Statistics for the Australian Pork Industry (SAPI)

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Co-operative Research Centre for High Integrity Australian Pork

By

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Executive Summary

The Pork CRC invested in statistical support after it was found that a large number of experiments conducted under the Premium Grains for Livestock Project (PGLP) were unfit for the purpose for which they were intended. In particular, it was not possible to be able to compare grains across experiments due to the low level of "connectivity" (comprising a single grain) between experiments.

The broad aim of the Statistics for the Australian Pork Industry (SAPI) project is to lower the risk associated with poor experimental outcomes by ensuring that for all experiments conducted under Program 4B there is a clear statement of the research question, an appropriate statistical design to answer that question, and that experimental data are analysed in an appropriate manner.

A major achievement of this project has been the application of so called multi-phase designs to experiments which involve the manufacture of a pellet which is then fed to pigs. In this project, it has been shown that variation at the pelleting stage can be an important source of non-grain variation. Furthermore, research undertaken as part of this project has shown, that by accounting for these sources of non-grain variation, the number of animals used in the experiment can be reduced. This has important animal ethics considerations. The adoption of proper design has also reduced the non-grain variation in experiments by ~ 80%, improving the estimate of faecal DE from ± 0.35 to ± 0.16 MJ/kg as fed for one experiment conducted at UQ.

This project has met and exceeded the aforementioned broad aims. Our recommendation is that a statistician continues to part of the Pork CRC's collaborative research program and that statistical research, particularly into optimal designs insofar as resource allocation is concerned, is encouraged.

Table of Contents

1. Introduction

During the first three years of the Premium Grains for Livestock Program (PGLP) a statistician was not associated with the research conducted under this program. During this period the PGLP conducted a number of experiments, however the experimental design only provided for one grain to be used as connectivity across all experiments. This proved to be totally inadequate. Approximately 30% of the grains in the experiments would need to be in common across experiments to be able to accurately compare grains in different experiments. Most of the results from these three years of research could not be used subsequently for development of NIR calibrations. A statistician has been part of this project and the subsequent Pork CRC and broiler NIR projects ever since.

2. Methodology

The primary responsibilities of the statistician attached to this project are:

1. Reviewing the protocol for every experiment to ensure there is a valid hypothesis that can be tested and interaction with Project Leaders.

2. Designing the order for milling and processing diets in partially or fully replicated experimental designs.

3. Designing animal experiments to account for all non-treatment variation including pelleting batch, pelleting day, pen, pig, live weight, feeding run and feeding period etc.

4. Analysing experiments to determine statistically significant treatment differences and interactions.

5. Providing spreadsheets with statistically corrected mean values and standard errors for all experimental treatments.

6. Writing reports on the statistical analyses for research scientists.

7. Undertaking simulations and other analyses to determine how best to optimise resource use in multi-phase (pellet manufacture and pig feeding) designs.

8. Analysing results across all experiments designed to determine ileal and faecal digestible energy (DE) content or DE intake of cereal grains for pigs to provide statistically corrected results for individual grains across all experiments. This analysis must be conducted every time a new experiment is completed with repeated 'connectivity' grains to bring all experiments into one overall experiment across time from the first Premium Grains for Livestock Program (PGLP) experiment to the last Pork CRC experiment. A similar process is used for all broiler experiments now they are under the AusScan project.

A major focus (and achievement) of this project has been the implementation of modern statistical designs followed by appropriate analyses of experimental data.

3. Outcomes

A full list of the Statistics for Australian Pork Industry (SAPI) project collaborative outcomes is provided in Table 1.

Table 1: SAPI collaborative work

AIA/TiO2 – ileal/faecal/diet AIA and TiO2 comparison (design/analysis)
CAD001 - new lines for NIR calibration (design/analysis/report)
PS028 - particle size (design/analysis/report)
PS029 - moisture (design/analysis/report)
PS030 - starch (design/analysis/report)
PS031 - protein (design/analysis/report)
PS032 - fat (design/analysis/report)
PS033 - AIA (design/analysis/report)
PS034 - pasting (RVA) (design/analysis/report)
PS035 - in-vitro starch digestion (design/analysis/report)
PS036 - in-vitro protein digestion (design/analysis/report)
PS037 - gelatinisation (design/analysis/report)
PS038 - Rivalea weaner trial - peas (design/analysis/report)
PS039 - Rivalea weaner trial - sorghum (design/analysis/report)
PS040 - Digestibility trial – sorghum/peas (design)
ER001 - chemosensing (design/analysis/report)
ER002 - chemosensing (design/analysis/report)
ER003 - chemosensing (design/analysis/report)
ER004 - chemosensing (design/analysis/report)
ER005 - chemosensing (design/analysis/report)
ER006 - chemosensing (design)
MUL001 - Dan Mullan field trial data 2009-2011 (analysis/report)
SYM001 - Symbio lab analysis (design/analysis)
NG001 - digestibility experiment (design/analysis)
NG002 - digestibility experiment (design/analysis)
NIR/pigs - meta analysis of existing data and incl. NG001 and NG002
MU001 - Melbourne University digestibility trial (design)
MU002 – Melbourne University digestibility trial (design)
MU003 – Melbourne University digestibility trial (design)
MU004 – Melbourne University digestibility trial (design)
MU005 – Melbourne University digestibility trial (design)
TE001 – Lysine data (analysis)
WA001 – Weaner intake trial (design/analysis/report)
WA002 – Weaner intake trial (design)
WA003 – Weaner intake trial (design)

Several abstracts were submitted and accepted to the APSA conference (Melbourne, 24-27 November 2013) with Dr Simon Diffey as a coauthor. A list of submitted abstracts is provided in Table 2.

Table 2: Submitted abstracts to APSA conference (Melbourne, 24-27 November 2013)

1. E. Roura, B. Shrestha, and S. Diffey. Pigs show very high preference and sensory-motivated intake for low levels of tartaric and phosphoric acids
2. E. Roura, B. Shrestha, and S. Diffey. Preference and sensory-motivated intake for four high intensity sweeteners in piglets.
3. E. Roura, B. Shrestha, and S. Diffey. Pigs show high sensory-motivated intake for low levels of dextrose but not for low levels of maltodextrins.
4. E. Roura, B. Shrestha, and S. Diffey. Pigs show no sensory-motivated intake for several cereal and tuber starches except hydrolysed corn starch.
5. J.L. Black, P.C. Flinn, S. Diffey, and A.M. Tredrea. Update on Near Infrared Reflectance Analysis of Cereal Grains to Estimate Digestible Energy for Pigs.
6. S. Diffey. A comparison of two statistical models for estimating digestion curves.
7. S. Diffey. Resource allocation for pig feed intake and digestibility experiments.

The last 2 abstracts were withdrawn based on the referees' comments, the one page limit, and in consultation with Dr John Black.

Statistical research undertaken as part of this project is described below.

1. Using linear mixed models incorporating cubic smoothing splines (LMM-CSS) to estimate the digestogram associated with rapid in-vitro starch digestion rather than using a first order kinetic model (FOKM) or one its' derivatives. In PS035 it was shown that using a LMM-CSS had a mean square error of prediction 38% less than using a FOKM. Furthermore, treatment and non-treatment effects can be accommodated in a LMM-CSS whereas this is not the case for a FOKM. The latter relies on an inefficient two stage procedure to determine treatment (and non-treatment) effects.
2. A simulation study conducted at the design stage of Rivalea weaner trial 2 (PS038) showed that the number of pigs used in these trials could be reduced significantly if resources were instead allocated to replicating diets produced in the pelleting stage. A number of experiments have now shown that variation between pelleting batches, variation between pelleting days, and variation between pelleting sessions (morning and afternoon) are potentially significant sources of non-treatment variation. In the presence of variation at the pelleting stage there is little to be gained in terms of the power of an experiment (ability to detect treatment effects) by sampling more pigs (e.g. going from 10 pigs to 30 pigs per treatment). In these situations it may be better (in terms of the power of the experiment) to reallocate resources so that the total number of pigs is reduced but diets produced at the pelleting stage are fully (rather than partially) replicated.

4. Application of Research

A major focus (and achievement) of this project has been the application of modern statistical designs followed by appropriate analyses of experimental data. A number of experiments involve the manufacture of pelleted grains which are later fed to pigs. By applying multi-phase designs in these types of experiments we have been able to show that variation at the pelleting stage can be an important

source of non-grain variation. Furthermore, research undertaken as part of this project has shown that by accounting for these sources of non-grain variation the number of animals used in the experiment can be reduced. This has important animal ethics considerations.

5. Conclusion

This project has contributed to the research program of the Pork CRC by ensuring that there is a clear statement of the research question, an appropriate statistical design to answer that question, and that experimental data is analysed in an appropriate manner. These three combined lower the risks associated with a poor experimental outcome and are therefore of significant benefit to the Pork CRC.

6. Limitations/Risks

No risks associated with this project.

7. Recommendations

As a result of the outcomes in this project the following recommendations have been made:
   1. For experiments requiring the manufacture of pellet diets that mutli-phase (pelleting and pig feeding) designs are a prerequisite.
   2. The Pork CRC continues to encourage statistical research into statistical design in order to optimize the use of scarce experimental resources.
   3. A statistician continues to be a part of the Pork CRC's collaborative research program.