



# Analysis of Dyes in Blue Denim by Microspectrophotometry



FORENSIC SCIENCE

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## Abstract

The key to connecting two fibers is the inability to make distinctions in physical, chemical, and optical characteristics. According to a study done in Germany in 2006 [1], "approximately 95% of all the denim material examined was made of 100% cotton and displayed the dye spectrum typical of Vat Blue 1". As this study in Germany confirmed, in the past blue denim fibers were not unique and were therefore classified as ubiquitous. Due to this, blue denim fibers have not typically been used for comparisons. In this study, 108 articles of denim clothing were analyzed to determine if there was a significant change in the composition of denim clothing. In contrast to the previous study, which reported that 95% of denim products were 100% cotton, this study found that only 30% of samples were composed of 100% cotton. Unlike the past, the dye spectra consisted of more than the typical Vat Blue 1 (indigo). With the significant changes in composition of current blue denim products, these fibers can now be considered a useful comparison fiber.

## Introduction

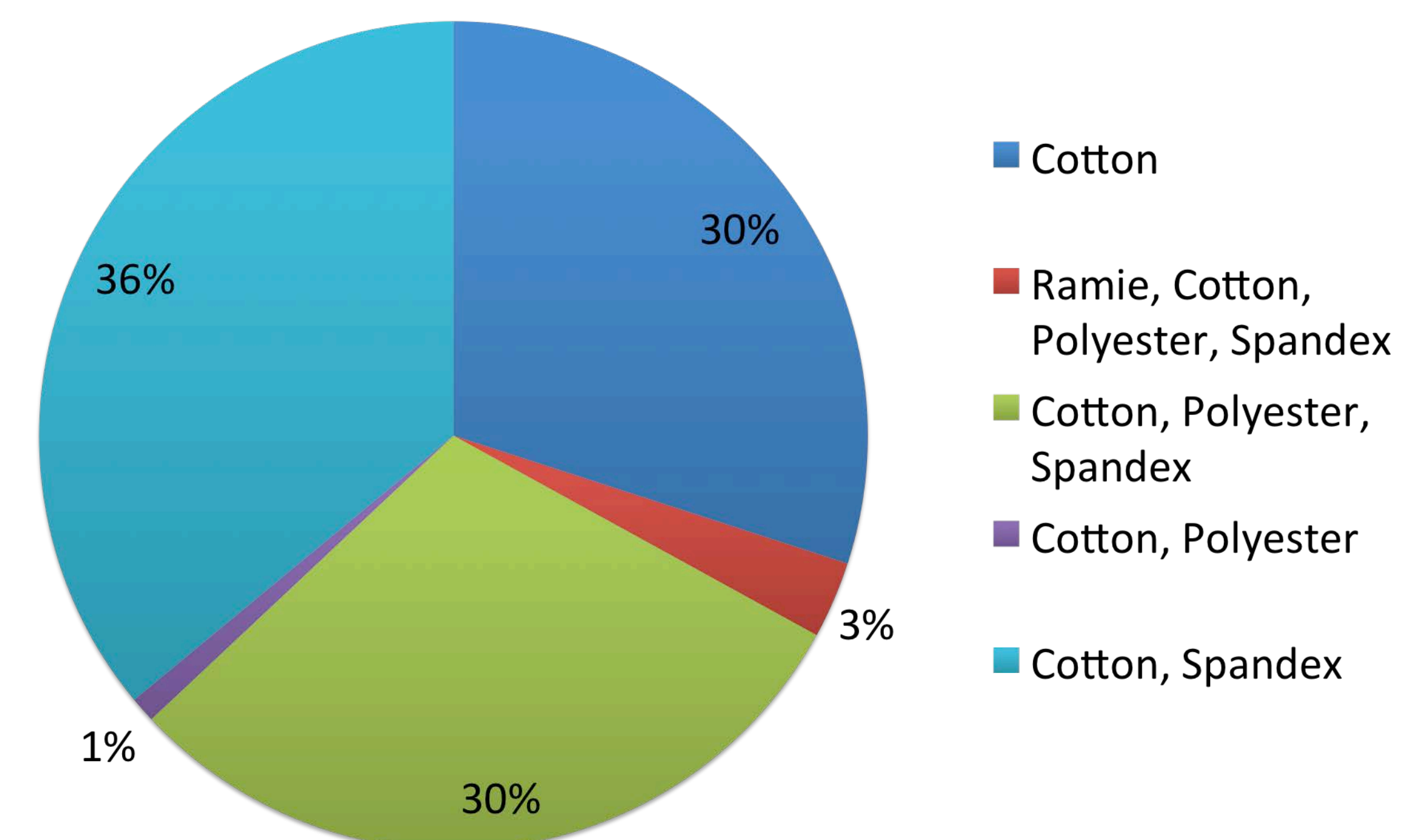
The inability to make distinctions, positive association, is the key to connecting two fibers from different sources. The rarity of the fibers must also be considered when associating two fibers. The fiber identity (fabric composition), as well as the color of the fiber are taken in to consideration when determining this rarity [3]. The fiber can be examined by Polarized Light Microscopy to determine its identity, among other characteristics. In addition to microscopic examination, instrumental analysis like microspectrophotometry can provide information regarding the fiber's color. The combination of both fiber identity and fiber color will discriminate only if the combination is not frequently found. Blue denim is an example of a fiber that was previously considered ubiquitous, thus not exhibiting these rare qualities. This study's purpose is to determine if a significant change has been made in the composition in order to make the blue denim fibers distinguishable. As fashion is consistently changing, a change in the composition of blue denim is to be expected.

## Materials & Method

Fibers were taken from 108 samples of blue denim material that were donated. The samples consisted of jeans, shorts, skirts, a jacket, and a hat. The Olympus BX51 polarized light microscope was used to confirm the fiber composition for each sample. For this process a fiber from each sample was mounted onto a slide using Meltmount<sup>®</sup> refractive index 1.539. The Zeiss SteREO Discovery V.8 stereoscope was used in the mounting process. All of the 108 samples were analyzed using Microspectrophotometry to compare the dye spectra. Three fibers from each sample were selected and mounted on a quartz-slide under a quartz cover slip. They were then immersed with glycerin to secure the fibers to the slide. In the case of more than one color found in the sample, three fibers of each color were mounted. Nine spectra were obtained from different areas along the length of the fiber. These were recorded in the ultraviolet and visible with a range from 250 nm to 820 nm provided by the CRAIC Technologies Microspectrophotometer. The obtained spectra were then compared to an indigo standard.

## Results

Figure 1: Fiber Type



According to Figure 1, only 30% of samples were composed of 100% cotton. This is a stark difference to the previous study, which found that 95% of their samples contained 100% cotton. Most of the samples in this study proved to be blends of cotton with one or more different fiber types. The most common composition found was a blend of cotton and spandex comprising 36% of the samples.

Figure 2: Fiber Color

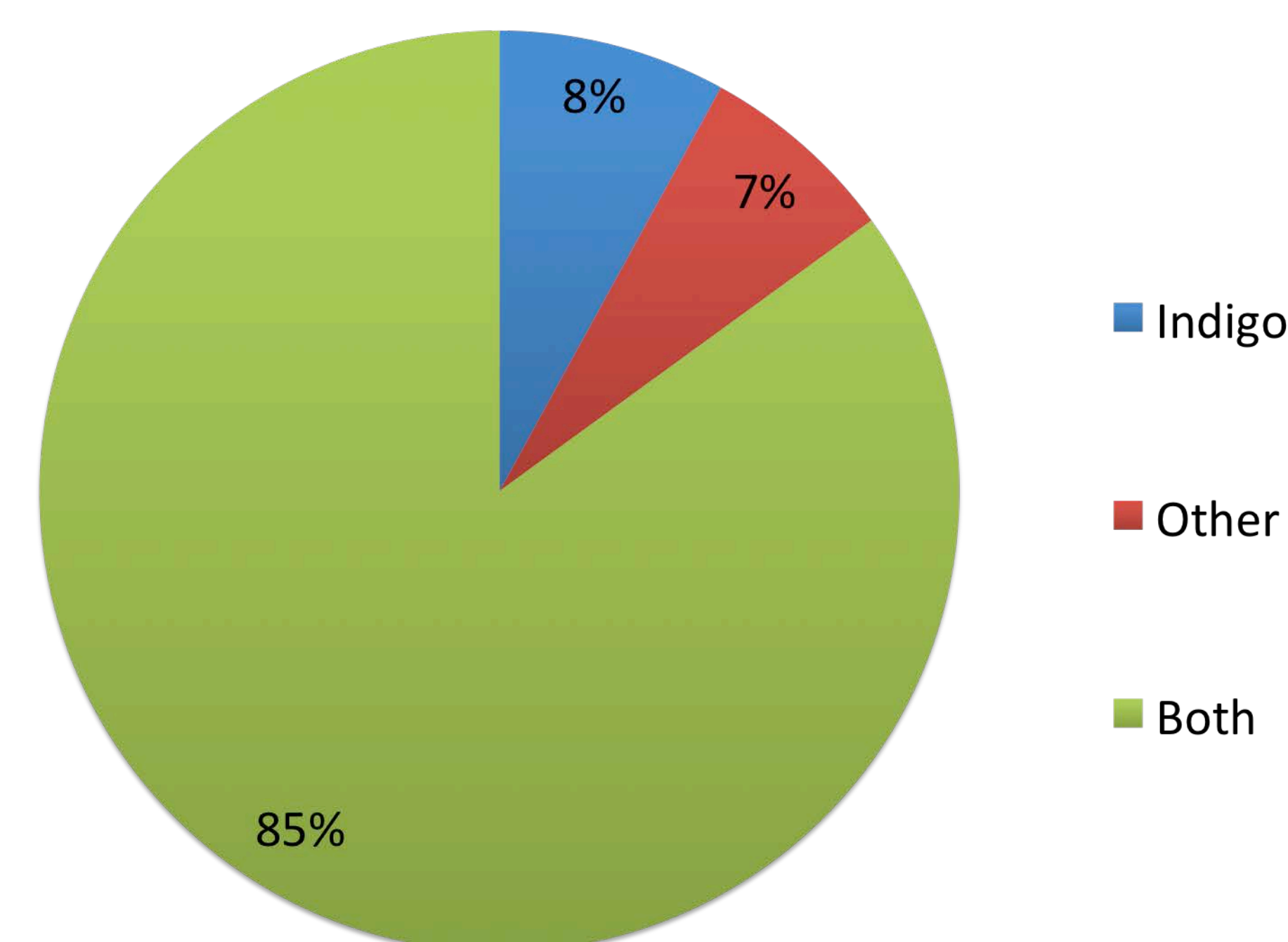


Figure 2 displays the results of the dye composition of the samples separated into whether the standard Vat Blue 1 indigo dyes was used, a different dye, or both. Unlike the past, only 8% of samples displayed the indigo dye spectrum as seen in Figure 3. The most frequent dye composition was that of Vat Blue 1 with other dyes; this represented 85% of samples. Figure 4 shows a common combination of dye spectra found in most of the samples. Only 7% of the samples were found to use strictly other dyes. These results are seen to be significantly different than the study presented 10 years ago.

## References

1. Goodpaster, J., and Liszewski, E., "Forensic Analysis of Dyed Textile Fibers," *Analytical and Bioanalytical Chemistry*, 394(8), Aug. 2009, pp. 2009-2018.
2. Grieve, M. C., Biermann, T. W., and Schaub, K., "The use of indigo derivatives to dye denim material," *Science & Justice*, Vol. 46, No. 1, Jan. 2006, pp. 15-24.

## Spectra

Figure 3: Indigo standard

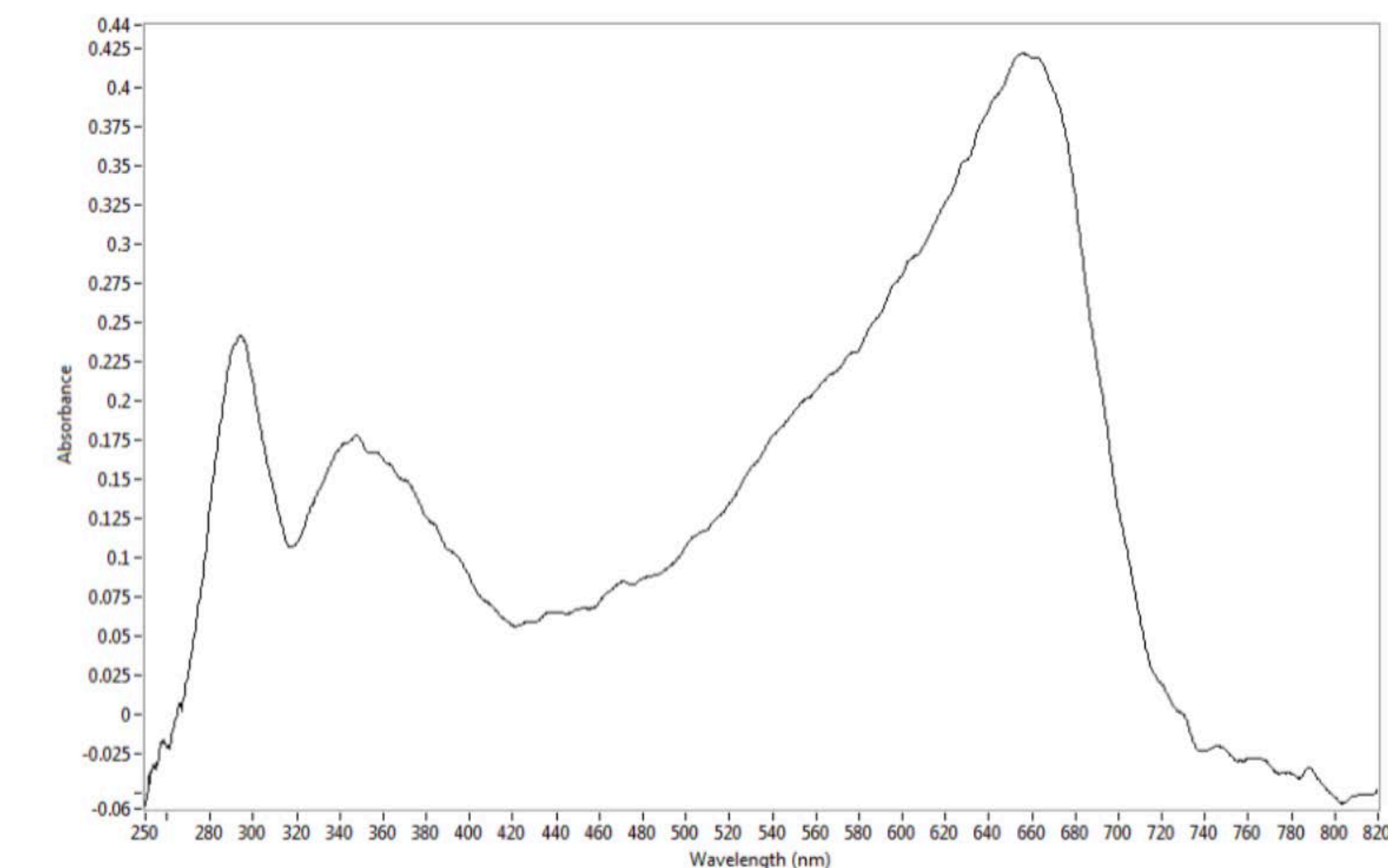
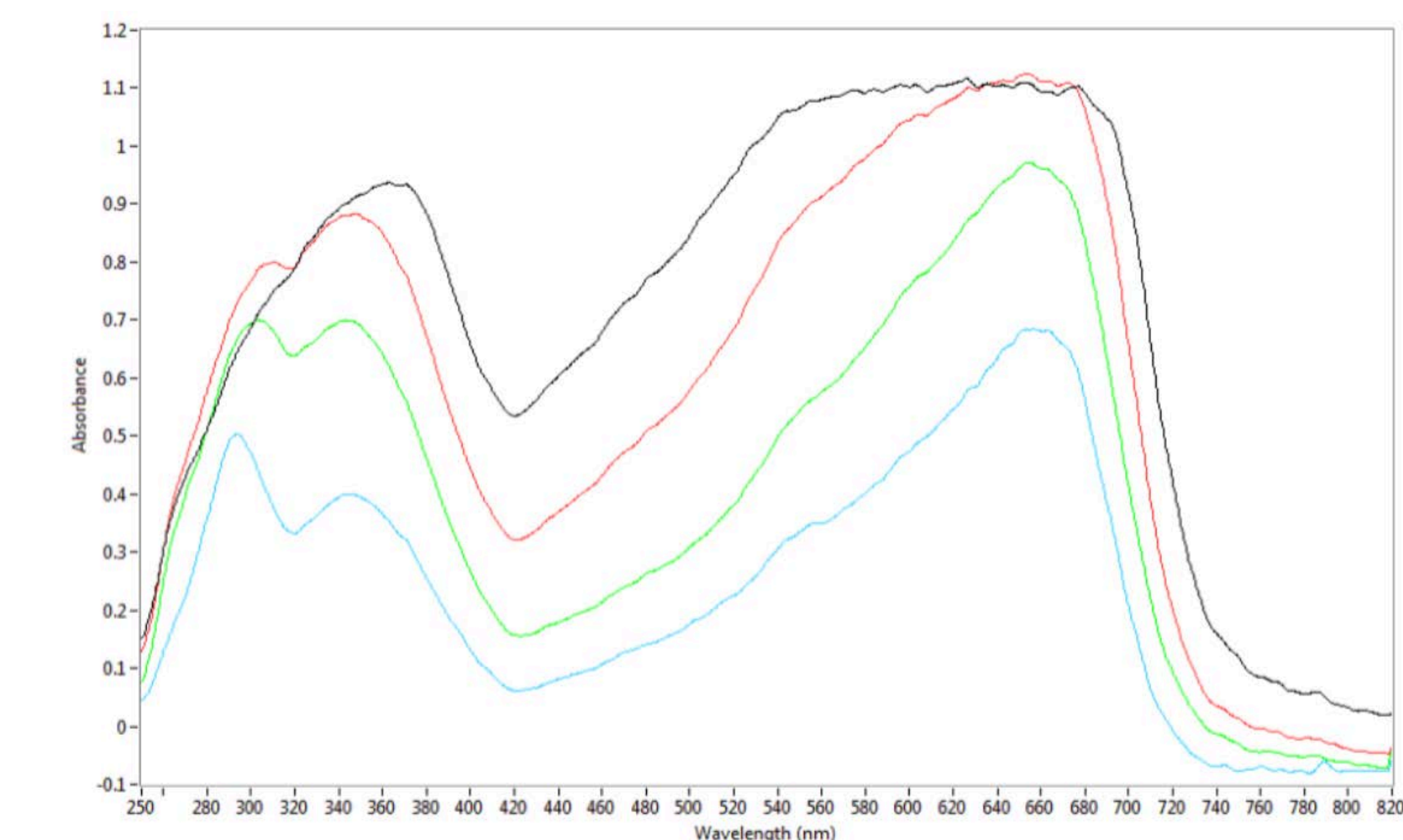


Figure 4: Two common spectra



## Conclusions

Blue denim has evolved from ten years ago. The changes seen in the fiber type and the fiber color allow for more distinction between different blue denim products. Being able to make more distinctions between blue denim products in turn, increases the rarity of blue denim fibers. With the increase in rarity, a positive association or discrimination in a fiber comparison is more likely to occur. Current blue denim products, compared to those of ten years ago, are now commonly manufactured with synthetic/manufactured fibers. This could be due to the evolution of fashion. Not only are different fiber types being used, the dye composition has also changed. This is most likely an adaptation to the use of various synthetic fibers which are not as accepting of the standard Vat Blue 1 dye. The composition and dye differentiation in newer denim products prove to have enough discriminating factors to allow them to become target fibers in forensic cases.

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