A STUDY TO INVESTIGATE THE POSSIBILITY OF USING WASHED BLOODSTAINS IN SELECTED COTTON AND POLYESTER WOVEN FABRICS AS DIRECT FORENSIC EVIDENCE

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INTRODUCTION

Forensic science could be defined as the application of scientific principles and techniques to solve matters of criminal justice, especially relating to the collection, examination, and analysis of physical evidence (Merriam-Webster, 2022). To build a forensic criminal case, the investigators require forensic evidence, which could be divided into direct and circumstantial evidence. Direct evidence could be defined as the evidence that "is known personally to the witness because they have a personal experience through their senses, such as something they saw, heard, or touched" (Immigration Enforcement UK, 2020). Circumstantial evidence is important in the absence of direct physical or scientific evidence. Circumstantial evidence "allows a conclusion to be drawn from a set of circumstances or information". (Immigration Enforcement UK, 2020). Although circumstantial evidence is not as powerful as direct evidence, a collection of circumstantial evidence could be crucial to prove a specific point in court. To build a powerful case against a suspect, or to conclusively know who the perpetrator is, forensic investigators should collect direct evidence along with powerful circumstantial evidence.

When considering modern-day forensic investigations, the knowledge of textile science could be mainly utilized for bloodstain pattern analysis (Carr, 2017). When compared with other types of evidence, bloodstain pattern analysis could produce a more definitive conclusion (Attinger, 2016), but this could be challenged when the perpetrator(s) wash or clean the bloodstained textile matter. A study has been carried out on cotton T-shirts to enhance the bloodstains on washed clothing (Adair, et al, 2005). As per the literature review, it was found that no specific research studies have been carried out on bloodstain analysis on Cotton and Polyester woven fabrics, which are widely used as household and apparel textiles. Therefore, the main objective of this study is to investigate the possibility of using washed bloodstains in selected Cotton and Polyester woven fabrics as direct forensic evidence to provide justice against criminal activities. The study was limited to 2 selected woven fabric types and 3 washing cycles.

METHODOLOGY

1. A comprehensive literature survey was carried out in relation to the research study.

2. Experiments were conducted on 4 sets of fabric samples, amounting to 60. They were used to produce drip and spatter stains samples and the results were photographed.

3. Sixty samples were washed in 3 cycles by using a domestic detergent after allowing 24 hours for stain fixation as per the part C of designing the experiment. After each washing cycle, the results were photographed.

4. Dried samples after each washing cycle, were treated with Luminol and the results were photographed.

5. By using Adobe Photoshop software, original blood-stained samples were compared with Luminol treated blood-stained samples after each washing cycle.

6. The relationship between the original blood-stained and the Luminol treated bloodstained samples was analyzed by using ImageJ software.

DESIGNING THE EXPERIMENT

Part A: Preparation of samples

100% Cotton and 100% Polyester woven fabrics were selected for the study as they are widely used for many household and apparel applications. The selection of fabrics for sample preparation is given in the table 1.

Table 1: Preparation of samples

Type of fabric	Number of Samples	Stain type to be introduced
100% Cotton plain-woven fabric	Set A – 15 samples	Drip stain
	Set B – 15 samples	Spatter stain
100% Polyester plain-woven fabric	Set C – 15 samples	Drip stain
	Set D – 15 samples	Spatter stain

Part B: Simulation experiments

Simulation experiments were carried out to produce drip and spatter bloodstain types on each set of samples. This was done by using the drip tower apparatus and modified mouse trap apparatus respectively (Attinger, 2016). Samples were mounted onto an embroidery hoop to insert and maintain a mild tension during stain formation and photography.

Figure 1: Drip tower apparatus (left) and modified mouse-trap apparatus (right)

During the experiment, 0.5 ml of blood was used for each drip or spatter stain. For drip stain formation, the blood was dispensed from a 3cc syringe above 0.5 m from the sample which was laid parallel to the ground. For spatter stain formation, the 0.5ml blood was dropped onto the wooden block and was clamped at an 80-degree angle to produce the stain on the sample which was kept perpendicular to the ground.

Part C: Washing and Drying

Sample washing was conducted as per the ISO 6330:2012 standard using the INNOVA DFA N60 top-loading agitator type washing machine. Three washing cycles, each of 12 minutes, were conducted by withdrawing 5 samples from each set (total 20 samples) after each cycle and introducing fresh 5 samples from each set (total 20 samples) to the washing machine to keep the weight constant. Line drying was done for 24 hours by keeping the warp direction vertical.

Part D: Testing the stained samples with Luminol

Luminol powder was used to produce a 250 ml solution. Three pumps of Luminol spray were applied to each sample in order to surface the already washed stains. The Luminol application to the samples was done inside a dark room in order to obtain quality photographs. Photographing was performed immediately after the application of Luminol to each sample.

DATA COLLECTION AND ANALYSIS

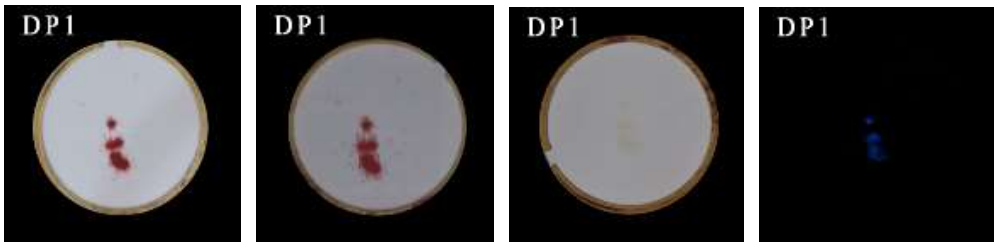
Part A: Data collection

Data collection was done as per the table given below.

Table 2: Summary of data collection

Type of sample	Set No:	Samples for washing cycle 1	Samples for washing cycle 2	Samples for washing cycle 3	Total samples
Drip stain -Cotton Samples (DC)	Set A	DC1-5	DC 6-10	DC 11-15	15
Spatter stain- Cotton Samples (SC)	Set B	SC 1-5	SC 6-10	SC 11-15	15
Drip stain -Polyester Samples (DP)	Set C	DP 1-5	DP 6-10	DP 11-15	15
Spatter stain- Polyester Samples (SP)	Set D	SP 1-5	SP 6-10	SP 11-15	15

A total of 60 samples were used for the experiment. These samples were photographed during various stages of the experiment for analysis. Figure 2 shows 4 photographs taken after each testing stage of DP1sample. DP1 indicates the Polyester sample 1 with Drip stain after the 1st washing cycle. Similarly, 4 stages of the other 59 samples were developed for data collection and analysis.



(A) (B) (C) (D)

Figure 2: Photograph of DP1 sample just after stain formation (A), after 20 minutes of stain formation (B), after washing and drying (C), and after testing with Luminol (D)

Part B: Analysis of qualitative data

In this qualitative analysis, each original blood-stained sample was compared with the relevant Luminol tested blood-stained sample as per the definitions stated in the Overseas Security Advisory Council, USA (2018). The summary of the qualitative analysis is given in the table 3.

Table 3: Summary of qualitative analysis

Type of sample	No of samples tested	No of samples matched with definition	No of samples deviated from definition
Drip stain -Cotton Samples (DC)	15	14	1
Spatter stain- Cotton Samples (SC)	15	12	3
Drip stain -Polyester Samples (DP)	15	15	0
Spatter stain- Polyester Samples (SP)	15	14	1

As per the results, it can be concluded that 55 out of 60 samples tested were matched with the testing definitions. Therefore, this qualitative analysis can be used with 91% accuracy to identify whether the Luminol tested samples had drip stains or spatter stains. Out of 5 deviated samples, 4 samples are Cotton. The reason could be the natural fibre structure of the Cotton samples.

Part C: Analysis of quantitative data

Statistical t-tests were performed to compare original blood-stained samples and Luminol tested samples. The average stain length and stain area are the parameters used for this analysis. Though all the sample sets were analysed for average stain length and stain area, only the results of the analysis of average stain length for drip stains of Polyester and Cotton

samples are given in the table 4. Only the dripped stained Cotton samples tested after the 3rd washing cycle showed a significant difference in the tested parameter of average stain length. The reason could be the combination of the natural nature of fibre composition and the increased number of washing cycles.

Table 4: Results of the t-test analysis for average stain length for Polyester and Cotton drip stain formation

Type of fabric	Number of washing cycles	Average stain length (cm)	Average Luminol stain length (cm)	t-test value obtained	Comparison with the level of significance
100% Polyester	1	1.6788	1.5238	0.276231483	α= 0.276231483> 0.05 No significant difference exists
	2	1.6018	2.2868	0.162574036	α= 0.162574036> 0.05 No significant difference exists
	3	1.5934	1.255	0.05737228	α= 0.05737228> 0.05 No significant difference exists
100% Cotton	1	1.9564	2.796	0.094635937	α= 0.094635937> 0.05 No significant difference exists
	2	2.9464	2.2634	0.760400423	α= 0.760400423> 0.05 No significant difference exists
	3	2.4794	3.4966	0.021934032	α= 0.021934032< 0.05 A significant difference exists

CONCLUSION

Through the literature survey, it was found that Luminol testing has been used to identify washed bloodstains on knitted garments. In this research study, the possibility of using washed bloodstains in selected Cotton and Polyester woven fabrics as direct forensic evidence was investigated. As per the results of the qualitative analysis, the washed bloodstain type can be identified with over 91% of accuracy irrespective of fabric type. Statistical t-tests were performed for all the sample sets on the average stain length, and the stain area. As per the results presented in table 4 in relation to the average stain length, it can be observed that there is no significant difference between original bloodstains and the washed bloodstains in Polyester samples after respective washing cycles. It was also observed that there is a significant difference between original bloodstains and the washed bloodstains in Cotton samples after the second washing cycle. The reason could be the combined effect of fibre type and the number of washing cycles. This project was conducted as a preliminary study to investigate the possibility of using washed and dried blood-stained fabrics as direct forensic evidence in criminal justice. Further studies should be carried out to validate the outcome by using an increased number of samples on the selected fabric types.

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