ANNEXURE J

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FINAL REPORT CONCERNING PROJECT FUNDED BY THE MAIZE TRUST

<u>PROJECT TITLE</u>:

THE EFFECT OF KERNEL SIZE VARIATION ON MILLING INDEX MEASUREMENTS AND ITS INFLUENCE ON CALIBRATION SENSITIVITY FOR PROCESS CONTROL

A PILOT PROJECT

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1. Introduction

During the evaluation stages (2011/2012 year) of the Milling Index (MI) project: *Improvement of the NIT calibration model for Milling Index*, a number of fundamental areas of technical needs were identified in order to improve and stabilise the calibration curves currently in use to measure MI on the Near Infrared Transmittance (NIT), currently in use in the Industry. Although some of these technical issues were successfully addressed in the completed MI project (final report submitted to the Trust in June 2014), there are areas where the scope of the supportive research is too big and required a separate project design and budget.

THE FOLLOWING PROJECTS WERE IDENTIFIED AS CRUCIAL IN ASSISTING WITH KNOWLEDGE GENERATION AND UNDERSTANDING OF CURRENT CALIBRATION INSTABILITIES:

1. Data mining of the past ten year's MI results generated at the SAGL as part of the Annual Crop Quality Survey. The report for this project is also submitted to the Trust on 30 September 2014.
2. The effect of kernel size variation on Milling Index measurements and its influence on calibration sensitivity for process control.

Short Technical Background

Sphericity of individual maize kernels plays an important role in the quantification of milling performance. Although some size indication can be obtained by sieving of kernels, sieving tests alone are not sensitive enough to be included in a milling performance prediction model.

Seed breeders indicated that variation in the size and shape of kernels on a cob (homogeneity) is a very important selection criterion for breeding programmes. In discussions with millers it also became very clear that size and shape homogeneity of maize kernels may be one of the "missing links" in the current tests, which may very well be one of the reasons for the unexplained data variation that has plagued the Milling Index method since its inception.

Milling requires kernels to be subjected to pressure and shear forces, especially during the degerming phases. As a result two cultivars with similar hardness will produce very different results if kernel sizes and shapes have different statistical bell curves (or Histograms) based on individual kernel sphericity measurements. Milling, as in any industrial process, requires consistency – i.e. kernels must preferably be in a narrow band of shapes and sizes. As this variability of the sphericity may be a significant trait, it is strongly supported by both breeders and millers to implement new and modern techniques for kernel shape and size quantification.

This project was a pilot study to explore the practicality of classifying maize into different size classes before Roff Milling to determine the possible effect on the results.

The primary objectives of the project were:

- To test the effect of maize kernel size variation on Roff Milling Index measurement repeatability
- To address the need of seed breeders and millers to understand the use of Milling Index as a quality trait on samples of varying homogeneity
- To determine whether size classification of maize before milling may be a future option for improved milling yield repeatability and process control.

2. Materials and methods

2.1 Sample preparation and size classification

In the original project plan it was envisaged that seed breeders grow large enough quantities of grain of various hardness that can be used for size classification. Due to a logistical problem from the seed breeder's side the grain was not supplied after the growing season, and therefore an alternative sample preparation had to be used.

Maize samples were constituted from smaller quantities of cultivars obtained from the Milling Index and Whiteness Index projects. These cultivars are part of the annual cultivar trials planted by the ARC, unfortunately only in limited quantities. After completion of the analytical tests on the samples, they were classified according to their NIT Milling Index values, and divided into seven groups. Two additional maize samples were received from a commercial mill and one from a seed breeder.

Originally it was also envisaged, as recommended by seed breeders, that each sample be divided into three size classes, based on a 3:3:3 distribution of the seed size histogram. After analysing the size distribution of the control samples, it was found not to be a feasible option to do the size classification according to the statistical classification. The reason for that is the unavailability of suitably sized round hole grading sieves, which meant that sieves would have had to be made with unusual sizes. The size of the project, however did not justify the cost of producing such sieves. Also, a method for maize size classification before Roff Milling or NIT measurement should focus on sieves that would be available for use in the industry. Therefore, all samples were then classified and sieved according to the following sieve sizes:

- 10mm
- 9mm
- 8mm
- 7.2mm
- 6.35mm

The maize were put on top of the sieve stack and sieved into its various fractions. For the purpose of this report, a size reference of 9 mm will refer to the maize kernels on top of the 9 mm sieve but that passed through the 10 mm sieve. For eight samples it was possible to produce fractions on the 8, 9 and 10 mm sieves and for two samples sufficient quantities could be produced on the 6.35 and 7. 2mm sieves. Most maize kernels are too big for the smaller sieve sizes, and it is not possible to produce enough of those fractions in order to perform Roff Milling experiments and NIT tests in triplicate. In order to test enough sample on the smallest sieve sizes, a commercial mill supplied a through fraction of small whole maize kernels produced during intake screening along with the unsieved maize at intake. Therefore one set of data contains a full range of maize sizes and tests on a commercial maize sample.

The sample names are given as Lot numbers and described as follows:

Table 1 Maize sample description

Lot 1	Yellow pure cultivar from seed breeder
Lot 2	Unsieved intake maize from miller (commercial sample)
Lot 3	Screenings of small grains from the intake maize from Lot 2, also received from the milling company
Lot 4	MIP project sample mix, white maize
Lot 5	MIP project sample mix, white maize
Lot 6	MIP project sample mix, white maize
Lot 7	Yellow cultivar mix from MIP project
Lot 8	WIP (whiteness Index samples from ARC)
Lot 9	WIP (whiteness Index samples from ARC)
Lot 10	WIP (whiteness Index samples from ARC)

2.2 *Image Analysis*

Image Analysis was done on the Digimiser 4 Image Analysis software after taking digital photos of the maize in grayscale. The Image analysis steps are shown in Figures 1, 2 and 3.

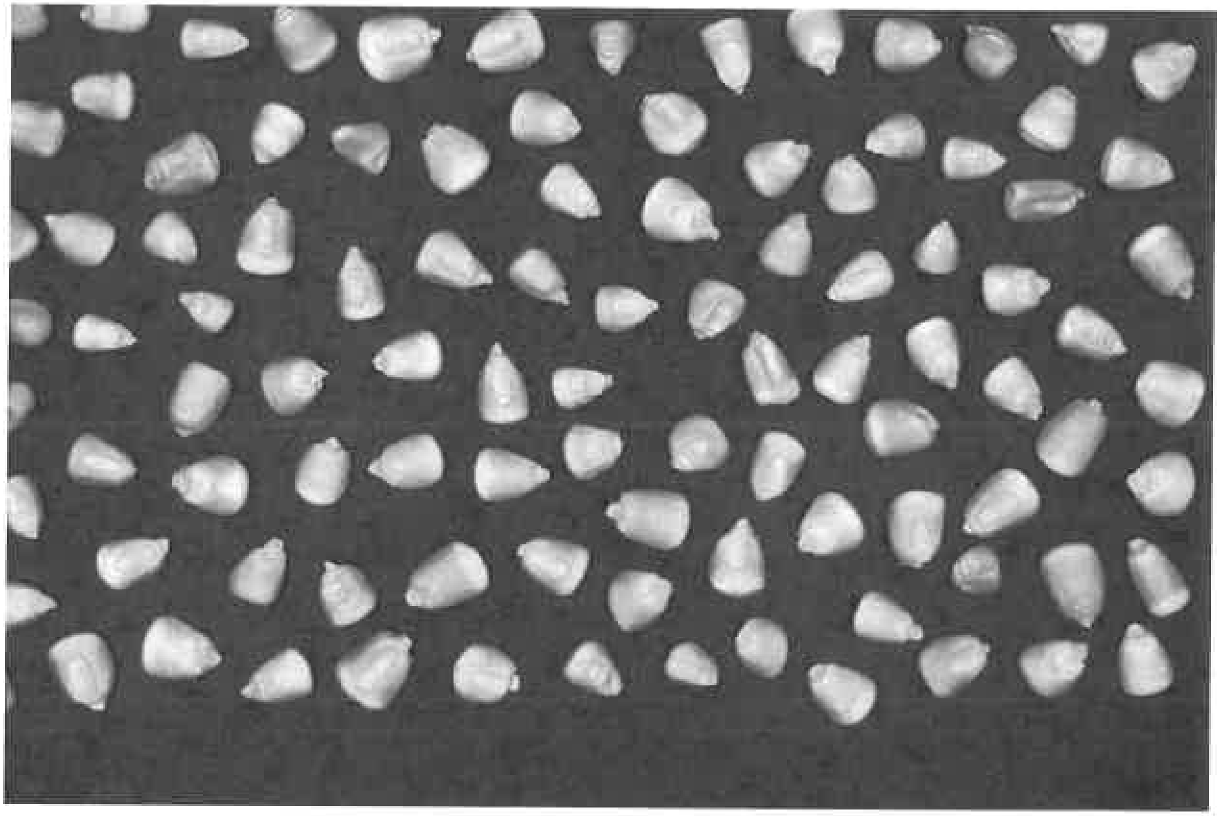


Figure 1. **Digital Image of maize kernels in Grayscale**

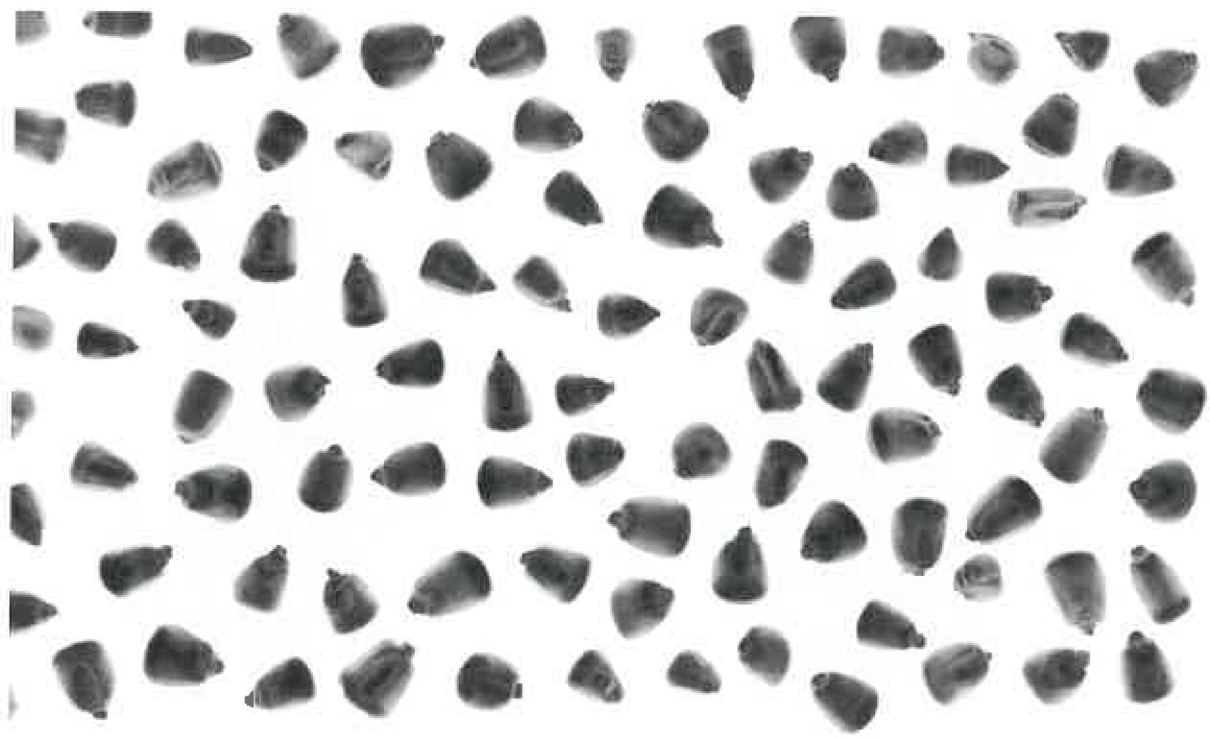


Figure 2. Inverted image for detection and optimum contrast

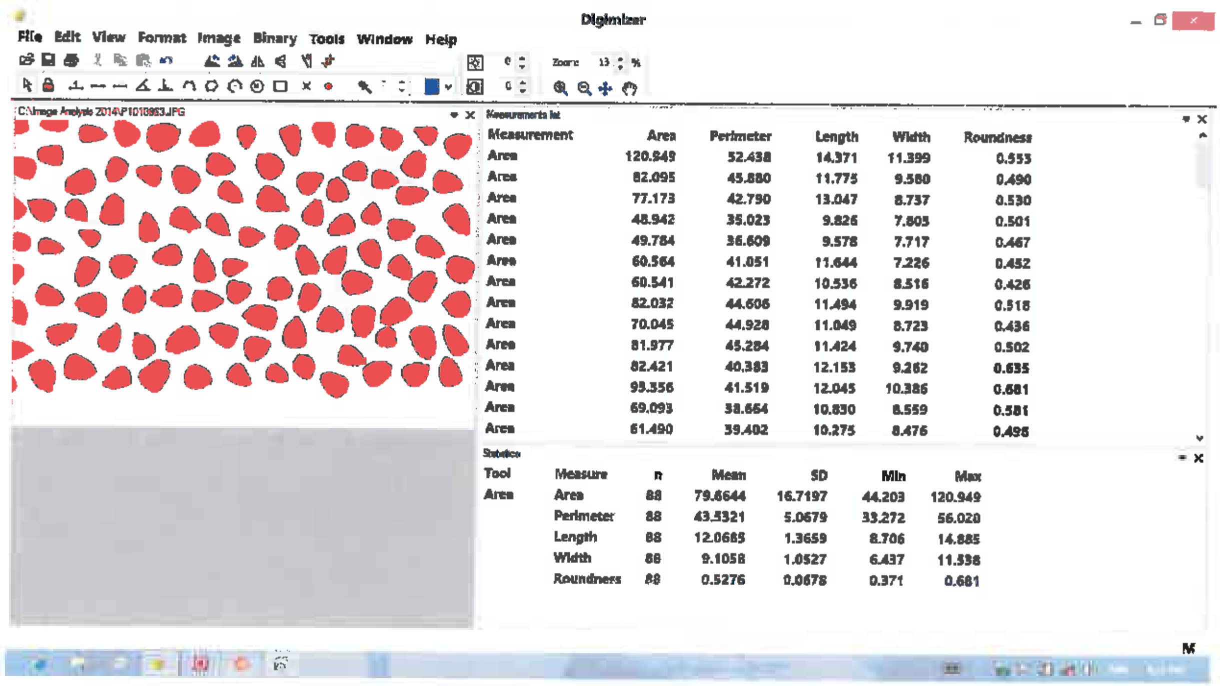


Figure 3. Binary detection and object measurements

2.3 *Near Infrared Transmittance (NIT)*

Near Infrared Transmittance tests were done according to the SAGL In-house SOP using the Foss Infratec. All NIT tests were done in triplicate using randomly assigned sample numbers.

2.4 *Roff Milling*

Roff Milling was done according to the Industry Accepted milling method (Method 013). The Roff Milling tests were conducted in triplicate on randomly assigned sample numbers.

2.5 *Statistics*

Basic ANOVA with Post Hoc tests were done, using Tukey's HSD test. For Image Analysis histogram data was also constructed using Statistica 10 software.

3. Results and Discussion

3.1 *Image Analysis*

Only an example of the histogram results is shown here (Figure 4), the results are comprehensive and are further summarised in Figures 5 to 7. During results evaluation of the data, it was found that three image analysis parameters had useful information for this experiment namely kernel length, kernel width and kernel roundness. Kernel width corresponds with the size of a round-hole sieve typically used in maize grading.

The kernel width illustrated in Figure 5 correlates well with the sieve classes, as expected for a round-hole sieve. The kernel length varied much more but there seems to be a trend towards longer kernels also on top of the 10 mm sieve.

The kernels were quite irregular in shape, mostly elongated, but no relationship can be established between sieve classes and roundness. The Image Analysis roundness factor is the ratio of two circle surface areas based on the radius obtained from the width measurement for the top value divided by the surface area form the radius from the length as the bottom value. A perfectly round kernel will have a value of 1 while a hair like structure will have a value approaching zero. Error bars were in a small band for all measurements, but was noticeably wider for the control (unsieved) samples indicating the wider size variability. Figure 8 shows an image outline of one sample to illustrate the elongated and angular shape of the maize.

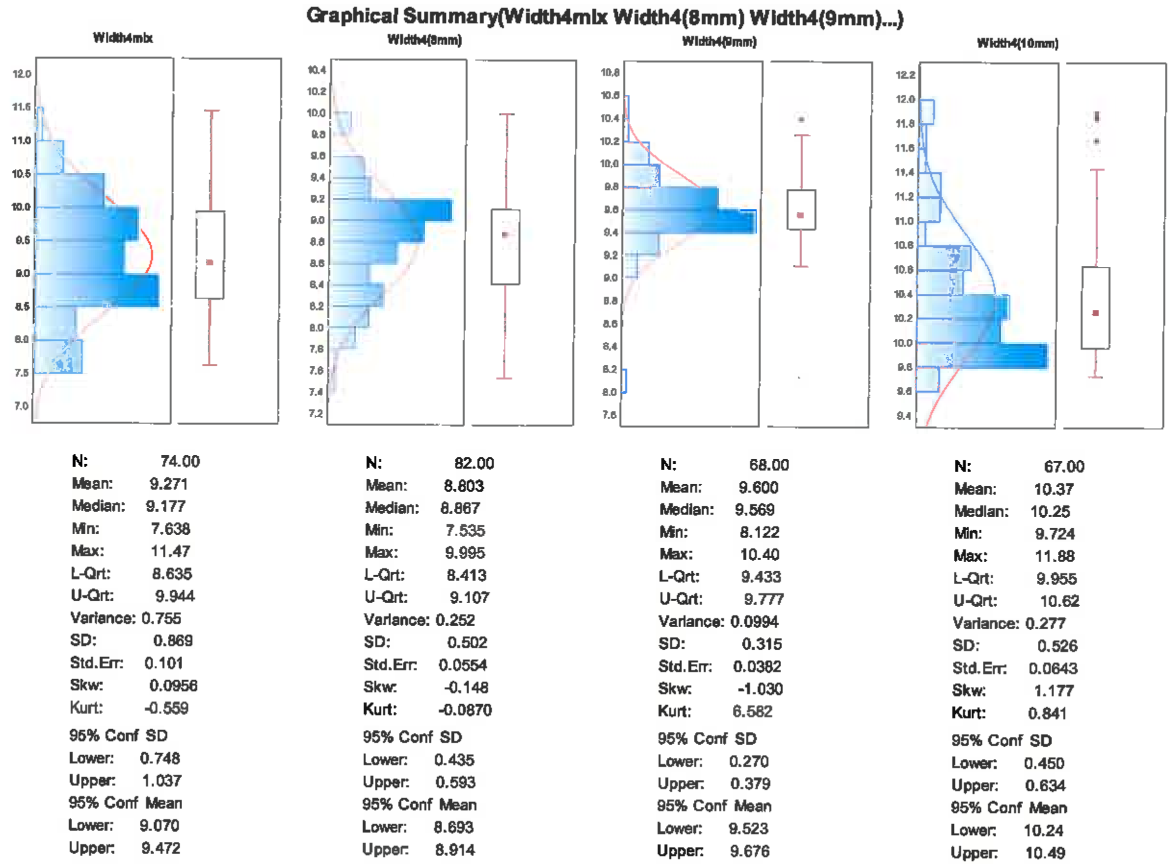


Figure 4. Image Analysis histogram comparing the size distribution of kernel width for Lot 4 maize. The Mix is the unsieved control while the other sizes are the 8, 9 and 10 mm sieve sizes. The sieve has a noticeable effect on the distribution pattern of the histogram.

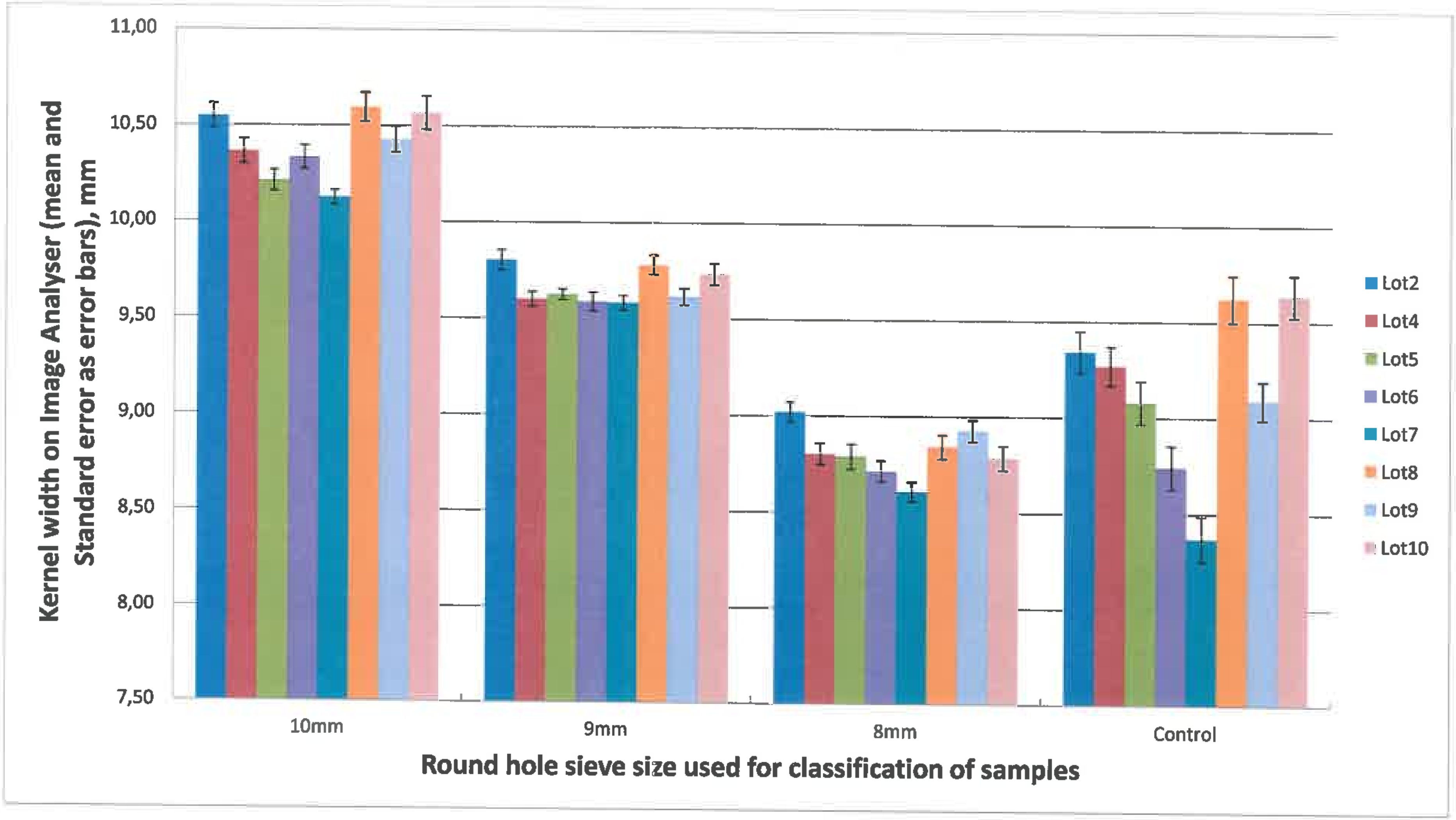


Figure 5. **The effect of round-hole sieve size (industry grading standard) for classification of maize on the measured kernel width using Image Analysis. The different lots represent the different Milling Index classes.**

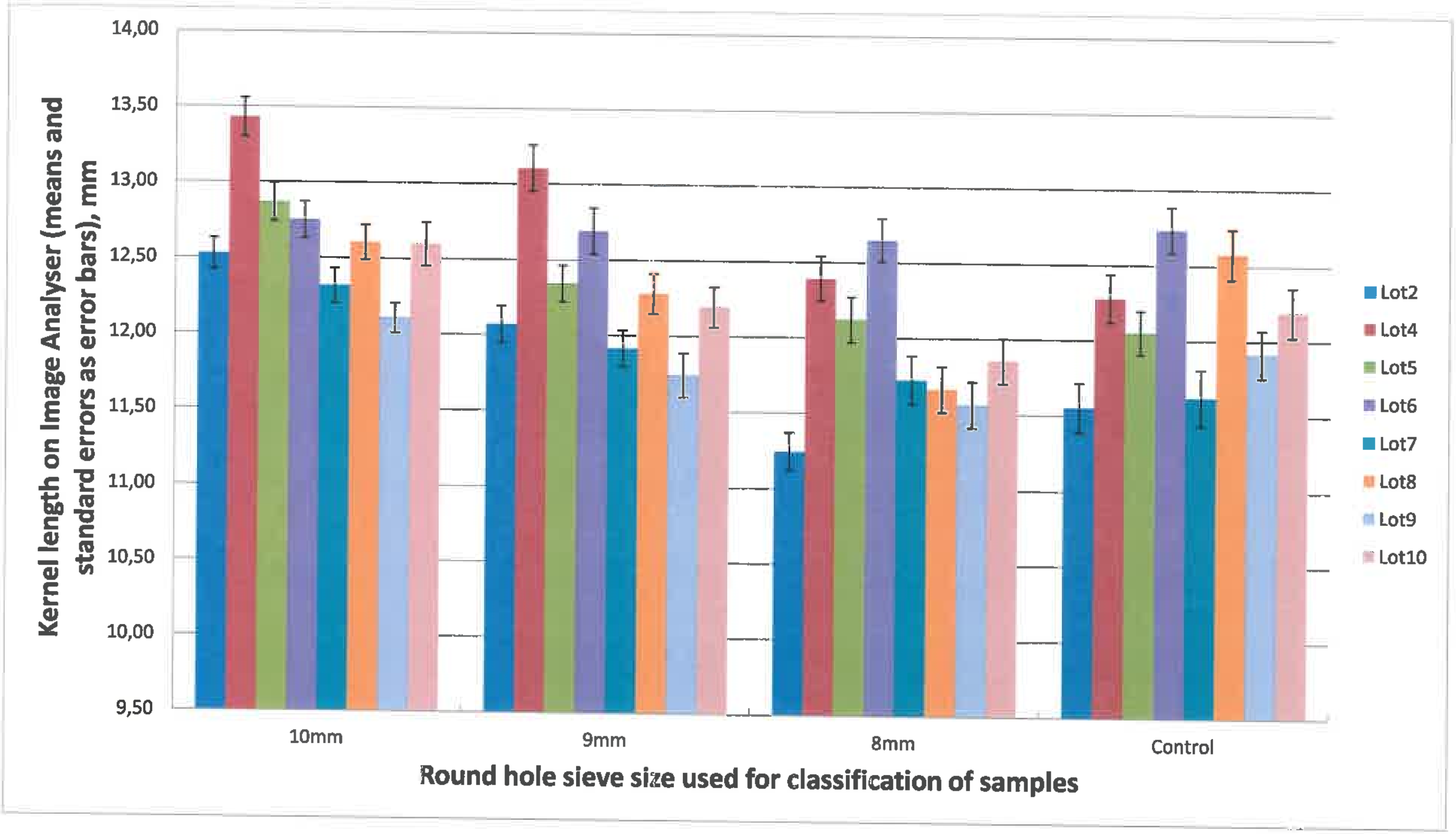


Figure 6. **The effect of round-hole sieve size (industry grading standard) for classification of maize on the measured kernel length using Image Analysis. The different lots represent the different Milling Index classes.**

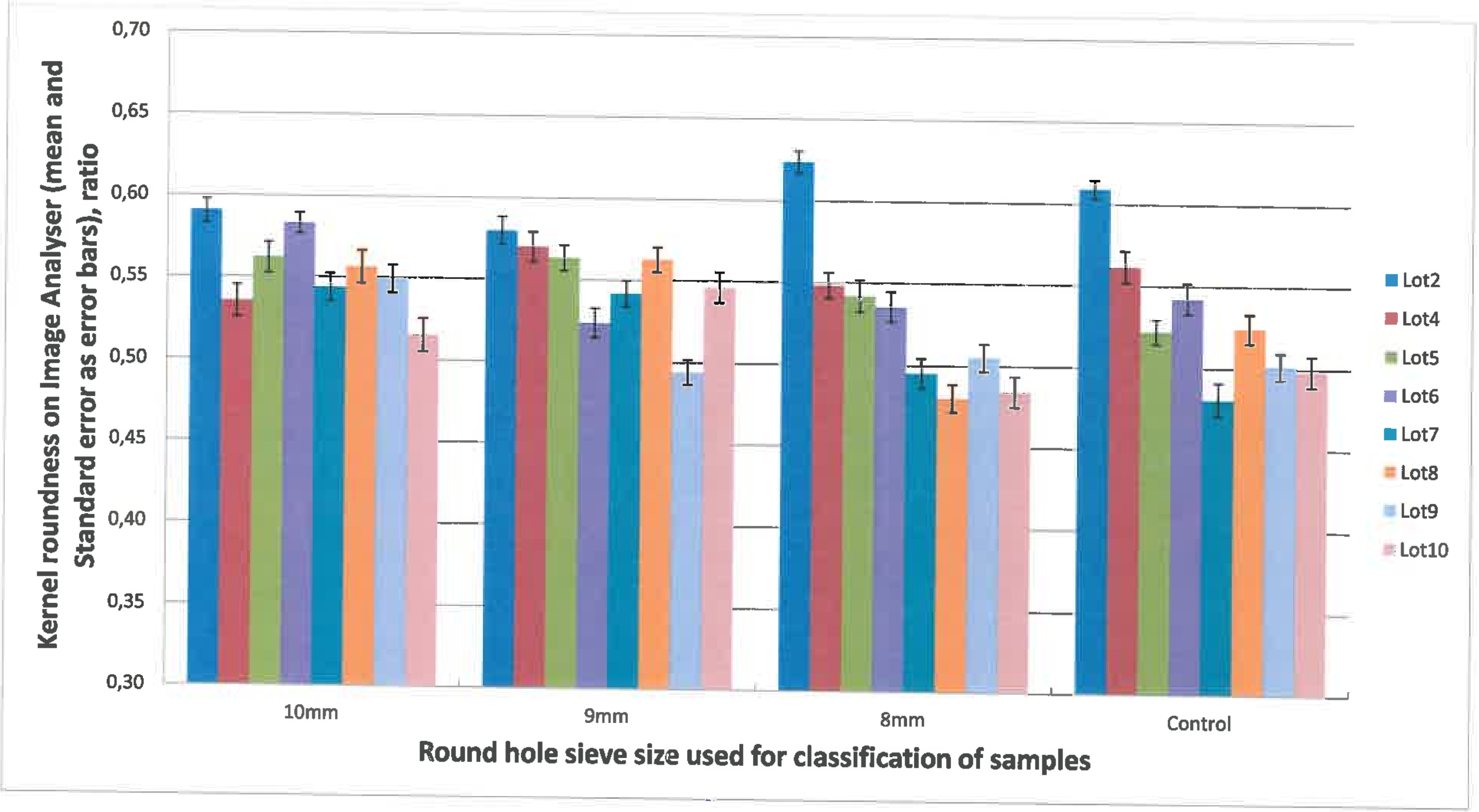


Figure 7. **The effect of round-hole sieve size (industry grading standard) for classification of maize on the measured kernel roundness using Image Analysis. The different lots represent the different Milling Index classes.**

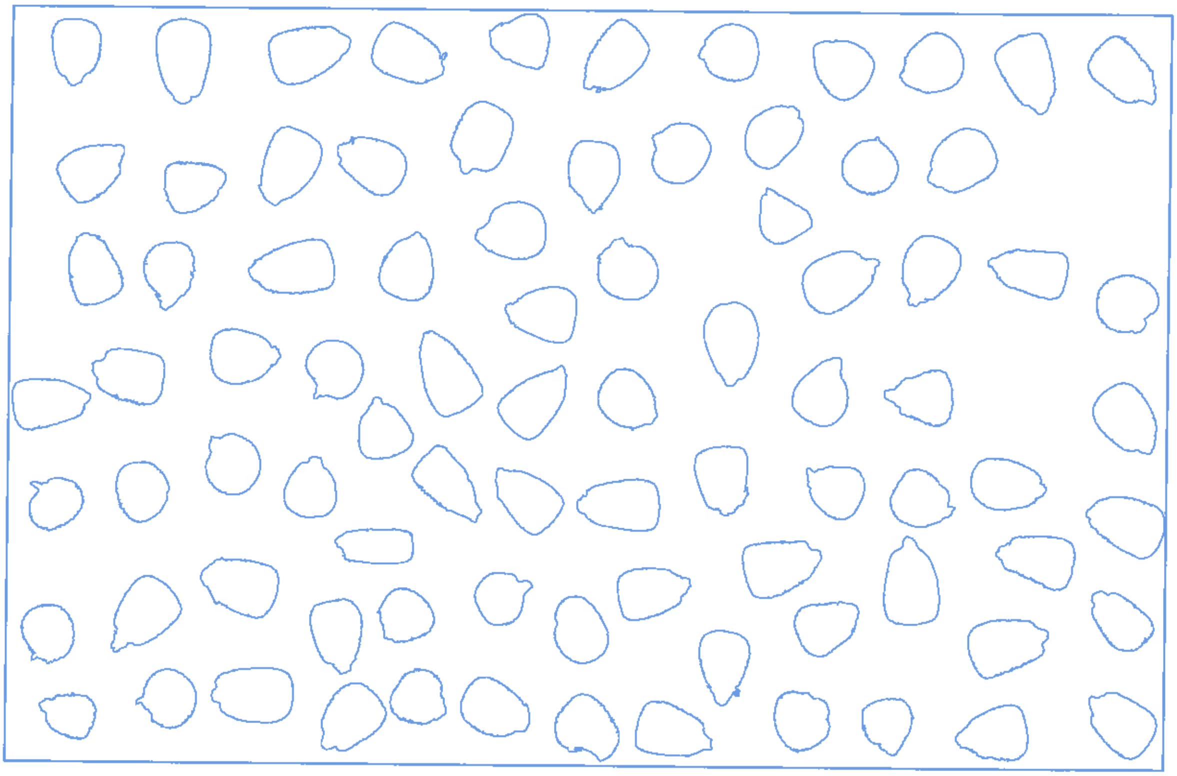


Figure 8. The highly irregular shapes of maize kernels, outlines detected taken lying flat, retained above the 8 mm round-hole sieve.

3.2 Near Infrared Transmittance (NIT) data

NIT results are summarised in Table 2.

Table 2 NIT results of each maize lot and sieve size, done in triplicate.

Lot	Sieve size	Oil DM		Protein DM		Moisture		Starch DM		Milling Index		Test Weight	
		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
1	8 mm	3.17	0.05	9.40	0.00	10.70	0.10	77.13	0.31	111.80	2.51	83.50	0.10
	7.2 mm	3.21	0.04	9.17	0.06	11.37	0.85	77.73	0.15	108.73	2.40	82.37	0.64
	Control	3.25	0.05	9.37	0.06	14.20	0.00	77.37	0.21	107.77	1.76	81.50	0.56
2	10 mm	4.14	0.08	8.77	0.15	12.23	0.75	75.40	0.10	98.30	1.83	79.03	0.32
	9 mm	4.01	0.09	8.60	0.10	12.63	0.91	75.70	0.46	95.20	4.14	79.10	0.10
	8 mm	4.14	0.03	8.70	0.10	11.83	0.25	75.87	0.12	93.23	2.60	79.13	0.61
	Control	4.07	0.03	8.70	0.17	12.83	0.15	76.50	0.46	95.17	0.49	79.23	0.40
3	7.2 mm	3.98	0.21	8.83	0.12	12.13	0.15	75.97	0.12	89.03	3.58	78.57	0.12
	6.35 mm	3.73	0.06	9.73	0.06	11.93	0.06	77.53	0.25	75.63	1.34	77.30	0.53
	Control	3.82	0.11	9.47	0.06	11.93	0.06	77.23	0.06	80.83	1.74	78.03	0.15
4	10 mm	3.75	0.15	9.70	0.10	10.97	0.38	75.10	0.30	96.70	1.77	78.27	0.45
	9 mm	3.76	0.06	9.70	0.10	10.63	0.06	75.27	0.31	95.03	1.85	78.73	0.51
	8 mm	3.83	0.05	9.40	0.10	10.33	0.06	75.83	0.15	95.80	0.90	78.80	0.17
	Control	3.81	0.02	9.63	0.12	10.67	0.06	75.63	0.15	94.43	3.19	78.63	0.64
5	10 mm	3.73	0.07	9.20	0.17	10.93	0.15	75.43	0.12	94.27	0.72	79.17	0.38
	9 mm	3.69	0.09	9.03	0.06	11.00	0.30	75.73	0.76	88.87	3.35	79.23	0.25
	8 mm	3.89	0.06	9.07	0.06	10.87	0.06	76.23	0.31	90.87	1.19	78.63	0.40
	Control	3.82	0.06	9.10	0.00	10.83	0.06	75.73	0.40	91.47	2.40	78.87	0.49
6	10 mm	3.96	0.02	10.33	0.06	10.93	0.15	74.63	0.42	112.13	2.16	81.33	0.29
	9 mm	3.89	0.04	10.23	0.12	10.97	0.12	74.80	0.35	113.83	1.86	82.87	0.32
	8 mm	4.03	0.09	10.47	0.06	10.83	0.06	75.00	0.10	115.37	1.01	83.10	0.20
	Control	3.95	0.06	10.30	0.10	10.57	0.06	75.40	0.00	115.27	0.61	82.17	0.55
7	10 mm	3.70	0.10	9.83	0.15	11.03	0.21	75.23	0.15	108.97	3.51	81.67	0.40
	9 mm	3.65	0.10	9.90	0.00	10.83	0.15	75.50	0.44	112.27	2.36	82.17	0.12
	8 mm	3.83	0.05	9.67	0.06	11.00	0.00	76.17	0.23	108.33	1.40	82.57	0.15
	Control	3.73	0.05	9.60	0.10	10.67	0.06	76.17	0.12	107.67	2.10	81.70	0.30
8	10 mm	3.79	0.07	10.57	0.21	11.63	0.23	74.43	0.29	103.33	4.24	80.33	0.31
	9 mm	3.89	0.06	10.50	0.10	11.33	0.06	74.83	0.15	104.70	2.40	80.67	0.40
	8 mm	3.93	0.03	10.33	0.15	11.27	0.06	75.20	0.20	102.43	2.30	80.93	0.31
	Control	3.76	0.11	10.20	0.17	11.43	0.15	74.93	0.25	103.70	3.76	80.23	0.21
9	10 mm	3.88	0.05	11.77	0.12	11.17	0.06	74.33	0.40	116.23	1.39	83.23	0.47
	9 mm	3.93	0.08	11.70	0.10	11.10	0.00	74.10	0.10	116.37	2.38	83.70	0.50
	8 mm	4.01	0.10	11.50	0.35	11.10	0.00	74.47	0.32	117.63	1.55	84.10	0.66
	Control	4.02	0.13	11.47	0.15	11.17	0.12	74.70	0.10	115.17	4.25	83.47	0.21
10	10 mm	3.92	0.12	10.83	0.12	11.57	0.21	74.17	0.31	108.43	1.76	81.37	0.78
	9 mm	3.98	0.01	10.87	0.06	11.40	0.00	74.63	0.15	110.17	2.45	81.53	0.15
	8 mm	4.03	0.02	10.43	0.06	11.43	0.15	74.83	0.31	105.30	4.62	81.07	0.47
	Control	4.04	0.06	10.70	0.10	11.37	0.06	74.53	0.29	107.53	3.40	80.57	0.72

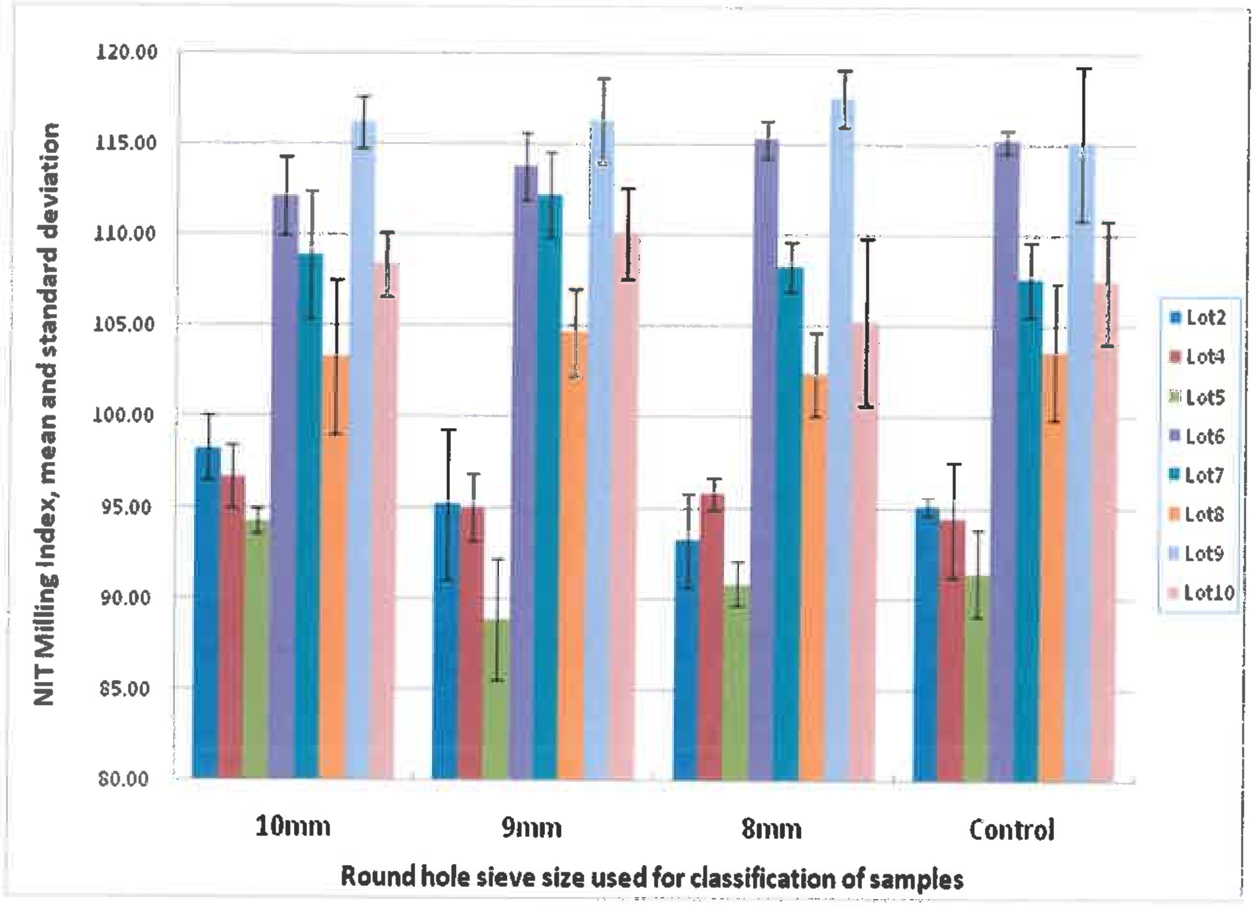


Figure 9. The effect of maize size classification on NIT measurements, triplicate samples

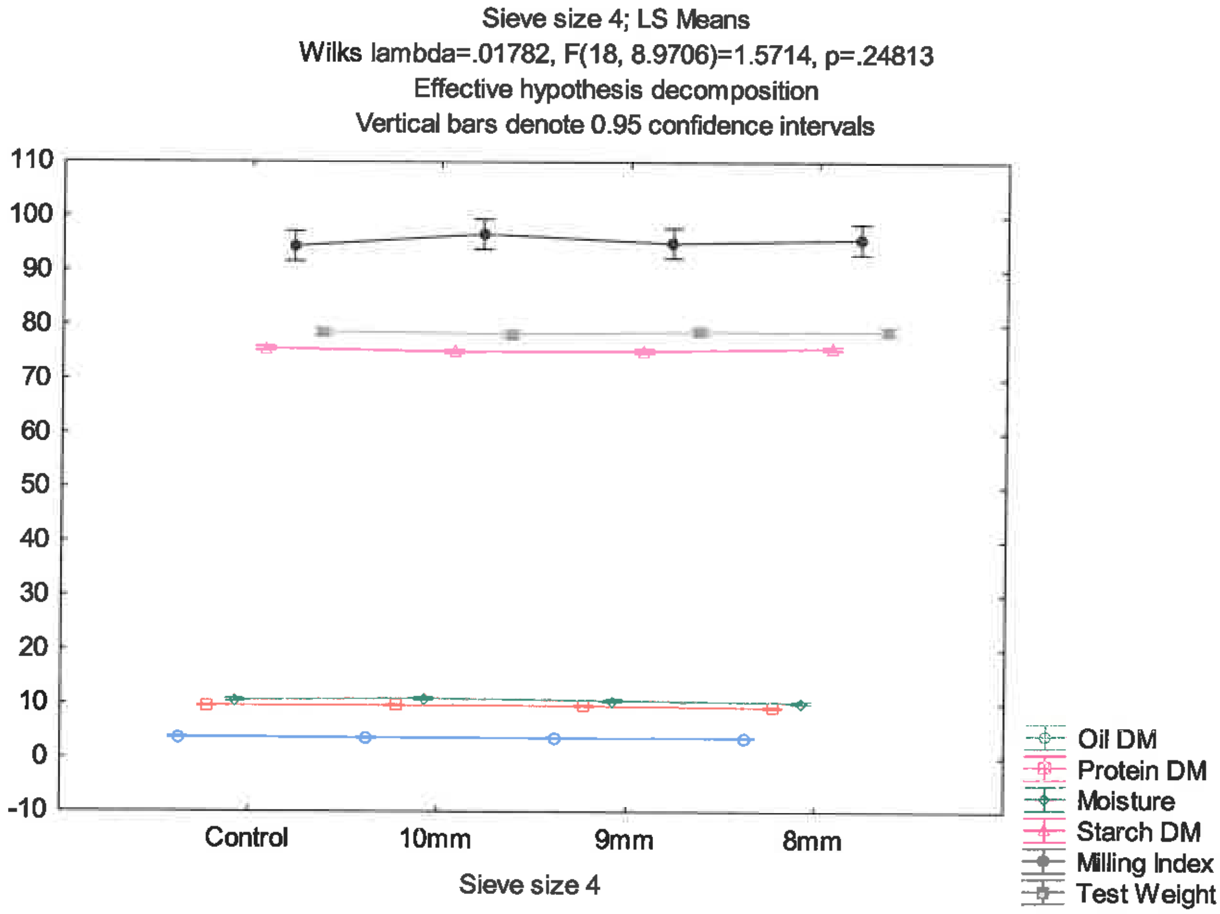
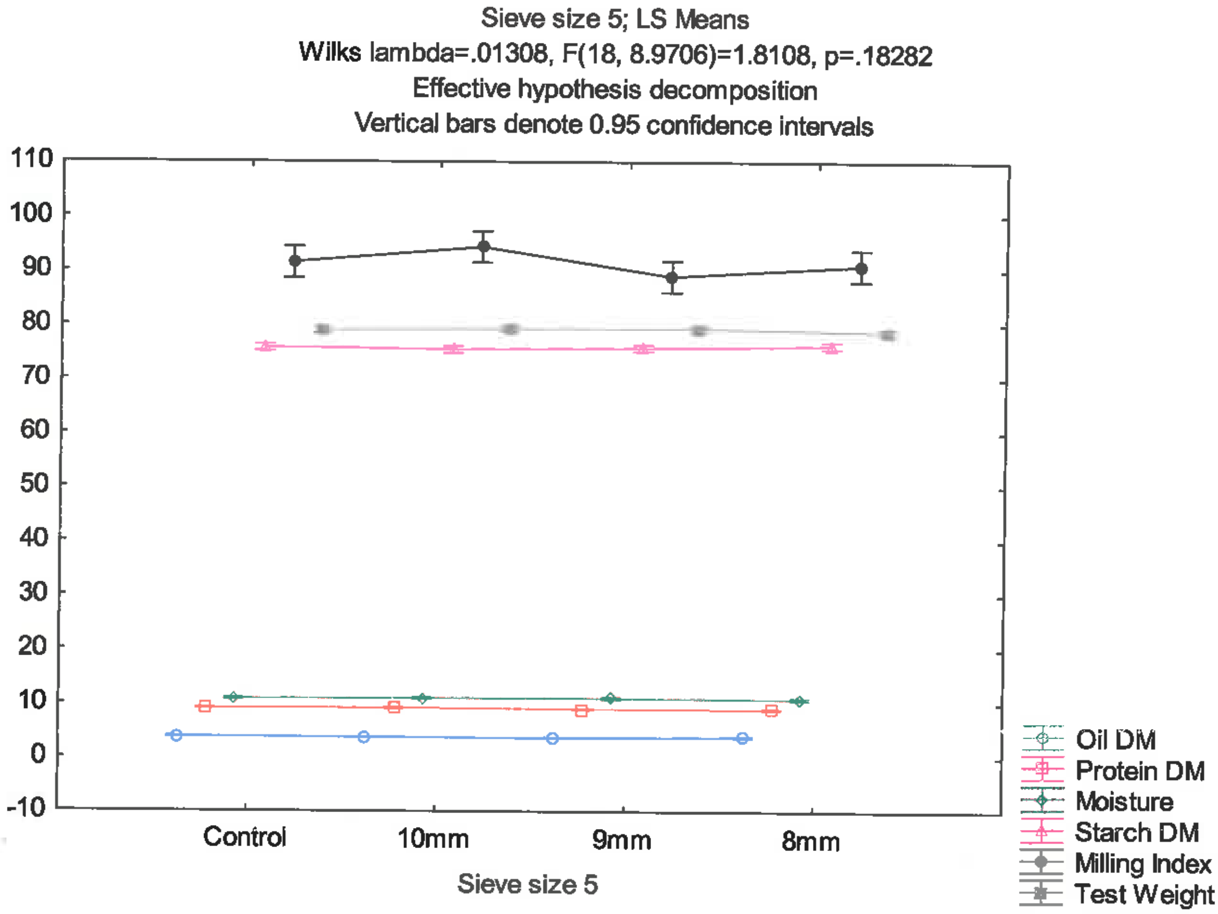


Figure 10. The effect of size classification on NIT values for Lot 4, LS Means.

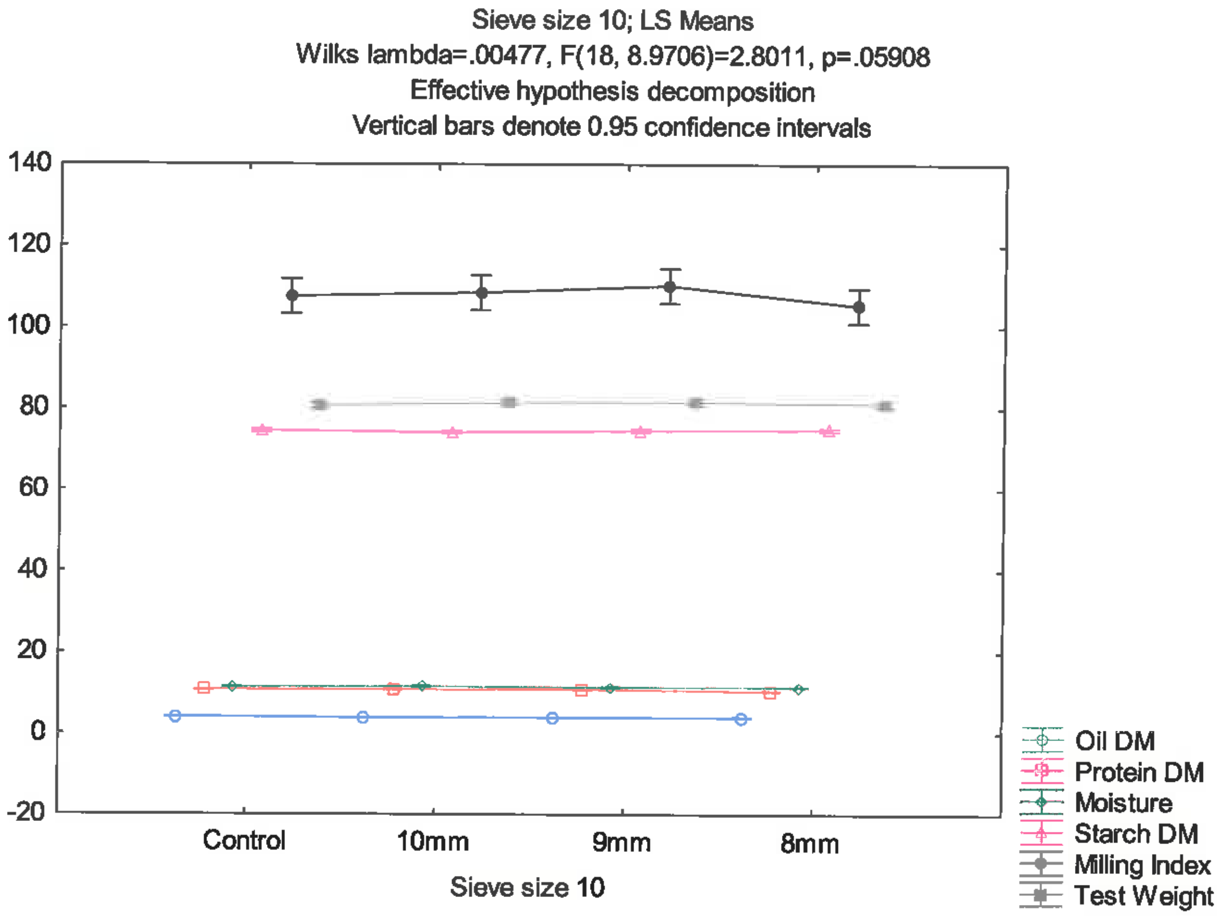


Cell No.	Tukey HSD test; variable Oil DM (NIT data) Homogenous Groups, alpha = .05000 Error: Between MS = .00501, df = 8.0000			
	Sieve size 5	Oil DM Mean	1	2
3	9mm	3.693333	****	
2	10mm	3.733333	****	****
1	Control	3.823333	****	****
4	8mm	3.893333		****

Cell No.	Tukey HSD test; variable Protein DM (NIT data) Homogenous Groups, alpha = .05000 Error: Between MS = .00917, df = 8.0000		
	Sieve size 5	Protein DM Mean	1
3	9mm	9.033333	****
4	8mm	9.066667	****
1	Control	9.100000	****
2	10mm	9.200000	****

Figure 11. The effect of size classification on NIT values for Lot 5, LS Means and ANOVA results

The only significant difference was for oil content between the 9 mm and the 8 mm samples. The rest of the samples showed no differences, as illustrated by homogenous group example for Protein DM. No differences were observed.



Cell No.	Tukey HSD test; variable Protein DM (NiT data) Homogenous Groups, alpha = .05000 Error: Between MS = .00750, df = 8.0000			
	Sieve size 10	Protein DM Mean	1	2
4	8mm	10.43333		****
1	Control	10.70000	****	
2	10mm	10.83333	****	
3	9mm	10.86667	****	

Figure 12. The effect of size classification on NIT values for Lot 10, LS Means and ANOVA results showing the only significant difference in the dataset.

3.3 *Roff Milling*

Table 3 The effect of maize size classification on Roff Milling data, on a dry base, triplicate milling tests.

		% Grits		% Break 1		% Break 2		% Break 3		% Bran		Milling Index Roff	
Lot	Sieve size	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
	8 mm	26.12	0.09	13.56	0.18	12.56	0.46	29.53	0.48	18.23	0.86	96.13	4.75
	7.2 mm	26.63	0.58	14.25	0.17	12.49	0.12	29.40	0.82	17.23	0.47	96.04	2.10
1	Control	27.58	1.46	13.34	0.38	12.82	0.20	28.88	1.47	17.37	0.98	99.26	2.55
	10 mm	24.73	0.23	13.30	0.07	13.38	0.07	29.10	0.67	19.49	0.45	96.23	2.22
	9 mm	24.53	0.50	13.68	0.07	13.16	0.17	29.71	0.49	18.92	0.27	96.47	1.79
	8 mm	25.80	0.58	13.66	0.29	13.04	0.47	28.25	0.57	19.25	0.39	93.11	1.99
2	Control	24.07	1.37	13.95	0.70	13.16	0.42	28.69	0.96	20.13	1.66	91.05	8.42
	7.2 mm	24.05	0.50	13.11	0.40	14.68	2.60	28.85	1.06	19.31	2.14	102.17	15.68
	6.35 mm	26.51	0.60	12.58	0.13	12.26	0.14	30.73	0.55	17.92	0.26	100.88	0.12
3	Control	26.05	0.20	12.87	0.31	12.48	0.17	29.35	0.80	19.24	1.16	95.26	3.95
	10 mm	24.75	1.34	13.40	0.42	12.90	0.71	25.56	2.98	23.40	0.62	79.35	3.33
	9 mm	23.93	0.39	13.54	0.14	12.82	0.34	27.50	0.36	22.20	0.35	83.91	2.77
	8 mm	23.59	0.13	13.74	0.20	12.90	0.26	27.53	0.28	22.24	0.10	83.48	1.68
4	Control	24.04	0.69	13.41	0.97	13.03	0.24	27.29	0.28	22.24	0.29	84.63	5.05
	10 mm	23.70	0.75	14.44	0.14	13.24	0.15	28.15	0.96	20.46	1.47	88.03	4.94
	9 mm	22.93	0.71	14.88	0.28	13.46	0.54	28.40	1.01	20.33	2.29	88.03	8.88
	8 mm	22.38	0.80	15.50	0.28	13.48	1.05	27.71	0.84	20.94	0.24	83.58	3.64
5	Control	23.00	1.27	15.06	0.57	13.51	0.98	27.96	0.89	20.46	3.65	86.59	12.64
	10 mm	29.20	0.46	9.94	0.09	11.91	0.33	29.02	0.55	19.93	0.59	100.75	1.75
	9 mm	30.43	1.21	10.49	0.46	12.13	0.38	28.19	1.09	18.75	1.87	102.09	6.64
	8 mm	30.14	1.11	9.42	0.18	13.03	2.83	27.70	0.51	19.71	1.19	105.94	14.16
6	Control	30.05	1.45	9.53	1.02	11.23	1.03	28.66	0.48	20.53	0.41	97.20	0.47
	9 mm	28.16	1.77	12.08	1.20	12.16	0.58	28.14	1.16	19.45	2.06	94.24	13.42
	8 mm	27.29	1.23	10.96	0.16	12.73	0.14	29.25	1.21	19.77	2.26	101.12	8.37
7	Control	27.59	2.16	12.28	0.72	12.48	0.10	28.29	1.22	19.36	0.76	95.43	2.01
	10 mm	26.25	0.74	10.98	0.31	13.14	0.65	28.62	0.72	21.01	0.24	98.56	3.80
	9 mm	25.85	1.09	11.56	0.81	13.07	0.15	29.47	0.87	20.04	0.60	100.01	1.38
	8 mm	26.39	0.18	11.87	0.11	12.42	0.43	30.01	0.59	19.30	0.83	99.23	3.29
8	Control	26.05	0.40	11.56	0.22	12.44	0.70	29.48	0.26	20.47	0.05	96.50	3.06
	10 mm	30.38	0.67	9.18	0.36	11.70	0.17	29.96	0.69	18.78	0.47	106.83	1.32
	9 mm	30.48	0.22	9.14	0.18	11.87	0.08	29.86	0.66	18.65	0.76	107.84	2.16
	8 mm	29.80	0.21	9.28	0.18	11.82	0.25	31.18	0.34	17.92	0.16	111.04	0.38
9	Control	29.32	0.62	8.98	0.15	12.16	0.50	30.49	0.48	19.05	0.51	109.49	2.38
	10 mm	28.65	0.26	10.33	0.22	12.28	0.21	28.72	0.45	20.02	0.46	100.19	1.46
	9 mm	28.18	0.57	10.73	0.16	12.37	0.15	29.03	0.78	19.69	1.22	100.47	3.77
	8 mm	27.10	0.48	11.42	0.27	12.33	0.57	30.28	0.94	18.87	0.46	101.92	1.25
10	Control	26.67	1.70	10.68	0.36	15.28	4.14	28.69	2.48	18.68	0.41	113.63	12.46

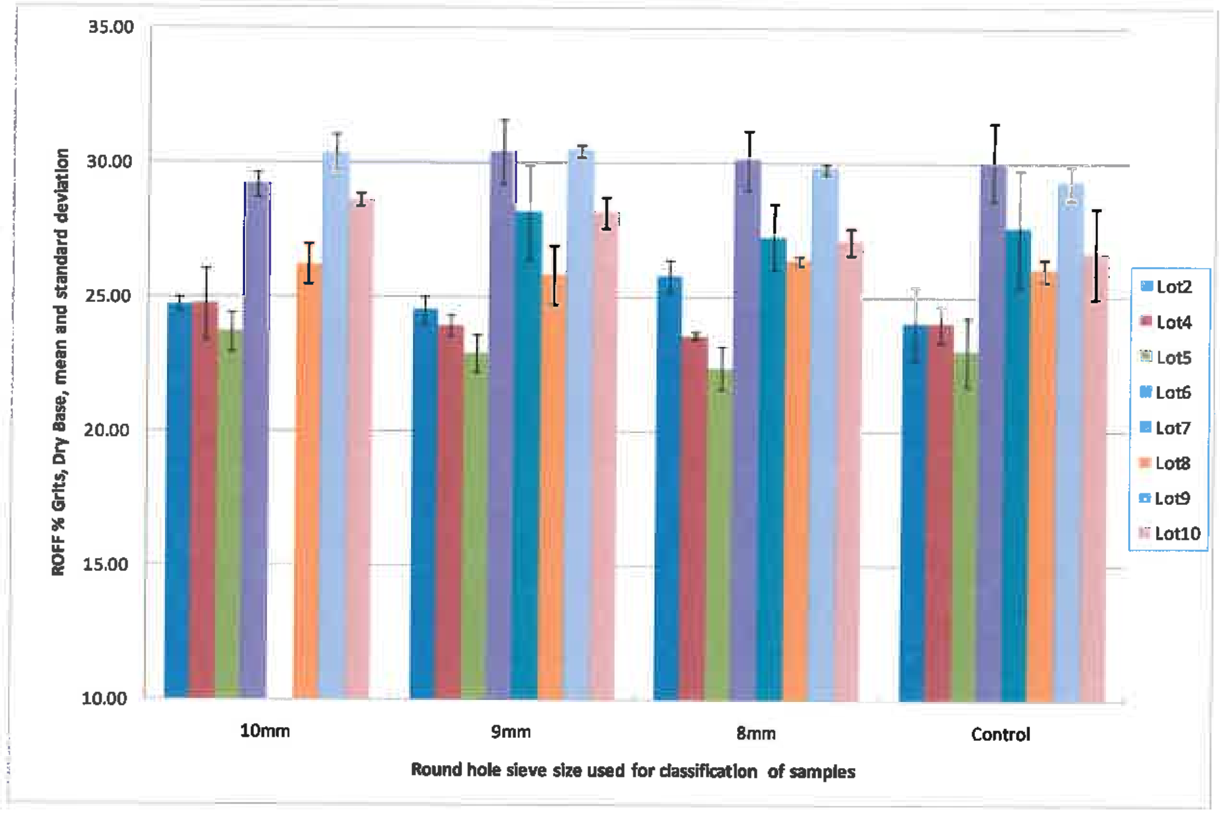


Figure 13. The effect of size classification on Roff %Grits (Dry Base) values for all lots except 1 and 3 which had only small maize kernels.

Very few differences could be observed in the data illustrated in Figure 13. It is possible that the Roff Milling test is not sensitive enough to quantify the small differences in yield expected for maize size classes within these narrow ranges. It is, however, a positive outcome that the standard deviations of the mixed sample (the Control) are similar to the size classified sample. Therefore the Roff Mill is not too sensitive for maize kernel size in these operating ranges as indicated in the Figure.

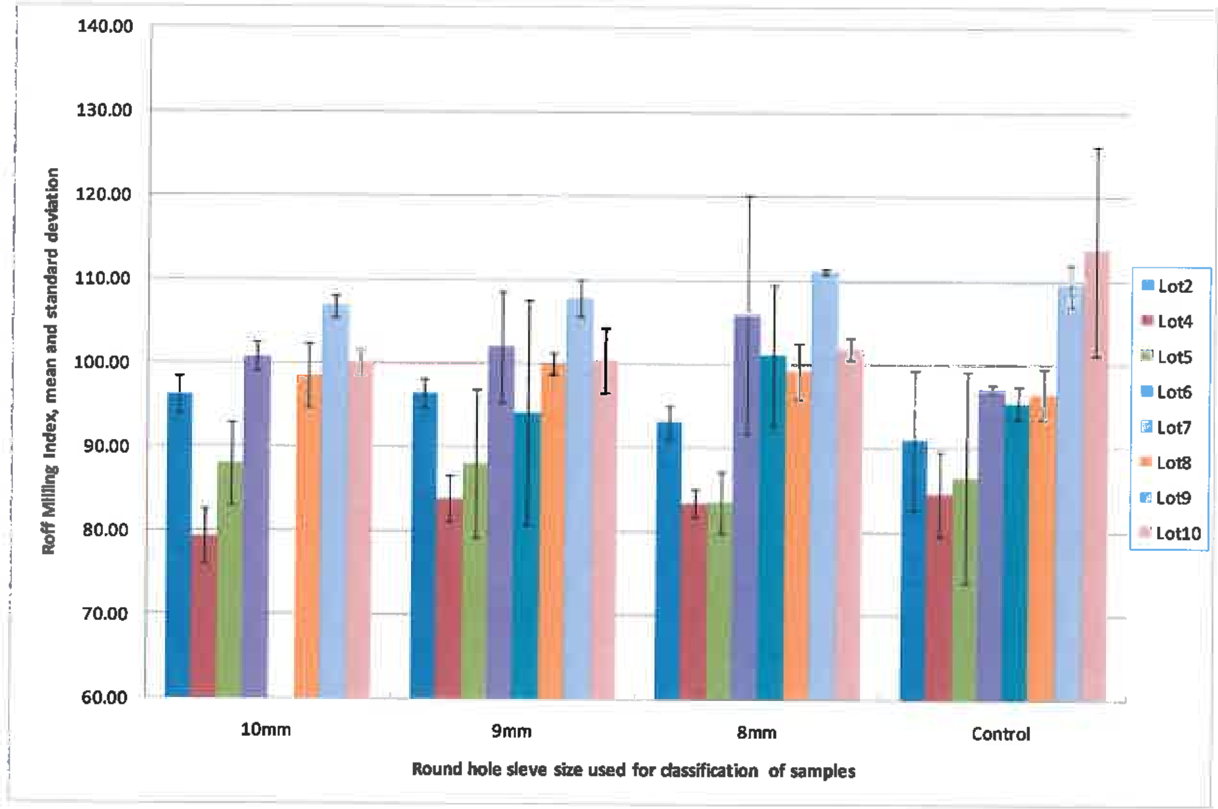
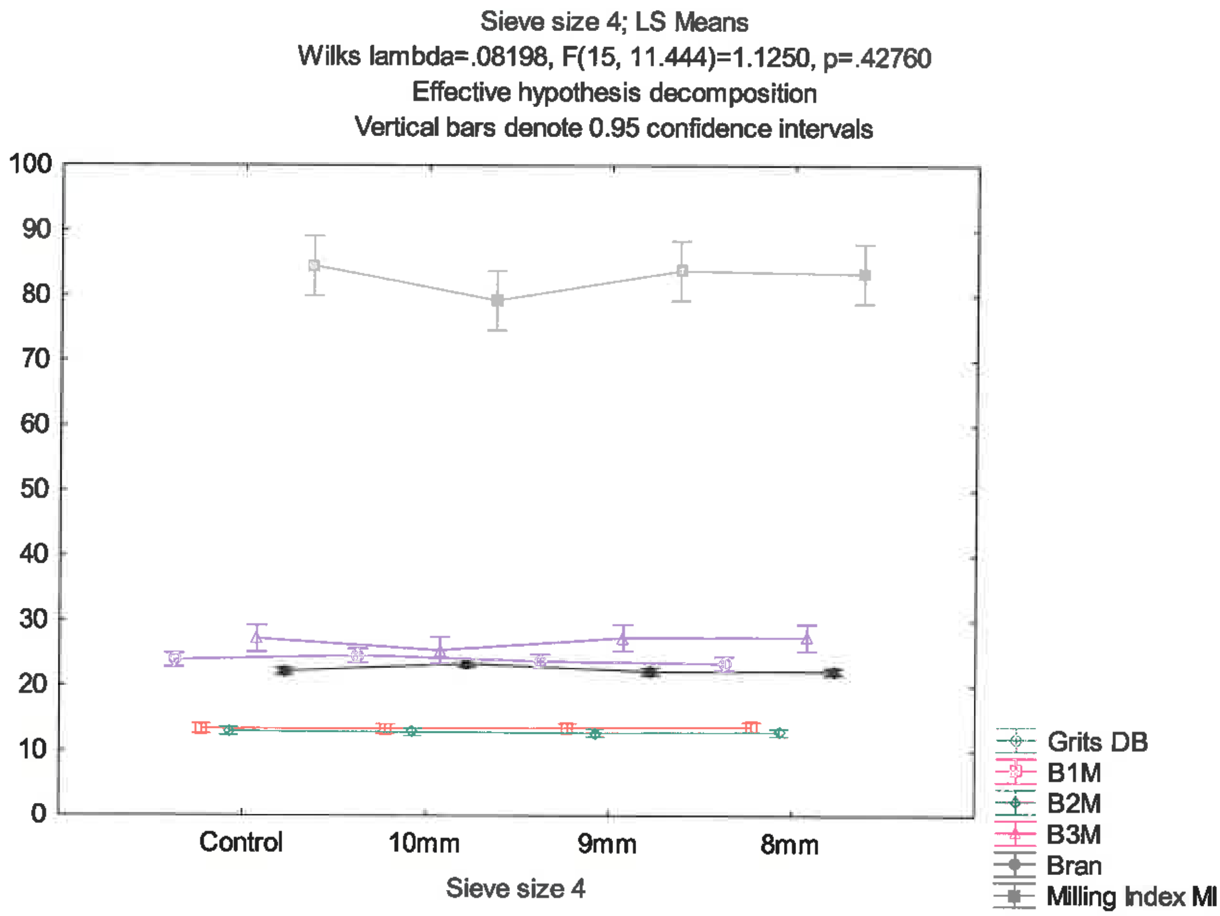


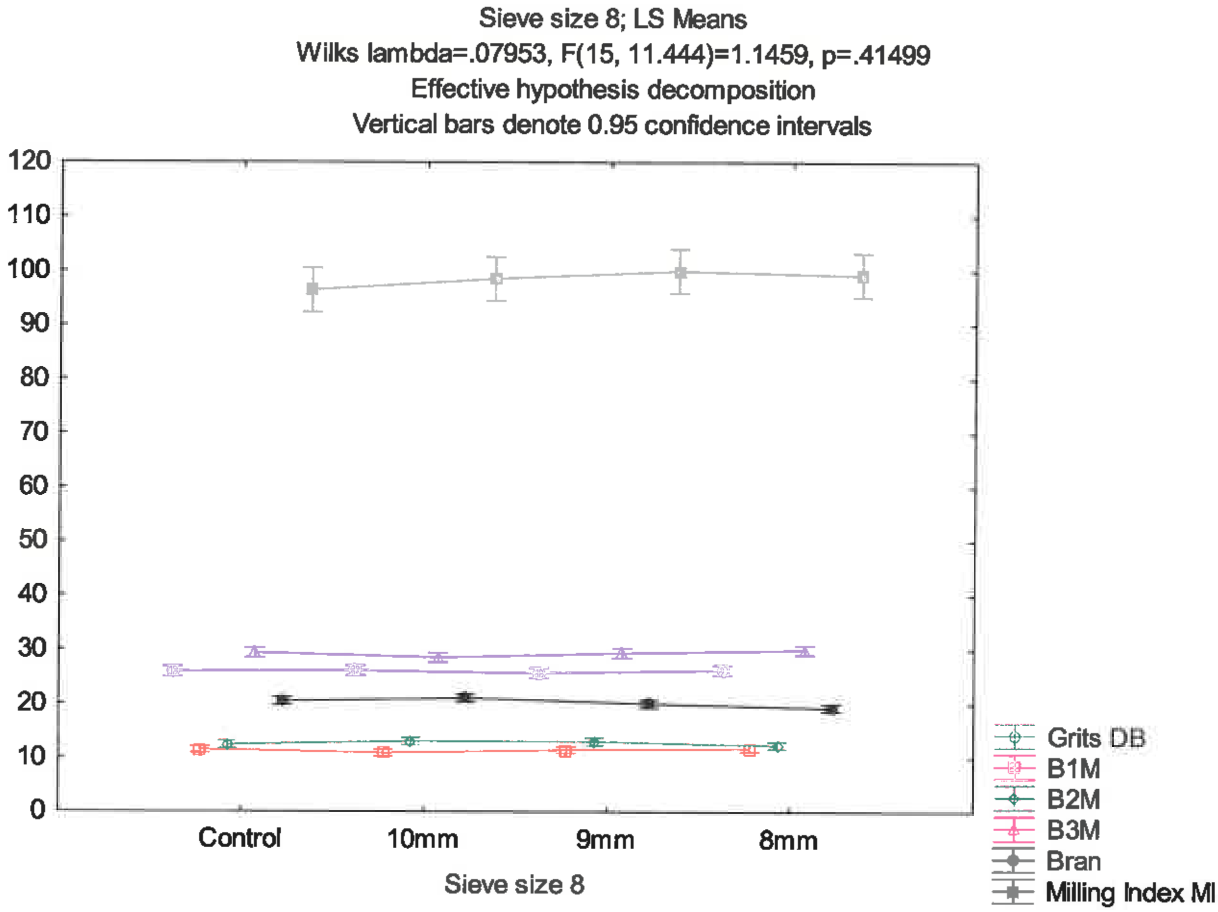
Figure 14. The effect of size classification on Roff Milling Index values for all lots excluding lots 1 and 3 (those had only small maize).

Figure 14 shows that there is atrend towards more variability in the control samples in terms of Roff Milling Index calculated on a dry base. However, the fairly large standard deviations made these differences mostly insignificant as can be seen in Figures 15 and 16 showing examples of some of the data. Significant differences are observed in the homogenous groups as shown for each lot in Figures 15 and 16.



Cell No.	Tukey HSD test; variable Bran (MT size project Roff samples) Homogenous Groups, alpha = .05000 Error: Between MS = .14908, df = 8.0000			
	Sieve size 4	Bran Mean	1	2
3	9mm	22.19803	****	
4	8mm	22.23688	****	
1	Control	22.24220	****	
2	10mm	23.40111		****

Figure 15. The effect of size classification on the Roff Milling Results for Lot 4 maize. The only significant difference was for the Bran content of the 10 mm maize.



Cell No.	LSD test; variable B1M (MT size project Roff samples) Homogenous Groups, alpha = .05000 Error: Between MS = .20089, df = 8.0000			
	Sieve size 8	B1M Mean	1	2
2	10mm	10.98060	****	
1	Control	11.56221	****	****
3	9mm	11.56346	****	****
4	8mm	11.87056		****

Cell No.	LSD test; variable B3M (MT size project Roff samples) Homogenous Groups, alpha = .05000 Error: Between MS = .42189, df = 8.0000			
	Sieve size 8	B3M Mean	1	2
2	10mm	28.62233	****	
3	9mm	29.47050	****	****
1	Control	29.47674	****	****
4	8mm	30.01291		****

Cell No.	LSD test; variable Bran (MT size project Roff samples) Homogenous Groups, alpha = .05000 Error: Between MS = .27520, df = 8.0000			
	Sieve size 8	Bran Mean	1	2
4	8mm	19.29956		****
3	9mm	20.04155	****	****
1	Control	20.47044	****	
2	10mm	21.01175	****	

Figure 16. The effect of size classification on the Roff Milling data for Lot 8 maize with a few significant differences shown.

3.4 Comparison of results with a wider range of maize sizes

Although it was very difficult to obtain sufficient quantities of maize with smaller kernels for Roff Milling tests, the commercial sample yielded sufficient sample sizes. The results shown in Figure 17 are the combined data from Lots 2 and 3 which were from the same sample source. The effect of the size classification now became significant as seen on the LS Means graph in Figure 17.

Effect	Multivariate Tests of Significance (NIT data) Sigma-restricted parameterization Effective hypothesis decomposition					
	Test	Value	F	Effect df	Error df	p
Intercept	Wilks	0.000015	148274.6	4	9.00000	0.000000
Size	Wilks	0.008274	5.0	20	30.79950	0.000036

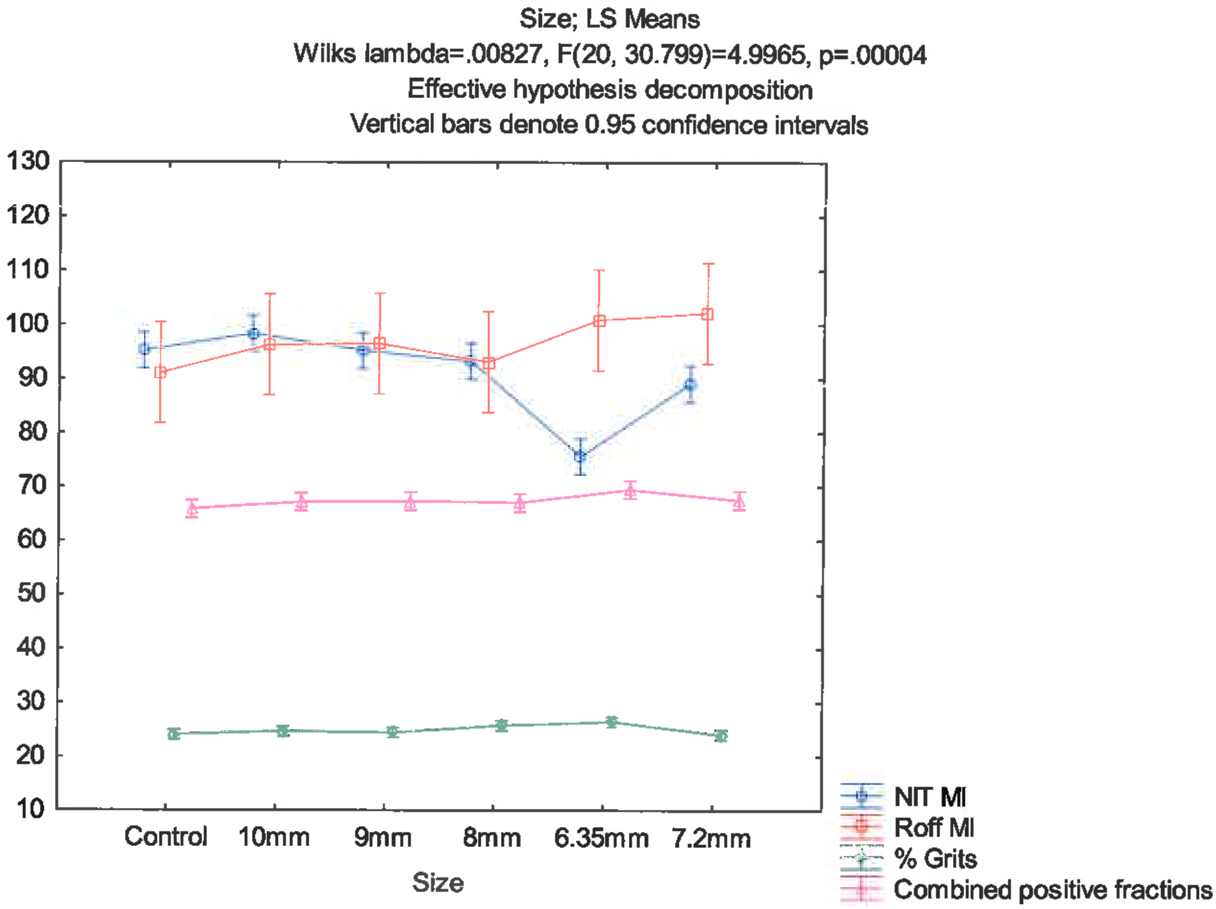


Figure 17. The effect of size classification on the combined Roff Milling Index, % Grits, Combined positive fractions and NIT Milling Index for the commercial white maize sample. The Combined positive fractions are the sum of the percentages of the Grits, Break 2 and Break 3 from the Roff mill, all calculated on a dry base. The positive fractions are used to calculate the positive score in the Milling Index formula (ARC).

Table 4 ANOVA and Homogenous groups showing some significant differences for the data in Figure 17.

Cell No.	Tukey HSD test; variable NIT MI (NIT data) Homogenous Groups, alpha = .05000 Error: Between MS = 7.0239, df = 12.000				
	Size	NIT MI Mean	1	2	3
5	6.35mm	75.63333			****
6	7.2mm	89.03333	****		
4	8mm	93.23333	****	****	
1	Control	95.16667	****	****	
3	9mm	95.20000	****	****	
2	10mm	98.30000		****	

Cell No.	Tukey HSD test; variable % Grits (NIT data) Homogenous Groups, alpha = .05000 Error: Between MS = .52120, df = 12.000			
	Size	% Grits Mean	1	2
6	7.2mm	24.04634	****	
1	Control	24.07011	****	
3	9mm	24.52732	****	
2	10mm	24.72976	****	****
4	8mm	25.80280	****	****
5	6.35mm	26.51308		****

Cell No.	Tukey HSD test; variable Combined positive fractions (NIT data) Homogenous Groups, alpha = .05000 Error: Between MS = 1.6648, df = 12.000			
	Size	Combined positive fractions Mean	1	2
1	Control	65.92092	****	
4	8mm	67.09045	****	****
2	10mm	67.21042	****	****
3	9mm	67.39297	****	****
6	7.2mm	67.57598	****	****
5	6.35mm	69.50177		****

4. Conclusion

At the outset of the project it was hypothesized that the effect of size classification of maize kernels would be significant in terms of influencing the Roff Milling fractions and possibly also the NIT measurements. The results in this report indicate that within the normal size range of maize kernels as received to date, the effect is smaller than anticipated. It does, however become significant in the smaller kernel ranges. It seems as if both the Roff Mill and the NIT are relatively robust towards the effect of kernel size. The NIT calibration already compensates largely for size effects because of scatter correction settings and if the Roff mill is running optimally, it should also not be affected too much by kernel size as it does not include a degermer as a pre-processing step. It is also possible that the Roff mill in its current format is not sensitive enough to clearly distinguish between subtle differences in maize kernel size. It must be noted however, that the size classification had quite a dramatic visual appearance effect on the samples, and cold also be seen clearly with the Image Analyser indicating the sensitivity of the method. The recommendation is to note the size distribution of maize samples as a potential influencing factor on milling yield, but for the Roff Milling system itself it seems not to be that critical. The effect of kernel size on NIT calibrations will be the focus of a future research project using larger sample sizes, and using the infrared scans instead of predicted measurements.