CURRENT AND FUTURE DIRECTIONS IN COTTON STRUCTURE AND QUALITY RESEARCH AT THE USDA SOUTHERN REGIONAL RESEARCH CENTER

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Abstract

The Cotton and Structure (CSQ) Research Unit is one of 3 core cotton research units at the Southern Regional Research Center (SRRC). The mission of the CSQ is to develop and improve the methods for assessing quality and structural attributes of cotton fiber through all stages of production and processing. Specific research areas include the improved understanding of cotton fiber structural components; a more complete understanding of the relationship of water to cotton and its impact on fiber processing characteristics; determination of the ability to measure and the desirability of measuring key cotton fiber-yarn-fabric properties; demonstration of the value of adding new quality measurements to better predict cotton processing efficiency and product quality; and development of new quality assessment tools for cotton breeders. As a result of recent stakeholder meetings and input and of a re-structuring and re-focus of the cotton programs at SRRC, our research emphasis is evaluating and developing new collaborations; strengthening and increasing our present extensive network of collaborators; re-focusing research programs; and looking for new ways to accomplish and expand our research objectives with continued program growth and outreach. High emphasis has been placed on strengthening the close relationship between the CSQ and the Cotton Quality Research Station (CQRS, Clemson, SC) so as to more closely align the two groups and to fully utilize the strengths of both units. Cotton quality assessment and instrumental analysis capabilities have increased sharply since 2004 with the installation of new instruments and software in the areas of fiber/yarn/fabric physical properties, structure analyses, advanced spectroscopy, and modular/small scale processing.

Introduction

The U.S. textile industry continues to shrink dramatically, and this shrinkage has led to the significant decrease in cotton's domestic market and to the dramatic increase in the export of U.S. produced cotton. The rapid globalization of cotton production and claims of inferior quality for machine picked US cotton (versus hand-picked foreign cottons) in Asia and elsewhere have placed severe pressure on the global marketing of US produced cotton. For U.S. cotton to successfully compete against world cottons, the industry must demonstrate the true quality of U.S. cotton relative to its competitors and establish improved quality measurement systems and traceable standards that will be accepted without reproach on the world stage. In addition, these improved quality systems should encompass quality measurements that will lead to the vertical integration of the cotton quality chain from the cotton field to final fabric. In order to provide a total "picture" of the fiber's quality, fundamental studies will be required to provide the basis and foundation for the product's quality ("what is happening"). *The CSQ contains both fundamental and applied components to address these important questions and issues.* (Rodgers, 2006).

CSQ is one of three cotton-specific research units at SRRC. It is composed of two "CRIS" or project teams/research areas—the fundamental "Structure and Moisture as Determinants of Commercially Important Cotton Fiber Properties" CRIS and the applied "Improved Cotton Quality Measurements" CRIS. The mission of the CSQ is to develop and improve the methods for assessing quality and structural attributes of cotton fiber through all stages of production and processing. Specific research areas include the improved understanding of cotton fiber structural components; a more complete understanding of the relationship of water to cotton and its impact on fiber processing characteristics; determination of the ability to measure and the desirability of measuring key cotton fiber-yarn-fabric properties; demonstration of the value of adding new quality measurements to better predict cotton processing efficiency and product quality; and development of new quality assessment tools for cotton breeders.

CSQ Research Direction and Focus—Present and Future

The overall state of CSQ is one of re-direction and re-organization. As a result of recent stakeholder meetings and input and of a re-structuring and re-focus of the cotton programs at SRRC, our research emphasis is evaluating and developing new collaborations; strengthening and increasing our present extensive network of collaborators; re-focusing research programs; and looking for new ways to accomplish and expand our research objectives with

continued program growth and outreach. The re-organized and re-directed CSQ is a focused, task-oriented group with emphasis on impact, providing critical results and knowledge to the cotton industry in a timely and efficient manner. We continue to receive strong and positive responses and support by stakeholders on a large variety of activities and projects. Internal and stakeholder supported research programs have been initiated and/or expanded in the areas of short fiber content/length algorithms, seed coat fragments, at-line/field analyses, color analyses, maturity measurements, computational analyses, moisture reference methods, moisture testing/instruments, and impact of environmental conditions on fiber test results.

Important recent accomplishments include:

- Determination of the impact of environmental conditions on the High Volume Instrument (HVI) fiber quality measurements. Changes in environmental conditions on HVI measurements were shown to significantly impact fiber strength and length but not micronaire over a wide range of environments with a diverse set of test cottons.
- Development of a new improved measurement for short fiber content and fiber length. A new length parameter, Lower Half Mean Length (LHML) was found to estimate cotton short fibers very well and predicted spinning performance and yarn quality equally well while maintaining low measurement variation.
- In collaboration with the Agricultural Marketing Service (AMS), research by CSQ scientists contributed to the adoption by China of the AMS Classing System, and this in turn facilitated the Chinese mills to use more U.S. cotton.
- Development of the Fiber Quality Evaluation Lab (FQEL), a comprehensive historical database developed in cooperation with the Cotton Quality Research Station (CQRS-ARS-USDA) in Clemson, SC. The FQEL is a database of quality measurements for a wide variety of cottons, from fiber to fabric, that can be used to assess the veracity of present and future quality measurements and their ability to predict the quality of downstream products. For CSQ, the database contains approximately 450 lots of cotton, with approximately 14,000 samples for a total of almost 100,000 observations.

Specific current research initiatives within CSQ are as follow:

- Unified FQEL database to include production, testing, and processing for a diverse set of cottons (foreign & domestic).
- Fiber quality measurements to better predict processing efficiency and product quality (short fiber content/length, seed coat fragments, at-line/field analyses, maturity, color, etc.). (Table 1, Figure 1 and 2)
- Quality assessment tools for cotton producers to aid in decision making.
- Develop new quality tools for field and at-line measurements that will lead to the vertical integration of the cotton chain from the cotton field to fabric, emphasizing new technologies.
- Structures and structure changes due to moisture and their relationship to fiber properties.
- Computational/structure analyses and mechanisms of fiber breakage, including influences of moisture. (Figure 3)
- Correlate moisture properties with fiber physical properties and processing performance. (Figure 4)
- Develop international standards for key fiber measurements to address the lack of internationally recognized, independent standards for cotton fiber measurements.
- Quantify and determine the quality of U.S. cottons as compared to foreign cottons.
- Shift textile mill processing from a small manufacturing mill to a pilot plant system, with emphasis on mini- and small-scale textile production of experimental/test items.
- Protocols for processing micro-, mini-, and small-scale samples in support of improved fiber quality measurement programs.
- Strengthen the close relationship between the CQRS and CSQ so as to more closely align the two groups and to fully utilize the strengths of both units.

In addition, significant improvements in analytical and instrument capabilities have been made in CSQ since 2004 in the areas of fiber physicals, structure analyses, advanced spectroscopy, and fabric testing. (Figure 5)

Summary

The Cotton Structure and Quality (CSQ) research unit (CSQ-ARS-USDA) is one of three primary cotton research units at SRRC in New Orleans, LA. The mission of the CSQ is to develop and improve the methods for assessing quality and structural attributes of cotton fiber through all stages of production and processing. It has both

fundamental and applied research components (called CRIS units). The overall state of the Management Unit (MU) is one of re-direction and re-organization. The re-organized and re-directed CSQ is a focused, task-oriented MU with emphasis on impact, providing critical results and knowledge to the cotton industry in a timely and efficient manner. In addition, significant improvements in analytical and instrument capabilities have been made in the areas of fiber physicals, structure analyses, advanced spectroscopy, and fabric testing.

Reference

Rodgers, J. Overview of Cotton Research, Cotton Structure and Quality (CSQ), SRRC. Cotton Research Listening Session, New Orleans, LA, September 2006.

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Disclaimer

The use of a company or product name is solely for the purpose of providing specific information and does not imply approval or recommendation by the United States Department of Agriculture to the exclusion of others.

Table 1. Comparison of Lower Half Mean Length (LHML) and Short Fiber Content (SFC) Measurements. LHML has a much lower variation and predicted yarn properties greater than or equal to SFC. (Cui)

YARN PROPERTIES	*LHML* R^2	*SFC* R^2
Ends Down	**0.8156**	**0.7909**
Irregularity (CV%)	**0.7867**	**0.7287**
Strength	**0.7709**	**0.7458**
Strength CV	**0.1742**	**0.1268**
Thick Places	**0.8264**	**0.7033**
Thin Places	**0.5695**	**0.5582**

Figure 1. Field Analyses of Cotton Fiber Properties by Near Infrared (NIR) Spectroscopy. (Rodgers)

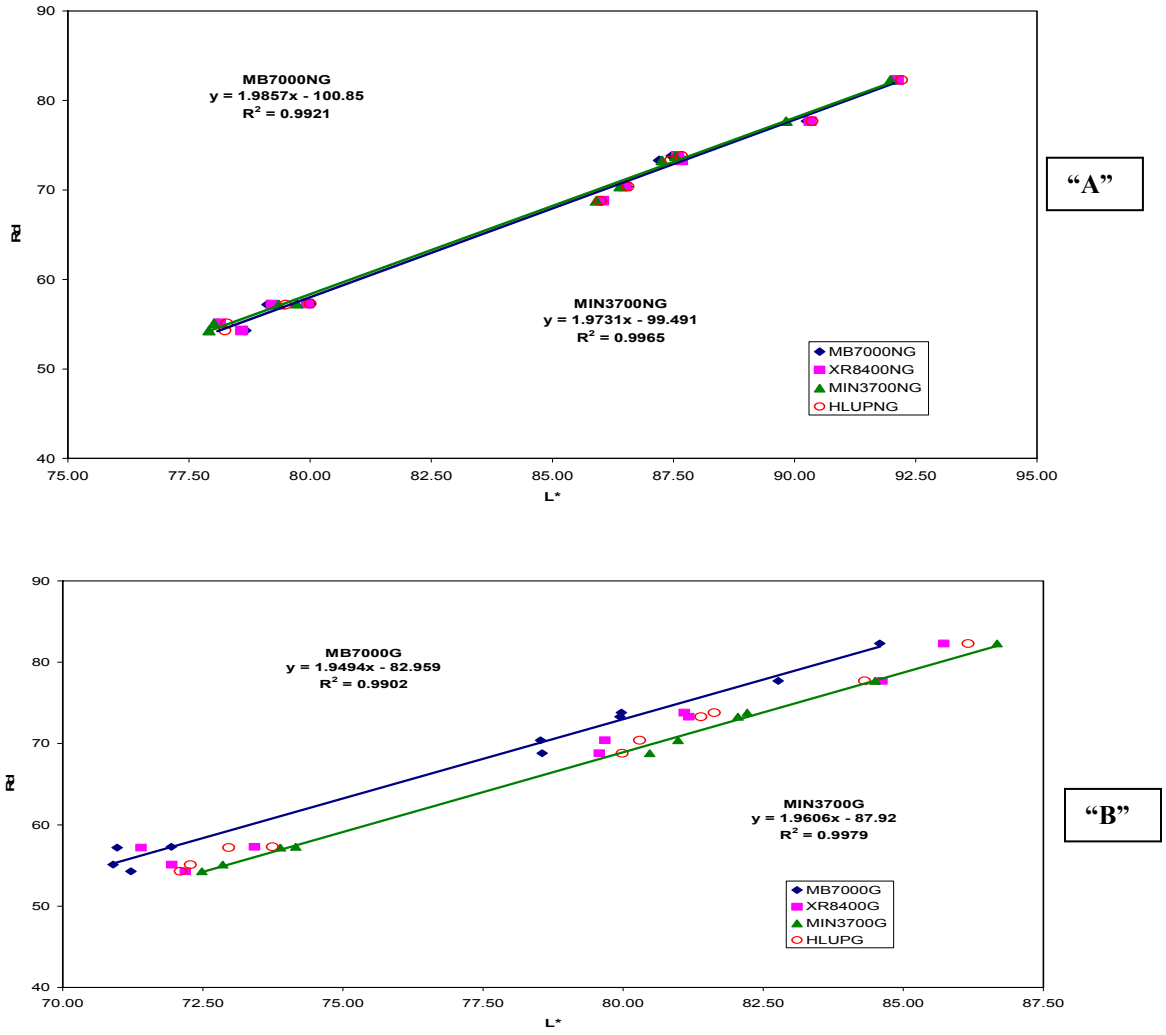

Figure 2. Impacts of Glass Use on Spectrophotometer Color Results, L*↔Rd relationships, AMS tiles, without glass (A) and with glass (B). (Rodgers)

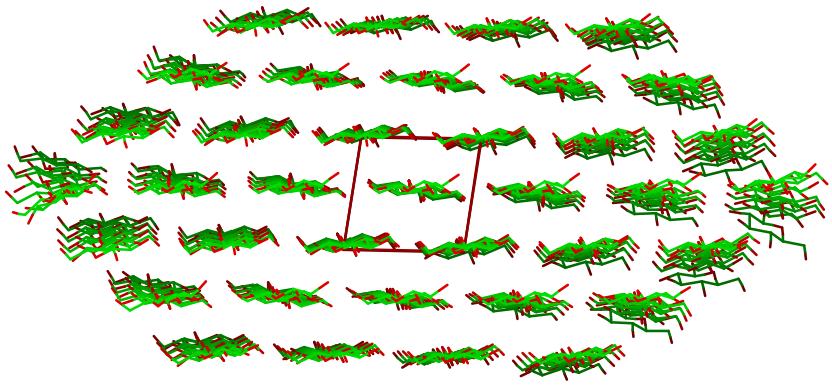

Figure 3. Example of Structure/Computational Analyses. Model of Cellulose Iβ starting from crystal structure. (French)

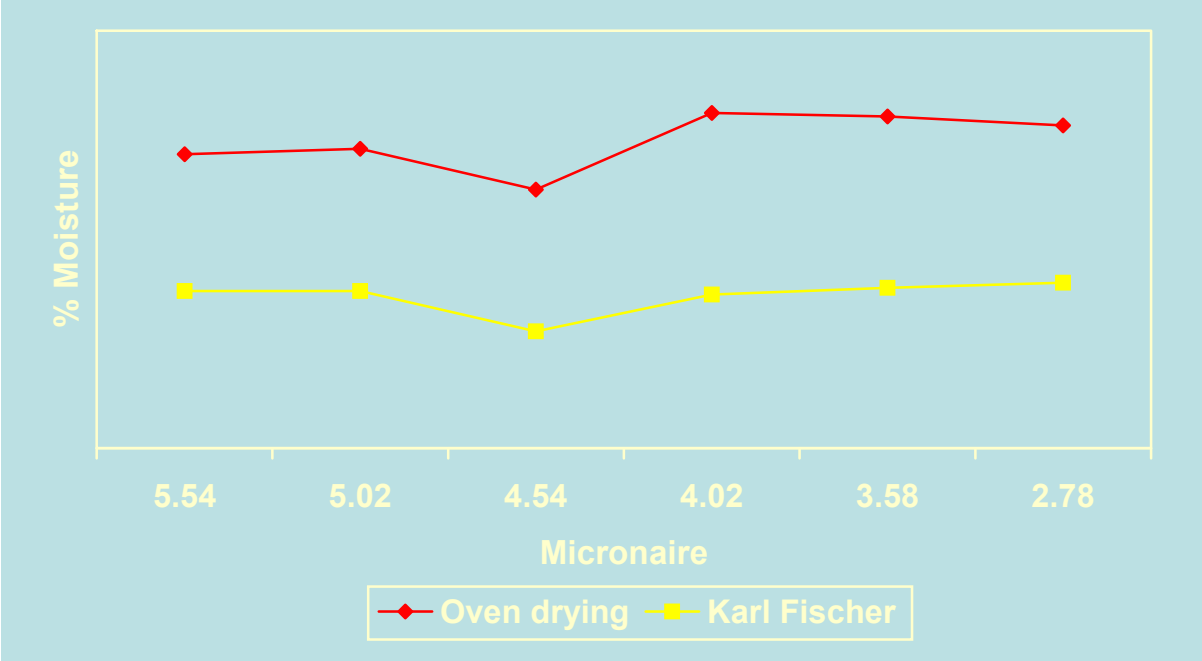

Figure 4. Comparison of Oven and Karl Fischer reagent (KFR) Moisture Analyses Over a Wide Micronaire Range. (Montalvo)

FIBER PHYSICALS:

1. **USTER® HVI 1000 Fiber Tester**
2. **USTER® AFIS-Pro Fiber Tester**
3. **USTER® UT4 Yarn Tester**
4. **USTER® Tensorapid 4**
5. **Fiber Image Analysis System (FIAS)**
6. **Favimat Automated Single Fiber Tester**
7. **Automated White Speck Analysis System**

STRUCTURE ANALYSES:

i. **Computer Cluster**
ii. **Microscope Software Upgrades**

ADVANCED SPECTROSCOPY:

b. **Bruker FT-NIR (Bench-Top)**
c. **Brimrose 5030 NIR (Portable)**
d. **Varian UV/VIS (2)**
e. **Bruker FT-IR (2)**
f. **Minolta And HunterLab Portable Color Units**
g. **Color Upgrades**

FABRIC TESTING:

- **Wear/Abrasion Tester**
- **Burst Tester**
- **Fadometer/Weatherometer**
- **Launderometer**

Figure 5. Major CSQ Analytical and Instrument Upgrades