Grading Suitable for Commercial Application

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ABSTRACT

Stickiness in cotton is a serious problem confronting both producers and users. The major causative agent of cotton lint stickiness is the honeydew excreted by the insects whitefly and aphid. The sugar constituents of the honeydew are the reducing monosaccharides glucose and fructose and the non-reducing oligosaccharides sucrose and melezitose. The concentration of the monosaccharides don't seem to change with increasing stickiness grade while that of the non-reducing oligosaccharides and the total soluble sugars increased with increasing stickiness grades. A chemical method based on the determination of total soluble sugars as reducing sugars was adopted. In this method, the sugars of the contaminating honey were extracted and hydrolyzed to monosaccharides by treatment with a weak organic acid. Based on sugars concentration five stickiness grades (0-4) were then established. Because of heterogeneity of honeydew contamination even within a single cotton plant, at least ten determinations of sugars concentration are required and the average of these is taken as the sugar concentration for a single cotton lint sample. The chemicals used are not expensive and their reagents are rather stable and do not require daily preparations. The equipment is not complicated. The test is easy to run and can be perfected quickly.

Introduction

Stickiness is one of the most important factors determining the quality of cotton fiber. It is important for producers and users of cotton to have an idea of the extent of stickiness because this seriously affects ginning and spinning of cotton. Sticky cotton can greatly affect the efficiency of the ginning machines and also negatively affect the subsequent processes of spinning and weaving.

The major cause of cotton stickiness was found to be honeydew excreted by the whitefly and aphid. This honeydew was found to contain the sugars fructose, glucose, mannose, sucrose and two unidentified sugars, X and Y (Gameel, 1969). Physical and chemical methods were used to detect and measure the extent of stickiness. Physical methods include minicard, thermodetector and shenkar tester while chemical methods mainly depend on estimating reducing sugars (Perkins, 1992).

Further work concerning the sugars of the whitefly and aphids honey-dew showed that it contains the reducing sugars fructose and glucose and the non-reducing sugars sucrose and melezitose (Ali, 1978). A chemical method based on the estimation of total soluble sugars was developed for grading stickiness into five grades (Ali and Khalifa, 1980). Because of the heterogeneity, samples of cotton lint for stickiness grading representing a lot (300 bales) should be taken from at least 25 bales and thoroughly mixed (Ali and Khalifa, 1982).

In previous methods the amount of sugars in ten oxalic acid extracts of cotton lint were determined separately and the amount of sugars in mg/100g lint was calculated from the average of these determinations for the determination of the stickiness grade. This is rather time-consuming and constituted the use of large amounts of chemical reagents for sugar determinations for a single cotton lint sample. This new modification is aiming at reducing the time for running the chemical test as well as reducing the amount of chemicals to be used. The objective is to make the chemical test suitable for commercial application because of its reliability compared to the subjective physical methods for stickiness grading.

Material and Methods

Samples necessary for this study were collected as previously described (Ali, 1978 and Ali and Khalifa, 1980). The soluble sugars in these samples were qualitatively identified and quantitatively determined as previously described (Rutherford and Ali, 1977).

A chemical method for stickiness grading based on determination of total soluble sugars was developed (Ali and Khalifa, 1980) and this was later modified for commercial application. The details of the modified methods is as follows.

Preparation of reagents

1. Oxalic acid (2%) is prepared by dissolving 20 g oxalic acid in 1 L distilled water (dw).

2. Sodium hydroxide (0.11 N) is prepared by dissolving 0.44 g sodium hydroxide in 1 L dist. water.

3. Copper reagent: This is prepared by dissolving 6.0 g hydrated copper sulphate (Cu_2SO_4 - 5 H_2O) in 1 L dw.

4. Harding's reagent: This is prepared by dissolving 12 g potassium tartrate, 20 g sodium carbonate (Na_2CO_3), 25 g sodium bicarbonate in 1 L dw.

5. Nelson reagent: This is prepared by dissolving 50 g ammonium molybdate in 900 ml, dw to this 42 ml concentrated sulfuric acid (H_2SO_4) were slowly added. 6 g hydrated sodium arsenate were dissolved in 50 ml dw and these were added to the first solution and the mixture was then aged for 3 days in a brown bottle at 37º C before use.

6. Stock solution containing 1 g glucose dissolved in 1 L dist. water. Volumes from this stock solution are diluted to give concentrations of 20, 40, 60, 80 and 100 ug glucose per 1 ml. These concentrations are used for constructing the standard curve.

Procedure for extraction and hydrolysis of sugars

1. Weigh 2gx10 for each of the cotton lint samples and put each in 10 separate clean dry test tubes.

2. Add to each test tube 10 ml of 2% oxalic acid. Cover the tubes with aluminum foil or glass balls to reduce evaporation and put the tubes in boiling water bath or heating block and leave for 25 minutes. This treatment is sufficient for extraction of sugars and the hydrolysis of oligosaccharides.

3. After cooling the tubes, take 0.2 ml from each of the oxalic acid extract and pool in one test tube to make a final volume of 2.0 ml. To this, add 3.0 ml of 0.11N Na OH for neutralisation. Aliquots of 0.05-0.1 ml can then be taken for the determination of reducing sugars by the Nelson method.

Determination of reducing sugars by Nelson method

1. In clean dry test tubes pipette aliquols from the glucose standard or the oxalic acid extract for the sample under test containing 20-100 ug reducing sugars in a final volume of 1 ml.

2. Add 1.0 ml copper reagent.

3. Add 1.0 ml Hardenings reagent and mix well.

4. Heat the tubes in boiling water bath for 10 minutes and then cool.

5. Add 1.0 ml Nelson regent. Agitate and then leave for 10 minutes for complete color development.

6. Add 6.0 ml distilled water to make a final volume of 10 ml, then mix well and read absorbence at 600 nm in 1 cm cuvette against a blank not containing sugars.

Calculations

Let the volume taken for reducing sugars determination be x with reducing sugars equivalent of y ug as taken from the glucose standard curve. Then the amount of reducing sugars (RS) in mg per 100 g cotton lint can be calculated as follows:

Then from the above value the stickiness grade can be determined according to the following ranges:

$$mg\ RS\ /\ 100\ g\ lint\ =\ \frac{y*5*10*100}{x*2*2*1000}=\ \frac{1.25y}{x}$$

Stickiness grade	mg RS/ 100 g lint
0 (free stickiness)	0-499
1 (light stickiness)	500- 699
2 (moderate stickiness)	700- 899
3 (heavy stickiness)	900- 1100
4 (very heavy stickiness)	over 1100

Results and Discussion

Physiological sugars may constitute up to 0.3% of the total cotton fiber weight (Brown and Ware, 1958). This is equivalent to 300 mg/100 g lint. This explains why cotton free of stickiness contains sugars mainly physiological sugars.

Table 1 shows the amount of total soluble sugars which include reducing and non-reducing sugars for samples collected from different sources. With the exception of plant gland honey-dew, the non-reducing sugars constitute 44-70% of the total soluble sugars while the reducing sugars constitute 30-56% of the total soluble sugars. This implies that the non-reducing sugars are very important in the problem of stickiness and due consideration should be given to these sugars when chemical stickiness grading for cotton fibers is being made.

Table 2 shows the amount of reducing sugars and total soluble sugars for cotton lint samples with varying stickiness grades. The concentration of reducing sugars is almost constant and didn't increase with increasing stickiness grade while that for non-reducing sugars showed an increase with increasing stickiness grade. This reflects the importance of non-reducing sugars in determining the extent of stickiness in cotton. Taken together as total soluble sugars, the concentration also increases with increaseing stickiness grade. This what we considered in our method, because further steps to determine reducing sugars and non-reducing sugars separately or destroy reducing sugars by treatment with hot alkali and then determining non-reducing sugars are chemical and time consuming.

Table 3 shows the comparison between the previous chemical method (Ali and Khalifa, 1980) and the new modification. T test showed that there is no difference between the two methods going a cross the ranges of sugars for the five stickiness grades. In this new

modification the time for extraction and hydrolysis of sugars with oxalic acid was reduced from 45 minutes to only 25 minutes. Also in this new modification the time for pipetting and the amount of chemicals used for sugars determination are both reduced by 90% because aliquats for sugars determination from the 10 oxalic acid extract for a single cotton lint sample are pooled in a single test tube for one determination instead of being determined separately as in the previous method.

Since sugars are the main causative agent of stickiness, chemical methods for stickiness grading should be preferred to subjective physical methods. With chemical methods samples of cotton lint could be distinguished with regard to stickiness by the commonly known stickiness grades or with sugar concentration in cases where stickiness grades are similar. Also with chemical methods clean cotton could be mixed with sticky cotton in calculated ratios to give cotton which can easily be processed.

This method considers both reducing and non-reducing sugars, while others consider reducing sugars only (Peles, 1992; Tsai, 1992). With the exception of the glucose standard which require refrigerated storage, the reagents used are fairly stable at room temperature and don't require daily preparation. With this new modification voluminous number of cotton lint samples can be chemically graded for stickiness, thus the method can be commercially adopted. The chemicals used are not expensive, the method doesn't require complicated equipments, it is not complicated and can easily be understood and perfected.

This method can be valuable at the ginning stage of cotton processing before or after baling. At these stages representative cotton lint samples can be taken and chemically graded for stickiness and then degree of stickiness together with sugars concentration can be established for whole lot (100 bales wt182 kg). On a per sample bases the time for running this chemical test can be greatly reduced by providing adequate laboratory facilities and an example to quote in this respect is that the time taken for extracting and hydrolysing one cotton lint sample for running a hundred or even a thousand cotton lint samples if laboratory facilities are made available to do this.

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Table 1. Soluble sugars (s.s.) from different sources.

%N.R.S from total (s.s.)	% R.S. from total (s.s.)	%Non-reducing Sugars (N.R.S)	%Reducing sugars (R.S)	Source
58	42	22	16	Whitefly honey-dew
70	30	1.9	0.8	Aphid honey-dew
67	33	1.0	0.5	Cotton leaf extract
44	56	20	25	Cotton leaf contaminant
50	50	30	30	Cake from ginning machine
14	86	5	30	Cotton leaf gland

Table 2. Soluble sugars (mg/100g) of cotton lint samples with different stickiness grades.

Total soluble sugars	Non-reducing sugars	Reducing sugars	Stickiness grade
405	47	358	0 free stickiness
613	93	520	1 light stickiness
769	262	507	2 medium stickiness
907	317	590	3 heavy stickiness
1622	1092	530	4 very heavy stickiness

Table 3. Comparison between the previous method (old) and the new modification (new).

Stickiness grades									
4		3		2		1		0	
Above 1100		900-1100		700-899		500-699		0-499	
New	Old	New	Old	New	Old	New	Old	New	Old
1150	1200	900	913	850	825	513	500	338	340
1325	1350	950	925	750	725	550	550	413	413
1350	1400	938	950	713	725	600	600	400	378
1225	1250	1013	1000	875	850	638	625	388	358
1600	1550	1025	1000	775	813	613	600	475	480
1200	1175	975	975	775	800	638	650	325	300
1200	1250	913	938	800	813	650	675	238	225
1300	1350	1050	1025	750	713	525	513	275	250
1325	1275	975	950	750	738	550	537	350	333
1500	1450	988	975	775	775	650	613	388	380
0.449		0.348		0.436		0.401		0.342	p

Results expressed as mg sugar/100g cotton lint for the different stickiness grades. (10 determinations).