DH001

The effect of grain type, processing, and particle size on digestibility in weaner pigs

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Introduction

The aim of this experiment is to consider the main effects of, and interactions between, grain type (Sorghum or Barley), diet state (pellet or mash), and particle size (ground or ground & recycled) on a number of different digestibility traits associated with weaner pigs.

The experiment comprises a total of 8 diets (the factorial of grain type, diet state, and particle size). Each diet was fed to a single weaner pig in a cage for 26 days where the first 5 days were an adaption period. Digestibility traits were measured every 7 days for 21 days after the adaption period. This report is based on 21 day data. The traits measured were average daily intake, rate of gain, feed conversion ratio, feed total intake, and total weight gain which are referred to in this report as "adi021", "rog021", "fcr021", "fti021", and "twt021" respectively.

The 8 diets are replicated 20 times so that there are a total of 160 pigs. Pigs were kept in cages that were organised in a 40 row by 5 column array (a total of 200 cages) where the first two columns, third and fourth columns, and the fifth column are separate cage "blocks". In this report these 3 blocks are referred to as "cblock". The first 17 cages in the first column, 4 cages in the fifth column from row 17 to 20, and 19 random cages throughout the rest of the cage layout were not used. The 8 diets were completely randomised to pigs in cages.

Statistical analysis

Note that "adi021" & "fti021" and "rog021" & "twt021" are very nearly perfectly correlated ($\rho > 0.99$ for both) so only results for "adi021" and "rog021" are presented. Furthermore, two outliers were identified for the traits "adi021" and "fcr021" and have been removed (MCatID 39707 and 39673). The statistical computing software R (R Development Core Team, 2009) and the R package `asreml` (Butler et al., 2007) were used for fitting a linear mixed model to the following traits - "adi021", "rog021", and "fcr021". The following linear mixed model, written in symbolic notation, was fitted to these traits.

$$
\begin{aligned}
\text{trait response} \quad \sim \quad & \text{mean} + \text{gtype} + \text{state} + \text{size} + \text{STWT} \\
& \text{gtype:state} + \text{gtype:size} + \text{state:size} \\
& \text{gtype:state:size} + \mathbf{cblock} + \mathbf{row} + \mathbf{col}
\end{aligned}
$$

The terms "gtype", "state", and "size" refer to grain type, diet state, and particle size respectively. The term "STWT" refers to pig start weight and is fitted as a covariate. Terms in bold typeface are fitted as random effects to determine if any

variation can be attributed to cage blocks, cage rows, or cage columns. For all traits the main effects of, and interactions between grain type, diet state and particle size have been tested using incremental F-statistics. These are provided below in the Results section.

Results

The Results section is divided into four sections. The first presents incremental F-statistics and associated p-values for the main effects of, and interactions between grain type, diet state, and particle size (Table 1).

The second section presents the predicted means and standard errors for all treatments, i.e., predicted means have been produced at the second order interaction level of gtype, state, and size (Table 2). Given the results in Table 1 this is not the appropriate level at which to consider significant differences between treatments as the second order interaction of gtype, state, and size is not significant (at the 5% level) for any of the 3 traits considered.

The third section presents predicted means, standard errors, average standard errors of difference, and least significant differences (LSD) at the 5% level. These statistics have been produced at the appropriate level, i.e., at the highest interaction level for which an incremental F-statistic was significant (at the 5% level).

The fourth and final section presents sources of random variation as a percentage of total random variation. This is used to determine if experimental or management factors are significant sources of variation.

Incremental F-statistics and associated p-values

Incremental F-statistics and associated p-values for the digestibility traits "adi021", "rog021", and "fcr021" are presented in Table 1. The covariate STWT is highly significant for "adi021" and "rog021" but not significant for "fcr021". This result is biologically sensible given that "fcr021" is a ratio.

The second order interaction of gtype, state, and sze is not significant at the 5% level for any of the 3 traits considered. The first order interaction of gtype and state is significant at the 5% level for both "adi021" and "rog021". For "adi021" the main effect of size is also significant. For "fcr021" the first order interaction of state and size is significant at the 5% level and the main effect of gtype is also significant.

Table 1: Incremental F-statistics and associated p-values for the main effects of, and interactions between "gtype", "state", and "size" for the digestibility traits "adi021", "rog021", and "fcr021".

	adi021		rog021		fcr021	
Term	F-inc.	p-val	F-inc.	p-val	F-inc.	p-val
gtype	10.45	0.003	0.20	0.659	16.46	<0.001
state	3.88	0.058	0.38	0.544	1.78	0.193
size	7.63	0.010	0.37	0.546	11.73	0.002
STWT	31.90	<0.001	56.66	<0.001	1.87	0.181
gtype:state	4.80	0.036	9.10	0.005	0.81	0.376
gtype:size	3.63	0.066	2.06	0.162	0.27	0.604
state:size	0.32	0.576	3.37	0.076	9.74	0.004
gtype:state:size	2.50	0.124	0.38	0.541	1.48	0.233

Predicted means and standard errors for all treatments

The predicted means and standard errors for all treatments is presented in Table 2. This table should not be used to conduct formal tests of differences between treatments given the results in Table 1.

Table 2: Predicted means ($\hat{\mu}$) and standard errors ($\hat{\sigma}$) for all treatments for the traits "adi021", "rog021", and "fcr021"

			adi021		rog021		fcr021	
gtype	state	size	$\hat{\mu}$	$\hat{\sigma}$	$\hat{\mu}$	$\hat{\sigma}$	$\hat{\mu}$	$\hat{\sigma}$
BARLEY	MASH	ground	0.47	0.027	0.23	0.013	2.06	0.094
BARLEY	MASH	ground + recycled	0.47	0.026	0.27	0.013	1.75	0.089
BARLEY	PELLET	ground	0.49	0.027	0.27	0.013	1.79	0.094
BARLEY	PELLET	ground + recycled	0.45	0.027	0.27	0.013	1.73	0.094
SORGHUM	MASH	ground	0.63	0.026	0.27	0.013	2.38	0.091
SORGHUM	MASH	ground + recycled	0.50	0.027	0.27	0.013	1.85	0.091
SORGHUM	PELLET	ground	0.50	0.028	0.25	0.013	2.06	0.097
SORGHUM	PELLET	ground + recycled	0.46	0.028	0.23	0.014	2.11	0.096

Predicted means for considering significant differences between treatments

In Table 1 the first order interaction of gtype and state is significant at the 5% level for both "adi021" and "rog021" and therefore it is appropriate to produce predicted means at that level (Table 3). For "adi021" the main effect of size is also significant, and since there are no significant interactions containing size, it is appropriate to produce predicted means for size (Table 4).

For "fcr021" the first order interaction of state and size is significant at the 5% level and therefore predicted means are presented at that level (Table 5). The main effect of gtype is also significant, and since there are no significant interactions containing gtype, it is appropriate to produce predicted means for gtype (Table 6).

Table 3: Predicted means ($\hat{\mu}$), standard errors ($\hat{\sigma}$), average standard error of differences (avsed), and least significant differences (LSD) at the 5% level for the traits "adi021" and "rog021" based on the first order interaction of gtype and state.

		adi021		rog021	
gtype	state	$\hat{\mu}$	$\hat{\sigma}$	$\hat{\mu}$	$\hat{\sigma}$
BARLEY	MASH	0.47	0.019	0.25	0.009
BARLEY	PELLET	0.47	0.020	0.27	0.009
SORGHUM	MASH	0.56	0.019	0.27	0.009
SORGHUM	PELLET	0.48	0.020	0.24	0.010
	avsed	0.027		0.013	
	LSD (5%)	0.054		0.026	

Table 4: Predicted means ($\hat{\mu}$), standard errors ($\hat{\sigma}$), average standard error of difference (avsed), and least significant difference (LSD) at the 5% level for the trait "adi021" based on the main effect of size.

	adi021	
size	$\hat{\mu}$	$\hat{\sigma}$
ground	0.52	0.014
ground + recycled	0.47	0.014
avsed	0.019	
LSD (5%)	0.038	

Table 5: Predicted means ($\hat{\mu}$), standard errors ($\hat{\sigma}$), average standard error of difference (avsed), and least significant difference (LSD) at the 5% level for the trait "fcr021" based on the first order interaction of state and size.

state	size	fcr021 $\hat{\mu}$	$\hat{\sigma}$
MASH	ground	2.22	0.065
MASH	ground + recycled	1.80	0.064
PELLET	ground	1.93	0.067
PELLET	ground + recycled	1.92	0.067
	avsed	0.093	
	LSD (5%)	0.190	

Table 6: Predicted means ($\hat{\mu}$), standard errors ($\hat{\sigma}$), average standard error of difference (avsed), and least significant difference (LSD) at the 5% level for the trait "fcr021" based on the main effect of gtype.

gtype	fcr021 $\hat{\mu}$	$\hat{\sigma}$
BARLEY	1.83	0.046
SORGHUM	2.10	0.047
avsed	0.066	
LSD (5%)	0.134	

Sources of total random variation

Little or no variation could be attributed to cage blocks, cage rows, or cage columns (Table 7).

Table 7: Sources of variation (as a percentage of total variation) for the traits "adi021", "rog021", and "fcr021".

	adi021	rog021	fcr021
cblock	0.00	0.00	0.00
row	0.06	0.00	0.00
col	0.01	0.00	0.00
residual	0.94	1.00	1.00

References

Butler, D., Cullis, B., Gilmour, A., and Gogel, B. (2007). *ASReml-R reference manual.* ISSN 0812-0005.

R Development Core Team (2009). *R: A Language and Environment for Statistical Computing.* R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0.