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Author:	Walker, L.; Wang, H.; Mahar, T.
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EXAMINATION OF THE EFFECT ON FABRIC HANDLE OF SOFTENER TREATMENT USING THE CRC WOOL HANDLE METER

Part II Rib and Pique

CRC SII Project 2.3.1

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Laura Walker, Henry Wang and Trevor Mahar

AWTA LTD,
PO Box 240, North Melbourne, Vic 3051

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EXAMINATION OF THE EFFECT ON FABRIC HANDLE OF SOFTENER TREATMENT USING THE CRC WOOL HANDLE METER

Part II: Rib and Pique

Executive Summary

This is the second report of a two part study. Part II is a repeat of Part I using rib and pique fabrics instead of single jersey fabrics. Two lightweight knitted wool fabrics, one rib and one pique, were treated with fatty acid and silicone softeners at different concentrations. The fabrics were assessed by five judges and tested on the CRC Wool Handle Meter (WHM) against the untreated fabrics.

The judges agreed that softening treatments slightly changed the handle of the rib and pique fabrics compared to their untreated fabrics. They found the treated rib fabrics to be slightly harder, tighter and less preferred than the untreated rib fabric; whereas they found the treated pique fabrics to be slightly rougher than the untreated pique samples. The treatments caused significant increases in fabric weight and thickness, which may have influenced the assessments of the judging panel.

Softener type and concentration were assessed by the judges to have no significant effect on fabric handle attributes.

The WHM performed well. Like the judging panel assessments, the WHM predicted the treated fabrics to be slightly harder and less preferred than the treated fabrics for the rib, and the treated pique fabrics to be slightly rougher than the untreated pique. However, the WHM was unable to predict consistent trends with either softener type or concentration level. Despite this, further principal component analysis showed that the CRC WHM may be able to differentiate between the treated and untreated fabrics and between the softener types.

The WHM also provided a more precise prediction of the average assessment of the judges (Average 95%CL: rib = 1.0, pique = 0.8) than did an individual judge (Average 95%CL: rib=1.6, pique = 1.8).

1 Background

The Background and Experimental sections (except for 2.1 Fabrics) from Part I are repeated here so that this can be a stand alone report.

A major objective of the Fabric Handle Project 2.3 in the Sheep CRC's Wool Program is to develop simple and cheap fabric measurement instrumentation and provide an associated knowledge package to measure the fabric handle of next-to-skin knitted fabrics. This will enable the engineering of predictable and desirable handle characteristics in garments made from lightweight knitted wool fabric.

A handle survey of the lightweight knitted fabrics in next-to-skin garments has shown that there are seven important handle attributes (Mahar and Wang, 2009). In order to predict these handle attributes, a prototype of the CRC WHM has been designed based on fabric extraction techniques (Alley, 1978, Pan and Yen, 1992). In conjunction with this fabric measurement, a series of models have been developed for the lightweight knitted fabrics in next-to-skin garments. The models have been validated for unwashed lightweight fabrics in single jersey (i.e. 140 – 210 g/m^2 in weight and less than 0.9mm in thickness).

In order to apply or extend the application of the CRC WHM in other areas, this report examines the effect of the application of softeners to rib and pique fabrics. Subjective assessments from five judges are used to evaluate the performance of the instrument and the associated models. Adjustments to the models will be made if required.

2 Experimental

2.1 Fabrics

Two knitted wool fabrics, a rib and a pique, were selected for softening treatments carried out at Macquarie Textiles. One sample from each fabric type, Rib 2 and Pique 7, were excluded from the testing due to alterations in their extensibility caused by a stenter during processing.

2.2 Softener Treatments

A full width fabric strip approximately 40cm in length was prepared for each treatment. Five individual strips were padded with one of two different softeners from a bath at the concentrations of 0.5%; 1%; 2%; 4%; or 8%. The first softener used was a generic fatty acid type while the second softener (Rucofin SIQ) was silicone based. A wetting agent, Ricowet – VM, was added at 4ml/litre to each bath.

The rollers that squeezed the excess liquid from the padded fabric were set at a pressure of two bar.

No control samples were prepared, although an untreated sample was retained. All treated samples were air dried overnight at approximately 20°C.

2.3 Subjective Assessments

Five judges from three organisations were selected to assess the seven handle attributes plus Overall Handle quality. Four of them were from the previous panel set up for the development of the models. No training was conducted for them prior to the assessments. The fifth judge was employed after some training.

A piece of approximately 25 x 25 cm fabric was prepared from each of the samples for the assessments. Each sample was randomly assigned a new ID in order to avoid any influence from the treatment strengths in the assessing.

The judges were asked to follow the instructions provided (Appendix 1), particularly to clean their hands using paper towelling and alcohol wipes before and during fabric assessment, because the softener material may deposit on the judge's hands.

A set of benchmark fabrics from the calibration set was provided with the average score from the previous 12 judges. The judges rated the samples for each of the handle attributes against the benchmark fabrics. The same scale of 1 – 10 was used as for the calibration fabrics (Table 1). The assessed results are shown in Appendix 2.

Table 1. Rating scales for the fabric handle sensory assessments

Handle attribute	Ratings of the handle assessments	
	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	
Rough - Smooth (RS)	Rough ----------►	Smooth
Hard - Soft (HS)	Hard ----------►	Soft
Loose - Tight (LT)	Loose ----------►	Tight
Heavy – Light (HL)	Light ----------►	Heavy
Hairy - Clean (HC)	Clean ----------►	Hairy
Warm - Cool (WC)	Cool ----------►	Warm
Greasy – Dry (GD)	Greasy ----------►	Dry
Overall Handle (OH)	Poor ----------►	Excellent

2.4 Objective Measurement

The samples were tested on the CRC Wool Handle Meter at AWTA Ltd. Before testing, the fabrics were conditioned overnight and three specimens were prepared. The testing was done according to the testing protocol established for the development of the models (Wang, 2008). A single operator was employed and instructed to clean the testing accessories (i.e. sample mounting plate, pressure plate and extraction orifice) for each test using paper towelling and alcohol wipes.

The average curve of the three specimens was used to predict the handle attributes. The curves are shown in Appendix 3 for individual fabrics and softener treatments.

3 Analysis of Subjective Assessments

3.1 Assessment Scores and Agreement among the Judges

Judges generally agreed on the mean scores for the fabrics over all the handle attributes. They also agreed that there was only a narrow variation in scores for each attribute over the each set of fabrics. Tables 3a and 3b list the mean, standard deviation (SD) and range of the scores for each of the handle attributes and fabrics from the individual judges, as well as the range of these parameters over the judging panel. Table 3a indicates that the judges generally graded the rib fabrics within narrow ranges (0.2 – 2.0) with the range of average scores for each attribute varying from 1.2 to 2.5 (on the 10 point scale). Table 3b also indicates that the judges generally graded the pique fabrics within narrow ranges (0.3 – 2.5) with the range of average scores varying from 1.1 to 4.4 (on the 10 point scale). The slightly higher range for the pique fabrics is due to two judges assessing the pique fabrics differently for Overall Handle. One judge gave a “Well below Average” overall score whereas another judge gave slightly above “Average” score average. The remaining three judges gave a slightly below “Average” rating for Overall Handle.

Table 3a Means, standard deviations and ranges of scores for each attribute from the individual judges for the rib fabric

Rib		Judge 1	Judge 2	Judge 3	Judge 4	Judge 5	Panel Range
OH	Mean	7.2	7.3	6.0	6.5	7.0	1.3
	SD	0.4	0.2	0.4	0.3	0.4	0.2
	Range	1.1	0.5	1.0	1.0	1.0	0.6
HS	Mean	7.2	6.9	5.6	6.5	6.4	1.7
	SD	0.2	0.4	0.3	0.3	0.9	0.7
	Range	0.5	1.5	1.0	1.0	2.0	1.5
RS	Mean	5.4	4.6	6.1	6.0	5.4	1.4
	SD	0.4	0.2	0.2	0.4	0.2	0.3
	Range	1.0	0.8	0.5	1.2	0.5	0.7
HC	Mean	8.2	6.9	7.0	5.7	6.5	2.5
	SD	0.3	0.3	0.0	0.5	0.0	0.5
	Range	0.8	0.8	0.0	1.0	0.0	1.0
HL	Mean	5.0	5.0	5.0	7.0	7.0	2.0
	SD	0.0	0.2	0.0	0.0	0.1	0.2
	Range	0.0	0.6	0.0	0.0	0.2	0.6
LT	Mean	3.1	2.6	3.0	4.2	5.0	2.4
	SD	0.4	0.4	0.4	0.3	0.0	0.4
	Range	1.1	1.2	1.0	0.5	0.0	1.2
WC	Mean	6.3	4.8	7.0	5.0	6.4	2.2
	SD	0.0	0.2	0.0	0.3	0.2	0.3
	Range	0.0	0.5	0.0	1.0	0.5	1.0
GD	Mean	6.4	5.2	5.5	5.4	5.3	1.2
	SD	0.2	0.2	0.3	0.3	0.3	0.2
	Range	0.5	0.5	1.0	1.0	1.0	0.5

Table 3b. Means, standard deviations and ranges of scores for each attribute from the individual judges for the pique fabric

Pique		Judge 1	Judge 2	Judge 3	Judge 4	Judge 5	Panel Range
OH	Mean	2.2	4.2	4.5	3.7	6.7	4.4
	SD	0.3	0.2	0.4	0.5	0.3	0.3
	Range	1.1	0.5	1.0	1.5	0.5	1.0
HS	Mean	5.2	4.4	4.0	3.6	5.7	2.1
	SD	0.7	0.3	0.0	0.3	0.3	0.7
	Range	2.2	0.8	0.0	1.0	0.5	2.2
RS	Mean	4.3	2.5	2.7	4.2	5.2	2.7
	SD	0.5	0.3	0.3	0.7	0.3	0.4
	Range	2.0	0.8	0.5	2.0	0.5	1.5
HC	Mean	7.1	5.3	6.0	6.0	5.4	1.8
	SD	0.3	0.3	0.0	0.0	0.1	0.3
	Range	1.1	0.8	0.0	0.0	0.3	1.1
HL	Mean	3.8	5.3	6.0	6.0	6.5	2.6
	SD	0.1	0.2	0.0	0.0	0.0	0.2
	Range	0.2	0.5	0.0	0.0	0.1	0.5
LT	Mean	5.4	6.4	5.3	5.0	6.5	1.5
	SD	0.4	0.4	0.7	0.0	0.0	0.7
	Range	1.5	1.5	2.5	0.0	0.0	2.5
WC	Mean	4.4	5.1	5.0	4.4	5.5	1.1
	SD	0.3	0.3	0.0	0.2	0.1	0.3
	Range	1.0	0.7	0.0	0.5	0.4	1.0
GD	Mean	5.6	5.1	6.0	5.5	6.7	1.7
	SD	0.5	0.2	0.3	0.3	0.5	0.3
	Range	2.0	0.7	1.0	1.0	1.0	1.3

Table 4 shows the poor agreement amongst the judges in the ranking of their assessments of these fabrics, as indicated by the relatively low correlation coefficients between each judge's scores and the mean score of the other four (4) judges.

Table 4. Correlation coefficients between each judge's scores and the mean score of the other four (4) judges

Correlations for Rib					
	Judge 1	Judge 2	Judge 3	Judge 4	Judge 5
OH	0.42	-0.63	0.29	-0.18	0.31
HS	-0.09	0.14	0.15	-0.09	0.15
RS	0.49	0.49	0.63	0.58	0.33
HC	0.25	-0.07	-	0.33	-
HL	-	0.13	-	-	0.13
LT	0.64	0.06	-0.1	-0.02	-
WC	0	0.35	-	0.44	0.1
GD	0.06	-0.04	0.03	-0.22	0.25
Average	0.25	0.05	0.2	0.12	0.21
Correlations for Pique					
	Judge 1	Judge 2	Judge 3	Judge 4	Judge 5
OH	0.31	0	0.78	0.68	0.37
HS	0.22	0.02	-	0.12	0.32
RS	0.59	0.31	0.65	0.78	0.27
HC	-0.3	-0.32	-	-	0.22
HL	-0.06	0.19	-	-	0.76
LT	-0.58	0.64	0.14	-	-
WC	-0.36	-0.38	-	-0.54	-0.25
GD	0.52	0.22	-0.08	0.47	-0.17
Average	0.04	0.09	0.37	0.3	0.22

Note: If a judge gave a constant score to all fabrics for an attribute no correlation coefficient is calculated for that attribute.

As Appendix 2 shows, the judges had different rankings and score ranges (i.e. different minimum and maximum values) for the same handle attributes. Therefore, normalisation of the scores was carried out when calculating the average score of the 5 judges. That is, the scores of each judge were normalised by his or her mean and standard deviation for each of the handle attributes. Then the average of the normalised scores of the five judges was calculated. Finally, the average of the normalised scores was transferred back to the scale of 1 – 10 using the grand mean and average range of the five judges. The normalised and transferred scores are listed Appendix 4 and Table 5.

Table 5. Average Scores of 5 Judges for each of the Handle Attributes for the Rib and Pique Fabrics.

Means for Rib								
	OH	HS	RS	HC	HL	LT	WC	GD
J1	7.2	7.2	5.4	8.2	5	3.1	6.3	6.1
J2	7.3	6.9	4.6	6.9	5	2.6	4.8	5.4
J3	6	5.6	6.1	7	5	3	7	5.7
J4	6.5	6.5	6	5.7	7	4.2	5	5.8
J5	7	6.4	5.4	6.5	7	5	6.4	6.2
Average	6.8	6.5	5.5	6.9	5.8	3.6	5.9	5.8
Means for Pique								
	OH	HS	RS	HC	HL	LT	WC	GD
J1	2.2	5.2	4.3	7.1	3.8	5.4	4.4	5.6
J2	4.2	4.4	2.5	5.3	5.3	6.4	5.1	5.1
J3	4.5	4	2.7	6	6	5.3	5	6
J4	3.7	3.6	4.2	6	6	5	4.4	5.5
J5	6.7	5.7	5.2	5.4	6.5	6.5	5.5	6.7
Average	4.3	4.6	3.8	6	5.5	5.7	4.9	5.8

3.2 Assessments of the Treatment Effect

Table 6 lists the differences in assessed scores between the treated and untreated fabrics. The treated fabrics were slightly smoother, harder, tighter, and less preferred than the untreated fabric for the rib only. Unexpectedly, the treated samples did not consistently show a clearly greasier feeling than the untreated, even though a high concentration of up to 8% softener was used in the application bath.

This preference by the judges for untreated fabrics may be due to the changes in fabric attributes following wet treatment. The treated fabrics were thicker and heavier following treatment as can be seen in Appendix 6. These effects may have been detected by the judges for the rib fabrics.

Table 6. Score Differences between the Treated and Untreated Fabrics (Treated – Untreated)

	OH	HS	RS	HC	HL	LT	WC	GD
Rib 1	-0.2	0.2	0.2	-0.1	0.0	0.5	0.4	0.0
Rib 3	-0.2	-0.3	0.2	-0.1	0.0	0.5	0.3	0.3
Rib 4	-0.8	-1.0	0.3	-0.5	-0.1	0.7	0.1	0.6
Rib 5	-0.9	-1.0	0.4	-0.5	0.0	0.6	0.2	0.1
Rib 6	-0.3	-0.1	0.4	-0.2	0.0	0.6	0.0	0.2
Rib 7	-0.2	-0.1	0.4	-0.1	0.0	0.6	0.1	-0.2
Rib 8	-0.5	-0.6	0.4	-0.3	0.0	0.2	0.1	0.0
Rib 9	-0.8	-0.5	0.5	-0.5	0.0	0.6	0.0	0.2
Rib 10	-0.7	-0.7	0.8	-0.4	-0.1	-0.1	0.3	0.1
Average	-0.5	-0.5	0.4	-0.3	0.0	0.5	0.2	0.1
Pique 1	0.2	0.5	-0.7	0.1	0.0	0.0	0.1	-0.1
Pique 2	-0.3	0.0	-1.1	-0.2	0.0	0.1	-0.2	0.1
Pique 3	-0.4	-0.3	-0.5	-0.2	0.0	0.2	-0.3	0.4
Pique 4	-0.3	-0.3	-0.5	-0.1	0.0	0.1	-0.2	0.4
Pique 5	-0.1	0.3	-0.4	-0.1	0.0	0.1	-0.1	0.2
Pique 6	0.0	0.2	0.1	0.0	0.0	-0.1	0.0	0.2
Pique 7	0.5	0.1	-0.6	0.2	0.0	1.0	0.3	0.0
Pique 8	0.0	0.4	0.1	0.0	-0.1	0.0	0.0	-0.1
Pique 9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pique 10	0.2	0.5	-0.7	0.1	0.0	0.0	0.1	-0.1
Average	-0.1	0.1	-0.4	0.0	0.0	0.1	0.0	0.1

3.3 Precision of the Subjective Assessments

The average of the standard deviations (SD) of the five judges' assessments for each fabric is used to estimate precision of the assessments. The calculation is as follows:

95% Confidence Limit = 1.96 * SD / sqrt (number of judges)

The estimates are listed on Table 7 for using a single judge and the panel of 5 judges .

Table 7. Precision estimates of the subjective assessments for each of the attributes

Rib	OH	HS	RS	HC	HL	LT	WC	GD
SD	0.61	0.77	0.63	0.93	1.10	1.03	0.97	0.54
1 Judge	1.2	1.5	1.2	1.8	2.2	2.0	1.9	1.1
5 Judges	0.5	0.7	0.5	0.8	1.0	0.9	0.8	0.5
Pique	OH	HS	RS	HC	HL	LT	WC	GD
SD	1.62	0.92	1.20	0.73	1.04	0.77	0.52	0.69
1 Judge	3.2	1.8	2.3	1.4	2.0	1.5	1.0	1.4
5 Judges	1.4	0.8	1.0	0.6	0.9	0.7	0.5	0.6

4 Analysis of Objective Measurement and Prediction

4.1 Effect of Treatments on Curve Parameters

As shown in Appendix 3, the extraction curves were very similar for the treated and untreated and between the two softeners for the pique fabric. The ribbed fabric extraction curves showed similarities independent of the softener type, but the curve of the untreated fabric differed markedly from the treated fabric curves.

The curve parameters plus fabric weight and thickness are listed in Appendix 5 for each sample. The differences in the curve parameters between the treated and untreated are listed in Appendix 6 for each sample.

It should be noted that the rib fabric differed sufficiently from the single jersey fabrics originally used in the development of the model to justify a single modification of the parameter extraction technique. This was necessary because the rib fabric showed a flatter peak than the single jersey fabrics the model was based on. The same modification was used for all rib fabrics.

4.2 Prediction Scores and Errors

The seven handle attributes and Overall Handle were predicted by the models using the curve parameters. The results are listed in Table 8. The differences between the predicted and assessed scores are listed in Table 9. Observations from Tables 8 and 9 follow:

- The average differences between the predicted and assessed values are from 0 - 2.3 subjective units for the rib and 1.0 – 1.9 for the pique.
- The differences are not dependent on the softener concentration
- For the ribbed fabric, the models consistently predicted slightly rougher, heavier, warmer and drier fabric handle than the assessors;
- For the pique fabric, the models consistently predicted slightly softer, smoother, cleaner, heavier and warmer fabric handle than the assessors.

Table 8. Predicted Scores for each of the Handle Attributes by the Models

Sample ID	Overall	HS	RS	HC	HL	LT	WC	GD
Rib Untreated	5.4	6.7	4.8	6.9	6.2	3.6	7.7	6.9
Rib 1	5.2	6.2	4.2	7.1	6.9	3.6	8.4	7.2
Rib 3	5.5	6.3	4.3	6.9	6.8	3.5	8.3	7.1
Rib 4	5	6.4	4.1	6.9	6.9	3.7	8.2	6.9
Rib 5	1.5	6.2	2.8	7.4	8.3	3.8	8.4	7.3
Rib 6	3.5	6.2	3	7	7.1	3.7	8.4	7.3
Rib 7	3.9	6.4	3.3	6.9	7	3.6	8.4	7.1
Rib 8	5.2	6.3	3.9	7	6.7	3.6	8.3	7.2
Rib 9	6.5	6.5	4.7	6.4	5.9	3.4	8.1	6.8
Rib 10	5	6.5	4.3	7	6.8	3.5	8.2	7
Pique Untreated	4.8	5.4	5.3	4	6.1	5.4	6	6.5
Pique 1	3.9	4.9	4.6	4	6.8	5.7	6.1	7
Pique 2	3.6	4.9	4.7	4.7	7.3	5.7	6.4	7.5
Pique 3	3.8	4.8	4.6	4.5	7.1	5.7	6.4	7.2
Pique 4	4.4	5.1	4.9	4.2	6.5	5.5	6.1	6.8
Pique 5	3.4	5	4.9	3.3	6.6	5.6	5.6	6.8
Pique 6	4	5.2	5	3.5	6.4	5.3	5.8	6.7
Pique 8	4	5.1	4.6	4.5	6.6	5.4	6.3	7.3
Pique 9	3	5	4.6	3.9	6.8	5.4	5.9	7.5
Pique 10	3.4	5	4.6	3.9	6.8	5.5	5.9	7.2

Table 9. Differences between the Predicted and Assessed Scores for each of the Handle Attributes (Predicted – Assessed)

	OH	HS	RS	HC	HL	LT	WC	GD
Rib untreated	-1.9	-0.3	-0.3	-0.3	0.4	0.4	2	1.4
Rib 1	-1.9	-0.9	-1.1	0.1	1.1	0	2.3	1.7
Rib 3	-1.5	-0.3	-1	-0.1	1	-0.1	2.2	1.4
Rib 4	-1.4	0.5	-1.3	0.2	1.2	-0.2	2.3	0.9
Rib 5	-4.8	0.2	-2.7	0.7	2.5	0	2.5	1.8
Rib 6	-3.4	-0.7	-2.4	0	1.3	0	2.6	1.6
Rib 7	-3.1	-0.5	-2.2	-0.1	1.2	-0.2	2.5	1.9
Rib 8	-1.6	-0.1	-1.6	0.1	0.9	0.3	2.5	1.8
Rib 9	0.1	0	-0.9	-0.2	0.1	-0.3	2.4	1.1
Rib 10	-1.6	0.2	-1.6	0.3	1.1	0.4	2.2	1.4
Ave	-2.1	-0.2	-1.5	0.1	1.1	0	2.3	1.5
SD	1.4	0.4	0.7	0.3	0.6	0.3	0.2	0.3
95% CL	2.6	0.8	1.5	0.6	1.2	0.5	0.4	0.6
Overall ave 95% CL	1.0							
Pique Untreated	0.9	1	1.2	-1.8	0.7	-0.5	1.3	-0.1
Pique 1	-0.3	0.7	1	-1.9	1.3	0.1	1.3	1.4
Pique 2	-0.4	0.4	1.6	-1.2	1.8	0.1	1.6	1.8
Pique 3	-0.1	0.6	0.9	-1.3	1.6	-0.1	1.7	1.3
Pique 4	0.3	0.9	1.2	-1.7	0.9	-0.2	1.4	0.8
Pique 5	-0.9	0.2	1.1	-2.7	1	0	0.7	1
Pique 6	-0.4	0.5	0.7	-2.5	0.8	-0.1	0.9	0.9
Pique 8	-0.4	0.2	0.3	-1.5	1.2	-0.2	1.4	1.8
Pique 9	-1.4	0.5	0.5	-2.1	1.2	-0.2	1	1.9
Pique 10	-1.2	0	1.1	-2.2	1.3	0	0.9	1.7
Ave	-0.4	0.5	1	-1.9	1.2	-0.1	1.2	1.2
SD	0.7	0.3	0.4	0.5	0.3	0.2	0.3	0.6
95% CL	1.3	0.7	0.8	1	0.7	0.3	0.6	1.2
Overall ave 95% CL	0.8							

Compared to the subjective precision shown in Table 9, the performance of the models are much better than using a single assessor.

4.3 Prediction of the Treatment Effects

The differences of the predicted scores between the untreated and treated fabrics are listed in Table 10. Observations from Table 10 follow:

- The untreated rib and pique fabrics were predicted to be preferred in Overall Handle. These results are similar to the assess ments of the judgeing panel.
- The treated fabrics were predicted to be slightly harder, smoother and heavier than the untreated fabric for both the rib and pique fabrics, as assessed by the judging panel for the pique but not for the rib fabrics.
- The treated rib fabrics were also predicted to be warmer, than the treated fabrics.
- The differences were not dependent on the softener concentration or type.

Table 10. Differences of the Predicted Scores between the untreated and Treated (Treated – Untreated)

Sample ID	Overall	HS	RS	HC	HL	LT	WC	GD
Rib 1	-0.2	-0.5	-0.6	0.2	0.7	0	0.6	0.3
Rib 3	0.2	-0.4	-0.5	0.1	0.6	0	0.5	0.3
Rib 4	-0.3	-0.3	-0.7	0	0.7	0.1	0.5	0.1
Rib 5	-3.8	-0.5	-2	0.5	2.1	0.2	0.7	0.5
Rib 6	-1.9	-0.5	-1.8	0.1	1	0.1	0.7	0.4
Rib 7	-1.5	-0.4	-1.5	0	0.8	0	0.6	0.2
Rib 8	-0.2	-0.4	-0.9	0.1	0.5	0	0.6	0.3
Rib 9	1.1	-0.2	-0.1	-0.4	-0.3	-0.1	0.3	-0.1
Rib 10	-0.4	-0.2	-0.5	0.2	0.6	-0.1	0.4	0.1
Average	-0.8	-0.4	-1	0.1	0.7	0	0.6	0.2
Pique 1	-0.9	-0.5	-0.7	0	0.7	0.3	0.2	0.5
Pique 2	-1.3	-0.5	-0.6	0.7	1.2	0.3	0.4	1
Pique 3	-1	-0.6	-0.7	0.5	1	0.3	0.4	0.8
Pique 4	-0.4	-0.3	-0.4	0.1	0.4	0.1	0.2	0.3
Pique 5	-1.5	-0.4	-0.4	-0.8	0.5	0.3	-0.4	0.3
Pique 6	-0.9	-0.2	-0.3	-0.5	0.3	-0.1	-0.2	0.3
Pique 8	-0.9	-0.3	-0.7	0.5	0.6	0	0.4	0.8
Pique 9	-1.9	-0.4	-0.7	-0.1	0.7	0	0	1
Pique 10	-1.5	-0.4	-0.7	-0.2	0.7	0.1	0	0.8
Average	-1.1	-0.4	-0.6	0	0.7	0.1	0.1	0.6

4.4 Prediction of Softener Effects

The differences of the predicted scores between the fabrics treated by the two softeners are listed in Table 11 for each of the fabrics. The observations are summarized as follows:

- It seems that the fatty acid softener and silicone softeners had different effects on handle of rib and pique fabrics. That is, the changes in each of the handle attributes were not consistent between the rib and pique fabrics;
- At concentrations of 4% or more, the silicon softener produced slightly softer, smoother and greasier handle in the rib fabric than the fatty acid softener but these changes did not occur for the pique.
- As a result, the rib sample treated at 8% by the silicone softener was the most preferred in the Overall Handle.

Table 11. Differences between the Fabrics Treated by the Two Softeners (Fatty Acid – Silicon)

Rib								
Concentration	Overall	HS	RS	HC	HL	LT	WC	GD
0.5%	1.7	0.1	1.2	0.1	-0.2	-0.1	0	-0.1
1%	NA	NA	NA	NA	NA	NA	NA	NA
2%	0.4	0	0.4	0	0.1	-0.1	-0.1	0
4%	-1.5	-0.1	-0.5	0.4	1	0.2	0.1	0.2
8%	-3.5	-0.3	-1.5	0.3	1.5	0.3	0.2	0.4
Average	-0.7	-0.1	-0.1	0.2	0.6	0.1	0.1	0.1
Pique								
Concentration	Overall	HS	RS	HC	HL	LT	WC	GD
0.5%	0	-0.4	-0.3	0.5	0.4	0.3	0.4	0.2
1%	NA	NA	NA	NA	NA	NA	NA	NA
2%	-0.2	-0.2	0	0	0.5	0.3	0	0
4%	1.4	0.1	0.2	0.2	-0.3	0.1	0.2	-0.7
8%	0	0	0.3	-0.6	-0.2	0.2	-0.4	-0.4
Average	0.3	-0.1	0	0	0.1	0.2	0	-0.2

4.5 Principal Component Analysis of the Curve Parameters

In order to examine the sensitivity of the CRC WHM, Principal Component Analysis (PCA) was carried out on the curve parameters. Figures 1 and 2 show the sample scores from the first and second principal components (i.e. PC-1 & PC-2). The PCA reduced the number of curve parameters to include only ‘h’ and ‘Dp’ in the rib analysis, and ‘a’, ‘h’, ‘pDp’ and thickness for the pique fabrics. For the ribbed fabric, approximately 100% of the variance was explained by the first two components. For pique, 71% of the variance was explained by the first two components. This shows that the fabrics were changed by the treatments, particularly the rib. Observations on the PCA are summarised as follows:

- Using PC-1 can differentiate between:
  - SJ1 and SJ2;
  - Untreated and Treated;
  - Fatty acid and Silicone softeners

- Using PC-1 and PC-2 can differentiate between:
  - Control and softened;
  - The softener' concentrations, particularly for the extremes.

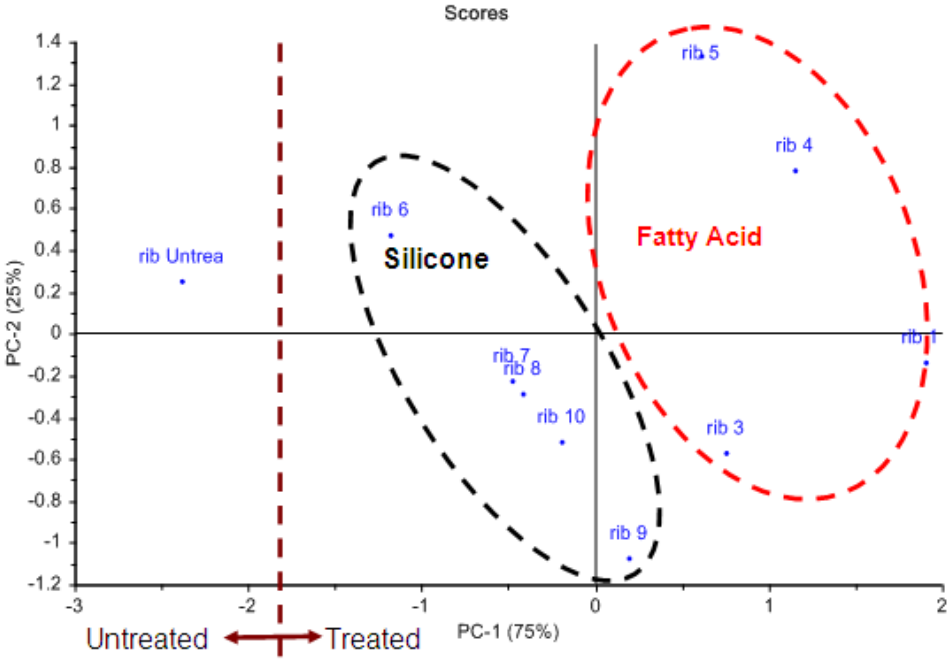

Figure 1. Score plot for the rib PCA.

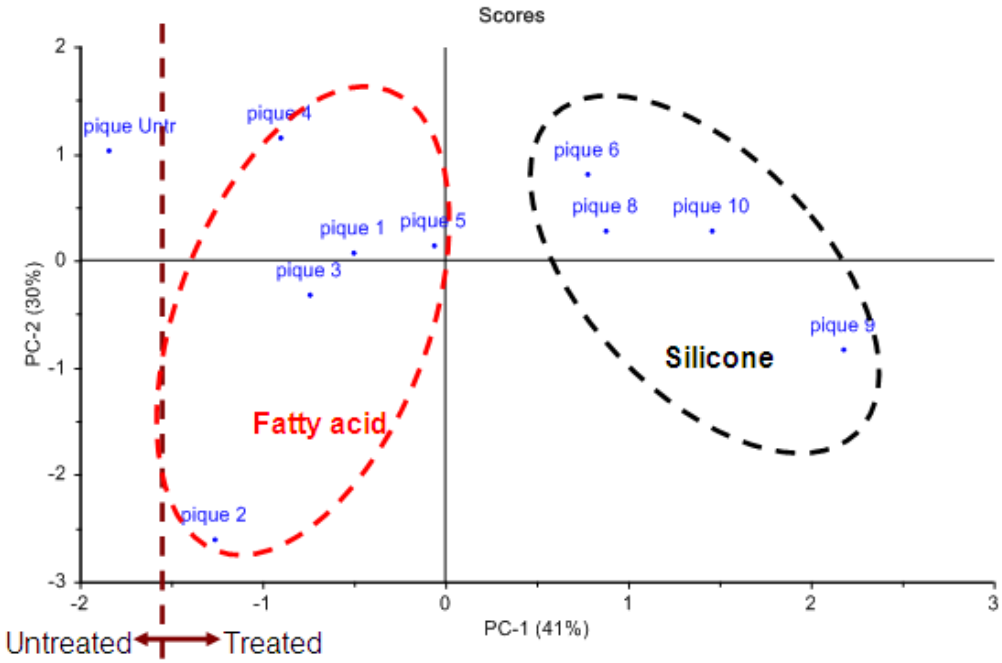

Figure 1. Score plot for the pique PCA.

5 Summary

The judges agreed that softening treatments slightly changed the handle of the rib and pique fabrics compared to their untreated fabrics. They found the treated rib fabrics to be slightly harder, tighter and less preferred than the untreated rib fabric; whereas they found the treated pique fabrics to be slightly rougher than the untreated pique samples. The treatments caused significant increases in fabric weight and thickness, which may have influenced the assessments of the judging panel.

Softener type and concentration were assessed by the judges to have no significant effect on fabric handle attributes.

The WHM performed well. Like the judging panel assessments, the WHM predicted the treated fabrics to be slightly harder and less preferred than the treated fabrics for the rib, and the treated pique fabrics to be slightly rougher than the untreated pique. However, the WHM was unable to predict consistent trends with either softener type or concentration level. Despite this, further principal component analysis showed that the CRC WHM may be able to differentiate between the treated and untreated fabrics and between the softener types.

The WHM also provided a more precise prediction of the average assessment of the judges (Average 95%CL: rib = 1.0, pique = 0.8) than did an individual judge (Average 95%CL: rib=1.6, pique = 1.8).

6 References

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Appendix 1

Instructions to judges

Softener Trial
Fabric Handle Assessment
Next-to-skin fabrics – 2011

Instructions to assessors

Please wash & dry your hands prior to commencing these assessments. Note that some of these fabrics have been treated with commercial fabric softeners. Paper towelling and alcohol wipes have been provided for you to remove any softener material which may sometimes deposit on your hands and fingers during fabric assessment.
Assess the fabrics for handle for the next-to-skin market using your usual method and provide a grade according to the attached scales. Ignore the effects of fabric colour and pattern in your assessment.

Appendix 2. *Subjective assessments*

Average Rib

	OH	HS	RS	HC	HL	LT	WC	GD
Rib untreated	7.3	7	5.1	7.1	5.8	3.2	5.7	5.4
Rib 1	7	7.1	5.3	7	5.8	3.6	6.1	5.5
Rib 3	7	6.6	5.3	7	5.8	3.7	6.1	5.7
Rib 4	6.4	5.9	5.4	6.7	5.7	3.8	5.9	6
Rib 5	6.4	6	5.5	6.6	5.8	3.8	5.9	5.5
Rib 6	6.9	6.9	5.5	6.9	5.8	3.7	5.8	5.7
Rib 7	7.1	6.9	5.5	7	5.8	3.8	5.8	5.2
Rib 8	6.8	6.4	5.5	6.9	5.8	3.3	5.8	5.4
Rib 9	6.5	6.5	5.6	6.7	5.8	3.7	5.7	5.6
Rib 10	6.6	6.3	5.9	6.7	5.7	3.1	6	5.5

Average Pique

	OH	HS	RS	HC	HL	LT	WC	GD
Pique Untreated	3.9	4.4	4.1	5.8	5.4	5.9	4.7	6.6
Pique 1	4.2	4.1	3.6	5.9	5.5	5.6	4.8	5.6
Pique 2	4	4.5	3.1	5.9	5.5	5.6	4.7	5.7
Pique 3	3.9	4.2	3.7	5.8	5.5	5.7	4.7	6
Pique 4	4.1	4.2	3.7	5.9	5.5	5.7	4.8	6
Pique 5	4.2	4.8	3.8	6	5.5	5.6	4.9	5.8
Pique 6	4.4	4.7	4.2	6	5.5	5.5	4.9	5.8
Pique 8	4.3	4.9	4.3	6	5.4	5.6	4.9	5.5
Pique 9	4.4	4.5	4.2	6	5.6	5.6	4.9	5.6
Pique 10	4.5	5	3.5	6.1	5.5	5.5	5	5.5

Judge 1

	OH	HS	RS	HC	HL	LT	WC	GD
Rib untreated	7.8	6	8	5	6.3	7.2	2.5	6.5
Rib 1	8	6	8	5	6.3	7.5	3	6.5
Rib 3	7.5	5.5	8	5	6.3	7.2	3.2	6.5
Rib 4	7	5	8.5	5	6.3	7.2	3	6.5
Rib 5	7	5.2	8.5	5	6.3	7.5	3.4	6.5
Rib 6	6.9	5.2	8	5	6.3	7.5	3.4	6.5
Rib 7	7.4	5.5	8	5	6.3	7.2	3.6	6
Rib 8	6.9	5	8.75	5	6.3	7	3.2	6.5
Rib 9	7	5	8	5	6.3	7	3.2	6.5
Rib 10	6.9	5.2	8	5	6.3	7	2.5	6

	OH	HS	RS	HC	HL	LT	WC	GD
Pique Untreated	1.9	3	6.5	3.8	5	4	6.5	7
Pique 1	2	4.5	7.2	3.8	4.2	5	5.4	5.5
Pique 2	2	3.8	6.9	3.8	4.2	5.4	5.2	5.5
Pique 3	2.4	4.5	7.6	3.8	4.2	5.5	5.3	5.6
Pique 4	2.4	4	7.2	3.8	4.7	4.5	5.6	5.9
Pique 5	2	4	7.2	3.8	4	6	5.3	5.5
Pique 6	2.5	4.5	7.2	3.8	4.2	5.6	5.2	5.4
Pique 8	2	4.5	6.9	3.8	4.6	5.8	5.3	5.7
Pique 9	2.4	4.5	7.4	4	4.2	4.3	5.2	5.4
Pique 10	2	4.5	7.2	3.8	4	6.2	5.2	5.5

Judge 2

	OH	HS	RS	HC	HL	LT	WC	GD
Rib untreated	7	4.8	6.5	5	4.5	6.8	2.8	5.3
Rib 1	7	5	7.3	5.1	5	7	2.9	5
Rib 3	7.3	4.6	7	5	4.7	6.5	2	5.1
Rib 4	7.5	4.8	6.7	4.9	5	7	2.5	5.5
Rib 5	7.5	4.2	6.8	5	4.6	6	3.2	5
Rib 6	7.4	4.5	7	5.2	4.9	7.2	2.5	5.3
Rib 7	7.2	4.6	7.3	5	4.5	7.1	2.5	5.1
Rib 8	7.4	4.3	7	4.9	4.8	6.8	2.8	5.2
Rib 9	7	4.8	6.5	4.9	4.6	7.5	3	5.2
Rib 10	7.2	4.5	7.3	4.6	5	7.3	2	5.4

	OH	HS	RS	HC	HL	LT	WC	GD
Pique Untreated	4.3	2.3	5.5	5	5	4.8	6	5.5
Pique 1	4.1	2.2	5.6	5.3	4.8	4	6.2	4.8
Pique 2	4.2	2.5	5.5	5.2	5	4.2	6.3	5.2
Pique 3	4	2.8	5	5.5	4.9	4.2	6.4	5
Pique 4	4	2.1	5.8	5.5	4.9	4	6.5	5.3
Pique 5	4.1	2.5	5.2	5.4	5.5	4.5	6.2	4.8
Pique 6	4.5	2.7	5	5.4	4.8	4.6	6.2	4.9
Pique 8	4.5	2.9	5.2	5.1	5.3	4.5	6.3	5
Pique 9	4.1	2.5	5.2	5.1	5.3	4.4	6.4	5.2
Pique 10	4.2	2.8	5	5.3	5.3	4.5	6	4.8

Judge 3

	OH	HS	RS	HC	HL	LT	WC	GD
Pique Untreated	6.5	6.5	7	5	7	6	2.5	5
Pique 1	6.5	6	7	5	7	6	2.5	5
Pique 2	5.5	6	7	5	7	5.5	3	5.5
Pique 3	6	6	7	5	7	5.5	3	5.5
Pique 4	5.5	6	7	5	7	5.5	3	5.5
Pique 5	6.5	6	7	5	7	5.5	3.5	5.5
Pique 6	6	6	7	5	7	5.5	3.5	5.5
Pique 8	6	6	7	5	7	5.5	3	6
Pique 9	6	6	7	5	7	5.5	2.5	5.5
Pique 10	5.5	6	7	5	7	5	3	6

	OH	HS	RS	HC	HL	LT	WC	GD
Pique Untreated	4	2.5	6	6	5	4	4.5	6
Pique 1	4.5	3	6	6	5	4	5	5.5
Pique 2	4	2.5	6	6	5	4	5.5	6
Pique 3	4	2.5	6	6	5	4	5.5	6
Pique 4	4	2.5	6	6	5	4	4.5	6.5
Pique 5	4.5	2.5	6	6	5	4	5.5	6.5
Pique 6	4.5	2.5	6	6	5	4	5	6
Pique 8	4.5	3	6	6	5	4	5	6
Pique 9	5	3	6	6	5	4	5	5.5
Pique 10	5	3	6	6	5	4	5.5	6

Judge 4

	OH	HS	RS	HC	HL	LT	WC	GD
Rib untreated	7	6.5	5	7	4.5	7	4	5
Rib 1	6	5.3	6	7	5.5	6	4.5	6
Rib 3	6.6	6	6	7	4.7	6.6	4	5.2
Rib 4	6.4	6	6	7	5.3	6.4	4.5	5.5
Rib 5	6.2	5.5	6	7	5.3	6.2	4	5.3
Rib 6	6.8	6.3	5	7	4.7	6.8	4	5.2
Rib 7	6.6	6	6	7	5	6.6	4	5.3
Rib 8	6.2	5.3	6	7	5.3	6.2	4.5	5.5
Rib 9	6.8	6.3	6	7	4.8	6.8	4.5	5.3
Rib 10	6.8	6.3	5	7	5	6.8	4	5.3

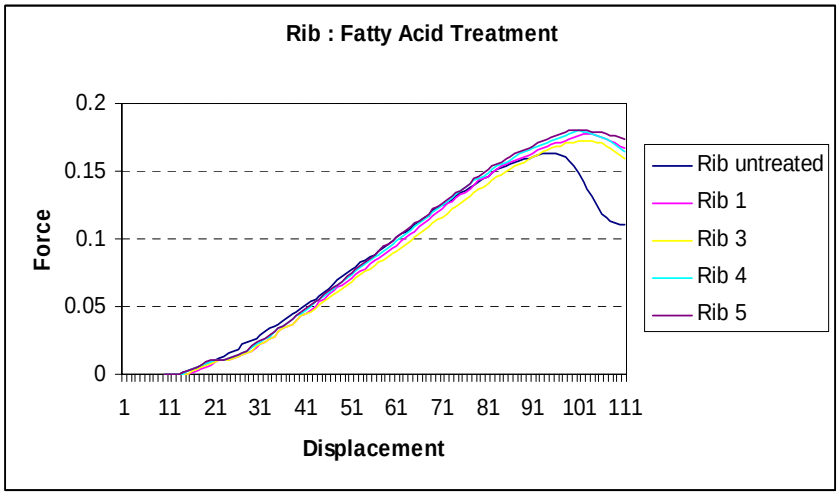
	OH	HS	RS	HC	HL	LT	WC	GD
Pique Untreated	3.1	3.3	6	6	4.5	3.2	5	6
Pique 1	3.3	3.5	6	6	4.5	3	5	5.7
Pique 2	3.7	4.4	6	6	4.5	3.6	5	5.6
Pique 3	3	3	6	6	4.5	3	5	5.9
Pique 4	3.9	4.6	6	6	4.5	3.7	5	5.5
Pique 5	3.6	4.2	6	6	4.5	3.5	5	5.4
Pique 6	3.4	4	6	6	4.5	3.4	5	5.8
Pique 8	4	4.8	6	6	4	3.8	5	5.2
Pique 9	4	4.8	6	6	4.5	3.8	5	5.3
Pique 10	4.3	4.9	6	6	4	3.9	5	5.1

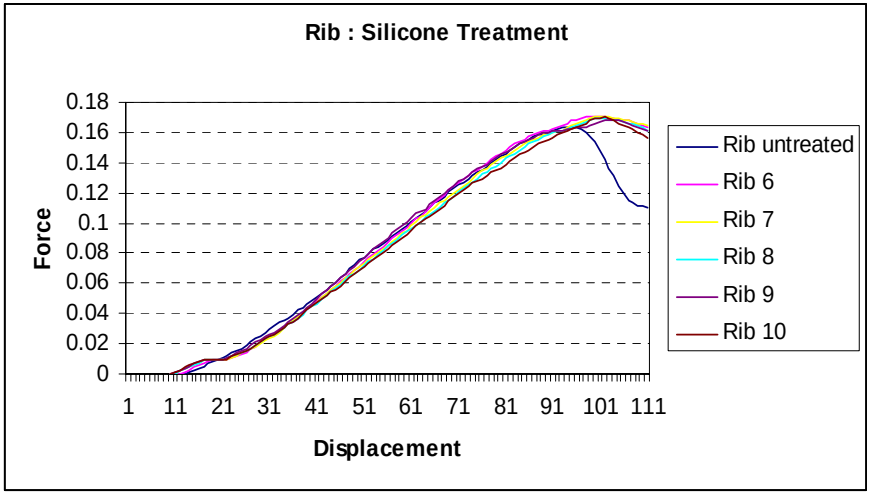
Judge 5

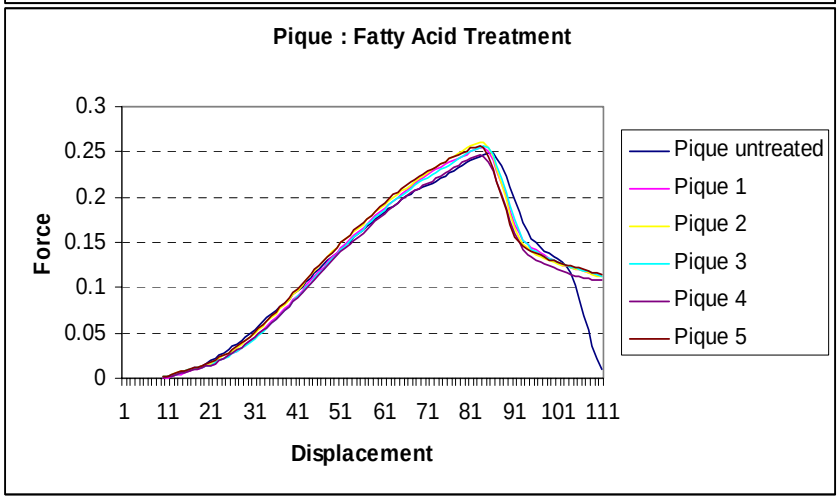
	OH	HS	RS	HC	HL	LT	WC	GD
Rib untreated	7	5.5	6.5	7	6.5	6.5	5	5.5
Rib 1	7.5	5.5	6.5	7	6.5	7.5	5	5
Rib 3	7	5.5	6.5	7	6.5	6.5	5	5
Rib 4	7.5	5.5	6.5	7	6.5	7.5	5	5
Rib 5	6.5	5.5	6.5	7	6.5	5.5	5	5.5
Rib 6	6.5	5	6.5	7	6	5.5	5	5.5
Rib 7	7.5	5.5	6.5	7	6.5	7.5	5	5
Rib 8	6.5	5	6.5	6.8	6	5.5	5	6
Rib 9	6.5	5	6.5	7	6	5.5	5	5.5
Rib 10	7	5.5	6.5	7	6.5	6.5	5	5

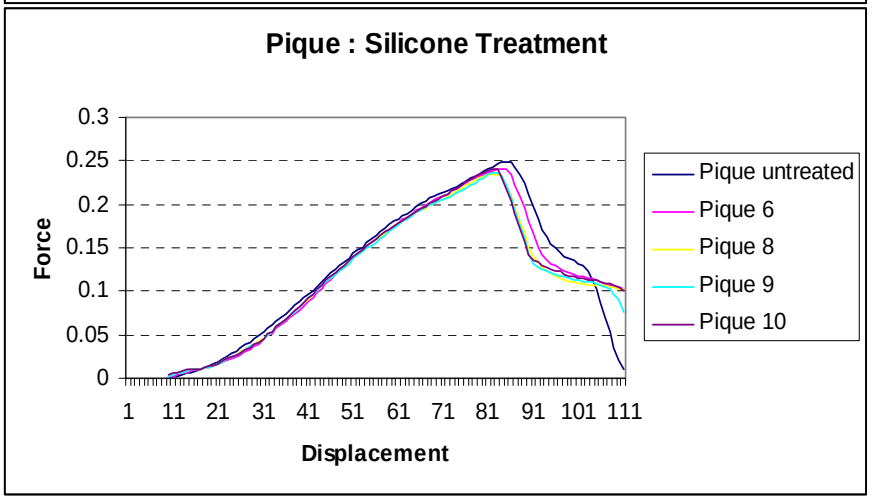
	OH	HS	RS	HC	HL	LT	WC	GD
Pique Untreated	6.5	5	5.2	6.4	5.2	5.5	6.5	7
Pique 1	7	5.5	5.5	6.5	5.5	6	6.5	7
Pique 2	6.5	5	5.5	6.5	5.5	5.5	6.5	6
Pique 3	6.5	5	5.2	6.5	5.2	5.5	6.5	7
Pique 4	6.5	5	5.5	6.5	5.5	5.5	6.5	6
Pique 5	7	5.5	5.5	6.5	5.5	6	6.5	7
Pique 6	6.5	5.5	5.5	6.5	5.5	5.5	6.5	7
Pique 8	6.5	5.5	5.5	6.4	5.5	5.5	6.5	6
Pique 9	6.5	5	5.5	6.5	5.6	5.5	6.5	7
Pique 10	7	5.5	5.5	6.5	5.5	6	6.5	7

Appendix 3. Average Extraction Curves for Individual fabrics and Softener Treatments.









Appendix 4. Average Normalised and Transferred Scores of Five Judges

	OH	HS	RS	HC	HL	LT	WC	GD
Rib untreated	7.3	7.0	5.1	7.1	5.8	3.2	5.7	5.4
Rib 1	7.0	7.1	5.3	7.0	5.8	3.6	6.1	5.5
Rib 3	7.0	6.6	5.3	7.0	5.8	3.7	6.1	5.7
Rib 4	6.4	5.9	5.4	6.7	5.7	3.8	5.9	6.0
Rib 5	6.4	6.0	5.5	6.6	5.8	3.8	5.9	5.5
Rib 6	6.9	6.9	5.5	6.9	5.8	3.7	5.8	5.7
Rib 7	7.1	6.9	5.5	7.0	5.8	3.8	5.8	5.2
Rib 8	6.8	6.4	5.5	6.9	5.8	3.3	5.8	5.4
Rib 9	6.5	6.5	5.6	6.7	5.8	3.7	5.7	5.6
Rib 10	6.6	6.3	5.9	6.7	5.7	3.1	6.0	5.5
Pique Untreated	3.9	4.4	4.1	5.8	5.4	5.9	4.7	6.6
Pique 1	4.2	4.1	3.6	5.9	5.5	5.6	4.8	5.6
Pique 2	4.0	4.5	3.1	5.9	5.5	5.6	4.7	5.7
Pique 3	3.9	4.2	3.7	5.8	5.5	5.7	4.7	6.0
Pique 4	4.1	4.2	3.7	5.9	5.5	5.7	4.8	6.0
Pique 5	4.2	4.8	3.8	6.0	5.5	5.6	4.9	5.8
Pique 6	4.4	4.7	4.2	6.0	5.5	5.5	4.9	5.8
Pique 7	4.8	4.6	3.6	6.2	5.6	6.6	5.2	5.6
Pique 8	4.3	4.9	4.3	6.0	5.4	5.6	4.9	5.5
Pique 9	4.4	4.5	4.2	6.0	5.6	5.6	4.9	5.6
Pique 10	4.5	5.0	3.5	6.1	5.5	5.5	5.0	5.5

Appendix 5. Curve Parameters and Weight and Thickness for 20 Fabrics

	Mass (gm-2)	Thickness (mm)	h	a	S1	pDp	Dp	S2	PPH	w	Work
Rib untreated	212.0	0.9587	0.1647	13.9130	0.0023	44.7266	91.6984	-0.0040	0.0142	9.7511	19.4646
Rib 1	226.8	1.0877	0.1793	19.2000	0.0025	46.0491	100.2464	-0.0044	0.0233	14.6045	34.4840
Rib 3	240.3	1.0757	0.1733	19.6000	0.0025	41.3256	98.9452	-0.0048	0.0250	15.2264	34.9628
Rib 4	226.5	1.0340	0.1800	18.0769	0.0026	58.7747	97.1967	-0.0035	0.0257	17.2352	44.7366
Rib 5	219.0	1.0423	0.18	15.29	0.0024	100.95	95.21	-0.0019	0.0118	11.13	29
Rib 6	212.9	1.0513	0.1700	18.5000	0.0026	84.7711	93.4898	-0.0023	0.0250	20.4632	56.3965
Rib 7	210.7	1.0490	0.1700	17.8400	0.0025	81.4804	96.0612	-0.0024	0.0256	20.8683	58.1955
Rib 8	224.5	1.0653	0.1700	17.7200	0.0025	53.0881	96.2903	-0.0037	0.0264	17.7124	43.7429
Rib 9	218.0	1.0467	0.1693	16.9200	0.0025	38.6444	98.8462	-0.0053	0.0355	20.8875	57.0268
Rib 10	223.3	1.0267	0.1700	17.7917	0.0024	55.9970	97.1207	-0.0034	0.0204	14.4926	32.8768
Pique untreated	208.30	0.9057	0.2507	15.4565	0.0046	16.1705	81.1931	-0.0187	0.0517	14.0097	42.0591
Pique 1	233.07	0.9677	0.2560	18.6863	0.0051	15.2704	79.4685	-0.0203	0.0540	13.2457	38.9815
Pique 2	234.37	0.9623	0.2620	4.7568	0.0037	15.6878	80.2279	-0.0178	0.0172	5.6291	17.1519
Pique 3	236.53	0.9763	0.2580	17.9375	0.0048	16.0172	80.0043	-0.0186	0.0399	10.4630	27.9389
Pique 4	226.10	0.9357	0.2473	18.8000	0.0050	15.9760	78.8697	-0.0188	0.0530	13.4230	38.4783
Pique 5	225.24	0.9452	0.2580	17.1800	0.0050	12.5794	79.5738	-0.0248	0.0540	12.9700	37.9345
Pique 6	232.43	0.9473	0.2420	17.2979	0.0047	13.1192	80.6606	-0.0227	0.0558	14.3317	41.9726
Pique 8	230.57	0.9677	0.2360	15.1395	0.0043	14.8591	78.7225	-0.0184	0.0374	10.7322	26.4687
Pique 9	231.17	0.9807	0.2393	11.6410	0.0039	11.6146	79.8396	-0.0229	0.0266	7.9944	19.1133
Pique 10	240.30	0.9717	0.2420	17.1522	0.0046	12.6796	78.8963	-0.0224	0.0420	11.0115	27.7882

Appendix 6. Differences in Parameters between Treated and Untreated Fabrics (Treated – Untreated)

	Mass (gm-2)	Thickness (mm)	h	a	S1	pDp	Dp	S2	PPH	w	Work
Rib 1	14.73	0.13	0.01	5.29	0.00	1.32	8.55	0.00	0.01	4.85	15.02
Rib 3	28.30	0.12	0.01	5.69	0.00	-3.40	7.25	0.00	0.01	5.48	15.50
Rib 4	14.50	0.08	0.02	4.16	0.00	14.05	5.50	0.00	0.01	7.48	25.27
Rib 5	6.93	0.08	0.02	1.38	0.00	56.22	3.51	0.00	0.00	1.38	9.76
Rib 6	0.87	0.09	0.01	4.59	0.00	40.04	1.79	0.00	0.01	10.71	36.93
Rib 7	-1.33	0.09	0.01	3.93	0.00	36.75	4.36	0.00	0.01	11.12	38.73
Rib 8	12.43	0.11	0.01	3.81	0.00	8.36	4.59	0.00	0.01	7.96	24.28
Rib 9	6.00	0.09	0.00	3.01	0.00	-6.08	7.15	0.00	0.02	11.14	37.56
Rib 10	11.23	0.07	0.01	3.88	0.00	11.27	5.42	0.00	0.01	4.74	13.41
Average	10.41	0.09	0.01	3.97	0.00	17.62	5.35	0.00	0.01	7.21	24.05
Pique 1	24.77	0.06	0.01	3.23	0.00	-0.90	-1.72	0.00	0.00	-0.76	-3.08
Pique 2	26.07	0.06	0.01	-10.70	0.00	-0.48	-0.97	0.00	-0.03	-8.38	-24.91
Pique 3	28.23	0.07	0.01	2.48	0.00	-0.15	-1.19	0.00	-0.01	-3.55	-14.12
Pique 4	17.80	0.03	0.00	3.34	0.00	-0.19	-2.32	0.00	0.00	-0.59	-3.58
Pique 5	16.94	0.04	0.01	1.72	0.00	-3.59	-1.62	-0.01	0.00	-1.04	-4.12
Pique 6	24.13	0.04	-0.01	1.84	0.00	-3.05	-0.53	0.00	0.00	0.32	-0.09
Pique 8	22.27	0.06	-0.01	-0.32	0.00	-1.31	-2.47	0.00	-0.01	-3.28	-15.59
Pique 9	22.87	0.08	-0.01	-3.82	0.00	-4.56	-1.35	0.00	-0.03	-6.02	-22.95
Pique 10	32.00	0.07	-0.01	1.70	0.00	-3.49	-2.30	0.00	-0.01	-3.00	-14.27
Average	23.90	0.06	0.00	-0.06	0.00	-1.97	-1.61	0.00	-0.01	-2.92	-11.41