Original Article

Latent Fingerprint Development on Multiple Surfaces: A Comparative Analysis using Black Sindoor (Black Vermillion), Redsindoor (Red Vermillion), and Sandalwood Powder

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Abstract

The research deals with development of latent fingerprint on different surfaces using commercially available natural powders like red sindoor(red vermillion), black sindoor (black vermillion),and sandalwood. Paper describe new method of developing latent fingerprints using simple and non-toxic powders which are easily available and have variety of domestics and traditional uses. The study is to evaluate how well these powders reveal latent prints on a variety of surfaces using forensic procedures. The research aims to clarify the advantages and disadvantages of each powder type with respect to surface type (Glass surface,lamination sheet, transparencysheet, metal surface,woodensurface, plainpaper, cardboard, plastic, tile, and steel)using methodical experimentation and comparative analysis. It has been observed that the results are positive on almost all the surfaces. Ultimately, this study contributes to enhancing forensic methodologies for latent fingerprint detection and analysis, thereby aiding law enforcement agencies in criminal investigations and justice administration.

Introduction

Impression evidence refers to the impressions left at a crime scene or elsewhere that can be used to identify or link a specific object, tool, or individual to the scene. It includes marks or impressions made by shoes, tires, tools, or other objects, as well as bite marks or marks left by tools on other surfaces[1]. This type of evidence can be crucial in investigations as it can help establish connections between suspects, victims, and crime scenes, and can provide valuable information about the events that occurred[2].

Fingerprints

Fingerprints represent one of the most commonly discovered types of impression evidence at crime scenes. It is considered as the most important type of impression evidence used for identification purpose[3]. The term fingerprint evidence describes the exclusive ridges, grooves, and identifiable patterns located on a person's fingers and palms. These patterns are formed during fetal developmentandremain unchangedthroughout a person'slife,makingfingerprintsareliablemeans of identification[4].

Types of finger print evidence found on the crime Scene

- **Visible prints:** These prints are easily noticeable to the naked eye and are generally formed when substances such as blood, ink, dust, or grease on the fingers come into contact with another surface[7].

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- **Plastic Print:**Aplastic print refersto a raised, three-dimensional markcreated when fingerspress into a soft surface.
- **Latent Print:** Latent print are the invisible prints that are not visible to the naked eyes and required tobe developed. These impressions can be present on different types of surfaces,including glass, metal, plastic, and paper.Forensic experts use various methods to reveal latent prints, such as dusting with powder, applying chemical reagents, or using alternative light sources like ultraviolet or infrared light[8].

Methods used in Developing Latent Prints

Latent prints can be developed by using different methods (physical method, chemical method and instrumentation).

- Physicalmethod: Physical method of developing finger prints are the most commonly used method. A fine powder is carefully dusted over the surface suspected to contain latent fingerprints. The powder adheres to the oily residue left behind by the friction ridges of the skin, making the latent print visible.
- Chemical method: chemical method is anothere ffective method for development of latent finger print son different surfaces using chemicals. The semethods involve the application of specific chemicals that react with the components of the fingerprint residue, making the latent print visible
- Istrumentation Method: Instrumentation method involves using different techniques and instruments for development of latent print. These methods offer advantages such as increased sensitivity, precision, and the ability to detect prints on challenging surfaces.

Importance of Finger Print Development

The discovery of fingerprints at a crime scene can aid in both establishing a suspect's involvement and excluding individuals who are not connected to the incident. The uniqueness and permanenceof fingerprint patterns make them invaluable in establishing identity, aiding law enforcement agencies in solving crimes, proving innocence, and ensuring the fair administration of justice. Additionally, the development of fingerprints provides crucial evidence in court proceedings, helping to convict perpetrators and uphold the rule of law. Since fingerprint technology was developed, it has greatly aided in case solving and is still regarded as the most reliable way to identify the offender[9].

Importance of Using Commercially Available Natural Powders

Natural powders are easily available in market and are non-toxic compare to chemical powders. Commercial powders have various traditional uses. The chemical powders that are available is market have adverse effects on health as it contains chemicals. The commercially available powders are non-toxic and are easily available. The commercially available powders are cheap compare to the chemical powders[10].

Data Collection

Fingerprint samples were obtained from local people, with a total of 10 individuals participating in the study. Proper consent was taken from all the participants before the collection process. The primary objective of the study is to examine whether the collected fingerprints can be successfully developed using fingerprint powders.

Methodology

The present study focus on development of latent prints using commercially available natural powders in replacement of chemical powders. Commercially available powders are non-toxic and are easily available compare to chemical powders.

Materialsand Methods

1. **Selection of surface:**

   Different types of surfaces were used for latent print development such as plastic, Wood,

plain paper, steel, metal, Lamination sheet, cardboard, transparency sheet, Glass, and Tile.

2. **Powder Preparation:**
Commercially available Red sindoor powder (Red vermillion)were taken and ground in theblender until fine powder is obtained. The prepared powder is stored in test tubes and the test tubes were sealed. Also the room temperature was maintained. Same procedure was followed for Black sindoor (black vermillion) and Sandalwood powder.

3. Latent Finger print development:

- To visualize latent fingerprints, prepared powders (Red Sindoor, Black Sindoor, and Sandalwood)were applied to ten different surfaces, namely plastic, wood, plain paper, steel, metal, lamination sheets, cardboard, transparency sheets, glass, and tiles.
- Anostrich feature brush was used to apply powder on the surface containing latent print.
- Once the latent print was developed photograph of the print was taken for analysis.
- The finger print was collected using adhesive tape. The fingerprint was later preserved by affixing the tape containing the developed print onto a lifting card.
- At last the print was compared to each other based on the clarity of the print on different surfaces.

Latent Finger Prints Developed using Red Sindoor Powder (Red Vermillion) On Different Surfaces

Glass Surface

Lamination Sheet

Transparency Sheet

Metal Surface

Wooden Surface

Plain Paper Surface

Cardboard Surface

Plastic Surface

TileSurface

Steel Surface

Latent Finger Prints Developed using Black Sindoor Powder (Black Vermillion) Ondifferent Surfaces

Glass Surface

Lamination Sheet

Transparency Sheet

Metal Surface

Wooden Surface

Plain Paper Surface

Cardboard Surface

Plastic Surface

Tile Surface

Steel Surface

Latent Finger Prints Developed using Sandal Wood Powder on Different Surfaces

Glass Surface

Lamination sheet

Transparency sheet

MetalSurface

WoodenSurface

Plain Paper Surface

Cardboard Surface

Plastic Surface

Tile Surface

Steel Surface

Data Analysis

Table 1. Development of latent finger print using Red Sindoor powder (Red Vermillion)

Surface	Development
Glass	Developed
Laminationsheet	Developed
Metal	Developed
Tile	Developed
Cardboard	Developed
Transparency sheet	Developed
Steel	Developed
Plain paper	Developed
Wood	Developed
Plastic	Developed

Table 2. Development of latent finger print using Black Sindoor Powder (Black Vermillion)

Surface	Development
Glass	Developed
Laminationsheet	Developed
Metal	Developed
Tile	Developed
Cardboard	Developed
Transparency sheet	Developed
Steel	Developed
Plain paper	Developed
Wood	Developed
Plastic	Developed

Table 3. Development of latent finger print using Sandal wood Powder

Surface	Development
Glass	Developed
Laminationsheet	Developed
Metal	Developed
Tile	Developed
Cardboard	Developed
Transparency sheet	Developed
Steel	Developed
Plain paper	Developed
Wood	Developed
Plastic	Developed

Comparison

The fingerprints were successfully developed on all the tested surfaces using three different powders: black powder (Black Vermillion), red sindoor(Red Vermillion), and sandalwood powder. In general, the ridge patterns were clearly visible across most surfaces, demonstrating the effectiveness of all three development techniques. However, certain limitations were observed during the process. Specifically, when red sindoor and sandalwood powder were used on cardboard surfaces, the ridge details were not as distinct compared to other surfaces, indicating reduced clarity or incomplete development. Additionally, on plain paper, the fingerprints developed with sandalwood powder appeared slightly smudged, which could be attributed to the texture or absorbent nature of the paper affecting the powder's adherence.

Major Findings

Red Sindoor powder (Red Vermillion)

The latent fingerprints developed using red sindoor powder showed successful results on most ofthe surfaces tested. Red sindoor, being a fine powder with bright coloration, provided good contrast against various backgrounds, allowing the ridge patterns of the fingerprints to become visible. The powder adhered effectively to the sweat and oily residues left by the fingerprint, resulting in clear development of ridgedetails on non-porous and semi-porous surfaces. However, the performance of red sindoor was not consistent across all materials. On cardboard surfaces, the finger prints developed using red sindoor were not as clear or defined. This is primarily due to the absorbent nature of cardboard, which tends to soak up the moisture and sweat present in the finger print residue. As a result, the ridge patterns become diffused or faded within the surface layers, preventing the red sindoor powder from properly adhering to and highlighting the finger print details. Therefore, while red sindoor proved to be an effective and easily available agent for developing latent prints on several surfaces, its performance was limited on porous materials like cardboard where the absorption of fingerprint residue reduced the clarity of the developed impressions.

Black Sindoor Powder (Black Vermillion)

The use of black sindoor powder for developing latent fingerprints yielded successful results on all examined surfaces. Black sindoor, known for its fine consistency and dark shade, provided excellent visibility of ridge patterns, even on surfaces with varying textures and colors. Thepowder adhered effectively to the moisture, natural oils, and residues left by the fingertips, making the finger print impressions stand out with good clarity. An important observation was that black sindoor performed consistently across both porous and non-porous surfaces. Even on challenging materials like cardboard, where fingerprint development is often difficult due to the surface absorbing sweat and other residues, black sindoor produced clear and distinguishable ridge details. Its strongcontrast and good sticking properties allowed the ridge patterns to be developed without smudging or loss of detail. The overall findings suggest that black sindoor is a reliable and affordable option for developing latent fingerprints, offering consistent results on different types of surfaces.

Sandalwood Powder

The development of latent fingerprints using sandalwood powder showed positive results on all tested surfaces, as the powder successfully revealed fingerprint impressions across different materials. Sandalwood powder, being finely ground and light in color, offered reasonable contrast, especially on darker backgrounds. It adhered to the residues left by the fingerprint, allowing the ridge patterns to become visible. However, certain limitations were noted during the process. On plain paper and cardboard surfaces, the developed fingerprints were not clear and appeared smudged. This can be attributed to the porous and absorbent nature of both materials. Surfaces like paper and cardboard tend to absorb the moisture, sweat, and oils from the fingerprint before the development process, causing the ridge

details to diffuse into the surface layers. As a result, when sandalwood powder was applied, it could not settle accurately on the ridge structures, leading to smudging and unclear impressions. Despite these limitations on porous surfaces, sandalwood powder proved to be an effective and natural alternative for fingerprint development, showing satisfactory results on most surfaces, particularly non-porous and semi-porous materials where better clarity was achieved.

Discussions

The present study evaluated the effectiveness of red sindoor powder, black sindoor powder, and sandalwood powder as locally available agents for latent fingerprint development on different surfaces. The findings demonstrate that each of the tested powders exhibited distinct advantages and limitations depending on the surface type.

Red sindoor powder showed good contrast and clear fingerprint ridge details on non-porous and semi-porous surfaces, but its effectiveness decreased on porous surfaces like cardboard. This observation aligns with previous studies (Cadd et al., 2015; Lee &Gaensslen, 2014), which reported that powders generally produce better results on smooth, non-porous substrates due to the oily substance that retents the residues. The inability of red sindoor to produce clear impressions on porous surfaces is consistent with the general challenge faced when developing fingerprints on absorbent materials.

In comparison, black sindoor powder performed consistently across all surfaces, including porous ones such as cardboard. Its fine texture and strong color contrast appear to enhance adhesion to fingerprint residues, enabling the visualization of ridge details with minimal smudging. These results are comparable to those obtained with standard black fingerprint powders, which have long been considered reliable for diverse surfaces (Saferstein, 2021; Champod et al., 2016). The consistency of black sindoor across porous and non-porous materials suggests that it may serve as a cost-effective alternative to commercially available powders in forensic casework.

Sandalwood powder also proved effective, particularly on non-porous and semi-porous surfaces, where satisfactory ridge clarity was observed. However, its performance on paper and cardboard was limited due to diffusion of fingerprint residues into the absorbent surface, resulting in smudged impressions. Similar limitations with light-colored powders on porous surfaces have been reported in earlier research (Fieldhouse, 2011; Cadd et al., 2015). Despite this drawback, sandalwood powder's natural origin and accessibility make it a potential eco-friendly option for fingerprint development.

Overall, the comparative findings indicate that black sindoor powder offered the most consistent and reliable performance across different surface types. Red sindoor and sandalwood powders demonstrated promising results on non-porous materials but were less effective on porous surfaces, a limitation widely acknowledged in prior fingerprint development studies. These findings reinforce the importance of surface characteristics in fingerprint development and support the use of sindoor powders, particularly black sindoor, as affordable and accessible alternatives to conventional forensic powders.

Conclusion

The present research highlights the effectiveness of easily available household powders—red sindoor, black sindoor, and sandalwood powder—in the development of latent fingerprints on various surfaces. Among the three, black sindoor demonstrated the most consistent results, successfully developing clear and visible ridge patterns on all tested surfaces, including porous materials like cardboard. Red sindoor also proved effective on most surfaces but showed reduced clarity on cardboard due to the absorbent nature of the material, which limits proper powder adherence. Sandalwood powder, though capable of developing prints on all surfaces, displayed certain limitations, especially on plain paper and cardboard, where the finger prints appeared smudged and the ridge details lacked definition. The findings suggest that while all three powders havepotential forlatent fingerprint

development, the surface text ure and porosity play a crucial role in the clarity and quality of the developed prints. Among the materials tested, black sindooremerged as the most reliable option for both porous and non-porous surfaces, making it a practical and cost-effective alternative in situations where conventional fingerprint powders are unavailable. This research demonstrates the feasibility of using readily available household materials in forensic fingerprint development, while also emphasizing the need to select development agents based on surface characteristics to achieve optimal results.

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