MEASURING NATURAL WAXES ON COTTON USING NIR ABSORBANCE

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Abstract

Natural waxes and lubricants are essential for efficient textile processing of cotton fibers. Research has shown that cotton containing a higher level of natural waxes produced stronger yarns. Studies have also shown that natural wax is also a significant contributor to fabric strength. Near-infrared (NIR) reflectance has provided a simple method to rapidly measure the amount of total extractable and wax content in bales prepared for market. Reported herein are NIR measurements for a series of cottons produced commercially in different locations from 1990 through 1994. NIR wax results are also reported for a series of experimental cottons grown in breeder plots during 1996 at USDA, ARS, Florence, SC.

Introduction

The textile industry has made significant progress in developing methods of selecting cotton bales with the best combination of fiber properties to meet quality demands of their customers. However, seasonal differences caused by the weather and other environmental conditions may cause unexplained changes in processing efficiencies and product quality. Additionally, some cotton varieties will process differently than others, even when all other measured fiber properties are equal.

Presently, bale selection is based on a series of fiber quality measurements provided with high volume instruments (HVI). Many textile mills monitor their product quality by testing yarn strength and evenness following the spinning process. A few mills are now testing their fabric to insure a high level of quality in the finished product. Recently, we published a report which suggested that the accuracy of fabric strength predictions could be improved by including NIR measurements of fiber extract content (Taylor, R. A., 1996 and Taylor, R. A., in press).

The presence of small quantities of natural waxes on cotton has been well established for many years. There are several different molecular forms of waxes which can be removed by extraction with a solvent (ASTM, 1996). Due to their molecular makeup, some waxes may be extracted by repeated rain and sun exposure between boll opening and harvest (Lewin, A. H. and Carroll, F. I., 1981). Natural extraction by the environment is called "weather damage" which will occasionally reduce the amount of natural wax to an unacceptable level making the cotton impossible to process through a textile mill (Marsh, P. B., et. al., 1958). Artificial spin finishes have been developed for application to severely damaged cotton (Perkins, H. H., Jr., 1988).

The purpose of this research was to examine the wax and total extractable content of commercially produced cotton from across the U. S. cotton belt using the near infrared method. These test cottons included varieties which represented the major production from all growing areas from 1990 thru 1994 which had been processed into different types of yarn for quality testing. A second group of cottons, produced during the 1996 season, at the USDA Experiment Station, Florence, SC, were examined to evaluate differences among varieties grown in the same environment.

Experimental Procedure

A typical near infrared spectra for cotton (Figure 1) shows several absorbance bands or peaks which indicates wavelengths or regions where a molecular compound in cotton exhibits increased light absorption. For example, the band near 1900nm is due to moisture in the cotton fibers while the peak near 2100nm is caused by the absorption of cellulose. The magnitude of other, less obvious bands, can be measured with a sensitive spectrometer to indicate the concentration of other chemical compounds.

Two different NIR calibrations were developed for a Perten Model 8144 filter-type spectrometer. One calibration was based on the total amount of material extracted using alcohol with the Soxhlet method (Figure 2). The second calibration was based on a wax-only extraction using trichloroethane solvent with the same Soxhlet procedure (Figure 3). Both calibrations used a five term model which involved measuring NIR absorbance values at five different prescribed wavelengths. Total extract and wax content values were estimated from absorbance values using calibration coefficients in a linear summation equation. Four absorbance readings (on a 40mm diameter area) were recorded and averaged to establish the NIR value for each cotton sample. Cotton samples used for these calibrations were selected separately (Taylor, R. A., 1996 and Taylor, R. A., in press) and independent from the survey cottons examined in this report.

Results

NIR extract and wax content values for all five years of leading variety cottons were entered into a statistical data set. When sorted the data by year, we could clearly see a significant seasonal difference in the NIR extract values (Table 1). NIR wax values remained constant.

When these same test data were sorted by cotton variety, we could clearly see a significant level difference among the NIR extract values (Table 2). These values ranged from a

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low of 1.41% for Deltapine Acala 90 to high 2.09% for Paymaster 200. Again, wax content values were not different among varieties.

When these same data were sorted by producing state (Table 3) and organized by growing region (Table 4), we could clearly see a tendency for a high level of extractables in western grown cottons while cottons produced in the Midsouth and Southeast were lower. While cottons for the Far West were highest in total extractable content, they were also slightly lower in wax content (Table 4).

When these data were compared with other fiber quality parameters in simple linear correlations, we could see that only fiber micronaire gave a significant negative correlation (Table 5). Similar correlation procedures using yarn strength data gave low but significant correlations with extract content while all correlations with wax content were not significant (Table 6).

Experimental Cottons

Thanks to the cooperation and assistance of Dr. O. Lloyd May ARS, Florence, SC, we were able to include some small fiber samples from 19 variety test plots produced during the 1996 season (Table 7 and 8). These data showed that accurate NIR measurements could be made with small test plot fiber samples. These data indicated an exceptionally low level of extractable content (1.23%) which was caused by exceptionally heavy rains at harvest time. Laboratory extract testing confirmed the low NIR extract values (Figure 4 and Table 7).

Summary

There appears to be a varietal as well as environmental influence on the amount of total extractable content in cotton fibers. In general, western produced cottons gave higher extractable content values when compared to eastern produced cottons. Total extractable content gave a low but significant contribution to yarn strength. Correlations were slightly higher for fine yarns. NIR wax content values were nearly constant among all samples tested. Wax did not contribute significantly to yarn strength.

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References

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Table 1. NIR Extract and Wax Content of Leading Cotton Varieties[1]

YEAR	NUMBER	NIR EXTRACT (%)	NIR Wax (%)
1990	26	1.45	0.48
1991	24	1.60	0.48
1992	25	1.83	0.49
1993	26	1.6	70.48
1994	26	1.7	20.50

[1] USDA, AMS Cotton Division Fiber and Processing Test Reports.

Table 2. Total Extract by Variety

VARIETY	NUMBER	NIR EXTRACT (%)	NIR Wax (%)
High Extract Cottons			
Paymaster 200	6	2.09	0.56
Acala Royale	2	2.05	0.47
Acala Maxxa	6	1.98	0.46
Paymaster HS-26	9	1.94	0.53
Acala SJ-2	6	1.91	0.48
GC-510	8	1.91	0.47
Medium Extract Cottons			
Paymaster 145	3	1.78	0.54
Pima S-7	4	1.73	0.49
Deltapine 5415	8	1.70	0.45
Pima S-6	6	1.66	0.48
Deltapine 20	10	1.62	0.52
Low Extract Cottons			
Stoneville 453	6	1.47	0.48
Deltapine 50	21	1.47	0.49
Deltapine 51	11	1.46	0.47
DES - 119	4	1.43	0.52
Deltapine Acala 90	22	1.41	0.46

Table 3. NIR Extract and Wax by Location

STATE	NUMBER	NIR EXTRACT (%)	NIR WAX (%0)
Southeastern Cottons			
Alabama	4	1.35	0.50
Georgia	6	1.24	0.44
North Carolina	1	1.39	0.52
South Carolina	3	1.40	0.52
Midsouth Cottons			
Arkansas	3	1.40	0.45
Louisiana	7	1.41	0.47
Tennessee	10	1.47	0.51
Mississippi	15	1.53	0.50
Missouri	4	1.61	0.52
Southwest Cottons			
Texas	34	1.77	0.51
Oklahoma	1	1.29	0.49
Far West Cottons			
New Mexico	1	1.62	0.51
Arizona	10	1.73	0.46
California	28	1.90	0.46

Table 4. NIR Extract and Wax by Region

REGION	NUMBER.	NIR EXTRACT (%)	NIR WAX (%)
Southeast	13	1.42	0.52
Midsouth	39	1.48	0.50
Southwest	35	1.76	0.51
Far West	39	1.85	0.46

Table 5. Comparison of Total Extract and Wax with Fiber Properties for Leading Variety Cottons[1]

FIBER PROPERTY	NIR EXTRACT	NIR WAX
Micronaire	-0.61	-0.63
Elongation	0.28	-0.24
Yellowness(+b)	0.21	0.01
HVI strength	0.20	-0.16
Trash area	-0.19	0.11
Grayness (Rd)	0.16	0.04

[1] Simple Correlation Coefficient (r)

Table 6. Comparison of NIR Extract and Wax with Yarn Strength for Leading Variety Cottons[1]

YARN STRENGTH	NIR EXTRACT	NIR WAX
Skein Testing		
22's Rotor Spun Yarn	0.38	-0.13
36's Ring Spun Yarn	0.47	-0.11
Single End Testing		
22's Rotor Spun Yarn	0.37	-0.03
36's Ring Spun Yarn	0.52	-0.01

[1] Simple Correlation Coefficient (r)

Table 7. NIR Extract Content of Experimental Cotton Varieties

VARIETY	NIR EXTRACT	LAB EXTRACT1
Acala Maxxa	1.40	1.50
Stoneville La 887	1.25	1.24
Sure Grow 125	1.18	1.29
Ark 870622	1.31	1.29
Ark 871209	1.04	1.18
AZ 93-248	1.18	1.35
AZ 93-259	1.30	1.35
GA 90-41	1.34	1.32
GA 91-143	1.21	1.52
B7413	1.29	1.65
SS 9501	1.43	1.27
SS 9303	1.29	1.21
SS 9506	1.36	1.67
PD 93054	1.18	1.38
89E-51	1.10	1.06
DPX 1111	1.07	0.99
DPX 93-05	1.05	1.07
AVERAGE	**1.23**	**1.31**

1 based on a single 2.5 gm test

Table 8. Small Samples Excluded from Experimental Varieties

VARIETY	NIR EXTRACT	LAB. EXTRACT
AZ 93-180	1.07	1.28
152B	0.96	1.15

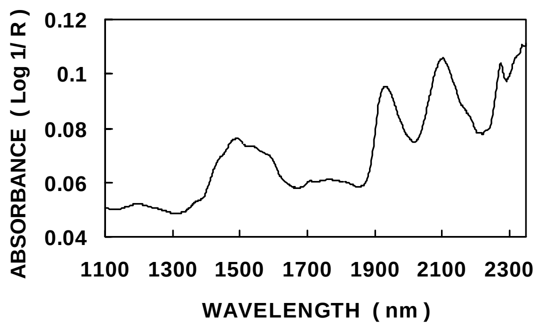

Figure 1 Near Infrared Spectral Absorbance of Cotton

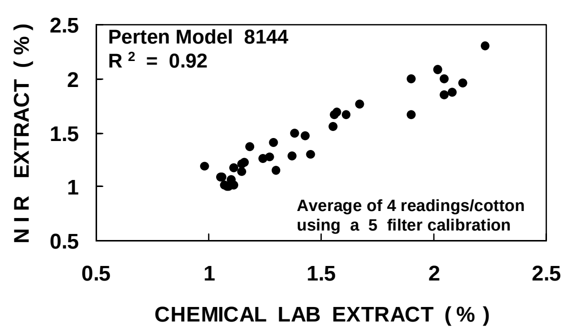

Figure 2 Comparison of Soxhlet Extract With N I R Data

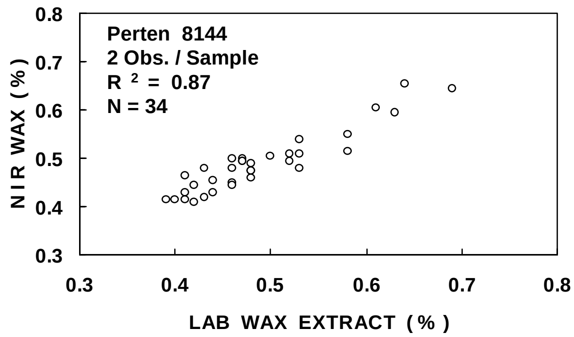

Figure 3. Estimating Cotton Wax Using N I R Absorbance

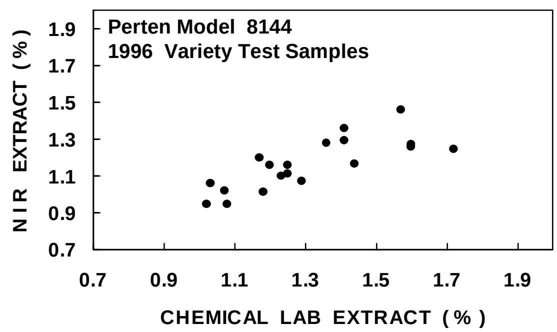

Figure 4 Comparison of Soxhlet With N I R Data.