

CHEMICAL COMPOSITION OF

ACETONE/WATER WASHED COTTON:

HUMAN RESPONSE TO CARD ROOM DUST

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Abstract

Cotton of high microbiological content was washed in a batch system by two methods: 1) The cotton was wet with water plus a wetting agent and then was rinsed with water and 2) The cotton was wet with a 70%/30% acetone/water mixture containing a wetting agent and then was rinsed with water. The thesis was that the acetone/water treatment would remove more tannins than the water wash treatment. The cottons were carded in a model card room and human subjects were exposed in a remote room to the dust generated. The washing treatments lowered the levels of bacteria, endotoxins, and tannins in the cotton. For the two washing treatments, tannin levels were similar, but bacteria and endotoxins were lower for the water wash treatment than for the aqueous acetone wash treatment. The response of the human subjects to the generated dust was lowered dramatically by the washing treatments, but there was no difference in level of response between the two washing treatments. The washings did not completely eliminate the human airway response to card room dust, thus indicating that the washings did not completely remove or neutralize the agent(s) responsible for the acute response.

Introduction

Tannins are present in significant quantities in cotton bract, leaf, and the dust from cotton. The quantities in cotton dust are sufficiently high to be possible causes of biological effects associated with byssinosis. Bell and Stipanovic have suggested that tannins be evaluated as possible etiological agents of byssinosis either by human exposure or animal studies (1). Tannins are more soluble in aqueous acetone than in water. Based on these factors, a high microbiological content cotton was washed in a batch system with aqueous acetone for use in human exposure studies.

Materials and Methods

A mix of high microbiological content cotton comprising 3 bales was prepared at the USDA, Cotton Quality Research Station (CQRS), Clemson, South Carolina. Three blended bales weighing 363, 355, and 367 pounds were produced from the mix by processing through six feeder hoppers. Each blended bale contained identical proportions of the 3 source bales. The bales were shipped to the USDA, Southern Regional Research Center (SRRRC), New Orleans, Louisiana, for the washing treatments. Each of the bales was opened on the SRRRC opening line that consisted of a feeder hopper and Superior Cleaner. One bale was retained as an untreated control. This bale had some extraneous woody trash that came from the blending line at CQRS; therefore, in addition to the hopper feeder and the Superior Cleaner, it was processed through a Rando Cleaner that removed the extraneous trash. The two bales for use in the washing treatments were not processed through the Rando Cleaner. The bales for the washing treatments were divided into lots weighing 41 pounds for use in the batch system.

The washing treatments were conducted outside the SRRRC wet processing pilot plant with elaborate safety precautions to provide adequate ventilation and to

prevent explosions. The two washing treatments were: 1) surfactant + 70% aqueous acetone, water rinse, SSC641 finish, oven dry (aqueous acetone wash) and 2) surfactant + water, water rinse, SSC641 finish, oven dry (water wash).

The container for the cotton was a screened basket that could be lowered into a large metal, cylindrical beak (28 inches diameter, 30 inches height) capable of holding more than 80 gallons of liquid. The washing solution for the aqueous acetone treatment contained 1.33 lbs of Wash Aid 1173, 56 gallons of acetone, and 24 gallons of water to give a 70% acetone solution. The cotton stock and solution were added slowly and simultaneously to the container to aid wetting of the stock. After all of the fiber and solution were added, the mixture was allowed to stand for 1 hour. The solution was then removed from the container by pumping into a 55-gallon drum for proper disposal. The fiber batt was rinsed with cold tap water for 15 minutes using two garden hoses to aid transport of solubilized materials and reduce acetone content. After excess liquid was drained from the tank, a new solution containing 4 pounds of SSC641 finish in 80 gallons of water was added to the batt. The cotton was allowed to stand for one hour and then the solution was drained by lifting the batt partially out of the container using a hoist. The cotton was centrifuged to a moisture content of about 40% and a theoretical SSC641 finish level of about 0.4%. Approximately one half of the batch was centrifuged at a time at 1700 g's for 6 minutes. After centrifuging, the cotton was opened by hand and dried on a wire rack in a Proctor-Swartz oven for 16 hours at 80°C. The procedure for the water wash treatment was exactly the same as for the aqueous acetone treatment except that 56 gallons of water was substituted for the 56 gallons of acetone.

Chemical and physical tests were conducted on stock taken at various stages of the washing treatments. Elemental analyses were conducted on the cottons at SRRRC. Chemical analyses for water soluble reducing substances (sugars) and finish contents were conducted at CQRS. Fiber property measurements and spinning quality evaluations were conducted by the usual methods employed at CQRS. Endotoxin contents of the fiber samples and viable microorganisms both in lint samples and in the air of the remote rooms were determined by one or more laboratories using methods reported previously (5,6,7). Analyses for tannins were conducted at the USDA, ARS, National Cotton Pathology Research Laboratory, College Station, Texas by use of reported methods (1).

The cottons were processed in model card rooms at CQRS to generate dust for the human exposures in the adjacent remote rooms using human subjects and procedures reported previously (3). The cottons were spun into 30's yarn at 13000 rpm spindle speed. The quantities of cotton were limited because of the complexity, expense, and exploratory nature of the washing procedures and only one replication was available for the human exposure studies and subsequent processing evaluations through spinning. Except for pulmonary function responses, statistical analyses were not conducted because of the lack of replications; thus, the results are interpreted with these factors taken into consideration.

Results and Discussion

Results of the elemental analyses are shown in Table 1. Both of the washing treatments reduced the quantities of the elements to essentially the same levels. The most dramatic reduction occurred with potassium which was reduced from 0.51% to 0.03%. This is in keeping with results reported by Domel Smith, et al (4). This property has been exploited as a potential indicator for verifying washed cotton.

Sugar contents of drawing sliver were 0.33% for the untreated control and 0.16% for both the aqueous acetone wash and the water wash. The residual sugar contents of the treated cottons are higher than that found for washed cottons in previous washing trials (2,8). This indicates that the treatments were not totally effective. As noted in earlier commercial scale batch washing trials, channeling of solution

can occur and also the cotton batt acts as a filter media and transport of both insoluble and solubilized impurities is poor (9). The finish contents of the two treated cottons were in the 0.3% - 0.5% range as targeted. Because of the variability of the stock sampled before addition of finish for use as a background control, more precise determination could not be made easily.

The fiber properties normally measured --- length, strength, micronaire --- were not affected by either of the two washing treatments. However, the processing and yarn qualities were adversely affected by both treatments (Table 2). Card web neps were the same for the control and the aqueous acetone treatment, but were higher for the water wash treatment. As compared to the untreated control, end breakage in spinning, yarn strength, and yarn appearance factors were all poorer for the two washing treatments. Comparison of the two washing treatments leads to the conclusion that the aqueous acetone treatment yielded stock that processed better and produced better yarn than did the stock produced by water washing. Because of the lack of replications, the processing and yarn quality evaluations should be used only as indicators of probable trends.

The endotoxin levels and the viable total and gram negative bacteria levels on lint samples as determined by the three laboratories are shown in Table 3. Although major level differences existed between laboratories, the treatments were ranked in the same order by the different laboratories. The two washing treatments reduced both total and gram negative bacteria by up to 3 log numbers with the water wash treatment apparently being more effective. The endotoxin levels were also reduced by the two washing treatments --- the aqueous acetone treatment brought about a 10 fold reduction and the water wash treatment a 25-100 fold reduction depending on which laboratory data is considered. The conclusion is that the bacteria and endotoxin levels are reduced by both washing treatments, but residual levels are higher for the aqueous acetone treatment than for the water wash treatment.

The total and gram negative bacteria and fungi present in the air of the remote rooms during human exposures are shown in Table 4. Each of these components was reduced by the washing treatments. Comparing the two washing treatments, total bacteria in air appeared lower for the water wash treatment. However, there was little difference, if any, in either gram negative bacteria or fungi between the two washing treatments. Analyses for endotoxin contents of air-borne dusts have not been completed.

The analyses for tannins were conducted on lint samples from the final stages of the preprocessing treatments. The untreated control sample was stock that had been processed through the SRRC opening line. The aqueous acetone wash sample and the water wash sample were collected after the final treatment rinses and were air dried. The average levels of tannins are shown in Table 5. The variations in levels of tannins was somewhat high between test replications and additional tests on blended stock are in progress. However, both washing treatments apparently lower the tannin levels in the cotton. There appears to be little, if any, difference between the two washing treatments in effectiveness in removing tannins.

Results of the human exposures are shown in Table 6. The observed decrease in mean FEV₁ of 8.4% for the panel when exposed to the untreated control is very large considering the low dust level (0.22 mg/m³). The extreme potency of the dust from this cotton on ventilatory response in human subjects is emphasized by the slope of the dose response linear regression, approximately 45% FEV₁ decrement per milligram/m³ of elutriated dust. Both washing treatments greatly reduced the response of the panel to the dust generated during carding. However, the panel responds to dusts from the two washed cottons were still greater than the response to the clean room exposure as indicated by the decrease in FEV₁ of about 2% for the washing treatments and an increase in FEV₁ of 0.4% for the clean room exposure. Thus,

the treatments have not completely removed or neutralized the agent(s) responsible for the acute response. The difference in responses between the two washing treatments was not statistically significant.

Conclusions

Washing high microbiological content cottons in a batch system by use of either an aqueous acetone/surfactant formulation or a water/surfactant formulation reduced the levels of tannins, viable total and gram negative bacteria, and endotoxins in the cotton. The washing treatments reduced the potency of the respirable dust on the ventilatory response of human subjects by about 75%, but not to the level of no exposure. It was not possible to completely isolate the individual effects of tannins, viable bacteria, or endotoxins on changes in human ventilatory response because the effects of the washing treatments on the residual contents of these materials was not independent. Further experimentation on a laboratory basis is suggested to determine the independent effects of acetone/water washing treatments on tannins, bacteria, and endotoxins.

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References

1. Bell, A. A. and Stipanovic, R. D. 1983. Biologically active compounds in cotton: an overview. Proceedings of the Seventh Cotton Dust Research Conference, P. J. Wakelyn and R. R. Jacobs (eds.), National Cotton Council, Memphis, TN, pp. 77-80.
2. Berni, R. J., Montalvo, J. G., Jr., Perkins, H. H., Jr., and Buco, S. Differentiation of washed and unwashed cotton. 1983. Proceedings of the Seventh Cotton Dust Research Conference, P. J. Wakelyn and R. R. Jacobs (eds.), National Cotton Council, Memphis, TN, pp. 126-129.
3. Cocke, J. B., Castellan, R. M., Hankinson, J. L., and Sasser, P. E. 1983. Pulmonary function response to washed and unwashed cotton. Proceedings of the Seventh Cotton Dust Research Conference, P. J. Wakelyn and R. R. Jacobs (eds.), National Cotton Council, Memphis, TN, pp. 62-65.
4. Domelsmith, L. N., Berni, R. J., and Piccolo, B. Potassium in washed and unwashed cottons. 1984. Proceedings of the Eighth Cotton Dust Research Conference, P. J. Wakelyn and R. R. Jacobs (eds.), National Cotton Council, Memphis, TN, pp. 74-77.
5. Fischer, Janet J. and Jacobs, R. R. 1983. Gram-negative bacterial and endotoxin levels in washed cotton. Proceedings of the Seventh Cotton Dust Research Conference, P. J. Wakelyn and R. R. Jacobs (eds.), National Cotton Council, Memphis, TN, pp. 59-61.
6. Millner, P. D., Perkins, H. H., Jr., Castellan, R. M., Jacobs, R. R., and Hankinson, J. L. 1983. Microbiological characteristics of dusts from standard and washed cottons. Proceedings of the Seventh Cotton Dust Research Conference, P. J. Wakelyn and R. R. Jacobs (eds.), National Cotton Council, Memphis, TN, pp. 72-76.
7. Olenchock, S. A., Castellan, R. M., Cocke, J. B., Rodak, D. J., Hankinson, J. L., and Mull, J. C. 1983. Endotoxins and acute pulmonary function changes during cotton dust exposures. Proceedings of the Seventh Cotton Dust Research Conference, P. J. Wakelyn and R. R. Jacobs (eds.), National Cotton Council, Memphis, TN, pp. 70-71.

8. Perkins, Henry H., Jr., and Cocke, Joseph B. 1982. Washing methods for cotton: effects on fiber, processing qualities, and dust generation. American Chemical Society Symposium Series 189, Cotton Dust: Controlling an Occupational Health Hazard, Joseph G. Montalvo, Jr., ed., pp. 37-51.

9. Perkins, Henry H., Jr. 1982. The effects of washing conditions on dust levels and processing quality of cotton. ASAE Winter Meeting, Chicago, IL, ASAE Paper # 81-3578.

Table 1. Effects of washing treatments on removal of selected elements from cotton

Element	ELEMENT QUANTITY (%)		
	Before Wash	Acetone Wash	Water Wash
Nitrogen	0.25	0.20	0.19
Aluminum	0.15	0.06	0.06
Phosphorus	0.14	0.12	0.13
Magnesium	0.06	0.00	0.01
Calcium	0.19	0.15	0.14
Potassium	0.51	0.03	0.03
Sulfur	0.07	0.05	0.05
Chlorine	0.04	0.01	0.01
Silicon	150(ppm)	64(ppm)	58(ppm)

Table 2. Processing and yarn qualities

Treatment	Card Web (no./645 cm ²)	Neps EDMSH ^{1/} (cm ²)	Yarn	Yarn
			Break Factor (units)	Appearance Grade
Untreated Control	10	29	1810	C+(103)
Aqueous Acetone Wash	10	47	1705	C (94)
Water Wash	16	85	1541	C (94)

^{1/}Ends down per thousand spindle hours

Table 3. Bacteria and endotoxin in lint

Treatment	Total Bacteria (cfu/g)		Gram Negative Bacteria (cfu/g)		Endotoxin (ng/g)	
	LAB A	LAB A	LAB B	LAB B	LAB C	LAB C
	Untreated Control	3.16x10 ⁶	1.66x10 ⁶	2x10 ⁵	100,000	15,917
Aqueous Acetone Wash	3.89x10 ⁵	3.55x10 ⁴	1x10 ²	10,000	1,253	
Water Wash	5.25x10 ⁴	5.75x10 ³	<50	1,000	637	

Table 4. Bacteria and fungi in air of remote rooms during human exposures

Treatment	Total Bacteria in Air		Gram Negative Bacteria in Air		Fungi in Air	
	cfu/mg	cfu/m ³	cfu/mg	cfu/m ³	cfu/mg	cfu/m ³
	Untreated Control	281000	61900	11900	2610	1960
Aqueous Acetone Wash	17700	3890	1460	322	1300	282
Water Wash	11400	2350	1420	292	1570	321
Clean Room	---	88	---	11	---	139

Table 5. Effects of washing treatments on removal of tannins from cotton

Treatment	Tannin Content (PPM)		
	Extractable	Residual	Total
Untreated Control	87	60	147
Aqueous Acetone Wash	14	45	59
Water Wash	20	46	66

Table 6. Effects of washing treatments on human responses to dust

Treatment	Dust Level (mg/m ³)	Mean ΔFEV ₁ (%)	Slope ΔFEV ₁ (%) per mg/m ³
Untreated Control	0.22	- 8.4	- 45.4
Aqueous Acetone Wash	0.22	- 2.3	- 14.4
Water Wash	0.21	- 1.8	- 13.1
Clean Room	0.03	+ 0.4	---

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