IMPACT OF STORAGE ON FIBER QUALITY

C.D. Delhom
C. Fortier
A.D. French
J.E. Rodgers
USDA ARS, SRRC
New Orleans, LA
G. Gamble
USDA ARS
Athens, GA
D.P. Thibodeaux
USDA, ARS (Retired)
Clemson, SC
V. Martin
Cotton Incorporated
Cary, NC

Abstract

The vast majority of cotton produced in the United States is exported. The exporting of the crop results in long storage and shipping times, which introduces a new challenge for cotton quality. The duration and environmental conditions of cotton storage and shipping can impact cotton quality in terms of color and processing. The most notable change is that the +b value for many bales increases between classing and processing overseas. The increased yellowness can result in appearance defects in the finished yarn as well as impact yarn strength and performance. A method has been created to easily update the original +b grade with a more recent +b grade measured using a handheld instrument at the mill. A long term project is underway to store multiple bales, produced from the same module, under various conditions and monitor the effects of storage condition on color and other physical properties as well as processing performance through to finished fabric. Twelve bales were ginned from a single module and are being subjected to 18 months of storage under various conditions. Standard physical testing as well as a variety of chemical and morphological analyses will be performed on the samples with the goal being to predict and model the quality changes due to storage time and condition.

Introduction

Over the last 20 years the U.S. cotton industry has evolved from an importer of raw cotton to an exporter of raw cotton. As more and more U.S. cotton is shipped globally, the mean time between ginning and mill-consumption has grown. This increase leads to longer and more diverse storage conditions for U.S. cotton. Domestic consumption of cotton occurs in a shorter timeframe than international consumption of cotton. U.S. cotton is now stored in a variety of warehouses, shipping containers and intermodal storage locations between the gin and mill floor.

The storage of cotton is known to alter some fiber quality properties, most notably color. This problem is not new and has been studied for a long time. Nickerson (1951) and Cable et al. (1964) both examined the color change of cotton during storage in the 1950s and 60s. More recently, Gamble (2007, 2008) has examined the color change and proposed that the Maillard reaction is responsible for changing the color of some cottons during storage. While most work has focused on upland cottons, Hughs et al. (2011) examined the color change of Pima cottons during storage.

The work reported here is focused exclusively on upland varieties. The work is intended to focus on the findings by Gamble that the Maillard reaction may be responsible. The Maillard reaction is a browning caused by a chemical reaction of sugars and amino acids, usually at elevated temperatures. It is commonly experienced in cooking foods. Gamble (2007, 2008) has hypothesized that prolonged exposure to elevated temperatures could cause a reaction in the natural sugars present in cotton fiber. This time/temperature combination could cause the changing of colors at lower temperatures than normally expected, if exposed to the elevated temperatures for a long enough period of time.

Complaints have been heard about a changing of +b values of cottons. These complaints, largely anecdotal, are being examined for common components. In general, the complaints seem to be that the +b value has changed enough to alter the color grade of the cotton 1 to 2 grades. This shift is enough to present shade problems with the yarn and fabric produced from the cottons in a lay down which has been calculated based on the original color data. Sometimes the shade difference appears to disappear after bleaching but returns after the material has been dyed.

Methods

There are several stages to this research. The first stage was an immediate solution to address the color change. The second stage was to examine some cottons under long-term storage, while the third stage is to attempt to replicate the color change over a shorter period of time and identify the cause, i.e. why does one cotton change and another not?

Immediate Solution

The immediate solution to address the color change was the implementation of a hand-held color measurement system (Rodgers et al., 2012) (Figure 1). This portable system allows the color of bales to be re-measured quickly in a warehouse or mill. The values from this hand-held system can be converted to new Rd and +b values to allow for accurate mill lay-downs. Although this solution allows for mills to avoid the problems caused by the color change, it requires additional work and handling of the bales by the mill and is only a stopgap solution.

Figure 1. HunterLab MiniScan EZ/MSEZ hand-held color instrument used by Rodgers, et al.

Long-term Storage Color Change

USDA-ARS has had eight bales in storage in a warehouse in New Orleans, LA for an extended period of time. These bales, from the 2001 crop year, have been sampled and measured periodically to monitor the change in properties. The color changes over the first few years with a reduction in Rd and an increase in +b (grayer and more yellow cotton), which is expected. Over a longer period of time some of the cottons stabilize while others continue to change (Table 1). These cottons represent seven varieties from three states and represent a broad range of growing conditions and maturity. These cottons have been stored together since shortly after ginning and have been exposed to a broad range of temperature and humidity.

Table 1. Color change of some 2001 crop year upland cottons over 10 years

Variety/Location	2001-2004 Change		2004-2005 Change		2005-2010 Change		2001-2010 Change	
	Rd	+b	Rd	+b	Rd	+b	Rd	+b
1-TX	-6.2	4.3	-0.2	-1.0	-3.0	0.0	-9.4	3.3
2-MS	-2.2	1.8	-0.9	-0.8	1.1	1.0	-2.0	2.0
3-GA	-2.4	2.8	-0.7	-0.3	-2.2	0.8	-5.2	3.2
3-MS	-2.6	2.1	-1.1	-1.1	1.2	1.5	-2.5	2.6
4-GA	-3.5	2.1	-1.2	0.0	1.3	3.2	-.34	5.3
5-TX	-4.6	4.2	-2.2	-1.5	-2.9	2.8	-9.7	5.5
6-TX	-4.4	4.2	-2.3	-1.3	-2.1	3.5	-8.7	6.4
7-TX	-4.9	3.0	-1.5	-0.9	-0.2	2.0	-6.7	4.1

Current Study

The current study began with the ginning of two modules of DPL 0912 B2RF at a commercial gin in Avon, MS in October 2012. The two modules were grown and harvested in the same field and ginned consecutively under normal conditions. The first module was ginned and not sampled. The first 12 bales produced from the second module were collected for this study. Three storage conditions were selected: 1) cold storage, 2) cotton warehouse and 3) shipping container. Four bales were sent to each storage condition. The cold storage bales are intended to be the control, as it is accepted practice to store cotton samples in cold storage to preserve the properties.

The cottons will be stored for up to 18 months, the mean time between ginning and mill-consumption. After being removed from storage the bales will be transported to New Orleans, LA for sampling, testing and processing at the USDA-Southern Regional Research Center. The bales will be sampled for color, color-distribution, HVI properties, sugar content, frictional properties and general textile processing performance. The cottons will be converted into finished textile goods with sampling and testing throughout the textile conversion process to determine any differences between the lots due to storage condition.

Results and Discussion

The bales are still in storage at this time. The bales were checked with a portable color instrument after 14 months in storage and a color change was found between storage conditions (Table 2). Further results will be published at the conclusion of the study.

Table 2. Color differences between storage conditions

Condition	Rd	+b	Color Grade
Cold Storage	81.03	7.46	31
Warehouse	78.35	7.63	31
Shipping Container	76.58	9.64	32

Summary

The change of cotton color due to storage condition is an important issue, although the problem is sporadic and thus far unpredictable. A study is underway to address the issue and to potential identify the cause(s) of this color shift. The current study is designed to address the issues raised in previous studies and to obtain scientific data to replace the anecdotal evidence that exists for this issue.

Acknowledgements

The authors thank Cotton Incorporated for the financial support of this research, Buddy Cochran and Avon Gin for cooperating in the production of the bales, as well as Mid-Delta Cold Storage and Staplcotn for the storage of the bales.

Disclaimer

Names of companies or commercial products are given solely for the purpose of providing specific information; their mention does not imply recommendation or endorsement by the U.S. Department of Agriculture over others not mentioned.

References

Cable, C., H. Smith, Jr., and Z. Looney. 1964. Changes in Quality and Value of Cotton Bales During Storage, USDA,ERS,ARS, Marketing Research Report No. 645, Feb. 1964.

Gamble, G.R. 2007. The Effect of Ageing on Cotton Fiber Friction. J. Cotton Sci. 11:98-103.

Gamble, G.R. 2008. The Relationship Between Maillard Reaction Product Formation and the Strength of Griege Yarns Subjected to Accelerated Ageing Conditions. World Cotton Research Conference Proceedings, September 10-14, 2007, Lubbock, TX.

Hughs, S.E., G. Gamble, C.B. Armijo, and D. C. Tristao. 2011. Long-Term Storage of Polyethylene Film Wrapped Cotton Bales and Effects on Fiber and Textile Quality. J. Cotton Sci. 15:127-136.

Nickerson, Nickerson, D. 1951. Effect of exposure and storage on color and other factors of quality in raw cotton. United States Dept. of Agriculture. Washington D.C.

Rodgers, J. E., Fortier, C. A., Cui, X., Delhom, C. D., Martin, V. B., Watson, M. D. 2012. Preliminary assessments of portable color spectrophotometer measurements of cotton color. Proceedings 2011 Beltwide Cotton Conferences, pp. 1313-1318.