Determining the variability of in-service SKCS instruments

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1. BACKGROUND

Single Kernel Characterisation System (SKCS 4100) instruments (Perten, Hägersten, Sweden) are used to measure grain uniformity and can differentiate grain hardness classes in wheat and help identify suitability of barley for pearl- ing and shochu production. Parameters including grain weight (mg), diameter (mm), moisture (%) and hardness (crushing force profile hardness index) are determined on an individual kernel basis from an approximate sample size of 300 kernels, which provides an estimate of the average and standard deviation of the bulk sample.

SKCS instruments are factory calibrated to NIST standards on assembly however these are not readily accessible to recalibrate and maintain instruments to original specifications to account for wear and tear over time.

2. EXPERIMENTAL

In this study a ring test was organised to determine the variability of six in-service SKCS instruments, of various ages, belonging to three individual grain industry laboratories. Six samples each of wheat and barley, assembled over a range in grain hardness, were used in a randomised block design experiment. Participating laboratories tested the samples according to a predefined randomised order over three test occasions (runs) which also included replication within runs (run reps) to account for wear and tear over time.

3. STATISTICAL ANALYSIS

A linear mixed model* was used to predict the effects associated with the SKCS machines after removing the fixed effect of test samples.

Table 1 shows the estimated variance terms derived from the model for each commodity and SKCS machine parameter. The largest variance component was attributed to machine effect in each case for this data set, with larger coefficients for barley than wheat, suggesting machines performed differently between commodities. The variance components for run and interaction terms were much smaller in comparison to machine effects, indicating high precision both within runs and between runs for each machine.

4. MACHINE VARIATION FOR SKCS PARAMETERS

The REML model was used to produce best linear unbiased prediction (BLUP) interval plots for each SKCS parameter for both barley (Figure 1) and wheat (Figure 2). The plots show prediction intervals and deviations from the estimated means (in parameter units) for each machine in cumulative distribution order. Overlapping prediction intervals indicate similar machine responses and those further from the overall estimated parameter mean indicate greater bias.

As interpreted from Figure 1 and Figure 2:

• Machine A generally showed the highest deviations above the mean for moisture, hardness and weight in both commodities while those for diameter were closer to the mean.
• Machine B deviations were generally below the mean for moisture, hardness, diameter while for weight they were above the mean in both cases.
• Machine C also generally showed deviations below the mean for moisture, diameter, weight and hardness was close to the mean for barley but highest above the mean in wheat.
• Machine D showed deviations above the mean for moisture and below for hardness but generally the other parameters were very close to the mean.
• Machine E parameter deviations were above the mean for moisture and below for hardness and near the mean for diameter and weight.
• Machine F had deviations near the mean for moisture, weight and hardness in barley but the lowest in wheat and the highest deviations above the mean for diameter.

Age of machine does appear to impact results. As a comparative reference, the age rankings for the machines in the study were: A-B-C-D-E-F (machine age ranking, oldest to youngest, according to serial number).

The machines were ranked in the same order for the diameter measure for both commodities and similarly for weight except machines F and D. The machines were also ranked similarly for moisture but there was greater ranking variation amongst machines for hardness between commodities.

5. CONCLUSIONS

This study set out to investigate the variation between SKCS instruments for two commodities between a number of in-service SKCS machines of varying ages. From the preliminary data we found that the machines performed consistently with low prediction intervals (high precision) and some parameter trends were similar across both commodities however some machines showed a consistent bias in one or more of the reported parameters. It is hoped that this exercise will facilitate practice change for the long term maintenance of SKCS machines in order to ensure standardised instrument operations.

Acknowledgements

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* lmer(y ~ Sample + (1|Run)+ (1|Machine)+ (1|Run:Machine)+ (1|Run:Machine:Sample), data=barley or wheat)