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The Minimum Number of Acceptable Subsample Results Required in an IWTO Certificate for Wools of UK Origin

By

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SUMMARY

The IWTO Core Test Regulations currently stipulate that a minimum of three subsamples shall be tested when conducting tests on wools of UK origin. Using data from more than 200 randomly-selected commercial lots, this report has examined the impact of using two subsamples for the calculation of test results.

It has been demonstrated that the accuracy of testing is not jeopardised when two subsamples, instead of three, are used to calculate Wool Base and VM Base results. The average difference between results based on two and three subsamples was 0.017% and 0.000% for Wool Base and VM Base respectively. The variability of the differences for both tests was small and individual differences were independent of the measured result. The method of drawing test specimens for fibre diameter and colour measurement ensures test results for these parameters are not affected by the number of subsamples tested.

The impact on test precision of using a two-subsample testing regime was also shown to be minimal. The 95% Confidence Limits from two-subsample testing procedures were approximately 0.06% larger than those calculated from three subsamples.

With technical equivalence demonstrated between two subsample and three subsample testing processes, and improved service times and reduced testing fees achievable using a two-subsample testing regime for UK wools, an amendment to the current requirement for the minimum number of subsamples for wools of UK origin is recommended.

INTRODUCTION

There are two requirements for the sampling of bales of wool to produce a representative sample for testing. Firstly the mass of cores sampled shall be sufficient to provide the minimum number of subsamples relevant to the type of wool being tested. Secondly the number of cores taken per bale shall be sufficient to ensure that the sampling precision is no worse than ±1% IWTO Clean Wool Content with 95% probability. Each of these requirements are clearly stipulated within the IWTO Core Test Regulations, and Tables 1 and 2 of that document provide the necessary information to determine the coring schedules for various wool types in the main wool-growing countries.

Table 9 of the current IWTO Core Test Regulations specify that most lot-categories from Australia, New Zealand, South Africa and South America, except where additional subsamples are tested to satisfy Range Test requirements, require a minimum of two subsamples to produce an IWTO Test Certificate. Wools from other countries and/or continents (including the UK) require a minimum of three acceptable subsample results to produce a valid IWTO Test Certificate.

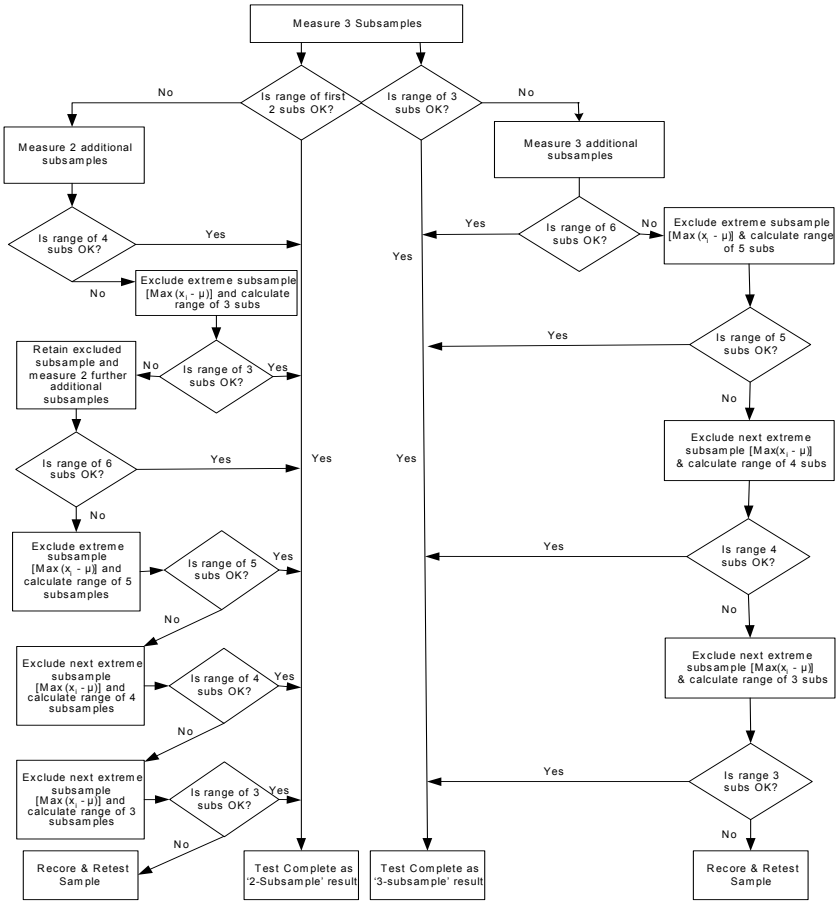
Interestingly, while the minimum number of subsamples required for an IWTO Test Certificate on wools of UK origin is not specified in Table 9, an estimate of the within-bale yield variability for British Halfbred and Cross Fleeces is given in Table 1 of the IWTO Core Test Regulations. The tabled value, determined from typically-prepared UK lots (bulk-classed), suggests that the variability of the wool is similar to that of New Zealand Crossbred wool. All New Zealand Crossbred lots, whether categorised as a Classed Grower Lot, Interlot or Bulk Classed Lot, require only a minimum of two subsamples for IWTO certification. An investigation was therefore conducted to examine the impact on IWTO-certified results of UK wools if measurements were determined on the results of two, rather than three, subsamples.

METHODOLOGY

Data from 226 randomly-selected lots of UK origin, covering the typical range of Wool Base and VM Base exhibited in UK greasy wools, was extracted and analysed. These lots had all been tested at NZWTA Ltd during the 2003/04 season. In accordance with the current IWTO Core Test Regulations, three subsamples were tested from each lot to produce IWTO Test Certificates for Wool Base and VM Base. Data from the first two subsamples of each lot was then used to calculate a corresponding two-subsample Wool Base and VM Base result. The two sets of Wool Base and VM Base values, based on two and three subsamples respectively, were then compared and analysed in accordance with Appendix B of IWTO-0. Note that fibre diameter and colour test results would not be affected by a change in the minimum number of subsamples tested, as test specimens are drawn from equal quantities of wool from each subsample.

Where the relevant Range Checks (IWTO-19, Table H1) were exceeded (for either a two-subsample or three-subsample test), further subsamples were tested. The final calculations of Wool Base and VM Base results for all tests followed the flow-chart presented in Figure 1, which is based on the range testing procedures within Section 7.3 of IWTO-19.

Fig 1. Determination of Wool Base and VM Base Values for 2-Subsample and 3-Subsample Testing



RESULTS AND DISCUSSION

Additional Subsampling Requirements

As could be expected, a small number of tests failed to satisfy Range Test requirements of Table H1 in IWTO-19. The actual number of subsamples tested to produce valid 2-subsample and 3-subsample tests are presented in Table 1.

Table 1. Number of Tests Requiring Additional Subsamples to Satisfy Range Check Procedures

Number of Subsamples Required to Complete 2-Subsample Test		Number of Subsamples Required to Complete 3-Subsample Test	
Initial 2 Subsamples	213	Initial 3 Subsamples	211
4 Subsamples (2+2)	10	6 Subsamples (3+3)	10
3 Subsamples (2+2-1)	3	5 Subsamples (3+3-1)	5
6 Subsamples (2+2+2)	0	4 Subsample (3+3-2))	0
5 Subsamples (2+2+2-1)	0	3 Subsamples (3+3-3)	0
4 Subsamples (2+2+2-2)	0	Recore and Retest Required	0
3 Subsamples (2+2+2-3)	0		
Recore and Retest Required	0		
Total	226	Total	226

Table 1 demonstrates that the additional testing requirements for two and three subsample tests were similar. 94.2% and 93.4% of tests (for 2-subsample and 3-subsample tests respectively) completed without additional subsamples needing to be measured. Furthermore, all testing was completed after one additional series of subsamples were measured. This was possible either through satisfying range check values with four or six subsamples (for two and three subsample testing respectively), or by identifying and deleting one outlier value from the range of Wool Base measurements.

For the comparison of Wool Base and VM Base results, all lots were treated as 'two-subsample' or 'three-subsample' tests regardless of whether they required additional subsamples to be tested to satisfy Range Check requirements.

Comparison of Wool Base Results

A statistical summary of the Wool Base results from tests with two and three subsamples is presented in Table 2. The average difference over the 226 lots was 0.017% and of no commercial significance. A t-value of 1.71 indicates the difference is also not statistically significant. The Standard Deviation of the differences indicates that 95% of test results obtained from two subsamples were within 0.30% of the result achieved using three subsamples.

Table 2. Summary Statistics for the Comparison of Wool Base Results Using 2 and 3 Subsamples

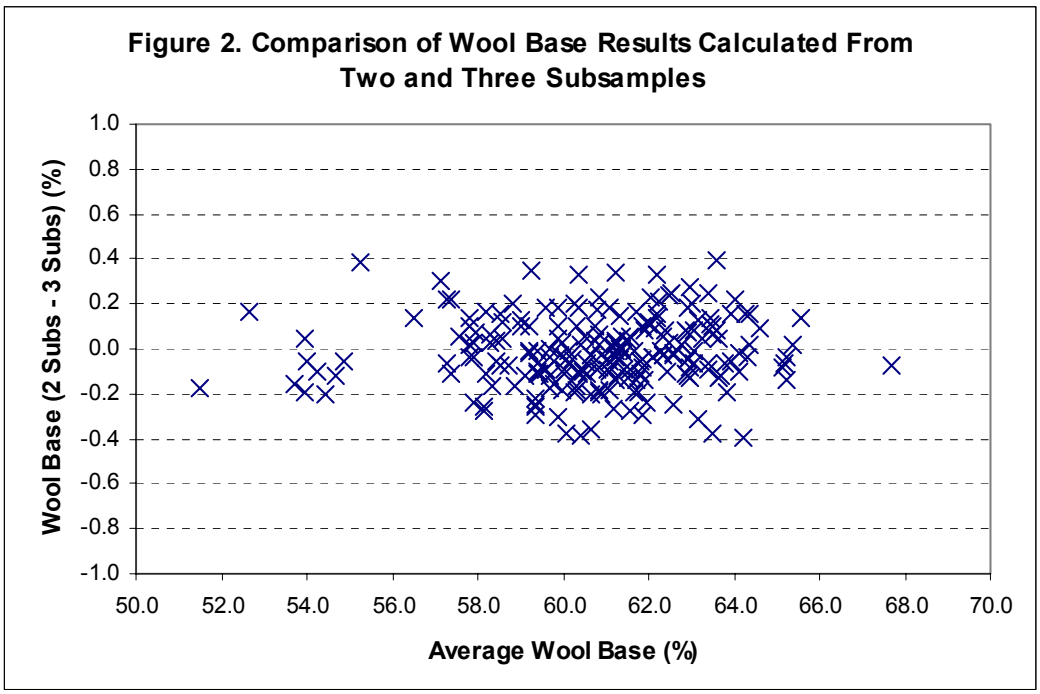
	Wool Base (2 Subsamples)	Wool Base (3 Subsamples)	Difference	Average
Number of Observations	226	226	226	226
Mean (%)	60.802	60.818	-0.017	60.810
Std Deviation (%)	2.510	2.501	0.152	2.505
Standard Error (%)	0.167	0.166	0.010	0.167

Geometric Mean and DVA regression analyses were also conducted and a summary of these analyses is displayed in Table 3. These demonstrate that no level-dependent bias was observed in the comparison between Wool Base results derived from two or three subsamples.

Table 3. Statistics from Regression Analyses Comparing Wool Base Results from 2 and 3 Subsamples

Regression Type	Estimated Slope	SE of Slope	t-value of Slope	Significance Level
Geometric Mean	1.0035	0.0041	-0.8537	NS
Difference vs. Average	0.0035	0.0041	0.8554	NS

The differences between the Wool Base results calculated from two and three subsamples are also presented in Figure 2. Whilst evident from the results in Tables 2 and 3, Figure 2 clearly reveals that the differences are randomly distributed around zero, and that there is no loss in testing accuracy by calculating Wool Base results using two, rather than three, subsamples.



Comparison of VM Base Results

A statistical summary of the VM Base results from tests with two and three subsamples is presented in Table 4. The average difference of the 226 lots was 0.000% which is neither statistically nor commercially significant. The Standard Deviation of the differences indicates that 95% of test results obtained from two subsamples were within 0.09% of the result achieved using three subsamples.

The results of Geometric Mean and DVA regression analyses are displayed in Table 5. No level-dependent bias was observed in the comparison between VM base results calculated from two or three subsamples.

Table 4. Summary Statistics for the Comparison of VM Base Results Using 2 and 3 Subsamples

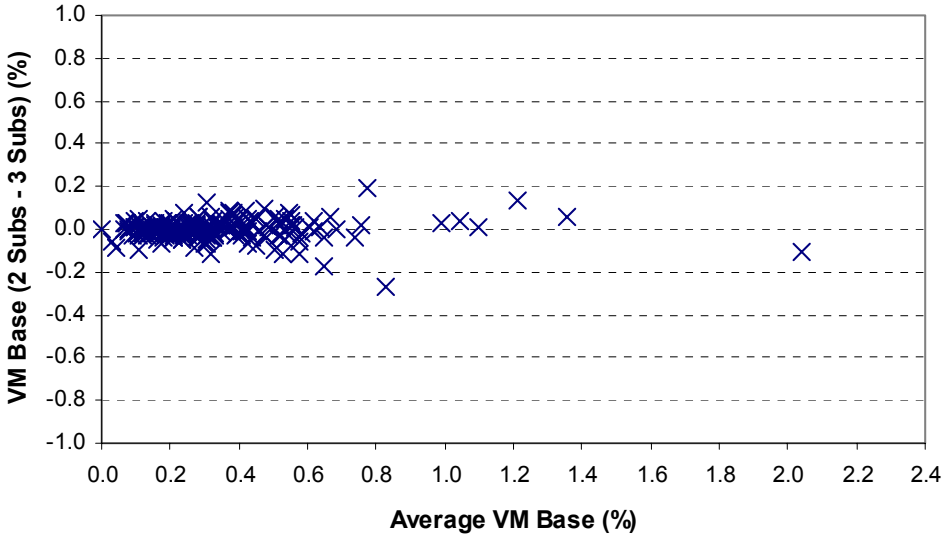
	VM Base (2 Subsamples)	VM Base (3 Subsamples)	Difference	Average
Number of Observations	226	226	226	226
Mean (%)	0.333	0.333	0.000	0.333
Std Deviation (%)	0.234	0.233	0.046	0.232
Standard Error (%)	0.016	0.016	0.003	0.015

Table 5. Statistics from Regression Analyses Comparing VM Base Results from 2 and 3 Subsamples

Regression Type	Estimated Slope	SE of Slope	t-value of Slope	Significance Level
Geometric Mean	1.0024	0.0132	-0.1818	NS
Difference vs. Average	0.0025	0.0133	0.1852	NS

VM Base differences between results calculated from two and three subsamples are also presented in Figure 3. As observed in the comparison of Wool Base results, testing accuracy was maintained by measuring two subsamples per lot.

Figure 3. Comparison of VM Base Results Calculated From Two and Three Subsamples



Impact on Testing Precision of Measuring 2 Subsamples

Most changes to sampling and/or testing procedure have an impact on the precision of the overall test. The effect on the precision of Wool Base results for individual lots when testing two subsamples, instead of three subsamples, can be determined by calculating the respective 95% Confidence Limits from the general formula:

$$95\%\ \text{Confidence Limit} = \pm 1.96 \times \delta_T \quad \ldots\ldots (1)$$

where:

$$\delta^2_T = (\delta^2_c / KN) + \delta^2_L + (\delta^2_S / n) \quad \ldots\ldots (2)$$

and:

δ^2_T = total variance

δ^2_c = between-cores variance

δ^2_L = between-laboratories variance

δ^2_S = between-subsamples variance

K = number of cores per bale

N = number of bales in the lot

n = number of 150g subsamples tested

As *n* (the number of subsamples tested) is the only variable being changed in equation (2), all other variance components can be substituted by constant values.

No experimental value of the between-cores variance has been determined for this trial. However the IWTO Core Test Regulations (Table 1) suggest a Standard Deviation of cores-within-bales for British wool of 2.6%. Hence a between-cores variance of 6.76 has been used in equation (2) above.

The actual number of cores taken per lot is dependent on the number of bales. For the lots in this trial, the number of cores per lot ranged between approximately 48 and 70. For the purpose of this trial, calculations for equation (2) were conducted using an average of 50 cores per lot.

The between-laboratories variance values specified in Table G1 of IWTO-19 were used as constants in equation (2).

The between-subsamples variance for two and three subsample tests has been calculated for each 5% range of Wool Base values and used with the other variance components to estimate the 95% Confidence Limits. These variances and estimated Confidence Limits are shown in Table 6.

Table 6. Precision Estimates for Wool Base Measurements of UK Wools from 2 and 3 Subsamples

Lot Information		Variance Components					2 Subsamples		3 Subsamples	
Wool Base	Number of Lots	δ^2_s (2 subs)	δ^2_s (3 subs)	δ^2_L	δ^2_c	KN	δ^2_T	95% CL	δ^2_T	95% CL
50.01-55.00	10	0.230	0.202	0.184	6.76	50	0.43	1.29	0.40	1.23
55.01 - 60.00	63	0.248	0.206	0.123	6.76	50	0.38	1.21	0.34	1.14
60.01 - 65.00	143	0.176	0.159	0.078	6.76	50	0.30	1.08	0.27	1.02
> 65.00	7	0.213	0.180	0.06	6.76	50	0.30	1.08	0.27	1.01

Table 6 indicates that the 95% Confidence Limits for Wool Base are similar whether two or three subsamples are tested, with the loss in precision being approximately 0.06% over the entire Wool Base range.

CONCLUSIONS

The IWTO Core Test Regulations currently stipulate that a minimum of three subsamples shall be tested when conducting tests on wools of UK origin. For several Southern Hemisphere countries, two subsamples are sufficient for testing most lot types. Using data from more than 200 randomly-selected commercial lots, this report has examined the impact of using two subsamples for the calculation of test results.

It has been demonstrated that the accuracy of testing is not jeopardised when two subsamples, instead of three, are used to calculate Wool Base and VM Base results. The average difference between results based on two and three subsamples was 0.017% and 0.000% for Wool Base and VM Base respectively. The variability of the differences for both tests was small and individual differences were independent of the measured result. The method of drawing test specimens for fibre diameter and colour measurement ensures test results for these parameters are not affected by the number of subsamples tested.

The impact on test precision of using a two-subsample testing regime was also shown to be minimal. The 95% Confidence Limits from two-subsample testing procedures were approximately 0.06% larger than those calculated from three subsamples.

With technical equivalence demonstrated between two subsample and three subsample testing processes, and improved service times and reduced testing fees achievable using a two-subsample testing regime for UK wools, an amendment to the current requirement for the minimum number of subsamples for wools of UK origin is recommended.

RECOMMENDATIONS

Having demonstrated equivalence in accuracy and precision between two-subsample and three-subsample testing of UK wools, and with its likely benefits to commercial users, an amendment to the current requirement to test a minimum of three subsamples for wools of UK origin is recommended. The proposed text is outlined in Appendix 1.

An inconsistency in the wording between Section 7.3 of IWTO-19 and the IWTO Core Test Regulations is also addressed in Appendix 1. In 1995, the note in Table 8 (now Table 9) of the IWTO Core Test Regulations represented by the '*' symbol read:

"If additional subsamples need to be tested in order to meet Range Test requirements, a minimum of 3 acceptable subsamples must be used. For 1, 2 and 3 bale lots, it is not necessary to test any additional subsamples provided that no obvious error exists."

However a proposal to the IWTO Nice conference in 1996 was presented which recommended that, after the removal of outlier subsamples, coring and retesting shall be repeated if three subsamples remain *which still exceeded the Range Test values of Table H1*. Where the range of the three subsamples did not exceed the Range Test value in Table H1, the test could be completed with the three valid subsamples (as stipulated in Section 7.3.5).

The minutes of the Nice 1996 Raw Wool Group meeting indicate:

"Mr van Zyl mentioned that if this recommendation is accepted there would need to be a change in to Table 8 of the Core Test Regulations, where the number of subsamples must change from 3 to 4."

The amendment to Table 8 of the IWTO Core Test Regulations in 1996 therefore changed the minimum number of acceptable subsamples from 3 to 4, and this figure has remained in the note to this day. The application of this amendment, or at least its interpretation, appears to have been incorrect. The note should have retained three subsamples as the minimum number for normal testing procedures, as the minimum of four subsamples only relates to procedures where the test can be completed (despite Range Test values still being exceeded) to prevent unnecessary recoring and retesting.

It is thus proposed to change this note in Table 9 (formerly Table 8) to reflect the intended application of Section 7.3 in IWTO-19.

APPENDIX 1

Proposed Amendments to the IWTO Core Test Regulations

Note: Proposed text is shown in *underlined italics*. Deleted text is shown as ~~double strikethrough~~.

TABLE 9

Minimum Number of Acceptable Subsample Results Required in an IWTO Test Certificate

Origin	Classed Grower Lots	Deliveries, Interlots and Bulk Classed Lots
Australia	2*	2#
New Zealand	2*	2*
South Africa	2*	2*
South America	2	3
United Kingdom	2*	2*
Not Specified	3	3

For 1, 2 and 3 bale lots, 2 subsamples are sufficient. For lots of 4 bales or more, a minimum of 3 subsamples must be tested.

* If additional subsamples need to be tested in order to meet Range Test requirements, a minimum of ~~4~~*3* acceptable subsamples must be used. *If the appropriate Range Test values are exceeded with less than 4 subsamples, the lot shall be recored and retested*. For 1, 2 and 3 bale lots, it is not necessary to test any additional subsamples provided that no obvious error exists.