THE USE OF ELEVATED TEMPERATURES TO REDUCE THE STICKINESS POTENTIAL OF HONEYDEW CONTAMINATED COTTONS

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Abstract

Whitefly honeydew contaminated cottons were treated at different temperatures and a fixed 65% relative humidity to reduce stickiness. Two sticky cottons, provided by the USDA Ginning Laboratory, Lubbock, TX, were stored for periods of 8, 16, 32 and 48 hours at 30EC (86EF), 40EC, (104EF), and 50EC (122EF). Reducing sugars, thermodetector and minicard stickiness tests, and carbohydrate contents, as determined by High Performance Chromatography (HPLC) were conducted to determine effective-ness of these treatments. Fiber quality measurements in the form of Stelometer strength and colorimeter reflectance and yellowness were also determined for each treatment. Reductions in thermodetector stickiness were achieved for each temperature and treatment time, however, fiber strength was adversely affected at the two higher temperatures for one of these cottons.

Introduction

Cotton stickiness from both high natural sugars and insect contamination is a worldwide problem. High natural sugars on cotton usually come from crops harvested in arid areas with no overhead irrigation. Insect honeydew contamination from whiteflies and aphids, continues to expand as the insect populations extend their habitats and has become an increased threat to U. S. cottons. High frequencies of these insects occur where other host vegetation is available.

Problems encountered in handling and processing these cottons in all phases of textile processing have prompted many strategies to control or reduce the influence of stickiness (13, 14, 15). Natural sugars that are uniformly distributed on the surface of cotton cause subtle buildups of sticky materials and lint on processing equipment. Long-term accumulation of these sticky deposits can require more frequent cleaning schedules and sometimes interrupt the lint processing. Problems associated with insect honeydew are often dramatic and devastating with acute effects on processing. Immediate attention is usually necessary and the offending cotton is usually removed from the process.

The most used method to control stickiness in textile processing is to blend sticky and nonsticky cottons to obtain a mix that will process satisfactorily. This method requires the identification of the cottons causing the stickiness and trial and error blending to achieve a good manageable level.

Other general methods of controlling sticky cottons have involved lint washing and dispersal or decomposition techniques using elevated levels of water on cottons (1, 6, 8, 12). One possible approach is in modular storage. Excessive levels of water, however, promotes microbial activity and may harm cotton quality properties such as strength and color.

Several decomposition treatment methods to reduce stickiness on cottons with enzymes, yeast, or bacteria to activate natural microorganisms have been conducted (9). Such treatments generally require special environmental conditions and delays (as in moduling), but have been effective in reducing cotton stickiness.

Technology to treat sticky cottons using controlled heating has not been fully explored. Results of gin heating experiments show that heating aids in the roller ginning of sticky cotton (10). Excessive heating and overdrying, however, can harm the fiber (2). This paper is a report on experiments using slightly elevated temperatures at controlled humidities to reduce the stickiness of two whitefly honeydew contaminated cottons. Routine reducing sugars analyses, thermodetector stickiness tests, and high performance liquid chromatography (HPLC) analysis to characterize and quantitate individual honeydew and plant sugars were determined. Physical property measurement of strength and colorimeter yellowness (+b) and reflectance (Rd) were determined to examine any adverse effects of these treatments on cotton quality.

Materials and Methods

Samples

Two 1995 crop New Mexico whitefly honeydew contaminated cottons stored in bales from warehouse inventories were selected for this study. Thermodetector (TD) analysis for these cottons rated one in the heavy sticky range and the other was rated as moderately sticky. Stickiness criteria for the TD test are defined in Table 1. Reducing sugars for these cottons averaged 1.45% and 0.45% respectively. Both cottons were in the form of ginned raw stock. After conditioning in the laboratory, the moisture content of these cottons was determined to be 7.0 " 0.1%.

Preparation

Both cottons were thoroughly blended a minimum of eight times by picker blender and three times by hand before sampling. Forty grams of each cotton were conditioned in a Rheem (Puffer-Hubbard) environmental chamber at 50EC (122EF), 40EC (104EF), and 30EC (86EF) for periods of 8, 16, 32, and 48 hours (2 days) at a controlled 65% relative humidity. Samples were re-conditioned at room

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temperature (20-24EC) and 65% relative humidity for two weeks, then tested.

Testing

Prior to testing each untreated (control samples) and treated cotton were thoroughly blended using a CSI rotary wire blender. Subsequent thermodetector (TD), reducing sugar content, HPLC individual carbohydrate and other component contents, Stelometer strengths, and colorimeter reflectance (Rd) and yellowness (+b) were run. A minimum of five replicates per sample were conducted. The reducing sugar (11), and thermodetector tests (3) were determined as described earlier. Randomly selected samples (2 grams each) were extracted for surface sugars and analyzed by HPLC using a Dionex Series DX-300 system by a procedure previously described (4, 5, 7). Calculations for specific individual carbohydrate concentrations were based on comparisons to authentic calibration sugar standards tested periodically during analysis to correct for variations in column and detector sensitivity.

Chromatograms (5 replications) were analyzed and averaged for each treated and untreated sample. Fiber strength was determined by Stelometer method. Reflectance (Rd) and yellowness (+b) were determined by colorimeter. Data was analyzed by PC/SAS as a 2-factor factorial with five replications and the following model:

$$Y = T + H + T * h + e$$

where Y	=	Dependent variable
T	=	Temperature
H	=	hours in stoage
T * H	=	interaction of T & H
and, e	=	Experimental error

Results and Discussion

The moderately sticky unheated control cotton (Cotton #1) averaged 15 " 4 thermodetector (TD) sticky spots and a reducing sugar content of 0.45 " 0.02% (20 replicates). A complete summary for test results for heated and unheated controls are shown in Table 4. Standard deviations for each test are included in with control data.

Reducing sugar content and total HPLC carbohydrate and other component concentrations did not significantly change as a result of heating or storage time. Calculated HPLC component percentages averaged 59% of the corresponding reducing sugar content.

Carbohydrates and other components determined by HPLC are not necessarily the same ones determined by the reducing sugar test. For example, the reducing sugar test may include other low molecular weight sugars that is not measured by the HPLC test. On the other hand, some carbohydrates determined by HPLC are non-reducing. The carbohydrates and components determined by HPLC were arabinose, arabitol, glucose, fructose, mannitol, mannose, myo-inositol, sucrose, trehalose, turanose, trehalulose and melezitose. Table 4 lists the two major plant sugars, glucose and fructose, and most abundant honeydew sugars (trehalulose and melezitose) as determined by HPLC. The reported concentrations are based on dry lint weight.

Normal non-honeydew cottons usually contain much more glucose than fructose. Honeydew contaminated cottons have been found to contain larger amounts of fructose. The untreated samples exhibited concentrations of fructose equal to that of the glucose. Combined, these two carbohydrates accounted for 50% of total HPLC sugars. Honeydew accounted for 18% of all HPLC sugars. Trehalulose averaged 12% and melezitose 6%. Glucose, fructose, and honeydew sugars accounted for 68% of total HPLC sugars. The di-saccharides sucrose and trehalose averaged 3.5 and 2.0% of total sugars, respectively.

At the 40 and 50EC treatment temperatures, total HPLC sugars, glucose and fructose contents increased slightly an average of 6.4, 4.6, and 8.2% respectively. The average sucrose content decreased 26% from 3.5 to 2.5% of total sugars at these temperatures. These changes were not significant enough at this level to affect reducing sugar determinations. There was no significant effect of these treatments on the overall content of the trehalulose or melezitose.

Thermodetector (TD) stickiness decreased an average of 27% after eight hours at 40 and 50EC and remained at this level up to two days of heating. Subsequent 30EC temperatures gave similar results after sixteen hours (Figure 1).

Fiber strength measurements actually increased slightly an average of 1g/tex at the 30 and 50EC treatment levels. Standard error for the Stelometer test with this unheated cotton was determined to be "0.5 g/tex. Colorimeter reflectance (Rd) values averaged initially 67.1 " 0.5 and were not affected by heating. Yellowness (+b) values initially averaged 11.7 " 0.1 and also did not change.

Table 5 is a summary of the second honeydew cotton (rated as heavily sticky by TD. Unheated control TD sticky spots averaged 20 " 4 and reducing sugars averaged 1.45 " 0.11%. The same carbohydrates and other components as extracted and quantitated with cotton #1 were determined. Total glucose, fructose, and the major honeydew sugars are listed in the table. Combined, these four carbohydrates accounted for 84% of all HPLC components. Forty-eight (48) percent was due to honeydew. This is 2.5 times higher than the honeydew found in moderately sticky cotton. The fructose to glucose ratio of 1.8 typical of the high fructose concentrations measured in extracts from heavily whitefly honeydew contaminated cottons. Unheated control fructose and glucose concentrations averaged 23% and 13%, respectively. The di-saccharides sucrose and trehalose averaged 1.8 and 3.0% of total sugars, respectively.

Reducing sugar determinations increased slightly an average of 0.06% at the 40 and 50EC treatments. HPLC glucose and fructose concentrations gradually increased at 40 and 50EC an average of 12 and 8.5% respectively, with sucrose concentrations subsequently decreasing about 50% to 1% of total HPLC sugars. Corresponding trehalulose and melezitose concentrations were not significantly affected. Other HPLC carbohydrates and component concentrations were not affected.

Thermodetector stickiness (Figure 2) gradually decreased an average of 15% at both 30EC and 50EC after 16 hours of storage and by an average of 25% at 40EC after eight hours of treatment.

Fiber strength measurements decreased an average of 0.5g/tex (2.7%), 40EC and 0.8g/tex (4.3%) at 50EC. Colorimeter reflectance (Rd) averaged 62.5 " 0.2 initially, and increased slightly with heating. Yellowness (+b) averaging 16.1 " 0.1 initially, decreased slightly (about 1%) after being heated.

Summary

Sticky honeydew cottons were heated at temperatures of 30EC, 40EC, and 50EC at 65% relative humidity for up to two days in an attempt to reduce stickiness. These treatments were successful in reducing TD sticky spots. Reducing sugar determinations increased slightly for the heavily honeydew contaminated cotton at 40 and 50EC. Individual glucose and fructose component concentrations increased with each heating temperature and the corresponding sucrose concentrations decreased. Heating obviously converted some of the non-reducing disaccharide sucrose to the monosaccharides glucose and fructose, hence higher reducing sugar determinations. Concentrations of the honeydew sugars trehalulose and melezitose were not affected by heating.

Fiber Stelometer strengths decreased slightly at the two higher heating temperatures for the above cotton (about 0.5 g/tex). Color seemed to be generally unaffected by heating for either cotton.

Thermodetector stickiness was reduced 15% after eight hours for the heavier sticky cotton and 30% for the other cotton at 30 and 50EC. The 40EC treatments was more effective in achieving reductions in TD stickiness for both cottons.

References

Balasubramarya, R. A., Bhalaudikar, S. P. and Paralikar, K. M. 1985. A new method of reducing the stickiness of cotton. Textile Res. J. 55:227-232.

Brushwood, D. E. 1998. Effects of Heating on Chemical and Physical Propertiese and Processing Quality of Cotton. Textile Res. J. 58:309-317.

Brushwood, D. E., and Perkins, H. H., Jr. 1993. Cotton sugar and stickiness test methods. Can.Textile Journal 110(6):54-62.

Brushwood, D. E. and Perkins, H. H., Jr. 1994. Characterization of sugar from honeydew contam-inated and normal cottons. Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN. pp 1408-1411.

Brushwood, D. E. and Perkins, H. H., Jr. 1996. Cotton plant sugars and insect honeydew characterized by high performance liquid chromatography. Proc. Beltwide Cotton Conferences, National Cotton Council, Memphis, TN. pp 1310-1313.

Brushwood, D. E. Carbohydrate, strength and color changes on high moisture treated honeydew contaminated cottons. Accepted by the Canadian Textile Journal for publication, Sept. 1997.

Brushwood, D. E. 1997. Measurement of sugar on raw cotton by HPLC, individual carbohydrate concentrations and their relationship to stickiness potential. Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN, pp 1656-1658.

Chun, D. T. W. 1997. Use of high cotton moisture contentduring storage to reduce sticki-ness. Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN, pp 1642-1648.

Hendrix, D. L., B. Blackledge, and H. H. Perkins, Jr. 1993. Development of methods for detection and elimination of insect honeydew on cotton fiber. Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN, pp 1600-1603.

Hughs, S. E., Perkins, H. H., Jr. and Lalor, W. F. 1993. Dealing with sticky cotton. Proc. Beltwide Cotton Conferences, National Cotton Council, Memphis, TN, pp 580-582.

Perkins, H. H., Jr. 1971. Some observations on sticky cottons. Textile Industries 135:4:49-64.

Perkins, H. H., Jr., J. B. Cocke, and C. K. Bragg. 1986. Evaluation of processing characteristics of wash cotton. U. S. Government Printing Office publication, Agriculture Research Service, New Orleans, LA, pp 118.

Perkins, H. H., Jr. 1991. Cotton stickiness - a major problem in textile processing. Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN, pp 523-524.

Perkins, H. H., Jr. 1993. Controlling cotton stickiness - summary of progress. Proc. 21st International Cotton Conf., Bremen, Germany, pp 219-224.

Perkins, H. H., Jr. 1993. Strategies for processing honeydew contaminated cotton. Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN, pp 1461-1462.

Table 1.Thermodetector stickiness ratings.

No. of Sticky spots	Rating
0 - 4	Non-Sticky
5 - 14	Slightly Sticky
15 - 24	Moderately Sticky
Above 24	Heavily Sticky

Table 2. Analysis of variance results for each variable - moderately sticky cotton.

Dependent variable	Source of variation	Mean square	F - value
Reducing	temperature	.00219	1.53
sugar	hours	.00528	3.68
(%)	interaction	.00252	1.76
TD	temperature	146.4125	15.74 **
sticky	hours	17.2125	1.85
spots	interaction	7.5347	0.81
Glucose	temperature	23812.50	9.74**
content	hours	3856.70	1.58
(mg/kg)	interaction	2396.93	0.98
Fructose	temperature	32338.75	14.67**
content	hours	3211.21	1.46
(mg/kg)	interaction	4217.22	1.91
Trehal.	temperature	12249.28	1.77
content	hours	9898.68	1.43
(mg/kg)	interaction	19952.72	2.88*
Melezitose	temperature	634.28	0.43
content	hours	766.32	0.52
(mg/kg)	interaction	4264.11	2.88*
Strength	temperature	19.078	15.75**
(g/tex)	hours	0.262	0.22
	interaction	1.761	1.45
Color	temperature	.1005	0.51
(Rd)	hours	.6671	3.38
	interaction	.3007	1.52
Color	temperature	.0530	3.37*
(+b)	hours	.0543	3.45*
	interaction	.0176	1.11

* significant at the 0.05 probability level
** significant at the 0.01 probability level

Table 3. Analysis of variance results for each variable - very sticky cotton.

Dependent variable	Source of variations	Mean square	F - value
Reducing	temperature	.0471	2.97**
sugar	hours	.0478	3.02*
(%)	interaction	.0604	3.82**
TD	temperature	51.250	3.11*
sticky	hours	40.317	2.45
spots	interaction	8.272	0.50
Glucose	temperature	163243.746	11.54**
content	hours	12164.213	0.86
(mg/kg)	interaction	5348.690	0.38
Fructose	temperature	307076.083	13.66**
content	hours	11919.150	0.53
(mg/kg)	interaction	7640.072	0.34
Trehal.	temperature	151723.483	2.45
content	hours	88358.483	1.43
(mg/kg)	interaction	36796.050	0.59
Melezitose	temperature	29319.617	2.67
content	hours	9192.417	0.84
(mg/kg)	interaction	11517.094	1.05
Strength	temperature	4.457	5.69**
(g/tex)	hours	2.984	3.81*
	interaction	0.423	0.54
Color	temperature	1.2418	4.97*
(Rd)	hours	0.1408	0.56
	interaction	.3453	1.38
Color	temperature	0.1835	9.85**
(+b)	hours	0.0288	1.55
	interaction	0.0495	2.66**

* Significant at the 0.05 probability level
** Significant at the 0.01 probability level

Table 4. The effect of elevated heat treatments at 65% relative humidity on whitefly honeydew contaminated cotton - moderately sticky cotton.

CHEMICAL PROPERTIES					
CARBOHYDRATE CONCENTRATIONS (mg/kg)					
unheated (N=20)	R.S.*(%)	HPLC S(%)	Glucose	Fructose	Honeydew
	0.45(.04)	0.25(.02)	620(23)	640(33)	450(30)
30E- 8 hrs.	0.46	0.23	560	570	460
-16 hrs.	0.44	0.25	590	610	500
-32 hrs.	0.46	0.24	580	600	520
-48 hrs.	0.46	0.25	590	650	530
40E- 8 hrs.	0.47	0.25	680	690	400
-16 hrs.	0.43	0.25	620	650	460
-32 hrs.	0.43	0.27	660	700	630
-48 hrs.	0.41	0.27	690	710	590
50E- 8 hrs.	0.41	0.27	640	700	530
-16 hrs.	0.41	0.27	620	690	610
-32 hrs.	0.44	0.25	670	670	400
-48 hrs.	0.43	0.26	620	680	480

PHYSICAL PROPERTIES				
unheated (N = 20)	Str(g/tex)	Rd	+b	TD
	19.6 (0.5)	67.1 (.5)	11.7 (.1)	15 (4)
30E - 8 hrs.	22.5	67.0	11.6	14
- 16 hrs.	21.1	66.9	11.7	8
-32 hrs.	21.4	67.3	11.6	9
-48 hrs.	20.7	67.3	11.7	9
40E- 8 hrs.	19.2	67.3	11.7	11
-16 hrs.	19.5	67.4	11.6	9
-32 hrs.	18.9	67.5	11.6	8
-48 hrs.	19.5	66.8	11.6	11
50E- 8 hrs.	20.0	66.7	11.8	11
-16 hrs.	20.8	66.9	11.6	9
-32 hrs.	21.1	67.3	11.6	8
-48 hrs.	21.4	66.9	11.7	10

* Standard deviation for determination

Table 5. The effect of elevated heat treatments at 65% relative humidity on whitefly honeydew contaminated cotton - heavily sticky.

CHEMICAL PROPERTIES					
CARBOHYDRATE CONCENTRATIONS (mg/kg)					
unheated (N=20)	R.S.*(%)	HPLC S(%)	Glucose	Fructose	Honeydew
	1.45(.11)	0.83(0.1)	1040(20)	1870(40)	3940(60)
30E- 8 hrs.	1.28	0.81	1010	1760	4110
-16 hrs.	1.43	0.83	980	1800	4110
-32 hrs.	1.41	0.80	990	1760	4030
-48 hrs.	1.53	0.80	1020	1770	3980
40E- 8 hrs.	1.43	0.90	1220	2110	4390
-16 hrs.	1.54	0.84	1140	1970	4010
-32 hrs.	1.57	0.93	1290	2000	4450
-48 hrs.	1.37	0.87	1160	2020	4080
50E- 8 hrs.	1.43	0.88	1130	2040	4120
-16 hrs.	1.50	0.86	1090	2000	4020
-32 hrs.	1.41	0.90	1140	2060	4340
-48 hrs.	1.48	0.86	1090	1970	4450

PHYSICAL PROPERTIES				
unheated (N = 20)	Str(g/tex)	Rd	+b	TD
	18.4 (0.4)	62.5(0.2)	16.1 (.1)	20 (4)
30E - 8 hrs.	19.2	63.5	15.8	21
- 16 hrs.	18.7	63.1	16.1	19
-32 hrs.	18.2	63.1	15.8	14
-48 hrs.	18.5	62.7	16.0	16
40E- 8 hrs.	18.4	62.8	15.8	19
-16 hrs.	17.8	63.0	15.9	16
-32 hrs.	18.3	63.4	15.9	14
-48 hrs.	17.4	62.7	15.8	13
50E- 8 hrs.	18.3	63.7	15.9	18
-16 hrs.	17.0	62.6	15.8	18
-32 hrs.	17.5	63.1	15.6	17
-48 hrs.	17.5	63.4	15.8	16

*Standard deviation for determination

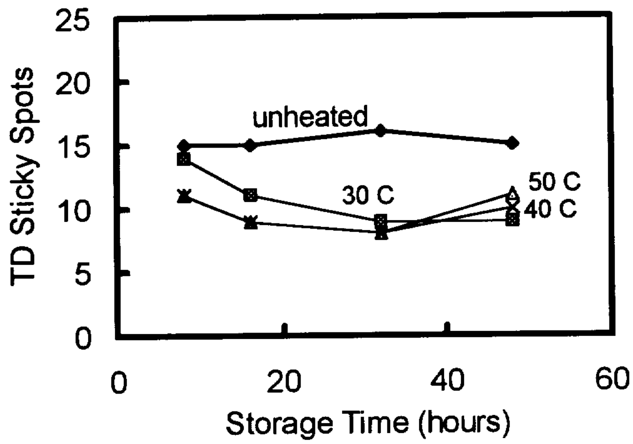

Figure 1. The effect of heating at 65% relative humidity on the thermodetector stickiness of honeydew cotton - moderately sticky sample.

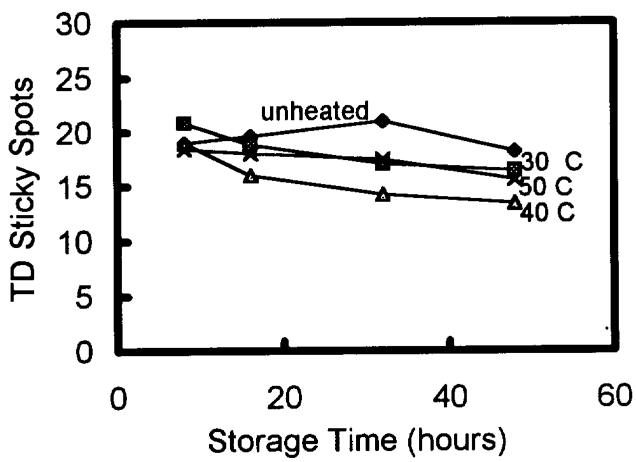

Figure 2. The effect of heating at 65% relative humidity on thermodetector stickiness of cotton - heavily sticky sample.