BOTANICAL TRASH MIXTURES ANALYZED WITH NEAR-INFRARED SPECTROSCOPY

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Abstract

Botanical cotton trash mixed with lint reduces cotton's marketability and appearance. During cotton harvesting, ginning, and processing, trash size reduction occurs, thus complicating its removal and identification. This trash causes problems by increasing ends down in yarn formation and thus processing efficiency. The High Volume Instrument (HVI™) and Shirley Analyzer are extensively used to determine trash levels in cotton lint, but they do not specifically identify its origin. This study was performed to determine the potential for recognizing differences between botanical cotton trash mixtures via Near-Infrared (NIR) spectroscopy. A "proof of concept" was demonstrated that shows the promise of NIR spectroscopy to be employed to identify binary mixtures of botanical cotton trash. The results of this study are presented herein.

Introduction

Cotton quality measurement of trash comingled with lint is important since it can affect its later use in yarn and fabric as well as its profitability. Conventional methods to determine trash content, such as the HVI and Shirley Analyzer, give information on the amount of trash present, but the identities of the trash components present are not specified. Having a better understanding of trash identity may improve textile processing efficiency. Specifically, the development of methods for improved trash removal based on specific trash types at various stages of cotton processing may be an advantage spawned by this study. Thus, there is interest in identifying the type of trash present with cotton using a technique that is fast, accurate and reproducible.

NIR spectroscopy meets these requirements since it is has been previously used to study textiles, particularly cotton, due to its speed, accuracy, precision, non-destruction of samples and user-friendliness (Taylor, 1980; Montalvo and von Hoven, 2004; Rodgers and Ghosh, 2008; Rodgers and Beck, 2009). Recently, NIR has been used to identify pure botanical trash components such as hull, leaf, seed coat, and stem (Fortier et al., 2010). Moreover, pure field trash components were also uniquely identified using NIR spectroscopy (Fortier, et al., 2011). The aim of the study is to determine the feasibility of using NIR spectroscopy to analyze binary mixtures of botanical trash with cotton. Specifically, trash mixtures of known composition were prepared and analyzed in the absence and presence of cotton. Pure trash components of 9 varieties were retrieved from South Carolina, Mississippi, and New Mexico.

Materials and Methods

Large raw binary trash samples composed of hull, leaf, seed coat, and stem were initially run on the NIR bench top instrument using the rotating cup accessory and rotating macrosampling integrating sphere. Raw samples were run in the absence of cotton lint. In addition, pure pepper-sized samples of hull, leaf, seed coat, and stem were used to compose the binary trash mixtures as follows. Five concentrations by weight were prepared: 50:50, 75:25, 25:75, 20:80 and 80:20. Pure trash samples were mixed and then placed in glass vials making sure the mixture were centered in the bottom of the vials. Next, a cotton ball was placed on top of the mixtures. Samples of the bottom of the glass vials were run on a Bruker MPA bench top NIR spectrometer using the rotating integrating sphere microsampling method. Five replicates were run for each mixture, turning the glass vial each time before the measurement was taken. Bruker OPUS IDENT software was used to develop NIR spectral libraries. Samples in the prediction set were identified based on their spectral similarity to mixtures in the calibration set.

Results and Discussion

Initially, large raw binary botanical trash mixtures were run on the NIR instrument in the absence of cotton. The calibration and prediction set were composed of binary mixtures of stem and seed coat, hull and seed coat, hull and

stem, leaf and stem, leaf and seed coat, and hull and leaf. Table 1 shows the result summary for the NIR identification of raw trash mixtures in the prediction set. As can be observed, the NIR technique was used to successfully identify botanical trash mixtures with greater than 95% accuracy.

Table 1.NIR Identification of Raw Trash Mixtures in the Prediction Set

	%Correct	Number of Samples	Number Correct
Hull and Leaf	100.00%	3	3
Hull and Seed Coat	80.00%	5	4
Hull and Stem	100.00%	3	3
Leaf and Seed Coat	100.00%	5	5
Leaf and Stem	100.00%	3	3
Stem and Seed Coat	100.00%	5	5
Total	95.83%	24	23

Next, a new approach was used to compare the spectra of the binary botanical mixtures sharing a common trash component. Four libraries were developed for each common trash component: hull, leaf, seed coat, and stem. For the spectral libraries, the spectra from the first three batches having a weight ratio of 50:50 were used to make up the calibration set. The prediction set was composed of Hull and Leaf, Hull and Seed Coat, and Hull and Stem. The mixtures in the prediction set were composed of 13 batches at a weight ratio of 20:80 and 80:20, and the 10 remaining 50:50 binary mixture weight ratios, Tables 2 summarizes the identification results of a representative study. For the hull concentration of 50% or less, the Hull and Leaf, Hull and Seed Coat, and Hull and Stem yielded favorable identification accuracy. However, for hull concentrations above 50%, only the Hull and Seed Coat yielded an encouraging result. Currently, it is unknown as to what effects largely influenced the identification results determined using the NIR technique. However, it seems logical that for the small particle size of pepper trash in the presence of cotton, the NIR method may be hindered by the sensitivity of this method, leading to some misidentifications.

Table 2. Representative NIR Identification of Hull Mixtures in the Prediction Set

Component Ratio- 50:50	Total Samples	Correct	%Correct
Hull and Leaf	10	8	80%
Hull and SC	10	7	70%
Hull and Stem	10	6	60%
Component Ratio- 20:80	Total Samples	Correct	%Correct
Hull and Leaf	13	11	85%
Hull and SC	13	10	77%
Hull and Stem	13	10	77%
Component Ratio-80:20	Total Samples	Correct	%Correct
Hull and Leaf	13	6	46%
Hull and SC	13	10	77%
Hull and Stem	13	4	31%

Summary

A program was implemented using NIR spectroscopy to identify binary mixtures of botanical trash in the absence and presence of cotton. Botanical binary trash mixture components consisting of hull, seed coat, stem, and leaf in cotton were studied. The large raw trash mixtures in the absence of cotton yielded highly accurate results, with greater than 95% correct identifications. Bleached cotton balls in glass vials were used as substrates to identify botanical trash pepper-sized binary mixtures. The libraries based on a common trash component yielded the favorable results.

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Disclaimer

The use of a company or product name is solely for the purpose of providing specific information and does not imply approval or recommendation by the United States Department of Agriculture to the exclusion of others.

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