

# INTERNATIONAL WOOL TEXTILE ORGANISATION

## IWTO TECHNOLOGY & COMMITTEE

## NICE MEETING

Raw Wool Group

December 1998

Chairman: A.C. BOTES (South Africa)

Report No: RWG 01

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Review of the Subsample Mass Limit for Yield Testing of Scoured Wool

by

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### SUMMARY

*Since the introduction of blending into AWTA Ltd's procedure for yield testing of scoured wool, difficulties have been experienced by operators in placing the minimum subsample mass of 100 grams into a drying can. In order to minimise this problem, a trial has been completed to assess the impact on the testing precision of reducing the minimum subsample mass to 80 grams. The results of the investigation indicate no significant effects on either the result that would be certified or the testing precision and it is therefore recommended that IWTO-33-88(E) be amended to allow for a minimum subsample mass of 80 grams.*

### INTRODUCTION

In December 1995, a paper<sup>1</sup> was presented which evaluated a prototype blender for core samples of scoured and carbonised wool. The blender was designed to minimise static electricity thus allowing scoured or carbonised wool to be blended when Wool Base or other parameters were to be measured. The results of the evaluation demonstrated that the prototype blender provided a satisfactory way of blending core samples of scoured or carbonised wool.

In a supporting paper<sup>2</sup> to the above, amendments were proposed to IWTO-33-88(E) that stated, "the whole of the representative global sample drawn from the lot (ie. not less than 500g) must be used to determine Oven-Dry mass unless the global sample is blended." The paper made a further recommendation stating that, "After blending, reweigh the sample to 0.1g and use the mass ( $W_b$ ) for determining the factor  $W_b / W$ . Immediately after reweighing, draw at least 3 subsamples of not less than 100g and weigh each to 0.1g."

Since the introduction of the scoured wool blender into each of the three AWTA Ltd laboratories, difficulties, due to the bulk of the subsample, have been experienced by laboratory operators in trying to place a 100g subsample of scoured wool into a drying can.

A potential solution to the problem is to reduce the minimum subsample weight required for determining Oven-Dry mass and additional information such as Wool Base, Vegetable Matter Base, Ash Content, and Residual Fatty Matter. The following trial aimed to assess the effect on these components using a minimum subsample mass of 80 grams compared to the 100 grams required in IWTO-33-88(E).

### MATERIALS AND METHOD

In the first quarter of 1998, ILRT members participated in a series of trials using scoured wool. A total of 40 trials were involved in the ILRT series with samples being supplied from both New Zealand and Australia. The components measured in each trial included Wool Base, Vegetable Matter Base, and Mean Fibre Diameter.

The testing process for the trial involved using the scoured wool blender to homogenise each sample prior to weighing three subsamples of 100 grams. These subsamples were then dried to obtain an Oven-Dry % and then processed to obtain Wool Base, Vegetable Matter Base, and Mean Fibre Diameter.

During trial numbers 18-40, AWTa Ltd laboratories weighed an additional three subsamples of 80 grams from the blended global sample. These subsamples were obtained subsequent to removing the three 100 gram subsamples required for the ILRT. Each subsample was then dried to achieve an Oven-Dry % and processed to determine Wool Base, Vegetable Matter Base, and Mean Fibre Diameter.

An evaluation of 80 gram subsample mass was made by comparing the Oven-Dry %, Ash Content, Alcohol Extractable Matter, Wool Base, Vegetable Matter, and Mean Fibre Diameter against the results obtained for the corresponding 100 gram subsample mass in the ILRT. Analysis was performed according to Appendix B of IWTO-0.

## RESULTS AND DISCUSSION

- Overall Relative Bias

Results of the comparison between 100 gram subsamples and 80 gram subsamples are shown in Table 1. The analysis of each tested component involved performing a paired t-test on the data obtained from the AWTa Ltd laboratories for the 23 trials. One trial from Sydney was excluded due to the loss of data for one set of subsamples reducing the paired comparisons available from 69 to 68.

Table 1: Comparison of Test Components for 100 gram and 80 gram Subsamples

|             |             | 80 gram Subsample | 100 gram Subsample | Difference (80g - 100g) | Significance |
|-------------|-------------|-------------------|--------------------|-------------------------|--------------|
| Oven Dry %  | Number      | 68                | 68                 |                         | NS           |
|             | Average (%) | 90.82             | 90.82              | -0.002                  |              |
|             | SD (%)      | 1.20              | 1.09               | 0.396                   |              |
|             | SE (%)      | 0.15              | 0.13               | 0.048                   |              |
|             | t-value     | 621.68            | 690.17             | -0.050                  |              |
|             | p-value     | 0.00              | 0.00               | 0.960                   |              |
| Ash Content | Number      | 68                | 68                 |                         | NS           |
|             | Average (%) | 1.11              | 1.10               | 0.01                    |              |
|             | SD (%)      | 0.27              | 0.28               | 0.142                   |              |
|             | SE (%)      | 0.03              | 0.03               | 0.017                   |              |
|             | t-value     | 33.56             | 31.73              | 1.121                   |              |
|             | p-value     | 0.00              | 0.00               | 0.266                   |              |
| AEM %       | Number      | 68                | 68                 |                         | NS           |
|             | Average (%) | 1.23              | 1.24               | -0.01                   |              |
|             | SD (%)      | 0.24              | 0.26               | 0.179                   |              |
|             | SE (%)      | 0.03              | 0.03               | 0.022                   |              |
|             | t-value     | 42.94             | 39.71              | -0.657                  |              |
|             | p-value     | 0.00              | 0.00               | 0.513                   |              |

|                       |             | 80 gram Subsample | 100 gram Subsample | Difference (80g - 100g) | Significance |
|-----------------------|-------------|-------------------|--------------------|-------------------------|--------------|
| Wool Base %           | Number      | 68                | 68                 |                         | NS           |
|                       | Average (%) | 87.27             | 87.32              | -0.05                   |              |
|                       | SD (%)      | 1.83              | 1.71               | 0.482                   |              |
|                       | SE (%)      | 0.22              | 0.20               | 0.059                   |              |
|                       | t-value     | 393.18            | 421.54             | -0.885                  |              |
|                       | p-value     | 0.00              | 0.00               | 0.379                   |              |
| VMB%                  | Number      | 68                | 68                 |                         | NS           |
|                       | Average (%) | 1.37              | 1.33               | 0.04                    |              |
|                       | SD (%)      | 0.84              | 0.82               | 0.177                   |              |
|                       | SE (%)      | 0.10              | 0.10               | 0.022                   |              |
|                       | t-value     | 13.43             | 13.25              | 1.916                   |              |
|                       | p-value     | 0.00              | 0.00               | 0.060                   |              |
| MFD ( $\mu\text{m}$ ) | Number      | 68                | 68                 |                         | NS           |
|                       | Average (%) | 23.50             | 23.43              | 0.07                    |              |
|                       | SD (%)      | 5.86              | 5.76               | 0.317                   |              |
|                       | SE (%)      | 0.71              | 0.70               | 0.038                   |              |
|                       | t-value     | 33.04             | 33.53              | 1.681                   |              |
|                       | p-value     | 0.00              | 0.00               | 0.097                   |              |

Based on the paired t-tests, there were no significant differences in any of the tested components at the 95% level of confidence. From this evidence, it can be concluded there is no overall bias in test results achieved between 100 gram subsamples and 80 gram subsamples.

- Level Dependent Bias

For each of the tested components, a Geometric Functional Regression (GM) and Differences versus Average Regression (DVA) was performed to determine whether a level dependent bias existed between 80 gram subsamples and 100 gram subsamples. The results of these regressions are summarised in Table 2.

Table 2: Summary Table for Test of Level Dependent Bias

|             | Regression | Slope  | SE of Slope | t-value | p-value | R <sup>2</sup> | Signif. |
|-------------|------------|--------|-------------|---------|---------|----------------|---------|
| Oven-Dry %  | GM         | 1.110  | 0.044       | 2.478   | 0.016   | 0.894          | *       |
|             | DVA        | 0.107  | 0.041       | 2.615   | 0.011   |                | *       |
| Ash Content | GM         | 0.962  | 0.058       | 0.654   | 0.516   | 0.760          | NS      |
|             | DVA        | -0.041 | 0.064       | 0.641   | 0.524   |                | NS      |
| AEM%        | GM         | 0.914  | 0.076       | 1.136   | 0.260   | 0.548          | NS      |
|             | DVA        | -0.103 | 0.095       | 1.088   | 0.281   |                | NS      |
| Wool Base % | GM         | 1.072  | 0.035       | 2.072   | 0.042   | 0.932          | *       |
|             | DVA        | 0.070  | 0.033       | 2.146   | 0.034   |                | *       |
| VM%         | GM         | 1.017  | 0.026       | 0.652   | 0.517   | 0.955          | NS      |
|             | DVA        | 0.017  | 0.026       | 0.657   | 0.513   |                | NS      |
| MFD         | GM         | 1.018  | 0.007       | 2.740   | 0.008   | 0.997          | **      |

|     |       |       |       |       |    |
|-----|-------|-------|-------|-------|----|
| DVA | 0.018 | 0.006 | 2.764 | 0.007 | ** |
|-----|-------|-------|-------|-------|----|

Appendix 1 shows the relationships graphically, with the Geometric Mean Regression Line as a solid line compared to the  $Y = X$  line. Appendix 2 shows the scatter plot of Difference versus Average for each of the test components with the dashed line as the regression line.

Level dependent biases were identified for Oven-Dry %, Wool Base %, and MFD. In reviewing the Difference versus Average regressions for each of these components, the scatter plots indicate some potential outlier points that could adversely affect the regressions. Dixon tests were applied to two Wool Base % points which resulted in their deletion due to Oven-Dry mass errors. In repeating the regression analysis with these two points removed, a level dependent bias was not evident for Wool Base %. (See Table 3). The level dependent bias for Oven-Dry Mass % did, however, remain. This bias was due to one data point at the extreme end of the regression that could not be deleted as an outlier but did have a significant influence on the remaining points. The removal of this additional point would have removed the level dependent bias.

In reviewing the data for MFD, there were two distinct groupings of micron in the regression (see Appendix 1 & 2). One was centered at 21 micron, while the other smaller grouping was centered at 38 micron. The choice of MFD was dictated by the samples included in the trial. However, these distinct groupings of MFD can reflect the commercial situation in which scoured blends are put together to produce wool with a particular MFD. The large difference between the two micron groups makes the regression statistics quite difficult and accounts for the level dependent bias that was observed. The Difference versus average plot for MFD (see Appendix 2) identifies one point at 38 microns that exceeds the 95% confidence limit. By deleting this one point, the level dependent bias for MFD was removed. This is summarised in Table 3.

Table 3 : Summary Table for Test of Level Dependent Bias with Outliers Removed

|             | Regression | Slope | Signif. | SE of Slope | t-value | p-value | R <sup>2</sup> |
|-------------|------------|-------|---------|-------------|---------|---------|----------------|
| Oven-Dry %  | GM         | 1.062 | *       | 0.025       | 2.444   | 0.017   | 0.964          |
|             | DVA        | 0.061 | *       | 0.024       | 2.520   | 0.014   |                |
| Wool Base % | GM         | 1.043 | NS      | 0.026       | 1.637   | 0.106   | 0.960          |
|             | DVA        | 0.042 | NS      | 0.025       | 1.672   | 0.099   |                |
| MFD         | GM         | 1.011 | NS      | 0.006       | 1.799   | 0.077   | 0.997          |
|             | DVA        | 0.011 | NS      | 0.006       | 1.810   | 0.075   |                |

- Precision Estimates

For all components other than MFD, a one-way analysis of variance was used to estimate the between-laboratory and within-laboratory sources of variance for each of the samples in the trial. (one sample was not included in the analysis due to a loss of data). In order to calculate the within-laboratory variance, each subsample of a test was assumed as a replicate. The variance for each individual subsample was then divided by three to estimate the precision that would be obtained for a three subsample test. Precision limits were not calculated for MFD as there was no replication of samples. Table 4 details the average confidence limits for each component with identified outliers removed. Appendix 3 summarises the Analysis of Variance data for each of the individual samples.

Table 4: Summary of Variances and 95% Confidence Limits (Outliers removed)

|             | <u>100g</u>       |                    |            | <u>80g</u>        |                    |            |
|-------------|-------------------|--------------------|------------|-------------------|--------------------|------------|
|             | $\sigma^2$ within | $\sigma^2$ between | 95% CL     | $\sigma^2$ within | $\sigma^2$ between | 95% CL     |
| ODW         | 0.006             | 0.129              | $\pm 0.72$ | 0.016             | 0.091              | $\pm 0.64$ |
| Ash Content | 0.007             | 0.009              | $\pm 0.25$ | 0.005             | 0.016              | $\pm 0.28$ |
| AEM%        | 0.010             | 0.045              | $\pm 0.46$ | 0.005             | 0.043              | $\pm 0.43$ |
| WB%         | 0.025             | 0.182              | $\pm 0.89$ | 0.037             | 0.205              | $\pm 0.96$ |
| VMB%        | 0.011             | 0.028              | $\pm 0.38$ | 0.011             | 0.022              | $\pm 0.35$ |

Appendix 4 shows the relationship between the 95% confidence limit for each component and the measured result. The regression for the 100 gram subsamples is shown as a dashed line while the regression for 80 gram subsamples is a solid line. For each component, the regression lines were not significantly different from each other at the 95% confidence limit indicating the precision for 80 gram and 100 gram subsamples to be similar.

## CONCLUSION

The data presented in this report demonstrates that a reduction in the minimum subsample mass for yield testing of scoured wool from 100 grams to 80 grams does not change the result that would be certified and does not change the precision of the result. However, the reduction in subsample mass does have the benefit of allowing testing operators to more easily place a blended subsample of scoured wool into a drying can for testing therefore reducing the potential for operator induced error.

It is recommended that Clause 5.3.1 of IWTO-33-88(E) be amended as follows:

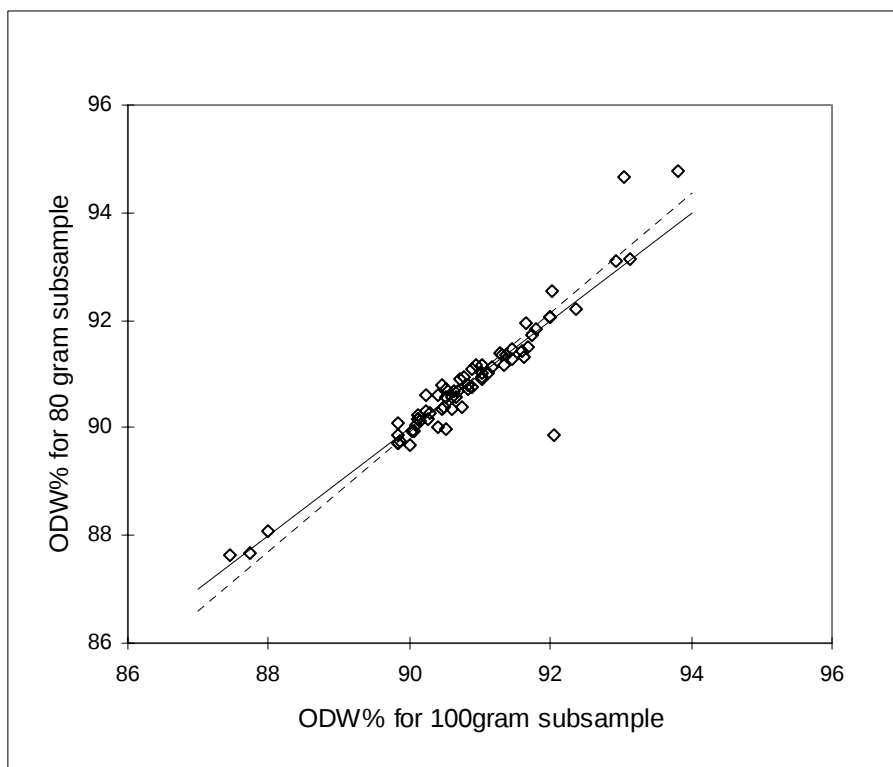
After blending, reweigh the sample to 0.1g and use the mass ( $W_b$ ) for determining the factor  $W_b/W$ . Immediately after reweighing, draw at least 3 subsamples of not less than ~~100g~~ 80g and weigh each to 0.1g.

## REFERENCES

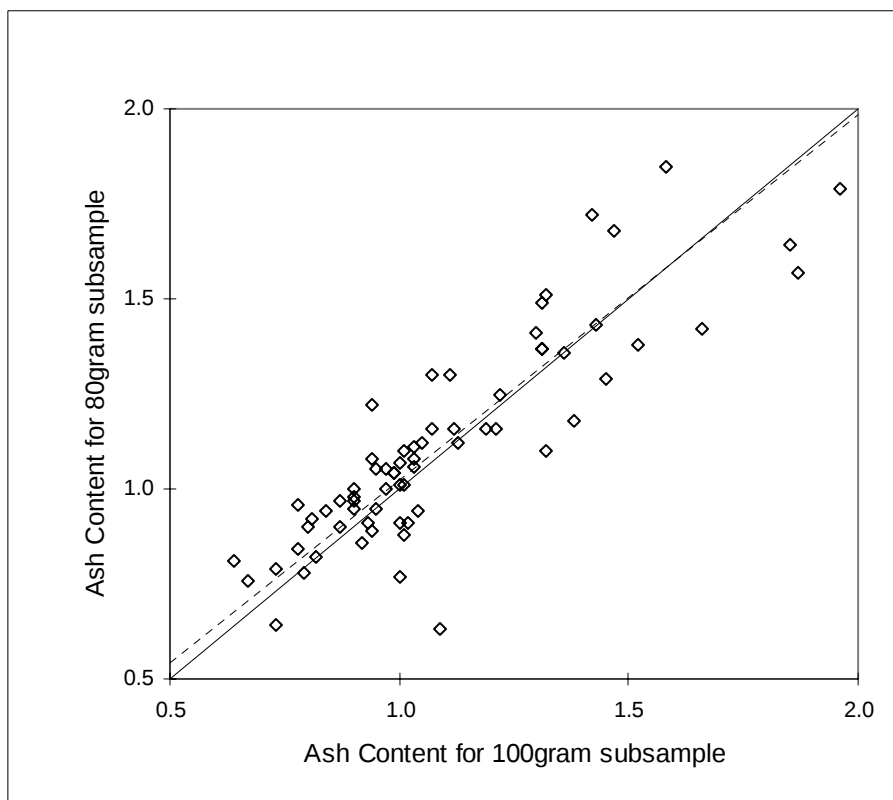
1. Semmel, P.J. and Morgan, P.D. (1995). Evaluation of a prototype blender for core samples of Scoured or Carbonised wool. *International Wool Textile Organisation Tech. Cttee.* Nice Meeting, December 1995. Appendix 3.
2. Ashman, I.A (1995). Review of the procedures in IWTO-19, IWTO-28 and IWTO-33 with respect to blending and subsampling Scoured or Carbonised wool for measurement. *International Wool Textile Organisation Tech. Cttee.* Nice Meeting, December 1995. Appendix 4.

**APPENDIX 1**

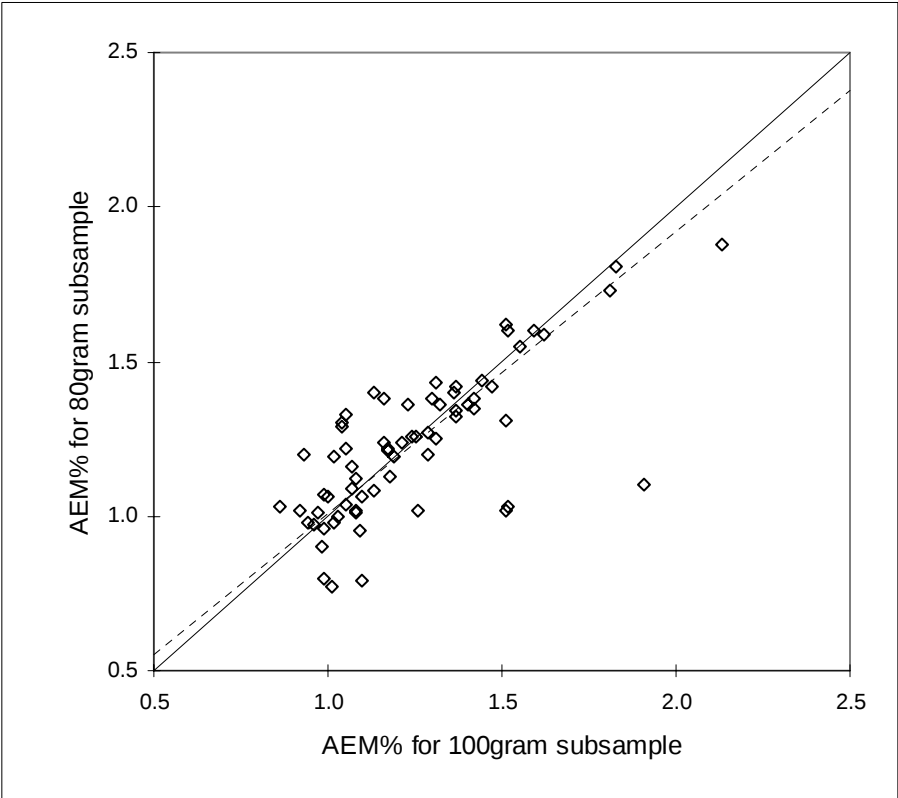
## i) Relationship in ODW% for 80g Subsamples and 100g Subsamples



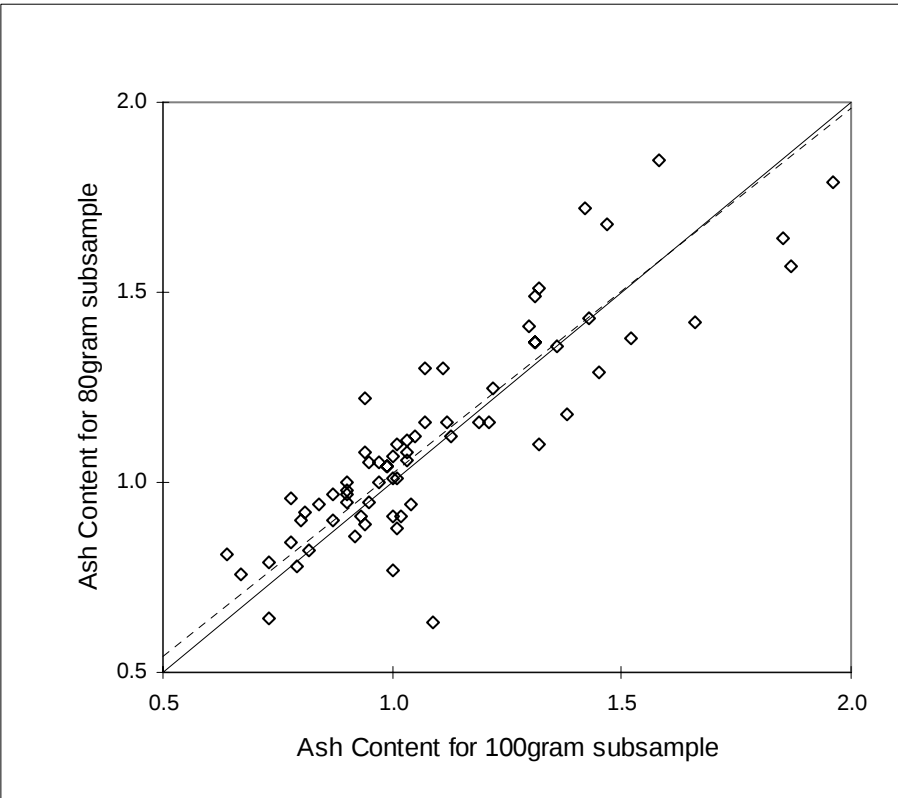
## ii) Relationship in Ash Content for 80g Subsamples and 100g Subsamples



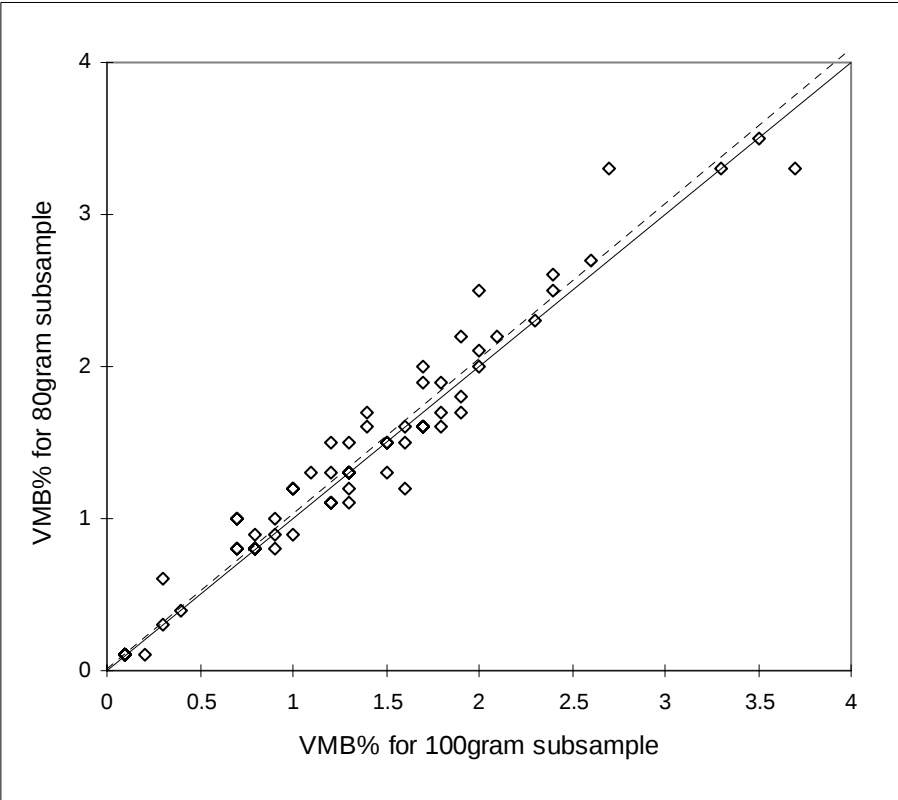
iii) Relationship in AEM% for 80g Subsamples and 100g Subsamples



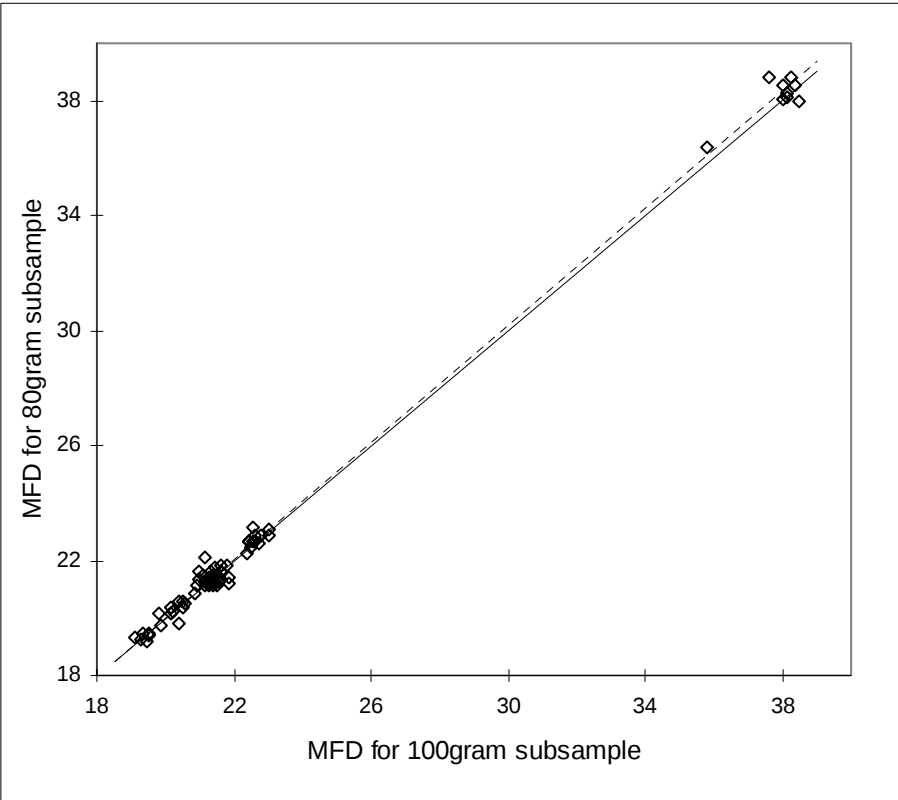
iv) Relationship in WB% for 80g Subsamples and 100g Subsamples



v) Relationship in VMB% for 80g Subsamples and 100g Subsamples

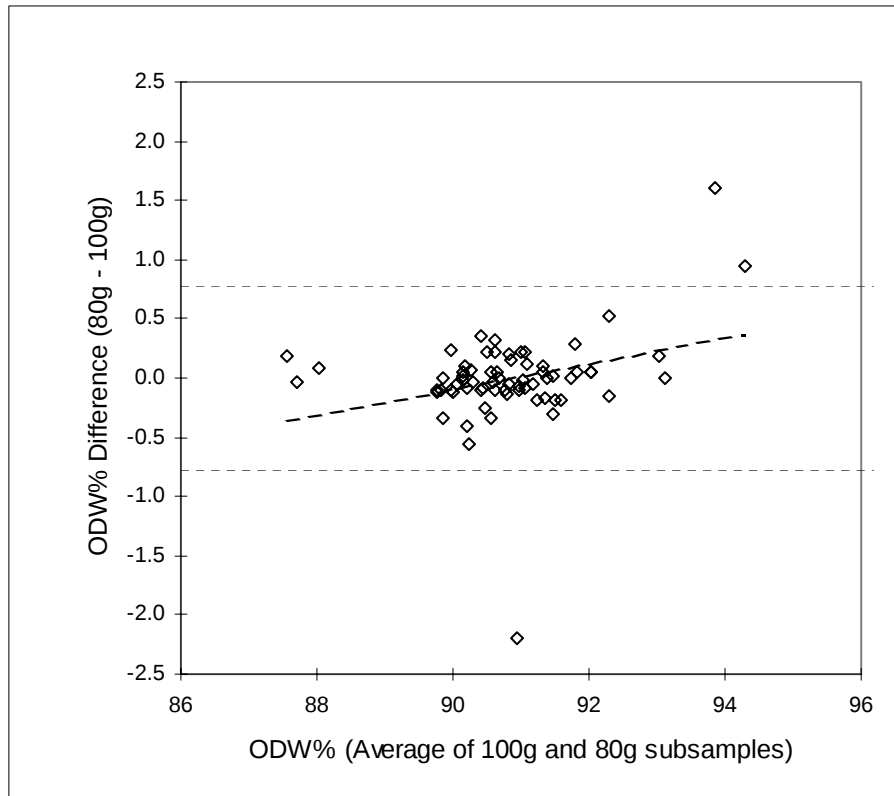


vi) Relationship in MFD for 80g Subsamples and 100g Subsamples

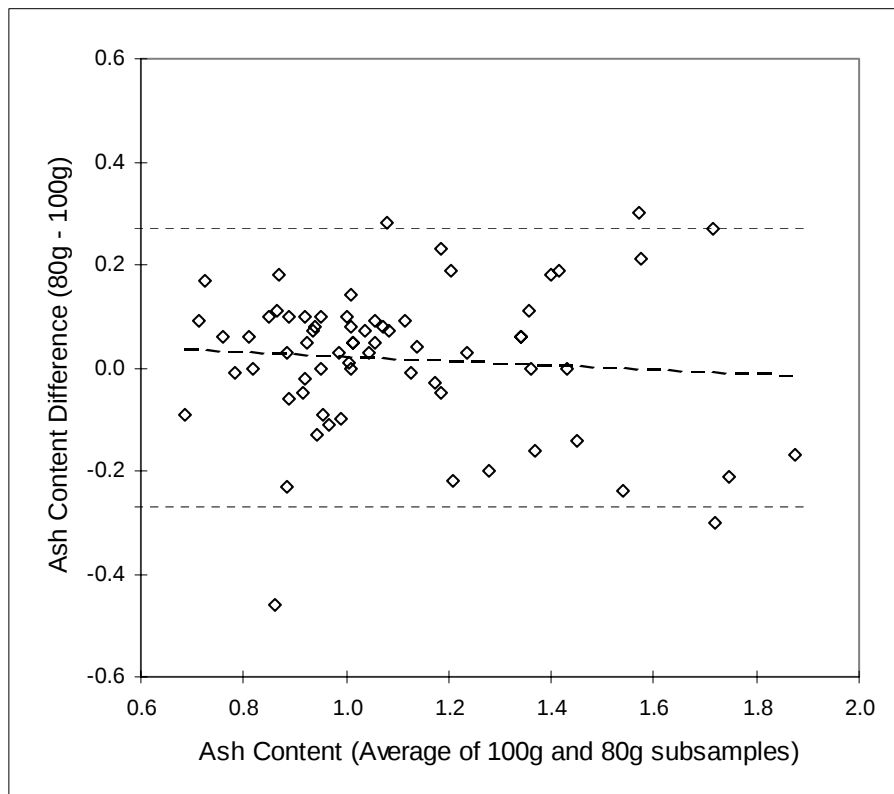


**APPENDIX 2**

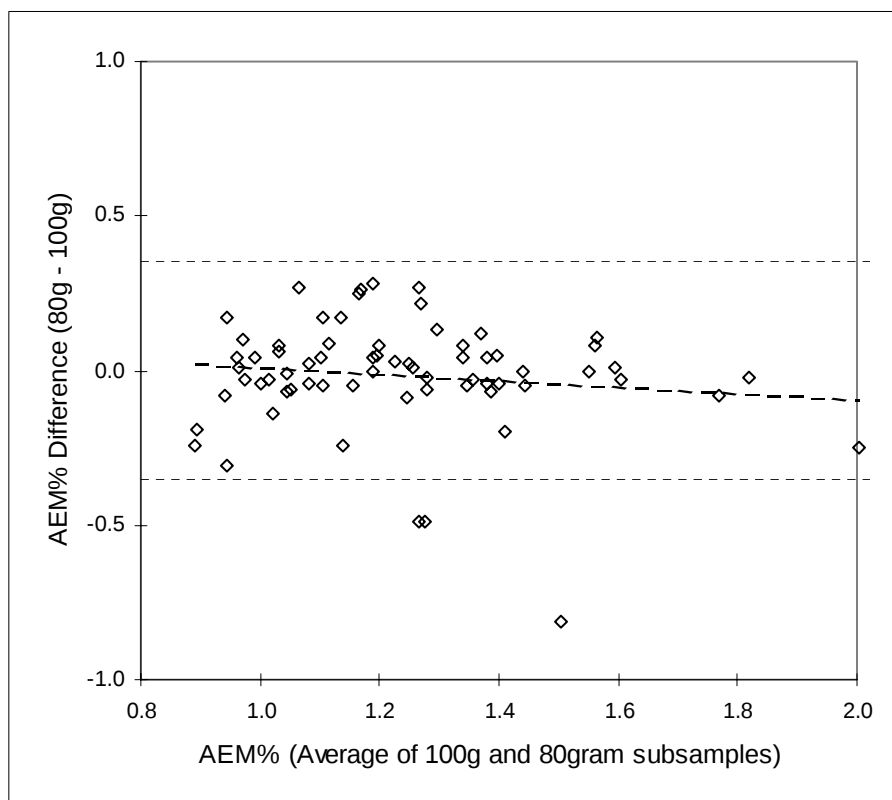
## i) ODW Comparison for 100 gram and 80 gram Subsamples



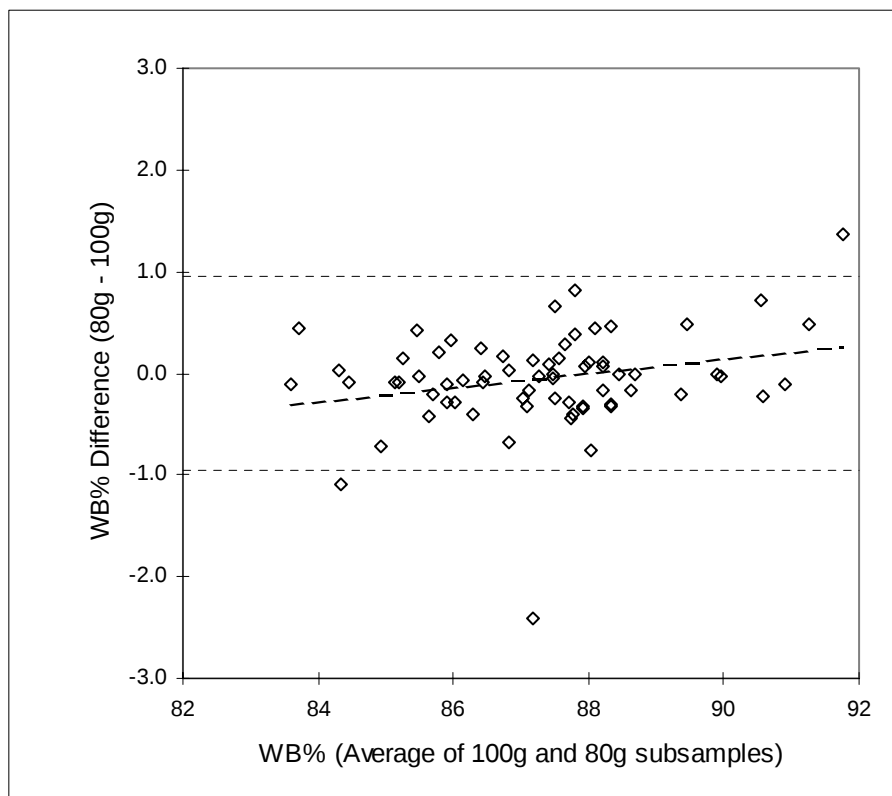
## ii) Ash Content Comparison for 100 gram and 80 gram Subsamples



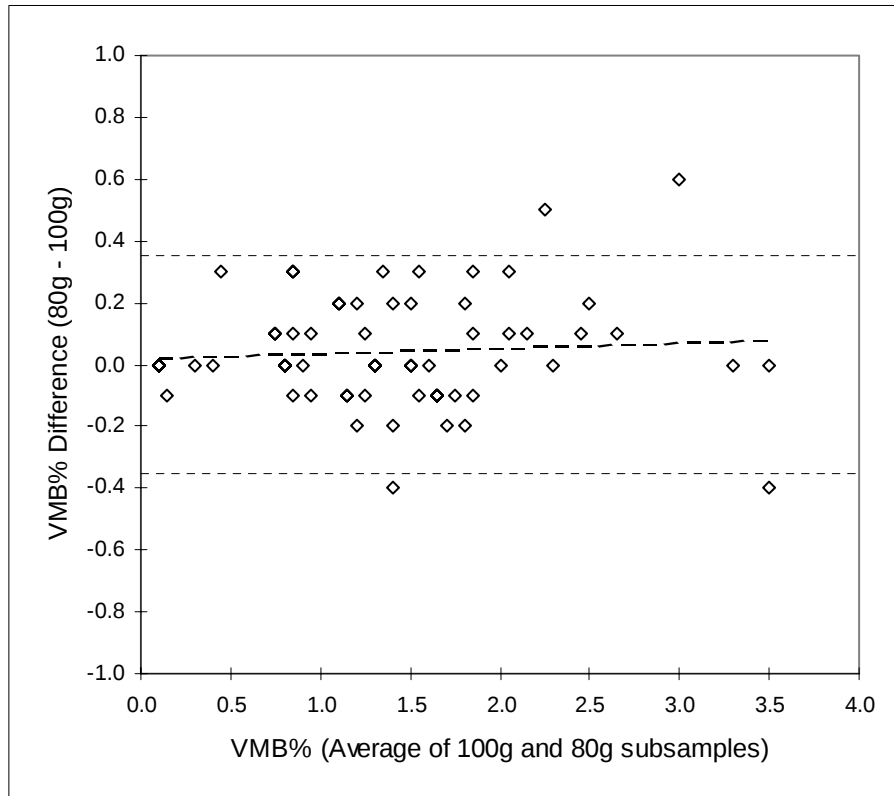
## iii) AEM% Comparison for 100 gram and 80 gram Subsamples



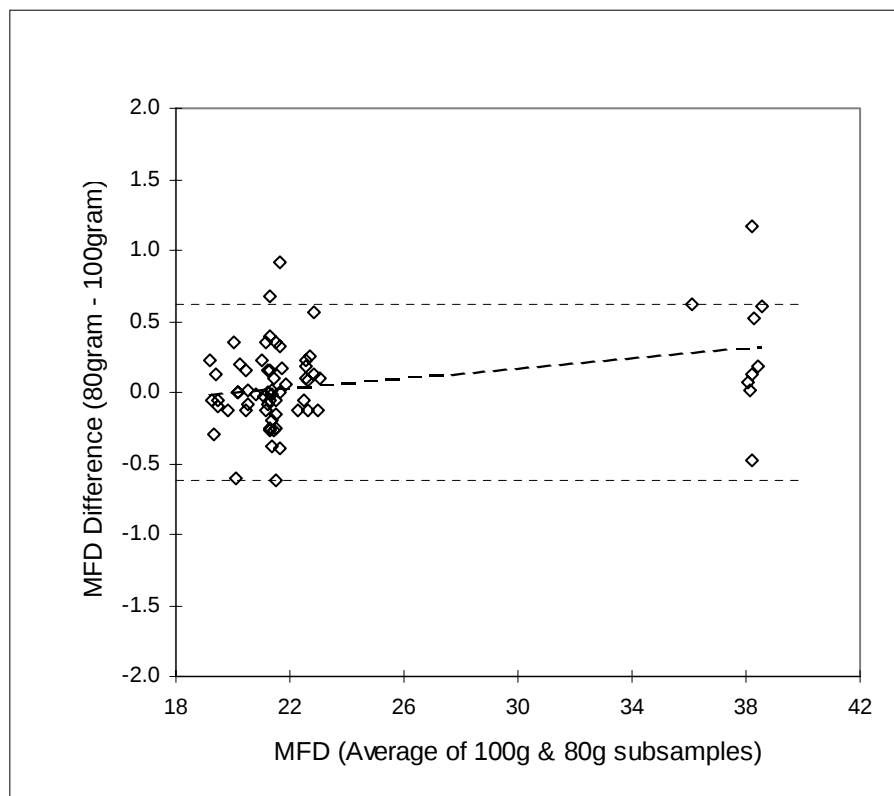
## iv) WB% Comparison for 100 gram and 80 gram Subsamples



## v) VMB% Comparison for 100 gram and 80 gram Subsamples



## vi) MFD Comparison for 100 gram and 80 gram Subsamples



**APPENDIX 3**

## i) Summary of Analysis of Variance for Oven-Dry %

| Sample Number | Mean ODW | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (100g) |
|---------------|----------|------------------------------|-------------------------------|---------------------|----------------------|-----------------------------|
| 18            | 93.03    | 0.0021                       | 0.1051                        | 0.0021              | 0.0343               | 0.37                        |
| 19            | 92.12    | 0.0012                       | 0.2163                        | 0.0012              | 0.0717               | 0.53                        |
| 20            | 91.56    | 0.0020                       | 0.0457                        | 0.0020              | 0.0146               | 0.25                        |
| 21            | 90.17    | 0.0474                       | 0.194                         | 0.0474              | 0.0489               | 0.61                        |
| *22           | 90.67    | 0.0079                       | 4.4722                        | 0.0079              | 1.4881               | 2.40                        |
| 24            | 87.72    | 0.0114                       | 0.1612                        | 0.0114              | 0.0499               | 0.49                        |
| 25            | 90.52    | 0.0007                       | 0.0068                        | 0.0007              | 0.0020               | 0.10                        |
| 26            | 90.67    | 0.0023                       | 0.0129                        | 0.0023              | 0.0035               | 0.15                        |
| 27            | 89.97    | 0.0015                       | 0.0528                        | 0.0015              | 0.0171               | 0.27                        |
| 28            | 91.02    | 0.0157                       | 0.0382                        | 0.0157              | 0.0000               | 0.25                        |
| 29            | 91.11    | 0.0046                       | 0.0274                        | 0.0046              | 0.0076               | 0.22                        |
| 30            | 90.66    | 0.0038                       | 0.0685                        | 0.0038              | 0.0216               | 0.31                        |
| 31            | 90.11    | 0.0016                       | 0.0139                        | 0.0016              | 0.0041               | 0.15                        |
| 32            | 91.01    | 0.0021                       | 2.1983                        | 0.0021              | 0.7321               | 1.68                        |
| 33            | 91.14    | 0.0077                       | 0.0571                        | 0.0077              | 0.0165               | 0.30                        |
| 34            | 92.45    | 0.0046                       | 4.3829                        | 0.0046              | 1.4594               | 2.37                        |
| 35            | 90.78    | 0.0047                       | 0.1542                        | 0.0047              | 0.0498               | 0.46                        |
| 36            | 90.31    | 0.0028                       | 0.0176                        | 0.0028              | 0.0049               | 0.17                        |
| 37            | 90.15    | 0.0019                       | 0.0301                        | 0.0019              | 0.0094               | 0.21                        |
| 38            | 91.36    | 0.0013                       | 0.1655                        | 0.0013              | 0.0547               | 0.46                        |
| 39            | 91.46    | 0.0025                       | 0.1089                        | 0.0025              | 0.0355               | 0.38                        |
| 40            | 90.67    | 0.0069                       | 0.166                         | 0.0069              | 0.0530               | 0.48                        |
| Average       |          | 0.0062                       | 0.5771                        | 0.0062              | 0.1903               | 0.87                        |

| Sample Number | Mean ODW | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (80g) |
|---------------|----------|------------------------------|-------------------------------|---------------------|----------------------|----------------------------|
| *18           | 93.63    | 0.0023                       | 2.354                         | 0.0023              | 0.7839               | 1.74                       |
| 19            | 92.11    | 0.0009                       | 0.0713                        | 0.0009              | 0.0235               | 0.31                       |
| 20            | 91.54    | 0.0107                       | 0.2429                        | 0.0107              | 0.0774               | 0.58                       |
| 21            | 90.01    | 0.0034                       | 0.083                         | 0.0034              | 0.0265               | 0.34                       |
| 22            | 89.94    | 0.0088                       | 0.1431                        | 0.0088              | 0.0448               | 0.45                       |
| 24            | 87.81    | 0.2344                       | 0.0884                        | 0.2344              | 0.0000               | 0.95                       |
| 25            | 90.22    | 0.0012                       | 0.1858                        | 0.0012              | 0.0615               | 0.49                       |
| 26            | 90.51    | 0.0040                       | 0.0308                        | 0.0040              | 0.0089               | 0.22                       |
| 27            | 89.9     | 0.0052                       | 0.0784                        | 0.0052              | 0.0244               | 0.34                       |
| 28            | 91.1     | 0.0047                       | 0.1386                        | 0.0047              | 0.0446               | 0.44                       |
| 29            | 91.08    | 0.0065                       | 0.1036                        | 0.0065              | 0.0324               | 0.39                       |
| 30            | 90.73    | 0.0009                       | 0.0947                        | 0.0009              | 0.0313               | 0.35                       |
| 31            | 90.08    | 0.0059                       | 0.001                         | 0.0059              | 0.0000               | 0.15                       |
| 32            | 91.23    | 0.0018                       | 3.8391                        | 0.0018              | 1.2791               | 2.22                       |
| 33            | 91.13    | 0.0028                       | 0.0194                        | 0.0028              | 0.0055               | 0.18                       |
| *34           | 92.79    | 0.0020                       | 9.0334                        | 0.0020              | 3.0105               | 3.40                       |
| 35            | 90.72    | 0.0019                       | 0.0528                        | 0.0019              | 0.0170               | 0.27                       |
| 36            | 90.39    | 0.0032                       | 0.08                          | 0.0032              | 0.0256               | 0.33                       |
| 37            | 90.26    | 0.0058                       | 0.2919                        | 0.0058              | 0.0954               | 0.62                       |
| 38            | 91.29    | 0.0050                       | 0.1071                        | 0.0050              | 0.0340               | 0.39                       |
| 39            | 91.38    | 0.0013                       | 0.0995                        | 0.0013              | 0.0327               | 0.36                       |
| 40            | 90.83    | 0.0039                       | 0.0156                        | 0.0039              | 0.0039               | 0.17                       |
| Average       |          | 0.0144                       | 0.7797                        | 0.0144              | 0.2551               | 1.02                       |

\* Data excluded from Table 4 summary due to being an outlier.

## ii) Summary of Analysis of Variance for Ash Content

| Sample Number | Mean Ash | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (100g) |
|---------------|----------|------------------------------|-------------------------------|---------------------|----------------------|-----------------------------|
| 18            | 0.99     | 0.0068                       | 0.0234                        | 0.0068              | 0.0055               | 0.22                        |
| 19            | 0.81     | 0.0006                       | 0.0512                        | 0.0006              | 0.0169               | 0.26                        |
| 20            | 1        | 0.0013                       | 0.0004                        | 0.0013              | 0.0000               | 0.07                        |
| 21            | 1.36     | 0.0099                       | 0.0166                        | 0.0099              | 0.0000               | 0.20                        |
| 22            | 1.3      | 0.0094                       | 0.0225                        | 0.0094              | 0.0000               | 0.19                        |
| 24            | 0.91     | 0.0068                       | 0.0444                        | 0.0068              | 0.0125               | 0.27                        |
| 25            | 0.89     | 0.0015                       | 0.0367                        | 0.0015              | 0.0117               | 0.23                        |
| 26            | 1.09     | 0.0071                       | 0.0504                        | 0.0071              | 0.0144               | 0.29                        |
| 27            | 1.43     | 0.0226                       | 0.0215                        | 0.0226              | 0.0000               | 0.29                        |
| 28            | 0.89     | 0.0077                       | 0.0437                        | 0.0077              | 0.0120               | 0.27                        |
| 29            | 0.97     | 0.0068                       | 0.0051                        | 0.0068              | 0.0000               | 0.16                        |
| 30            | 0.78     | 0.0012                       | 0.0045                        | 0.0012              | 0.0011               | 0.09                        |
| 31            | 0.77     | 0.0041                       | 0.0786                        | 0.0041              | 0.0248               | 0.33                        |
| 32            | 1.28     | 0.0019                       | 0.0074                        | 0.0019              | 0.0018               | 0.12                        |
| 33            | 1.02     | 0.0069                       | 0.0065                        | 0.0069              | 0.0000               | 0.16                        |
| 34            | 1.02     | 0.0022                       | 0.0045                        | 0.0022              | 0.0000               | 0.09                        |
| 35            | 0.91     | 0.0262                       | 0.0813                        | 0.0262              | 0.0184               | 0.41                        |
| 36            | 1.47     | 0.0041                       | 0.0894                        | 0.0041              | 0.0284               | 0.35                        |
| 37            | 1.07     | 0.0010                       | 0.0205                        | 0.0010              | 0.0065               | 0.17                        |
| 38            | 1.04     | 0.0031                       | 0.0005                        | 0.0031              | 0.0000               | 0.11                        |
| 39            | 0.91     | 0.0025                       | 0.0303                        | 0.0025              | 0.0093               | 0.21                        |
| 40            | 1.64     | 0.0175                       | 0.1235                        | 0.0175              | 0.0353               | 0.45                        |
| Average       |          | 0.0069                       | 0.0347                        | 0.0069              | 0.0093               | 0.25                        |

| Sample Number | Mean Ash | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (80g) |
|---------------|----------|------------------------------|-------------------------------|---------------------|----------------------|----------------------------|
| 18            | 0.85     | 0.0051                       | 0.1313                        | 0.0051              | 0.0421               | 0.43                       |
| 19            | 0.83     | 0.0017                       | 0.0194                        | 0.0017              | 0.0059               | 0.17                       |
| 20            | 1.05     | 0.0046                       | 0.0073                        | 0.0046              | 0.0000               | 0.13                       |
| 21            | 1.29     | 0.0092                       | 0.1127                        | 0.0092              | 0.0345               | 0.41                       |
| 22            | 1.24     | 0.0051                       | 0.0409                        | 0.0051              | 0.0119               | 0.26                       |
| 24            | 0.93     | 0.0052                       | 0.0027                        | 0.0052              | 0.0000               | 0.14                       |
| 25            | 0.86     | 0.0034                       | 0.0325                        | 0.0034              | 0.0097               | 0.22                       |
| 26            | 1.17     | 0.0048                       | 0.0073                        | 0.0048              | 0.0000               | 0.14                       |
| 27            | 1.49     | 0.0076                       | 0.1238                        | 0.0076              | 0.0387               | 0.42                       |
| 28            | 0.92     | 0.0018                       | 0.2378                        | 0.0018              | 0.0787               | 0.56                       |
| 29            | 0.99     | 0.0059                       | 0.0307                        | 0.0059              | 0.0083               | 0.23                       |
| 30            | 0.78     | 0.0018                       | 0.0566                        | 0.0018              | 0.0183               | 0.28                       |
| 31            | 0.85     | 0.0030                       | 0.0211                        | 0.0030              | 0.0060               | 0.19                       |
| 32            | 1.34     | 0.0082                       | 0.0193                        | 0.0082              | 0.0000               | 0.18                       |
| 33            | 1.07     | 0.0022                       | 0.0188                        | 0.0022              | 0.0055               | 0.17                       |
| 34            | 1.09     | 0.0044                       | 0.1143                        | 0.0044              | 0.0366               | 0.40                       |
| 35            | 0.95     | 0.0038                       | 0.0083                        | 0.0038              | 0.0000               | 0.12                       |
| 36            | 1.45     | 0.0026                       | 0.017                         | 0.0026              | 0.0048               | 0.17                       |
| 37            | 1.17     | 0.0054                       | 0.0448                        | 0.0054              | 0.0131               | 0.27                       |
| 38            | 1.1      | 0.0043                       | 0.0029                        | 0.0043              | 0.0000               | 0.13                       |
| 39            | 1        | 0.0012                       | 0.0173                        | 0.0012              | 0.0054               | 0.16                       |
| 40            | 1.7      | 0.0141                       | 0.0612                        | 0.0141              | 0.0157               | 0.34                       |
| Average       |          | 0.0048                       | 0.0513                        | 0.0048              | 0.0155               | 0.28                       |

## iii) Summary of Analysis of Variance for AEM%

| Sample Number | Mean Grease | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (100g) |
|---------------|-------------|------------------------------|-------------------------------|---------------------|----------------------|-----------------------------|
| 18            | 1.08        | 0.0010                       | 0.009                         | 0.0010              | 0.0027               | 0.12                        |
| 19            | 1.2         | 0.0007                       | 0.08                          | 0.0007              | 0.0264               | 0.32                        |
| 20            | 1.43        | 0.0015                       | 0.3643                        | 0.0015              | 0.1209               | 0.69                        |
| 21            | 1.03        | 0.0024                       | 0.0056                        | 0.0024              | 0.0000               | 0.10                        |
| 22            | 1.08        | 0.0003                       | 0.0703                        | 0.0003              | 0.0233               | 0.30                        |
| 24            | 0.97        | 0.0021                       | 0.0056                        | 0.0021              | 0.0000               | 0.09                        |
| 25            | 1.39        | 0.0778                       | 0.6658                        | 0.0778              | 0.1960               | 1.03                        |
| 26            | 0.99        | 0.0173                       | 0.0714                        | 0.0173              | 0.0180               | 0.37                        |
| 27            | 1.06        | 0.0335                       | 0.0502                        | 0.0335              | 0.0000               | 0.36                        |
| 28            | 1.2         | 0.0180                       | 0.2109                        | 0.0180              | 0.0643               | 0.56                        |
| 29            | 1.06        | 0.0050                       | 0.0267                        | 0.0050              | 0.0072               | 0.22                        |
| 30            | 1.28        | 0.0293                       | 0.2545                        | 0.0293              | 0.0751               | 0.63                        |
| 31            | 1.27        | 0.0003                       | 0.0872                        | 0.0003              | 0.0290               | 0.34                        |
| 32            | 1.34        | 0.0021                       | 0.0049                        | 0.0021              | 0.0000               | 0.09                        |
| 33            | 1.43        | 0.0013                       | 0.0179                        | 0.0013              | 0.0055               | 0.16                        |
| 34            | 1.33        | 0.0019                       | 0.0516                        | 0.0019              | 0.0166               | 0.27                        |
| 35            | 1.31        | 0.0071                       | 0.5695                        | 0.0071              | 0.1875               | 0.86                        |
| 36            | 1.66        | 0.0030                       | 0.5501                        | 0.0030              | 0.1824               | 0.84                        |
| 37            | 1.22        | 0.0020                       | 0.0027                        | 0.0020              | 0.0000               | 0.09                        |
| 38            | 1.49        | 0.0018                       | 0.0057                        | 0.0018              | 0.0013               | 0.11                        |
| 39            | 1.12        | 0.0011                       | 0.0834                        | 0.0011              | 0.0274               | 0.33                        |
| 40            | 1.51        | 0.0015                       | 0.0227                        | 0.0015              | 0.0071               | 0.18                        |
| Average       |             | 0.0096                       | 0.1459                        | 0.0096              | 0.0454               | 0.46                        |

| Sample Number | Mean Grease | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (80g) |
|---------------|-------------|------------------------------|-------------------------------|---------------------|----------------------|----------------------------|
| 18            | 1.2         | 0.0018                       | 0.1124                        | 0.0018              | 0.0369               | 0.39                       |
| 19            | 1.22        | 0.0003                       | 0.1094                        | 0.0003              | 0.0364               | 0.38                       |
| 20            | 1.41        | 0.0009                       | 0.3609                        | 0.0009              | 0.1200               | 0.68                       |
| 21            | 1.04        | 0.0003                       | 0.0363                        | 0.0003              | 0.0120               | 0.22                       |
| 22            | 1.18        | 0.0006                       | 0.0966                        | 0.0006              | 0.0320               | 0.35                       |
| 24            | 0.99        | 0.0010                       | 0.021                         | 0.0010              | 0.0067               | 0.17                       |
| 25            | 0.97        | 0.0231                       | 0.0732                        | 0.0231              | 0.0167               | 0.39                       |
| 26            | 1.08        | 0.0004                       | 0.0592                        | 0.0004              | 0.0196               | 0.28                       |
| 27            | 1.24        | 0.0005                       | 0.0189                        | 0.0005              | 0.0061               | 0.16                       |
| 28            | 0.91        | 0.0262                       | 0.0513                        | 0.0262              | 0.0000               | 0.32                       |
| 29            | 1.23        | 0.0134                       | 0.1061                        | 0.0134              | 0.0309               | 0.41                       |
| 30            | 1.15        | 0.0170                       | 0.4889                        | 0.0170              | 0.1573               | 0.82                       |
| 31            | 1.24        | 0.0015                       | 0.0393                        | 0.0015              | 0.0126               | 0.23                       |
| 32            | 1.37        | 0.0006                       | 0.0055                        | 0.0006              | 0.0016               | 0.09                       |
| 33            | 1.34        | 0.0013                       | 0.0019                        | 0.0013              | 0.0000               | 0.07                       |
| 34            | 1.34        | 0.0019                       | 0.0267                        | 0.0019              | 0.0083               | 0.20                       |
| 35            | 1.26        | 0.0019                       | 0.5094                        | 0.0019              | 0.1692               | 0.81                       |
| 36            | 1.57        | 0.0010                       | 0.3522                        | 0.0010              | 0.1171               | 0.67                       |
| 37            | 1.25        | 0.0004                       | 0.0375                        | 0.0004              | 0.0124               | 0.22                       |
| 38            | 1.36        | 0.0145                       | 0.27                          | 0.0145              | 0.0852               | 0.62                       |
| 39            | 1.2         | 0.0101                       | 0.1238                        | 0.0101              | 0.0379               | 0.43                       |
| 40            | 1.53        | 0.0010                       | 0.0552                        | 0.0010              | 0.0181               | 0.27                       |
| Average       |             | 0.0054                       | 0.1344                        | 0.0054              | 0.0430               | 0.43                       |

## iv) Summary of Analysis of Variance for Wool Base %

| Sample Number | Mean WB% | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (100g) |
|---------------|----------|------------------------------|-------------------------------|---------------------|----------------------|-----------------------------|
| 18            | 91.02    | 0.0169                       | 0.0425                        | 0.0169              | 0.0000               | 0.25                        |
| 19            | 90.19    | 0.0036                       | 0.7246                        | 0.0036              | 0.2403               | 0.97                        |
| 20            | 89.13    | 0.0153                       | 0.5135                        | 0.0153              | 0.1661               | 0.83                        |
| 21            | 86.31    | 0.1036                       | 0.0449                        | 0.1036              | 0.0000               | 0.63                        |
| *22           | 86.71    | 0.0107                       | 6.365                         | 0.0107              | 2.1181               | 2.86                        |
| 24            | 85.3     | 0.0148                       | 0.0462                        | 0.0148              | 0.0105               | 0.31                        |
| 25            | 87.7     | 0.0503                       | 0.5224                        | 0.0503              | 0.1574               | 0.89                        |
| 26            | 87.05    | 0.0412                       | 0.1188                        | 0.0412              | 0.0000               | 0.40                        |
| 27            | 84.82    | 0.0275                       | 0.9028                        | 0.0275              | 0.2918               | 1.11                        |
| 28            | 87.81    | 0.0339                       | 0.325                         | 0.0339              | 0.0970               | 0.71                        |
| 29            | 87.74    | 0.0068                       | 0.7001                        | 0.0068              | 0.2311               | 0.96                        |
| 30            | 87.88    | 0.0164                       | 0.6684                        | 0.0164              | 0.2173               | 0.95                        |
| 31            | 87.34    | 0.0129                       | 0.3874                        | 0.0129              | 0.1248               | 0.73                        |
| 32            | 86.68    | 0.0096                       | 1.6773                        | 0.0096              | 0.5559               | 1.47                        |
| 33            | 87.49    | 0.0509                       | 0.0213                        | 0.0509              | 0.0000               | 0.44                        |
| 34            | 88.98    | 0.0110                       | 3.5209                        | 0.0110              | 1.1700               | 2.13                        |
| 35            | 88.35    | 0.0045                       | 0.5085                        | 0.0045              | 0.1680               | 0.81                        |
| 36            | 84.98    | 0.0244                       | 0.4964                        | 0.0244              | 0.1573               | 0.84                        |
| 37            | 86.43    | 0.0185                       | 0.2415                        | 0.0185              | 0.0743               | 0.60                        |
| 38            | 87.57    | 0.0090                       | 0.3313                        | 0.0090              | 0.1074               | 0.67                        |
| 39            | 88.36    | 0.0148                       | 0.1992                        | 0.0148              | 0.0615               | 0.54                        |
| 40            | 85.78    | 0.0423                       | 0.006                         | 0.0423              | 0.0000               | 0.40                        |
| Average       |          | 0.0245                       | 0.8347                        | 0.0245              | 0.2704               | 1.06                        |

| Sample Number | Mean WB% | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (80g) |
|---------------|----------|------------------------------|-------------------------------|---------------------|----------------------|----------------------------|
| *18           | 91.6     | 0.0095                       | 2.0481                        | 0.0095              | 0.6795               | 1.63                       |
| 19            | 90.11    | 0.0026                       | 0.4288                        | 0.0026              | 0.1421               | 0.75                       |
| 20            | 89.17    | 0.0188                       | 0.9123                        | 0.0188              | 0.2978               | 1.10                       |
| 21            | 86.35    | 0.0084                       | 0.1833                        | 0.0084              | 0.0583               | 0.51                       |
| 22            | 85.98    | 0.0271                       | 0.0938                        | 0.0271              | 0.0222               | 0.44                       |
| 24            | 85.32    | 0.1922                       | 0.016                         | 0.1922              | 0.0000               | 0.86                       |
| 25            | 87.63    | 0.0162                       | 0.055                         | 0.0162              | 0.0129               | 0.33                       |
| 26            | 86.75    | 0.0291                       | 0.1618                        | 0.0291              | 0.0442               | 0.53                       |
| 27            | 84.22    | 0.0866                       | 0.567                         | 0.0866              | 0.1601               | 0.97                       |
| 28            | 88.12    | 0.0474                       | 0.1926                        | 0.0474              | 0.0484               | 0.61                       |
| 29            | 87.59    | 0.0564                       | 0.9068                        | 0.0564              | 0.2835               | 1.14                       |
| 30            | 88.08    | 0.0197                       | 1.0851                        | 0.0197              | 0.3551               | 1.20                       |
| 31            | 87.3     | 0.0109                       | 0.0951                        | 0.0109              | 0.0281               | 0.39                       |
| 32            | 86.54    | 0.0121                       | 3.5055                        | 0.0121              | 1.1645               | 2.13                       |
| 33            | 87.52    | 0.0076                       | 0.0724                        | 0.0076              | 0.0216               | 0.34                       |
| *34           | 89.16    | 0.0518                       | 7.2083                        | 0.0518              | 2.3855               | 3.06                       |
| 35            | 88.14    | 0.0198                       | 0.9225                        | 0.0198              | 0.3009               | 1.11                       |
| 36            | 85.07    | 0.0192                       | 1.2217                        | 0.0192              | 0.4008               | 1.27                       |
| 37            | 86.38    | 0.0642                       | 0.7811                        | 0.0642              | 0.2390               | 1.08                       |
| 38            | 87.63    | 0.0147                       | 1.2022                        | 0.0147              | 0.3958               | 1.26                       |
| 39            | 88.04    | 0.0326                       | 0.4115                        | 0.0326              | 0.1263               | 0.78                       |
| 40            | 85.64    | 0.0557                       | 0.2295                        | 0.0557              | 0.0579               | 0.66                       |
| Average       |          | 0.0365                       | 1.0137                        | 0.0365              | 0.3257               | 1.18                       |

\* Data excluded from Table 4 summary due to being an outlier.

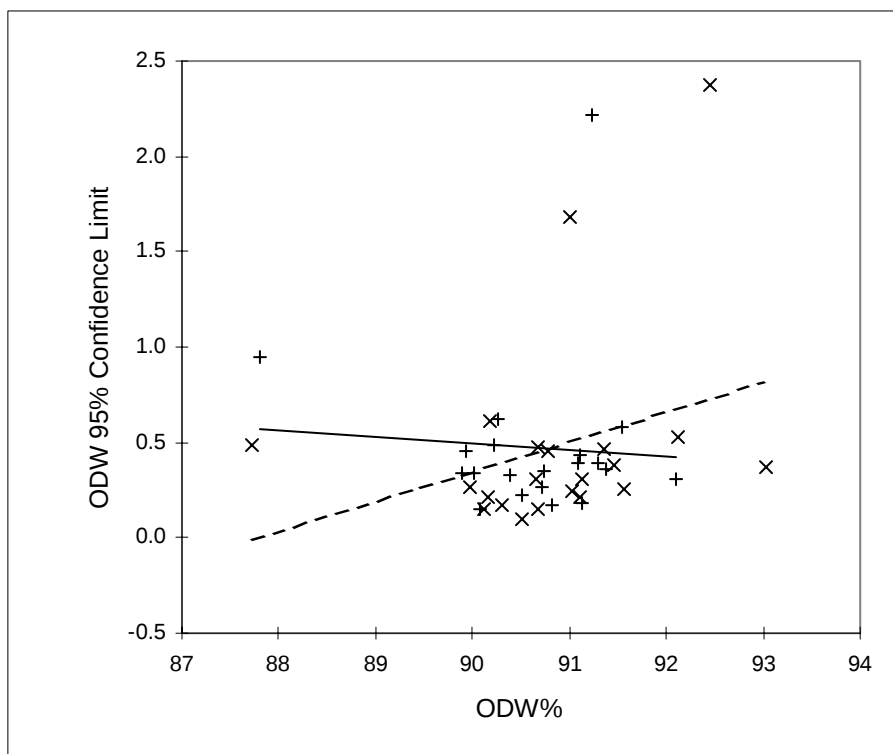
## v) Summary of Analysis of Variance for Vegetable Matter Base %

| Sample Number | Mean VMB% | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (100g) |
|---------------|-----------|------------------------------|-------------------------------|---------------------|----------------------|-----------------------------|
| 18            | 0.1       | 0.0169                       | 0.1486                        | 0.0169              | 0.0439               | 0.48                        |
| 19            | 0.1       | 0.0001                       | 0.0026                        | 0.0001              | 0.0008               | 0.06                        |
| 20            | 0.1       | 0.0009                       | 0.0203                        | 0.0009              | 0.0065               | 0.17                        |
| 21            | 1.6       | 0.0159                       | 0.0199                        | 0.0159              | 0.0000               | 0.25                        |
| 22            | 1.8       | 0.0273                       | 0.3189                        | 0.0273              | 0.0972               | 0.69                        |
| 24            | 0.8       | 0.0009                       | 0.0023                        | 0.0009              | 0.0000               | 0.06                        |
| 25            | 0.7       | 0.0050                       | 0.0217                        | 0.0050              | 0.0056               | 0.20                        |
| 26            | 1.8       | 0.0111                       | 0.0134                        | 0.0111              | 0.0000               | 0.21                        |
| 27            | 2.8       | 0.0518                       | 0.5843                        | 0.0518              | 0.1775               | 0.94                        |
| 28            | 1.2       | 0.0096                       | 0.0083                        | 0.0096              | 0.0000               | 0.19                        |
| 29            | 1.5       | 0.0057                       | 0.2291                        | 0.0057              | 0.0745               | 0.55                        |
| 30            | 0.8       | 0.0032                       | 0.0192                        | 0.0032              | 0.0053               | 0.18                        |
| 31            | 0.9       | 0.0055                       | 0.0042                        | 0.0055              | 0.0000               | 0.14                        |
| 32            | 1.9       | 0.0018                       | 0.0936                        | 0.0018              | 0.0306               | 0.35                        |
| 33            | 1.3       | 0.0214                       | 0.246                         | 0.0214              | 0.0749               | 0.61                        |
| 34            | 1.3       | 0.0038                       | 0.0123                        | 0.0038              | 0.0028               | 0.16                        |
| 35            | 0.3       | 0.0008                       | 0.0053                        | 0.0008              | 0.0015               | 0.09                        |
| 36            | 2.4       | 0.0077                       | 0.0709                        | 0.0077              | 0.0211               | 0.33                        |
| 37            | 1.7       | 0.0167                       | 0.1429                        | 0.0167              | 0.0421               | 0.48                        |
| 38            | 1.5       | 0.0070                       | 0.0386                        | 0.0070              | 0.0105               | 0.26                        |
| 39            | 1.1       | 0.0045                       | 0.0157                        | 0.0045              | 0.0037               | 0.18                        |
| 40            | 1.9       | 0.0137                       | 0.0585                        | 0.0137              | 0.0149               | 0.33                        |
| Average       |           | 0.0105                       | 0.0944                        | 0.0105              | 0.0280               | 0.38                        |

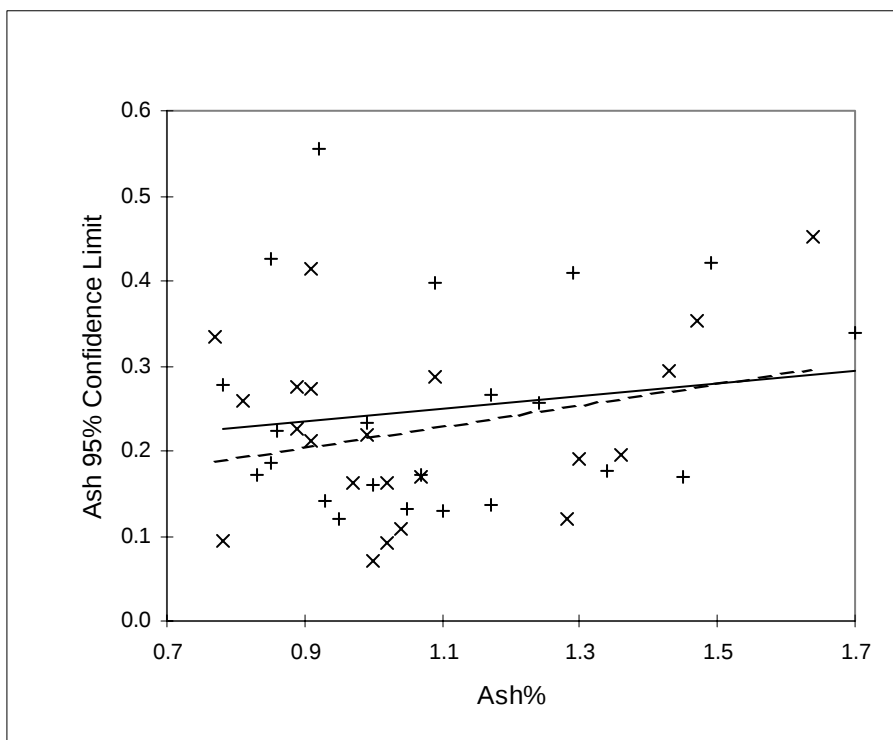
| Sample Number | Mean VMB% | Within Lab Mean Square (MSW) | Between Lab Mean Square (MSB) | Within Lab Variance | Between Lab Variance | 95% Confidence Limit (80g) |
|---------------|-----------|------------------------------|-------------------------------|---------------------|----------------------|----------------------------|
| 18            | 0.1       | 0.0002                       | 0.007                         | 0.0002              | 0.0023               | 0.10                       |
| 19            | 0.1       | 0.0002                       | 0.002                         | 0.0002              | 0.0006               | 0.06                       |
| 20            | 0.1       | 0.0001                       | 0                             | 0.0001              | 0.0000               | 0.02                       |
| 21            | 1.6       | 0.0035                       | 0.005                         | 0.0035              | 0.0000               | 0.12                       |
| 22            | 1.8       | 0.0197                       | 0.0759                        | 0.0197              | 0.0187               | 0.38                       |
| 24            | 0.8       | 0.0023                       | 0.0034                        | 0.0023              | 0.0000               | 0.09                       |
| 25            | 0.9       | 0.0074                       | 0.0398                        | 0.0074              | 0.0108               | 0.26                       |
| 26            | 1.7       | 0.0171                       | 0.1216                        | 0.0171              | 0.0348               | 0.45                       |
| 27            | 3.1       | 0.0370                       | 0.4602                        | 0.0370              | 0.1411               | 0.83                       |
| 28            | 1.2       | 0.0019                       | 0.053                         | 0.0019              | 0.0170               | 0.27                       |
| 29            | 1.4       | 0.0128                       | 0.2112                        | 0.0128              | 0.0661               | 0.55                       |
| 30            | 0.9       | 0.0027                       | 0.0009                        | 0.0027              | 0.0000               | 0.10                       |
| 31            | 0.9       | 0.0043                       | 0.0163                        | 0.0043              | 0.0040               | 0.18                       |
| 32            | 2.2       | 0.0060                       | 0.2711                        | 0.0060              | 0.0884               | 0.60                       |
| 33            | 1.3       | 0.0146                       | 0.0582                        | 0.0146              | 0.0145               | 0.33                       |
| 34            | 1.2       | 0.0145                       | 0.058                         | 0.0145              | 0.0145               | 0.33                       |
| 35            | 0.4       | 0.0017                       | 0.0422                        | 0.0017              | 0.0135               | 0.24                       |
| 36            | 2.5       | 0.0257                       | 0.0296                        | 0.0257              | 0.0000               | 0.31                       |
| 37            | 1.7       | 0.0292                       | 0.0265                        | 0.0292              | 0.0000               | 0.34                       |
| 38            | 1.4       | 0.0077                       | 0.0739                        | 0.0077              | 0.0221               | 0.34                       |
| 39            | 1.3       | 0.0107                       | 0.0431                        | 0.0107              | 0.0108               | 0.29                       |
| 40            | 2.1       | 0.0241                       | 0.0613                        | 0.0241              | 0.0000               | 0.30                       |
| Average       |           | 0.0111                       | 0.0755                        | 0.0111              | 0.0215               | 0.35                       |

**APPENDIX 4**

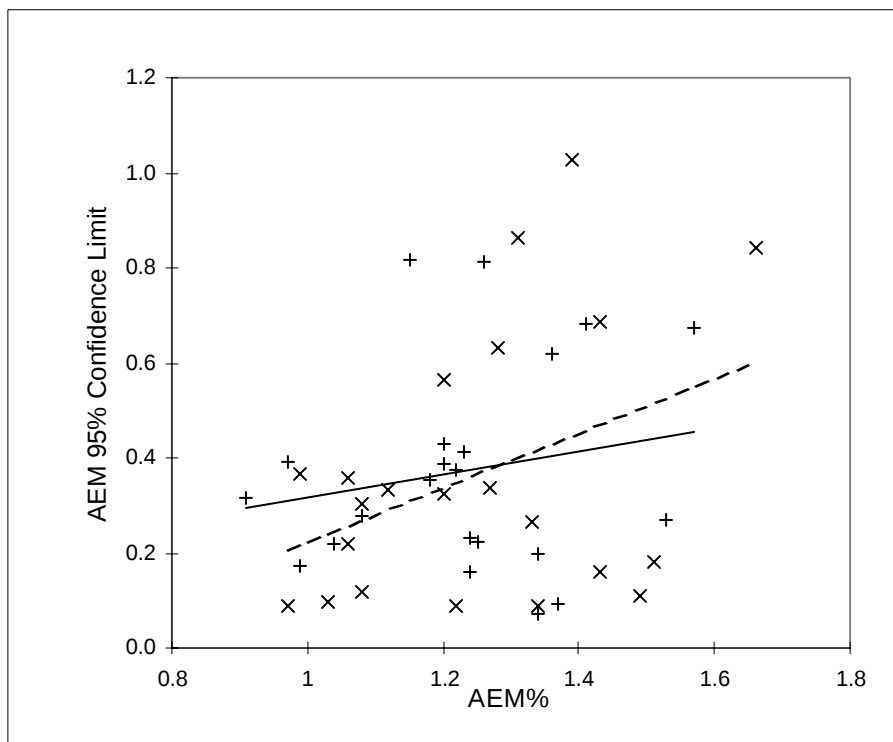
i) ODW% Confidence Limits for 100g (--- x ---) and 80g (— + —) Subsamples



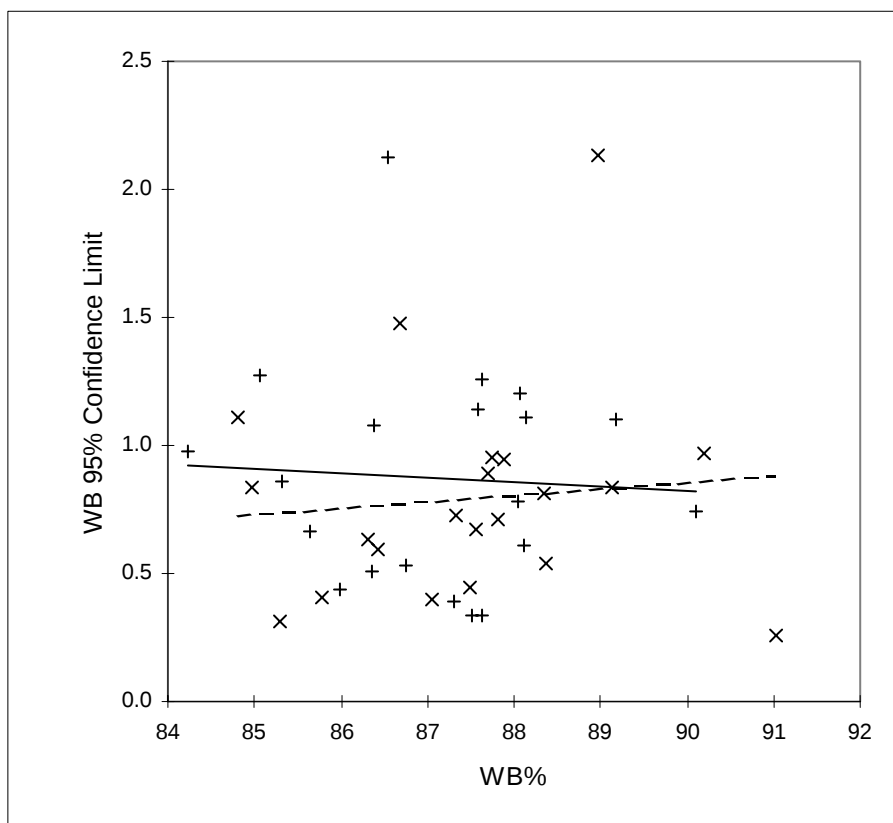
ii) Ash Content Confidence Limits for 100g (--- x ---) and 80g (— + —) Subsamples



## iii) AEM% Confidence Limits for 100g (--- x ---) and 80g (— + —) Subsamples



## iv) WB% Confidence Limits for 100g (--- x ---) and 80g (— + —) Subsamples



v) VMB% Confidence Limits for 100g ( --- x --- ) and 80g ( — + — ) Subsamples

