EVIDENCE ON THE ORIGINS OF SUGARS CAUSING STICKINESS IN COTTON

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Abstract

Since the mid-1990s, the International Textile Center (ITC) has been engaged in a collaborative research effort aimed at developing reliable measurements for stickiness of cotton fibers, in order to enable efficient management of this contamination problem.

The HPLC is indispensable for identifying the sources of stickiness contamination (plant sugars vs. insect honeydew and the types of insects involved). Nevertheless, the HPLC cannot be a good predictor of stickiness. Apparently the stickiness potential of cotton is not only linked to the percentage of a specific sugar, but to the balance between the various sugars as well. Another likely factor is that moderate amounts of rainfall renders the cotton fiber less sticky by diluting the honeydew deposits on the lint, spreading the sugars over a larger fiber surface without significantly lowering the sugar content.

Introduction

Since the mid-1990s, the International Textile Center (ITC) has been engaged in a collaborative research effort aimed at developing reliable measurements for stickiness of cotton fibers, in order to enable efficient management of this contamination problem.

In 1996, fifty bales were selected by PCCA (Plains Cotton Cooperative Association, Lubbock - USA) to get a wide range of stickiness due to aphid (Aphis gossypii) infestation. Eleven of these bales were from one module.

In 1998, fifty bales from Arizona and fifty bales from California were selected by Calcot (Bakersfield, California) to get a wide range of stickiness due to white fly (Bemisia tabaci) infestation. Within the California bales, 23 were bales coming from one module.

Material

The bales were broken and layered. Ten samples were taken from each bale. Stickiness data were collected on these cottons using the ITC's HPLC (High Performance Liquid Chromatography) instrument and card machine.

Results and Discussion

The sugars present on the lint were extracted, then the 1500 samples obtained were analyzed with the HPLC to identify entomological and physiological sugars. By a careful use of columns and eluants, the sugars present in the extract can be separated and characterized. The following sugars were detected: inositol, trehalose, glucose, fructose, threhalulose, sucrose and melezitose. In general these sugars account for at least 85% of the known carbohydrates present on honeydew contaminated cotton lint. A high percentage of melezitose reveals the presence of aphid honeydew, whereas with both melezitose and trehalulose present and trehalulose being dominant indicates white flies. The other sugars are generally found on both non-contaminated and honeydew-contaminated cottons. Tarczinski using the aphis-stylet technique to obtain pure phloem sap from cotton plants showed that the major sugar translocated is sucrose (>90%). Hendrix (1995) reported that "only a few of the sugars in white fly or aphids honeydew are found in the insect's diet; most sugars in these secretions are produced by the insects from phloem sap". The glucose and fructose contained in the honeydew are created from sucrose by the insect.

As shown in figure 1, the HPLC total sugars, expressed as a percent of the lint weight, ranged from an average of 0.382 for the Texas samples to 0.586 for the California samples. In spite of this the card grades are very close, as shown in figure 2. Miller (1994), by spraying sugar solutions on non-sticky cotton lint, reported that trehalulose and sucrose were very sticky sugars, they both cause maximum stickiness at only 0.08-0.10% of the fiber weight. In his experiment, "melezitose and glucose did not cause maximum stickiness until they were applied at a final content approaching 1%. Fructose was relatively non-sticky even at concentration of 1%.

Figure 3 shows the averaged HPLC profile for the 50 selected Texas bales. Glucose and fructose are clearly dominant (63% of the total sugars), while trehalulose and melezitose together represent only 16% of the total sugars. The trehalulose content ranges between 0.001% and 0.075% of the sample weight and the melezitose content between 0.008% and 0.113% of the sample weight. This means that all of the bales were contaminated by insect honeydew to some degree. Only eleven bales, all coming from the same module, have a trehalulose content higher than 0.05% but 22 bales have a card grade equal or higher than 2. In all the cases the melezitose content is too low to cause stickiness problems; therefore, the honeydew contamination alone cannot explain the high stickiness level of these 22 bales. The quite high sucrose content can in few cases explain the high stickiness ratings. Miller (1994) reported that an artificial honeydew containing the major carbohydrates present in the natural whitefly honeydew was very sticky even in the range 0.08%-0.1%. But around 35 to 40% of the sugars in this mixture were non-sticky sugars. This means

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that the relative percentage of each sugar is also important. Our observations show that even a low insect infestation can cause stickiness problems. It seems that the different sugars interact.

Figure 4 shows the averaged HPLC profile for the 50 selected Arizona bales. Trehalulose and melezitose are clearly dominant (62% of the total sugars), when glucose and fructose together represent 29% of the total sugars. Sucrose is at an extremely low level (0.2% of the total sugars). The trehalulose content ranges between 0.005% and 0.510% of the sample weight and the melezitose content between 0.024% and 0.280% of the sample weight. This means that all of the bales were contaminated by insect honeydew to some degree. The trehalulose content alone can explain all the high stickiness ratings. But few bales have trehalulose content above 0.08% and a very low card rating. This could be due to rainfall events which do not reduce the sugar content but solubilize and disseminate the sugars on a much larger lint surfaces than originally. Stickiness is mainly due a *localized* high sugar concentration.

Figure 5 shows the averaged HPLC profile for the 50 selected California bales. Glucose and fructose are dominant (48% of the total sugars), when trehalulose and melezitose together represent 34% of the total sugars. The trehalulose content ranges between 0.001% and 0.310% of the sample weight and the melezitose content between 0.013% and 0.241% of the sample weight. This means that all of the bales were contaminated by insect honeydew to some degree. The trehalulose content alone can explain all the high stickiness ratings.

Figure 6 shows the HPLC profile of each of the 150 cotton bales. It appears clearly that within the two modules (bales 32 to 42 and 101 to 123), the HPLC profiles of the bales are very similar. This low variability between bales within a module lets us postulate that it will be the same for the high-speed stickiness measurements as the FCT (Fiber Contamination Tester) or the H2SD (High Speed Stickiness Detector) measurements.

Figure 7 shows that the trehalulose content is much lower in the Texas bales than in the Arizona and California bales. Compared to the Texas bales: (1)the trehalulose percentage averaged 7.2 times higher in the Arizona bales and and 5 times higher in the California bales, and (2) the melezitose percentage averaged 2.8 times higher in Arizona and 2.5 times higher in California (figure 8). Despite these facts, the Texas bales averaged about the same card grade as did the other bales.

The figures 9 and 10 show that for the Texas bales the melezitose is in general the dominant sugar except for 13 bales (including the 11 from one module). In these exceptional bales we found significant amounts of both trehalulose and melezitose. The percentage of the total sugars is around 10 percent for both types of sugars. It means that we probably have in this area a contamination coming from white flies and possibly from aphids. Hendrix (1992), analyzing honeydew from Aphis gossypii and Bemisia tabaci found around 40% of melezitose in the aphid honeydew and 40% of trehalulose plus 17% of melezitose in the white fly honeydew. We have found lower percentages of these sugars in our bale samples, which suggests that we had a relatively high content of physiological sugars.

For the Arizona bales melezitose and trehalulose together are the dominant sugars in 37 of the 50 bales (accounting for 62% of the total sugars in these bales). Such results reveal white fly contamination. In the other 13 bales we found a high percentage of melezitose (around 25%) and a low percentage of trehalulose (around 10%): therefore, in addition to the white fly infestation, this area probably had contamination by aphids. Most of the California bales also exhibited contamination by both insects.

The presence of trehalulose and melezitose reveals contamination by insect honeydew, but is it an accurate predictor of stickiness? Figure 11 shows the relation between trehalulose and the ITC's card grade. (The relation between melezitose and the card grade is very similar). The coefficient of correlation is quite low for the Texas cottons ($r = 0.755$) and very good for the Arizona cottons ($r = 0.925$) and the California cottons ($r = 0.953$). Thus, the relationships appear quite different among the three lots of cotton. This leads to the conclusion that the HPLC cannot be a good predictor of stickiness. Apparently the stickiness potential of a cotton is not only linked to the percentage of a specific sugar, but to the balance between the various sugars as well. Another likely factor is that moderate amounts of rainfall renders the cotton fiber less sticky by diluting the honeydew deposits on the lint, spreading the sugars over a larger fiber surface without significantly lowering the sugar content.

Conclusions

The HPLC measurements confirmed that these 1995 cotton bales from Texas were contaminated by aphid honeydew. They also revealed that 13 of the bales – obtained from outside the Texas High Plains production region - were contaminated by white fly honeydew. Furthermore, in some cases the levels of physiological sugars were high enough to contribute toward stickiness problems.

The Arizona and California cottons were contaminated by white fly honeydew. In some cases we found a high percentage of melezitose and a low percentage of trehalulose: therefore, besides the white fly infestation, these areas probably had additional contamination coming from aphids, too.
The HPLC profile of some bales and the quantity of sugars present on the fiber indicated a high rate of insect

infestation, yet the cotton was not sticky. This is probably linked to the spreading of the sticky deposits by rainfall, which renders the cotton less sticky.

Acknowledgment

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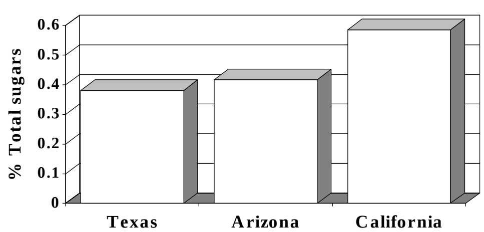

Figure 1. HPLC Total Sugars (%)

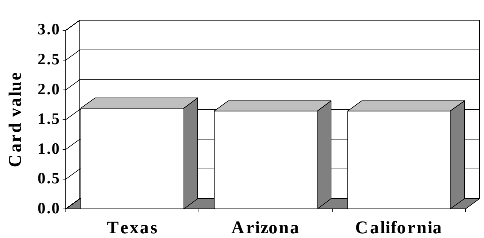

Figure 2. Card values

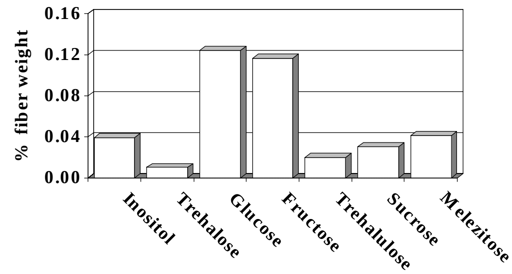

Figure 3. HPLC Profile: Texas bales

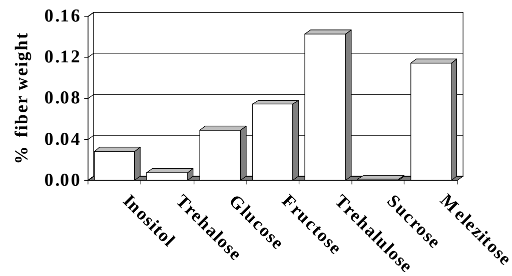

Figure 4. HPLC Profile: Arizona bales

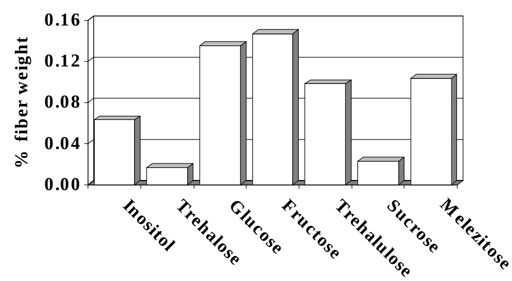

Figure 5. HPLC Profile: California bales

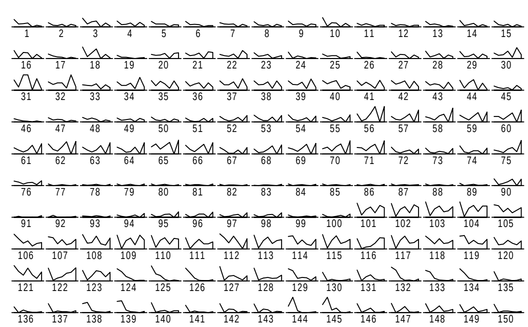

Figure 6. HPLC Profile: From left to right: Inositol, Trehalose, Glucose, Fructose, Trehalulose, Sucrose, Melezitose

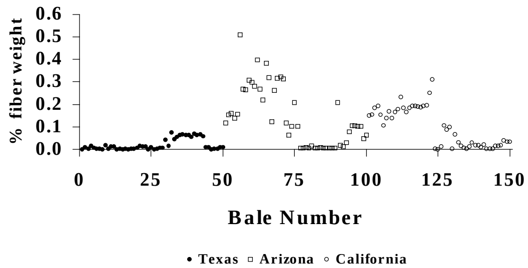

Figure 7. Trehalulose content (percent of fiber weight)

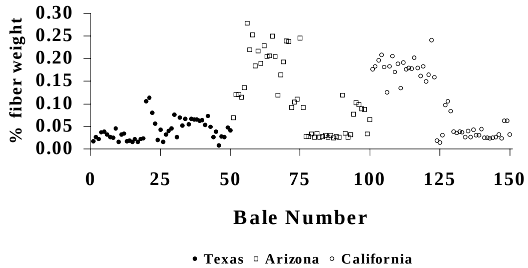

Figure 8. Melezitose content (percent of fiber weight)

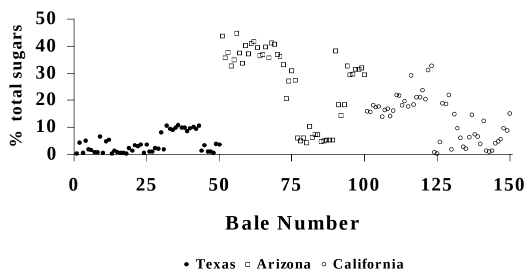

Figure 9. Trehalulose content (percent of the total sugars)

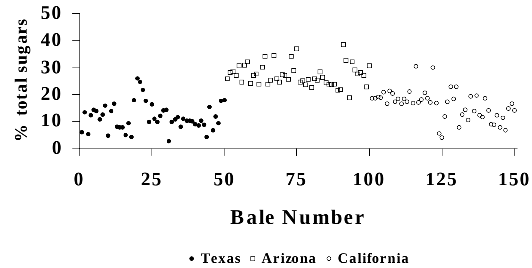

Figure 10. Melezitose content (percent of the total sugars)

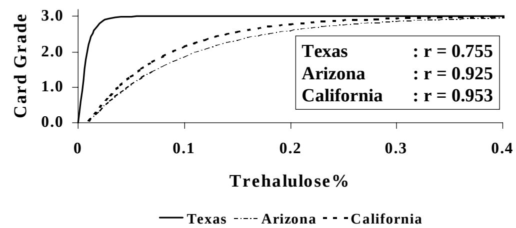

Figure 11. Card grade vs. Trehalulose