLET	0.054	0.017	a
Ground+Recycled	MASH	0.065	0.018	a
Ground+Recycled	PELLET	0.102	0.019	ab
Ground	MASH	0.122	0.018	b

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	0.111	0.024
BARLEY	Ground	PELLET	0.040	0.025
BARLEY	Ground+Recycled	MASH	0.061	0.025
BARLEY	Ground+Recycled	PELLET	0.093	0.028
SORGHUM	Ground	MASH	0.132	0.026
SORGHUM	Ground	PELLET	0.068	0.024
SORGHUM	Ground+Recycled	MASH	0.069	0.024
SORGHUM	Ground+Recycled	PELLET	0.111	0.025

Average Daily Wasted Feed 7 - 28 days DM

The ANOVA table for Average Daily Wasted Feed 7 - 28 days follows:

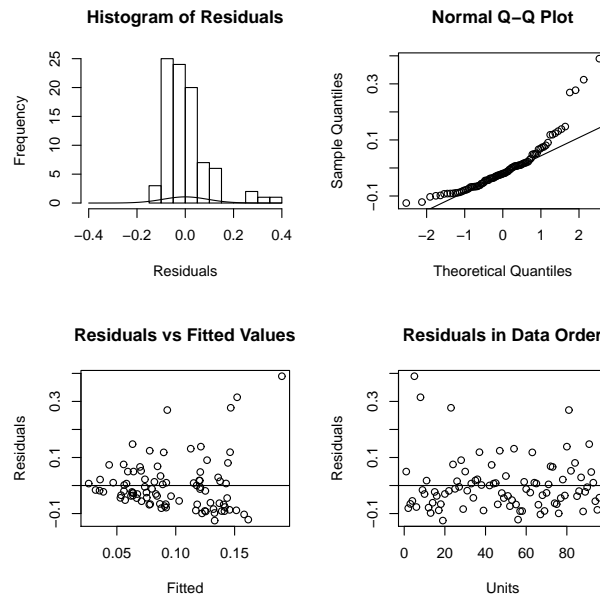
	Df	denDF	F.inc	Pr
StartWeight	1	16.3	0.76	0.395
TotTroughResDM21day	1	41.1	0.22	0.638
GrainType	1	70.0	0.77	0.383
ParticleSize	1	71.6	0.01	0.937
FeedForm	1	76.9	1.05	0.308
ParticleSize:FeedForm	1	71.3	8.77	0.004
GrainType:ParticleSize	1	69.4	0.01	0.941
GrainType:FeedForm	1	69.6	0.13	0.720
GrainType:ParticleSize:FeedForm	1	70.0	0.01	0.940

Neither of the covariates StartWeight and TotTroughResDM21day were significant, having p-values > 0.050 . The interaction term of ParticleSize and FeedForm was significant, having a p-value of 0.004. Of the random effects there was evidence of Replicate only, this was not significant at the 5% level of significance.

The coefficient of variation for this response is 102.59%. The residual variation was equal to 0.01. If another similar experiment was used to determine treatment differences 9270 replicates would be required. This calculation is based on the residual variation from the analysis of this experiment and allowing for a bound of 3% with a 95% confidence level.

To test the model assumptions the residuals need to be normally distributed, independent and identically distributed. These assumptions are checked visually in the residual graphs below:

Residual Plots



There was not any evidence to suggest that the assumptions associated with the residuals had been violated, therefore, there is no need to transform the data.

The predicted interaction of ParticleSize and FeedForm values follows:

ParticleSize	FeedForm	Predicted Value	Standard Error	Ranking
Ground	PELLET	0.056	0.022	a
Ground+Recycled	MASH	0.077	0.022	ab
Ground+Recycled	PELLET	0.121	0.024	bc
Ground	MASH	0.138	0.022	c

The predicted Diet values follow:

GrainType	ParticleSize	FeedForm	Predicted Value	Standard Error
BARLEY	Ground	MASH	0.130	0.030
BARLEY	Ground	PELLET	0.042	0.031
BARLEY	Ground+Recycled	MASH	0.072	0.031
BARLEY	Ground+Recycled	PELLET	0.107	0.034
SORGHUM	Ground	MASH	0.146	0.032
SORGHUM	Ground	PELLET	0.070	0.029
SORGHUM	Ground+Recycled	MASH	0.082	0.030
SORGHUM	Ground+Recycled	PELLET	0.136	0.031

Bibliography

Butler, D., Cullis, B., Gilmour, A. & Gogel, B. (2007), *ASReml-R reference manual*,
The State of Queensland, Department of Primary Industries and Fisheries.