COTTON DUST POTENTIAL ASSOCIATED WITH MICROBIAL DECOMPOSITION DURING STORAGE

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Abstract

Studies were conducted to examine the feasibility of using high cotton moisture content during storage to reduce cotton stickiness. Initially, water alone was added to bring the moisture content to 15%, 30% and 40% moisture. The cottons were stored for 5, 11 and 15 days at 10◦C. At each storage period, microbial population, cotton quality (strength and color), cotton stickiness, and cotton dust potential were determined. Later, a second set of cottons were brought to 30% moisture using water augmented with urea or ammonia to minimize microbial effects. The cottons were stored for 15 days at room temperature. Microbial population, cotton quality (strength and color), cotton stickiness, and cotton dust potential were determined. The changes in microbial population and cotton dust potential results will be reported.

Introduction

Cotton fiber contains natural fiber sugars and may also become contaminated with honeydew. When either or both natural sugars and honeydew levels are high, the cotton is referred to as being 'sticky'. Sticky cotton can be a serious production and quality problem which varies with location and year (Perkins, 1971), resulting in fibers sticking onto the rolls of processing equipment, producing knots, interrupted processing, reduced fiber quality resulting from microbial activity, etc. Many approaches have been taken to improve processability of sticky cotton such as blending, spraying with yeast, bacteria, surfactants, or enzymes, and increasing the moisture levels or otherwise enhancing the environmental conditions to activate natural microorganisms, washing the cotton, etc. (Balasubramanya, 1985; Heuer & Plaut, 1985; Hendrix et al., 1993; Perkins, 1993; Perkins et al. 1986). One promising approach initiated by Hendrix et al. (1993) is the application of enzymes as the cotton is being harvested and placed in cotton modules before ginning. Part of the success of enzyme application may be that microbial activation occurs from the application of the enzyme solution (Heuer & Plaut, 1983; Hendrix et al., 1993). This is of concern since microbial activation may adversely affect cotton quality and increase potential health problems associated with cotton (Schneiter et. al., 1942; Rylander et al., 1979). Heuer and Plaut (1985) noted that when ammonium compounds at low moisture contents (7.2% to 12.2%) was applied to sticky cotton, stickiness was reduced without affecting quality. As part of the ongoing studies on microbial effects on cotton quality, a study was undertaken to look at the effect of high cotton moisture content during storage on stickiness reduction, cotton quality changes, cotton dust potential and microbial population, and on the effect of urea and ammonia on high moisture content cottons to minimize microbial effects (Chun & Lockwood, 1985; Chun et al., 1984). The effect on microbial population and cotton dust results will be reported.

Methods and Materials

Cotton

Cotton used throughout the stickiness-moisture study was Arizona Pima cotton from the 1995 harvest year. The cotton was provided as unginned cotton by Dr. Don L. Hendrix (Western Cotton Research Laboratory, USDA, ARS, PWA, 4135 E. Broadway Rd, Phoenix, Arizona 85040). Shortly after arrival, the cotton was ginned with a 7 blade (6 in. dia.) saw gin. The ginned cotton was then homogenized. The first homogenization step involved passing the cotton through a blender (Syncromatic Blending System, Fibers Control Corporation, P.O. Box 1358, Gastonia, NC) three times. At the third and final passage through the blender, the entire cotton lot was passed through a pin beater (Model No. HV10024, Fibers Control Corporation) and underwent a final blending and collection on the apron of a Trützschler Axi-flo (type No, 052-25-02, Trützschler Gmbll and Co., KG, Textilmachinenfabrik, Mönchengladbach 3, Fed. Rep. Germany). The homogenized cotton was then stored in the original 55 gallon shipping barrel until used.

Viable Microbial Counts

Viable total and Gram-negative bacterial populations were determined for each samples as described in Chun & Perkins, Jr., 1991. The plates were incubated for 3 days at 28°±0.5°C before being counted. Fungal population determinations were made using potato dextrose agar with chloramphenicol and rose bengal (250 mg/L and 100 mg/L, respectively [Chun and McDonald, 1987]) and incubating at room temperature (20°±2°C) for a week.

Cotton Dust Potential, Stickiness and Quality Determinations

The cottons were tested for stickiness on a thermodetector as described by Brushwood and Perkins (1993) and the percent sugar was also determined. Quality measurements were made by the Testing Laboratory at CQRS. Strength was measured on a stelometer as average grams per tex and color as reflectance and yellowness on a colorimeter. Stickiness and quality results will be reported elsewhere (Chun, 1997). Cotton dust was collected on a Microdust & Trash Monitor ([MTM], Zellweger Uster, Inc., Technologies, Knoxville, TN) as described by Chun and Perkins, Jr. (1992).

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Effect of Water Alone

Eighty 30-gm cotton samples were sprayed with sufficient water (plus 0.005% Tween-80) to make up 20 samples each of ambient (~7.0%), 15%, 30%, and 40% moisture content. Each sample was stored in pleated Ziplock Gripper Zipper sandwich bags (6 1/2 x 5 7/8" [16.51 cm x 14.92 cm] DowBrands L. P., P.O. Box 68511, Indianapolis, IN 46268I-0811). Treatment assignments were applied randomly to the cotton samples. The samples were placed in a 10°±2°C incubator and stored for 0, 5, 11 and 15 days. At each sampling period, 20 samples were removed for microbial population, moisture content, stickiness, quality and dust potential determinations. For the 30% and 40% moisture content samples, lint was removed for microbial population determinations and the remainder of the sample was quick dried in an oven (105°±2°C) to approximately ambient moisture content before stickiness, quality and dust potential determinations were made.

Effect of Ammonia and Urea on Stickiness

Forty eight 30-gm cotton samples were sprayed with freshly prepared ammonia solution or urea solutions to a moisture content of 30%. A water and waterless control were used, 0.005% Tween 80 surfactant was used throughout. Treatment assignments were applied randomly to the cotton samples. A zero time and 15 day storage at room temperature (22°±2°C) reading were taken of microbial population, moisture content, stickiness, quality and dust potential as described above.

Results & Discussion

Actual Moisture Contents

The actual percent moisture of water treated cottons over storage from 0 to 15 days at cool temperature (10°±2°C) was very close to the calculated percent moisture. Overall, the ambient moisture, 15% moisture, 30% moisture, and 40% moisture content throughout the study averaged 7.2% (2 s.e. = 0.2011), 14.1% (2 s.e. = 0.5364), 30.1% (2 s.e. = 2.4572), and 38.1% (2 s.e. = 1.7966), respectively. The individual changes over storage time is shown in Figure 1. The greatest variation was observed immediately after moisture was applied which is expected; but as a whole, very close agreement between calculated moisture and actual moisture was obtained. However, moisture was lost and the actual percent moisture of the cottons made up to 30% moisture content and over 15 days storage at room temperature (22°±2°C) was between 22% and 24% (Figure 6). The difference between the two calculated 30% moisture contents (Figure 1 and Figure 6) was probably due to the higher temperature of storage. Ambient moisture content fluctuated very little.

Microbial Population over storage time

The microbial population tended to increase over time despite the cool conditions of storage which prevents excluding microbial effects on cotton properties as had been attempted (Figures 2-4). The most interesting trend is that the ambient and 15% moisture content cottons behaved similarly and the 30% and 40% cottons behaved similarly. The high variability shown in the 15 day sampling suggest possible problems with the assay otherwise the ambient moisture content cotton show an unexpected increase of total, Gram-negative and fungal populations.

Microbial Population: Water plus Urea or Ammonia Treated Cottons The general microbial trend is that after 15 days storage, the 30% moisture content cottons show significantly increased microbial populations — total, Gram-negative and fungal populations (Figures 7-9). What is interesting is that treatment with 10% ammonia resulted in total bacteria, Gram-negative and fungal populations being the lowest populations of the 30% moisture content cottons. In the case of fungal populations and Gram-negative populations, the population count is even lower than the ambient moisture content cottons! Except for fungal populations, the 10% treated cottons showed high variability for total bacteria and Gram-negative bacteria (Figure 7 & 8) which indicates wide fluctuation in the populations in the samples, very possibly due to treatment effects. Sensitivity to ammonia by soil organisms is well documented (Chun et al., 1984; Rush & Lyda, 1982a,b; Schippers & Palm, 1973) and possibly the decreased fungal population observed on 1% urea treated cottons results from natural degradation of urea to ammonia (Chun & Lockwood, 1985).

Cotton Dust Potential

Cotton dust potential at moisture contents higher than ambient levels increased during storage (Figures 5) and the higher moisture content cottons tended to increase more. The ambient and 15% moisture content cottons tended to group together and the 30% and 40% moisture content cottons tended to group together. However, after 15 days storage, higher cotton dust potential is observed with the 15% moisture content cottons compared to ambient moisture content cottons which tend to retain the same cotton dust potential over 15 days storage.

When urea and ammonia was added to the 30% moisture content cottons, cotton dust potential after 15 days storage at room temperature increased to levels significantly higher than the ambient moisture content cottons (Figure 10). Also, the levels of the 30% moisture content cottons were higher than when storage was at a lower temperature (compare figures 5 & 10). Most surprising was that cotton dust potential for the 30% moisture content cottons treated with 10% ammonia were about the same as for the ambient moisture content cottons! This strongly suggests that high ammonia levels can keep cotton dust potential from increasing when cotton is stored wet and because gram-negative bacterial population is reduced, may actually result in decreased endotoxin in the airborne dust! This warrants further investigation.

Summary

Increased microbial populations was observed with cottons stored under higher moisture contents than with ambient moisture content cottons. Over the same storage time, cotton dust potential increased and the greater increases occurred with the wetter cottons. However, when moist cotton is treated with high levels of ammonia before storage, fungal and Gram-negative bacterial populations did not increase during storage and was at levels lower than the ambient moisture cottons. While the cotton dust potential was higher with the 30% moisture content cottons than the ambient control cottons, the 30% moisture content cottons which were treated with high levels of ammonia had the same cotton dust potential as ambient moisture content levels. This along with the reduced Gram-negative population suggests that ammonia may help control development of endotoxin potential in wet stored cottons.

Acknowledgment

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Disclaimer

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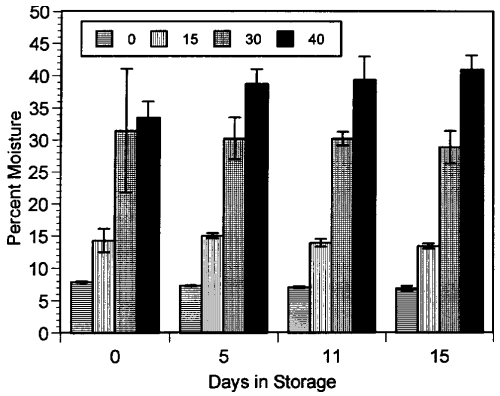

Figure 1. Actual moisture content and variation vs. calculated moisture of lint over 15 days storage (each half bar represents 2 s.e.).

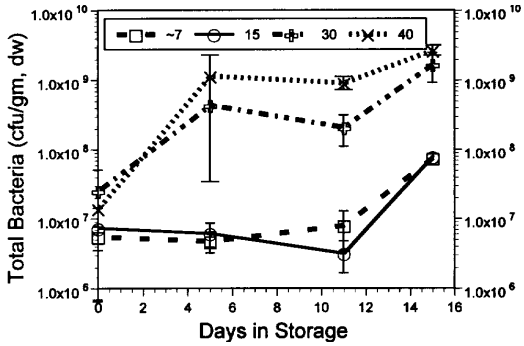

Figure 2. Total viable bacterial population during storage at 10°±2°C of cotton at different moisture contents (each half bar represents 2 s.e.; no error bars shown if s.e. > than mean.

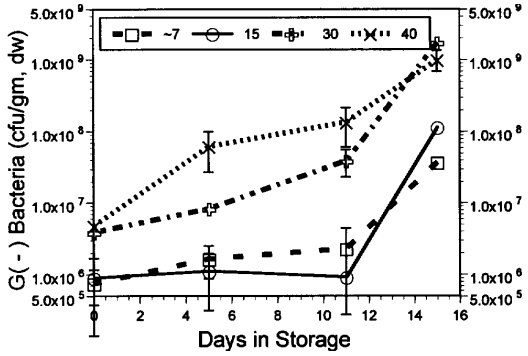

Figure 3. Viable gram-negative bacterial population during the storage at 10°±2C° of cotton at different moisture contents (each half bar represents 2 s.e.; no error bars shown if 2 s.e. > than mean).

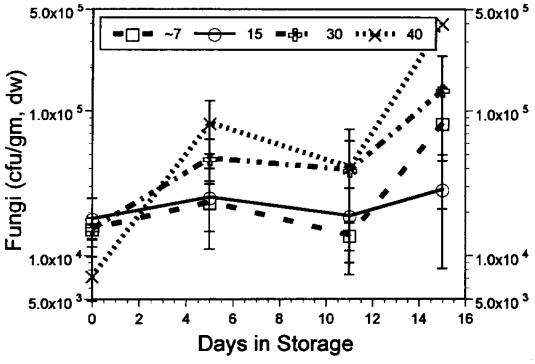

Figure 4.Viable fungal population during storage at 10°±2°C of cotton at different moisture contents (each half bar represents 2 s.e.; no error bars shown is 2 is s.e. > than mean).

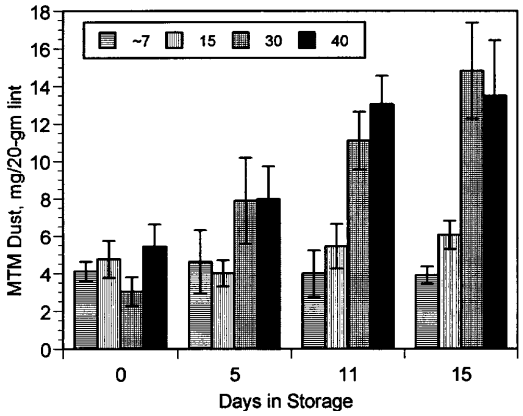

Figure 5. Cotton dust potential during storage at 10°±2°C of cotton at different moisture contents (each half bar represents 2 s.e.).

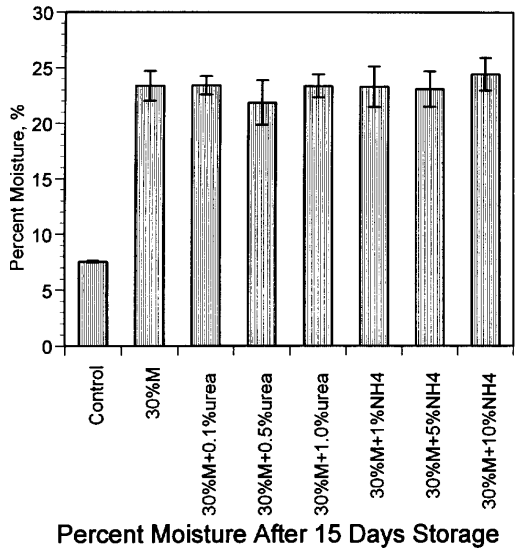

Figure 6. Actual moisture content vs. 30% calculated moisture content for urea and ammonia treatments after 15 days storage at room temperature, 22°±2°C (each half bar represents 2 s.e.).

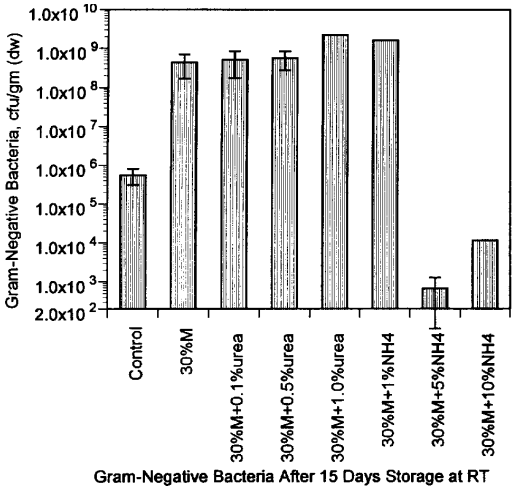

Figure 8. Gram-negative bacterial population during storage at 30% calculated moisture content for urea and ammonia treatments after 15 days storage at room temperature 22°±2°C (each half bar represents 2 s.e.; no error bars shown if 2 s.e. > than mean).

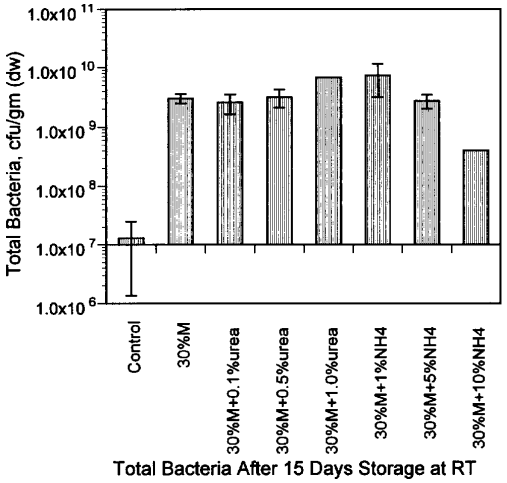

Figure 7. Total viable bacterial population during storage at 30% calculated moisture content for urea and ammonia treatments after 15 days storage at room temperature, 22°±2°C (each half bar represents 2 s.e.; no error bars shown if 2 s.e. > than mean).

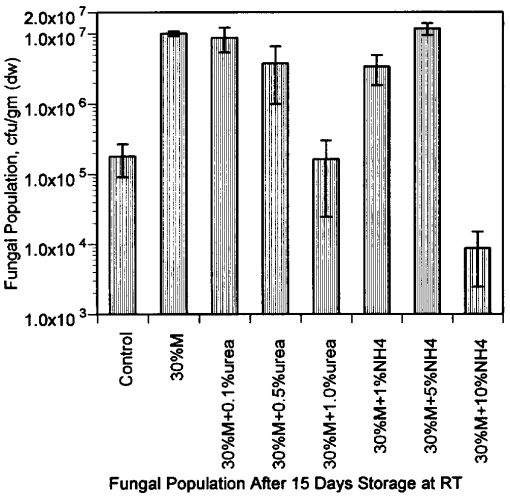

Figure 9. Gram-negative bacterial population during storage at 30% calculated moisture content for urea and ammonia treatments after 15 days storage at room temperture, 22°±2°C (each half bar represents 2 s.e).

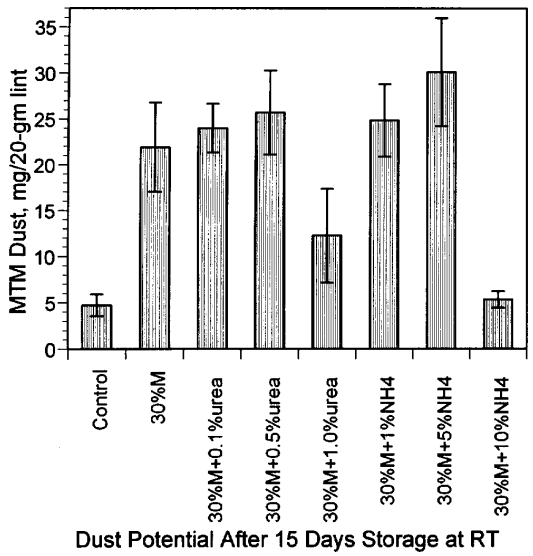

Figure 10. Cotton dust potential during storage at 30% calculated moisture content for urea and ammonia treatments after 15 days storage at room temperature, 22°±2°C (each half bar represents 2 s.e.).