Botanical Trash Analysis of Cottonseed Oil Mill Process Streams

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ABSTRACT

The objective of this study was to determine the content of bract and leaf (likely carriers of suspect byssinotic agent[s]) in the process and trash streams in a cottonseed oil mill. A rapid procedure is described to determine the percentage of bract and leaf particles in trash sieved from cottonseed samples. Using this technique, it was found that bract and leaf particles were largely removed from cottonseed by the sum total of processing steps occurring during cleaning and delintering. With the exception of the trash streams from the safety shaker, bract and leaf particles were almost nonexistent in the hulling and separating room. Processing of linters through cleaners and beaters was ineffective in removing the bract and leaf fragments entangled in the fiber mass.

INTRODUCTION

Cottonseed oil mills process seed received from gins into a number of valuable products, including seed meat, hulls and linters. The seed received from gins contains variable amounts of vegetable and inorganic trash which is mostly removed from oil mill process streams by mechanical and pneumatic cleaning (1,2). Linters are removed from cottonseed mostly by mechanical means. Linters are then cleaned, baled and sold to garnetters, plus paper and chemical cellulose industries, depending on quality. During hulling and separating, the delintered seed is partitioned into hulls and meats for use in the livestock feed and vegetable oil industries.

The concentration of respirable dust in the work place in cottonseed oil mills is considerably higher than that encountered in the textile industry (3,4). However, the incidence of byssinosis in cottonseed oil mills is low (3,5). The combination of high dust levels with "less adverse health effects than the textile data would predict" (p. 27361 in ref. 6) was one of the reasons cited by OSHA for the selection of the proposed 500 $\mu g/m^3$ environmental standard for occupational exposure to cotton dust in the nontextile cotton industry vs the more severe 200 $\mu g/m^3$ standard now mandated for the textile sector.

Byssinosis is caused by the inhalation of cotton dust. The bioactive agents in the dust (e.g., endotoxin, pharmacological materials) are thought to arise primarily from bract and leaf trash entrained in cotton materials (7-9). This study was undertaken to determine the content of bract and leaf (potentially byssinogenic materials) in as many locations as possible in both process and trash streams in the cleaning, delintering, hulling and separating, and linter handling areas of a cottonseed oil mill.

EXPERIMENTAL PROCEDURES

Samples of cottonseed and cottonseed products were obtained from one mill (mill A) in Texas that was utilizing seed from gins processing machine-stripped cotton and from a second oil mill (mill F) in California that received seed from gins using machine-picked cotton. Using a stereomicroscope, bract and leaf fragments were identified (10) and sorted from all other trash components. The content of bract and leaf in a given sample was expressed either gravimetrically as percentage by weight (wt %) of total trash, seed and fiber, or as the percentage of bract and leaf particles in the trash alone (number percent = no. %).

RESULTS AND DISCUSSION

Analysis of Botanical Trash in Mill A

Mill A was processing 363,000 kg (400 tons) of seed/day. Analysis of four 0.125-kg grab samples of unprocessed seed showed that the amount of bract and leaf trash in the sample was 0.05 ± 0.02 wt %. This was well within the industry-wide average (0.11 ± 0.13 wt %) for the average amount of leaflike trash present in the seed received by oil mills (2).

Determination of the wt % content of bract and leaf was a laborious process (10) requiring an estimated 200 man-hours for a 0.5-kg sample of cottonseed. An attempt was therefore made to develop a quick estimation technique for bract and leaf content so that many 0.5-kg samples collected at multiple points in cottonseed oil mill process streams could be evaluated. Cottonseed samples were first sifted for 1 hr in a Ro-Tap Shaker on screens with a 4,750, 2,000, 1,420, 825, 420 and 250 μm mesh openings. Over 99% of the bulk sample (seeds, linters and seed hulls) remained on the 4,750 and 2,000 μm screens. Bract and leaf fragments, loose fiber and other trash materials were collected on the finer screens. The number of bract and leaf fragments divided by the total number of trash particles collected on top of the 250 μm screen (250-419 μm fraction) times 100 (no. %) was used as a simple index of bract and leaf contamination of the sample. In this size range, between 500 and 1,000 trash particles can be examined and identified botanically in as little as 2 hr.

To obtain an estimate of the presence of bract and leaf particles in mill A process streams, samples of raw seed; cleaned seed; seed after first-, second- and third-cut saw delintering; seed material from the top shaker of the huller, the huller beater, and recycle seed returning to the huller; and first- and second-cut linters were processed and examined as already described. Raw seed and cleaned seed contained 8 ± 6 and 8 ± 5 no. % bract and leaf, respectively. The content of bract and leaf in the seed exiting the first-, second- and third-cut delinter machines declined to 4.4 ± 9, 2.5 ± 0.8 and 0.7 ± 1.1 no. %, respectively. Seed material on the top shaker of the huller and in the huller beater contained 0.2 ± 0.5 no. % bract and leaf. Bract and leaf particles were absent in the seed recycling to the huller in mill A. First- and second-cut linters contained 0.8 ± 1.5 and 1.4 ± 1.7 no. % bract and leaf trash, respectively. These data suggested that, as a general trend, the content of bract and leaf particles was greatly reduced during delintering so that very little of this botanical material was available for entrainment in the seed and hull streams in the hulling and separating room. By contrast, some bract and leaf appeared to enter and remain in linter process streams. This aspect of the study carried out with cotton materials from mill A demonstrated that it was possible to rapidly estimate the number of bract and leaf particles in the vegetable trash entrained in oil mill process streams.

Analysis of Botanical Trash in Mill F

A more detailed study of the content of bract and leaf in mill process streams was undertaken in mill F. The wt % of the bract and leaf was found to be 0.04% in 1.0 kg of unprocessed seed from this mill, which is well within the industry-wide average for this type of contaminant (2). Whole seed with attached fiber accounted for 99.45 wt % of the unprocessed seed mass. The rest of the seed mass consisted of other types of trash and loose fiber.

An additional sample of unprocessed seed from mill F was sieved on a Ro-Tap shaker as had been done earlier for mill A. As expected, most of the weight of the sample was located on the largest mesh screen and consisted of whole seed (Table I). Although the amount of material on the 420, 825 and 1420 μm mesh screens was small (<0.1 wt% of original sample weight for each size fraction) the content of bract and leaf in each trash fraction was substantial (> 25 wt %) (Table I). Grab samples were now collected from 31 locations in mill F process streams, including the cleaning-delintering, hulling and separating, and linter cleaning-linter press work areas. These samples were sieved and the resulting trash fractions were examined for bract and leaf content. Because of the substantial weight of bract and leaf found in the larger (420-1420 μm) size trash from the unprocessed seed (Table I), the no. % of bract and leaf particles was determined in the 420-824 in addition to the 250-419 μm trash fractions from the 31 grab samples.

Over half of the 420-824 μm size trash present in samples of raw seed entering the cleaning room was bract or leaf (Table II). The amount of bract and leaf declined to 40 no. % in seed falling through the Bauer cleaners and to less than 20 no. % for seed that exited the cleaning room and saw delinters (Table II). Bract and leaf particles accounted for almost half of the 420-824 μm size material in the large trash line exiting from the Bauer cleaner. The sieving and aspiration processes in the cleaning room of mill F appeared to be very effective in reducing the content of this botanical material in the product stream (Table II, seed exiting cleaning room vs unprocessed seed).

Table III lists the content (no. %) of bract and leaf in the trash at 16 locations in the hulling and separating room of mill F. The trash lines that exited the safety shakers for recycle of seed to the cleaners appeared to be the only consistent place where bract and leaf particles were found. Bract and leaf fragments were few or almost nonexistent in the hullers, seed separators and beaters, and were never found in any of the "meats" process streams. If the large amount of bract and leaf in the 420-824 μm size fraction in the cleaning and delintering room was being broken up into finer botanical fragments, a spike in bract and leaf content would have been expected in the 250-419 μm size fraction somewhere in the hulling and separating area. As this did not occur (Tables II and III), a likely conclusion was that the combined aspiration and trash removal systems in mill F had effectively eliminated almost all bract and leaf particles by the time the seed mass entered the hulling and separating room.

The validity of the data in Table III might be questioned based on the presence of bract and leaf, e.g., in the vacuum line transporting hulls to a cyclone and the absence of the same botanical materials at several upstream locations. This apparent inconsistency can be explained by noting that mill F was processing 680,000 kg (750 tons) of seed/day and that all samples examined were grab samples collected at intervals over a 2-hr period. The variable nature and amount of vegetable contamination in seed from different gins entering the mill process streams would almost certainly be expected to result in variation of bract and leaf content at downstream locations as seen in Table III.

The data in Table IV show that a substantial amount of bract and leaf fragments remained entrained in all linter and mote streams sampled both during cleaning and at the linter

TABLE I

Composition of Unprocessed Seed from Mill F

Screen opening (μm)	Wt of fraction (g)	Wt % of each size botanical fraction			
		Bract and leaf trash	Whole or part seed	Loose fiber	Other trash
4750	351.65	0.01	99.68	–	0.31
2000	0.78	1.1	35.8	0.2	62.9
1420	0.07	47.4	–	5.2	47.3
825	0.18	47.2	–	2.2	50.6
420	0.23	29.3	–	10.4	60.3
250	0.06	4.8	–	16.5	78.7

TABLE II

Bract and Leaf Particles in the Trash at Various Locations in Process Streams in the Cleaning-Delintering Areas of Mill F

Description of sample	No. % bract and leaf in size fraction	
	420-824 μm	250-419 μm
Unprocessed seed	51.5	11.1
Seed in Bauer 199 Cleaner falling through screen	40.2	7.8
Large trash from Bauer Cleaner	49.2	20.9
Floor trash around Bauer Cleaner	6.5	0.3
Rocks, sticks, grabbots, and burs from Bauer Cleaner	27.8	7.8
Seed from safety shaker returned to Bauer Cleaner	28.4	4.8
Seed exiting cleaning room	11.8	0.5
Seed exiting first-cut delinter	14.8	7.9
Seed exiting second-cut delinter	12.4	2.6

TABLE III

Bract and Leaf Particles in the Trash at Various Locations in Process Streams in the Hulling and Separating Area of Mill F

Description of sample	No. % bract and leaf in size fraction	
	420-824 μm	250-419 μm
Trash line exiting safety shaker for return to cleaner	1.0	0.8
Magnet trash from safety shaker	0	0.4
Second trash line exiting safety shaker	4.8	0.3
Seed from second safety shaker	1.2	0
Particulate from IMPCO decorticator	0	0
Seed and hulls from top tray of Carver huller	0.1	0
Meats line from Carver huller	0	0
Floor trash around hull and seed separators	0	0
Uncut seed from hull and seed separators returning to Carver huller	0	0
Seed on bottom tray of purifier being recycled to Carver huller	0	1.0
Meats line from purifier	0	0
Hull line from purifier	1.0	0
Hulls and seed in double drum beaters following hull and seed separators	0	0.2
Seed and hulls from double drum beaters to tailings beater	0	0
Vacuum line transporting hulls to cyclone	0.3	0
Meats from tailings beater	0	0

TABLE IV

Bract and Leaf Particles in the Trash at Various Locations in the Process Streams from Linter Cleaning to the Linter Press of Mill F

Description of sample	No. % bract and leaf in size fraction	
	420-824 μm	250-419 μm
First-cut linters in Carver Beater	12.3	7.0
Trash in baghouse exhausting first-cut linter press	8.6	0.9
Floor trash around second-cut Ft. Worth BC-4 Beaters	1.6	0.3
Second-cut linters just after Ft. Worth BC-4 Beaters	3.7	0.6
Second-cut linters	3.6	0.3
Bottom trash from mote beater processing motes from first and second-cut linters	2.8	0
Baled linter motes	9.5	0

press. The content of bract and leaf in trash streams in linter cleaning work areas was not greater than that characteristic of the linter mass itself (Table IV). Thus, the combined effect of aspiration and mechanical cleaning of linters was ineffective in preferentially separating light-buoyant bract and leaf particles from the fibers of the linter mass.

This study, together with other investigations (2,11), indicated that the amount of potentially byssinogenic material (bract and leaf) that entered oil mill process streams entrained in cottonseed was substantially less than that which entered cotton textile mills entrained in raw cotton. A large amount of the bract and leaf that does enter cottonseed oil mills was removed during seed cleaning. With the exception of trash lines from safety shakers, bract and leaf fragments were almost nonexistent in hulling and separating work areas. However, cleaning in the linter process lines was ineffective in removing bract and leaf fragments entangled in the fiber mass. In terms of decreasing content of potentially byssinogenic material, work areas in cottonseed oil mills can be divided into cleaning-delintering, linter cleaning-linter press, and hulling and separating, respectively. Using the technique described in this study, it is now possible to determine the content of bract and leaf particles in sifted trash at numerous locations in oil mill process streams.

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