PRELIMINARY STUDIES OF COTTON NON-LINT CONTENT IDENTIFICATION BY ULTRAVIOLET-VISIBLE SPECTROSCOPY

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Abstract

Cotton trash can become comingled with the lint during the harvesting and processing of cotton. Compounding this problem is the tendency of cotton trash to become smaller in size during the processing of cotton. Thus, the development of a method, which can analyze these small trash samples based on their chemical or physical properties, would be advantageous. In addition, high specificity in the determination of the type of cotton trash present would be desirable. A program was implemented to determine the capabilities of Ultraviolet-Visible (UV-Vis) spectroscopy to classify cotton trash components, including hull, leaf, seed coat, seed meat, and stem. Minute spectral differences between the cotton trash components were used to classify the cotton trash types. The advantages of this method include moderate cost, short analysis time, and non-destruction of samples.

Introduction

Cotton is widely studied due to its importance globally. (Wakelyn., 2007). The presence of cotton trash with cotton lint has presented a major challenge during cotton ginning, processing, and harvesting. The main source of the problem involves removal of the cotton foreign matter. Compounding the problem is the formation of small-sized cotton trash including pepper and powder-sized trash. The presence of cotton trash yields adverse effects on the quality of cotton including increasing yarn breakage (Brashears 1992), deposits in rotors, and an increased amount of neps (Frey 1989). In particular, classifying the different types of cotton trash has been studied due to the deleterious effects cotton foreign matter can have when present, with lint as well as the efficiency of cotton ginning and processing. Currently, trained "classers" and the High Volume Instrument (HVI) technique are commonly used to evaluate trash content. As can be expected, the "classer" method can be disadvantageous due to the subjectivity and lack of agreement between different "classers".

The HVI method is currently used widely to determine the amount of trash content in a cotton sample. Although it has been successfully used to determine color, length, length uniformity, strength, micronaire, and total trash content, it currently measures the amount of trash content without yielding specific information on the individual types of cotton trash components. In addition, the HVI method is costly, requires measurements to be performed in climate controlled environments, and lacks specificity in the identification of individual trash components such as the hull, leaf, seed coat, seed meat, and stem.

The types of cotton trash have been previously classified using clustering analysis focusing largely on color measurements and secondly on size and shape of trash particles (Xu 1999). In this study, computational analysis was used to differentiate bark, leaf, and smooth and hairy seed coats. Although the method was successful, the highest degree of accuracy involving neural network clustering is required substantial computational time. Trash classification has also been studied using visible spectroscopy and Near-Infrared (NIR) imaging (Taylor, 1996). It was determined in this study that the visible techniques were not sufficient to differentiate bark from grass particles and, that, NIR imaging was complicated by the low levels of trash particle contrast between bark and grass. With the many advantages of UV-Vis spectroscopy, including being rapid, non-destructive, easy to use and relatively inexpensive compared to other analytical instruments, it is an attractive technique for the analysis of textiles (Venkataraman, 1987).

A program was implemented to classify individual cotton trash components using UV-visible spectroscopy. It is the goal of this study to develop a classification method to differentiate between cotton and different types of cotton trash. The ability of the UV-Vis method to separate and classify/identify botanical cotton trash (hull, leaf, seed coat, seed meat, and stem) from each other and from clean cotton fiber (lint) will be demonstrated.

Materials and Methods

Powder and pepper-size cotton trash of 5 varieties, from three sites including Mississippi, South Carolina, and New Mexico, were studied in the presence of a "clean" cotton reference. For each class of cotton trash, the hull, leaf, seed coat, seed meat, and stem were analyzed. All samples were run through a plastic bag. UV-Visible spectra were baseline corrected at 100% using a spectralon reference standard for % reflectance versus wavelength. At 0% baseline no standard was used.   All spectra were acquired using a Varian Cary 100 Scan UV-Visible Spectrophotometer in Scan mode. Both the first and second derivatives of the data were acquired and analyzed. UV-Vis data were then uploaded into the Camo Unscrambler chemometric software. Many spectral regions and derivative pre-processing methods were analyzed to optimize the separation and classification of the cotton and cotton trash samples.

Results and Discussion

As mentioned previously, a program was developed in the current study to classify cotton and individual cotton trash components using UV-visible spectroscopy.
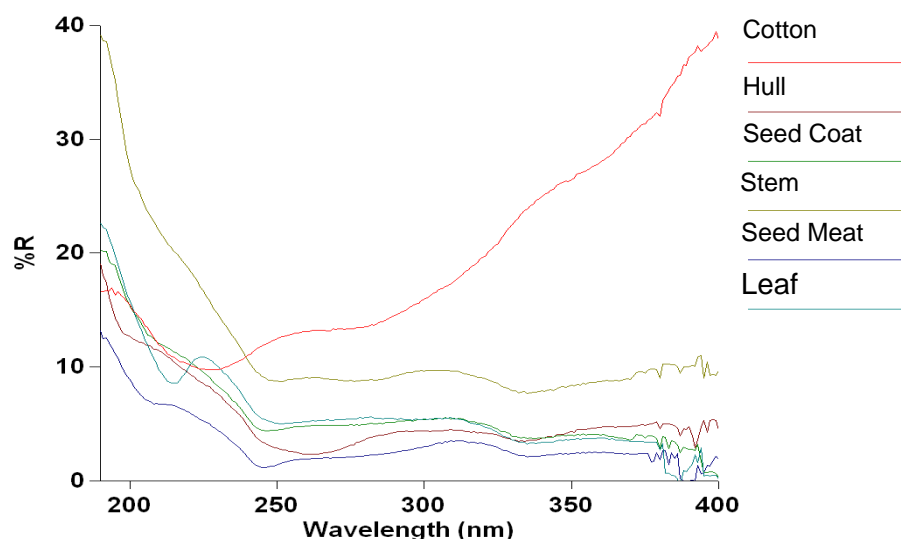

Figure1. Representative %Reflectance of cotton and cotton trash over UV range.

For the UV-Visible data comparing the cotton to the various types of cotton trash (hull, seed coat, stem, seed meat, and leaf), there appeared to be distinctive spectral bands identifying clearly the cotton from the cotton trash, as shown in Figure 1. However, under these conditions it was very difficult to determine the different classes of cotton trash from each other due to their high spectral similarities. Thus, it was necessary to try different pre-processing techniques to enhance the specificity of the different types of cotton trash.

In the development of the UV-Vis spectroscopy classification routine, it was necessary to include spectra from numerous sources so as to make the qualitative method robust. Thus, both powder- and pepper-sized trash components representing 3 states and 5 cotton varieties were incorporated into a calibration and a prediction set. To further analyze the UV-Visible data, the first and second derivatives of the cotton and cotton trash were observed. The spectral data was smoothed, and a derivative performed. The use of derivatives minimizes baseline scatter and drift and accent small spectral differences between samples. Figures 2 and 3 show the cotton and cotton trash spectra of the first and second derivative spectra, respectively.
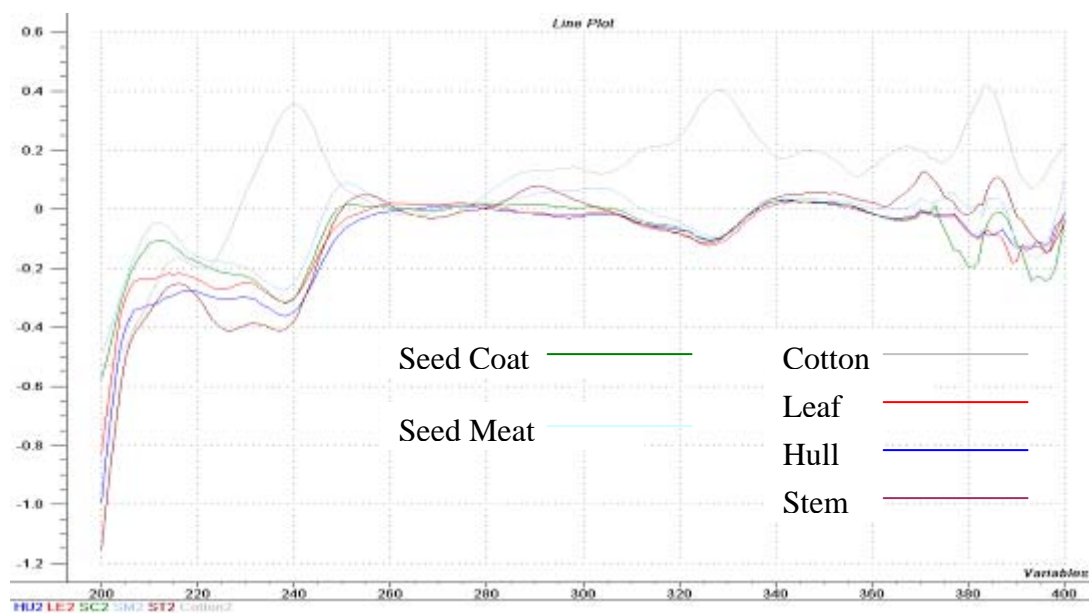
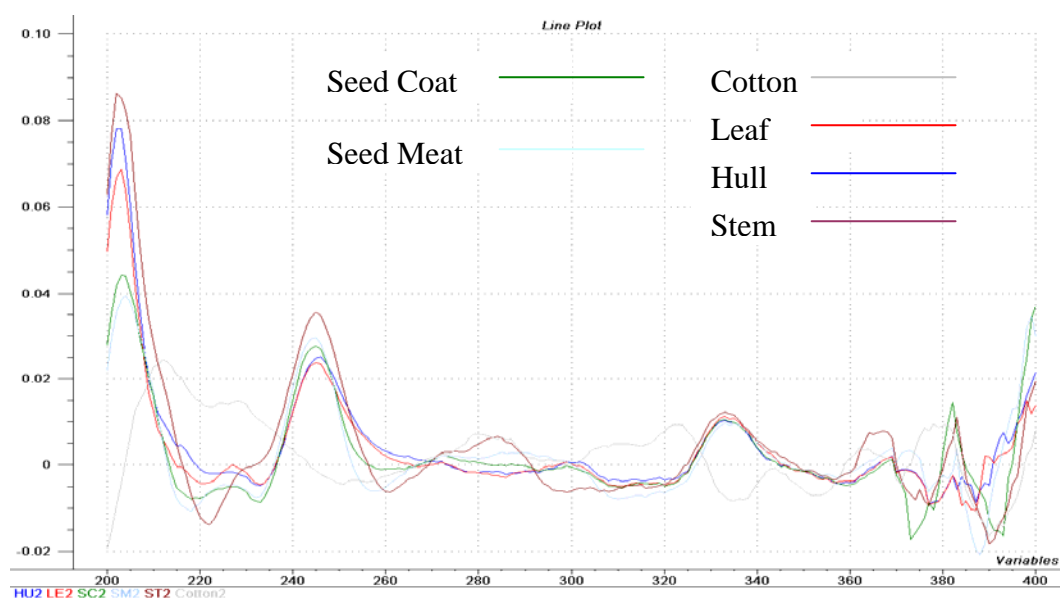Figure 2. First derivative of cotton and cotton trash spectra.

Figure 3. Second derivative of cotton and cotton trash spectra.

Both the first and second derivative spectra were closely examined over multiple spectral regions to optimize the classification of the trash spectra. It was found that a narrow spectral region using the first derivative spectra gave the best results. Table 1 shows the classification results for the trash components independently and overall. The most accurate identification results were obtained for the stem class at 89%. The seed meat results were the most inaccurate with 67% correct. This may be due to the lower number of available samples for this trash class. Overall, 80% correctly identified samples were observed.

Table 1. UV-Vis identification by cotton trash type.

	Powder and Pepper Samples		
Prediction Set	% Correct	Number of Samples	Number Correct
Hull	87%	15	13
Leaf	75%	12	9
Seed Coat	83%	12	10
Seed Meat	67%	9	6
Stem	89%	18	16
Total	80%	66	54

Summary

A technique was implemented to specifically classify various types of botanical trash. Samples from three states (New Mexico, Mississippi, and South Carolina), with 5 different varieties were included in the identification calibration and prediction sets. Various pre-processing methods and spectral regions were used to optimize identification of cotton trash components. In addition, both powder- and pepper-sized cotton trash samples were included in the classification routine. Overall, 80% of the prediction set was correctly identified with the stem identification having the highest component accuracy at 89%.

Acknowledgements

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