2005 Beltwide Cotton Conferences, New Orleans, Louisiana - January 4 - 7, 2005

DETERMINATION OF FIBER AND PRODUCT QUALITY THROUGH SMALL-SCALE PROCESSING TRIALS: FIBER TO YARN

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Abstract

Much attention has been focused on measuring the physical properties of raw cotton fiber. These properties have been used for decades to predict the performance of the fiber in processing and of the resultant materials. The Southern Regional Research Center (SRRC) has recently begun a new research agenda to measure and predict the processing and performance characteristics of cotton fibers and resultant materials. As part of this agenda, fibers have been collected and analyzed throughout the processing line, from raw fiber to ring and rotor spun yarns. Various quantities, usually 15-30lbs, have been processed in the SRRC pilot plant textile mill. Testing has been performed to characterize the fiber at different stages of processing. The change in properties throughout processing lends a greater understanding of how different properties interact in processing as well as helping to explain unexpected outcomes. In the last year, the SRRC textile mill has processed over 200 lots. Selected results are shown and analyses performed.

Introduction

The cotton program at the United States Department of Agriculture, Agricultural Research Service, Southern Regional Research Center has undergone reorganization and begun a new research program. The Fiber Quality Evaluation Laboratory (FQEL) was established in response to input from a number of industry stakeholders. The FQEL has established standard small-scale (10-30 lbs) processing and testing protocols for cotton fiber, from bale through finished fabric. The FQEL is operating under a standardized processing protocol, not an optimized protocol. Fiber samples are collected from the bale and throughout the processing line. Ring spun and open-end rotor spun yarns are produced and tested (with ring spun yarns going into both knit and woven test fabrics). The standardized testing and processing protocol is designed to allow a large database of fiber properties and resultant yarn and fabric properties to be developed. Scientists will be able to mine this large data set for relationships of fiber properties to resultant textile products as well as to assess the best measure of quality. Quality is understood to be defined differently at various points in the textile production process. The properties that indicate quality in spinning yarns do not necessarily indicate quality in finished goods, particularly when quality will vary based on the end product and its application. The FQEL database is designed to contain a dataset that is diverse enough to allow the various definitions of quality to be accommodated.

Standard Processing and Testing Protocol

The FQEL protocol is designed to accommodate small-scale samples, typically between 10 and 30 pounds. A bale sample is taken for color, Shirley Analyzer, High Volume Instrumentation (HVI) and Advanced Fiber Information System (AFIS) testing. AFIS testing is performed utilizing 5 replications of 5000 fibers each. The bale samples are utilized in determining proper processing settings, such as ratch settings. Samples are processed through an opening hopper, incline cleaner, and a fine opener/cleaner; after which a fiber sample is collected for AFIS testing. The opening/cleaning line feeds a chute fed card line where additional fiber samples are collected at the reserve hopper and the card chute.

Nominal 55 grain/yd card sliver is produced and processed through two drawing frame passes, with 6 doublings on each pass. The second pass through the draw frame employs autoleveling to help produce a consistent product. Card sliver, breaker sliver, and finisher sliver samples are collected for AFIS testing. At this point a portion of the sliver is diverted for rotor spinning. The remaining sliver is sent on to a roving frame for conversion into 1 hank roving for ring spinning. A roving sample is collected for further AFIS testing.

The FQEL protocol calls for the production of the same count yarns on both ring and rotor frames. Ne 22/1 yarns are produced for all lots with Ne 16/1 and 30/1 being produced when sufficient fiber is provided for processing. A constant twist multiple is used for each yarn size. This prevents a change in twist from altering the effects of fiber

properties on yarn quality. The protocol is intended to produce comparable, not optimal, yarns. The yarns are sent for evenness testing, yarn sizing, count strength product, and single-end strength testing.

Fabrics are produced for testing from Ne 22/1 ring spun yarns. The FQEL protocol calls for the production of knit fabrics on a 3 ½ inch diameter FAK knitting machine for color and dye ability testing. Woven fabrics are produced utilizing common warps on both a shuttle loom and a rapier loom. The shuttle loom is used to produce a filling-face fabric for appearance rating. The rapier loom is utilized to produce a plain-weave fabric for physical testing.
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Selected Results

In 2004, the first year of the FQEL, more then 200 samples were processed from fiber to yarn. Approximately 100 yarn samples were converted into fabric by the FQEL. The FQEL also tested several hundred fiber samples which were not processed into yarn. The FQEL has performed work for government and university scientists as well as cotton breeders. The following results are one small example of what can be learned through the FQEL testing and processing protocol.

The change in the length distribution of a cotton through processing is explored in the following three figures.

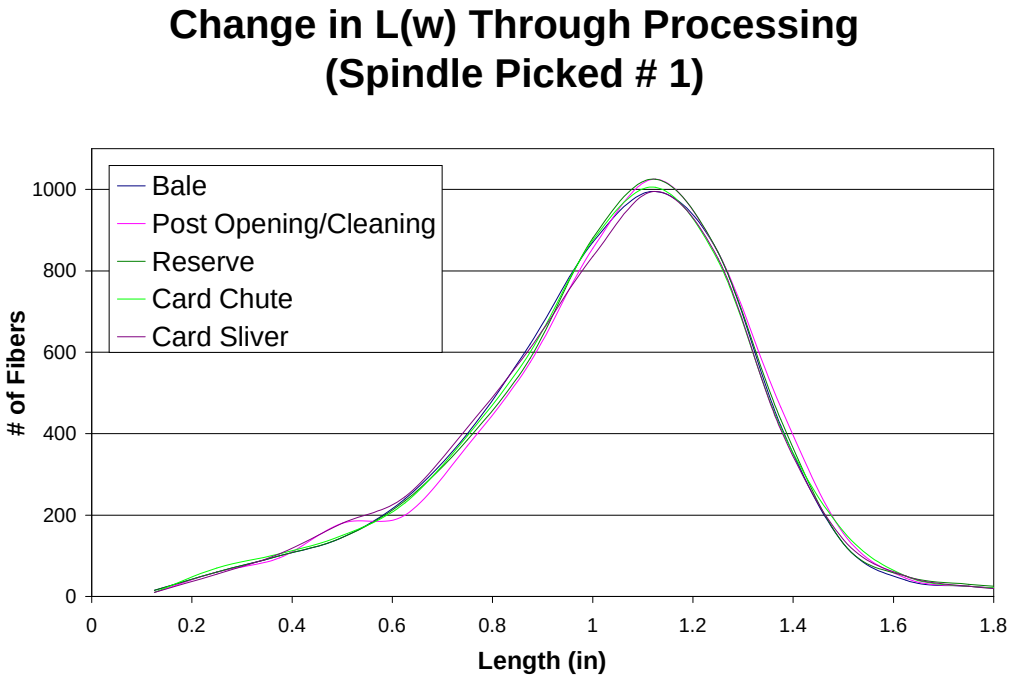

Figure 1. Length distribution through processing of a sample spindle picked cotton

Figure 1 shows the entire length distribution (L(w) from AFISPro) for the representative cotton. The distribution does not show large changes. Figures 2 and 3 zoom in on areas of interest. Figure 2 focuses on the fiber from 0.5 to 1.5 inches in length. This is fiber, which is not considered to be “short”. Figure 3 focuses on the region of “short” fiber, less then 0.5 inches. The enlarged areas allow for the changes, which occur during processing to be seen.

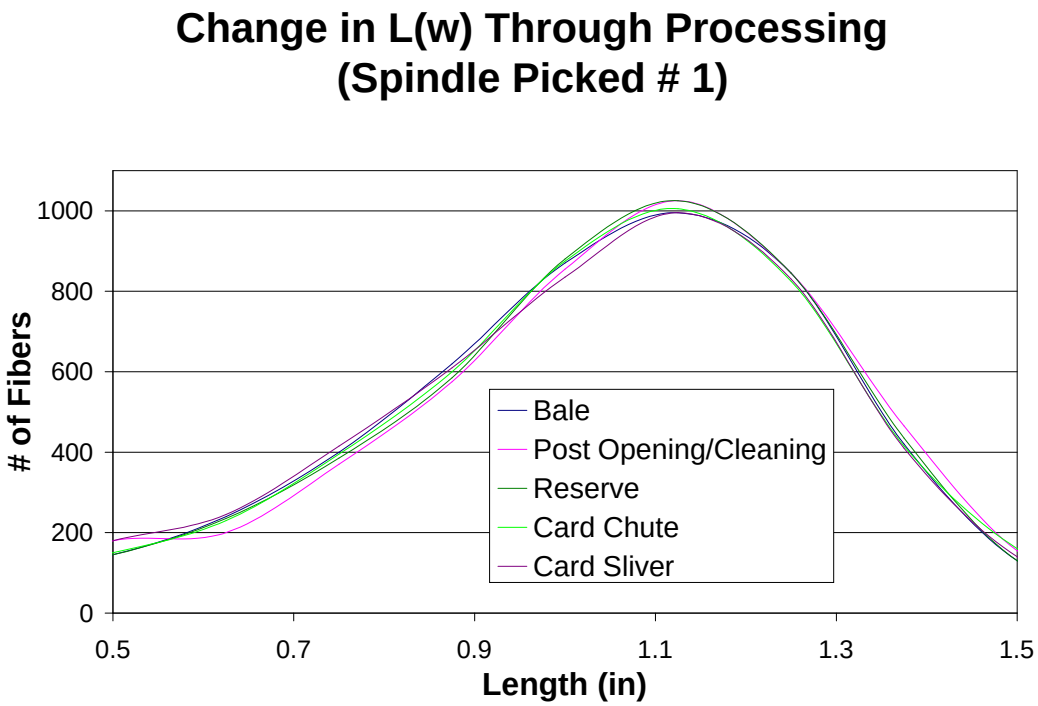

Figure 2. Length distribution, 0.5 to 1.5 inches, through processing of a sample spindle picked cotton

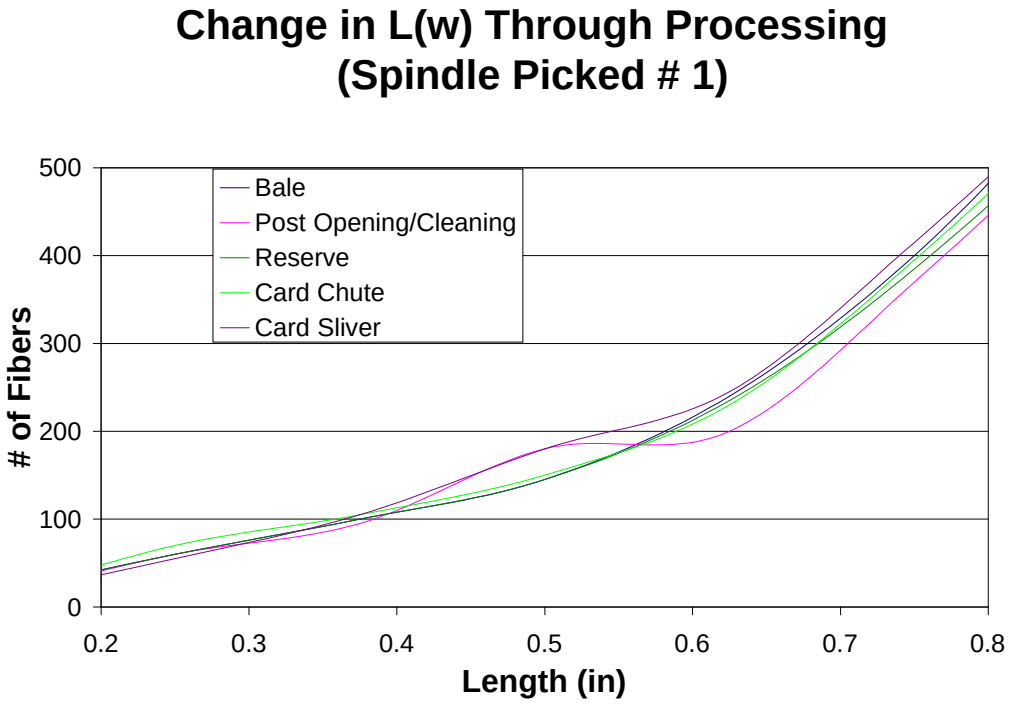

Figure 3. Length distribution, 0.2 to 0.8 inches, through processing of a sample spindle picked cotton

Figures 4-8 show the change in length distribution from the bale through opening/cleaning. Five cottons are shown, in which three cottons are spindle picked and two are hand picked. The fiber and yarn (Ne 22/1) properties of the cottons are shown in Table 1. These figures illustrate the various ways the length distribution can shift as well as the various shapes of the distributions. The peak of the distributions can shift to the left, indicating a reduced mean

length, or shift to the right, indicating an increased mean length. Additionally, the peak can rise or fall; this represents a change in uniformity. Each of the cottons behaves differently, which indicates the unpredictability of the behavior of the fiber length distribution at this time. However, the graphs do provide insight and direction for research.

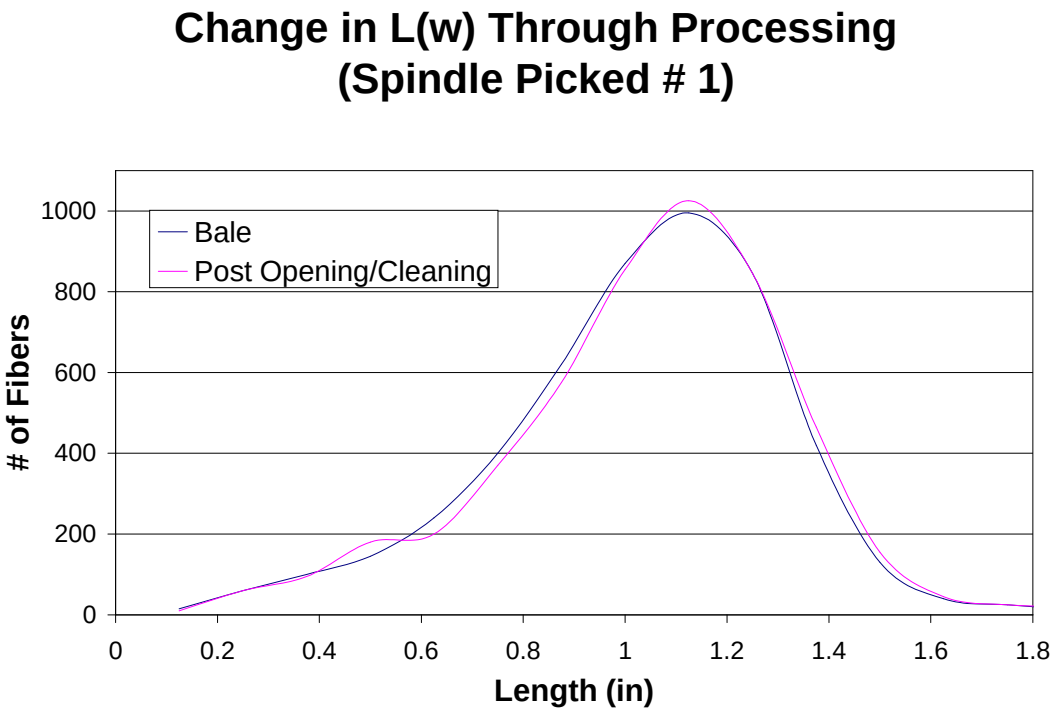

Figure 4. Length distribution through opening/cleaning of a spindle picked cotton

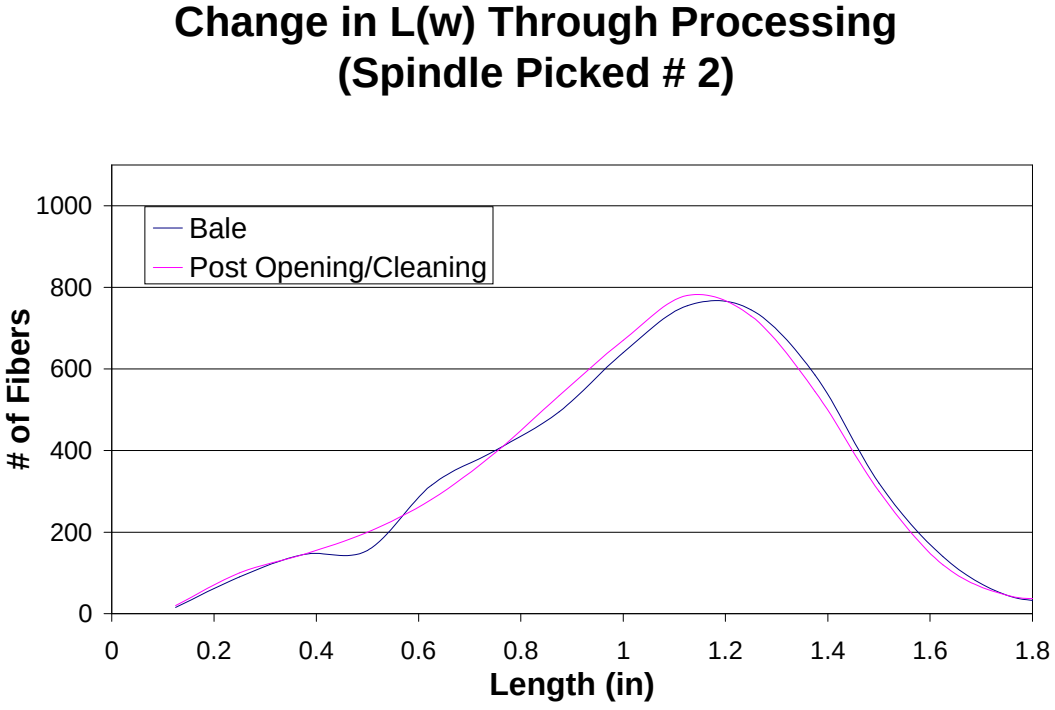

Figure 5. Length distribution through opening/cleaning of a spindle picked cotton

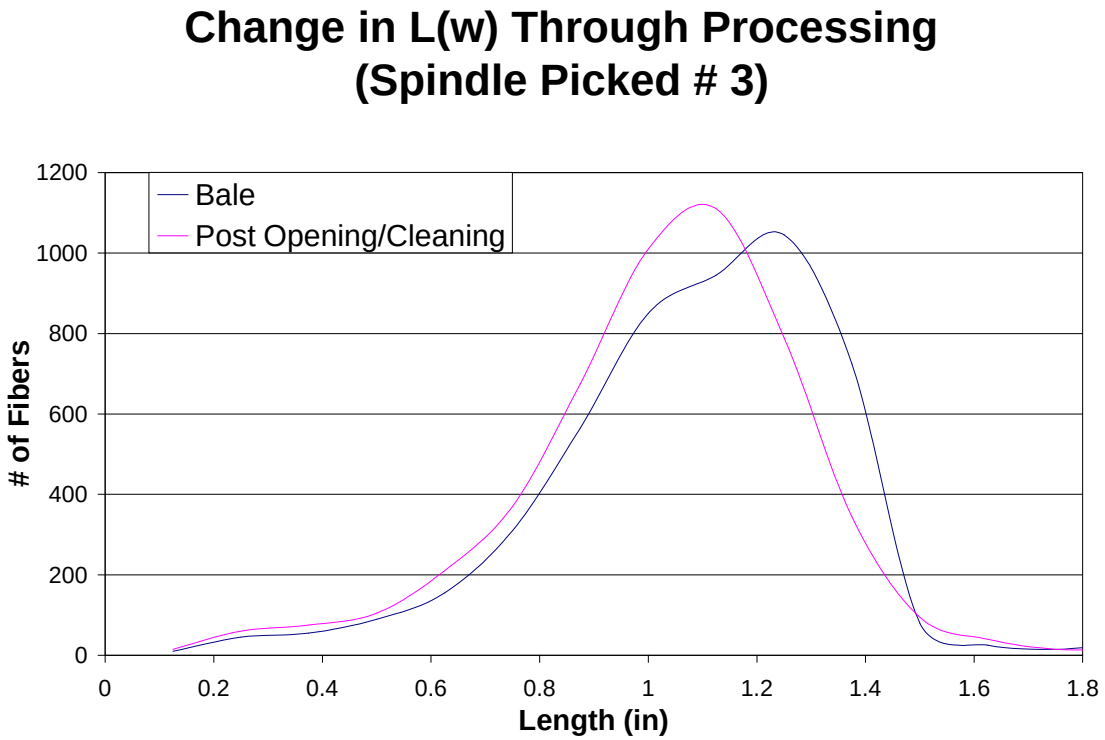

Figure 6. Length distribution through opening/cleaning of a spindle picked cotton

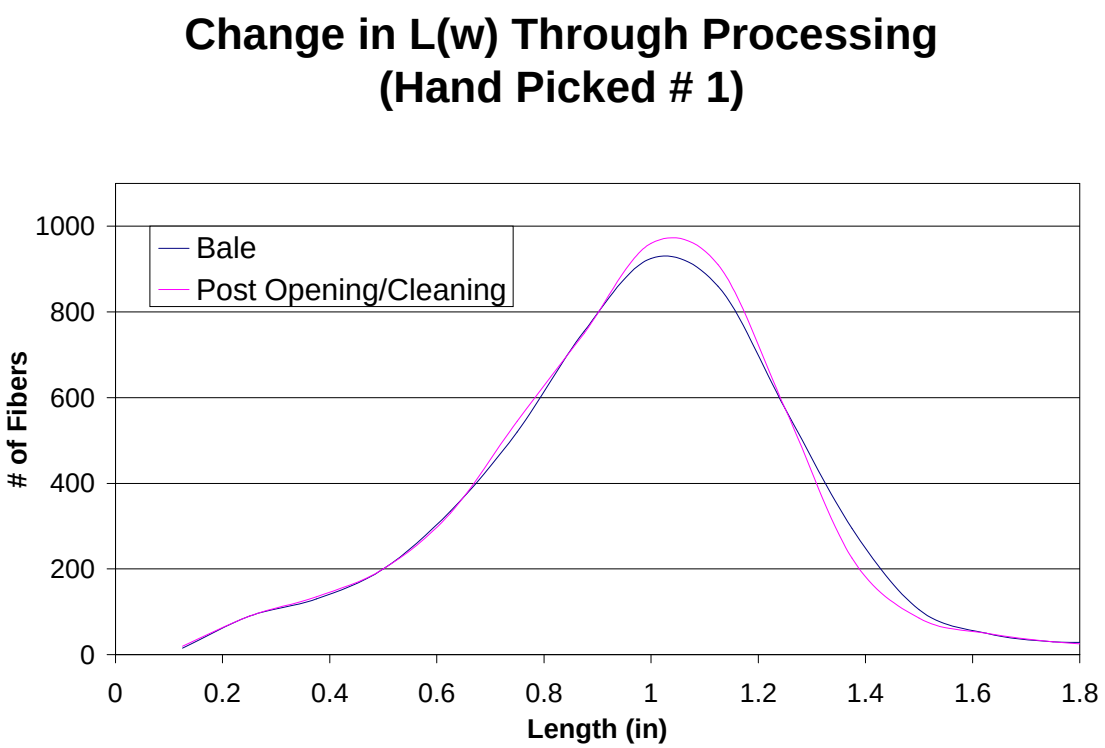

Figure 7. Length distribution through opening/cleaning of a hand picked cotton

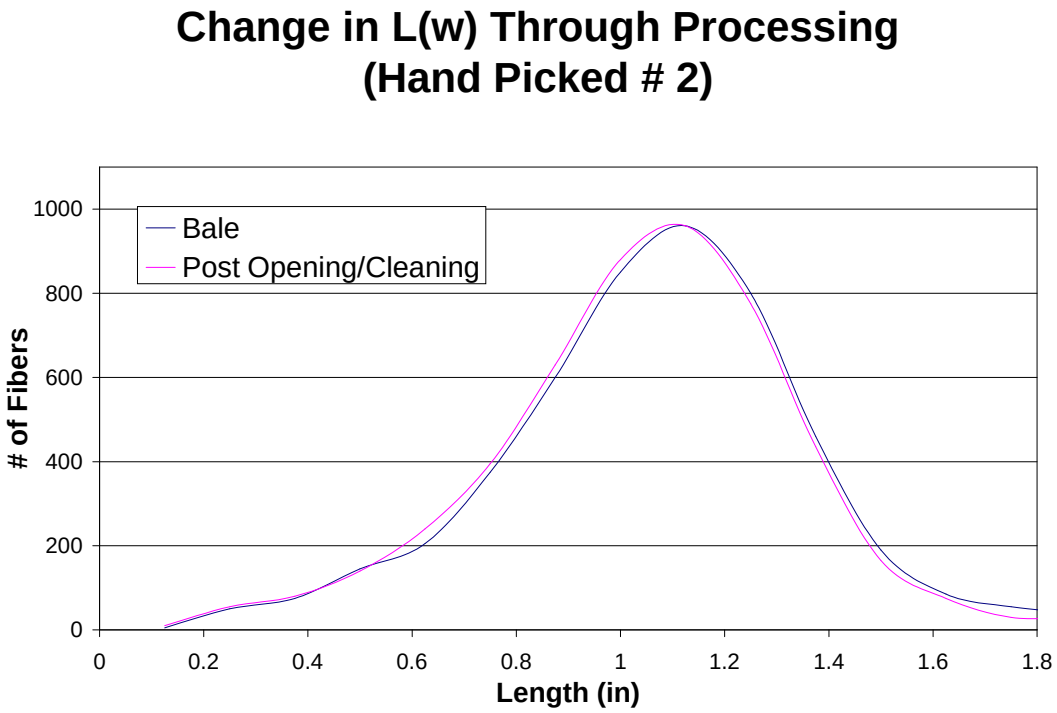

Figure 8. Length distribution through opening/cleaning of a hand picked cotton

Table 1. Fiber and yarn properties of sample cottons

	Bale		Opened/Cleaned		Bale HVI	Yarn Tenacity (cN/tex)		
Fiber	L(w)	SFC(w)	L(w)	SFC(w)	Strength (g/tex)	Mic	Ring	Rotor
Spindle Picked #1	0.978	6.62	0.994	6.42	28.8	4.4	13.83	12.46
Spindle Picked #2	1.036	6.96	0.962	7.16	32.4	3.9	18.64	16.74
Spindle Picked #3	0.986	4.50	0.978	4.78	28.4	5.4	14.97	12.68
Hand Picked #1	0.930	8.68	0.916	8.94	30.1	3.9	15.45	13.57
Hand Picked #2	1.018	5.30	1.002	5.68	33.3	4.2	16.41	13.98

Conclusions

The Southern Regional Research Center has successfully formed the Fiber Quality Evaluation Laboratory (FQEL). The FQEL has established a standard protocol for the testing and processing of small-scale samples from fiber through fabric. Testing performed to date indicates that the approach is valid and capable of producing useful data for scientists, breeders, and the textile industry. Additionally, fiber length distribution is an area in which research has recently begun to focus. FQEL preliminary data indicates that this area may prove to be a significant indicator of quality. However, the results also show that much work is needed. The database demonstrates the changes in fiber length and fiber length distribution through processing.