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AN EVALUATION OF THE

DURABILITY ADVANTAGES

OF USING U.S. COTTON IN KNIT FABRICS

A RESEARCH WHITE PAPER FROM COTTON COUNCIL INTERNATIONAL



STUDY CONDUCTED BY DR. YEHIA ELMOGAHZY AND DAVID SASSO
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BACKGROUND

In the fall of 2016, Dr. Yehia Elmogahzy and David Sasso conducted experiments at a spinning mill in Asia. This mill was undergoing major expansion to accommodate new exporting demand of high quality combed ring spun yarns and attempting to determine which country's cotton they should use for this expansion.

As a part of the experimental work, three cotton samples were used to produce identical greige and blue single-jersey knit fabrics made from combed ring-spun yarns with yarn counts of 20's Ne and 26's Ne. The samples were made from three cottons: (a) 100% U.S. cotton, (b) 100% Indian cotton (Shankar-6 type) and (c) a blend of 1/3 each Australian/Pakistani/Uzbek cottons.

CONTROL PROCEDURES

In order to make sure that a fair comparison was conducted between the three different cottons, a serious attempt was made to maintain similar average values of basic fiber properties in the three cottons. All cotton bales were tested using the HVI system and the AFIS system available in the company's laboratory.

The HVI fiber properties (micronaire, length, and strength) of the three cotton mixes (shown in Appendix I) show the three cottons were virtually equal. Other fiber properties (also shown in Appendix I) that are largely influenced by production and storage conditions showed some variations, but were generally close enough to each other to ensure that differences in performance were largely due to the quality of the cottons based on origin.

CONTROL PROCEDURES

All of the experimental trials were conducted on the processing line depicted in Appendix II. The stages were:

1. ROTARY BALE PLUCKER
2. AXIFLOW PRE-OPENING AND CLEANING UNIT
3. MULTI-MIXER
4. LVS
5. FINE CLEANING AND OPENING UNIT
6. CHUTE FEED SYSTEM
7. CARDING MACHINE
8. BREAKER DRAWFRAME
9. UNILAP AND COMBING MACHINE
10. COMBER NOIL

With these controls (fiber quality and processing) in place, the experimenters believe that differences in performance were related to cotton country of origin, rather than variations within each country.

FINDINGS—KNIT FABRICS MADE FROM THE THREE COTTONS

Using the yarns produced from the different cottons, three single-jersey knit fabrics were produced in the knitting tester at the spinning mill. The basic construction parameters of these fabrics are illustrated below.

Greige Knit (20's NE)

	100% U.S. cotton	100% Indian cotton	AUS/Uzbek/Pakistan cotton
Fabric Weight (g/sq. m)	171.2	171.3	171.2
Fabric Thickness (mm)	0.73	0.727	0.73
Wales/Inch	28	28	27
Course/Inch	42	42	41

Greige Knit (26's NE)

	100% U.S. cotton	100% Indian cotton	AUS/Uzbek/Pakistan cotton
Fabric Weight (g/sq. m)	137	136.8	136.8
Fabric Thickness (mm)	0.62	0.62	0.63
Wales/Inch	28.1	27.9	28.3
Course/Inch	40	39.7	40.1

Blue Knit (20's NE)

	100% U.S. cotton	100% Indian cotton	AUS/Uzbek/Pakistan cotton
Fabric Weight (g/sq. m)	191	191.3	191
Fabric Thickness (mm)	0.8	0.79	0.8
Wales/Inch	50	50	50
Course/Inch	36	37	37

Blue Knit (26's NE)

	100% U.S. cotton	100% Indian cotton	AUS/Uzbek/Pakistan cotton
Fabric Weight (g/sq. m)	160	159.5	160
Fabric Thickness (mm)	0.7	0.7	0.7
Wales/Inch	38	38.1	38
Course/Inch	35	34.9	35.3

The experimenters were satisfied that both cotton fiber properties and fabric construction parameters were so close between the samples that they would get results based on country of origin of the cottons and no other variability.

DURABILITY MEASURES—FABRIC ABRASION AND BURSTING STRENGTH

Fabric Abrasion

The method used to measure fabric abrasion resistance is based on ASTM D3884 in which fabric samples are subjected to abrasion action for a number of cycles (in this case 200) and the weight loss resulting from abrading the sample based on AATCC93 is measured. The less weight lost, the more durable the fabric will be. As the results below show, the U.S. cotton consistently outperformed the other cottons on fabric abrasion.

Fabric Abrasion Resistance
(Rotary 200 cycles, weight loss in mg.)

	100% U.S. cotton	100% Indian cotton	AUS/Uzbek/ Pakistan cotton
Greige 20's	24.2	27.6	26.0
Greige 26's	22.0	26.3	25.0
Blue 20's	26.0	30.6	30.0
Blue 26's	26.0	28.7	29.0

The fabrics made from U.S. cotton dramatically outperformed fabrics made from the other cottons, losing 13% less fabric than Indian cotton and 10% less than the Australian/Pakistani/Uzbek blend. These results strongly suggest that fabrics made from U.S. cotton are more durable and will last longer.

FABRIC BURSTING STRENGTH

Fabric bursting strength is measured using two different methods.

The first is the Mullin (Diaphragm method, ASTM D3787), which measures bursting strength in pressure units (PSI). The results from the Mullin are below.

Bursting Strength—Mullin Bursting Pressure PSI

	100% U.S. cotton	100% Indian cotton	AUS/Uzbek/Pakistan cotton
Greige 20's	133	127.1	125
Greige 26's	110	107.1	108
Blue 20's	143	138.2	140
Blue 26's	121	116.8	114

The fabrics made from U.S. cotton needed 4% more pressure to burst than either Indian or Australian/Pakistani/Uzbek fabrics, once again suggesting that fabrics made from U.S. cotton are more durable and last longer.

FABRIC BURSTING STRENGTH

The second method for measuring fabric-bursting strength is the ball bursting method (ASTM 3786) which measures bursting strength in force units (pounds). The results from the ball bursting method are below.

Bursting Strength—Ball Bursting Force, Lbs.

	100% U.S. cotton	100% Indian cotton	AUS/Uzbek/ Pakistan cotton
Greige 20's	113	110.7	111
Greige 26's	84.3	81.3	80.9
Blue 20's	127	120.7	123
Blue 26's	102	92.3	91

The fabrics made from U.S. cotton needed 5% more pounds of force to burst than either Indian or Australian/Pakistani/Uzbek fabrics, once again suggesting that fabrics made from U.S. cotton are more durable and last longer.

CONCLUSIONS

This in-factory experiment proves what many fabric manufacturers already know. Fabrics made from U.S. cotton are more durable and last longer than fabrics made from other cottons—and that means that they provide more value to consumers.

APPENDIX 1

AVERAGE VALUES OF BASIC FIBER PROPERTIES IN 3 MIXES

Table 1. Average Values of the Basic Fiber Properties of the Three Mixes

MIX	Fineness (Mic.)	Fiber Strength (FS, g/tex)	Elongation (FE, %)	Upper Half Mean Length (UHML, Inch)
100% U.S.	4.3	27.8	6.8	1.09
100% INDIAN	4.4	27.8	6.5	1.09
AUS/UZ/PAK	4.3	28	7.0	1.09

	Uniformity (LU%)	Color Rd	Color+b	Trash Area (%)	Moisture (%)
100% U.S.	81.7	80.0	8.7	0.50	8.0
100% INDIAN	81.7	77.3	9.3	0.55	8.8
AUS/UZ/PAK	81.6	80.3	8.8	0.58	8.6

Table 2. Average Values of HVI and AFIS Fiber Properties of the Three Mixes

MIX	Short Fiber By Weight (SFCw%)	Short Fiber By Number (SFCn%)	Neps/g	Seed Coat Neps/g (Count/g)	Trash (Count/g)
100% U.S.	9.7	23.7	228.8	18.7	44.8
100% INDIAN	9.4	24.8	162.7	18.5	71.8
AUS/UZ/PAK	10.2	26.0	227.8	23.5	76.7

	Dust (Count/g)	Vis For Matter (VFM,%)	Nep Size (mu)	Maturity Ratio	Immature Fiber (IFC)
100% U.S.	176.0	1.47	388	0.93	7
100% INDIAN	335.3	1.75	482	0.89	8
AUS/UZ/PAK	335.3	1.73	412	0.90	8

APPENDIX 2

PROCESSING LINE USED IN EXPERIMENTAL TRIALS

PROCESSING LINE FOR EXPERIMENTAL TRIALS

The experimental trials were made in the processing line shown in Figure 4. This line consists of the following stages of processing:

1. Rotary bale plucker – This is typically ideal for running mixes of small number of bales (up to 20 bales) and at a relatively low speed of 800 kg/hr. Cotton bales of Indian, Pakistani and Uzbekistani cottons were opened in a separate mixing room and carefully inspected for removal of contaminants prior to processing. This was by the request of the mill's personnel.
2. Axiflow pre-opening and cleaning unit (RN) – This is a coarse beater, which has the capability of removing heavy trash particles. Therefore, it is typically installed after the bale plucker.
3. Multi-mixer – This machine consists of 8 mixing chambers and it represents another critical opportunity of blending in the opening line. The purpose of this mixer is to ensure that tufts representing different bales in the laydown coexist in the mix cross-section.
4. LVS – This is a condenser unit, which sucks the material with airflow and separates the air from materials for transfer to the next unit. Samples taken from this unit represent the extent of homogeneity of the cotton mix.
5. Fine cleaning and opening unit (RST) – At this stage, cotton is ready for more fine opening and cleaning (much smaller tuft sizes) and the concern at this point is the extent of fiber damage (short-fiber content) and the formation of fiber neps.
6. Chute-Feed System – This is a critical process in which the fiber mat fed to the carding machine is prepared and it should be of a high degree of uniformity to ensure consistent carding.
7. Carding Machine – This is perhaps the most critical machine in the entire processing line as it provides the finest opening and cleaning of cotton fibers and produces a very thin fiber web that is converted into the card sliver. Cotton samples taken after carding should normally exhibit a significant drop in trash and dust content, and a significant drop in neps/g. As to the extent of fiber damage (inevitable) in this process, it can be determined by the short-fiber content in the waste.
8. Breaker Drawframe – This is the process of doubling and drawing card slivers. It should have little influence on the AFIS fiber properties provided that the draft setting is appropriate.
9. Unilap and Combing Machine – Since combed yarns were produced in this experiment, we used a combing process, which is normally used to produce a smoother, finer, stronger, and more uniform than otherwise would be possible. Therefore, combing is commonly confined to more uniform yarn and high grad cotton fibers to produce high quality yarns and knit fabrics. The main objectives of combing are: (a) removal of short fibers (b) removal of residual trash and neps and (c) the production of more straight and parallel fibers leading to a uniform combed sliver. Therefore, it is considered as the most critical process in evaluating the overall effect of the processing line on cotton fiber properties. The objectives of combing are accomplished through two stages of processing: (i) combing preparation and (ii) the combing machine. The purpose of combing preparation is to form a uniform fiber lap suitable for the combing process. This process should have little influence on AFIS fiber properties provided that the machine is set appropriately. The combing machine works in a precise sequence to straighten the fibers, and remove short fibers, tiny trash particles, and neps. The combed sliver produced should be uniquely different from the card sliver in that it has more straight and parallel fibers and it exhibits a significantly lower cohesion than the card sliver. The high degree of fiber orientation in the combed sliver results in yarns that are stronger and more uniform than those produced from carded slivers. It was important, therefore, to collect combed slivers and test the AFIS properties of the sliver.
10. Comber Noil – The use of the combing process comes at the expense of a significant waste material, which is normally called 'comber noil.' Therefore, it was critical to test comber noil to evaluate a number of parameters including: the percent of trash and dust, the percent of short fibers and neps, and the percent of re-usable fibers (fibers longer than 0.6 inch).